CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

American Calibration Inc.

4410 Route 176, Suite 11
Crystal Lake, IL 60014

Fulfills the requirements of

ISO/IEC 17025:2017

and national standard

ANSI/NCSL Z540-1-1994 (R2002)

In the fields of

CALIBRATION, DIMENSIONAL MEASUREMENT and TESTING

This certificate is valid only when accompanied by a current scope of accreditation document.
The current scope of accreditation can be verified at www.anab.org.

Jason Stine, Vice President

Expiry Date: 06 August 2024
Certificate Number: ACT-1886

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

AND

ANSI/NCSL Z540-1-1994 (R2002)

American Calibration Inc.
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CALIBRATION, DIMENSIONAL MEASUREMENT, AND TESTING

Valid to: **August 6, 2024** Certificate Number: **ACT-1886**

CALIBRATION

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Accelerometer [1] Voltage Sensitivity – Frequency Response (100 mV/g) (Up to 800 g payload)	7 Hz to 10 Hz 7 Hz to 30 Hz (30 to 2000) Hz (2 to 10) kHz	7.44 % of reading 5 % of reading 6.09 % of reading 7.21 % of reading	Accelerometer Calibrator, Reference Accelerometer Utilizing Back-to-Back Method
Sound Level Meters [1]	1 kHz 94 dB 114 dB	0.76 dB 0.76 dB	Acoustic Calibrator

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1,7]	4 pH 7 pH 10 pH 12 pH	0.017 pH 0.023 pH 0.052 pH 0.045 pH	Accredited pH Solutions
Conductivity Meters [1,7]	10 µS/cm 100 µS/cm 1 000 µS/cm 1 400 µS/cm 10 000 µS/cm 100 mS/cm	0.65 µS/cm 2.9 µS/cm 20 µS/cm 28 µS/cm 0.19 mS/cm 1.8 mS/cm	Accredited Conductivity Solutions

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Refractometers [1,7]	(10 to 60) ºBx	0.94 °Bx	Reference Sucrose Solutions
Viscosity [1,7]	500 cP	39 cP	Reference Viscosity Solution
Carbon Dioxide (CO_2) Analyzers [1,7] CO_2 Concentration in Gas	0 % CO_2 5 % CO_2 20 % CO_2	0.26 % CO_2 0.17 % CO_2 0.59 % CO_2	Comparison to Vaisala GMP221 CO_2 Sensor

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure [1]	Up to 10 µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 30) A	26 pA/µA + 0.42 nA 10 pA/µA + 0.41 nA 9.5 nA/mA + 4.3 nA 14 nA/mA + 42 nA 57 nA/mA + 1 µA 0.13 mA/A + 0.1 mA 0.24 mA/A + 0.41 mA 0.55 mA/A + 4.4 mA	Fluke 8588A Reference Multimeter
DC Current – Source [1]	(0 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	55 pA/µA + 6 nA 38 nA/mA + 7 nA 41 nA/mA + 40 nA 57 nA/mA + 0.7 µA 0.1 mA/A + 12 µA	Fluke 5730A Multiproduct Calibrator
DC Current – Source [1,2]	Up to 120 µA (0.12 to 1.2) mA (1.2 to 12) mA (12 to 120) mA (0.12 to 1.2) A (1.2 to 3.1) A (3.1 to 12) A (12 to 30.2) A	98 pA/µA + 5 nA 83 nA/mA + 12 nA 80 nA/mA + 63 nA 79 nA/mA + 0.63 µA 0.12 mA/A + 8 µA 0.23 mA/A + 12 µA 0.23 mA/A + 0.2 mA 0.8 mA/A + 0.39 mA	Fluke 5560A Multiproduct Calibrator
DC Clamp-on Meters [1]	(12 to 1 000) A	24.5 mA/A + 0.5 A	Fluke 5502A Multiproduct Calibrator, 50-turn Coil

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	Up to 1 A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz (1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	 12 mA 40 mA 1.8 mA 40 mA 14 mA 8.5 mA	Keysight 34401A 6.5 Digit Multimeter
AC Current – Measure [1]	(3 to 5) A (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	 17.3 mA/A + 2.8 mA 9.3 mA/A + 3 mA 4.9 mA/A + 6.6 mA	Fluke 289 Digital Multimeter
	(5 to 10) A (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	 17.3 mA/A + 6.3 mA 9.3 mA/A + 6.6 mA 4.9 mA/A + 12 mA	
Magnetic Inspection Unit [1] AC Current – Measure	(500 to 10 000) A	15 A/kA + 13 A	Ammeter, Current Shunt
AC Current – Source [1]	(9 to 220) µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (0.22 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	 0.28 nA/µA + 16 nA 0.19 nA/µA + 10 nA 0.11 nA/µA + 8 nA 0.35 nA/µA + 12 nA 1.2 nA/µA + 65 nA 0.29 µA/mA + 40 nA 0.19 µA/mA + 35 nA 0.12 µA/mA + 35 nA 0.25 µA/mA + 0.11 µA 1.3 µA/mA + 0.65 µA 0.29 µA/mA + 0.4 µA 0.19 µA/mA + 0.35 µA 0.12 µA/mA + 0.35 µA 0.25 µA/mA + 0.55 µA 1.3 µA/mA + 5 µA	Fluke 5730A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1]	(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 (0.22 to 2.2) A (20 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz	 0.29 µA/mA + 4 µA 0.16 µA/mA + 3.5 µA 0.13 µA/mA + 2.5 µA 0.24 µA/mA + 3.5 µA 1.3 µA/mA + 10 µA 0.32 mA/A + 35 µA 0.55 mA/A + 80 µA 7.9 mA/A + 0.16 mA	Fluke 5730A Multiproduct Calibrator
AC Current – Source [1,2]	Up to 120 µA (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (0.12 to 1.2) mA (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (1.2 to 12) mA (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (12 to 120) mA (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	 0.2 nA/µA + 8 nA 0.2 nA/µA + 8 nA 0.2 nA/µA + 8 nA 1.3 nA/µA + 31 nA 4 nA/µA + 1 µA 0.2 µA/mA + 0.1 µA 0.2 µA/mA + 0.1 µA 0.2 µA/mA + 0.1 µA 1.3 µA/mA + 0.1 µA 4 µA/mA + 4 µA 0.2 µA/mA + 0.8 µA 0.2 µA/mA + 0.8 µA 0.2 µA/mA + 1 µA 1.3 µA/mA + 1 µA 4 µA/mA + 8 µA 0.2 µA/mA + 8 µA 0.2 µA/mA + 4 µA 0.2 µA/mA + 7 µA 1.3 µA/mA + 8 µA 4 µA/mA + 78 µA	Fluke 5560A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1,2]	(0.12 to 1.2) A (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (1.2 to 3.1) A (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (3.1 to 12) A (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (12 to 30.2) A (3 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	 0.19 mA/A + 78 µA 0.19 mA/A + 39 µA 0.19 mA/A + 63 µA 1.9 mA/A + 0.24 mA 3.9 mA/A + 0.24 mA 0.3 mA/A + 0.38 mA 0.3 mA/A + 0.24 mA 0.3 mA/A + 0.24 mA 2 mA/A + 0.38 mA 0.3 mA/A + 0.78 mA 0.3 mA/A + 0.38 mA 0.3 mA/A + 0.62 mA 2 mA/A + 0.78 mA 0.8 mA/A + 7.8 mA 0.6 mA/A + 6.2 mA 4 mA/A + 6.2 mA	Fluke 5560A Multiproduct Calibrator
AC Clamp-on Meters [1]	60 Hz (12 to 1 000) A	 6.1 mA/A + 0.52 A	Fluke 5502A Multiproduct Calibrator, 50-turn Coil
Resistance – Source [1] (Fixed Artifacts)	0.1 mΩ 1 mΩ 10 mΩ 100 mΩ	58 nΩ 0.58 µΩ 5.8 µΩ 58 µΩ	Precision Resistance Standard
Resistance – Source [1] (Fixed Artifacts)	500 kΩ 1 MΩ 5 MΩ 10 MΩ 25 MΩ 50 MΩ 100 MΩ 500 MΩ 1 GΩ 2 GΩ 50 GΩ 100 GΩ 200 GΩ	5.8 kΩ 12 kΩ 58 kΩ 0.12 MΩ 0.29 MΩ 0.58 MΩ 1.2 MΩ 5.8 MΩ 12 MΩ 25 MΩ 0.58 GΩ 1.2 GΩ 2.3 GΩ	Resistance Test Box

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source [1] (Synthesized-Fixed)	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 28 μΩ 29 μΩ 12 μΩ 12 μΩ 7.7 mΩ 7.9 mΩ 7.7 mΩ 7.9 mΩ 10 mΩ 10 mΩ 16 Ω 22 Ω 47 Ω 68 Ω 0.15 kΩ	Fluke 5730A Multiproduct Calibrator
Resistance – Source [1,2] (Synthesized-Fixed)	Up to 12 Ω (12 to 120) Ω (0.12 to 1.2) kΩ (1.2 to 12) kΩ (12 to 120) kΩ (0.12 to 1.2) MΩ (1.2 to 12) MΩ (12 to 120) MΩ (120 to 1 200) MΩ	21 μΩ/Ω + 0.8 mΩ 20 μΩ/Ω + 0.8 mΩ 20 mΩ/kΩ + 1.6 mΩ 20 mΩ/kΩ + 16 mΩ 20 mΩ/kΩ + 0.16 Ω 20 Ω/MΩ + 10 mΩ 28 Ω/MΩ + 30 mΩ 0.33 kΩ/MΩ + 2 kΩ 3.2 Ω/MΩ + 78 kΩ	Fluke 5560A Multiproduct Calibrator
Resistance – Measure [1]	Up to 1 Ω (1 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	17 μΩ/Ω + 4 μΩ 11 μΩ/Ω + 14 μΩ 9.2 μΩ/Ω + 54 μΩ 9.2 μΩ/Ω + 0.49 mΩ 9.3 μΩ/Ω + 4.9 mΩ 9.5 μΩ/Ω + 49 mΩ 11 μΩ/Ω + 0.92 Ω 20 μΩ/Ω + 99 Ω 0.12 mΩ/Ω + 10 kΩ 1.3 mΩ/Ω + 1 MΩ	Fluke 8588A Reference Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices – Source [1,2]	Pt 385, 100 Ω		Fluke 7526A Precision Process Calibrator
	(-200 to -80) ºC	0.013 ºC	
	(-80 to 0) °C	0.02 ºC	
	(0 to 100) °C	0.02 ºC	
	(100 to 300) °C	0.024 ºC	
	(300 to 400) °C	0.026 ºC	
	(400 to 630) °C	0.033 ºC	
	(630 to 800) °C	0.038 ºC	
	Pt 3926, 100 Ω		
	(-200 to -80) ºC	0.013 ºC	
	(-80 to 0) °C	0.015 ºC	
	(0 to 100) °C	0.017 ºC	
	(100 to 300) °C	0.022 ºC	
	(200 to 400) °C	0.026 ºC	
	(400 to 630) °C	0.032 ºC	
	Pt 3916, 100 Ω		
	(-200 to -190) ºC	0.01 ºC	
	(-190 to -80) °C	0.013 ºC	
	(-80 to 0) °C	0.015 ºC	
	(0 to 100) °C	0.017 ºC	
	(100 to 300) °C	0.022 ºC	
	(300 to 400) °C	0.026 ºC	
	(400 to 600) °C	0.031 ºC	
	(600 to 630) °C	0.33 ºC	
	Pt 385, 200 Ω		
	(-200 to -80) ºC	0.053 ºC	
	(-80 to 0) °C	0.056 ºC	
	(0 to 100) °C	0.06 ºC	
	(100 to 260) °C	0.06 ºC	
	(260 to 300) °C	0.069 ºC	
	(300 to 400) °C	0.071 ºC	
	(400 to 630) °C	0.088 ºC	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices – Source [1,2]	Pt 385, 500 Ω (-200 to 0) ºC (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C Pt 385, 1 000 Ω (-200 to 0) ºC (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C Ni 120, 120 Ω (-80 to 260) ºC Cu 427, 10 Ω (-100 to 260) ºC	 0.025 ºC 0.028 ºC 0.034 °C 0.038 ºC 0.045 ºC 0.015 ºC 0.018 °C 0.024 ºC 0.026 ºC 0.033 ºC 0.009 ºC 0.11 ºC	Fluke 7526A Precision Process Calibrator
Capacitance – Measure [1]	(1 to 5) nF (5 to 50) nF (50 to 500) nF 500 nF to 5 µF	0.1 nF 1 nF 10 nF 0.15 nF	Fluke 87 Digital Multimeter
Capacitance – Measure [1] (1 kHz)	100 pF to 1µF	5.65 pF/nF + 1.2 nF	B&K Precision 885 LCR/ESR Meter
Capacitance – Measure [1] (50, 60) Hz	Up to 2 nF (1.8 to 20) nF (18 to 200) nF (0.18 to 2) µF (1.8 to 20) µF (18 to 200) µF (0.18 to 2) mF (1.8 to 20) mF (18 to 200) mF	0.094 % of reading + 1.2 pF 0.075 % of reading + 1.8 pF 0.044 % of reading + 10 pF 0.02 % of reading + 60 pF 0.045 % of reading + 1.2 nF 0.049 % of reading + 2.6 nF 0.064 % of reading + 0.11 µF 0.074 % of reading + 1.1 µF 0.07 % of reading + 1.1 µF	Fluke 8588A Reference Multimeter
Capacitance – Source [1,2] (Synthesized)	Up to 1.2 nF (1.2 to 12) nF (12 to 120) nF (0.12 to 1.2) µF (1.2 to 12) µF (12 to 120) µF (0.12 to 1.2) mF (1.2 to 12) mF (12 to 120) mF	0.09 % of reading + 2 pF 0.09 % of reading + 4 pF 0.1 % of reading + 24 pF 0.1 % of reading + 0.23 nF 0.1 % of reading + 2.3 nF 0.12 % of reading + 19.4 nF 0.2 % of reading + 0.19 µF 0.2 % of reading + 2.3 µF 0.39 % of reading + 23.3 µF	Fluke 5560A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Source [1] (Variable Artifact)	(1 to 10) mH (10 to 100) mH 100 mH to 1 H (1 to 10) H	23 µH/mH 12 µH/mH 8.7 µH/mH 9 mH/H	Decade Inductor
Inductance – Source [1,2] (Artifacts)	1 kHz Up to 120 µH (0.12 to 1.2) mH 110 Hz (1.2 to 12) mH 100 Hz (12 to 120) mH 10 Hz (0.12 to 1.2) H 3 Hz (1.2 to 12) H 2 Hz (12 to 120) H	 0.16 % of reading + 0.16 µH 0.09 % of reading + 0.78 µH 0.09 % of reading + 7.8 µH 0.09 % of reading + 78 µH 0.12 % of reading + 0.78 mH 0.16 % of reading + 7.8 mH 0.19 % of reading + 78 mH	Fluke 5560A Multiproduct Calibrator
Inductance – Measure (1 kHz)	100 µH to 1 H	2.7 µH/mH + 1.2 mH	B&K Precision 885 LCR/ESR Meter
DC Voltage – Source [1]	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	7.5 nV/mV + 0.4 µV 5.5 µV/V + 0.7 µV 3.6 µV/V + 2.5 µV 3.6 µV/V + 4 µV 5.6 µV/V + 40 µV 7.7 µV/V + 0.4 mV	Fluke 5730A Multiproduct Calibrator
DC Voltage – Source [1,2]	(0 to 120) mV (0.12 to 1.2) V (1.2 to 12) V (12 to 120) V (120 to 1 020) V	9.5 nV/mV + 0.62 µV 6.5 µV/V + 0.78 µV 6.3 µV/V + 7.8 µV 8.8 µV/V + 78 µV 8.7 µV/V + 0.78 mV	Fluke 5560A Multiproduct Calibrator
DC Voltage – Measure [1]	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1 000) V	8 µV/V + 0.21 µV 3 µV/V + 0.4 µV 3 µV/V + 0.7 µV 4.4 µV/V + 29 µV 4.7 µV/V + 0.48 mV	Fluke 8588A Reference Multimeter
DC High Voltage – Measure [1]	100 V to 10 kV (10 to 35) kV (35 to 90) kV	0.036 % of reading + 40 mV 0.041 % of reading + 0.91 V 0.064 % of reading + 1 V	Vitrek 4700 Precision High Voltage Meter

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) mV		Fluke 5730A Multiproduct Calibrator
	(10 to 20) Hz	0.8 µV/mV + 4 µV	
	(20 to 40) Hz	0.8 µV/mV + 4 µV	
	40 Hz to 20 kHz	0.75 µV/mV + 4 µV	
	(20 to 50) kHz	0.8 µV/mV + 4 µV	
	(50 to 100) kHz	1 µV/mV + 5 µV	
	(100 to 300) kHz	0.7 µV/mV + 10 µV	
	(300 to 500) kHz	3.1 µV/mV + 20 µV	
	500 kHz to 1 MHz	4.3 µV/mV + 20 µV	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.29 µV/mV + 4 µV	
	(20 to 40) Hz	0.13 nV/mV + 4 µV	
	40 Hz to 20 kHz	0.12 nV/mV + 4 µV	
	(20 to 50) kHz	0.25 µV/mV + 4 µV	
	(50 to 100) kHz	0.6 µV/mV + 5 µV	
	(100 to 300) kHz	1.2 µV/mV + 10 µV	
	(300 to 500) kHz	1.7 µV/mV + 20 µV	
	500 kHz to 1 MHz	3.3 µV/mV + 20 µV	
	(22 to 220) mV		
	(10 to 20) Hz	0.75 µV/mV + 7 µV	
	(20 to 40) Hz	0.11 µV/mV + 7 µV	
	40 Hz to 20 kHz	0.07 µV/mV + 7 µV	
	(20 to 50) kHz	0.14 µV/mV + 7 µV	
	(50 to 100) kHz	0.36 µV/mV + 17 µV	
	(100 to 300) kHz	0.75 µV/mV + 20 µV	
	(300 to 500) kHz	1.5 µV/mV + 25 µV	
	500 kHz to 1 MHz	3.3 µV/mV + 45 µV	
	(0.22 to 2.2) V		
	(10 to 20) Hz	0.12 mV/V + 15 µV	
	(20 to 40) Hz	0.11 mV/V + 15 µV	
	40 Hz to 20 kHz	61 µV/V + 8 µV	
	(20 to 50) kHz	88 µV/V + 10 µV	
	(50 to 100) kHz	0.14 mV /V + 30 µV	
	(100 to 300) kHz	0.55 mV/V + 80 µV	
	(300 to 500) kHz	2.5 mV/V + 0.2 mV	
	500 kHz to 1 MHz	3.2 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 (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (220 to 1 100) V (15 to 50) Hz 50 Hz to 1 kHz	 0.28 mV/V + 0.4 mV 0.11 mV /V + 0.15 mV 57 µV/V + 50 µV 84 µV/V + 0.1 mV 0.54 mV/V + 0.2 mV 0.62 mV/V + 0.6 mV 2.4 mV/V + 2 mV 3.2 mV/V + 3.2 mV 0.28 mV/V + 4 mV 0.11 mV/V = 1.5 mV 82 µV/V + 0.6 mV 0.3 mV/V + 1 mV 0.19 mV/V + 2.5 mV 0.38 mV/V + 16 mV 0.13 mV/V + 3.5 mV	Fluke 5730A Multiproduct Calibrator
AC Voltage – Source [1,2]	(1 to 12) mV (3 to 5) Hz (5 to 10) Hz 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (12 to 120) mV (3 to 5) Hz (5 to 10) Hz 10 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	 2 µV/mV + 6 µV 0.7 µV/mV + 6 µV 0.13 µV/mV + 5 µV 0.3 µV/mV + 5 µV 1.3 µV/mV + 12 µV 6.3 µV/mV + 24 µV 6.3 µV/mV + 24 µV 2 µV/V + 6 µV 0.73 µV/mV + 6 µV 0.12 µV/V + 5 µV 0.27 µV/V + 7 µV 0.64 µV/V + 16 µV 1.6 µV/V + 24 µV 1.6 µV/mV + 24 µV	Fluke 5560A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1,2]	(0.12 to 1.2) V		Fluke 5560A Multiproduct Calibrator
	(3 to 5) Hz	2.1 mV/V + 59 µV	
	(5 to 10) Hz	0.71 mV/V + 55 µV	
	(10 to 40) Hz	0.12 mV/V + 47 µV	
	40.01 Hz to 20 kHz	0.12 mV/V + 6.2 µV	
	(20 to 50) kHz	0.24 mV/V + 11 µV	
	(50 to 100) kHz	0.55 mV/V + 31 µV	
	(100 to 300) kHz	1.6 mV/V + 63 µV	
	(300 to 500) kHz	1.5 mV/V + 63 µV	
	(1.2 to 12) V		
	(3 to 5) Hz	2 mV/V + 0.6 mV	
	(5 to 10) Hz	0.7 mV/V + 0.6 mV	
	(10 to 40) Hz	0.12 mV/V + 0.3 mV	
	40.01 Hz to 20 kHz	0.12 mV/V + 40 µV	
	(20 to 50) kHz	0.24 mV/V + 40 µV	
	(50 to 100) kHz	0.56 mV/V + 0.1 mV	
	(100 to 300) kHz	1.7 mV/V + 0.5 mV	
	(300 to 500) kHz	1.7 mV/V + 0.5 mV	
	(12 to 120) V		
	(3 to 5) Hz	2 mV/V + 5.9 mV	
	(5 to 10) Hz	0.7 mV/V + 5.9 mV	
	(10 to 40) Hz	0.12 mV/V + 2.8 mV	
	40.01 Hz to 20 kHz	0.12 mV/V + 0.4 mV	
	(20 to 50) kHz	0.24 mV/V + 0.4 mV	
	(50 to 100) kHz	0.57 mV/V + 1 mV	
	(120 to 300) V		
	(3 to 5) Hz	2 mV/V + 59 mV	
	(5 to 10) Hz	0.7 mV/V + 59 mV	
	10 Hz to 20 kHz	0.12 mV/V + 6.2 mV	
	(20 to 50) kHz	0.24 mV/V + 6.2 mV	
	(50 to 100) kHz	1.3 mV/V + 9.7 mV	
	(300 to 1 020) V		
	(3 to 5) Hz	2 mV/V + 59 mV	
	(5 to 10) Hz	0.7 mV/V + 59 mV	
	10 Hz to 10 kHz	0.12 mV/V + 63 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	Up to 2.2 mV		Fluke 5790A AC Measurement Standard
	(10 to 20) Hz	1.3 mV/V + 1 µV	
	(20 to 40) Hz	0.6 mV/V + 1 µV	
	40 Hz to 20 kHz	0.38 mV/V + 1 µV	
	(20 to 50) kHz	0.66 mV/V + 1.6 µV	
	(50 to 100) kHz	0.94 mV/V + 1.9 µV	
	(100 to 300) kHz	1.8 mV/V + 3.1 µV	
	(300 to 500) kHz	2 mV/V + 6.2 µV	
	500 kHz to 1 MHz	4 mV/V + 6.2 µV	
	(2.2 to 7) mV		
	(10 to 20) Hz	0.66 mV/V + 1 µV	
	(20 to 40) Hz	0.31 mV/V + 1 µV	
	40 Hz to 20 kHz	0.19 mV/V + 1 µV	
	(20 to 50) kHz	0.33 mV/V + 1.6 µV	
	(50 to 100) kHz	0.48 mV/V + 1.9 µV	
	(100 to 300) kHz	0.97 mV/V + 3.1 µV	
	(300 to 500) kHz	1.1 mV/V + 6.2 µV	
	500 kHz to 1 MHz	2.8 mV/V + 6.2 µV	
	(7 to 22) mV		
	(10 to 20) Hz	0.9 mV/V + 1 µV	
	(20 to 40) Hz	0.38 mV/V + 1 µV	
	40 Hz to 20 kHz	0.22 mV/V + 1 µV	
	(20 to 50) kHz	0.21 mV/V + 1.6 µV	
	(50 to 100) kHz	0.28 mV/V + 1.9 µV	
	(100 to 300) kHz	0.73 mV/V + 3.1 µV	
	(300 to 500) kHz	0.85 mV/V + 6.2 µV	
	500 kHz to 1 MHz	2.1 mV/V + 6.2 µV	
	(22 to 70) mV		
	(10 to 20) Hz	0.47 mV/V + 1.2 µV	
	(20 to 40) Hz	0.45 mV/V + 1.2 µV	
	40 Hz to 20 kHz	0.28 mV/V + 1.2 µV	
	(20 to 50) kHz	0.18 mV/V + 1.6 µV	
	(50 to 100) kHz	0.26 mV/V + 1.9 µV	
	(100 to 300) kHz	0.56 mV/V + 3.1 µV	
	(300 to 500) kHz	0.77 mV/V + 6.2 µV	
	500 kHz to 1 MHz	1.1 mV/V + 6.2 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(70 to 220) mV		Fluke 5790A AC Measurement Standard
	(10 to 20) Hz	0.96 mV/V + 1.2 µV	
	(20 to 40) Hz	0.59 mV/V + 1.2 µV	
	40 Hz to 20 kHz	0.26 mV/V + 1.2 µV	
	(20 to 50) kHz	0.31 mV/V + 1.6 µV	
	(50 to 100) kHz	0.44 mV/V + 1.9 µV	
	(100 to 300) kHz	0.59 mV/V + 3.1 µV	
	(300 to 500) kHz	1.1 mV/V + 6.2 µV	
	500 kHz to 1 MHz	1.9 mV/V + 6.2 µV	
	(220 to 700) mV		
	(10 to 20) Hz	2.4 mV/V + 1.2 µV	
	(20 to 40) Hz	2.2 mV/V + 1.2 µV	
	40 Hz to 20 kHz	1.1 mV/V + 1.2 µV	
	(20 to 50) kHz	1.5 mV/V + 1.6 µV	
	(50 to 100) kHz	0.82 mV/V + 1.9 µV	
	(100 to 300) kHz	2.4 mV/V + 3.1 µV	
	(300 to 500) kHz	1.2 mV/V + 6.2 µV	
	500 kHz to 1 MHz	1.9 mV/V + 6.2 µV	
	(0.7 to 2.2) V		
	(10 to 20) Hz	0.15 mV/V	
	(20 to 40) Hz	53 µV/V	
	40 Hz to 20 kHz	23 µV/V	
	(20 to 50) kHz	40 µV/V	
	(50 to 100) kHz	60 µV/V	
	(100 to 300) kHz	0.15 mV/V	
	(300 to 500) kHz	0.24 mV/V	
	500 kHz to 1 MHz	0.94 mV/V	
	(2.2 to 7) V		
	(10 to 20) Hz	60 µV/V	
	(20 to 40) Hz	55 µV/V	
	40 Hz to 20 kHz	26 µV/V	
	(20 to 50) kHz	42 µV/V	
	(50 to 100) kHz	69 µV/V	
	(100 to 300) kHz	0.17 mV/V	
	(300 to 500) kHz	0.36 mV/V	
	500 kHz to 1 MHz	1.2 mV/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(7 to 22) V		Fluke 5790A AC Measurement Standard
	(10 to 20) Hz	0.29 mV/V	
	(20 to 40) Hz	65 µV/V	
	40 Hz to 20 kHz	45 µV/V	
	(20 to 50) kHz	44 µV/V	
	(50 to 100) kHz	68 µV/V	
	(100 to 300) kHz	0.17 mV/V	
	(300 to 500) kHz	0.36 mV/V	
	500 kHz to 1 MHz	1.2 mV/V	
	(22 to 70) V		
	(10 to 20) Hz	0.64 mV/V	
	(20 to 40) Hz	0.27 mV/V	
	40 Hz to 20 kHz	62 µV/V	
	(20 to 50) kHz	0.14 mV/V	
	(50 to 100) kHz	0.19 mV/V	
	(100 to 300) kHz	0.45 mV/V	
	(300 to 500) kHz	0.5 mV/V	
	500 kHz to 1 MHz	1.2 mV/V	
	(70 to 220) V		
	(10 to 20) Hz	3.3 mV/V	
	(20 to 40) Hz	0.2 mV/V	
	40 Hz to 20 kHz	0.15 mV/V	
	(20 to 50) kHz	0.23 mV/V	
	(50 to 100) kHz	0.39 mV/V	
	(100 to 300) kHz	0.31 mV/V	
	(300 to 500) kHz	0.56 mV/V	
	(220 to 700) V		
	(10 to 20) Hz	0.95 mV/V	
	(20 to 40) Hz	0.79 mV/V	
	40 Hz to 20 kHz	0.9 mV/V	
	(20 to 50) kHz	6.1 mV/V	
	(50 to 100) kHz	6.6 mV/V	
	(700 to 1 000) V		
	(10 to 20) Hz	0.32 mV/V	
	(20 to 40) Hz	1.1 mV/V	
	40 Hz to 20 kHz	1.3 mV/V	
	(20 to 50) kHz	1.5 mV/V	
	(50 to 100) kHz	6.6 mV/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1] (relative to 1 kHz)	Up to 2.2 mV		Fluke 5790A AC Measurement Standard with Wideband Option
	500 kHz to 1.2 MHz	0.08 % of reading + 1 µV	
	(1.2 to 2) MHz	0.08 % of reading + 1 µV	
	(2 to 10) MHz	0.16 % of reading + 1 µV	
	(10 to 20) MHz	0.27 % of reading + 1 µV	
	(20 to 30) MHz	0.62 % of reading + 1.6 µV	
	(2.2 to 7) mV		
	500 kHz to 1.2 MHz	0.11 % of reading + 1 µV	
	(1.2 to 2) MHz	0.14 % of reading + 1 µV	
	(2 to 10) MHz	0.16 % of reading + 1 µV	
	(10 to 20) MHz	0.18 % of reading + 1 µV	
	(20 to 30) MHz	0.62 % of reading + 1 µV	
	(7 to 22) mV		
	500 kHz to 1.2 MHz	0.22 % of reading	
	(1.2 to 2) MHz	0.18 % of reading	
	(2 to 10) MHz	0.24 % of reading	
	(10 to 20) MHz	0.52 % of reading	
	(20 to 30) MHz	0.74 % of reading	
	(22 to 70) mV		
	500 kHz to 1.2 MHz	0.22 % of reading	
	(1.2 to 2) MHz	0.23 % of reading	
	(2 to 10) MHz	0.39 % of reading	
	(10 to 20) MHz	0.7 % of reading	
	(20 to 30) MHz	0.7 % of reading	
	(70 to 220) mV		
	500 kHz to 1.2 MHz	0.32 % of reading	
	(1.2 to 2) MHz	0.34 % of reading	
	(2 to 10) MHz	0.49 % of reading	
	(10 to 20) MHz	0.62 % of reading	
	(20 to 30) MHz	0.84 % of reading	
	(220 to 700) mV		
	500 kHz to 1.2 MHz	0.31 % of reading	
	(1.2 to 2) MHz	0.28 % of reading	
	(2 to 10) MHz	0.43 % of reading	
	(10 to 20) MHz	0.47 % of reading	
	(20 to 30) MHz	0.65 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1] (relative to 1 kHz)	(0.7 to 2.2) V 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (2.2 to 7) V 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	 0.07 % of reading 0.13 % of reading 0.2 % of reading 0.25 % of reading 0.42 % of reading 0.05 % of reading 0.05 % of reading 0.11 % of reading 0.16 % of reading 0.36 % of reading	Fluke 5790A AC Measurement Standard with Wideband Option
AC High Voltage – Measure [1]	60 Hz 10 V to 10 kV (10 to 35) kV (35 to 70) kV	 0.14 % of reading + 0.12 V 0.12 % of reading + 0.84 V 0.14 % of reading + 1.4 V	Vitrek 4700 Precision High Voltage Meter
Phase – Measure [1]	Up to 360 ° 5 Hz to 2 kHz (2 to 5) kHz (5 to 10) kHz (10 to 50) kHz 50 kHz to 1 MHz	 0.026 ° 0.037 ° 0.051 ° 0.062 ° 0.24 °	Clarke-Hess 6000A Precision Phase Meter
Phase – Source [1,2]	(0 to 360) ° (3 to 65) Hz (1 to 360) ° (65 to 500) Hz (2 to 360) ° 500 Hz to 1 kHz (3 to 360) ° (1 to 5) kHz (4 to 360) ° (5 to 10) kHz (5 to 360) ° (10 to 30) kHz	 0.1 ° 0.2 ° 0.4 ° 1.9 ° 3.9 ° 7.8 °	Fluke 5560A Multiproduct Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicators – Source/Measure [1]	Type B		Fluke 7526A Precision Process Calibrator
	(600 to 800) °C	0.36 °C	
	(800 to 1 550) °C	0.29 °C	
	(1 550 to 1 820) °C	0.22 °C	
	Type C		
	(0 to 1 000) °C	0.16 °C	
	(1 000 to 1 800) °C	0.23 °C	
	(1 800 to 2 000) °C	0.27 °C	
	(2 000 to 2 316) °C	0.36 °C	
	Type E		
	(-250 to -200) °C	0.26 °C	
	(-200 to -100) °C	0.12 °C	
	(-100 to 0) °C	0.09 °C	
	(0 to 600) °C	0.08 °C	
	(600 to 1 000) °C	0.1 °C	
	Type J		
	(-210 to -100) °C	0.14 °C	
	(-100 to 800) °C	0.09 °C	
	(800 to 1 200) °C	0.1 °C	
	Type K		
	(-250 to -200) °C	0.47 °C	
	(-200 to -100) °C	0.16 °C	
	(-100 to 800) °C	0.1 °C	
	(800 to 1 372) °C	0.13 °C	
	Type L		
	(-200 to 0) °C	0.1 °C	
	(0 to 900) °C	0.09 °C	
	Type N		
	(-250 to -200) °C	0.74 °C	
	(-200 to -100) °C	0.23 °C	
	(-100 to 0) °C	0.12 °C	
	(0 to 100) °C	0.11 °C	
	(100 to 800) °C	0.1 °C	
	(800 to 1 300) °C	0.12 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicators – Source/Measure [1]	Type R (-50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1 000) °C (1 000 to 1 600) °C (1 600 to 1 767) °C Type S (-50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1 000) °C (1 000 to 1 600) °C (1 600 to 1 767) °C Type T (-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 200) °C (200 to 400) °C	 0.56 °C 0.46 °C 0.4 °C 0.29 °C 0.22 °C 0.21 °C 0.19 °C 0.23 °C 0.52 °C 0.44 °C 0.39 °C 0.3 °C 0.23 °C 0.22 °C 0.22 °C 0.27 °C 0.36 °C 0.16 °C 0.11 °C 0.09 °C 0.09 °C	Fluke 7526A Precision Process Calibrator
Oscilloscopes [1] Amplitude 50 Ω Load 1 MΩ Load Bandwidth (relative to 50 kHz) 50 Ω load Risetime 50 Ω load	 1.8 mVp-p to 2.2 Vp-p 1.8 mVp-p to 105 Vp-p 50 kHz to 100 MHz (100 to 300) MHz Nominal: (250 to 350) ps	 2.3 mV/V + 0.81 mV 2.7 mV/V + 81 µV 5.2 % of reading + 0.38 V 5.9 % of reading + 0.37 V 100 ps	Fluke 5500A w/SC300 Multiproduct Calibrator
Gauss Meters / Hall Effect Meters	(-5 to 5) Gs (-10 to 10) Gs (-20 to 20) Gs (-50 to 50) Gs (-100 to 100) Gs	0.1 Gs 0.2 Gs 0.4 Gs 1 Gs 2 Gs	Helmholtz Coil, Power Supply

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Measure [1,3]	(-23 to +10) dBm 100 MHz ≤ f < 6 GHz 6 GHz ≤ f ≤ 18 GHz (> 10 to 20) dBm 100 MHz ≤ f < 500 MHz 500 MHz ≤ f < 1.2 GHz 1.2 GHz ≤ f < 6 GHz 6 GHz ≤ f ≤ 18 GHz (-30 to -10) dBm 100 kHz ≤ f < 10 MHz 10 MHz ≤ f < 1.2 GHz 1.2 GHz ≤ f ≤ 4.2 GHz (> -10 to +20) dBm 100 kHz ≤ f < 10 MHz 10 MHz ≤ f < 1.2 GHz 1.2 GHz ≤ f ≤ 4.2 GHz	 0.08 dB 0.16 dB 0.18 dB 0.17 dB 0.18 dB 0.19 dB 0.1 dB 0.18 dB 0.11 dB 0.17 dB 0.17 dB 0.17 dB	Agilent E4418B RF Power Meter, Agilent 8481A Power Sensor
Distortion – Measure [1]	(-80 to 0) dB 20 Hz to 20 kHz (20 to 100) kHz	 1.2 dB 2.3 dB	Agilent 8903B Audio Analyzer
Absolute Power – Source [1,3] into 50 Ω	(0.05 to 10) Vp-p Up to 100 kHz 100 kHz to 1 MHz (1 to 15) MHz	 60 mV 75 mV 92 mV	Agilent 33120A Arbitrary Function Generator
Absolute Power – Measure [1] (-120 to 20) dBm	(-120 to 20) dBm 10 MHz to 1.3 GHz	 1 dB	Rigol DSA1030A-TG Spectrum Analyzer
Tuned RF Power – Measure [1] 2.5 MHz to 1.3 GHz	(-115 to 0) dBm (-127 to -115) dBm	2 dB 1.3 dB	Agilent 8902A Modulation Analyzer, Agilent 11722A Power Sensor
Frequency Modulation – Measure [1] Freq: 250 kHz to 10 MHz Freq: 10 MHz to 1.3 GHz Freq: 10 MHz to 1.3 GHz	 Deviation: ≤ 40 kHz Rate: 20 Hz to 10 kHz Deviation: ≤ 40 kHz Rate: 20 Hz to 100 kHz Deviation: ≤ 40 kHz Rate: 20 Hz to 200 kHz	 0.41 kHz 1.5 kHz 5.9 kHz	Agilent 8902A Modulation Analyzer

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation –Measure [1]	Rate: 200 Hz to 10 kHz 150 kHz ≤ f_c < 10 MHz Rate: 200 Hz to 20 kHz 10 MHz ≤ f_c < 1.3 GHz	1.6 rad 0.58 rad	Agilent 8902A Modulation Analyzer
Amplitude Modulation – Measure [1] Freq: 150 kHz to 10 MHz Freq: 10 MHz to 1.3 GHz	Depth: (5 to 99) % Rate: 50 Hz to 10 kHz Depth: (5 to 99) % Rate: 20 Hz to 10 kHz Depth: (5 to 99) % Rate: 50 Hz to 50 kHz Depth: (5 to 99) % Rate: 20 Hz to 100 kHz	2.5 % Depth 3.7 % Depth 1.5 % Depth 3.7 % Depth	Agilent 8902A Modulation Analyzer
Attenuation – Source Coaxial, Fixed [1] 3 dB	DC to 8 GHz, SWR < 1.25:1 (8 to 12.4) GHz, SWR < 1.3:1	0.35 dB 0.35 dB	Agilent 8491A Coaxial Fixed Attenuator with Type-N
Attenuation – Source Coaxial, Fixed [1] 6 dB 10 dB 20 dB	DC to 8 GHz, SWR < 1.2:1 (8 to 12.4) GHz, SWR < 1.3:1 DC to 8 GHz, SWR < 1.2:1 (8 to 12.4) GHz, SWR < 1.3:1 DC to 8 GHz, SWR < 1.2:1 (8 to 12.4) GHz, SWR < 1.3:1	0.47 dB 0.47 dB 0.7 dB 0.7 dB 0.7 dB 0.7 dB	Agilent 8491A Coaxial Fixed Attenuator with Type-N

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Attenuation – Source Coaxial, Fixed [1] 30 dB 60 dB	DC to 8 GHz, SWR < 1.2:1 (8 to 12.5) GHz, SWR < 1.3:1 DC to 8 GHz, SWR < 1.2:1 (8 to 12.5) GHz, SWR < 1.3:1	1.2 dB 1.2 dB 2.3 dB 2.3 dB	Agilent 8491A Coaxial Fixed Attenuator with Type-N
Thermal Noise Figure System – Measure [1] (0 to 30 dB)	10 MHz to 1.5 GHz SWR 1.7:1 ENR (14 to 16) dB	0.3 dB	Agilent 8970A Noise Figure Meter, Agilent 346B Noise Source
Thermal Noise Figure System – Generate [1] ENR (14 to 16) dB	10 MHz to 18 GHz SWR 1.25:1	0.003 2 dB/GHz + 0.27 dB	Agilent 346B Noise Source

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inside Micrometers [1,5] (0.001 in Resolution)	Up to 4 in (4 to 20) in (20 to 36) in (36 to 60) in	580 µin (560 + 2.1*L*) µin (500 + 4.6*L*) µin (400 + 6.7*L*) µin	Gage Blocks
Feeler Gages	Up to 0.25 in Up to 6 mm	20 µin 0.51 µm	Gages Blocks, Universal Length Measuring Machine
Surveillance Micrometer Masters [5]	(1 to 12) in (25 to 300) mm	(5.5 + 11*L*) µin (0.14 + 0.011*L*) µm	Gages Blocks, Universal Length Measuring Machine

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Taper Thread Plugs Pitch Diameter	Up to 3 in	130 µin	Thread Measuring Wires, Taper Block, Universal Length Measuring Machine
Major Diameter	Up to 3 in	100 µin	Taper Block, Universal Length Measuring Machine
Length at Notch	Up to 3 in	250 µin	Gage Blocks, Height Gage
Radius Gage	(0 to 0.5) in	260 µin	Vision System
Rulers	Up to 24 in	0.005 8 in	Vision System
Steel Tape [1]	Up to 10 m	250 µm	Master Tape
Vision System X-Y Linearity	Up to 18 in	100 µin	Master Grid, Gage Blocks
Z Linearity	Up to 4 in	52 µin	
Levels [1] Base Flatness Parallelism	Up to 12 in	100 µin	Height Transfer Standard, Gage Blocks, Surface Plate
Metal / X-Ray Detector Standards [4,5]	(0.031 5 to 0.28) in	(5.5 + 11*L*) µin	Universal Length Measuring Machine
Gage Blocks [5]	(0.01 to 5) in	(7 + 1.3*L*) µin	Gage Block Comparator, Master Gage Blocks
Gage Blocks [5]	(5 to 12) in	(2.3 + 2.4*L*) µin	P&W LMU 175 Labmaster Universal, Master Gage Blocks
Laser Micrometer [1] (1 µin Resolution)	(0.01 to 2) in	23 µin	XXX Pin Gages
Angle Blocks [4]	(1 to 45)°	0.2 ″/ ° + 14″	Sine Block, Height Transfer Standard, Surface Plate

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bench / Super Micrometers / Universal Length Measuring Machine [5] Linearity Anvil Parallelism Force	 Up to 4 in 25 µin TIR 2 ozf 4 ozf 8 ozf 16 ozf 40 ozf	 (3 + 22*L*) µin 4 µin 0.019 ozf 0.021 ozf 0.027 ozf 0.74 ozf 0.78 ozf	 Gage Blocks Optical Flats w/ Monochromatic Light Digital Force Gage
Snap Gages [1]	(0.05 to 4) in	22 µin	Gage Blocks
Pin Gages / Cylindrical Plug Gages	(0.01 to 2) in	46 µin	Laser Micrometer
Pin Gages / Cylindrical Plug Gages [5]	Up to 2 in (1.9 to 18) in	(6.9 + 10*D*) µin (4.7 + 11*D*) µin	Universal Length Measuring Machine
Cylindrical Rings [5]	(0.275 to 13.25) in	(41 + 11*D*) µin	Master Rings, Universal Length Measuring Machine
Thread Wires [5]	Up to 0.144 34 in	(11 + 13*D*) µin	Universal Length Measuring Machine
Measuring Rods [5]	(1 to 12) in (12 to 18) in (18 to 59) in	(5.5 + 11*L*) µin (1.7 + 12*L*) µin (91 + 13*L*) µin	Gage Blocks, Universal Length Measuring Machine
Height Masters [5] Micrometer Linearity Step Height, Top/Bottom Step Parallelism	 Up to 1 in (1 to 24) in Up to 100 µin	 66 µin (43 + 2*L*) µin 84 µin	Height Transfer Standard, Gage Blocks, Surface Plate
Thread Plugs [5] Pitch Diameter (5 to 100) TPI	Up to 8 in	(76 + 7.7*D*) µin	Thread Wires, Universal Length Measuring Machine
Thread Rings [1]	Up to 2 in	340 µin	Master Thread Plugs
Solid Thread Rings [5] (5.5 to 40) TPI (0.7 to 4.5) Pitch	(0.125 to 4) in	(23 + 6.8*L*) µin	P&W LMU 175 Labmaster Universal. Class XX Master Ring Gage

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
External Spline Gages [5] Measurement over Pins	Up to 8 in	(180 + 30*D*) µin	Gear Wires, Universal Length Measuring Machine
Circular Tooth Thickness	Up to 8 in	(120 + 20*L*) µin	Vision System
Major Diameter	Up to 8 in	(30 + 16*D*) µin	Universal Length Measuring Machine
Chamfer Gages / Countersink Gages [1]	Up to 3 in	540 µin	Master Cylindrical Rings
Bore Gages [1] (0.000 1 in Resolution)	(0.25 to 6) in (1 to 8) in	190 µin 0.002 % of reading + 1 800 µin	Master Cylindrical Rings, Bore Gage Calibrator
Calipers [1] (0.000 5 in Resolution) (0.001 in Resolution)	(0.05 to 24) in (0.05 to 12) in (12 to 60) in	470 µin 800 µin 1 800 µin	Gage Blocks, End Measuring Rod, Surface Plate
Outside Micrometers [1,5] 50 µin Resolution 100 µin Resolution 100 µin Resolution 0.001 in Resolution	Up to 1 in Up to 1 in (1 to 12) in (12 to 20) in	(35 + 8.8*L*) µin (66 + 19*L*) µin (770 + 26*L*) µin (1 600 + 106*L*) µin	Gage Blocks, End Measuring Rods, Surface Plate
Depth Micrometers[1,5] (0.000 1 in Resolution) (0.001 in Resolution)	Up to 12 in Up to 12 in	(88 + 4*L*) µin (890 + 23*L*) µin	Gage Blocks, Surface Plate
V-Anvil OD Micrometers [1,5] 100 µin Resolution 500 µin Resolution	(0.4 to 1) in (1.25 to 4) in	60 µin (330 + 54*L*) µin	Cylindrical Plug Gages, Pin Gages
Ultrasonic Thickness Gage [1,5]	Up to 12 in	(760 + 13*L*) µin	Gage Blocks
Dial / Digital Indicators [1] 10 µin resolution 20 µin resolution 50 µin resolution 100 µin resolution 500 µin resolution 0.001 in resolution	(-0.015 to 0.015) in (-0.001 to 0.001) in Up to 2 in Up to 2 in Up to 2 in Up to 2 in	7.3 µin 13 µin 61 µin 110 µin 300 µin 1 200 µin	Gage Blocks, Indicator Calibrator, Surface Plate
Test Indicators [1]	50 µin to 0.01 in	61 µin	Indicator Calibrator, Surface Plate
Height Gages [1,5]	Up to 12 in (12 to 36) in	(59 + 5*L*) µin (93 + 39*L*) µin	Gage Blocks, Surface Plate, Measuring Rods

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Linear Scales [1]	(1 to 142) in	7 µin/in + 0.009 5 µin	Measuring Rods
Extensometers [1] 50 µin resolution	Up to 2 in	140 µin	Micrometer Head
Extensometers [1] 10 µin resolution	Up to 2 in	61 µin	Extensometer Calibrator
Optical Comparators [1] Magnification Linearity (10 µin Resolution) Angularity	 10 X to 100 X Up to 18 in Up to 30°	 210 µin 0.001 5 % of reading + 59 µin 2′10″	 Glass Scale Glass Scale Angle Blocks
Coating Thickness Measuring Systems [1]	Up to 0.018 in	7.7 % of reading	Ferrous Coated Thickness Standards
Protractors	Up to 180º	0.06º	Height Transfer Standard, Sine Block, Surface Plate
Microscopes [1]	Up to 2 in	160 µin	Glass Scale
Profilometers [1]	118 µin 123 µin	3.1 µin 3.1 µin	Roughness Standard
Surface Roughness Specimen (Ra)	(10 to 500) µin	3.7 µin	Surface Finish Analyzer
Roundness Measuring System [1] Radial Error	 Up 5 in	 5.5 µin	Precision Ball
Coordinate Measuring Machines [5] Linear Accuracy Volumetric Accuracy Squareness	 (0.5 to 24.5) in (9 to 25) in (0.25 to 11.75) in	 (88 + 7*L*) µin 209 µin 362 µin	Step Gage, Ball Bars, and ASME B89.4.1 utilized in the calibration of this system parameter.
Coordinate Measuring Machines [5] Linear Accuracy	(0.5 to 39) in	(20 + 4*L*) µin	Gage Blocks and ISO 10360-2 utilized in the calibration of this system parameter.

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surface Plates [1,5] Overall Flatness Local Area Flatness	Up to 68 in*DL* Up to 0.03 in	(5 + 0.5*DL*) µin 16 µin	In accordance with ASME B89.3.7 using Optodyne LDDM Laser Measurement System Repeat Reading Gage
Optical Flats	Up to 100 µin	5 µin	Optical Flat, Monochromatic Light
Inclinometers	Up to 45°	0.06°	Sine Plate and Gage Blocks
Crosshead Displacement	(0.2 to 2) in	0.001 5 in/in + 1 800 µin	Dial Depth Indicator and ASTM E2309 utilized in the calibration of this parameter.
Laser Interferometer System (Device for Measuring Displacement w/out Atmospheric Compensation)	Up to 80 in	(0.95 + 0.72*L*) µin	Master Laser Interferometer per ASME B89.1.8, Back-to-Back Method.
Laser Interferometer System Flatness	Up to 100 µin	5.5 µin	Flatness Master

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Aqueous Volumetric Flow Rate [1] (Inline)	Up to 65 gpm Up to 150 gpm	0.2 % of reading + 0.6 gpm 0.2 % of reading + 0.3 gpm	Comparison to Coriolis Meter
Aqueous Volumetric Flow Rate [1] (Non-Intrusive)	(100 to 500) gpm (150 to 900) gpm	1.84 % of reading + 0.64 gpm 1.8 % of reading + 0.65 gpm	Comparison to Ultrasonic Transducers
Volumetric Gas Flow Meters, Rotameters	(2 to 20) sccm (10 to 100) sccm (100 to 1 000) sccm (0.5 to 5) slpm (5 to 50) slpm	1 % of reading + 0.6 sccm 1 % of reading + 0.9 sccm 0.81 % of reading + 5.5 sccm 0.14 % of reading + 0.3 slpm 1 % of reading + 0.4 slpm	Comparison to Thermal Volumetric Flow Sensors
Gas Flow Velocity	(50 to 6 000) ft/min	1.3 % of reading + 2 ft/min	Master Anemometer, Open Jet Wind Tunnel
Metal Detectors – Magnetic Separation [1]	(0.5 to 6) lbf	0.37 lbf	Digital Magnetic Pull Tester

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Gauges [1]	Up to 21.5 lbf (10 to 110) lbf (50 to 1 050) lbf	0.035 % of reading + 0.000 93 lbf 0.043 % of reading + 0.007 3 lbf 0.051 % of reading + 0.073 lbf	NIST Class F Weights, Weight Hanger
Force Machines – Tension [1]	(5 to 50) lbf (76 to 500) lbf (290 to 3 000) lbf (480 to 5 000) lbf (261 to 10 000) lbf (3 000 to 30 000) lbf (3 000 to 60 000) lbf (3 000 to 120 000) lbf (10 000 to 300 000) lbf	0.025 lbf 0.25 lbf 0.61 lbf 2.2 lbf 4.2 lbf 6.5 lbf 12 lbf 0.03 % of reading + 16 lbf 0.02 % of reading + 8 lbf	Load Cell w/ Indicator and ASTM E74 utilized in the calibration of this system.
Force Machines – Compression [1]	(5 to 50) lbf (48 to 500) lbf (88 to 3 000) lbf (450 to 5 000) lbf (1 000 to 10 000) lbf (3 000 to 30 000) lbf (6 000 to 60 000) lbf (60 000 to 120 000) lbf (19 000 to 300 000) lbf (52 000 to 800 000) lbf	0.03 lbf 0.25 lbf 0.61 lbf 2.3 lbf 7.5 lbf 6.4 lbf 17 lbf 0.03 % of reading + 16 lbf 0.02 % of reading + 6 lbf 0.03 % of reading + 10 lbf	Load Cell w/ Indicator and ASTM E74 utilized in the calibration of this system.
Ductility Tester, Olsen Cup Tester [1]	(300 to 6 000) lbf (6 000 to 30 000) lbf	7.5 lbf 17 lbf	Master Load Cell w/ Indicator and ASTM E74 utilized in the calibration of this system.
Load Cell – Tension [1]	(5 to 50) lbf (76 to 500) lbf (290 to 3 000) lbf (480 to 5 000) lbf (261 to 10 000) lbf (3 000 to 30 000) lbf (3 000 to 60 000) lbf (3 000 to 120 000) lbf (10 000 to 300 000) lbf	0.025 lbf 0.25 lbf 0.61 lbf 2.2 lbf 4.2 lbf 6.5 lbf 12 lbf 0.03 % of reading + 16 lbf 0.02 % of reading + 6 lbf	Master Load Cell w/ Indicator and ASTM E74 utilized in the calibration of this system.
Load Cell – Compression [1]	(5 to 50) lbf (48 to 500) lbf (88 to 3 000) lbf (450 to 5 000) lbf (1 000 to 10 000) lbf (3 000 to 30 000) lbf (6 000 to 60 000) lbf	0.03 lbf 0.25 lbf 0.61 lbf 2.3 lbf 7.5 lbf 6.4 lbf 17 lbf	Master Load Cell w/ Indicator and ASTM E74 utilized in the calibration of this system.

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Load Cell – Compression [1]	(60 000 to 120 000) lbf (19 000 to 300 000) lbf (52 000 to 800 000) lbf	0.03 % of reading + 16 lbf 0.02 % of reading + 6 lbf 0.03 % of reading + 10 lbf	Master Load Cell w/ Indicator and ASTM E74 utilized in the calibration of this system.
Rockwell Hardness Testers [1]	HRA Low Middle High HRBW Low Middle High HRC Low Middle High HRE Low High HRF Low High HRGw Low High HRHw Low High HRLw Low High	 0.44 HRA 0.38 HRA 0.26 HRA 0.74 HRBW 0.69 HRBW 0.59 HRBW 0.41 HRC 0.36 HRC 0.36 HRC 0.62 HRE 0.55 HRE 0.69 HRF 0.62 HRF 1.1 HRGw 0.91 HRGw 0.87 HRHw 0.45 HRHw 0.9 HRLw 0.46 HRLw	Indirect verification per ASTM E18 using Hardness Blocks
Rockwell Hardness Testers [1]	HRMw Low High HRRw Low High	 0.69 HRMw 0.51 HRMw 0.58 HRRw 0.58 HRRw	Indirect verification per ASTM E18 using Hardness Blocks

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Superficial Rockwell Hardness Testers [1]	HR15N Low Middle High HR30N Low Middle High HR45N Low Middle High HR15TW Low Middle High HR30TW Low Middle High HR45TW Low Middle High HR15Yw Low High	 0.13 HR15N 0.16 HR15N 0.1 HR15N 0.67 HR30N 0.59 HR30N 0.51 HR30N 0.49 HR45N 0.57 HR45N 0.5 HR45N 0.69 HR15TW 0.62 HR15TW 0.4 HR15TW 0.52 HR30TW 0.45 HR30TW 0.44 HR30TW 0.49 HR45TW 0.46 HR45TW 0.62 HR45TW 0.83 HR15Yw 0.8 HR45Yw	Indirect verification per ASTM E18 using Hardness Blocks
Leeb Hardness [1]	784 LD	17 LD	Indirect verification per ASTM E18 using Hardness Blocks
Brinell Hardness Testers [1]	(500 to 3 000) kgf	6.7 kgf	Direct verification per ASTM E10, ASTM E74; Class A Proving Ring

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Brinell Hardness Testers [1] Verification	HBW2.5/62.5 Low High HBW2.5/187.5 Low High HBW5/750 Low High HBW10/500 Low High HBW10/1500 Low High HBW10/3000 Low High	 2.8 HBW2.5/62.5 6.1 HBW2.5/62.5 2.3 HBW2.5/187.5 16 HBW2.5/187.5 4.9 HBW5/750 16 HBW5/750 0.63 HBW10/500 2.1 HBW10/500 1.2 HBW10/1 500 3.2 HBW10/1 500 3.3 HBW10/3 000 13 HBW10/3 000	Indirect verification per ASTM E10 using Hardness Standards,
Indenter Error	Up to 0.1 mm	57 µm	Stage Micrometer
Brinell Scope [1]	(0 to 7) mm	6.7 µm	Stage Micrometer
Vickers Hardness Tester – Force [1]	10 gf 25 gf 50 gf 100 gf 200 gf 300 gf 500 gf 1 kgf 2 kgf 5 kgf 10 kgf 20 kgf 30 kgf 50 kgf	1.1 gf 1.1 gf 1.1 gf 1.1 gf 1.1 gf 2.3 gf 3.4 gf 6.6 gf 13 gf 33 gf 66 gf 0.13 kgf 0.2 kgf 0.33 kgf	Direct verification per ASTM E92 / ISO 6507-2 using Force Gage

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Knoop Hardness Tester – Force [1]	10 gf 25 gf 50 gf 100 gf 200 gf 300 gf 500 gf 1 kgf 3 kgf 10 kgf 15 kgf 30 kgf 45 kgf 60 kgf 100 kgf 150 kgf	1.1 gf 1.1 gf 1.1 gf 1.1 gf 1.1 gf 2.3 gf 3.4 gf 6.1 gf 11 gf 11 gf 11 gf 11 gf 11 gf 33 gf 33 gf 33 gf	Direct verification per ASTM E92 / ISO 6507-2 using Force Gage
Rockwell Hardness Tester – Force [1]	3 kgf 10 kgf 15 kgf 30 kgf 45 kgf 60 kgf 100 kgf 150 kgf	8 gf 24 gf 0.21 kgf 0.22 kgf 0.23 kgf 0.25 kgf 0.31 kgf 0.41 kgf	Direct Verification per ASTM E18 using Load Cell w/ Indicator
Rockwell Hardness Testers – Indenter Depth [1]	(0.1 to 200) µm	0.3 µm	Comparison with LVDT Probe w/ Indicator
Rockwell Hardness Testers – Hysteresis [1] B, E, F, G, H and K Scale All Other Scales	 100 Rockwell Units 130 Rockwell Units	 0.31 HR 0.15 HR	Direct verification using Blunt Indenter and Flat Anvil

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Vickers Hardness Tester [1]	< 240 HV 0.01 > 600 HV 0.01 < 240 HV 0.025 > 600 HV 0.025 < 240 HV 0.05 > 600 HV 0.05 < 240 HV 0.1 > 600 HV 0.1 < 240 HV 0.2 > 600 HV 0.2 < 240 HV 0.3 > 600 HV 0.3 < 240 HV 0.5 > 600 HV 0.5 < 240 HV 1 > 600 HV 1 < 240 HV 5 (240 to 600) HV 5 > 600 HV 5 < 240 HV 10 (240 to 600) HV 10 > 600 HV 10 < 240 HV 30 (240 to 600) HV 30 > 600 HV 30	12 HV 0.01 44 HV 0.01 11 HV 0.025 33 HV 0.025 11 HV 0.05 30 HV 0.05 11 HV 0.1 28 HV 0.1 9 HV 0.2 22 HV 0.2 9 HV 0.3 21 HV 0.3 8 HV 0.5 20 HV 0.5 7 HV 1 17 HV 1 6 HV 5 13 HV 5 22 HV 5 5 HV 10 10 HV 10 17 HV 10 7 HV 30 11 HV 30 18 HV 30	Indirect verification per ASTM E92 / ISO 6507-2 using Hardness Blocks
Knoop Hardness Tester [1]	< 250 HK 0.01 > 650 HK 0.01 < 250 HK 0.025 > 650 HK 0.025 < 250 HK 0.05 > 650 HK 0.05 < 250 HK 0.1 > 650 HK 0.1 < 250 HK 0.2 > 650 HK 0.2 < 250 HK 0.3 > 650 HK 0.3 < 250 HK 0.5 > 650 HK 0.5 < 250 HK 1 > 650 HK 1	9 HK 0.01 35 HK 0.01 9 HK 0.025 24 HK 0.025 9 HK 0.05 22 HK 0.05 9 HK 0.1 21 HK 0.1 7 HK 0.2 17 HK 0.2 7 HK 0.3 21 HK 0.3 7 HK 0.5 18 HK 0.5 8 HK 1 18 HK 1	Indirect verification per ASTM E92 / ISO 6507-2 using Hardness Blocks

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Durometers Spring Force Only Types A, B, O Types D, C, DO	 (10 to 90) Duro (10 to 90) Duro	 0.7 Duro 0.6 Duro	Partial Direct Verification per ASTM D2240-02B using Durometer Calibrator.
Duro Calibrator Types A, B, O Types D, C, DO	 (1.3 to 8.05) N (4.445 to 44.45) N	 0.033 N 0.046 % of reading + 0.03 N	Comparison to Digital Force Gage
Pneumatic Pressure Gages [1]	(-0.25 to 0.25) in H_2O (-30 to 30) in H_2O (20 to 200) in H_2O	0.07 % of reading + 0.004 1 inH_2O 0.002 9 inH_2O 0.72 in H_2O	Setra & Meriam Calibrator
Pneumatic Pressure Gages	(> 0 to 36) psig (> 0 to 145) psig (> 0 to 500) psig	0.008 5 % of reading + 0.007 2 psi 0.006 5 % of reading + 0.01 psi 0.008 7 % of reading + 0.019 psi	Fluke 6270A Pressure Controller with Associated Module
Pneumatic/Hydraulic Pressure Gages [1]	(10 to 2000) psig (100 to 10 000) psig	0.18 % of reading + 0.27 psi 0.075 % of reading + 0.52 psi	Deadweight Testers
Pneumatic/Hydraulic Pressure Gages [1]	(0 to 30) psig (0 to 300) psig (0 to 300) psia (0 to 500) psig (0 to 1 000) psig (1 000 to 10 000) psig (5 000 to 50 000) psig (10 000 to 100 000) psig	0.1 % of reading 0.1 % of reading 0.1 % of reading 0.3 psi 0.03 % of reading + 0.54 psi 0.05 % of reading + 17 psi 0.05 % of reading + 58 psi 0.04 % of reading + 380 psi	Comparison to High Accuracy Pressure Gage, Pressure Calibrator
Absolute Pneumatic Pressure Gages	(> 0 to 17.4) psia	0.001 5 % of reading + 0.007 7 psi	Fluke 6270A Pressure Controller with Associated Module
Vacuum Gage	(-14.7 to < 0) psiv	0.034 % of reading + 0.008 7 psi	Fluke 6270A Pressure Controller with Associated Module
Vacuum Gage [1]	(-660 to < 0) mmHg	0.1 % of reading	Pressure Calibrator
Conventional Mass NIST Class F (Metric)	(1 to 40) g (40 to 100) g (100 to 220) g (0.22 to 3.1) kg 500 g 1 kg 5 kg 10 kg 20 kg	0.000 6 % of reading + 20 µg 0.000 4 % of reading + 0.11 mg 0.000 5 % of reading + 0.17 mg 0.000 13 % of reading + 36 mg 27 mg 27 mg 36 mg 39 mg 0.49 g	Comparison to ASTM E617 Class 1 Weights, Balance

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Conventional Mass NIST Class F (Avoirdupois)	0.5 lb 1 lb 2 lb 5 lb 10 lb 20 lb 25 lb 50 lb	26 mg 27 mg 27 mg 14 mg 21 mg 31 mg 37 mg 1.6 g	Comparison to ASTM E617 Class 1 Weights, Balance
Scales and Balances [1,6] Metric (SI)	Up to 40 g (40 to 100) g (100 to 220) g (220 to 2 100) g (2 100 to 4 200) g (4 200 to 14 200) g (14 200 to 32 000) g	0.000 4 % of reading + 14 µg 0.000 4 % of reading + 16 µg 0.000 5 % of reading + 3.2 µg 0.000 7 % of reading + 3.6 mg 0.000 7 % of reading + 3.1 mg 0.000 3 % of reading + 2.7 mg 0.000 3 % of reading + 30 mg	ASTM E617 Class 1 weights and NIST Handbook 44 utilized for the calibration of the weighing system.
Scales and Balances [1,6] Avoirdupois	Up to 10 lb (10 to 50) lb (50 to 250) lb (250 to 500) lb (500 to 1 000) lb	0.008 % of reading + 0.002 lb 0.15 % of reading + 0.001 lb 0008 % of reading + 0.01 lb 0.006 % of reading + 0.05 lb 0.016 % of reading + 0.18 lb	ASTM E617 Class 3 weights, NIST Class F Weights, and NIST Handbook 44 utilized for the calibration of the weighing system.
Pipettes	(2 to 100) µl (100 to 1 000) µl (1 000 to 10 000) µl	0.37 µl 0.036 % of reading + 0.33 µl 0.005 7 % of reading + 0.61 µl	Analytical Balance
Moisture Analyzers [1,6] Weighing System Temperature	Up to 220 g 160 °C	0.000 4 % of reading + 0.14 mg 2.5 ºC	ASTM E617 Class 1 weights and NIST Handbook 44 utilized for the calibration of the weighing system. Reference Thermometer
Torque Watch [1]	(0.5 to 2.5) ozf·in (2 to 10) ozf·in (6 to 43) ozf·in (30 to 215) ozf·in	0.3 % of reading + 0.08 ozf·in 0.2 % of reading + 0.07 ozf·in 0.2 % of reading + 0.3 ozf·in 0.2 % of reading + 3 ozf·in	Torque Watch Calibrator
Torque Devices [1]	(2.5 to 25) lbf·in (25 to 250) lbf·in (100 to 1 000) lbf·in (25 to 250) lbf·ft (80 to 800) lbf·ft (100 to 1 000) lbf·ft (500 to 5 000) lbf·ft	0.54 % of reading + 0.05 lbf·in 0.64 % of reading + 0.02 lbf·in 0.76 % of reading + 0.24 lbf·in 1.2 % of reading + 0.05 lbf·in 2 lbf·ft 1.1 % of reading + 0.84 lbf·in 1.1 % of reading + 9.1 lbf·in	Torque Wrench Calibration System

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Torque Analyzers, Torque Transducers [1]	(2.5 to 25) lbf·in (25 to 250) lbf·in (100 to 1 000) lbf·in (300 to 3 000) lbf·in (100 to 1 200) lbf·ft	0.4 % of reading 0.004 % of reading + 0.13 lbf·in 0.06 % of reading + 0.066 lbf·in 0.04 % of reading + 0.11 lbf·in 0.024 % of reading + 0.07 lbf·ft	NIST Class F Weights, Torque Wheel, Torque Arm
Torque Watch Calibrators [1] Masses Dial	 0.5 oz 2 oz 8.5 oz 42.5 oz 13.25° 76.75°	 0.000 004 oz 0.000 012 oz 0.001 3 oz 0.001 4 oz 0.58° 0.58°	 ASTM E617 Class 1 Weights, Balance Masses
Hydrometers [1,5]	(0.9 to 1) SG (1.2 to 1.4) SG	0.001 7 SG 0.002 9 SG	Comparison to Reference Hydrometer per ASTM E126-19

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gloss Meters [1,5]	93.5 GU, 20° 95.4 GU, 60° 99.6 GU, 85°	1.2 GU 0.65 GU 0.58 GU	Per ASTM D523-08 using Gloss Standards
Spectrophotometers Total Hemispherical Diffuse Reflectance [2] (8°:t)	(360 to 390) nm (400 to 830) nm	0.37 % of reading 0.27 % of reading	Ultra-White Ceramic Reflectance Standard, ΔE CIELAB values reported.
Xenon arc Weathering Instruments [1] Illuminance (380 to 780) nm	Up to 240 000 lux	4.8 % of reading	Atlas XenoCal BST Measure and Calibration Sensor
Xenon arc Weathering Instruments [1] Irradiance (300 to 800) nm	Up to 1 300 W/m^2	8.2 % of reading	Atlas XenoCal 300-800 Measure and Calibration Sensor

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thermometers [1]	(-196 to 0) ºC (0 to 420) ºC (420 to 660) °C	0.008 % of reading + 0.031 °C 0.001 % of reading + 0.031 °C 0.005 % of reading + 0.01 °C	Comparison to SPRT
Humidity Indicators [1] (at 23 ± 5 °C)	11 % RH 33 % RH 75 % RH 98 % RH	1.7 % RH 1.5 % RH 1.9 % RH 2.8 % RH	Vaisala HMK15 Humidity Calibrator, Accredited Salts
Thermohygrometer Humidity Temperature	 (10 to 95) % RH (10 to 60) ºC	 0.16 % of reading + 0.67 % RH 0.12 ºC	Thunder Scientific 1200 Two-Pressure Humidity Generator
Radiation (Infrared) Thermometers [1]	35 °C 100 °C 200 °C 350 °C 500 °C	0.47 °C 0.66 °C 0.95 °C 1.7 °C 2.1 °C	Fluke 4181 Black Body Source (flat plate) Ɛ = 0.95, λ = (8 to 14) µm
Radiation (Infrared) Thermometers [1]	100 °C 250 °C 400 °C 550 °C 700 °C 850 °C 982 °C	2.3 °C 2.6 °C 3.4 °C 4 °C 4.8 °C 5.6 °C 6.5 °C	Omega BB-4A Black Body Source (cavity) Ɛ = 0.99, λ = (8 to 14) µm
Ovens, Incubators, Stirred Water Baths, Fridges [1]	(0 to 100) °C (0 to 600) °C (-190 to 0) ºC (0 to 1 300) °C	0.16 % of reading + 2.8 °C 0.5 % of reading + 2.8 °C 0.07 % of reading + 2.7 °C 0.65 % of reading + 2.8 °C	Process Calibrator, Type K Thermocouple Probe
Ovens, Incubators, Stirred Water Baths, Fridges [1]	(-50 to 0) °C (0 to 500) °C	0.8 % of reading + 0.5 °C 0.6 % of reading + 0.5 °C	Process Calibrator, Pt 100 RTD Probe
Thermocouples and Thermometers [1]	(-15 to 110) °C (50 to 350) °C (350 to 600) °C	0.41 °C 0.77 °C 0.1 % of reading + 0.25 °C	Dry Block Calibrator
Xenon arc Weathering Instruments [1] Surface Temperature	 (20 to 120) °C	 0.084 % of reading + 1.2 °C	Atlas XenoCal BST Measure and Calibration Sensor

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Non-contact Tachometer [1,5]	(60 to 100 000) rpm	0.025 % of reading	Function Generator, LED Light Source
Contact Tachometers [1,5]	(10 to 10 000) rpm	0.67 % of reading + 2.5 rpm	Tachometer Standard
Stopwatches, Timers [1]	Up to 48 h	40 ms	Function Generator, Frequency Counter
Stopwatches, Timers [1]	Up to 1 d	53 ms/d	Timometer
Frequency – Source [1]	10 mHz to 120 Hz 120 Hz to 1.2 kHz (1.2 to 12) kHz (12 to 120) kHz 120 kHz to 1.2 MHz (1.2 to 2) MHz	13 mHz 0.13 Hz 1.3 Hz 13 Hz 0.13 kHz 1.3 kHz	Fluke 5502A Multiproduct Calibrator
Frequency – Source [1] Sine and Square Triangle and Ramp	 100 µHz to 15 MHz 100 µHz to 100 kHz	 0.002 5 % of reading 0.002 5 % of reading	Agilent 33120A Arbitrary Function Generator
Frequency – Source [1]	(2 to 8.4) GHz	12 Hz	Anritsu MG3691A RF/Microwave Signal Generator
Frequency – Measure [1] into 50 Ω load into 1 MΩ load into 50 Ω load	 (10 to 525) MHz 10 Hz to 80 MHz (10 to 100) MHz (0.1 to 1) GHz (1 to 10) GHz (10 to 20) GHz	 10.7 mHz/Hz + 1.8 Hz 19.3 nHz/Hz + 1.2 Hz 1.2 Hz/MHz + 1 Hz 0.12 kHz/GHz + 1 Hz 1.2 kHz/GHz + 1 Hz 8 kHz/GHz + 1 Hz	HP 5350B Frequency Counter
Frequency – Measure [1]	10 Hz to 10 MHz	0.013 % of reading + 5 mHz	Keysight 3458A 8.5 Digit Multimeter
Frequency – Time Based Aging [1]	10 MHz	1 pHz/Hz	Fluke 910R GPS Controlled Atomic Clock
Rotational Viscometers [1,5]	(2 to 2 000) rpm	1.5 rpm	Optical Tachometer
Crosshead Speed [1]	(0.2 to 2) in/min	0.07 % of reading + 0.005 3 in/min	Stopwatch, Depth Indicator, and ASTM E2658 utilized in the calibration of this parameter.

DIMENSIONAL MEASUREMENT

1 Dimensional

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Measurement – 1D [5]	Up to 12 in (12 to 18) in	(5.5 + 11*L*) µin (2.7 + 12*L*) µin	Universal Length Measuring Machine utilized as the reference standard for these measurements.
Dimensional Measurement – 1D [5]	Up to 24 in	(260 + 4*D*) µin	Vision System utilized as the reference standard for these measurements.
Flatness Measurement [5] Up to 4 in*D*	Up to 100 µin	10 µin	ZyGo Verifier QPZ Laser Interferometer utilized as the reference standard for flatness measurements.

3 Dimensional

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Measurement – 3D [5]	X = Up to 35 in Y = Up to 35 in Z = Up to 27 in	(20 + 4*L*) µin (20 + 4*L*) µin (20 + 4*L*) µin	Coordinate Measuring Machine utilized as the reference standard for these measurements.

TESTING

Mechanical

Specific Tests and/or Properties Measured	Specification, Standard, Method, or Test Technique	Items, Materials or Product Tested	Key Equipment or Technology
Rockwell Hardness	ASTM E18	HRA, HRB, HRC	Rockwell Hardness Tester
Rockwell Superficial Hardness	ASTM E18	HR15N, HR30N, HR45N, HR15TW, HR30TW, HR45TW	Rockwell Hardness Tester

Mechanical

Specific Tests and/or Properties Measured	Specification, Standard, Method, or Test Technique	Items, Materials or Product Tested	Key Equipment or Technology
Brinell Hardness	ASTM E10	BHN	Brinell Hardness Tester
Micro-Hardness	ASTM E384	Knoop, Vickers	Micro-Hardness Tester

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. This laboratory calibration services in its laboratory and on-site at customer-designated locations. 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. The uncertainty does not include gage R&R study, and the unit under test resolution. Larger measurement uncertainties are expected.
3. Mismatch uncertainty is not considered in the CMC as it is DUT dependent. Higher uncertainties will be reported based on DUT VSWR.
4. This calibration is only applicable to the dimensional properties. The metallurgical properties/composition of the test spheres are not tested.
5. L = length in inches; D = diameter in inches; ″ = arc-second; DL = diagonal length; GU = gloss unit; rpm = revolutions per minute; SG = specific gravity.
6. 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.
7. The values in the Range column are Nominal values. The actual certified values will be used at the time of calibration, along with the associated measurement Uncertainty.
8. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1886.

Jason Stine, Vice President