



CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Calibration Laboratory, LLC
3330 East 83rd Place
Merrillville, IN 46410

Fulfills the requirements of

ISO/IEC 17025:2017

and national standards

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

In the fields of

CALIBRATION and DIMENSIONAL MEASUREMENT

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

Jason Stine, Vice President

Expiry Date: 15 February 2025
Certificate Number: L2216



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)

ANSI/NCSL Z540.3-2006 (R2013)

Calibration Laboratory, LLC

3330 East 83rd Place

Merrillville, IN 46410

Jeff Breidigan 708-596-5800

CALIBRATION AND DIMENSIONAL MEASUREMENT

Valid to: February 15, 2025

Certificate Number: L2216

CALIBRATION

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters ¹ (Fixed Points)	4 pH	0.05 pH	Certified Reference Solutions and RTD Probe
	7 pH	0.05 pH	
	10 pH	0.05 pH	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Measure @ 1 kHz	(0.1 to 10) pF	4.8 mF/F	GenRad 1689M LCR Meter
	(10 to 100) pF	0.6 mF/F	
	100 pF to 10 μF	0.26 mF/F	
	(10 to 100) μF	0.6 mF/F	
	(100 to 1 000) μF	4.7 mF/F	
Capacitance – Source ^{1,15} (Fixed Artifacts)	0.1 nF	0.58 pF	Arco SS-32 Standard Capacitors
	1 nF	1.2 pF	
	10 nF	12 pF	
	100 nF	0.12 nF	
	200 nF	0.24 nF	
	300 nF	0.36 nF	
	400 nF	0.47 nF	
500 nF	0.59 nF		

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source ^{1,15} (Simulation)	(0.19 to 3.3) nF (3.3 to 110) nF (110 to 330) nF (0.33 to 1.1) μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF (0.33 to 1.1) mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	4 pF/nF + 7.9 pF 2 pF/nF + 7.8 pF 2 pF/nF + 24 pF 2 nF/μF + 0.75 nF 2 nF/μF + 0.77 nF 2 nF/μF + 0.13 nF 3 nF/μF + 2.2 nF 3 nF/μF + 78 nF 3 nF/μF + 0.23 μF 3 nF/μF + 0.78 μF 3 μF/mF + 2.3 μF 4 μF/mF + 7.8 μF 6 μF/mF + 24 μF 9 μF/mF + 77 μF	Fluke 5522A/SC1100 Multi Product Calibrator
AC Current – Source	(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 (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 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.29 nA/μA + 23 nA 0.19 nA/μA + 14 nA 0.12 nA/μA + 10 nA 0.35 nA/μA + 15 nA 1.3 nA/μA + 80 nA 0.2 μA/mA + 350 nA 0.19 μA/mA + 78 nA 0.12 μA/mA + 47 nA 0.24 μA/mA + 0.13 μA 1.3 μA/mA + 0.8 μA 0.12 μA/mA + 4.3 μA 0.2 μA/mA + 0.42 μA 0.12 μA/mA + 0.44 μA 0.24 μA/mA + 0.7 μA 1.3 μA/mA + 6 μA 0.25 μA/mA + 4.3 μA 0.14 μA/mA + 8.6 μA 0.1 μA/mA + 3.3 μA 0.2 μA/mA + 3.6 μA 1.1 μA/mA + 10 μA 0.3 mA/A + 4.4 μA 0.45 mA/A + 81 μA 7 mA/A + 0.16 mA	Fluke 5730A Multi Product Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source	(2.2 to 11) A 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.46 mA/A + 19 nA 0.95 mA/A + 6.3 μA 3.6 mA/A + 2.6 μA	Fluke 5730A Multi Product Calibrator, Fluke 5725A Amplifier
AC Current – Source	(0.2 to 2) A (10 to 850) Hz 850 Hz to 6 kHz (6 to 10) kHz (2 to 20) A 10 Hz to 850 Hz 850 Hz to 6 kHz (6 to 10) kHz (20 to 120) A 10 Hz to 850 Hz 850 Hz to 6 kHz (6 to 10) kHz	0.11 mA/A + 36 μA 0.44 mA/A + 72 μA 16 mA/A + 62 mA 0.11 mA/A + 36 μA 0.44 mA/A + 72 μA 23 mA/A + 94 mA 29 μA/A + 23 mA 0.44 mA/A + 72 μA 31 mA/A + 0.7 A	Fluke 5730A Multi Product Calibrator, Fluke 52120A Transconductance Amplifier
AC Current – Source ^{1,15}	(30 to 330) μA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (0.33 to 3.3) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz (3.3 to 33) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	1.6 nA/μA + 78 nA 1.2 nA/μA + 78 nA 0.97 nA/μA + 78 nA 2.3 nA/μA + 0.12 μA 6.2 nA/μA + 0.16 μA 12 nA/μA + 0.31 μA 1.5 μA/mA + 0.18 μA 0.97 μA/mA + 0.12 μA 0.77 μA/mA + 0.12 μA 1.6 μA/mA + 0.16 μA 3.9 μA/mA + 0.23 μA 7.8 μA/mA + 0.47 μA 1.4 μA/mA + 1.6 μA 0.7 μA/mA + 1.6 μA 0.31 μA/mA + 1.6 μA 0.62 μA/mA + 1.6 μA 1.6 μA/mA + 2.3 μA 3.1 μA/mA + 3.1 μA	Fluke 5522A/SC1100 Multi Product 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 ^{1,15}	(33 to 330) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz 10 kHz to 30 kHz (0.33 to 1.1) A (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (1.1 to 3) A (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (3 to 11) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (11 to 20) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	1.4 μ A/mA + 16 μ A 0.69 μ A/mA + 17 μ A 0.31 μ A/mA + 16 μ A 0.78 μ A/mA + 39 μ A 1.6 μ A/mA + 78 μ A 3.1 μ A/mA + 0.16 mA 1.1 μ A/mA + 78 μ A 0.3 μ A/mA + 78 μ A 3.6 μ A/mA + 0.78 mA 15 μ A/mA + 3.9 mA 1.4 mA/A + 79 μ A 0.47 mA/A + 78 μ A 4.7 mA/A + 0.78 mA 19 mA/A + 3.9 mA 0.47 mA/A + 1.6 mA 0.78 mA/A + 1.6 mA 23 mA/A + 1.6 mA 0.93 mA/A + 3.9 mA 1.2 mA/A + 3.9 mA 23 mA/A + 3.9 mA	Fluke 5522A/SC1100 Multi Product Calibrator
AC Current Source – Current Clamps ^{1,15}	(45 to 65) Hz (10 to 16.5) A (16.5 to 150) A (150 to 1 025) A (65 to 440) Hz (10 to 16.5) A (16.5 to 150) A (150 to 1 025) A	2.2 mA/A + 3.5 mA 2.1 mA/A + 44 mA 2.5 mA/A + 52 mA 4.6 mA/A + 30 mA 6.2 mA/A + 33 mA 6.4 mA/A + 62 mA	Fluke 5522A/SC1100 Multi Product Calibrator, Fluke 50-Turn Coil

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current Source – Current Clamps	(0.2 to 25) A (6 kHz to 10 kHz)	39 mA/A + 16 mA	Fluke 5730A Multi Product Calibrator, Fluke 52120A Transconductance Amplifier, Fluke 3KA 25-Turn Coil
	(0.2 to 50) A (3 kHz to 6 kHz)	12 mA/A + 16 mA	
	(0.2 to 50) A (1 kHz to 3 kHz)	6.2 mA/A + 16 mA	
	(0.2 to 50) A 10 Hz to 1 kHz	5.4 mA/A + 11 mA	
	(50 to 75) A (3 kHz to 6 kHz)	12 mA/A + 0.15 A	
	(50 to 300) A (1 kHz to 3 kHz)	6.2 mA/A + 0.16 A	
	(50 to 500) A 10 Hz to 1 kHz	5.4 mA/A + 0.11 A	
	(500 to 1 000) A 300 Hz to 1 kHz	3.6 mA/A + 0.45 A	
	(500 to 3 000) A 10 Hz to 300 Hz	3.6 mA/A + 0.45 A	
	DC Current – Source ^{1,15}	(0 to 330) μ A	
(0.33 to 3.3) mA		78 nA/mA + 39 nA	
(3.3 to 33) mA		77 nA/mA + 37 nA	
(33 to 330) mA		77 nA/mA + 2.2 μ A	
(0.33 to 1.1) A		0.13 mA/A + 75 μ A	
(1.1 to 3) A		0.29 mA/A + 32 μ A	
(3 to 11) A (11 to 20) A		0.39 mA/A + 0.41 mA 0.78 mA/A + 0.59 mA	
DC Current – Source	(0 to 220) μ A	50 μ A/A + 7 nA	Fluke 5730A Multi Product Calibrator
	(0.22 to 2.2) mA	35 μ A/A + 7 nA	
	(2.2 to 22) mA	35 μ A/A + 40 nA	
	(22 to 220) mA (0.22 to 2.2) A	45 μ A/A + 0.7 μ A 80 μ A/A + 12 μ A	
DC Current – Source	(2.2 to 11) A	0.36 mA/A + 0.51 mA	Fluke 5730A Multi Product Calibrator, Fluke 5725A Amplifier
DC Current – Source	(0 to 100) A	35 μ A/A + 23 mA	Fluke 5730A Multi Product Calibrator, Fluke 52120A Transconductance Amplifier



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current Source – Current Clamps ^{1,15}	(10 to 150) A (150 to 1 025) A	2 mA/A + 1.4 mA 2 mA/A + 48 mA	Fluke 5522A/SC1100 Multi Product Calibrator, Fluke 50-Turn Coil
DC Current Source – Current Clamps	(0 to 2 500) A	5.7 mA/A + 78 mA	Fluke 5730A Multi Product Calibrator, Fluke 52120A Transconductance Amplifier, Fluke 3KA 25-Turn Coil
DC Current – Measure	10 pA to 10 nA (20 to 30) A	4.5 pA/nA + 5.9 pA 0.49 mA/A + 4.4 mA	Transmille 8081 8.5 Digit Multimeter
DC Current – Measure ^{1,15}	(0 to 200) μA (0.2 to 2) mA (2 to 20) mA (20 to 200) mA (0.2 to 2) A	0.33 mA/A + 12 nA 0.35 mA/A + 69 nA 2.8 μA/A + 9.5 μA 0.37 mA/A + 7.5 μA 0.74 mA/A + 0.11 mA	Keithley 2002 8.5 Digit Multimeter
DC Current – Measure ^{1,15}	(1 to 3) A	1.23 mA/A + 0.63 mA	Agilent 34401A 6.5 Digit Multimeter
DC Current – Measure	(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	10 pA/μA + 0.7 nA 12 nA/mA + 4.2 nA 13 nA/mA + 41 nA 37 nA/mA + 0.82 μA 200 μ A/A + 17 μA 0.4 mA/A + 440 μA	Fluke 8508A 8.5 Digit Multimeter
AC Current – Measure	0.1 nA to 0.1 mA (10 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz (20 to 30) A (10 to 40) Hz 40 Hz to 1 kHz	0.92 nA/μA + 16 nA 0.51 nA/μA + 13 nA 1.2 nA/μA + 31 nA 1.6 mA/A + 12 mA 1.2 mA/A + 9.2 mA	Transmille 8081 8.5 Digit Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure	(20 to 200) μ A		Fluke 8508A 8.5 Digit Multimeter
	(1 to 10) Hz	0.28 nA/ μ A + 83 nA	
	10 Hz to 10 kHz	0.46 nA/ μ A + 19 nA	
	(10 to 30) kHz	0.6 nA/ μ A + 19 nA	
	(30 to 100) kHz	3 nA/ μ A + 19 nA	
	(0.2 to 2) mA		
	(1 to 10) Hz	0.17 μ A/mA + 0.7 μ A	
	10 Hz to 10 kHz	0.26 μ A/mA + 0.19 μ A	
	(10 to 30) kHz	0.6 μ A/mA + 0.19 μ A	
	(30 to 100) kHz	3.1 μ A/mA + 0.19 μ A	
	(2 to 20) mA		
	(1 to 10) Hz	0.29 μ A/mA + 1.9 μ A	
	10 Hz to 10 kHz	0.26 μ A/mA + 1.9 μ A	
	(10 to 30) kHz	0.60 μ A/mA + 1.9 μ A	
	(30 to 100) kHz	3.1 μ A/mA + 1.9 μ A	
	(20 to 200) mA		
(1 to 10) Hz		0.29 μ A/mA + 19 μ A	
10 Hz to 10 kHz		0.24 μ A/mA + 19 μ A	
(10 to 30) kHz		0.54 μ A/mA + 19 μ A	
(0.2 to 2) A			
10 Hz to 2 kHz		0.55 mA/A + 0.19 mA	
(2 to 10) kHz		0.63 mA/A + 0.19 mA	
(10 to 30) kHz		2.3 mA/A + 0.19 mA	
(2 to 20) A			
10 Hz to 2 kHz		0.70 mA/A + 1.9 mA	
(2 to 10) kHz		1.9 mA/A + 1.9 mA	
Up to 200 μ A			
(20 to 50) Hz		3.5 mA/A + 36 nA	
(50 to 200) Hz		2 mA/A + 38 nA	
200 Hz to 1 kHz		4 mA/A + 35 nA	
(1 to 10) kHz		4 mA/A + 0.27 μ A	
(0.2 to 2) mA			
(20 to 50) Hz		3.5 mA/A + 0.34 μ A	
(50 to 200) Hz		1.5 mA/A + 0.3 μ A	
200 Hz to 1 kHz		1.2 mA/A + 0.37 μ A	
(1 to 10) kHz		0.51 mA/A + 3.2 μ A	
(10 to 30) kHz		1.6 mA/A + 3.1 μ A	
(30 to 50) kHz		2.1 mA/A + 3 μ A	
(50 to 100) kHz		5 mA/A + 0.3 μ A	
AC Current – Measure ^{1,15}			Keithley 2002 8.5 Digit Multimeter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure ^{1,15}	(2 to 20) mA (20 to 50) Hz (50 to 200) Hz 200 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz (30 to 50) kHz (50 to 100) kHz (20 to 200) mA (20 to 50) Hz (50 to 200) Hz 200 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz (30 to 50) kHz (50 to 100) kHz (0.2 to 2) A (20 to 50) Hz (50 to 200) Hz 200 Hz to 1 kHz (1 to 10) kHz (10 to 30) kHz (30 to 50) kHz	3 mA/A + 3.4 μA 1.5 mA/A + 3.6 μA 1.2 mA/A + 3.7 μA 0.54 mA/A + 30 μA 1.6 mA/A + 28 μA 2.1 mA/A + 28 μA 4.1 mA/A + 25 μA 3 mA/A + 33 μA 1.5 mA/A + 34 μA 1.2 mA/A + 35 μA 0.94 mA/A + 0.21 mA 4.4 mA/A + 0.17 mA 9.6 mA/A + 0.13 mA 29.8 mA/A + 71 μA 3.4 mA/A + 0.44 mA 1.9 mA/A + 0.48 mA 2.9 mA/A + 0.45 mA 2.4 mA/A + 7.2 mA 12.8 mA/A + 5.7 mA 38.6 mA/A + 3.5 mA	Keithley 2002 8.5 Digit Multimeter
AC Current – Measure ^{1,15}	(1 to 3) A (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	11 mA/A + 1.8 mA 3.5 mA/A + 1.9 mA 1.5 mA/A + 2 mA	Agilent 34401A 6.5 Digit Multimeter
AC Current – Measure ¹	60 Hz (5 to 30 000) A	10 mA/A + 1.8 A	AEMC 30K-24-2 Current Probe
Inductance – Measure	1 kHz (10 to 100) μH (0.1 to 1) mH (1 to 10) mH (10 to 100) mH (0.1 to 1) H (1 to 10) H	0.1 nH/μH + 0.2 μH 0.6 μH/mH + 0.2 μH 0.8 μH/mH + 0.2 μH 0.8 μH/mH + 2 μH 0.8 mH/H + 20 μH 0.8 mH/H + 0.2 mH	GenRad 1689M LCR Meter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Source ^{1,15} (Fixed Artifacts)	100 μH 500 μH 1 mH 10 mH 50 mH 100 mH 200 mH 1 H 2 H 10 H	0.12 μH 0.62 μH 1.2 μH 12 μH 61 μH 0.12 mH 0.24 mH 1.2 mH 2.2 mH 12 mH	GenRad 1482 Series Standard Inductors
Phase – Measure/Source ^{1,15} (0.01 to 100) V	(0 to 360) ° 1 Hz to 100 Hz 1 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz 100 kHz to 1 MHz	0.037 ° 0.056 ° 0.068 ° 0.13 ° 0.36 °	Keysight 53220A Phase Meter, Fluke 5522A/SC1100 Multi Product Calibrator
DC Power – Source ^{1,15}	(0 to 336) W (336 to 3 060) W (3 060 to 20 910) W	0.037 % of reading 0.053 % of reading 0.12 % of reading	Fluke 5522A/SC1100 Multi Product Calibrator
AC Power – Source ^{1,15}	(45 to 65) Hz (0.11 to 3) mW (3 to 11) mW (11 to 30) mW (30 to 110) mW (110 to 300) mW (300 to 730) mW (0.73 to 1.5) W (1.5 to 6.8) W (6.8 to 9.2) W (9.2 to 34) W (34 to 92) W (92 to 337) W (337 to 918) W (918 to 2 244) W (2 244 to 4 590) W (4 590 to 11 220) W	0.11 % of reading 0.12 % of reading 0.17 % of reading 0.12 % of reading 0.16 % of reading 0.13 % of reading 0.15 % of reading 0.14 % of reading 0.14 % of reading 0.1 % of reading 0.14 % of reading 0.1 % of reading 0.13 % of reading 0.11 % of reading 0.14 % of reading 0.12 % of reading	Fluke 5522A/SC1100 Multi Product Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source (Fixed Artifacts)	25 Ω	0.3 mΩ	Vishay Resistance Standards
	100 Ω	1.2 mΩ	
	200 Ω	2.3 mΩ	
	400 Ω	4.7 mΩ	
	1 kΩ	13 mΩ	
	1.9 kΩ	23 mΩ	
	4 kΩ	48 mΩ	
	10 kΩ	0.13 Ω	
	40 kΩ	0.47 Ω	
	90 kΩ	1.1 Ω	
	100 kΩ	1.2 Ω	
	400 Ω	4.7 Ω	
	900 kΩ	12 Ω	
	1 MΩ	12 Ω	
Resistance – Source (Simulation)	0 Ω	40 μΩ	Fluke 5730A Multi Product Calibrator
	1 Ω	95 μΩ	
	1.9 Ω	0.18 mΩ	
	10 Ω	0.23 mΩ	
	19 Ω	0.44 mΩ	
	100 Ω	1.5 mΩ	
	190 Ω	1.9 mΩ	
	1 kΩ	6.5 mΩ	
	1.9 kΩ	12 mΩ	
	10 kΩ	66 mΩ	
	19 kΩ	0.12 Ω	
	100 kΩ	0.85 Ω	
	190 kΩ	1.6 Ω	
	1 MΩ	13 Ω	
	1.9 MΩ	39 Ω	
	10 MΩ	0.42 kΩ	
19 MΩ	1.2 kΩ		
100 MΩ	10 kΩ		
Resistance – Source (Fixed Artifacts)	1 GΩ	49 kΩ	Measurements International Resistance Standards
	10 GΩ	0.64 MΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source ^{1,15} (Simulation)	(0 to 11) Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (0.33 to 1.1) kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 33) kΩ (33 to 110) kΩ (110 to 330) kΩ (0.33 to 1.1) MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (0.33 to 1.1) GΩ	31 μΩ/Ω + 0.8 mΩ 23 μΩ/Ω + 1.2 mΩ 22 μΩ/Ω + 1.1 mΩ 22 μΩ/Ω + 1.7 mΩ 22 μΩ/Ω + 1.6 mΩ 22 μΩ/Ω + 16 mΩ 20 μΩ/Ω + 16 mΩ 20 μΩ/Ω + 0.16 Ω 22 μΩ/Ω + 0.17 Ω 25 μΩ/Ω + 1.6 Ω 46 μΩ/Ω + 24 Ω 44 μΩ/Ω + 35 Ω 93 μΩ/Ω + 160 Ω 0.18 mΩ/Ω + 2.7 kΩ 0.38 mΩ/Ω + 3.9 kΩ 2.3 mΩ/Ω + 84 kΩ 13 mΩ/Ω - 0.18 MΩ	Fluke 5522A/SC1100 Multi Product Calibrator
Resistance – Measure ^{1,15}	(0 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	9.1 μΩ/Ω + 0.45 mΩ 13.3 μΩ/Ω + 1.1 mΩ 5.5 μΩ/Ω + 11 mΩ 4.8 μΩ/Ω + 0.12 Ω 30.7 μΩ/Ω + 1.2 Ω 55 μΩ/Ω + 0.11 kΩ 0.23 mΩ/Ω + 0.58 kΩ 0.53 mΩ/Ω + 4.7 kΩ	Keithley 2002 8.5 Digit Multimeter
Resistance – Measure	(0.1 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	10 μΩ/Ω + 5 μΩ 9 μΩ/Ω + 14 μΩ 7.4 μΩ/Ω + 62 μΩ 7.4 μΩ/Ω + 0.6 mΩ 7.4 μΩ/Ω + 7 mΩ 7.5 μΩ/Ω + 60 mΩ 3.9 μΩ/Ω + 20 Ω 46 mΩ/MΩ + 0.8 kΩ	Fluke 8508A 8.5 Digit Multimeter
Resistance – Measure	(2 to 20) MΩ (20 to 200) MΩ (0.2 to 2) GΩ (2 to 20) GΩ	15 Ω/MΩ + 10 Ω 60 Ω/MΩ + 1 kΩ 0.15 MΩ/GΩ + 0.1 MΩ 0.52 MΩ/GΩ + 10 MΩ	Fluke 8508A 8.5 Digit Multimeter (HV mode)
Resistance – Measure	24 GΩ to 2 TΩ	16 MΩ/GΩ + 2.8 MΩ	Transmille 8081 8.5 Digit Multimeter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices – Source ^{1,15}	Pt 385, 100 Ω		Fluke 5522A/SC1100 Multi Product Calibrator
	(-200 to -80) °C	0.041 °C	
	(-80 to 0) °C	0.041 °C	
	(0 to 100) °C	0.056 °C	
	(100 to 300) °C	0.071 °C	
	(300 to 400) °C	0.079 °C	
	(400 to 630) °C	0.094 °C	
	(630 to 800) °C	0.18 °C	
	Pt 385, 200 Ω		
	(-200 to -80) °C	0.034 °C	
	(-80 to 0) °C	0.027 °C	
	(0 to 100) °C	0.034 °C	
	(100 to 260) °C	0.034 °C	
	(260 to 300) °C	0.086 °C	
	(300 to 400) °C	0.095 °C	
	(400 to 600) °C	0.095 °C	
	(600 to 630) °C	0.11 °C	
	Pt 385, 500 Ω		
	(-200 to -80) °C	0.034 °C	
	(-80 to 0) °C	0.041 °C	
	(0 to 100) °C	0.041 °C	
	(100 to 260) °C	0.049 °C	
	(260 to 300) °C	0.064 °C	
	(300 to 400) °C	0.064 °C	
(400 to 600) °C	0.071 °C		
(600 to 630) °C	0.086 °C		
Pt 385, 1 kΩ			
(-200 to -80) °C	0.027 °C		
(-80 to 0) °C	0.027 °C		
(0 to 100) °C	0.034 °C		
(100 to 260) °C	0.041 °C		
(260 to 300) °C	0.048 °C		
(300 to 400) °C	0.056 °C		
(400 to 600) °C	0.056 °C		
(600 to 630) °C	0.18 °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 ^{1,15}	Pt 3916, 100 Ω		Fluke 5522A/SC1100 Multi Product Calibrator
	(-200 to -190) °C	0.19 °C	
	(-190 to -80) °C	0.034 °C	
	(-80 to 0) °C	0.041 °C	
	(0 to 100) °C	0.048 °C	
	(100 to 260) °C	0.056 °C	
	(260 to 300) °C	0.063 °C	
	(300 to 400) °C	0.071 °C	
	(400 to 600) °C	0.079 °C	
	(600 to 630) °C	0.18 °C	
	Pt 3926, 100 Ω		
	(-200 to -80) °C	0.041 °C	
	(-80 to 0) °C	0.041 °C	
	(0 to 100) °C	0.056 °C	
	(100 to 300) °C	0.071 °C	
(300 to 400) °C	0.079 °C		
(400 to 630) °C	0.094 °C		
Ni 385, 120 Ω			
(-80 to 0) °C	0.063 °C		
(0 to 100) °C	0.063 °C		
(100 to 260) °C	0.11 °C		
Cu 427, 10 Ω			
(-100 to 260) °C	0.23 °C		
DC Voltage – Source	(0 to 220) mV	7.5 μV/V + 0.41 μV	Fluke 5730A Multi Product Calibrator
	(0.22 to 2.2) V	5 μV/V + 0.77 μV	
	(2.2 to 11) V	0.45 μV/V + 3.5 μV	
	(11 to 22) V	3.5 μV/V + 0.59 μV	
	(22 to 220) V	5.8 μV/V + 51 μV	
	(220 to 1 100) V	6.5 μV/V + 0.42 mV	
DC High Voltage – Source ^{1,15}	(0.01 to 1 400) V	0.3 mV/V + 37 mV	HV Output monitored with Vitretek 4700 High Voltage Meter, HVL-35 Probe, HVL-100 Probe
	(1.4 to 10) kV	0.28 V/kV + 0.34 V	
	(1 to 35) kV	0.8 V/kV + 0.25 V	
	(10 to 100) kV	0.56 V/kV	
DC Voltage – Source ^{1,15}	(0 to 330) mV	13 μV/V + 2 μV	Fluke 5522A/SC1100 Multi Product Calibrator
	(0.33 to 3.3) V	8 μV/V + 4.1 μV	
	(3.3 to 33) V	8.9 μV/V + 34 μV	
	(33 to 330) V	13.6 μV/V + 0.26 mV	
	(330 to 1 000) V	14 μV/V + 1.1 mV	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source	(0.22 to 2.2) mV		Fluke 5730A Multi Product Calibrator
	(10 to 20) Hz	0.23 $\mu\text{V}/\text{mV}$ + 3.9 μV	
	(20 to 40) Hz	410 nV/mV + 3.8 μV	
	40 Hz to 20 kHz	81 nV/mV + 3.9 μV	
	(20 to 50) kHz	0.19 $\mu\text{V}/\text{mV}$ + 3.9 μV	
	(50 to 100) kHz	0.46 $\mu\text{V}/\text{mV}$ + 4.7 μV	
	(100 to 300) kHz	1 $\mu\text{V}/\text{mV}$ + 9.3 μV	
	(300 to 500) kHz	1.3 $\mu\text{V}/\text{mV}$ + 19 μV	
	500 kHz to 1 MHz	2.6 $\mu\text{V}/\text{mV}$ + 19 μV	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.23 $\mu\text{V}/\text{mV}$ + 3.9 μV	
	(20 to 40) Hz	89 nV/mV + 3.9 μV	
	40 Hz to 20 kHz	77 nV/mV + 3.9 μV	
	(20 to 50) kHz	0.19 $\mu\text{V}/\text{mV}$ + 3.9 μV	
	(50 to 100) kHz	0.47 $\mu\text{V}/\text{mV}$ + 4.7 μV	
	(100 to 300) kHz	1 $\mu\text{V}/\text{mV}$ + 9.3 μV	
	(300 to 500) kHz	1 $\mu\text{V}/\text{mV}$ + 9.3 μV	
	500 kHz to 1 MHz	2.6 $\mu\text{V}/\text{mV}$ + 19 μV	
	(22 to 220) mV		
	(10 to 20) Hz	0.23 $\mu\text{V}/\text{mV}$ + 12 μV	
	(20 to 40) Hz	89 nV/mV + 6.3 μV	
	40 Hz to 20 kHz	54 nV/mV + 6.2 μV	
	(20 to 50) kHz	0.12 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	(50 to 100) kHz	0.31 $\mu\text{V}/\text{mV}$ + 16 μV	
(100 to 300) kHz	1 $\mu\text{V}/\text{mV}$ + 9.3 μV		
(300 to 500) kHz	1.3 $\mu\text{V}/\text{mV}$ + 27 μV		
500 kHz to 1 MHz	2.6 $\mu\text{V}/\text{mV}$ + 47 μV		
(0.22 to 2.2) V			
(10 to 20) Hz	0.23 mV/V + 45 μV		
(20 to 40) Hz	85 $\mu\text{V}/\text{V}$ + 16 μV		
40 Hz to 20 kHz	37 $\mu\text{V}/\text{V}$ + 8.5 μV		
(20 to 50) kHz	62 $\mu\text{V}/\text{V}$ + 9.7 μV		
(50 to 100) kHz	78 $\mu\text{V}/\text{V}$ + 31 μV		
(100 to 300) kHz	0.31 mV/V + 78 μV		
(300 to 500) kHz	0.93 mV/V + 0.2 mV		
500 kHz to 1 MHz	1.6 mV/V + 0.31 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source	(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 (220 to 1 100) V (15 to 50) Hz 50 Hz to 1 kHz	0.23 mV/V + 0.46 mV 85 μV /V + 0.13 mV 37 μV/V + 58 μV 62 μV/V + 0.95 mV 77 μV/V + 0.2 mV 0.23 mV/V + 0.62 mV 0.93 mV/V + 1.9 mV 1.4 mV/V + 3.1 mV 0.23 mV/V + 4.2 mV 85 μV/V + 1.7 mV 50 μV/V + 0.69 mV 77 μV /V + 0.96 mV 0.14 mV/V + 2.4 mV 0.85 mV/V + 16 mV 0.28 mV/V + 16 mV 66 μV /V + 3.6 mV	Fluke 5730A Multi Product Calibrator
AC Voltage – Source	(220 to 750) V (30 to 50) kHz (50 to 100) kHz (220 to 1 100) V (1 to 20) kHz (20 to 30) kHz	8.6 mV + 0.47 mV/V 35 mV + 1.8 mV/V 4.7 mV + 0.13 mV/V 8.5 mV + 0.47 mV/V	Fluke 5730A Multi Product Calibrator, Fluke 5725A Amplifier
AC Voltage – Source ^{1,15}	(1 to 33) 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	0.62 μV/mV + 5 μV 0.11 μV/mV + 5.1 μV 0.13 μV/mV + 1.3 μV 0.77 μV/mV + 4.9 μV 2.7 μV/mV + 9.4 μV 6.2 μV/mV + 39 μV	Fluke 5522A/SC1100 Multi Product Calibrator

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment	
AC Voltage – Source ^{1,15}	(33 to 330) mV		Fluke 5522A/SC1100 Multi Product Calibrator	
	(10 to 45) Hz	0.23 μ V/mV + 6.4 μ V		
	45 Hz to 10 kHz	0.11 μ V/mV + 6.4 μ V		
	(10 to 20) kHz	0.12 μ V/mV + 6.5 μ V		
	(20 to 50) kHz	0.27 μ V/mV + 6.4 μ V		
	(50 to 100) kHz	0.62 μ V/mV + 25 μ V		
	(100 to 500) kHz	1.6 μ V/mV + 54 μ V		
	(0.33 to 3.3) V			
	(10 to 45) Hz	0.12 mV/V + 47 μ V		
	45 Hz to 10 kHz	0.12 mV/V + 47 μ V		
	(10 to 20) kHz	0.15 mV/V + 47 μ V		
	(20 to 50) kHz	0.23 mV/V + 39 μ V		
	(50 to 100) kHz	0.54 mV/V + 97 μ V		
	(100 to 500) kHz	1.9 mV/V + 0.47 mV		
	(3.3 to 33) V			
	(10 to 45) Hz	0.23 mV/V + 0.5 mV		
45 Hz to 10 kHz	0.12 mV/V + 0.47 mV			
(10 to 20) kHz	0.23 mV/V + 0.51 mV			
(20 to 50) kHz	0.27 mV/V + 0.47 mV			
(50 to 100) kHz	0.7 mV/V + 1.2 mV			
AC High Voltage – Source ^{1,15}	(33 to 330) V		HV Output Monitored with Vitretek 4700 High Voltage Meter	
	45 Hz to 1 kHz	0.15 mV/V + 1.7 mV		
	(1 to 10) kHz	0.16 mV/V + 4.8 mV		
	(10 to 20) kHz	0.19 mV/V + 4.8 mV		
	(20 to 50) kHz	0.23 mV/V + 4.9 mV		
	(50 to 100) kHz	1.6 mV/V + 39 mV		
	(330 to 1 000) V	45 Hz to 1 kHz		0.23 mV/V + 7.9 mV
		(1 to 5) kHz		0.19 mV/V + 8.1 mV
		(5 to 10) kHz		0.23 mV/V + 7.9 mV
		60 Hz		
10 mV to 1 400 V	0.3 mV/V + 40 mV			
	(1.4 to 10) kV		58 mV/kV + 17 V	
DC Voltage – Measure ^{1,15}	(0 to 200) mV	16.6 μ V/V + 2.6 μ V	Keithley 2002 8.5 Digit Multimeter	
	(0.2 to 2) V	7.3 μ V/V + 9.4 μ V		
	(2 to 20) V	7.8 μ V/V + 59 μ V		
	(20 to 200) V	19.3 μ V/V + 1.1 mV		
	(200 to 1 000) V	18.6 μ V/V + 4.5 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Measure	(0 to 200) mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1 000) V	4.4 $\mu\text{V/V} + 0.12 \mu\text{V}$ 3 $\mu\text{V/V} + 0.4 \mu\text{V}$ 3 $\mu\text{V/V} + 1.2 \mu\text{V}$ 4.5 $\mu\text{V/V} + 46 \mu\text{V}$ 4.5 $\mu\text{V/V} + 0.53 \text{ mV}$	Fluke 8508A 8.5 Digit Multimeter
DC High Voltage – Measure ^{1,15}	10 mV to 1 400 V (1.4 to 10) kV (1 to 35) kV (10 to 100) kV	0.3 mV/V + 37 mV 0.29 mV/V + 37 mV 0.27 mV/V + 0.65 V 0.57 mV/V	Vitrek 4700 High Voltage Meter, HVL-35 Probe, HVL-100 Probe
AC Voltage – Measure ^{1,15}	(2 to 200) mV (1 to 10) Hz (10 to 50) Hz (50 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 50) kHz (50 to 100) kHz (100 to 200) kHz 200 kHz to 1 MHz (1 to 2) MHz (0.2 to 2) V (1 to 10) Hz (10 to 50) Hz (50 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 50) kHz (50 to 100) kHz (100 to 200) kHz 200 kHz to 1 MHz (1 to 2) MHz	0.79 mV/V + 59 μV 0.59 mV/V + 34 μV 0.34 mV/V + 34 μV 0.18 mV/V + 26 μV 0.18 mV/V + 26 μV 0.45 mV/V + 33 μV 0.45 mV/V + 33 μV 2.9 mV/V + 60 μV 7.3 mV/V + 0.1 mV 19 mV/V + 0.44 mV 49.5 mV/V + 0.52 mV 0.9 mV/V + 0.3 mV 0.4 mV/V + 0.3 mV 0.25 mV/V + 0.31 mV 0.2 mV/V + 0.22 mV 0.19 mV/V + 0.23 mV 0.49 mV/V + 0.23 mV 0.49 mV/V + 0.23 mV 3 mV/V + 0.31 mV 7.5 mV/V + 0.51 mV 20 mV/V + 2 mV 37 mV/V + 39 mV	Keithley 2002 8.5 Digit Multimeter



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure ^{1,15}	(2 to 20) V		Keithley 2002 8.5 Digit Multimeter
	(1 to 10) Hz	0.92 mV/V + 5.2 mV	
	(10 to 50) Hz	0.6 mV/V + 3.1 mV	
	(50 to 100) Hz	0.35 mV/V + 3.1 mV	
	100 Hz to 2 kHz	0.3 mV/V + 3.1 mV	
	(2 to 10) kHz	0.4 mV/V + 3.1 mV	
	(10 to 30) kHz	0.49 mV/V + 3.3 mV	
	(30 to 50) kHz	0.69 mV/V + 3.2 mV	
	(50 to 100) kHz	0.29 mV/V + 3.3 mV	
	(100 to 200) kHz	7.5 mV/V + 5.1 mV	
	200 kHz to 1 MHz	39.8 mV/V + 45 mV	
	(1 to 2) MHz	70 mV/V + 43 mV	
	(20 to 200) V		
	(1 to 10) Hz	0.92 mV/V + 52 mV	
	(10 to 50) Hz	0.49 mV/V + 31 mV	
	(50 to 100) Hz	0.29 mV/V + 32 mV	
	100 Hz to 2 kHz	0.29 mV/V + 32 mV	
	(2 to 10) kHz	0.39 mV/V + 32 mV	
	(10 to 30) kHz	0.49 mV/V + 33 mV	
	(30 to 50) kHz	0.69 mV/V + 33 mV	
	(50 to 100) kHz	3 mV/V + 30 mV	
	(100 to 200) kHz	7.5 mV/V + 53 mV	
	200 kHz to 1 MHz	40 mV/V + 0.4 V	
	(200 to 750) V		
	(1 to 10) Hz	1.3 mV/V + 0.12 V	
	(10 to 50) Hz	0.89 mV/V + 0.12 V	
	(50 to 100) Hz	0.49 mV/V + 0.12 V	
100 Hz to 2 kHz	0.49 mV/V + 0.12 V		
(2 to 10) kHz	0.6 mV/V + 0.11 V		
(10 to 30) kHz	0.57 mV/V + 0.42 V		
(30 to 50) kHz	0.76 mV/V + 0.4 V		
(50 to 100) kHz	4.9 mV/V + 0.23 V		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	Up to 2.2 mV		Fluke 5790A AC Voltage Measurement Standard
	(10 to 20) Hz	1.3 $\mu\text{V}/\text{mV}$ + 1 μV	
	(20 to 40) Hz	0.55 $\mu\text{V}/\text{mV}$ + 1.1 μV	
	40 Hz to 20 kHz	0.32 $\mu\text{V}/\text{mV}$ + 1 μV	
	(20 to 50) kHz	0.81 $\mu\text{V}/\text{mV}$ + 2 μV	
	(50 to 100) kHz	0.93 $\mu\text{V}/\text{mV}$ + 1.9 μV	
	(100 to 300) kHz	1.8 $\mu\text{V}/\text{mV}$ + 3.1 μV	
	(300 to 500) kHz	1.9 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	500 kHz to 1 MHz	2.7 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	(2.2 to 7) mV		
	(10 to 20) Hz	0.85 $\mu\text{V}/\text{mV}$ + 1.3 μV	
	(20 to 40) Hz	0.28 $\mu\text{V}/\text{mV}$ + 1.1 μV	
	40 Hz to 20 kHz	0.16 $\mu\text{V}/\text{mV}$ + 1 μV	
	(20 to 50) kHz	2.8 nV/mV + 320 μV	
	(50 to 100) kHz	0.46 $\mu\text{V}/\text{mV}$ + 2 μV	
	(100 to 300) kHz	0.93 $\mu\text{V}/\text{mV}$ + 3.1 μV	
	(300 to 500) kHz	1 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	500 kHz to 1 MHz	1.8 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	(7 to 22) mV		
	(10 to 20) Hz	0.22 $\mu\text{V}/\text{mV}$ + 1.1 μV	
	(20 to 40) Hz	0.14 $\mu\text{V}/\text{mV}$ + 1.1 μV	
	40 Hz to 20 kHz	84 nV/mV + 1.1 μV	
	(20 to 50) kHz	0.16 $\mu\text{V}/\text{mV}$ + 1.6 μV	
	(50 to 100) kHz	0.24 $\mu\text{V}/\text{mV}$ + 1.9 μV	
(100 to 300) kHz	0.63 $\mu\text{V}/\text{mV}$ + 3.1 μV		
(300 to 500) kHz	0.69 $\mu\text{V}/\text{mV}$ + 6.2 μV		
500 kHz to 1 MHz	1.3 $\mu\text{V}/\text{mV}$ + 6.2 μV		
(22 to 70) mV			
(10 to 20) Hz	0.19 $\mu\text{V}/\text{mV}$ + 1.2 μV		
(20 to 40) Hz	0.09 $\mu\text{V}/\text{mV}$ + 1.4 μV		
40 Hz to 20 kHz	0.05 $\mu\text{V}/\text{mV}$ + 1.2 μV		
(20 to 50) kHz	0.1 $\mu\text{V}/\text{mV}$ + 1.6 μV		
(50 to 100) kHz	0.2 $\mu\text{V}/\text{mV}$ + 1.9 μV		
(100 to 300) kHz	0.4 $\mu\text{V}/\text{mV}$ + 3.1 μV		
(300 to 500) kHz	0.52 $\mu\text{V}/\text{mV}$ + 6.2 μV		
500 kHz to 1 MHz	0.85 $\mu\text{V}/\text{mV}$ + 6.2 μV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	(70 to 220) mV		Fluke 5790A AC Voltage Measurement Standard
	(10 to 20) Hz	0.16 $\mu\text{V}/\text{mV}$ + 1.6 μV	
	(20 to 40) Hz	65 nV/mV + 1.3 μV	
	40 Hz to 20 kHz	30 nV/mV + 1.2 μV	
	(20 to 50) kHz	50 nV/mV + 1.6 μV	
	(50 to 100) kHz	0.12 $\mu\text{V}/\text{mV}$ + 2 μV	
	(100 to 300) kHz	0.19 $\mu\text{V}/\text{mV}$ + 3.1 μV	
	(300 to 500) kHz	0.29 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	500 kHz to 1 MHz	0.78 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	(220 to 700) mV		
	(10 to 20) Hz	0.16 $\mu\text{V}/\text{mV}$ + 2.4 μV	
	(20 to 40) Hz	60 nV/mV + 1.8 μV	
	40 Hz to 20 kHz	30 nV/mV + 1.7 μV	
	(20 to 50) kHz	40 nV/mV + 1.9 μV	
	(50 to 100) kHz	60 nV/mV + 2.1 μV	
	(100 to 300) kHz	0.14 $\mu\text{V}/\text{mV}$ + 3.6 μV	
	(300 to 500) kHz	0.23 $\mu\text{V}/\text{mV}$ + 6.3 μV	
	500 kHz to 1 MHz	0.74 $\mu\text{V}/\text{mV}$ + 6.2 μV	
	(0.7 to 2.2) V		
	(10 to 20) Hz	0.15 mV/V + 6 μV	
	(20 to 40) Hz	51 $\mu\text{V}/\text{V}$ + 90 nV	
	40 Hz to 20 kHz	18 $\mu\text{V}/\text{V}$ + 1 μV	
	(20 to 50) kHz	35 $\mu\text{V}/\text{V}$ + 0.5 μV	
	(50 to 100) kHz	55 $\mu\text{V}/\text{V}$ + 0.1 μV	
	(100 to 300) kHz	0.12 mV/V + 0.6 μV	
	(300 to 500) kHz	0.20 mV/V - 0.2 μV	
	500 kHz to 1 MHz	0.7 mV/V	
(2.2 to 7) V			
(10 to 20) Hz	200 $\mu\text{V}/\text{V}$ + 10 μV		
(20 to 40) Hz	50 $\mu\text{V}/\text{V}$ + 5 μV		
40 Hz to 20 kHz	20 $\mu\text{V}/\text{V}$ + 9 μV		
(20 to 50) kHz	40 $\mu\text{V}/\text{V}$ + 2 μV		
(50 to 100) kHz	60 $\mu\text{V}/\text{V}$ + 0.8 μV		
(100 to 300) kHz	0.1 mV/V + 1 μV		
(300 to 500) kHz	0.3 mV/V + 80 μV		
500 kHz to 1 MHz	0.9 mV/V - 1 μV		



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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	(7 to 22) V		Fluke 5790A AC Voltage Measurement Standard
	(10 to 20) Hz	0.2 mV/V + 70 μV	
	(20 to 40) Hz	50 μV/V + 20 μV	
	40 Hz to 20 kHz	20 μV/V + 10 μV	
	(20 to 50) kHz	40 μV/V + 3 μV	
	(50 to 100) kHz	60 μV/V + 2 μV	
	(100 to 300) kHz	0.1 mV/V + 2 μV	
	(300 to 500) kHz	0.3 mV/V	
	500 kHz to 1 MHz	0.9 mV/V + 4 μV	
	(22 to 70) V		
	(10 to 20) Hz	0.2 mV/V + 50 μV	
	(20 to 40) Hz	50 μV/V + 0.3 mV	
	40 Hz to 20 kHz	20 μV/V + 70 μV	
	(20 to 50) kHz	40 μV / V + 30 μV	
	(50 to 100) kHz	70 μV/V + 20 μV	
	(100 to 300) kHz	0.2 mV/V + 0.2 mV	
	(300 to 500) kHz	0.3 mV/V + 10 μV	
	500 kHz to 1 MHz	0.9 mV/V + 7 μV	
	(70 to 220) V		
	(10 to 20) Hz	0.2 mV/V + 0.3 mV	
	(20 to 40) Hz	50 μV/V + 0.2 mV	
	40 Hz to 20 kHz	20 μV/V + 0.2 mV	
	(20 to 50) kHz	50 μV/V + 30 μV	
	(50 to 100) kHz	80 μV/V + 20 μV	
	(100 to 300) kHz	0.2 mV/V + 0.2 mV	
	(300 to 500) kHz	0.4 mV/V + 90 μV	
	(220 to 700) V		
	(10 to 20) Hz	0.2 mV/V + 0.2 mV	
(20 to 40) Hz	0.08 mV/V + 0.4 mV		
40 Hz to 20 kHz	30 μV/V + 0.4 mV		
(20 to 50) kHz	0.1 mV/V + 0.1 mV		
(50 to 100) kHz	0.4 mV/V + 60 μV		
(700 to 1 000) V			
(10 to 20) Hz	0.2 mV/V - 0.4 mV		
(20 to 40) Hz	80 μV/V + 0.5 mV		
40 Hz to 20 kHz	30 μV/V + 0.2 mV		
(20 to 50) kHz	0.1 mV/V + 30 μV		
(50 to 100) kHz	0.4 mV/V - 6 μV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC High Voltage – Measure ^{1,15}	(50 to 600) Hz 10 mV to 1 400 V (1.4 to 10) kV (1 to 35) kV	1.2 V/kV + 0.16 V 1.2 V/kV + 0.2 V 0.8 V/kV + 0.25 V	Vitrek 4700 High Voltage Meter, HVL-35 Probe, HVL-100 Probe
	50 or 60 Hz (10 to 75) kV	1.2 V/kV + 1.1 V	
	(50 to 400) Hz (1 to 100) kV	10 V/kV + 0.12 V	Hipotronics KVM 100 High Voltage Meter w/Probe
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure ^{1,15}	Type B (600 to 800) °C	0.34 °C	Fluke 5522A/SC1100 Multi Product Calibrator
	(800 to 1 000) °C	0.28 °C	
	(1 000 to 1 550) °C	0.25 °C	
	(1 550 to 1 820) °C	0.26 °C	
	Type C (0 to 150) °C	0.23 °C	
	(150 to 650) °C	0.21 °C	
	(650 to 1 000) °C	0.24 °C	
	(1 000 to 1 800) °C	0.39 °C	
	(1 800 to 2 316) °C	0.65 °C	
	Type E (-250 to -100) °C	0.41 °C	
	(-100 to -25) °C	0.13 °C	
	(-25 to 350) °C	0.11 °C	
	(350 to 650) °C	0.13 °C	
	(650 to 1 000) °C	0.17 °C	
	Type J (-210 to -100) °C	0.23 °C	
	(-100 to -30) °C	0.13 °C	
	(-30 to 150) °C	0.11 °C	
	(150 to 760) °C	0.13 °C	
	(760 to 1 200) °C	0.18 °C	
	Type K (-200 to -100) °C	0.26 °C	
(-100 to -25) °C	0.14 °C		
(-25 to 120) °C	0.13 °C		
(120 to 1 000) °C	0.2 °C		
(1 000 to 1 372) °C	0.31 °C		

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure ^{1,15}	Type N		Fluke 5522A/SC1100 Multi Product Calibrator
	(-200 to -100) °C	0.31 °C	
	(-100 to -25) °C	0.17 °C	
	(-25 to 120) °C	0.15 °C	
	(120 to 410) °C	0.14 °C	
	(410 to 1 300) °C	0.21 °C	
	Type R		
	(0 to 250) °C	0.45 °C	
	(250 to 400) °C	0.27 °C	
	(400 to 1 000) °C	0.26 °C	
	(1 000 to 1 767) °C	0.31 °C	
	Type S		
	(0 to 250) °C	0.37 °C	
(250 to 1 000) °C	0.28 °C		
(1 000 to 1 400) °C	0.29 °C		
(1 400 to 1 767) °C	0.36 °C		
Type T			
(-250 to -150) °C	0.49 °C		
(-150 to 0) °C	0.19 °C		
(0 to 120) °C	0.13 °C		
(120 to 400) °C	0.11 °C		
Oscilloscopes ^{1,15}			Fluke 5522A/SC1100 Multi Product Calibrator
Amplitude – DC Signal into 50 Ω load	± 1 mV to ± 6.6 V	1.5 mV/V + 28 μV	
into 1 MΩ load	± 1 mV to ± 130 V	0.39 mV/V + 32 μV	
Amplitude – Square Wave into 50 Ω load	1 mVp-p to 6.6 Vp-p 10 Hz to 10 kHz	1.9 mV/V + 32 μV	
into 1 MΩ load	1 mVp-p to 130 Vp-p 10 Hz to 1 kHz	0.78 mV/V + 34 μV	
	(1 to 10) kHz	2 mV/V + 48 μV	



ANSI National Accreditation Board

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes ^{1,15} Leveled Sine Wave – Amplitude (50 kHz ref) into 50 Ω load	5 mV to 5.5 V 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 5 mV to 3.5 V (600 to 1 100) MHz 5 mVp-p to 5.5 Vp-p 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz 4 mVp-p to 3.5 Vp-p (600 to 1 100) MHz	27 mV/V + 1.7 mV 31 mV/V + 0.25 mV 47 mV/V + 0.25 mV 0.42 mV + 54 mV/V 12 mV/V + 0.1 mV 16 mV/V + 0.1 mV 31 mV/V + 0.1 mV 39 mV/V + 90 μV	Fluke 5522A/SC1100 Multi Product Calibrator
Time Markers	1 ns to 20 ms 50 ms 0.1 s 0.2 s 0.5 s 1 s 2 s 5 s	2. ps/μs 4.4 μs 9.8 μs 35 μs 0.2 ms 0.8 ms 3.1 ms 20 ms	
Edge – Rise Time	(250 to 350) ps 1 kHz to 11 MHz	310 ps	
Total Harmonic Distortion ^{1,15}	10 Hz to 500 kHz (-95 to -50) dB (-50 to -20) dB (-20 to 0) dB	0.021 dB 0.13 dB 0.89 dB	Pico Technologies 4262 Digital Oscilloscope

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Caliper Masters ²	(0.5 to 4) in (4 to 40) in (40 to 60) in	(1.8 + 4L) μin (4.5L) μin (130 + 1L) μin	P&W Labmaster Universal 1000A, Gauge Blocks

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Cylindrical Plug Gauges ^{2,12}	(0.01 to 0.1) in (0.1 to 0.42) in (0.42 to 4) in (4 to 12) in	(3.1 – 2L) μin (2.9 + 2L) μin (1.9 + 4L) μin (1 + 4L) μin	P&W Labmaster Universal 1000A, Gauge Blocks
Cylindrical Ring Gauges ^{2,14}	(0.01 to 0.22) in (0.22 to 1) in (1 to 2) in (2 to 3) in (3 to 4) in (4 to 7) in (7 to 10) in (10 to 13) in	(8.3 + 2.8L) μin (8 + 4.5L) μin (7.9 + 5L) μin (8.1 + 5L) μin (8.4 + 5L) μin (8.7 + 5L) μin (9.2 + 5L) μin (9.4 + 5L) μin	P&W Labmaster Universal 1000A, Gauge Blocks, Master Ring Gauges
Depth Micrometer Master ²	(0.5 to 11.5) in	(28 + 1L) μin	Gauging Amplifier, Gauge Blocks
End Measuring Rods ²	(0.5 to 4) in (4 to 20) in (20 to 80) in	(4.1 + 3L) μin (0.61 + 4L) μin (100 + 4L) μin	P&W Labmaster Universal 1000A, Gauge Blocks
Feeler Gauges ¹ (Leaf-Style)	Up to 0.25 in	76 μin	Bench Micrometer
Gauge Balls ² (size only)	(0.0625 to 0.1) in (0.1 to 0.42) in (0.42 to 2) in	(10 – 2L) μin (9 + 2L) μin (8 + 5L) μin	P&W Labmaster Universal 1000A, Gauge Blocks
Gauge Blocks ^{2,6}	(0.005 to 4) in	(3 + 0.45L) μin	Mahr 130-B24 Comparator, Master Gauge Blocks
Gauge Blocks ^{2,6}	(0.005 to 0.1) in (0.1 to 0.42) in (0.42 to 4) in (5 to 20) in	(2.9 – 2L) μin (2.7 + 0.8L) μin (2.4 + 1L) μin (1.3 + 1L) μin	P&W Labmaster Universal 1000A, Master Gauge Blocks
Micrometer Masters ²	Up to 0.1 in (0.1 to 0.42) in (0.42 to 4) in (4 to 20) in (20 to 40) in	(3.1 – 4L) μin (2.6 + 2L) μin (1.8 + 4L) μin (0.53 + 4L) μin (4L – 8.1) μin	P&W Labmaster Universal 1000A, Gauge Blocks
Optical Flats and Parallels Flatness Up to 4 in Diameter	Up to 100 μin	5.6 μin	Optical Flat, Monochromatic Light
	Parallelism (0 to 2) in thickness	4.5 μin	Mahr 130-B24 Comparator
Parallels	Up to 36 in	66 μin	Gauging Amplifier, Gauge Blocks

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pin Gauges – Class ZZ ²	(0.01 to 1) in	$(93 + 2.44L) \mu\text{in}$	Digital Micrometer
Riser Blocks ²	(6 to 24) in	$(19 + 7L) \mu\text{in}$	Gauging Amplifier, Gauge Blocks
Snap Gauges ²	(0.01 to 0.22) in (0.22 to 1) in (1 to 13) in	$(23 - 1L) \mu\text{in}$ $(24 - 4L) \mu\text{in}$ $(16 + 3.7L) \mu\text{in}$	P&W Labmaster Universal 1000A, Gauge Blocks
Squares – Perpendicularity ²	Up to 36 in	$(35 + 8L) \mu\text{in}$	Indi-Square, Gauging Amplifier, Gauge Blocks, Tri-Square
Tapered Plugs ²	Up to 0.1 in (0.1 to 0.42) in (0.42 to 2) in	$(23 - 0.8L) \mu\text{in}$ $(22 + 0.26L) \mu\text{in}$ $(22 + 0.87L) \mu\text{in}$	P&W Labmaster Universal 1000A, Gauge Blocks, Plug Gauges
Tapered Rings ²	(0.01 to 0.22) in (0.22 to 1) in (1 to 2) in	$(24 - 0.14L) \mu\text{in}$ $(25 - 1.7L) \mu\text{in}$ $(17 + 6.3L) \mu\text{in}$	P&W Labmaster Universal 1000A, Gauge Blocks
Thickness (Film) Gauge Standards (Non-Ferrous)	Up to 0.05 in	6.1 μin	P&W Labmaster Universal 1000A, Gauge Blocks
Thread Measuring Wires ^{2,10}	Unified 60° (4 to 80) TPI Acme 29° (1 to 20) TPI	$(13 - 50L) \mu\text{in}$ $(13 - 50L) \mu\text{in}$	P&W Labmaster Universal 1000A, Gauge Blocks
Thread Micrometer Standards	1 in 2 in 3 in 4 in 5 in 6 in	8.8 μin 16 μin 24 μin 31 μin 40 μin 48 μin	P&W Labmaster Universal 1000A, Gauge Blocks
Angle Blocks	(1 to 60)°	0.002 2°	Master Angle Blocks, Sine Plate, Gauging Amplifier
Angle Gauges (Leaf Style) ²	Up to 90°	3.7'	STI Optical Comparator
Electronic Differential Levels ²	Up to 1 000"	1.4"	Brunson 470 Angle Generator
Functional Gauges & Fixtures	Linear Up to 12 in	190 μin	STI Optical Comparator
	Angle Up to 90°	0.065°	

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Radius Gauges (Leaf Style)	Up to 1 in	210 μin	STI Optical Comparator
Sine Bars, Sine Plates ²	Angle (1 to 60)°	6.48"	Gauge Blocks, Angle Blocks, Gauging Amplifier
Thread Pitch Gauges ¹⁰ (Leaf Style)	(4 to 84) TPI	160 μin	STI Optical Comparator
Tri-Blocks	Length (1 to 6) in	48 μin	Gauging Amplifier, Gauge Blocks
	Flatness	41 μin	Gauging Amplifier
	Perpendicularity	69 μin	Indi-Square, Gauging Amplifier
V-Blocks	Parallelism	47 μin	Gauging Amplifier, Gauge Blocks
	Perpendicularity	66 μin	Gauging Amplifier, Indi-Square
	V-Centrality	55 μin	Gauging Amplifier, Master Plugs
Pipe Thread Plugs ^{2,10}	Simple Pitch Diameter (4 to 80 TPI)	(100 + 2L) μin	P&W Labmaster Universal 1000A, Gauge Blocks, Sine Plug
	Standoff Up to 1 in (1 to 2) in	(36 + 0.9L) μin (35 + 0.59L) μin	Gauging Amplifier Gauge Blocks
Thread Plugs – Setting ^{2,5,10}	Simple Pitch Diameter (4 to 80 TPI)	(47 + 5L) μin	P&W Labmaster Universal 1000A, Gauge Blocks, Thread Measuring Wires
	Major Diameter (0.06 to 4) in	(16 + 4.7L) μin	P&W Labmaster Universal 1000A, Gauge Blocks
Thread Plugs – Setting ^{2,5,10}	Root Radius & Minor Diameter	203 μin	STI Optical Comparator
Thread Plugs – Working ^{2,5,10}	Simple Pitch Diameter (4 to 80 TPI)	(96 + 0.4L) μin	P&W Labmaster Universal 1000A, Gauge Blocks, Thread Measuring Wires

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Plugs – Working ^{2,5,10}	Major Diameter (0.060 to 4) in	$(26 + 4L) \mu\text{in}$	P&W Labmaster Universal 1000A, Gauge Blocks
Thread Plugs – Working ^{2,5,10}	Root Radius & Minor Diameter	200 μin	STI Optical Comparator
Bench Micrometers ¹	Length Up to 2 in	12 μin	Gauge Blocks
Bench Micrometers ^{1,2} Length	Up to 2 in	12 μin	Gauge Blocks
Anvil Flatness	Up to 0.5 in Diameter	9.4 μin	Optical Flat, Monochromatic Light
Bore Gauges (2 point) ^{1,2}	Up to 1 in	$(48 + 0.6L) \mu\text{in}$	Indi-Check
Bore Gauges ² (2 point)	Up to 4 in (4 to 40) in	$(8.4 + 7L) \mu\text{in}$ $(3.6 + 8L) \mu\text{in}$	P&W Labmaster Universal 1000A, Gauge Blocks
Bore Gauges (3 point) ^{1,2}	Up to 8 in	$(72 + 3L) \mu\text{in}$	Ring Gauges
Calipers ^{1,2,3} (Inside and Outside)	Up to 20 in (20 to 40) in (40 to 60) in	$(280 + 10L) \mu\text{in}$ $(440 + 5L) \mu\text{in}$ $(920 + 4L) \mu\text{in}$	Gauge Blocks, Gauge Block Accessories
Chamfer Gauges ^{1,2}	Up to 1 in	$(77 + 3.2L) \mu\text{in}$	Modified Ring Gauges
Gauging Amplifiers, LVDT Heads	Up to 0.001 in	$(6.8 - 3L) \mu\text{in}$	P&W Labmaster Universal 1000A
Height Gauges ^{1,2}	Up to 24 in (24 to 40) in	$(430 + 2L) \mu\text{in}$ $(390 + 4L) \mu\text{in}$	Gauge Blocks, Surface Plate
Height Masters ² Length	Up to 24 in	$(68 + 6L) \mu\text{in}$	Gauging Amplifier, Gauge Blocks
Parallelism	Up to 0.001 in	15 μin	
Indicators ^{2,7}	(0 to 0.1) in (0.1 to 0.42) in (0.42 to 4) in (4 to 8) in	$(58 - 0.3L) \mu\text{in}$ $(58 + 0.1L) \mu\text{in}$ $(58 + 0.6L) \mu\text{in}$ $(46 + 4L) \mu\text{in}$	P&W Labmaster Universal 1000A, Gauge Blocks
Indicators ^{1,2,7}	(0 to 1) in	$(48 + 0.6L) \mu\text{in}$	Indi-Check

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometer Heads ² Length	(0 to 0.1) in (0.1 to 0.42) in (0.42 to 2) in	(11 – 2L) μin (10 + 1.6L) μin (8.9 + 4.72L) μin	P&W Labmaster Universal 1000A Gauge Blocks
Anvil Flatness	Up to 3 in Diameter	9.4 μin	Optical Flat, Monochromatic Light
Depth Micrometers ^{1,2} Length	Up to 12 in	(45 + 5L) μin	Gauge Blocks
Base Flatness	Up to 3 in	9.4 μin	Optical Flat, Monochromatic Light
Inside Micrometer ^{1,2}	Up to 4 in (4 to 20) in (21 to 40) in (41 to 60) in	(37 + 5L) μin (55 + 7L) μin (300 + 6L) μin (590 + 4L) μin	Gauge Blocks, Gauge Block Accessories
Outside Micrometer ^{1,2}	Up to 4 in (4 to 20) in (21 to 40) in (41 to 60) in	(37 + 5L) μin (55 + 7L) μin (270 + 6L) μin (580 + 5L) μin	Gauge Blocks
Micrometer Anvil Flatness	Up to 3 in Diameter	9.4 μin	Optical Flat, Monochromatic Light
Screw Thread Micrometer ^{1,2,4}	Up to 1 in	(160 + 7.7L) μin	Thread Setting Plugs
V-Anvil Micrometer ^{1,2}	(0.062 5 to 2) in	(53 + 1L) μin	Gauge Balls
Steel Rules, Tape Measures ^{2,11}	Up to 12 in	890 μin	Optical Comparator
	(1 to 300) ft	(1 800 + 5L) μin	Optodyne LDDM
Thickness Gauges ¹ (Dial & Digital)	Up to 0.5 in	60 μin	Gauge Blocks
Optical Comparators, Vision Measuring Machines ¹ Magnification	10X, 20X, 31.25X, 50X and 62.5X	0.001 2 in	Magnification Checker Glass Scale
Linear Length	X and Y Up to 6 in (6 to 12) in	110 μin 150 μin	Glass Scale Gauge Blocks
Angle	Up to 90°	0.021°	Angle Blocks

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Protractors, Inclinometers ²	Up to 90°	0.59'	Gauge Blocks, Angle Blocks, Gauging Amplifier, Sine Plate
Levels ²	Up to 1 000"	2.9"	Brunson 470 Angle Generator

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Gauges (Tension & Compression)	(0.5 to 5) lbf (5 to 50) lbf (50 to 600) lbf	0.2 % of reading + 0.000 2 lbf 0.02 % of reading + 0.008 lbf 0.02 % of reading + 0.042 lbf	NIST Class F Weights
Force Gauges (Tension & Compression)	(2.5 to 100) lbf (10 to 500) lbf (20 to 1 000) lbf	0.015 % of reading + 0.01 lbf 0.015 % of reading + 0.06 lbf 0.004 6 % of reading + 0.6 lbf	Morehouse Force Calibration System, Load Cell
Cable/Wire Tensiometers	(1 to 600) lbf	0.01 % of reading + 0.058 lbf	NIST Class F Weights
Cable/Wire Tensiometers	(600 to 1 000) lbf	0.3 % of reading + 0.18 lbf	CDI 2000 Force Tension Kit
Durometers Indenter Dimensions Angle Radius Diameter/Length	Up to 30° Up to 0.05 in Up to 0.2 in	0.065° 250 μin 180 μin	Full Verification per ASTM D2240 using STI Optical Comparator
Spring Force Types A, B, E, O Types C, D, DO	Up to 7.3 N Up to 40 N	0.087 N 0.12 N	Durometer Calibrator
Durometer Calibrator Force Types A, B, E, O Types C, D, DO	Up to 7.3 N Up to 40 N	0.000 23 N 0.000 85 N	ASTM E617 Class 1 Weights
Hydraulic Pressure – Measure/Source	(10 to 50) psig (50 to 500) psig (500 to 10 000) psig	0.011 psi 0.035 psi 0.007 9 % of reading + 0.043 psi	Fluke P3224-PSI Deadweight Tester
Low Pressure/Vacuum – Measure/Source	Up to 2 inH ₂ O	0.000 69 inH ₂ O	Dwyer 1430 Microtector
	(-20 to 20) inH ₂ O	0.003 1 inH ₂ O	Meriam 34FBT2M Manometer



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pneumatic Absolute Pressure – Measure/Source	(0.2 to 1 015) psia	0.002 3 % of reading	Ruska 2465 Deadweight Tester
Pneumatic Gauge Pressure – Measure/Source	(-14.4 to 1 000) psig	0.002 3 % of reading	Ruska 2465 Deadweight Tester
Pressure/Vacuum – Measure/Source ^{1,15}	(0 to 15) psig (-14.4 to 0) psiv (-14.4 to 30) psig Up to 100 psig Up to 500 psig Up to 1 000 psig Up to 10 000 psig	0.008 9 psi 0.011 psi 0.023 psi 0.056 psi 0.25 psi 0.59 psi 8.3 psi	Fluke 700 Series Pressure Transducers
Scales & Balances ¹ (0.000 1 g resolution)	Up to 610 g	0.000 2 % of reading + 0.1 mg	ASTM E617 Class 1 weights and NIST HB 44 utilized in the calibration of the weighing system.
Scales & Balances ¹ (0.001 g resolution)	Up to 5 000 g	0.000 2 % of reading + 1 mg	
Scales & Balances ¹ (0.01 g resolution)	Up to 35 000 g	0.000 2 % of reading + 10 mg	
Scales & Balances ¹ (0.000 1 kg resolution)	Up to 35 kg	0.000 8 % of reading + 95 mg	
Scales & Balances ¹ (0.001 lb resolution)	Up to 10 lb	0.004 % of reading + 0.001 lb	NIST Class F weights and NIST HB 44 utilized in the calibration of the weighing system.
Scales & Balances ¹ (0.01 lb resolution)	Up to 100 lb	0.005 % of reading + 0.009 5 lb	
Scales & Balances ¹ (0.1 lb resolution)	Up to 600 lb	0.003 % of reading + 0.1 lb	
Torque Indicating Devices	(15 to 200) ozf·in (4 to 50) lbf·in (30 to 400) lbf·in (80 to 1000) lbf·in (20 to 250) lbf·ft (100 to 1 000) lbf·ft (200 to 2 000) lbf·ft	0.2 % of reading + 0.05 ozf·in 0.2 % of reading + 0.009 lbf·in 0.2 % of reading + 0.06 lbf·in 0.18 % of reading + 0.98 lbf·in 0.14 % of reading + 0.4 lbf·ft 0.61 % of reading + 0.01 lbf·ft 0.5 % of reading + 0.02 lbf·ft	CDI 2000 Torque Tester
Torque Calibration Systems	(20 to 400) ozf·in (2.5 to 100) lbf·in (50 to 3 000) lbf·in (250 to 1 000) lbf·ft (200 to 2 000) lbf·ft	0.2 % of reading + 0.002 ozf·in 0.06 % of reading + 0.009 lbf·in 0.038 % of reading + 0.19 lbf·in 0.04 % of reading + 0.1 lbf·ft 0.04% of reading + 0.09 lbf·ft	CDI Torque Arms, CDI Torque Wheels, NIST Class F Weights



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Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity – Measure ^{1,15}	(10 to 30) °C (5 to 95) %RH	0.14 % of reading + 1.1 %RH	Rotronic HC2A Humidity Probe
Temperature and Humidity Devices			
Humidity	(15 to 40) °C (5 to 95) %RH	0.27 % of reading + 0.56 %RH	Thunder Scientific 2500LT Two-pressure Humidity Generation System
Temperature	(-10 to 70) °C	0.000 4 % of reading + 0.14 °C	
Radiation (Infrared) Thermometers ^{1,15}	50 °C 100 °C 200 °C 300 °C 400 °C 500 °C	0.86 °C 1.6 °C 3.1 °C 4.7 °C 6.4 °C 8.2 °C	Fluke 9132 Blackbody Source (Flat Plate) $\epsilon = 0.95, \lambda = (8 \text{ to } 14) \mu\text{m}$
Radiation (Infrared) Thermometers	-15 °C 0 °C 50 °C 100 °C 120 °C	0.78 °C 0.57 °C 0.7 °C 0.69 °C 0.75 °C	Fluke 4180 Blackbody Source (Flat Plate) $\epsilon = (0.9 \text{ to } 1), \lambda = (8 \text{ to } 14) \mu\text{m}$
	35 °C 100 °C 200 °C 350 °C 500 °C	0.54 °C 0.84 °C 1 °C 1.8 °C 2.4 °C	Fluke 4181 Blackbody Source (Flat Plate) $\epsilon = (0.9 \text{ to } 1), \lambda = (8 \text{ to } 14) \mu\text{m}$
Temperature – Source ⁸	-196 °C	0.028 °C	Fluke 7196 Liquid N ₂ Calibrator, Fluke 5628 PRT
Temperature – Source ^{1,8,15}	0.0 °C	0.058 °C	Kaye X0240 Ice Point
Temperature – Source ⁸	0.01 °C	0.005 °C	Triple Point of Water Cell
Temperature – Source	0 °C 25 °C 50 °C (-50 to 0) °C (0 to 100) °C	0.028 °C 0.025 °C 0.03 °C 0.056 °C 0.057 °C	Fluidized Baths, Thermometrics 1925-A, Fluke 5628 PRT
	Temperature – Source ⁸	(100 to 250) °C	

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Source ^{1,8,15}	(-15 to 350) °C	0.26 °C + 0.15 % of reading	Hart 9009 Drywell
Temperature – Source ⁸	(-95 to 140) °C	0.032 °C	Fluke 9190A Drywell, Fluke 5628 PRT
	(-45 to 140) °C	0.045 °C	Fluke 9170 Drywell, Fluke 5628 PRT
	(50 to 700) °C	0.003 7 % of reading + 0.087 °C	Fluke 9173 Drywell, Fluke 5628 PRT
Temperature – Measure	(-200 to 660) °C	0.004 % of reading + 0.013 °C	Comparison to Fluke 1586 Scanner, Fluke 5628 PRT
	(0 to 100) °C	0.003 % of reading + 0.009 °C	Comparison to Fluke 1586 Scanner, Thermometrics 1925-A
Temperature – Measure ^{1,15}	(-10 to 60) °C	0.4 °C	Comparison to Rotronic HygroPalm HP22-A, HC2A
Temperature – Measure ^{1,15}	(-200 to 0) °C	0.53 % of reading + 0.64 °C	Comparison to Type T Thermocouple Probe, Fluke 52 II Temperature Indicator
	(0 to 175) °C	0.06 % of reading + 0.64 °C	
	(175 to 350) °C	0.6 % of reading + 0.34 °C	
Temperature – Measure ^{1,15}	(-200 to 0) °C	0.24 % of reading + 1.2 °C	Comparison to Type K Thermocouple Probe, Fluke 52 II Temperature Indicator
	(0 to 275) °C	0.02 % of reading + 1.2 °C	
	(275 to 1 000) °C	0.4 % of reading + 0.16 °C	
Dew Point	(-25 to 69) °C	0.22 °C	Thunder Scientific 2500LT Chamber

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure	10 Hz to 1.3 GHz	5.3 pHz/Hz+ 0.1 mHz	Keysight 53220A Counter, HP 58503A GPS Receiver

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure ^{1,15}	0.1 Hz to 160 MHz	29 nHz/Hz + 6.1 mHz	Phillips PM6669 Frequency Counter, Efratom FRK-LN Oscillator
Frequency – Source	10 Hz to 1.3 GHz	59 pHz/Hz + 0.1 mHz	Comparison to Keysight 53220A Universal Counter, Efratom FRK-LN Oscillator
Contact Tachometers ^{1,2,15}	(1 to 40 000) rpm	0.88 rpm	Quantum Dynamics N-11-ECS/3A Tachometer, Keithley 53220A Counter
Non-contact Tachometers ^{1,2,15}	(25 to 90 000) rpm	0.000 2 % of reading + 0.1 rpm	Fluke 5522A Multi Product Calibrator, Light Emitting Diode
Strobe Tachometers ^{1,2,15}	(25 to 90 000) rpm	0.000 5 % of reading + 0.13 rpm	Keysight 53220A Counter, Solar Cell
Stopwatches & Timers ¹⁵	Up to 24 h	58 ms/24 h	Helmut Klein 4500 Timometer

DIMENSIONAL MEASUREMENT

1 Dimensional

Parameter	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Length Measures ²	Up to 300 in	(3 100 + 10.2L) μin	ProScale OptoDyne LDDM
Length Measures – External ^{2,9}	Up to 0.1 in (0.1 to 0.42) in (0.5 to 4) in (4 to 20) in (20 to 80) in	(3.2 – 3L) μin (2.3 + 5L) μin (1.6 + 4L) μin (0.61 + 4L) μin (75 + 5L) μin	P&W Labmaster Universal 1000A

1 Dimensional

Parameter	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Length Measures – Internal ^{2,9}	(0.01 to 0.22) in (0.22 to 1) in (1 to 2) in (2 to 3) in (3 to 4) in (4 to 7) in (7 to 10) in (10 to 13) in	(8.8 + 0.7L) μin (8 – 4.54L) μin (7.9 + 5L) μin (8.1 + 5L) μin (8.4 + 5L) μin (8.7 + 5L) μin (9.2 + 5L) μin (9.9 + 5L) μin	P&W Labmaster Universal 1000A
Length Measures – Using Hand Tools ^{2,9}	Up to 1 in	(93 + 2.44L) μin	Digital Micrometer
	Up to 8 in	(1 400 + 5L) μin	Digital Caliper

2 Dimensional

Parameter	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
2D Angles	Up to 360°	0.065°	STI Optical Comparator
2D Length ⁹	X/Y Axis: Up to 12 in	210 μin	STI Optical Comparator
Gauges and Fixtures – 2D Length ^{2,9}	X Axis: Up to 15.75 in Y Axis: Up to 15.75 in Z Axis: Up to 7.87 in	(110 + 12L) μin	Mitutoyo QV-L404Z1L-D with 1.0x, 1.5x, and 2.0x Objective Lenses
Gauges and Fixtures – 2D Angles	Up to 360°	0.015°	Mitutoyo QV-L404Z1L-D with 1.0x, 1.5x, and 2.0x Objective Lenses

3 Dimensional

Parameter	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Volumetric Measurement ^{2,9}	X Axis: Up to 35.43 in Y Axis: Up to 39.37 in Z Axis: Up to 23.62 in	(110 + 3.1L) μin	Mitutoyo Crysta-Apex S 9106 CMM with SP25M Scanning Probe
3D Angles	Up to 360°	0.02°	Mitutoyo Crysta-Apex S 9106 CMM with SP25M Scanning Probe

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 based out of the Merrillville, Indiana laboratory. 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, DL = Diagonal Length; ' = arc-minute; " = arc-second; rpm = revolutions per minute.
 3. Measurements include the following measurement functions: Outside, Inside, Step and Depth Extension Rods.
 4. Inch thread setting plugs only with 60° Included Angle.
 5. Includes 60° Metric, Unified and 55° Whitworth pitch gauges.
 6. Uncertainty is for Steel Blocks. Carbide and Ceramic Blocks may have a different uncertainty due to deformation coefficients and different coefficients of thermal expansion.
 7. Includes dial, digital and test indicators.
 8. Includes Liquid-in-Glass Thermometers, RTDs, Thermocouples, Bi-metallic Thermometers, etc. Liquid-in-Glass Thermometers are only calibrated in fluidized baths to ensure correct immersion depth and stem effect corrections.
 9. Metric equivalencies for this type of equipment are available and converted by 1 in equals 25.4 mm exactly.
 10. TPI indicates threads per inch.
 11. Verification performed in 12 ft. increments before repositioning.
 12. Includes Master Setting Discs and Progressive Diameter Plugs.
 13. This instrument/parameter has been characterized to lower the uncertainty.
 14. The stated uncertainty is associated with a primary calibration which utilizes a comparison datum set with gauge blocks rather than a master ring.
 15. On-site calibration service is available for this parameter based out of the Brookfield, Wisconsin office. 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.
 16. This scope is formatted as part of a single document including Certificate of Accreditation No. L2216.



Jason Stine, Vice President

