



CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board

500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

Fox Valley Metrology, Ltd.
3114 Medalist Drive
Oshkosh, WI 54902

has been assessed by ANAB
and meets the requirements of international standard

ISO/IEC 17025:2005

and national standard

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

while demonstrating technical competence in the fields of

TESTING AND CALIBRATION

Refer to the accompanying Scope of Accreditation for information regarding the types of calibrations and/or tests to which this accreditation applies.

ACT-1272

Certificate Number


ANAB Approval

Certificate Valid: 10/15/2018-06/15/2019
Version No. 010 Issued: 10/15/2018



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. 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 17025:2005,
ANSI/NCSL Z540-1-1994 (R2002) AND ANSI/NCSL Z540.3-2006 (R2013)**

Fox Valley Metrology, Ltd.

3114 Medalist Drive
Oshkosh, WI 54902
Mark Toll 920-426-5894

CALIBRATION

Valid to: **June 15, 2019**

Certificate Number: **ACT-1272**

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
Accelerometers 1 g reference 1 g reference	20 Hz to 2 kHz (2 to 15) kHz	1.7 % of reading 2.6 % of reading	PCB 9150C Accelerometer Calibration Workstation

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
Conductivity Meters ¹	12.85 mS/cm 1408 µS/cm	0.18 mS/cm 14 µS/cm	Conductivity Solutions
Refractometers ¹	(0.0, 18.0, 29.7) Brix	0.24 Brix	Refractive Index Solutions

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



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 V to 1.1 kV	12 $\mu\text{V/V} + 0.4 \mu\text{V}$ 5.8 $\mu\text{V/V} + 0.7 \mu\text{V}$ 4.2 $\mu\text{V/V} + 2.5 \mu\text{V}$ 4.1 $\mu\text{V/V} + 4 \mu\text{V}$ 5.8 $\mu\text{V/V} + 40 \mu\text{V}$ 7.6 $\mu\text{V/V} + 0.4 \text{mV}$	Fluke 5720A Multiproduct Calibrator
DC Voltage - Measure ¹	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV	7.8 $\mu\text{V/V} + 0.8 \mu\text{V}$ 5.7 $\mu\text{V/V} + 0.8 \mu\text{V}$ 5.6 $\mu\text{V/V} + 1 \mu\text{V}$ 7.9 $\mu\text{V/V} + 80 \mu\text{V}$ 7.9 $\mu\text{V/V} + 0.15 \text{mV}$	Agilent 3458A Opt 002 Multimeter
DC Voltage - Measure ¹	Up to 200 mV 200 mV to 2 V (2 to 20) V (20 to 200) V 200 V to 1.05 kV	5 $\mu\text{V/V} + 0.10 \mu\text{V}$ 3.5 $\mu\text{V/V} + 0.4 \mu\text{V}$ 3.5 $\mu\text{V/V} + 4 \mu\text{V}$ 5.5 $\mu\text{V/V} + 40 \mu\text{V}$ 5.5 $\mu\text{V/V} + 500 \mu\text{V}$	Fluke 8508A Multimeter
DC High Voltage - Measure ¹	(1 to 10) kV (10 to 100) kV	60 V 0.6 kV	Hipotronics KVM-100 High Voltage Meter
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 $\mu\text{A/A} + 7 \text{nA}$ 41 $\mu\text{A/A} + 40 \text{nA}$ 52 $\mu\text{A/A} + 0.7 \mu\text{A}$ 93 $\mu\text{A/A} + 12 \mu\text{A}$	Fluke 5720A Multiproduct Calibrator
	(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 5520A Multiproduct Calibrator
	(20.5 to 1 000) A	86 mA/A + 0.5 A	Fluke 5520A Multiproduct Calibrator with 50-turn Coil
DC Current - Measure ¹	Up to 100 nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA 100 μA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	48 $\mu\text{A/A} + 65 \text{pA}$ 35 $\mu\text{A/A} + 65 \text{pA}$ 35 $\mu\text{A/A} + 0.15 \text{nA}$ 35 $\mu\text{A/A} + 1.3 \text{nA}$ 35 $\mu\text{A/A} + 10 \text{nA}$ 36 $\mu\text{A/A} + 0.1 \mu\text{A}$ 15 $\mu\text{A/A} + 1 \mu\text{A}$ 0.14 mA/A + 20 μA	Agilent 3458A Opt 002 Multimeter



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 Multimeter
DC Current - Measure ¹	(1 to 10) A	2.4 mA/A + 0.7 mA	Fluke DMM
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 Multimeter
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 Multimeter
Resistance - Source ¹	0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 k Ω 1.9 k Ω 10 k Ω 19 k Ω 100 k Ω 190 k Ω 1 M Ω 1.9 M Ω	0.11 m Ω 0.11 m Ω 0.21 m Ω 0.27 m Ω 0.51 m Ω 1.4 m Ω 2.6 m Ω 11 m Ω 21 m Ω 0.11 Ω 0.21 Ω 1.3 Ω 2.7 Ω 24 Ω 48 Ω	Fluke 5720A Multiproduct Calibrator



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Resistance - Source ¹	10 MΩ 19 MΩ 100 MΩ	0.48 kΩ 1.1 kΩ 23 kΩ	Fluke 5720A Multiproduct Calibrator
	1 GΩ 10 GΩ 100 GΩ	1.9 MΩ 47 MΩ 0.95 GΩ	
Resistance - Measure ¹	Up to 10 Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ	24 μΩ/Ω + 0.1 mΩ 20 μΩ/Ω + 1 mΩ 18 μΩ/Ω + 1 mΩ 18 μΩ/Ω + 10 mΩ 18 μΩ/Ω + 0.1 Ω 24 μΩ/Ω + 7 mΩ 87 μΩ/Ω + 0.2 Ω 0.73 mΩ/Ω + 2 Ω 7.2 mΩ/Ω + 20 kΩ	Agilent 3458A Opt 002 Multimeter
AC Voltage - Source ¹	Up to 2.2 mV (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 (2.2 to 22) mV (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	2.4 mV/V + 4 μV 2.4 mV/V + 4 μV 2.2 mV/V + 4 μV 2.2 mV/V + 4 μV 2.3 mV/V + 5 μV 2.5 mV/V + 10 μV 2.7 mV/V + 20 μV 3.8 mV/V + 20 μV 0.61 mV/V + 4 μV 0.56 mV/V + 4 μV 0.36 mV/V + 4 μV 0.42 mV/V + 4 μV 0.70 mV/V + 5 μV 1.3 mV/V + 10 μV 1.7 mV/V + 20 μV 3.4 mV/V + 20 μV	Fluke 5720A Multiproduct Calibrator



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage - Source ¹	(22 to 220) mV		Fluke 5720A Multiproduct Calibrator
	(10 to 20) Hz	0.29 mV/V + 12 μV	
	(20 to 40) Hz	0.13 mV/V + 7 μV	
	40 Hz to 20 kHz	0.11 mV/V + 7 μV	
	(20 to 50) kHz	0.24 mV/V + 7 μV	
	(50 to 100) kHz	0.54 mV/V + 17 μV	
	(100 to 300) kHz	1.1 mV/V + 20 μV	
	(300 to 500) kHz	1.6 mV/V + 25 μV	
	500 kHz to 1 MHz	3.3 mV/V + 45 μV	
	(0.22 to 2.2) V		
	(10 to 20) Hz	0.28 mV/V + 40 μV	
	(20 to 40) Hz	0.11 mV/V + 15 μV	
	40 Hz to 20 kHz	55 μV/V + 8 μV	
	(20 to 50) kHz	0.12 mV/V + 10 μV	
	(50 to 100) kHz	0.13 mV/V + 30 μV	
	(100 to 300) kHz	0.49 mV/V + 80 μV	
	(300 to 500) kHz	1.2 mV/V + 0.2 mV	
	500 kHz to 1 MHz	2.0 mV/V + 0.3 mV	
	(2.2 to 22) V		
	(10 to 20) Hz	0.28 mV/V + 0.2 mV	
	(20 to 40) Hz	0.11 mV/V + 0.15 mV	
	40 Hz to 20 kHz	56 μV/V + 50 μV	
	(20 to 50) kHz	0.12 mV/V + 0.1 mV	
	(50 to 100) kHz	0.12 mV/V + 0.2 mV	
	(100 to 300) kHz	0.32 mV/V + 0.6 mV	
	(300 to 500) kHz	1.2 mV/V + 2 mV	
	500 kHz to 1 MHz	1.8 mV/V + 3.2 mV	
(22 to 220) V			
(10 to 20) Hz	0.28 mV/V + 4 mV		
(20 to 40) Hz	0.11 mV/V + 1.5 mV		
40 Hz to 20 kHz	65 μV/V + 0.6 mV		
(20 to 50) kHz	0.12 mV/V + 1 mV		
(50 to 100) kHz	0.18 mV/V + 2.5 mV		
(100 to 300) kHz	1.1 mV/V + 16 mV		
(300 to 500) kHz	5.1 mV/V + 40 mV		
500 kHz to 1 MHz	9.3 mV/V + 80 mV		
220 V to 1.1 kV			
(15 to 50) Hz	0.35 mV/V + 16 mV		
50 Hz to 1 kHz	88 μV/V + 3.5 mV		



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage Harmonics – Source (2 nd to 50 th) ¹ (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 kV 33 mV to 1 kV 330 mV to 1 kV 3.3 V to 1 kV	0.35 mV/V + 16 μV 0.21 mV/V + 16 μV 0.21 mV/V + 16 μV 0.21 mV/V + 0.21 mV 0.21 mV/V + 1.2 mV	Fluke 5520A Multiproduct Calibrator
AC Voltage - Measure ¹ Bandwidth < 2 MHz	Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (10 to 100) mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz 100 mV to 1 V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.46 mV/V + 13 μV 0.35 mV/V + 11 μV 0.46 mV/V + 11 μV 1.3 mV/V + 11 μV 5.9 mV/V + 11 μV 46 μV/V + 12 μV 0.14 mV/V + 4.5 μV 0.14 mV/V + 2.5 μV 0.22 mV/V + 2.5 μV 0.41 mV/V + 2.5 μV 0.99 mV/V + 2.5 μV 3.5 mV/V + 11 μV 12 mV/V + 11 μV 18 mV/V + 11 μV 0.14 mV/V + 45 μV 0.14 mV/V + 25 μV 0.22 mV/V + 25 μV 0.41 mV/V + 25 μV 0.99 mV/V + 25 μV 3.5 mV/V + 0.11 mV 12 mV/V + 0.11 mV 18 mV/V + 0.11 mV	Agilent 3458A Opt 002 Multimeter



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage - Measure ¹ Bandwidth < 2 MHz	(1 to 10) V		Agilent 3458A Opt 002 Multimeter
	(1 to 40) Hz	0.14 mV/V + 0.45 mV	
	40 Hz to 1 kHz	0.14 mV/V + 0.25 mV	
	(1 to 20) kHz	0.22 mV/V + 0.25 mV	
	(20 to 50) kHz	0.41 mV/V + 0.25 mV	
	(50 to 100) kHz	0.98 mV/V + 0.25 mV	
	(100 to 300) kHz	3.5 mV/V + 1.1 mV	
	300 kHz to 1 MHz	12 mV/V + 1.1 mV	
	(1 to 2) MHz	18 mV/V + 1.1 mV	
	(10 to 100) V		
(1 to 40) Hz	0.29 mV/V + 4.5 mV		
40 Hz to 1 kHz	0.29 mV/V + 2.5 mV		
(1 to 20) kHz	0.29 mV/V + 2.5 mV		
(20 to 50) kHz	0.29 mV/V + 2.5 mV		
(50 to 100) kHz	1.5 mV/V + 2.5 mV		
(100 to 300) kHz	4.7 mV/V + 11 mV		
300 kHz to 1 MHz	18 mV/V + 11 mV		
100 V to 1 kV			
(1 to 40) Hz	0.52 mV/V + 45 mV		
40 Hz to 1 kHz	0.52 mV/V + 25 mV		
(1 to 20) kHz	0.75 mV/V + 25 mV		
(20 to 50) kHz	1.5 mV/V + 25 mV		
(50 to 100) kHz	3.5 mV/V + 25 mV		
(1 to 10) kV			Hipotronics KVM-100 High Voltage Meter
(50 to 60) Hz	0.12 kV		
(10 to 100) kV			Hipotronics KVM-100 High Voltage Meter
(50 to 60) Hz	1.2 kV		
AC Voltage - Measure ¹ Bandwidth > 2 MHz	Up to 10 mV		Agilent 3458A Opt 002 Multimeter
	45 Hz to 100 kHz	1.2 mV/V + 6 μV	
	100 kHz to 1 MHz	14 mV/V + 5.1 μV	
	(1 to 4) MHz	83 mV/V + 7.1 μV	
	(4 to 8) MHz	0.24 V/V + 8.1 μV	
	(10 to 100) mV		
	45 Hz to 100 kHz	1.1 mV/V + 61 μV	
	100 kHz to 1 MHz	24 mV/V + 51 μV	
	(1 to 4) MHz	47 mV/V + 71 μV	
	(4 to 8) MHz	47 mV/V + 81 μV	
(8 to 10) MHz	0.18 V/V + 0.1 mV		

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage - Measure ¹ Bandwidth > 2 MHz	100 mV to 1 V 45 Hz to 100 kHz 100 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) MHz	1.1 mV/V + 0.61 mV 24 mV/V + 0.51 mV 47 mV/V + 0.71 mV 47 mV/V + 0.81 mV 0.18 V/V + 1 mV	Agilent 3458A Opt 002 Multimeter
	(1 to 10) V 45 Hz to 100 kHz 100 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) MHz	1.2 mV/V + 6.1 μV 24 mV/V + 5.1 μV 47 mV/V + 7.1 μV 47 mV/V + 8.1 μV 0.18 V/V + 10 μV	
	(10 to 100) V 45 Hz to 100 kHz	1.5 mV/V + 2.5 mV	Hipotronics KVM-100 High Voltage Meter
	100 V to 1 kV 45 Hz to 100 kHz	3.6 mV/V + 0.11 V	
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	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	Fluke 8508A Multimeter



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage - Measure ¹ Bandwidth < 1 MHz	(2 to 20) V		Fluke 8508A Multimeter
	(1 to 10) Hz	0.15 mV/V + 1.2 mV	
	(10 to 40) Hz	0.12 mV/V + 0.2 mV	
	(40 to 100) Hz	90 μV/V + 0.2 mV	
	100 Hz to 2 kHz	75 μV/V + 0.2 mV	
	(2 to 10) kHz	0.11 mV/V + 0.2 mV	
	(10 to 30) kHz	0.22 mV/V + 8.4 mV	
	(30 to 100) kHz	0.57 mV/V + 2 mV	
	(100 to 300) kHz	3 mV/V + 20 mV	
	300 kHz to 1 MHz	10 mV/V + 20 mV	
	(20 to 200) V		
	(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		
AC Current - Source ¹	200 V to 1.05 kV		Fluke 5720A Multiproduct Calibrator
	(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	
	Up to 220 μA		
	(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		



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current - Source ¹	(2.2 to 22) mA (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 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	0.32 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 0.30 mA/A + 4 μA 0.20 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 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
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 5520A Multiproduct Calibrator
AC Current - Source ¹	(20.5 to 1 000) A (45 to 65) Hz (20.5 to 150) A (65 to 440) Hz	90 mA/A + 0.5 A 0.55 mA/A + 0.5 mA	Fluke 5520A Multiproduct Calibrator w/ 50-turn Coil



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 5520A Multiproduct Calibrator
AC Current - Measure ¹	Up to 100 μA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz 100 μA to 1 mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz (1 to 10) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz (10 to 100) mA (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	4.8 mA/A + 30 nA 1.9 mA/A + 30 nA 0.83 mA/A + 30 nA 0.83 mA/A + 30 nA 4.9 mA/A + 0.2 μA 1.9 mA/A + 0.2 μA 0.83 mA/A + 0.2 μA 0.47 mA/A + 0.2 μA 0.83 mA/A + 0.2 μA 4.9 mA/A + 0.4 μA 6.6 mA/A + 1.5 μA 4.9 mA/A + 2 μA 1.9 mA/A + 2 μA 0.83 mA/A + 2 μA 0.47 mA/A + 2 μA 0.83 mA/A + 2 μA 4.9 mA/A + 4 μA 6.6 mA/A + 15 μA 4.9 mA/A + 20 μA 1.9 mA/A + 20 μA 0.83 mA/A + 20 μA 0.47 mA/A + 20 μA 0.47 mA/A + 20 μA 4.9 mA/A + 40 μA 6.6 mA/A + 0.15 mA	Agilent 3458A Opt 002 Multimeter



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current - Measure ¹	100 mA to 1 A (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	4.8 mA/A + 0.2 mA 2 mA/A + 0.2 mA 1.1 mA/A + 0.2 mA 1.3 mA/A + 0.2 mA 3.7 mA/A + 0.2 mA 12 mA/A + 0.4 mA	Agilent 3458A Opt 002 Multimeter
AC Current - Measure ¹	(1 to 10) A (20 to 50) Hz 50 Hz to 2 kHz	0.23 A/A + 10 mA 36 mA/A + 10 mA	Fluke DMM
AC Current - Measure ¹	Up to 200 μ A (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz 200 μ A 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 μ A 0.3 mA/A + 0.2 μ A 0.71 mA/A + 0.2 μ A 4 mA/A + 0.2 μ A 0.31 mA/A + 2 μ A 0.3 mA/A + 2 μ A 0.71 mA/A + 2 μ A 4 mA/A + 2 μ A 0.31 mA/A + 20 μ A 0.3 mA/A + 20 μ A 0.63 mA/A + 20 μ A 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 Multimeter
Capacitance - Measure ¹ 42 Hz to 5 MHz	0.32 pF to 370 mF	1.1 mF/F	Hioki 3532-50 LCR Meter



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Capacitance - Source ¹	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 5520A Multiproduct Calibrator
Phase - Measure ¹	(0 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
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 5520A Multiproduct Calibrator
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 5520A Multiproduct Calibrator



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Oscilloscopes ¹			Fluke 5520A SC1100 Multiproduct Calibrator
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 mV to 6.6 V	2.9 mV/V + 40 μV	
AC Voltage (1 MΩ)	1 mV to 130 V	1.1 mV/V + 40 μV	
Leveled Sine Wave 50 kHz to 1.1 GHz	5 mV to 5.5 V	51 mV/V + 0.1 mV	
Time Markers	1 ns to 5 s	6.4 μs/s	
Wave Generator (50 Ω)	1.8 mV to 2.5 V p-p	35 mV/V + 0.10 mV	
Wave Generator (1 MΩ)	1.8 mV to 55 V p-p	35 mV/V + 0.10 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 RTDs 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	0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.10 °C 0.12 °C 0.23 °C	Fluke 5520A Multiproduct Calibrator



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Electrical Simulation of RTDs ¹	Pt 3926, 100 Ω		Fluke 5520A Multiproduct Calibrator
	(-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	0.10 °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	0.10 °C	
	(600 to 630) °C	0.23 °C	
	Pt 385, 200 Ω		
	(-200 to -80) °C	0.04 °C	
	(-80 to 0) °C	0.04 °C	
	(0 to 100) °C	0.04 °C	
	(100 to 260) °C	0.05 °C	
	(260 to 300) °C	0.12 °C	
	(300 to 400) °C	0.13 °C	
	(400 to 600) °C	0.14 °C	
(600 to 630) °C	0.16 °C		
Pt 385, 500 Ω			
(-200 to -80) °C	0.04 °C		
(-80 to 0) °C	0.05 °C		
(0 to 100) °C	0.05 °C		
(100 to 260) °C	0.06 °C		
(260 to 300) °C	0.08 °C		
(300 to 400) °C	0.08 °C		
(400 to 600) °C	0.09 °C		
(600 to 630) °C	0.11 °C		



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Electrical Simulation of RTDs ¹	Pt 385, 1 000 Ω		Fluke 5520A Multiproduct Calibrator
	(-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	
Electrical Simulation of Thermocouples ¹	Cu 427, 10 Ω		Fluke 5520A Multiproduct Calibrator
	(-100 to 260) °C	0.03 °C	
	Type K		
	(-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	0.40 °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	0.50 °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		



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Electrical Simulation of Thermocouples ¹	Type S (0 to 250) °C	0.47 °C	Fluke 5520A Multiproduct Calibrator
	(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	0.30 °C	
	(120 to 1 000) °C	0.33 °C	
	Type C (0 to 150) °C	0.30 °C	
	(150 to 650) °C	0.26 °C	
	(650 to 1 000) °C	0.31 °C	
	(1 000 to 1 800) °C	0.50 °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	0.40 °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	0.40 °C		
Type U (-200 to 0) °C	0.56 °C		
(0 to 600) °C	0.27 °C		
Inductance - Source ¹	(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



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
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
ESD Simulators Rise Time Peak Current 30 nS Current 60 nS Current RC Time Constant 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 0.10 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

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	(+20 to +30) dBm	0.37 dB 0.39 dB 0.4 dB	Agilent N5531S Measuring Receiver with N5532A Sensor Modules
100 kHz to 3 GHz (3 to 18) GHz (18 to 26.5) GHz	(-20 to +20) dBm	0.15 dB 0.18 dB 0.21 dB	
Relative Level (3.05 to 6.6) GHz (6.6 to 13.2) GHz (13.2 to 19.2) GHz (19.2 to 26.5) 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 (-62 to +30) dBm (-85 to -62) 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 0.026 dB + 0.005 dB/10 dB 0.051 dB + 0.12 dB/10 dB	Agilent N5531S Measuring Receiver with N5532A Sensor Modules



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Amplitude Modulation - Source ^{1,4} Rate: DC to 100 kHz Depths: 0 % to 100 %	250 kHz to 40 GHz	7.1 % of setting + 1 %	Agilent E8257D Signal Generator
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
Phase Modulation - Source ^{1,4} Rate: DC to 100 kHz	250 kHz to 40 GHz	5.9 % setting + 0.1 rad	Agilent E8257D Signal Generator
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 (13.2 to 19.2) 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 (+20 to +30) dBm (-70 to +20) dBm (-93 to -70) 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 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



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Tuned RF Level - Measure ^{1,4} Absolute Level (19.2 to 26.5) GHz 500 kHz to 3.05 GHz	(+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 0.24 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
RF Power - Source ¹ 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	> -10 dBm (-10 to -70) dBm (-70 to -90) dBm	0.72 dB 0.96 dB 1.1 dB 0.89 dB 1.1 dB 1.2 dB 0.95 dB 1.2 dB 1.21 dB	Agilent E8257D Signal Generator
RF Power Sensors- Calibration Factor ^{1,4} 100 kHz to 10 MHz 10 MHz to 10 GHz (10 to 18) GHz	(-20 to +14) dBm	1.5 % 1.5 % 1.7 %	Tegan 1827 Power Sensor Calibrator, Agilent 3458A Multimeter, Agilent E8257D Signal Generator, Agilent E4419B Power Meter, Agilent 3325B Function Generator
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



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: $\leq (N \times 800 \text{ kHz})$	4.2 % setting + 20 Hz	Agilent E8257D Signal Generator
Pulse Generation - Measure ^{1,4} DC to 225 MHz Pulse Width Rise/Fall Time	5 ns to 10 ⁵ S 5 ns to 10 ⁵ S	1.1 nS 1.1 nS	Agilent 53132A Counter
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	17 ns	Agilent E8257D Signal Generator

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Gage Blocks ²	Up to 10 in	$(3.9 + 1.3L) \mu\text{in}$	LabMaster Universal Measuring Machine Per ASME B89.1.9
	(10 to 20) in	$(8.5 + 1L) \mu\text{in}$	ULM 600 Measuring Machine Per ASME B89.1.9
	Up to 20 in	$(3.9 + 1.3L) \mu\text{in}$	Mahr 828 Measuring Machine Per ASME B89.1.9
Length Standards ²	Up to 9 in	$(39 + 0.4L) \mu\text{in}$	P&W Supermicrometer
	(9 to 24) in	$(12 + 1L) \mu\text{in}$	ULM 600 Measuring Machine
	(24 to 70) in	$(390 + 2.6L) \mu\text{in}$	CMM
Cylindrical Rings ²	(0.25 to 8) in (0.025 to 12) in	$(13 + 1.3D) \mu\text{in}$ $(13 + 1.8D) \mu\text{in}$	LabMaster Universal ULM 600 ASME B89.1.6

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Cylindrical Rings ²	(0.025 to 18) in	$(8 + 1.8D) \mu\text{in}$	Mahr 828 CIM Measuring Machine ASME B89.1.6
Cylindrical Rings ^{1,2}	(0.25 to 5) in	$(12 + 3D) \mu\text{in}$	Fowler Lab Concept Measuring Machine ASME B89.1.6
Cylindrical Plugs ²	(0.010 to 8) in	$(2.7 + 6D) \mu\text{in}$	LabMaster Universal
Cylindrical Plugs ^{1,2}	(0.010 to 4) in	$(53 + 0.4D) \mu\text{in}$	Plug gage Comparator
Thread Rings ² Pitch Diameter Pitch Diameter Minor Diameter	Up to 8 in Up to 8 in Up to 8 in	$(240 + 0.3D) \mu\text{in}$ 38 μin 120 μin	Setting Plug Gages ULM 600 Measuring Machine ID Bore Gages ASME B1.2
NPT Rings ² Standoff and Basic Length	(0.0625 to 6) in	250 μin	NPT Plugs, P&W LabMaster ASME B1.20.5
NPT Plugs ² Standoff and Basic Length	(0.0625 to 6) in	490 μin	NPT Rings, P&W LabMaster ASME B1.20.5
Threaded Plugs ² Pitch Diameter Major Diameter	(0.01 to 10) in (0.01 to 10) in	$(73 + 0.9D) \mu\text{in}$ $(40 + 1.2D) \mu\text{in}$	P&W Supermicrometer, Thread Measuring Wires ASME B1.2
Threaded Plugs ^{1,2} Pitch Diameter Major Diameter	(0.01 to 4) in (0.01 to 4) in	$(73 + 3.2D) \mu\text{in}$ $(53 + 4.1D) \mu\text{in}$	Plug gage Comparator
Thread Wires ²	(0.005 to 0.5) in	$(11 + 1.5D) \mu\text{in}$	ULM 600 Measuring Machine ASME B89.1.17
Calipers ^{1,2}	Up to 80 in	$(380 + 15L) \mu\text{in}$	Gage Blocks
Indicators ^{1,2}	Up to 4 in	$(36 + 10L) \mu\text{in}$	Indicator Checker
Test Indicators ^{1,2}	Up to 0.06 in	39 μin	Indicator Checker
OD Micrometers ^{1,2}	Up to 60 in	$(72 + 12L) \mu\text{in}$	Gage Blocks
ID Micrometer ^{1,2}	(1.5 to 40) in	$(370 + 7L) \mu\text{in}$	Gage Blocks



Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Height Gages ^{1,2}	Up to 40 in	(96 + 14L) μin	Gage Blocks
Bore Gages ^{1,2}	(0.25 to 12) in	350 μin	Cylindrical Rings
Crimpers ^{1,2} 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
Profilometers ^{1,2} Ra	(2 to 300) μin	2.2 μin	Roughness Specimen
Profilometer Reference Specimens Ra	(0.01 to 300) μin	2.1 μin	Profilometer
Surface Plates ^{1,2} Repeat Reading Overall Flatness	(4 to 34) in <i>DL</i> (34 to 175) in <i>DL</i>	(30 + 0.2 <i>DL</i>) μin (66 + 0.2 <i>DL</i>) μin	Repeat – O – Meter Electronic Levels
CMM Calibration ^{1,2} Volumetric Linearity Linearity	(5 to 40) in (1 to 60) in Above 60 in	(12 + 14L) μin (7 + 14L) μin (20 + 0.4L) μin	Ball Bars Step Gage Renishaw Laser System B89.4.1
Linear Measurements	Up to 1 560 in	(38 + 0.5L) μin	Laser
Optical Comparators ^{1,2} Linearity Magnification	Up to 12 in 10x, 20x, 31.25x, 50x, 62.5x, 100x, 200x	(97 + 12L) μin 0.00046 in	Glass Scale Precision Balls Calibration Sphere
Roundness Testers ^{1,2} Axial Error Radial Error	(-1 000 to 1 000) μm	0.15 μm 0.15 μm	Test Sphere
ULMs ^{1,2} Length	(1 to 100) mm	0.19 μm	Gage Blocks
Film Thickness Gages ^{1,2}	(0.01 to 0.06) in	380 μin	Film Thickness Standards
Brinell Scopes ^{1,2}	(1 to 6) mm	11 μm	Stage Micrometer



Mass and Mass Related

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Bench and Floor Scales ¹	(0.001 to 5 000) lb	0.000 7 lb/lb	NIST 105 Class F Weights NIST Handbook 44
Analytical Balances ¹	(0.001 mg to 13 kg)	0.19 µg/g	ASTM E617 Class 1 Weights NIST Handbook 44
Mass	0.5 lb	24 mg	Class 1 Weights and Analytical Balance Modified Substitution
	1 lb	73 mg	
	5 lb	84 mg	
	10 lb	0.14 g	
	20 lb	0.37 g	
	25 lb	0.46 mg	
	50 lb	0.65 mg	
	5 000 g	46 mg	
	3 000 g	30 mg	
	2 000 g	23 mg	
	1 000 g	18 mg	
	500 g	16 mg	
	300 g	16 mg	
	200 g	1.8 mg	
	100 g	0.9 mg	
	50 g	0.47 mg	
	30 g	0.32 mg	
	20 g	0.25 mg	
	10 g	0.2 mg	
	5 g	0.18 mg	
3 g	0.18 mg		
2 g	0.18 mg		
1 g	0.17 mg		
Pressure ¹	(-13 to 300) psi	0.1 psi	Pressure Calibrator
	(300 to 1 000) psi	1.3 psi	
	(1 000 to 10 000) psi	3.9 psi	Pressure Transducers
	(10 000 to 30 000) psi	35 psi	
Pressure	(0.2 to 500) psia	1.3 x 10 ⁻⁵ psi/psi	Ruska 2465 Deadweight Tester
	(500 to 3 000) psi	3 x 10 ⁻⁵ psi/psi	Ruska 2470 Piston Gage
Pressure	(3 000 to 16 000) psi	2 x 10 ⁻⁴ psi/psi	Budenburg 380 Deadweight Tester
Environmental Pressure Gage ¹	(0 to 100) in H ₂ O	0.017 in H ₂ O	Pressure Module



Mass and Mass Related

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Durometers ¹	Up to 100 duro	0.35 duro	Direct Verification per ASTM D2240 Durometer Calibrator
Spring Force	(0.1 to 45) N	0.05 N	Triple Beam Balance, Video Measuring Machine
Indenter Angle	(20 to 40) °	0.07 °	
Indenter Radius	(0.05 to 0.1) in	340 μin	
Indenter Length	(0.049 to 0.198) in	330 μin	
Brinell Hardness Testers ¹ Verification of Test Force	(500, 750, 1 500, 2 000, 3 000) kgf	7.2 Kgf	Direct Verification per ASTM E10 using Morehouse Proving Ring
Verification of Indenter Mean Diameter	10 mm 5 mm	0.002 mm 0.002 mm	
Brinell Hardness Testers ¹	(1 to 7) mm	0.03 mm	Indirect Verification per ASTM E10 using Brinell Test Blocks & Brinell Scope
Knoop and Vickers Hardness Testers ¹	(1 to 200) μm	0.25 μm	Indirect Verification per ASTM E384 using Knoop & Vickers Test Blocks
	(1 to 200) μm	0.17 μm	
Leeb Hardness Tester ¹	550 LD, 836 LD	20 LD	Indirect Verification per ASTM A596 using Leeb Test Block
Rockwell Hardness Testers ¹	HRBW Low	1.2 HRA	Indirect Verification per ASTM E18 using Rockwell Test Blocks
	HRBW Med	1.2 HRA	
	HRBW High	0.75 HRA	
	HRC Low	1.4 HRBW	
	HRC Med	1.4 HRBW	
	HRC High	1.3 HRBW	
	HRA Low	1.2 HRC	
	HRA Med	1.2 HRC	
	HRA High	0.7 HRC	
	HRE Low	1.3 HRE	
	HRE Med	1.4 HRE	
	HRE High	1.4 HRE	



Mass and Mass Related

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Rockwell Hardness Testers ¹	HRF Low	1.4 HRF	Indirect Verification per ASTM E18 using Rockwell Test Blocks
	HRF Med	1.4 HRF	
	HRF High	1.4 HRF	
	HRH Low	1.4 HRH	
	HRH Med	1.4 HRH	
	HRH High	1.4 HRH	
	HRKW Low	1.4 HRKW	
	HRKW Med	1.3 HRKW	
	HRKW High	1.3 HRKW	
	HRMW Low	1.4 HRMW	
	HRMW Med	1.4 HRMW	
	HRMW High	1.3 HRMW	
	HR15N Low	1.5 HR15N	
	HR15N Med	1.3 HR15N	
	HR15N High	0.9 HR15N	
	HR30N Low	1.3 HR30N	
	HR30N Med	1.3 HR30N	
	HR30N High	0.9 HR30N	
	HR45N Low	1.4 HR45N	
	HR45N Med	1.3 HR45N	
	HR45N High	0.95 HR45N	
	HR15TW Low	2 HR15TW	
	HR15TW Med	1.4 HR15TW	
	HR15TW High	1.5 HR15TW	
HR30TW Low	2 HR30TW		
HR30TW Med	1.5 HR30TW		
HR30T High	1.3 HR30TW		
HR45TW Low	2.0 HR45TW		
HR45TW Med	1.3 HR45TW		
HR45TW High	1.4 HR45TW		

Mass and Mass Related

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Force ¹	(0.001 to 200) lb (200 to 10 000) lb (10 000 to 50 000) lb	0.05 % of reading 0.07 % of reading 0.1 % of reading	Dead Weight Load Cell Load Cell
Force	1 g to 500 lb (500 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, Proving Ring
Wedge Tester ¹	(0 to 40 000) N	32 N	Load Cell
Torque Transducers ¹	(0.001 to 250) lbf-ft (250 to 2 000) lbf-ft	0.05 % of reading 0.06 % of reading	Torque Arms, Dead Weight
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
Viscosity Rotational Viscometers	500 cP 5 000 cP	0.02 cP/cP	Viscosity Solutions, Temperature Bath
Viscosity Cups	17.82 cP 65.28 cP 231 cP	0.03 cP/cP	Viscosity Solutions, Temperature Bath, Stopwatch ASTM D4212
Pipettes	(100 to 200) µL (200 to 1 000) µL (1 000 to 5 000) µL (5 000 to 10 000) µL	0.6 µL 0.7 µL 1.9 µL 3.6 µL	Analytical Balance ISO 8655-6
Graduated Cylinder	(1 to 200) mL (200 to 6 000) mL (6 000 to 34 000) mL	0.003 mL 0.46 mL 2.8 mL	Balances



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	(0 to 10) min	1.2 s	Stopwatch
Friability Tester	60 s	1.2 s	Stopwatch
Sand Rammer	(0 to 2) in	0.01 in	Impact Rings
Moisture Teller	(0 to 300 °F)	1.9 °F	Temperature Calibrator
Permmeter	(0 to 500) perm	0.43 perm	Perm Standards
Sand Strength Tester	(0 to 500) psi (0 to 1 000) lb	1.1 psi 4.2 lb	Proving Ring
Core Scratch Tester	(0 to 0.1) in	0.006 in	Flatness Block
Green Sand Hardness Tester (B&C)	(0 to 0.1) in	0.006 in	Flatness Block
Foundry Sand Test Equipment / Measurement ¹			
Ultrasonic Cleaner/Scrubber	18 °F 30 min	1.7 °F 1.2 sec	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	(0 to 200) psi	3.8 psi	Proving Ring
Tensile Testers	(0 to 10 000) lb	7.2 lb	Load Cell

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



Photometry and Radiometry

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
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, and 81578A Optical Attenuator
Optical Attenuation - Source ¹ (700 to 1 650) nm	(-60 to 0) dB	0.04 dB/dB	Agilent 81570A and 81578A Optical Attenuators
Optical Wavelength - Measure ¹	(700 to 1 650) nm	0.05 nm	Agilent 86120B Multi-Wavelength Meter
Gloss Meters 20°, 60°, 85°	0 to 100 GU	0.73 GU	Standard Gloss Tiles

Thermodynamic

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Temperature - Source	(-30 to 600) °C	0.03 °C	Hart Scientific 9011 Drywell with PRT
Immersion Probes ¹	(-95 to 140) °C	0.03 °C	Fluke 9190A Drywell with PRT
Infrared ¹	(122 to 932) °F	0.9 °F	Hart Scientific 9132 Blackbody $\lambda = (8 \text{ to } 14) \mu\text{m}$, $\epsilon = 0.95$
Surface Probes ¹	(35 to 400) °C	1.3 °C	Hart Scientific 2200 Temperature Controller
Temperature - Measure ¹	(-30 to 600) °C	0.03 °C	Hart Scientific 1502 Indicator with PRT
Thermo-Hygrometers Temperature Humidity	(0 to 70) °C (10 to 98) %RH	0.2 °C 0.9 %RH	Thunder Scientific 2500 Humidity Chamber
System Accuracy Test ¹ (SAT)	(0 to 2 200) °F	2.6 °F	Certified Thermocouple



Thermodynamic

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Temperature Uniformity Survey ¹ (TUS)	(0 to 2 200) °F	4.9 °F	MV 1000 Data Logger or Equivalent
Calibration of Thermocouples and Thermocouple Wire ¹			Martel M3001 Multifunction Calibrator, AMS2750D
Type E	(100 to 1 600) °F	2.9 °F	
Type J	(100 to 1 400) °F	2.9 °F	
Type K	(100 to 2 200) °F	2.9 °F	
Type N	(100 to 2 200) °F	2.9 °F	
Type R	(100 to 2 200) °F	3.4 °F	
Type S	(100 to 2 200) °F	3.4 °F	
Type C	(100 to 2 200) °F	3 °F	
Type B	(1 112 to 2 200) °F	3.4 °F	

Time and Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Time Interval ¹	(1 to 86 400) s	0.000 45 s	Agilent 53132A Counter & Spectracom 8197B GPS Oscillator
Frequency - Measure ¹	0.1 Hz to 225 MHz	2.4 parts in 10 ⁻¹¹ Hz	Agilent 53132A Counter & Spectracom 8197B GPS Oscillator
	0.1 Hz to 26.5 GHz	2.4 parts in 10 ⁻¹¹ Hz	Agilent N5531S Measuring Receiver, SRS FS725 Frequency Standard
Frequency - Source ¹	10 MHz	2.4 parts in 10 ⁻¹¹ Hz	Spectracom 8197B GPS Oscillator
	0.1 mHz to 40 GHz	2.4 parts in 10 ⁻¹¹ Hz	Agilent 3325B Function Generator, Agilent E8257D Signal Generator, SRS FS725 Frequency Standard
Tachometers ¹ Contact Non-Contact	(1 to 6 500) rpm (500 to 40 000) rpm	0.08 % of reading	King Nutronics 3711-B Tachometer Test Set
Tachometers ¹ Non-Contact	(0.01 to 100 000) rpm	0.005 % of reading	Fluke 5520A Multiproduct Calibrator

TESTING

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 μ in (38 + 5.2L) μ in	CMM CMM
Linear	(0 to 8) in (0 to 20) in	(210 + 1.5L) μ in 0.000 9 in	Video Measuring Machine
Surface Finish (Ra)	(0.01 to 300) μ in	2.1 μ in	Profilometer

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
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. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1272.



Vice President