



# CERTIFICATE OF ACCREDITATION

## The ANSI National Accreditation Board

Hereby attests that

**CBRE GWS, LLC**  
9410 Bunsen Parkway, Suite 100B  
Louisville, KY 40220

Fulfills the requirements of

**ISO/IEC 17025:2017**

In the fields of

**CALIBRATION AND DIMENSIONAL MEASUREMENT**

This certificate is valid only when accompanied by a current scope of accreditation document.  
The current scope of accreditation can be verified at [www.anab.org](http://www.anab.org).

Jason Stine, Vice President

Expiry Date: 12 February 2025  
Certificate Number: L1117-1



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**

**CBRE GWS, LLC**  
 9410 Bunsen Parkway, Suite 100B  
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**CALIBRATION AND DIMENSIONAL MEASUREMENT**

Valid to: **February 12, 2025**

Certificate Number: **L1117-1**

**CALIBRATION**

**Acoustics and Vibration**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Acceleration <sup>1</sup> (Sensitivity/Frequency Response)	(2 to 20) Hz (20 to 100) Hz (100 to 2 500) Hz (2.5 to 10) kHz	2.4 % of reading 2.2 % of reading 2 % of reading 2.8 % of reading	Vibration Controller w/ Reference Accelerometer
Sound Level Meters <sup>1</sup>	94 dB @ 250 Hz 114 dB @ 250 Hz 94 dB @ 1 kHz 114 dB @ 1 kHz	0.45 dB 0.45 dB 0.45 dB 0.45 dB	Sound Level Calibrator

**Chemical Quantities**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Conductivity Meters <sup>1,5</sup> (Range values referenced to 25°C)	5 µS 10 µS 100 µS 1 000 µS 1 400 µS 10 000 µS 100 mS	0.35 µS 0.52 µS 0.88 µS 4.9 µS 5.6 µS 33 µS 0.38 mS	Accredited Conductivity Solutions
pH Meters w/ Controllers <sup>1,5</sup>	4.01 pH 7 pH 10 pH	0.02 pH 0.02 pH 0.02 pH	Accredited pH Solutions

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Indicators – Electrical Simulation <sup>1</sup>	(0 to 14) pH	0.006 4 pH	Voltage Calibrator
Capacitance – Source <sup>1</sup> 10 Hz to 10 kHz	(220 to 399.9) pF (0.4 to 1.099 9) nF (1.1 to 3.299 9) nF (3.3 to 10.999 9) nF (11 to 32.999 9) nF (33 to 109.999) nF (110 to 330) nF	14 pF 15 pF 25 pF 38 pF 0.18 nF 0.38 nF 1.1 nF	Multifunction Calibrator
Capacitance – Source <sup>1</sup> (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz (10 to 120) Hz (10 to 80) Hz (0 to 50) Hz (0 to 20) Hz (0 to 6) Hz (0 to 2) Hz (0 to 0.6) Hz (0 to 0.2) Hz	(0.33 to 1.099 99) μF (1.1 to 3.299 99) μF (3.3 to 10.999 9) μF (11 to 32.999 9) μF (33 to 109.999) μF (110 to 329.999) μF (0.33 to 1.099 99) mF (1.1 to 3.299 99) mF (3.3 to 10.999 9) mF (11 to 32.999 9) mF (33 to 110) mF	3.8 nF 11 nF 38 nF 0.15 μF 0.6 μF 1.7 μF 6 μF 17 μF 60 μF 0.26 mF 1.4 mF	Multifunction Calibrator (Frequencies indicate Maximum Charge/Discharge Rate)
Capacitance Source <sup>1</sup> (Variable Artifact)	1 kHz 50 pF to 1.1 mF	0.6 % of reading + 5 pF	Decade Capacitor
Capacitance – Measure <sup>1</sup> 50, 60, 100 & 120 Hz 200 Hz to 20 kHz (100 Hz Steps)	0.1 pF to 1.1 mF	0.09 % of reading	LCR Meter (set to 1 V)
	100 kHz	1.3 % of reading	
DC Current – Measure <sup>1</sup>	(0 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	0.01 % of reading + 2 μA 0.003 7 % of reading + 2 μA 0.003 5% of reading + 2 μA 0.005 5 % of reading + 4 μA 0.02 % of reading + 8 μA 0.04 % of reading + 20 μA	Digital Multimeter
DC Current – Measure <sup>1</sup>	(0 to 100) A (0 to 300) A (200 to 500) A (500 to 1 000) A (1 000 to 1 200) A	10 mA 90 mA 0.26 % of reading 0.47 % of reading 0.48 % of reading	Digital Multimeter with Current Shunts



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source <sup>1</sup>	(0 to 330) $\mu$ A (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA (0.33 to 1.1) A (1.1 to 3.0) A (3 to 11) A (11 to 20.5) A	0.03 % of reading + 16 nA 0.01 % of reading + 40 nA 0.02 % of reading + 0.2 $\mu$ A 0.02 % of reading + 2 $\mu$ A 0.03 % of reading + 32 $\mu$ A 0.05 % of reading + 32 $\mu$ A 0.07 % of reading + 0.4 mA 0.12 % of reading + 0.6 mA	Fluke 5522A Multifunction Calibrator characterized with Fluke 8508A Digital Multimeter
DC Current – Source <sup>1</sup>	(0 to 220) $\mu$ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	0.006 4 % of reading + 7 nA 0.003 4 % of reading + 8 nA 0.003 3 % of reading + 50 nA 0.004 2 % of reading + 0.8 $\mu$ A 0.007 5 % of reading + 15 $\mu$ A	Fluke 5730A Multifunction Calibrator
DC Current – Source <sup>1</sup>	(20 to 100) A (50 to 300) A (300 to 600) A	0.15 % of reading 0.12 % of reading 0.18 % of reading	High Current Power Supply monitored with Current Shunts and Digital Multimeter
DC Current – Source <sup>1</sup> Clamp-on Meters	(11 to 1 050) A	0.8 A	Multifunction Calibrator with 50-turn Coil
AC Current – Source <sup>1</sup>	(29 to 329.99) $\mu$ A (10 to 20) Hz (20 to 45) Hz (45 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz  (0.33 to 3.299 99) mA (10 to 20) Hz (20 to 45) Hz (45 to 1 000) Hz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.34 % of reading + 0.1 $\mu$ A 0.28 % of reading + 0.1 $\mu$ A 0.26 % of reading + 0.1 $\mu$ A 0.46 % of reading + 0.1 $\mu$ A 1.1 % of reading + 0.2 $\mu$ A 2.1 % of reading + 0.3 $\mu$ A  0.24 % of reading + 0.3 $\mu$ A 0.16 % of reading + 0.3 $\mu$ A 0.13 % of reading + 0.3 $\mu$ A 0.25 % of reading + 0.3 $\mu$ A 0.61 % of reading + 0.3 $\mu$ A 1.2 % of reading + 0.3 $\mu$ A	Multifunction Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source <sup>1</sup>	(3.3 to 32.999 9) mA		Multifunction Calibrator
	(10 to 20) Hz	0.34 % of reading + 1.6 $\mu$ A	
	(20 to 45) Hz	0.12 % of reading + 1.6 $\mu$ A	
	(45 to 1 000) Hz	0.06 % of reading + 1.6 $\mu$ A	
	(1 to 5) kHz	0.11 % of reading + 1.6 $\mu$ A	
	(5 to 10) kHz	0.25 % of reading + 2.3 $\mu$ A	
	(10 to 30) kHz	0.49 % of reading + 3.1 $\mu$ A	
	(33 to 329.999) mA		
	(10 to 20) Hz	0.22 % of reading + 16 $\mu$ A	
	(20 to 45) Hz	0.12 % of reading + 16 $\mu$ A	
	(45 to 1 000) Hz	0.06 % of reading + 16 $\mu$ A	
	(1 to 5) kHz	0.14 % of reading + 39 $\mu$ A	
	(5 to 10) kHz	0.28 % of reading + 78 $\mu$ A	
	(10 to 30) kHz	0.55 % of reading + 0.16 mA	
	(0.33 to 1.099 99) A		
	(10 to 45) Hz	0.22 % of reading + 78 $\mu$ A	
	(45 to 1 000) Hz	0.07 % of reading + 78 $\mu$ A	
	(1 to 5) kHz	0.81 % of reading + 0.78 mA	
	(5 to 10) kHz	3.5 % of reading + 3.9 mA	
	(1.1 to 2.999 99) A		
(10 to 45) Hz	0.22 % of reading + 78 $\mu$ A		
(45 to 1 000) Hz	0.08 % of reading + 78 $\mu$ A		
(1 to 5) kHz	0.74 % of reading + 0.78 mA		
(5 to 10) kHz	3.2 % of reading + 3.9 mA		
(3.0 to 10.999 9) A			
(45 to 100) Hz	0.92 % of reading + 1.6 mA		
(100 to 1 000) Hz	0.14 % of reading + 1.6 mA		
(1 to 5) kHz	3.6 % of reading + 1.6 mA		
(11 to 20.5) A			
(45 to 100) Hz	0.17 % of reading + 3.9 mA		
(100 to 1 000) Hz	0.21 % of reading + 3.9 mA		
(1 to 5) kHz	3.6 % of reading + 3.9 mA		
AC Current – Source <sup>1</sup>	Up to 100 A (1 to 60) Hz 60 Hz to 1 kHz	10 mA 0.12 A	Current Source monitored with Current Shunt and Digital Multimeter

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source <sup>1</sup>	(9 to 220) $\mu$ A		Fluke 5730A Multifunction Calibrator
	(10 to 20) Hz	0.03 % of reading + 20 nA	
	(20 to 40) Hz	0.02 % of reading + 12 nA	
	40 Hz to 1 kHz	0.02 % of reading + 10 nA	
	(1 to 5) kHz	0.03 % of reading + 15 nA	
	(5 to 10) kHz	0.13 % of reading + 80 nA	
	220 $\mu$ A to 2.2 mA		
	(10 to 20) Hz	0.03 % of reading + 50 nA	
	(20 to 40) Hz	0.02 % of reading + 40 nA	
	40 Hz to 1 kHz	0.01 % of reading + 40 nA	
	(1 to 5) kHz	0.02 % of reading + 0.13 $\mu$ A	
	(5 to 10) kHz	0.13 % of reading + 0.8 $\mu$ A	
	(2.2 to 22) mA		
	(10 to 20) Hz	0.03 % of reading + 0.5 $\mu$ A	
	(20 to 40) Hz	0.02 % of reading + 0.4 $\mu$ A	
40 Hz to 1 kHz	0.01 % of reading + 0.4 $\mu$ A		
(1 to 5) kHz	0.02 % of reading + 0.7 $\mu$ A		
(5 to 10) kHz	0.13 % of reading + 6 $\mu$ A		
(22 to 220) mA			
(10 to 20) Hz	0.03 % of reading + 5 nA		
(20 to 40) Hz	0.02 % of reading + 4 nA		
40 Hz to 1 kHz	0.01 % of reading + 3 nA		
(1 to 5) kHz	0.02 % of reading + 4 nA		
(5 to 10) kHz	0.11 % of reading + 12 nA		
(0.22 to 2.2) A			
20 Hz to 1 kHz	0.03 % of reading + 40 nA		
(1 to 5) kHz	0.03 % of reading + 0.1 $\mu$ A		
(5 to 10) kHz	0.03 % of reading + 0.2 $\mu$ A		
AC Current – Source <sup>1</sup> Clamp-on Meters	(110 to 2 500) A (50 to 400) Hz	1.3 A	Multifunction Calibrator with Multi-turn Coils
AC Current – Measure <sup>1</sup>	200 $\mu$ A		Digital Multimeter
	(1 to 10) Hz	0.06 % of reading + 0.12 nA	
	10 Hz to 10 kHz	0.06 % of reading + 0.12 nA	
	(10 to 30) kHz	0.08 % of reading + 0.12 nA	
	(30 to 100) kHz	0.33 % of reading + 0.12 nA	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment		
AC Current – Measure <sup>1</sup>	2 mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.05 % of reading + 1.2 μA 0.04 % of reading + 1.2 μA 0.07 % of reading + 1.2 μA 0.33 % of reading + 1.2 μA	Digital Multimeter		
	20 mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.05 % of reading + 12 μA 0.04 % of reading + 12 μA 0.08 % of reading + 12 μA 0.33 % of reading + 12 μA			
	200 mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.08 % of reading + 0.12 mA 0.08 % of reading + 0.12 mA 0.26 % of reading + 0.12 mA			
	2 A 10 Hz to 2 kHz (2 to 10) kHz	0.09 % of reading + 1.2 mA 0.21 % of reading + 1.2 mA			
	20A 10 Hz to 2 kHz (2 to 10) kHz	0.09 % of reading + 0.12 mA 0.21 % of reading + 0.12 mA			
	AC Current – Measure <sup>1</sup>	60 Hz (1 to 20) A (20 to 100) A (100 to 300) A		0.18 % of reading + 20 nA 10 mA 90 mA	Digital Multimeter, Current Shunts
		1 kHz (20 to 100) A (100 to 300) A		0.12 A 0.35 A	
		Inductance – Measure <sup>1</sup>			
	(50, 60, 100 & 120) Hz 200 Hz to 20 kHz (100 Hz Steps)	100 μH to 10 H		0.14 % of reading	LCR Meter (set to 1 V)
	100 kHz	100 μH to 10 H		0.47 % of reading	
Inductance – Source <sup>1</sup> (Variable Artifact)	100 Hz to 1 kHz (1 to 10) mH	2.4 % of reading	Decade Inductor		
	10 mH to 10 H	1 % of reading			

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Source <sup>1</sup> (45 to 65) Hz Power Factor = 1	(1.1 to 3) mW (3 to 11) mW (11 to 300) mW (300 to 726) mW (0.7 to 1.5) W (1.5 to 6.77) W (0.6 to 92) W (92 to 336) W (336 to 918) W (918 to 2 244) W (2 244 to 4 590) W (4.5 to 20.9) kW	0.11 % of reading 0.08 % of reading 0.1 % of reading 0.08 % of reading 0.11 % of reading 0.09 % of reading 0.09 % of reading 0.06 % of reading 0.93 % of reading 0.07 % of reading 0.09 % of reading 0.08 % of reading	Multifunction Calibrator
DC Power – Source <sup>1</sup>	11 μW to 330 W 330 W to 3 kW (3 to 21) kW	0.02 % of reading 0.02 % of reading 0.06 % of reading	Multifunction Calibrator
Energy – Watt Hour Meters <sup>1</sup> (45 to 65) Hz Power Factor = 1	1.5 W·h to 20.9 kW·h	0.08 % of reading	Multifunction Calibrator with Electronic Counter
Resistance – Current Shunt <sup>1</sup> 100 A  300 A	Up to 100 mΩ  Up to 100 mΩ	2.5 mΩ/Ω  29 mΩ/Ω	Digital Multimeter, Current Shunt
DC Resistance – Measure <sup>1</sup>	Up to 2 Ω (2 to 20) Ω (20 to 200) Ω (0.2 to 2) kΩ (2 to 20) kΩ (20 to 200) kΩ (0.2 to 2) MΩ (2 to 20) MΩ (20 to 200) MΩ (0.2 to 2) GΩ	0.001 8 % of reading + 2.5 μΩ 0.001 1 % of reading + 1 μΩ 0.000 8 % of reading + 0.3 μΩ 0.001 1 % of reading + 0.3 μΩ 0.000 8 % of reading + 0.3 μΩ 0.001 % of reading + 0.3 μΩ 0.001 1 % of reading + 0.6 μΩ 0.005 8 % of reading + 6 μΩ 0.019 % of reading + 60 μΩ 0.14 % of reading + 0.6 mΩ	Digital Multimeter
AC Resistance – Measure <sup>1</sup>	10 kΩ to 200 MΩ 50 Hz to 2 kHz (2 to 20) kHz 100 kHz	0.06 % of reading 0.13 % of reading 0.47 % of reading	Philips RLC Meter





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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance – Source <sup>1</sup>	(0 to 10.999 9) Ω (11 to 32.999 9) Ω (33 to 109.999 9) Ω (110 to 329.999 9) Ω (0.33 to 1.099 999) kΩ (1.1 to 3.299 999) kΩ (3.3 to 10.999 99) kΩ (11 to 32.999 99) kΩ (33 to 109.999 9) kΩ (110 to 329.999 99) kΩ (0.33 to 1.099 999) MΩ (1.1 to 3.299 999) MΩ (3.3 to 10.999 99) MΩ (11 to 32.999 99) MΩ (33 to 109.999 9) MΩ (110 to 329.999 9) MΩ (0.33 to 1.1) GΩ	0.02 % of reading + 0.8 mΩ 0.008 % of reading + 1.2 mΩ 0.004 8 % of reading + 1.1 mΩ 0.004 % of reading + 1.6 mΩ 0.003 5 % of reading + 1.6 mΩ 0.004 % of reading + 16 mΩ 0.003 5 % of reading + 16 mΩ 0.004 % of reading + 0.16 Ω 0.003 5 % of reading + 0.16 Ω 0.005 % of reading + 1.6 Ω 0.004 % of reading + 1.6 Ω 0.008 4 % of reading + 24 Ω 0.02 % of reading + 40 Ω 0.05 % of reading + 2 kΩ 0.07% of reading + 2.4 kΩ 0.4 % of reading + 78 kΩ 2 % of reading + 0.39 MΩ	Multifunction Calibrator
DC Resistance – Source <sup>1</sup>	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	50 μΩ 87 μΩ 0.11 mΩ 21 μΩ 22 μΩ 10 μΩ 10 μΩ 7 μΩ 7 μΩ 7 μΩ 7 μΩ 8 μΩ 10 μΩ 12 μΩ 17 μΩ 45 μΩ 47 μΩ 0.15 mΩ	Fluke 5730A Multifunction Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Resistance – Source <sup>1,5</sup> (Fixed Artifacts)	25 Ω	3 μΩ/Ω	Fixed Resistors
	75 Ω	3 μΩ/Ω	
	100 Ω	3 μΩ/Ω	
	200 Ω	8 μΩ/Ω	
	400 Ω	8 μΩ/Ω	
	10 kΩ	2 μΩ/Ω	
	40 kΩ	2 μΩ/Ω	
	100 kΩ	2 μΩ/Ω	
	300 kΩ	2 μΩ/Ω	
	500 kΩ	2 μΩ/Ω	
	1 GΩ	2 MΩ	
	10 GΩ	19 MΩ	
	100 GΩ	0.6 GΩ	
1 TΩ	2.3 GΩ		
Electrical Simulation of RTD Indicating Devices – Source <sup>1</sup>	Pt 385, 100 Ω		Multifunction Calibrator
	(-200 to 0) °C	0.04 °C	
	(0 to 100) °C	0.05 °C	
	(100 to 300) °C	0.07 °C	
	(300 to 400) °C	0.08 °C	
	(400 to 630) °C	0.09 °C	
	(630 to 800) °C	0.18 °C	
	Pt 3916, 100 Ω		
	(-200 to -190) °C	0.19 °C	
	(-190 to -80) °C	0.03 °C	
	(-80 to 0) °C	0.04 °C	
	(0 to 260) °C	0.06 °C	
	(260 to 300) °C	0.06 °C	
	(300 to 400) °C	0.07 °C	
	(400 to 600) °C	0.08 °C	
	(600 to 630) °C	0.18 °C	
	Pt 3926, 100 Ω		
	(-200 to 0) °C	0.04 °C	
	(0 to 100) °C	0.06 °C	
	(100 to 300) °C	0.07 °C	
(300 to 400) °C	0.08 °C		
(400 to 630) °C	0.09 °C		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices – Source <sup>1</sup>	Pt 385, 200 Ω		Multifunction Calibrator
	(-200 to 100) °C	0.03 °C	
	(100 to 260) °C	0.04 °C	
	(260 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 600) °C	0.11 °C	
	(600 to 630) °C	0.12 °C	
	Pt 385, 500 Ω		
	(-200 to -80) °C	0.03 °C	
	(-80 to 100) °C	0.04 °C	
	(100 to 260) °C	0.05 °C	
	(260 to 400) °C	0.06 °C	
	(400 to 600) °C	0.07 °C	
	(600 to 630) °C	0.09 °C	
	Pt 385, 1 kΩ		
	(-190 to 0) °C	0.02 °C	
	(0 to 100) °C	0.03 °C	
(100 to 260) °C	0.04 °C		
(260 to 600) °C	0.05 °C		
(600 to 630) °C	0.18 °C		
Ni 120, 120 Ω			
(-80 to 100) °C	0.08 °C		
(100 to 260) °C	0.12 °C		
Cu 427, 10 Ω			
(-100 to 260) °C	0.24 °C		
DC Voltage – Measure <sup>1</sup>	(0 to 200) mV	0.000 5 % of reading + 0.6 μV	Digital Multimeter
	200 mV to 2 V	0.000 4 % of reading + 0.25 μV	
	(2 to 20) V	0.000 4 % of reading + 0.25 μV	
	(20 to 200) V	0.000 5 % of reading + 0.25 μV	
	(200 to 1 000) V	0.000 6 % of reading + 0.6 μV	
DC High Voltage – Measure <sup>1</sup>	(1 to 10) kV	0.07 % of reading + 30 mV	High Voltage Meter
	(10 to 100) kV	0.69 % of reading	Digital Multimeter with High Voltage Probe
DC Voltage – Source <sup>1</sup>	(0 to 329.999 9) mV	0.002 8 % of reading + 1 μV	Fluke 5522A Multifunction Calibrator
	(0.33 to 3.299 999) V	0.001 4 % of reading + 2 μV	
	(3.3 to 32.999 99) V	0.001 3 % of reading + 16 μV	
	(33 to 329.999 9) V	0.002 2 % of reading + 0.12 mV	
	(330 to 1 020) V	0.002 3 % of reading + 1.2 mV	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source <sup>1</sup>	(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	0.001 % of reading + 0.4 μV 0.000 5 % of reading + 0.6 μV 0.000 4 % of reading + 3 μV 0.000 5 % of reading + 4 μV 0.000 6 % of reading + 40 μV 0.001 % of reading + 0.39 mV	Fluke 5730A Multifunction Calibrator
AC Voltage – Source <sup>1</sup> (True RMS)	(1 to 32.999) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (33 to 329.999) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (0.33 to 3.299 99) V (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (3.3 to 32.999 9) V (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (33 to 329.999) V 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.33 % of reading + 5 μV 0.26 % of reading + 5 μV 0.03 % of reading + 5 μV 0.14 % of reading + 5 μV 0.5 % of reading + 10 μV 1.2 % of reading + 40 μV 0.07 % of reading + 7 μV 0.05 % of reading + 7 μV 0.03 % of reading + 7 μV 0.05 % of reading + 7 μV 0.11 % of reading + 25 μV 0.3 % of reading + 55 μV 0.06 % of reading + 2 μV 0.04 % of reading + 50 μV 0.03 % of reading + 50 μV 0.04 % of reading + 40 μV 0.09 % of reading + 0.1 mV 0.31 % of reading + 0.5 mV 0.06 % of reading + 0.51 mV 0.04 % of reading + 0.5 mV 0.04 % of reading + 0.5 mV 0.05 % of reading + 0.5 mV 0.12 % of reading + 1.3 mV 0.03 % of reading + 1.6 mV 0.05 % of reading + 5 mV 0.04 % of reading + 5 mV 0.04 % of reading + 5 mV 0.3 % of reading + 40 mV	Fluke 5522A Multifunction Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1</sup> (True RMS)	(330 to 1 020) V 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.04 % of reading + 8 mV 0.04 % of reading + 8 mV 0.04 % of reading + 8 mV	Fluke 5522A Multifunction Calibrator
AC Voltage – Source <sup>1</sup>	Up to 2.2 mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (2.2 to 22) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz 220 mV to 2.2 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	0.2 % of reading + 5 μV 0.026 % of reading + 5 μV 0.031 % of reading + 5 μV 0.029 % of reading + 5 μV 0.1 % of reading + 6 μV 0.11 % of reading + 12 μV 0.14 % of reading + 25 μV 0.27 % of reading + 25 μV 0.038 % of reading + 5 μV 0.015 % of reading + 5 μV 0.008 % of reading + 5 μV 0.026 % of reading + 5 μV 0.055 % of reading + 6 μV 0.11 % of reading + 12 μV 0.14 % of reading + 25 μV 0.27 % of reading + 25 μV 0.033 % of reading + 15 μV 0.013 % of reading + 8 μV 0.006 % of reading + 8 μV 0.012 % of reading + 8 μV 0.033 % of reading + 20 μV 0.07 % of reading + 25 μV 0.14 % of reading + 30 μV 0.26 % of reading + 60 μV 0.038 % of reading + 50 μV 0.013 % of reading + 20 μV 0.004 % of reading + 10 μV 0.02 % of reading + 12 μV 0.008 % of reading + 40 μV 0.03 % of reading + 0.1 mV 0.1 % of reading + 0.25 mV 0.16 % of reading + 0.4 mV	Fluke 5730A Multifunction Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1</sup>	(2.2 to 22) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (220 to 1 100) V (15 to 50) Hz 50 Hz to 1kHz	0.05 % of reading + 0.5 mV 0.02 % of reading + 0.2 mV 0.004 % of reading + 70 μV 0.007 % of reading + 0.12 mV 0.009 % of reading + 0.25 mV 0.03 % of reading + 0.8 mV 0.1 % of reading + 2.5 mV 0.14 % of reading + 4 mV 0.04 % of reading + 5 mV 0.015 % of reading + 2 mV 0.005 % of reading + 0.7 mV 0.008 % of reading + 1.2 mV 0.015 % of reading + 3 mV 0.34 % of reading + 20 mV 0.45 % of reading + 50 mV 0.82 % of reading + 0.1 V 0.03 % of reading + 20 mV 0.007 % of reading + 4 mV	Fluke 5730A Multifunction Calibrator
Wideband AC Voltage – Source	1 kHz Reference 1.1 mV 3.3 mV 11 mV 33 mV 110 mV 330 mV 1.1 V 3.3 V	0.63 % of reading + 2 μV 0.6 % of reading + 3 μV 0.6 % of reading + 8 μV 0.05 % of reading + 16 μV 0.5 % of reading + 40 μV 0.4 % of reading + 0.1 mV 0.1 % of reading + 0.4 mV 0.32 % of reading + 0.5 mV	Fluke 5730A Multifunction Calibrator
Wideband AC Voltage – Amplitude Flatness	1.1 mV (10 to 30) Hz 30 Hz to 119.99 kHz 120 kHz to 1.199 9 MHz (1.2 to 1.999) MHz (2 to 11.9) MHz (12 to 20) MHz (20 to 30) MHz (30 to 50) MHz	0.24 % of reading 0.08 % of reading 0.4 % of reading + 3 μV 0.4 % of reading + 3 μV 0.53 % of reading + 3 μV 0.7 % of reading + 3 μV 2.3 % of reading + 15 μV 3.4 % of reading + 15 μV	Fluke 5730A Multifunction Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Wideband AC Voltage – Amplitude Flatness	3.3 mV (10 to 30) Hz 30 Hz to 119.99 kHz 120 kHz to 1.199 9 MHz (1.2 to 1.999) MHz (2 to 11.9) MHz (12 to 20) MHz (20 to 30) MHz (30 to 50) MHz	0.24 % of reading 0.08 % of reading 0.15 % of reading + 3 μV 0.15 % of reading + 3 μV 0.3 % of reading + 3 μV 0.46 % of reading + 3 μV 1.3 % of reading + 3 μV 2.4 % of reading + 3 μV	Fluke 5730A Multifunction Calibrator
	> 3.3 mV (10 to 30) Hz 30 Hz to 119.99 kHz 120 kHz to 1.199 9 MHz (1.2 to 1.999) MHz (2 to 11.9) MHz (12 to 20) MHz (20 to 30) MHz (30 to 50) MHz	0.24 % of reading 0.08 % of reading 0.08 % of reading + 3 μV 0.08 % of reading + 3 μV 0.16 % of reading + 3 μV 0.31 % of reading + 3 μV 0.8 % of reading + 3 μV 1.6 % of reading + 3 μV	
AC Voltage – Measure <sup>1</sup> (True RMS)	Up to 200 mV (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (0.2 to 2) V (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.04 % of reading + 80 μV 0.018 % of reading + 25 μV 0.013 % of reading + 25 μV 0.012 % of reading + 12 μV 0.016 % of reading + 25 μV 0.035 % of reading + 50 μV 0.08 % of reading + 0.12 mV 0.042 % of reading + 70 μV 0.015 % of reading + 12 μV 0.01 % of reading + 12 μV 0.008 % of reading + 12 μV 0.012 % of reading + 12 μV 0.023 % of reading + 25 μV 0.07 % of reading + 0.12 mV 0.34 % of reading + 2.4 mV 1.8 % of reading + 24 mV	Digital Multimeter

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure <sup>1</sup> (True RMS)	(2 to 20) V		Digital Multimeter
	(1 to 10) Hz	1.2 mV + 0.1 mV/V	
	(10 to 40) Hz	0.2 mV + 0.11 mV/V	
	(40 to 100) Hz	0.2 mV + 85 μV/V	
	100 Hz to 2 kHz	0.2 mV + 65 μV/V	
	(2 to 10) kHz	0.2 mV + 85 μV/V	
	(10 to 30) kHz	0.4 mV + 0.21 mV/V	
	(30 to 100) kHz	2 mV + 0.51 mV/V	
	(100 to 300) kHz	20 mV + 0.3 % of reading	
	300 kHz to 1 MHz	0.2 V + 1 % of reading	
	(20 to 200) V		
	(1 to 10) Hz	12 mV + 0.1 mV/V	
	(10 to 40) Hz	2 mV + 0.11 mV/V	
	(40 to 100) Hz	2 mV + 85 μV/V	
	100 Hz to 2 kHz	2 mV + 65 μV/V	
(2 to 10) kHz	2 mV + 85 μV/V		
(10 to 30) kHz	4 mV + 0.21 mV/V		
AC High Voltage – Measure <sup>1</sup> (True RMS)	(20 to 200) V		High Voltage Meter
	(30 to 100) kHz	20 mV + 0.51 mV/V	
	(100 to 300) kHz	0.2 V + 0.3 % of reading	
AC High Voltage – Measure <sup>1</sup> (True RMS)	300 kHz to 1 MHz	2 V + 1 % of reading	Digital Multimeter w/ High Voltage Probe
	(200 to 1 000) V		
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure <sup>1</sup>	(1 to 10) Hz	70 mV + 0.1 mV/V	Multifunction Calibrator
	(10 to 40) Hz	20 mV + 0.11 mV/V	
	40 Hz to 10 kHz	20 mV + 95 μV/V	
	(10 to 30) kHz	40 mV + 0.21 mV/V	
	30 kHz to 1 MHz	200 mV + 0.51 mV/V	



**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure <sup>1</sup>	Type E		Multifunction Calibrator
	(-250 to -100) °C	0.6 °C	
	(-100 to -25) °C	0.2 °C	
	(-25 to 350) °C	0.18 °C	
	(350 to 650) °C	0.2 °C	
	(650 to 1 000) °C	0.25 °C	
	Type J		
	(-210 to -100) °C	0.33 °C	
	(-100 to -30) °C	0.2 °C	
	(-30 to 150) °C	0.18 °C	
	(150 to 760) °C	0.23 °C	
	(760 to 1 200) °C	0.27 °C	
	Type K		
	(-200 to -100) °C	0.39 °C	
	(-100 to -25) °C	0.22 °C	
	(-25 to 120) °C	0.2 °C	
	(120 to 1 000) °C	0.31 °C	
	(1 000 to 1 372) °C	0.47 °C	
	Type N		
	(-200 to -100) °C	0.47 °C	
	(-100 to -25) °C	0.27 °C	
	(-25 to 120) °C	0.22 °C	
	(120 to 410) °C	0.23 °C	
	(410 to 1 300) °C	0.32 °C	
	Type R		
	(0 to 250) °C	0.67 °C	
	(250 to 400) °C	0.41 °C	
	(400 to 1 000) °C	0.36 °C	
(1 000 to 1 767) °C	0.48 °C		
Type S			
(0 to 250) °C	0.56 °C		
(250 to 1 000) °C	0.43 °C		
(1 000 to 1 400) °C	0.39 °C		
(1 400 to 1 767) °C	0.54 °C		
Type T			
(-250 to -150) °C	0.75 °C		
(-150 to 0) °C	0.31 °C		
(0 to 120) °C	0.2 °C		
(120 to 400) °C	0.17 °C		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Angle – Source <sup>1</sup>	(0 to 360) <sup>o</sup> (10 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.08 <sup>o</sup> 0.19 <sup>o</sup> 0.39 <sup>o</sup> 1.9 <sup>o</sup> 3.9 <sup>o</sup> 7.8 <sup>o</sup>	Multifunction Calibrator
Phase Angle – Measure <sup>1</sup>	(0 to 360) ° (±180) <sup>o</sup> 5 Hz to 2 kHz (2 to 5) kHz (5 to 10) kHz (10 to 50) kHz (50 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz	0.03 <sup>o</sup> 0.04 <sup>o</sup> 0.05 <sup>o</sup> 0.06 <sup>o</sup> 0.13 <sup>o</sup> 0.61 <sup>o</sup> 1.2 <sup>o</sup>	Phase Meter
Oscilloscopes <sup>1</sup> Square wave – Amplitude into 50 Ω load  into 1 MΩ load  Square wave Frequency	1mV <sub>p-p</sub> to 6.6V <sub>p-p</sub> (10 Hz to 10 kHz)  1 mV <sub>p-p</sub> to 130 V <sub>p-p</sub> (10 Hz to 1 kHz) (> 1 Hz to 10 kHz)  10 Hz to 10 kHz	0.19 % of reading + 31 μV  0.08 % of reading + 31 μV 0.19 % of reading + 31 μV  0.002 % of reading	Fluke 5522A/SC1100 Multifunction Calibrator
Oscilloscopes <sup>1</sup> Edge Transition Time	1 kHz to 2 MHz Nominal 250 ps (2 to 10) MHz Nominal 250 ps	300 ps  350 ps	Fluke 5522A/SC1100 Multifunction Calibrator
Oscilloscopes <sup>1</sup> Leveled Sinewave Amplitude (50 kHz ref.)	5 mV p-p to 5.5 V p-p	1.6 % of reading + 0.24 mV	Fluke 5522A/SC1100 Multifunction Calibrator
Oscilloscopes <sup>1</sup> Leveled Sinewave Flatness (50 kHz ref.)	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1 100) MHz	1.3 % of reading + 78 μV 1.7 % of reading + 78 μV 3.2 % of reading + 78 μV 3.9 % of reading + 78 μV	Fluke 5522A/SC1100 Multifunction Calibrator
Oscilloscopes <sup>1</sup> Time Marker	1 ns to 20 ms 50 ms to 5 s	2 μs/s 20 μs/s	Fluke 5522A/SC1100 Multifunction Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes <sup>1</sup> Function Generation (Square, Triangle and Sine) (10 Hz to 10 kHz) into 1 MΩ load into 50 Ω load	1.8 mV to 55 V p-p 1.8 mV to 2.5 V p-p	2.3 % of reading + 78 μV 2.3 % of reading + 78 μV	Fluke 5522A/SC1100 Multifunction Calibrator
Oscilloscopes <sup>1</sup> Pulse Generation Pulse Width Pulse Period	(4 to 500) ns 200 ns to 20 ms	3.9 % of reading + 1.6 ns 1.9 μs	Fluke 5522A/SC1100 Multifunction Calibrator
Oscilloscope <sup>1</sup> Input Impedance	(40 to 60) Ω 500 kΩ to 1.5 mΩ (5 to 50) pF	0.08 % of reading 0.08 % of reading 4 % of reading + 0.4 pF	Fluke 5522A/SC1100 Multifunction Calibrator

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
End Measuring Rods <sup>2</sup> (Micrometer Standards)	(0.5 in to 39) in (12.7 to 1 000) mm	(63 + 10L) μin (1.6 + 0.25L) μm	Universal Length Measuring Machine (ULM)
Cylindrical Pins, Plugs, Wires <sup>1,2</sup>	Up to 4 in Up to 100 mm	(16 + 7.1D) μin (0.4 + 0.2D) μm	
Plain Ring Gages <sup>2</sup>	(0.25 to 12) in (6 to 300) mm	(18 + 15.6D) μin (0.5 + 0.4D) μm	
Thickness/Feeler Gages <sup>1</sup>	Up to 0.2 in Up to 5 mm	34.5 μin 0.88 μm	
Precision Squares <sup>2</sup> (Perpendicularity)	Up to 24 in Up to 700 mm	(52 + 2.1L) μin (1.3 + 0.002L) μm	Comparison to Master Square and Gage Amp
Straight Edges & Precision Parallels	Up to 0.02 in	92 μin	Gage Amp
Angle Gages <sup>2</sup>	(1 to 90)°	28"	Optical Comparator with Micropak 2
Thread Pitch Gages <sup>2</sup> (2.25 to 84) tpi Length Measure	(0.011 to 0.44) in	340 μin	Optical Comparator with Micropak 2
Angular Measure	Up to 60°	27"	

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Bars/Plates <sup>2</sup> Parallelism	Up to 0.02 in	33 μin	Gage Amp, Master Angle Block
Angle Calibration	15°	4"	
Radius Gages	(0.02 to 1) in	280 μin	Optical Comparator with Micropak 2
Angle Blocks <sup>2</sup>	(0.25 to 45)°	7.8"	Gage Amplifier, Sine Plate
V-Blocks <sup>2</sup> Parallelism – Side Parallelism – Vee Squareness	Up to 0.02 in Up to 0.02 in Up to 0.02 in	50 μin 50 μin (38 + 1.7G) μin	Gage Amplifier, Gage Blocks, Master Square, Plug Gage
Surface Plates <sup>1,2</sup>  Overall Flatness	Up to (12 x 12) in Up to (48 x 72) in	(19 + 1.2DL) μin (20 + 1.3DL) μin	In accordance with B89.3.7 using Electronic Levels, Planekator
Local Area Flatness (Repeat Readings)	Up to 0.031 in	29 μin	Repeat-O-Meter
Thread Plugs (4 to 80) tpi <sup>1,2</sup> (Pitch Diameter)	Up to 4 in Up to 100 mm	87.2 μin 2.2 μm	ULM, Thread Wires, 3-Wire Method
Thread Plugs (4 to 80) tpi <sup>1,2</sup> (Major Diameter)	Up to 4 in Up to 100 mm	(14 + 6.7D) μin (0.36 + 0.17 D) μm	Universal Length Measuring Machine
Torque Arms and Wheels <sup>2</sup> (Effective Length)	Up to 1 016 mm	0.13 mm	Articulating Measuring Arm, Micrometer
Height Gages <sup>1,2</sup>	Up to 24 in Up to 1 000 mm	(480 + 13.5L) μin (12.2 + 0.34L) μm	Gage Blocks
Height Master, Riser Block	Up to 12 in Up to 18 in Up to 24 in	71 μin 81 μin 85 μin	Gage Blocks, Gage Amp
Indicators <sup>1,2</sup> (Digital, Dial & Test)	Resolution = 50 μin Up to 4 in Up to 100 mm	(38 + 5.5L) μin (1 + 0.004L) μm	Gage Blocks

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Indicators (Digital, Dial & Test) <sup>1</sup>	Resolution $\geq 100 \mu\text{in}$	58 $\mu\text{in}$	Gage Blocks
	Up to 1 in	1.5 $\mu\text{m}$	Indicator Calibrator
	Up to 25 mm		
	2 in (50 mm)	59 $\mu\text{in}$ (1.5 $\mu\text{m}$ )	
	3 in (75 mm)	59 $\mu\text{in}$ (1.5 $\mu\text{m}$ )	
	4 in (100 mm)	61 $\mu\text{in}$ (1.6 $\mu\text{m}$ )	
Micrometers <sup>1,2</sup> (Inside, Outside, Depth, Bore) Length	Up to 4 in	(31 + 8L) $\mu\text{in}$	Gage Blocks
	Up to 100 mm	(0.79 + 0.008L) $\mu\text{m}$	
	(5 to 20) in	(92 + 6L) $\mu\text{in}$	
	(100 to 500) mm	(2.4 + 0.006L) $\mu\text{m}$	
	(21 to 82) in	(1 200 + 4L) $\mu\text{in}$	
	(500 to 2 000) mm	(31 + 0.004L) $\mu\text{m}$	
Anvil/Spindle Flatness	Up to 100 $\mu\text{in}$	9.7 $\mu\text{in}$	Optical Flats
Anvil/Spindle Parallelism	Up to 800 $\mu\text{in}$	14 $\mu\text{in}$	Optical Parallels
Gage Amplifiers, Comparators <sup>2</sup>	Up to 0.03 in	(9 + 220L) $\mu\text{in}$	Gage Blocks
	Up to 0.8 mm	(0.23 + 0.22L) $\mu\text{m}$	
Calipers, Linear Scales <sup>1,2</sup>	Up to 24 in	(280 + 10L) $\mu\text{in}$	Gage Blocks
	Up to 600 mm	(7.1 + 0.01L) $\mu\text{m}$	
	(25 to 96) in	(430 + 5L) $\mu\text{in}$	
	(600 to 2 400) mm	(11 + 0.005L) $\mu\text{m}$	
Flexible Tape Measures <sup>1,2</sup>	Up to 100 ft	(0.01 + 0.001 5L) in	Glass Microrule
Steel Rules <sup>1</sup>	(0.1 to 96) in	0.02 % of reading	Glass Microrule
Pi Tapes <sup>1</sup>	(2 to 40) in	0.02 % of reading	
Steel Rules	Up to 40 in	0.02 in	Optical Measuring System
Ultrasonic Foam – Height Testers <sup>1</sup>	(5 to 300) mm	0.04 % of reading	Gage Blocks
Coating Thickness Gages <sup>1</sup>	0.354 mils	10 $\mu\text{in}$	Coating Thickness Masters
	0.838 mils	10 $\mu\text{in}$	
	3.05 mils	10 $\mu\text{in}$	
Universal Protractors <sup>1,2</sup>	Up to 90°	12"	Optical Comparator with Micropac2

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bubble Levels <sup>1</sup> Level Vial Setting (Vial Sensitivity)	(2 to 48) in	93 μin 110 μin	Gage Blocks, Surface Plate
Digital Protractors, Clinometers <sup>1</sup>	Up to 90°	0.05°	Gage Blocks, Sine Bar/Plate
Electronic Levels <sup>1,2</sup>	(0.1 to 990)''	0.26 % of reading	Gage Blocks, Sine Bar/Plate
Optical Comparators, Video Comparators <sup>1,2</sup> Magnification	10x, 20x, 50x	0.12 % of reading	Magnification Checker
Linear Scales	X, Y, Z Axis: Up to 8 in	95 μin	Gage Blocks, Glass Micro-rule
Angle	Up to 90°	2.5''	Angle Blocks
Measuring Microscopes <sup>1,6</sup> X, Y Axis Linear Scales	Up to 4 in Up to 100 mm	93 μin 2.4 μm	Stage Micrometer
Profilometers, Surface Roughness Testers <sup>1</sup>	Ra: (14 to 16) μin Ra: (116 to 120) μin	2.5 μin 3.9 μin	Roughness Specimen

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Density Meters / Hydrometers	≈ 0.001 2 g/cm <sup>3</sup>	3.2 mg/cm <sup>3</sup>	Air Density at Ambient Conditions
Density Meters / Hydrometers	(0.75 to 1.8) g/cm <sup>3</sup>	4.2 mg/cm <sup>3</sup>	Gravimetric method at Ambient Conditions
Air Velocity (Hotwire, DP Anemometers)	(0.125 to 45) m/s	2.4 % of reading	Wind Tunnel, Differential Pressure Meter
Air Velocity (Vane Anemometers)	2.5 m/s 5.0 m/s 10 m/s 15 m/s	0.05 m/s 0.1 m/s 0.15 m/s 0.28 m/s	Wind Tunnel
Gas Mass Flow Rate <sup>3</sup>	(5 to 100) sccm (0.1 to 2) slpm (3 to 50) slpm	0.14 % of reading	Molbox1+, Premium Laminar Flow Elements



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**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gas Mass Flow Rate <sup>3</sup>	(12 to 120) slpm	0.15 % of reading	Sonic Nozzle Element
Liquid Flow Rate	(0.1 to 15) lpm	1.3 % of reading	Turbine Flow Meters
Force Gages <sup>1,6</sup> (Tension and Compression)	Up to 10 lbf (10 to 100) lbf (100 to 500) lbf	0.02 % of reading 0.06 % of reading 0.03 % of reading	Dead Weights
Load Cells <sup>1</sup> (Tension and Compression)	(10 to 20 000) lbf	0.007 % of reading + 0.22 lbf	Force Machine, Elastic Force Devices
	(0.5 to 1 000) lbf	0.012 % of reading	Dead Weights
Durometer Calibrator Types A, B, E, O Types C, D, DO	Up to 8.1 N Up to 44.45 N	0.046 N 0.26 N	ASTM E617 Class 1 Weights
Durometer <sup>2</sup> Spring Force Types A, B, E, O Types C, D, DO	Up to 8.1 N Up to 45.45 N	0.046 N 0.26 N	Full Verification per ASTM D2240 using Balance
	Indenter Dimensions Length Radius Diameter Angle	Up to 2.54 mm Up to 0.1 mm Up to 2.4 mm Up to 35°	
Rockwell Hardness Testers <sup>1</sup>	HRA		Indirect Verification IAW ASTM E-18
	Low	0.52 HRA	
	Mid	0.31 HRA	
	High	0.26 HRA	
	HRBW		
	Low	0.56 HRBW	
Mid	0.69 HRBW		
High	0.61 HRBW		
HRC			
Low	0.48 HRC		
Mid	0.45 HRC		
High	0.61 HRC		

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers <sup>1</sup>	HR15N Low Mid High	0.49 HR15N 0.5 HR15N 0.51 HR15N	Indirect Verification IAW ASTM E-18
	HR15TW Low Mid High	0.26 HR15TW 0.41 HR15TW 0.47 HR15TW	
Pressure – Barometric <sup>1</sup>	(8 to 17) psia	0.002 psi	Pressure Calibrator
Pressure – Hydraulic <sup>1,6</sup>	(200 to 16 000) psig	0.008 % of reading	Deadweight Tester
Pressure – Pneumatic <sup>1,6</sup>	Up to 300 psig	0.02 % of reading	Deadweight Tester
Pressure – Pneumatic <sup>1</sup>	Up to 75 psia (-10 to 10) inH <sub>2</sub> O (-50 to 50) inH <sub>2</sub> O (-100 to 100) inH <sub>2</sub> O (-7 to 7) psig (-15 to 15) psig (-20 to 20) psig Up to 500 psig Up to 1 500 psig	0.02 psi 0.007 inH <sub>2</sub> O 0.01 inH <sub>2</sub> O 0.02 inH <sub>2</sub> O 0.002 psi 0.004 psi 0.01 psi 0.06 psi 0.04 % of reading + 0.01 psi	Precision Pressure Controller
	Up to 35 psia (-10 to 10) inH <sub>2</sub> O (-30 to 30) inH <sub>2</sub> O	0.003 psi 0.012 % of reading 0.006 % of reading + 0.000 2 inH <sub>2</sub> O	Comparison to Reference Pressure Monitor
Pressure – Pneumatic <sup>1</sup>	(1 500 to 3 000) psig (3 000 to 5 000) psig (5 000 to 10 000) psig	0.35 psi 5.8 psi 12 psi	Digital Pressure Gages, Pressure Intensifier
Pressure – Pneumatic <sup>1</sup>	(-2 to 2) inH <sub>2</sub> O	0.000 5 inH <sub>2</sub> O	Electronic Point Gage
Micro-Balances <sup>1</sup> (0.01 mg resolution)	Up to 230 g	0.59 mg	ASTM E617 Class 1 Weights and NIST HB 44 utilized in the calibration of the weighing system.
Precision Balances <sup>1</sup> (0.1 mg resolution)	Up to 1 050 g	2.9 mg	
Analytical Balances <sup>1</sup> (1 mg resolution)	1 200 g 5 200 g	5.8 mg 0.1 g	ASTM E617 Class 1 Weights and NIST HB 44 utilized in the calibration of the weighing system.
	(10 mg resolution) 8 200 g	0.12 g	



**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bench Scales <sup>1</sup> (SI) (0.1 g resolution)	Up to 32 kg	0.14 g	NIST Class F Weights or ASTM E617 Class 6 Weights and NIST HB 44 utilized in the calibration of the weighing system.
Floor Scales <sup>1</sup> (Avoirdupois) (0.01 lb resolution)	Up to 300 lb	0.017 lb	NIST Class F Weights or ASTM E617 Class 6 Weights and NIST HB 44 utilized in the calibration of the weighing system.
(0.02 lb resolution)	Up to 600 lb	0.07 lb	
(0.05 lb resolution)	Up to 1 000 lb	0.1 lb	
(0.1 lb resolution)	Up to 3 000 lb	0.3 lb	
(0.2 lb resolution)	Up to 6 000 lb	0.14 lb	
(1 lb resolution)	Up to 6 000 lb	0.32 lb	
Moisture Balances <sup>1</sup> (Scale) (0.1 mg resolution)	Up to 100 g	2.9 mg	NIST Class F Weights or ASTM E617 Class 6 Weights and NIST HB 44 utilized in the calibration of the weighing system.
Torque Transducers, Torque Analyzers <sup>1</sup>	4 lbf-in to 250 lbf-ft (250 to 600) lbf-ft	0.17 % of reading 0.13 % of reading	Torque Moment Arms, ASTM E617 Class 6 & 7 Weights
Torque Tools <sup>1</sup>	0.5 lbf-in to 600 lbf-ft	0.54 % of reading	Torque Analyzer
Electrical Simulation of Torque Assembly Tools	0.59 mV/V Up to 100 N·m 2.0 mV/V Up to 110 N·m	0.11 N·m 0.18 N·m	Reference Torque Simulator
Viscosity Dip Cups <sup>1</sup> Efflux Time	(5 to 120) s	0.1 s	Stopwatch
Viscosity Dip Cups <sup>1</sup> (Kinematic Viscosity)	18 mm <sup>2</sup> /s 34 mm <sup>2</sup> /s 50 mm <sup>2</sup> /s 66 mm <sup>2</sup> /s 120 mm <sup>2</sup> /s 465 mm <sup>2</sup> /s 500 mm <sup>2</sup> /s	0.3 mm <sup>2</sup> /s 0.6 mm <sup>2</sup> /s 0.59 mm <sup>2</sup> /s 1.2 mm <sup>2</sup> /s 1.8 mm <sup>2</sup> /s 11 mm <sup>2</sup> /s 7 mm <sup>2</sup> /s	ASTM D1200 & D4212 using Standard Viscosity Oils (nominal Viscosities at 25 °C)



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rotational Viscometers <sup>1</sup> (Dynamic Viscosity)	Up to 10 mPa·s (10 to 100) mPa·s (100 to 1 000) mPa·s (1 000 to 10 000) mPa·s	0.34 % of reading 0.45 % of reading 0.54 % of reading 0.66 % of reading	Viscosity Standard Reference Fluids (nominal Viscosities at 25 °C)
Pipettes, Volumetric Containers, Glassware	1 mL ≤ 5 mL ≤ 10 mL ≤ 25 mL ≤ 50 mL ≤ 100 mL ≤ 200 mL ≤ 250 mL ≤ 500 mL ≤ 1 000 mL ≤ 2 000 mL ≤ 4 000 mL	4.8 µL 6.1 µL 7 µL 8.1 µL 8.9 µL 14 µL 26 µL 32 µL 69 µL 0.14 mL 0.27 mL 0.52 mL	ISO 8655-6 and ASTM E542: Gravimetric Method with Distilled Water
Mass Determination (SI)	30 kg 25 kg 20 kg 10 kg 5 kg 2 kg 1 kg 500 g 200 g 100 g 50 g 30 g 20 g 10 g 5 g 2 g 1 g 500 mg 200 mg 100 mg 50 mg 20 mg 10 mg 5 mg 2 mg 1 mg	0.16 g 0.15 g 0.13 g 39 mg 21 mg 10 mg 4.2 mg 2 mg 0.6 mg 0.43 mg 0.2 mg 0.12 mg 0.12 mg 96 µg 56 µg 56 µg 56 µg 16 µg 16 µg 16 µg 16 µg 16 µg 16 µg 16 µg 16 µg 16 µg	Comparison to ASTM E617 Class 1 Weights with Electronic Balances.

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass Determination (Avoirdupois)	0.5 lb	0.000 006 lb	Comparison to ASTM E617 Class 1 Weights with Electronic Balances; SAE J826 and SAE J4002.
	1 lb	0.000 007 lb	
	2 lb	0.000 009 lb	
	5 lb	0.000 06 lb	
	10 lb	0.000 07 lb	
	20 lb	0.000 6 lb	
	50 lb	0.000 6 lb	
H-point Machine Weights	20 kg	0.14 g	Comparison to ASTM E617 Class 1 Weights with Electronic Balances; SAE J826 and SAE J4002.
	10 kg	0.12 g	
	5 kg	18 mg	
	3 kg	12 mg	
	2 kg	12 mg	
	1 kg	1.4 mg	

**Photometry and Radiometry**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Correlated Color Temperature	(2 300 to 3 200) K	48 K	Chroma Meter IAW Detroit Color Council Bulletin No. 3 and SAE J361
	(3 200 to 7 600) K	122 K	
Illuminance Responsivity (Illuminant A – CIE)	Up to 20 000 lx Up to 1 858 fc	2.7 % of reading + 2.3 lx 2.7 % of reading + 0.21 fc	
Gloss Meters <sup>2</sup>	89.3 SGU @ 20° 93.2 SGU @ 60° 99.5 SGU @ 85°	1.2 SGU 1.2 SGU 1.2 SGU	Master Gloss Tile

**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Infrared Thermometers <sup>1</sup>	(50 to 100) °C	1.2 °C	Blackbody Source (flat plate) $\epsilon = 0.95, \lambda = (8 \text{ to } 14) \mu\text{m}$
	(100 to 300) °C	1.6 °C	
	(300 to 500) °C	2 °C	
Humidity – Measure <sup>1</sup>	(5 to 98) %RH	0.68 %RH	Chilled Mirror Hygrometer
Dew Point / Frost Point – Measure <sup>1</sup>	(-20 to 50) °C	0.45 °C	Chilled Mirror Hygrometer

### Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mechanical and Digital Thermometry Systems <sup>1,2</sup>	-196 °C (-95 to 140) °C (140 to 500) °C	11 mK 31 mK 85 mK	Comparison to SPRT
Resistance Temperature Devices (RTDs)	-196 °C	11 mK	SPRT w/Super-thermometer, Liquid N <sub>2</sub> comparator
	0.01 °C	8 mK	TPW Cell
	419.527 °C	20 mK	Zinc Cell
	(-95 to 140) °C (-45 to 150) °C (50 to 420) °C (420 to 650) °C	23 mK 31 mK 56 mK 85 mK	Comparison to SPRT
Baths, Chambers, Drywells <sup>1</sup>	(-95 to 140) °C 140 to 650 °C	30 mK 76 mK	Comparison to PRT
Moisture Balances <sup>1</sup> (Temperature)	(0 to 230) °C	0.3 °C	PRT

### Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure <sup>1</sup>	Up to 1.3 GHz	0.000 2 % of reading + 2.6 mHz	Electronic Counter Locked to GPS
Frequency – Source <sup>1</sup>	10 MHz	5.9 pHz	GPS Receiver
Stop Watches <sup>1</sup>	Up to 24 hr	52 ms/d	Timometer
Tachometers, Stroboscopes <sup>1</sup>	(6 to 99 999) rpm	0.001 % of reading	Multifunction Calibrator
Time Interval <sup>1</sup> (Process Timers)	Up to 8 000 000 s	0.17 ms	Electronic Counter
Linear Belt Speed – Measure <sup>1</sup>	(2 to 200) RPM	0.8 % of reading	Tachometer w/ 10 cm Wheel
Rotational Speed – Measure <sup>1</sup>	(5 to 25 000) RPM	0.03 % of reading	Laser Tachometer

## DIMENSIONAL MEASUREMENT

### 1 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Check Gages and Fixtures – 1D Length	Up to 3 m	0.13 mm	Articulating Measuring Arm

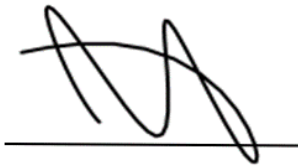
### 3 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Check Gages and Fixtures – 3D Length	Up to 3 m	0.13 mm	Articulating Measuring Arm

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 ( $k=2$ ), corresponding to a confidence level of approximately 95%.

Notes:

1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2.  $L$  = length in inches or metric equivalent (mm),  $M$  = length in meters,  $D$  = diameter in inches or metric equivalent,  $DL$  = diagonal length in inches or metric equivalent,  $G$  = length of side in inches or metric equivalent.  $T$  = Temperature in Kelvin,  $t$  = time interval in seconds; " = arc-second; SGU = Standard Gloss Unit.
3. Gas flow range and CMC values are applicable to Nitrogen gas.
4. This parameter includes Positive Displacement, Multi-Jet, and Class 1 Turbine Meters through 2-inch.
5. The values presented here are approximate values. The actual calibrated values will be noted on the Calibration Certificate at the time of calibration.
6. The resolution is to be calculated at the time of calibration, where as  $0.6R$  will be added to the value shown on the Scope ( $R$  = resolution)
7. This scope is formatted as part of a single document including Certificate of Accreditation No. L1117-1.



Jason Stine, Vice President