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.
303 Polk Parkway
St. Croix Falls WI 54024

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-1272.01
Certificate Number

ANAB Approval

Certificate Valid: 07/07/2017-06/15/2019
Version No. 001 Issued: 07/07/2017

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).

ANSI-ASQ National Accreditation Board

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.
303 Polk Parkway
St. Croix Falls, WI 54024
Chris Kuczynski 715-483-5334

CALIBRATION

Valid to: **June 15, 2019** Certificate Number: **ACT-1272.01**

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

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

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 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
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 µV/V + 0.8 µV 5.7 µV/V + 0.8 µV 5.6 µV/V + 1 µV 7.9 µV/V + 80 µV 7.9 µV/V + 0.15 mV	Agilent 3458A Opt 002
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 µV/V + 0.10 µV 3.5 µV/V + 0.4 µV 3.5 µV/V + 4 µV 5.5 µV/V + 40 µV 5.5 µV/V + 500 µV	Fluke 8508A
DC High Voltage - Measure[1]	(1 to 10) kV (10 to 100) kV	60 V 0.6 kV	Hipotronics KVM-100
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
	(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
	(20.5 to 1 000) A	86 mA/A + 0.5 A	Fluke 5520A 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 µA/A + 65 pA 35 µA/A + 65 pA 35 µA/A + 0.15 nA 35 µA/A + 1.3 nA 35 µA/A + 10 nA 36 µA/A + 0.1 µA 15 µA/A + 1 µA 0.14 mA/A + 20 µA	Agilent 3458A Opt 002
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
DC Current - Measure[1]	(1 to 10) A	2.4 mA/A + 0.7 mA	Fluke DMM

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
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
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
Resistance - Source[1]	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 10 MΩ 19 MΩ 100 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 0.48 kΩ 1.1 kΩ 23 kΩ	Fluke 5720A
	1 GΩ 10 GΩ 100 GΩ	1.9 MΩ 47 MΩ 0.95 GΩ	IET Labs HRRS Decade Box

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Resistance - Measure[1]	Up to 10 Ω	24 μΩ/Ω + 0.1 mΩ	Agilent 3458A Opt 002
	(10 to 100) Ω	20 μΩ/Ω + 1 mΩ	
	100 Ω to 1 kΩ	18 μΩ/Ω + 1 mΩ	
	(1 to 10) kΩ	18 μΩ/Ω + 10 mΩ	
	(10 to 100) kΩ	18 μΩ/Ω + 0.1 Ω	
	100 kΩ to 1 MΩ	24 μΩ/Ω + 7 mΩ	
	(1 to 10) MΩ	87 μΩ/Ω + 0.2 Ω	
	(10 to 100) MΩ	0.73 mΩ/Ω + 2 Ω	
	100 MΩ to 1 GΩ	7.2 mΩ/Ω + 20 kΩ	
AC Voltage - Source[1]	Up to 2.2 mV		Fluke 5720A
	(10 to 20) Hz	2.4 mV/V + 4 μV	
	(20 to 40) Hz	2.4 mV/V + 4 μV	
	40 Hz to 20 kHz	2.2 mV/V + 4 μV	
	(20 to 50) kHz	2.2 mV/V + 4 μV	
	(50 to 100) kHz	2.3 mV/V + 5 μV	
	(100 to 300) kHz	2.5 mV/V + 10 μV	
	(300 to 500) kHz	2.7 mV/V + 20 μV	
	500 kHz to 1 MHz	3.8 mV/V + 20 μV	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.61 mV/V + 4 μV	
	(20 to 40) Hz	0.56 mV/V + 4 μV	
	40 Hz to 20 kHz	0.36 mV/V + 4 μV	
	(20 to 50) kHz	0.42 mV/V + 4 μV	
	(50 to 100) kHz	0.70 mV/V + 5 μV	
	(100 to 300) kHz	1.3 mV/V + 10 μV	
	(300 to 500) kHz	1.7 mV/V + 20 μV	
	500 kHz to 1 MHz	3.4 mV/V + 20 μV	
	(22 to 220) mV		
	(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	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage - Source[1]	(0.22 to 2.2) V		Fluke 5720A
	(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	
AC Voltage Harmonics – Source (2^{nd} to 50^{th}) [1]			Fluke 5520A
(10 to 45) Hz	32 mV to 33 V	0.35 mV/V + 16 µV	
(45 to 65) Hz	33 mV to 1 kV	0.21 mV/V + 16 µV	
(65 to 500) Hz	33 mV to 1 kV	0.21 mV/V + 16 µV	
500 Hz to 5 kHz	330 mV to 1 kV	0.21 mV/V + 0.21 mV	
(5 to 10) kHz	3.3 V to 1 kV	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] Bandwidth < 2 MHz	Up to 10 mV		Agilent 3458A Opt 002
	(1 to 40) Hz	0.46 mV/V + 13 µV	
	40 Hz to 1 kHz	0.35 mV/V + 11 µV	
	(1 to 20) kHz	0.46 mV/V + 11 µV	
	(20 to 50) kHz	1.3 mV/V + 11 µV	
	(50 to 100) kHz	5.9 mV/V + 11 µV	
	(100 to 300) kHz	46 µV/V + 12 µV	
	(10 to 100) mV		
	(1 to 40) Hz	0.14 mV/V + 4.5 µV	
	40 Hz to 1 kHz	0.14 mV/V + 2.5 µV	
	(1 to 20) kHz	0.22 mV/V + 2.5 µV	
	(20 to 50) kHz	0.41 mV/V + 2.5 µV	
	(50 to 100) kHz	0.99 mV/V + 2.5 µV	
	(100 to 300) kHz	3.5 mV/V + 11 µV	
	300 kHz to 1 MHz	12 mV/V + 11 µV	
	(1 to 2) MHz	18 mV/V + 11 µV	
	100 mV to 1 V		
	(1 to 40) Hz	0.14 mV/V + 45 µV	
	40 Hz to 1 kHz	0.14 mV/V + 25 µV	
	(1 to 20) kHz	0.22 mV/V + 25 µV	
	(20 to 50) kHz	0.41 mV/V + 25 µV	
	(50 to 100) kHz	0.99 mV/V + 25 µV	
	(100 to 300) kHz	3.5 mV/V + 0.11 mV	
	300 kHz to 1 MHz	12 mV/V + 0.11 mV	
	(1 to 2) MHz	18 mV/V + 0.11 mV	
	(1 to 10) V		
	(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	

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 V to 1 kV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	 0.52 mV/V + 45 mV 0.52 mV/V + 25 mV 0.75 mV/V + 25 mV 1.5 mV/V + 25 mV 3.5 mV/V + 25 mV	Agilent 3458A Opt 002
	(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
AC Voltage - Measure[1] Bandwidth > 2 MHz	Up to 10 mV 45 Hz to 100 kHz 100 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz (10 to 100) mV 45 Hz to 100 kHz 100 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) 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 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 µV 14 mV/V + 5.1 µV 83 mV/V + 7.1 µV 0.24 V/V + 8.1 µV 1.1 mV/V + 61 µV 24 mV/V + 51 µV 47 mV/V + 71 µV 47 mV/V + 81 µV 0.18 V/V + 0.1 mV 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 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	Agilent 3458A Opt 002
	(10 to 100) V 45 Hz to 100 kHz 100 V to 1 kV 45 Hz to 100 kHz	 1.5 mV/V + 2.5 mV 3.6 mV/V + 0.11 V	Hipotronics KVM-100

AC Voltage - Measure[1] Bandwidth < 1 MHz	Up to 200 mV		Fluke 8508A
	(1 to 10) Hz	0.17 mV/V + 14 µV	
	(10 to 40) Hz	0.14 mV/V + 4 µV	
	(40 to 100) Hz	0.12 mV/V + 4 µV	
	100 Hz to 2 kHz	0.11 mV/V + 2 µV	
	(2 to 10) kHz	0.14 mV/V + 4 µV	
	(10 to 30) kHz	0.34 mV/V + 8 µV	
	(30 to 100) kHz	0.77 mV/V + 20 µV	
	200 mV to 2 V		
	(1 to 10) Hz	0.15 mV/V + 0.12 mV	
	(10 to 40) Hz	0.12 mV/V + 20 µV	
	(40 to 100) Hz	90 µV/V + 20 µV	
	100 Hz to 2 kHz	75 µV/V + 20 µV	
	(2 to 10) kHz	0.11 mV/V + 20 µV	
	(10 to 30) kHz	0.22 mV/V + 0.84 mV	
	(30 to 100) kHz	0.57 mV/V + 0.2 mV	
	(100 to 300) kHz	3 mV/V + 2 mV	
	300 kHz to 1 MHz	10 mV/V + 2 mV	
	(2 to 20) V		
	(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	
	200 V to 1.05 kV		
	(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	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current - Source[1]	Up to 220 µA		Fluke 5720A
	(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	0.30 mA/A + 4 µA	
	(20 to 40) Hz	0.20 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	
	220 mA to 2.2 A		
	20 Hz to 1 kHz	0.31 mA/A + 35 µA	
	(1 to 5) kHz	0.53 mA/A + 80 µA	
	(5 to 10) kHz	8.1 mA/A + 0.16 mA	
	(2 to 3) A		
	(10 to 45) Hz	2.1 mA/A + 0.1 mA	
	40 Hz to 1 kHz	0.75 mA/A + 0.1 mA	
	(1 to 5) kHz	6.9 mA/A + 1 mA	
	(5 to 10) kHz	29 mA/A + 5 mA	
AC Current - Source[1]	(3 to 11) A		Fluke 5520A
	(45 to 100) Hz	0.74 mA/A + 2 mA	
	(0.1 to 1) kHz	1.2 mA/A + 2 mA	
	(1 to 5) kHz	35 mA/A + 2 mA	
	(11 to 20.5) A		
	(45 to 100) Hz	1.4 mA/A + 5 mA	
	(0.1 to 1) kHz	1.8 mA/A + 5 mA	
	(1 to 5) kHz	35 mA/A + 5 mA	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
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 w/ 50-turn Coil
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
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

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
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 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 2A 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
Capacitance - Measure[1] 42 Hz to 5 MHz	0.32 pF to 370 mF	1.1 mF/F	Hioki 3532-50

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
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
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
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

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
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 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	Fluke 5520A SC1100
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 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	 0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.10 °C 0.12 °C 0.23 °C 0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.10 °C 0.12 °C	Fluke 5520A

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Electrical Simulation of RTDs[1]	Pt 3916 (JIS) 100 Ω		Fluke 5520A
	(-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	
	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 Thermocouples[1]	Type K		Fluke 5520A
	(-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	
	Type S		
	(0 to 250) °C	0.47 °C	
	(250 to 1 000) °C	0.36 °C	
	(1 000 to 1 400) °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 2316) °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	

Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Electrical Simulation of Thermocouples[1]	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	 0.40 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °C 0.57 °C 0.35 °C 0.33 °C 0.40 °C 0.56 °C 0.27 °C	Fluke 5520A
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
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

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
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

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Amplitude Modulation - Measure[1,4]			Agilent N5531S Measuring Receiver with N5532A Sensor Modules
100 kHz to 10 MHz	Rate: 50 Hz to 10 kHz Depths: 5 % to 99 %	2.2 % of reading	
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[3,4,7,13,14] Rate: DC to 100 kHz	250 kHz to 40 GHz	5.9 % setting + 0.1 rad	Agilent E8257D
Phase Modulation - Measure[1,4]			Agilent N5531S Measuring Receiver with N5532A Sensor Modules
100 kHz to 6.6 GHz	Rate: 200 Hz 20 kHz Dev.: > 0.7 rad	1.2 % of reading	
100 kHz to 6.6 GHz	Rate: 200 Hz 20 kHz Dev.: > 0.3 rad	3.6 % of reading	
(6.6 to 13.2) GHz	Rate: 200 Hz 20 kHz Dev.: > 2.0 rad	1.2 % of reading	
(6.6 to 13.2) GHz	Rate: 200 Hz 20 kHz Dev.: > 0.6 rad	3.6 % of reading	
(13.2 to 26.5) GHz	Rate: 200 Hz 20 kHz Dev.: > 2.0 rad	1.2 % of reading	
(13.2 to 26.5) GHz	Rate: 200 Hz 20 kHz Dev.: > 0.6 rad	3.6 % of reading	
Tuned RF Level - Measure[1,4] Relative Level			Agilent N5531S Measuring Receiver with N5532A Sensor Modules
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	

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Tuned RF Level - Measure[1,4] Absolute Level			Agilent N5531S Measuring Receiver with N5532A Sensor Modules
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	
(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	
(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	
(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	
RF Power - Source[1]			Agilent E8257D
250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	> -10 dBm	0.72 dB 0.96 dB 1.1 dB	
250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	(-10 to -70) dBm	0.89 dB 1.1 dB 1.2 dB	
250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	(-70 to -90) dBm	0.95 dB 1.2 dB 1.21 dB	
RF Power Sensors- Calibration Factor[1,4]			Tegam 1827, Agilent 3458A, Agilent E8257D, Agilent E4419B, Agilent 3325B
100 kHz to 10 MHz 10 MHz to 10 GHz (10 to 18) GHz	(-20 to +14) dBm	1.5 % 1.5 % 1.7 %	

Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
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
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 % setting + 20 Hz	Agilent E8257D
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
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
Pulse Modulation - Source[1,4] Level Rise/Fall Time	 (0 to 9) dBm 10 MHz to 40 GHz	 0.59 dBm 12 ns	Agilent E8257D

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Gage Blocks[2] Per ASME B89.1.9	Up to 10 in (10 to 20) in Up to 20 in	(3.9 + 1.3*L*) µin (8.5 + 1*L*) µin (3.9 + 1.3*L*) µin	LabMaster Universal ULM 600 Mahr 828
Length Standards[2]	Up to 9 in (9 to 24) in (24 to 70) in	(39 + 0.4*L*) µin (12 + 1*L*) µin (390 + 2.6*L*) µin	P&W Supermicrometer ULM 600 CMM
Cylindrical Rings[2]	(0.25 to 8) in (0.025 to 12) in	(13 + 1.3*D*) µin (13 + 1.8*D*) µin	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[1,2]	(0.25 to 5) in	(12 + 3*D*) µin	Fowler Lab Concept ASME B89.1.6
Cylindrical Plugs[2]	(0.010 to 8) in	(2.7 + 6*D*) µin	LabMaster Universal
Cylindrical Plugs[1,2]	(0.010 to 4) in	(53 + 0.4*D*) µin	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 + 0.3*D*) µin 38 µin 120 µin	Setting Plug Gages ULM 600 ID Bore Gages ASME B1.2
NPT Rings Standoff and Basic Length	(0.0625 to 6) in	250 µin	NPT Plugs, P&W LabMaster ASME B1.20.5
NPT Plugs Standoff and Basic Length	(0.062 5 to 6) in	490 µin	NPT Rings, P&W LabMaster ASME B1.20.5
Tapered Thread Gages[3,7,8]	(0.25 to 5) in	(53 + 6.2*D*) µin	Universal Supermicrometer ASME B1.20.5
Threaded Plugs[2] Pitch Diameter Major Diameter	 (0.01 to 10) in (0.01 to 10) in	 (73 + 0.9*D*) µin (40 + 1.2*D*) µin	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 + 3.2*D*) µin (53 + 4.1*D*) µin	Plug gage Comparator
Thread Wires[2]	(0.005 to 0.5) in	(11 + 1.5*D*) µin	ULM 600 ASME B89.1.17
Calipers[1,2]	Up to 80 in	(380 + 15*L*) µin	Gage Blocks
Indicators[1,2]	Up to 4 in	(36 + 10*L*) µin	Indicator Checker
Test Indicators[1]	Up to 0.06 in	39 µin	Indicator Checker
OD Micrometers[1,2]	Up to 60 in	(72 + 12*L*) µin	Gage Blocks
ID Micrometer[1,2]	(1.5 to 40) in	(370 + 7*L*) µin	Gage Blocks
Height Gages[1,2]	Up to 40 in	(96 + 14*L*) µin	Gage Blocks
Bore Gages[1]	(0.25 to 12) in	350 µin	Cylindrical Rings
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

Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Profilometers[1] Ra	(2 to 300) µin	2.2 µin	Roughness Specimen
Surface Plates[1,2] Repeat Reading Overall Flatness	(4 to 34) in Diagonal (34 to 175) in Diagonal	(30 + 0.2*D*) µin (66 + 0.2*D*) 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 + 14*L*) µin (7 + 14*L*) µin (20 + 0.4*L*) µin	Ball Bars Step Gage Renishaw Laser System B89.4.1
Optical Comparators[1,2] Linearity Magnification	Up to 12 in 10x, 20x, 31.25x, 50x, 62.5x, 100x, 200x	(97 + 12*L*) µin 0.000 46 in	Glass Scale Precision Balls Calibration Sphere
Roundness Testers[1] Axial Error Radial Error	(-1 000 to 1 000) µm	0.15 µm 0.15 µm	Test Sphere
ULMs[1] Length	(1 to 100) mm	0.19 µm	Gage Blocks
Film Thickness Gages[1]	(0.01 to 0.06) in	380 µin	Film Thickness Standards
Brinell Scopes[1]	(1 to 6) mm	11 µm	Stage Micrometer

Mass

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
Pressure[1]	(-13 to 300) psi (300 to 1 000) psi	0.1 psi 1.3 psi	Pressure Calibrator
	(1 000 to 10 000) psi	3.9 psi	Pressure Transducers

Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Direct Verification per ASTM D2240 of Durometers[1]	Up to 100 duro	0.35 duro	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 Length	(0.049 to 0.198) in	330 µin	Gage Blocks
Indenter Radius	(0.05 to 0.1) in	340 µin	
Indirect Verification per ASTM E18 of Rockwell Hardness Testers[1]	HRA Low	1.2 HRA	Rockwell Test Blocks
	HRA Med	1.2 HRA	
	HRA High	0.75 HRA	
	HRBW Low	1.4 HRBW	
	HRBW Med	1.4 HRBW	
	HRBW High	1.3 HRBW	
	HRC Low	1.2 HRC	
	HRC Med	1.2 HRC	
	HRC High	0.7 HRC	
	HRE Low	1.3 HRE	
	HRE Med	1.4 HRE	
	HRE High	1.4 HRE	
	HRF Low	1.4 HRF	
	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	

Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Indirect Verification per ASTM E18 of Rockwell Superficial Hardness Testers[1]	HR15N Low HR15N Med HR15N High HR30N Low HR30N Med HR30N High HR45N Low HR45N Med HR45N High HR15TW Low HR15TW Med HR15TW High HR30TW Low HR30TW Med HR30T High HR45TW Low HR45TW Med HR45TW High	1.5 HR15N 1.3 HR15N 0.9 HR15N 1.3 HR30N 1.3 HR30N 0.9 HR30N 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 2.0 HR45TW 1.3 HR45TW 1.4 HR45TW	Rockwell Test Blocks
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
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]	4 lbf·in to 2 500 lbf·ft	0.3 % of reading	AKO 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

Mass

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/cm² (300 to 320) °F	0.003 1 N/cm² 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, 81525A
Optical Power - Source[1] (820, 1 310, 1 550) nm	(-60 to 20) dB	0.05 dB/dB	Agilent 81554SM, 81533B, 81525A, 81655A, 81570A, and 81578A

Photometry and Radiometry

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Optical Attenuation - Source[1] (700 to 1 650) nm	(-60 to 20) dB	0.04 dB/dB	Agilent 81570A and 81578A
Optical Wavelength - Measure[1]	(700 to 1 650) nm	0.05 nm	Agilent 86120B

Thermodynamic

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Immersion Probes[1]	(-95 to 140) °C	0.03 °C	Fluke 9190A with PRT
Infrared[1]	(122 to 932) °F	0.9 °F	Hart Scientific 9132
Temperature - Measure[1]	(-30 to 600) °C	0.03 °C	Hart Scientific 1502 with PRT
Thermo-Hygrometers Temperature Humidity	(0 to 70) °C (10 to 98) %RH	0.2 °C 0.9 %RH	Thunder Scientific 2500
System Accuracy Test[1] (SAT)	(0 to 2 200) °F	2.6 °F	Certified Thermocouple
Temperature Uniformity Survey[1] (TUS)	(0 to 2 200) °F	4.9 °F	MV 1000 Data Logger or Equivalent

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 & Spectracom 8197B
Frequency Measure[1]	0.1 Hz to 225 MHz	6.7 parts in 10^{-11} Hz	Agilent 53132A, SRS FS725
	0.1 Hz to 26.5 GHz	6.7 parts in 10^{-11} Hz	Agilent N5531S, SRS FS725
Frequency Source[1]	10 MHz	6.7 parts in 10^{-11} Hz	SRS FS725
	0.1 mHz to 40 GHz	6.7 parts in 10^{-11} Hz	Agilent 3325B, Agilent E8257D, SRS FS725

Time and Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Tachometers[1] Contact Non-Contact	 (1 to 6 500) rpm (500 to 40 000) rpm	 0.08 % of reading	 King Nutronics 3711-B
Tachometers[1] Non-Contact	(0.01 to 100 000) rpm	0.005 % of reading	Fluke 5520A

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 µin (38 + 5.2*L*) µin	 CMM CMM

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. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1272.01.