



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017
& ANSI/NCSL Z540-1-1994

CONSUMERS ENERGY/LABORATORY SERVICES

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CALIBRATION

Valid To: July 31, 2024

Certificate Number: 1097.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations^{1, 9}:

I. Dimensional

Parameter/Equipment	Range	CMC ^{2, 4} ($\pm$)	Comments
Steel Rules & Scales	Up to 60 in	0.0015 in	Renishaw XL-80 laser measuring system
Step Blocks	Up to 9 in	$(30 + 3.9L) \mu\text{in}$	Gage blocks & gage head amplifier
Torque Arms	5 in 10 in 24 in 60 in	0.0010 in 0.0011 in 0.0017 in 0.0051 in	End rods, gage blocks, dial indicator, micrometer
Calipers & Micrometers ³	Up to 36 in	$(9.0 + 6.0L) \mu\text{in} + 0.6R$	Gage blocks
Height Gages ³	Up to 36 in	$(86 + 1.3L) \mu\text{in} + 0.6R$	Gage blocks
Length Standards	Up to 6 in (6 to 39) in	$(6.4 + 4.3L) \mu\text{in}$ $(-22 + 8.9L) \mu\text{in}$	P&W Labmaster TM & gage blocks

II. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 5, 7} (±)	Comments
DC Voltage – Generate ³	Up to 220 mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	6.0 $\mu\text{V/V} + 0.46 \mu\text{V}$ 3.5 $\mu\text{V/V} + 0.74 \mu\text{V}$ 2.5 $\mu\text{V/V} + 2.5 \mu\text{V}$ 2.5 $\mu\text{V/V} + 4.0 \mu\text{V}$ 3.5 $\mu\text{V/V} + 40 \mu\text{V}$ 4.5 $\mu\text{V/V} + 0.40 \text{ mV}$	Fluke 5730A
Fixed Point	10 V	0.40 $\mu\text{V/V}$	Fluke 732B
DC Voltage – Measure ³	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 500) V (500 to 1000) V	10 $\mu\text{V/V} + 0.49 \mu\text{V}$ 9.2 $\mu\text{V/V} + 0.49 \mu\text{V}$ 9.2 $\mu\text{V/V} + 5.8 \mu\text{V}$ 12 $\mu\text{V/V} + 35 \mu\text{V}$ 15 $\mu\text{V/V} + 0.12 \text{ mV}$ 25 $\mu\text{V/V} + 0.12 \text{ mV}$	HP 3458A
DC High Voltage – Measure ³	(1 to 10) kV (10 to 100) kV	0.085 % 0.073 %	Agilent 34401A & divider
DC Current – Generate ³	Up to 220 μA 220 μA to 2.2 mA (2.2 to 22) mA (22 to 100) mA (100 to 220) mA 220 mA to 1 A (1 to 2.2) A (2.2 to 11) A (11 to 20.5) A (11 to 16.5) Amp Turns (16.5 to 150) Amp Turns (150 to 1000) Amp Turns	35 $\mu\text{A/A} + 6.0 \text{ nA}$ 30 $\mu\text{A/A} + 7.0 \text{ nA}$ 30 $\mu\text{A/A} + 40 \text{ nA}$ 40 $\mu\text{A/A} + 0.70 \mu\text{A}$ 50 $\mu\text{A/A} + 0.70 \mu\text{A}$ 60 $\mu\text{A/A} + 12 \mu\text{A}$ 0.011 % + 12 μA 0.034 % + 0.48 mA 0.078 % + 0.58 mA 0.20 % + 2.5 mA 0.20 % + 12 mA 0.22 % + 39 mA	Fluke 5730A Fluke 5730A, Fluke 5725A Fluke 5522A Fluke 5522A & Fluke 50 turn coil

Parameter/Equipment	Range	CMC ^{2, 5, 7} ($\pm$)	Comments
DC Current – Measure ³	(10 to 100) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	23 μ A/A + 0.93 nA 23 μ A/A + 6.0 nA 23 μ A/A + 58 nA 40 μ A/A + 0.58 μ A 0.013 % + 0.12 mA	HP 3458A
DC Resistance – Measure ³	(0 to 10) Ω (10 to 100) Ω 100 Ω to 1 k Ω (1 to 10) k Ω (10 to 100) k Ω 100 k Ω to 1 M Ω (1 to 10) M Ω (10 to 100) M Ω 100 M Ω to 1 G Ω	17 $\mu\Omega/\Omega$ + 58 $\mu\Omega$ 14 $\mu\Omega/\Omega$ + 0.58 m Ω 12 $\mu\Omega/\Omega$ + 0.58 m Ω 12 $\mu\Omega/\Omega$ + 5.8 m Ω 12 $\mu\Omega/\Omega$ + 58 m Ω 17 $\mu\Omega/\Omega$ + 2.3 Ω 58 $\mu\Omega/\Omega$ + 0.12 k Ω 0.058 % + 1.2 k Ω 0.58 % + 12 k Ω	HP 3458A
DC Resistance – Measure	(0.000 025 to 0.001) Ω (0.001 to 0.01) Ω (0.01 to 0.1) Ω (0.1 to 1) Ω 1 Ω to 10 k Ω (10 to 100) k Ω 100 k Ω to 1 M Ω (1 to 10) M Ω (10 to 100) M Ω 100 M Ω to 1 G Ω 90 k Ω to 20 M Ω (20 to 200) M Ω 200 M Ω to 2 G Ω (2 to 20) G Ω (20 to 200) G Ω 200 G Ω to 2 T Ω (2 to 20) T Ω (20 to 200) T Ω	0.0025 % + 0.071 $\mu\Omega$ 3.6 $\mu\Omega/\Omega$ 3.7 $\mu\Omega/\Omega$ 1.3 $\mu\Omega/\Omega$ 1.4 $\mu\Omega/\Omega$ 1.2 $\mu\Omega/\Omega$ 1.2 $\mu\Omega/\Omega$ 1.6 $\mu\Omega/\Omega$ 2.0 $\mu\Omega/\Omega$ 6.2 $\mu\Omega/\Omega$ 0.029 % 0.017 % 0.023 % 0.069 % 0.092 % 0.14 % 0.40 % 0.69 %	MI 6011 range extender, standard resistor & Agilent 34420A MI 6010 bridge, MI 6011 range extender & standard resistors MI 6010 bridge & standard resistors MI 6000 bridge & standard resistors Guildline 6530-XR teraohmmeter

Parameter/Equipment	Range	CMC ^{2, 5, 7} (±)	Comments
DC Resistance – Generate ³ , Fixed Points	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	40 μΩ 82 μΩ/Ω 80 μΩ/Ω 21 μΩ/Ω 21 μΩ/Ω 9.0 μΩ/Ω 9.0 μΩ/Ω 7.5 μΩ/Ω 7.6 μΩ/Ω 7.5 μΩ/Ω 7.5 μΩ/Ω 9.0 μΩ/Ω 9.0 μΩ/Ω 15 μΩ/Ω 16 μΩ/Ω 31 μΩ/Ω 40 μΩ/Ω	Fluke 5730A
	100 MΩ 1 GΩ 10 GΩ 100 GΩ 1 TΩ 10 TΩ 100 TΩ	31 μΩ/Ω 30 μΩ/Ω 0.059 % 0.064 % 0.062 % 0.060 % 2.6 %	Measurements International 9331G resistors
Capacitance – Generate ³	(0.19 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF 330 μF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	0.39 % + 0.0078 nF 0.40 % + 0.0078 nF 0.39 % + 0.0078 nF 0.22 % + 0.0078 nF 0.20 % + 0.078 nF 0.22 % + 0.078 nF 0.22 % + 0.23 nF 0.22 % + 0.000 78 μF 0.22 % + 0.0023 μF 0.22 % + 0.0078 μF 0.33 % + 0.023 μF 0.36 % + 0.078 μF 0.36 % + 0.23 μF 0.36 % + 0.000 78 mF 0.36 % + 0.0023 mF 0.36 % + 0.0078 mF 0.59 % + 0.023 mF 0.86 % + 0.078 mF	Fluke 5522A
Fixed Point	1000 pF	0.0025 %	GenRad 1404-A

Parameter/Range	Frequency	CMC ^{2, 5} (±)	Comments
AC Voltage – Generate ³			
Up 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	0.022 % + 4.0 µV 87 µV/V + 4.0 µV 78 µV/V + 4.0 µV 0.018 % + 4.0 µV 0.046 % + 5.0 µV 0.090 % + 10 µV 0.12 % + 20 µV 0.25 % + 20 µV	Fluke 5730A
(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	0.023 % + 12 µV 92 µV/V + 7.0 µV 76 µV/V + 7.0 µV 0.018 % + 7.0 µV 0.042 % + 17 µV 0.075 % + 20 µV 0.12 % + 25 µV 0.25 % + 45 µV	
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	0.022 % + 40 µV 81 µV/V + 15 µV 41 µV/V + 8.0 µV 70 µV/V + 10 µV 0.011 % + 30 µV 0.034 % + 80 µV 0.090 % + 0.20 mV 0.15 % + 0.30 mV	
(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	0.022 % + 0.40 mV 80 µV/V + 0.15 mV 40 µV/V + 50 µV 70 µV/V + 0.10 mV 96 µV/V + 0.20 mV 0.026 % + 0.60 mV 0.090 % + 2.0 mV 0.13 % + 3.2 mV	
(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	0.022 % + 4.0 mV 80 µV/V + 1.5 mV 47 µV/V + 0.60 mV 75 µV/V + 1.0 mV 0.013 % + 2.5 mV 0.080 % + 16 mV 0.42 % + 40 mV 0.72 % + 80 mV	Maximum output, capability of 2.2 x 10 ⁷ V-Hz

Parameter/Range	Frequency	CMC ^{2, 5} ($\pm$)	Comments
AC Voltage – Generate ³ (cont)			
(220 to 250) V	(15 to 50) Hz	0.026 % + 16 mV	Fluke 5730A
(220 to 1100) V	(40 to 50) Hz 50 Hz to 1 kHz	80 μ V/V + 4.0 mV 63 μ V/V + 3.5 mV	Fluke 5730A, Fluke 5725A
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.036 % + 11 mV 0.13 % + 45 mV	
(220 to 1100) V	(1 to 20) kHz (20 to 30) kHz	0.013 % + 6.0 mV 0.036 % + 11 mV	
AC Voltage – Generate			
(60 to 630) V	(47 to 63) Hz	92 μ V/V	Radian RS-933
AC Voltage – Measure ³			
(1 to 10) mV	(1 to 40) Hz	0.035 % + 3.5 μ V	HP 3458A
(10 to 100) mV	(1 to 40) Hz	88 μ V/V + 4.6 μ V	
100 mV to 1 V	(1 to 40) Hz	81 μ V/V + 46 μ V	
(1 to 10) V	(1 to 40) Hz	81 μ V/V + 0.46 mV	
(10 to 100) V	(1 to 40) Hz	0.023 % + 4.6 mV	
(100 to 700) V	(1 to 40) Hz	0.046 % + 46 mV	
(40 to 600) V	(47 to 63) Hz	70 μ V/V	Radian RD-22
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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.17 % + 1.3 μ V 0.074 % + 1.3 μ V 0.042 % + 1.3 μ V 0.081 % + 2.0 μ V 0.12 % + 2.5 μ V 0.23 % + 4.0 μ V 0.26 % + 8.0 μ V 0.50 % + 8.0 μ V 0.11 % + 1.5 μ V 0.26 % + 1.5 μ V 0.45 % + 1.5 μ V 1.1 % + 3.0 μ V	Fluke 5790B, frequencies > 1 MHz are referenced to 1 kHz

Parameter/Range	Frequency	CMC ^{2, 5, 7} ($\pm$)	Comments
AC Voltage – Measure ³ (cont)			
(2.2 to 7) 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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.085 % + 1.3 μ V 0.037 % + 1.3 μ V 0.021 % + 1.3 μ V 0.041 % + 2.0 μ V 0.061 % + 2.5 μ V 0.12 % + 4.0 μ V 0.14 % + 8.0 μ V 0.36 % + 8.0 μ V 0.11 % + 1.5 μ V 0.15 % + 1.5 μ V 0.26 % + 1.5 μ V 0.56 % + 1.5 μ V	Fluke 5790B, frequencies > 1 MHz are referenced to 1 kHz
(7 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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.029 % + 1.3 μ V 0.019 % + 1.3 μ V 0.011 % + 1.3 μ V 0.021 % + 2.0 μ V 0.031 % + 2.5 μ V 0.082 % + 4.0 μ V 0.10 % + 8.0 μ V 0.26 % + 8.0 μ V 0.11 % + 1.5 μ V 0.15 % + 1.5 μ V 0.26 % + 1.5 μ V 0.56 % + 1.5 μ V	
(22 to 70) 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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.024 % + 1.5 μ V 0.012 % + 1.5 μ V 0.0069 % + 2.5 μ V 0.013 % + 2.0 μ V 0.026 % + 2.5 μ V 0.053 % + 4.0 μ V 0.068 % + 8.0 μ V 0.13 % + 8.0 μ V 0.075 % 0.15 % 0.23 % 0.53 %	

Parameter/Range	Frequency	CMC ^{2, 5, 7} ($\pm$)	Comments
AC Voltage – Measure ³ (cont)			
(70 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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.021 % + 1.5 μ V 0.0087 % + 1.5 μ V 0.0043 % + 1.5 μ V 0.0073 % + 2.0 μ V 0.016 % + 2.5 μ V 0.028 % + 4.0 μ V 0.040 % + 8.0 μ V 0.12 % + 8.0 μ V 0.075 % 0.15 % 0.23 % 0.53 %	Fluke 5790B, frequencies > 1 MHz are referenced to 1 kHz
(220 to 700) 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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.021 % + 1.5 μ V 0.0078 % + 1.5 μ V 0.0038 % + 1.5 μ V 0.0056 % + 2.0 μ V 0.0084 % + 2.5 μ V 0.021 % + 4.0 μ V 0.034 % + 8.0 μ V 0.12 % + 8.0 μ V 0.075 % 0.15 % 0.23 % 0.53 %	
700 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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.020 % 0.0069 % 0.0029 % 0.0052 % 0.0076 % 0.020 % 0.031 % 0.12 % 0.075 % 0.15 % 0.23 % 0.53 %	

Parameter/Range	Frequency	CMC ^{2, 5, 7} (±)	Comments
AC Voltage – Measure ³ (cont)			
(2.2 to 7) 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 (0.5 to 1) MHz (1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.020 % 0.0070 % 0.0029 % 0.0053 % 0.0088 % 0.022 % 0.047 % 0.15 % 0.075 % 0.15 % 0.23 % 0.53 %	Fluke 5790B, frequencies > 1 MHz are referenced to 1 kHz
(7 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 (0.5 to 1) MHz	0.020 % 0.0070 % 0.0031 % 0.0053 % 0.0085 % 0.022 % 0.047 % 0.15 %	
(22 to 70) 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 (0.5 to 1) MHz	0.020 % 0.0072 % 0.0039 % 0.0063 % 0.011 % 0.022 % 0.051 % 0.15 %	
(70 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	0.020 % 0.0072 % 0.0038 % 0.0077 % 0.011 % 0.026 % 0.070 %	
(220 to 700) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.020 % 0.011 % 0.0047 % 0.015 % 0.085 %	
(700 to 1000) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.020 % 0.011 % 0.0040 % 0.015 % 0.085 %	

Parameter/Range	Frequency	CMC ^{2, 5, 7} ($\pm$)	Comments
AC Voltage – Measure			
(1 to 10) kV (10 to 50) kV	60 Hz 60 Hz	0.57 % 0.49 %	Agilent 34401A & HV divider
AC Current – Generate ³			
(9 to 220) μ A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.023 % + 16 nA 0.014 % + 10 nA 0.011 % + 8.0 nA 0.025 % + 12 nA 0.090 % + 65 nA	Fluke 5730A
220 μ A 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	0.023 % + 40 nA 0.014 % + 35 nA 0.011 % + 35 nA 0.018 % + 0.11 μ A 0.090 % + 0.65 μ A	
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.023 % + 0.40 μ A 0.014 % + 0.35 μ A 0.011 % + 0.35 μ A 0.018 % + 0.55 μ A 0.090 % + 5.0 μ A	
(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	0.023 % + 4.0 μ A 0.014 % + 3.5 μ A 0.011 % + 2.5 μ A 0.018 % + 3.5 μ A 0.090 % + 10 μ A	
220 mA to 2.2 A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.024 % + 35 μ A 0.039 % + 80 μ A 0.60 % + 0.16 mA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.040 % + 0.17 mA 0.085 % + 0.38 mA 0.33 % + 0.75 mA	Fluke 5730A, Fluke 5725A
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.093 % + 1.6 mA 0.12 % + 3.9 mA 2.3 % + 3.9 mA	Fluke 5522A
(11 to 16.5) Amp Turns	(45 to 65) Hz (65 to 440) Hz	0.23 % + 0.0023 A 0.62 % + 0.0023 A	Fluke 5522A & Fluke 50 turn coil
(16.5 to 150) Amp Turns	(45 to 65) Hz (65 to 440) Hz	0.23 % + 0.019 A 0.62 % + 0.021 A	
(150 to 1000) Amp Turns	(45 to 65) Hz (65 to 440) Hz	0.24 % + 0.070 A 0.62 % + 0.078 A	

Parameter/Equipment	Range	CMC ^{2, 5, 7} (±)	Comments
AC Power – Generate (47 to 63) Hz (60 to 600) V (0.2 to 200) A (0 to 360) °	(1 to 120k) W, VAR, or VA	0.0098 %	Radian RS-933
AC Power – Measure (47 to 63) Hz (60 to 600) V (0.2 to 200) A (0 to 360) °	(1 to 120k) W, VAR, or VA	0.0072 %	Radian RD-22
AC Energy – Generate (47 to 63) Hz (60 to 600) V (0.2 to 200) A (0 to 360) ° 5s to 10min.	(0.01 to 20k) Wh, VARh, or VAh	0.0098 %	Radian RS-933
AC Energy – Measure (47 to 63) Hz (60 to 600) V (0.2 to 200) A (0 to 360) ° 5 s to 10 min	(0.01 to 20k) Wh, VARh, or VAh	0.0078 %	Radian RD-22
Thermocouple Indicators ³ – Type E Type J Type K Type T	 (-270 to -180) °C (-180 to 1000) °C (-210 to 1200) °C (-200 to 1372) °C (-250 to -180) °C (-180 to 400) °C	 0.32 °C 0.075 °C 0.067 °C 0.073 °C 0.11 °C 0.069 °C	 Fluke 5730A with ice bath

III. Fluid Quantities

Parameter/Equipment	Range	CMC ^{2, 7} (±)	Comments
Specific Gravity – Hydrometers & Density Meters	(0.60 to 1.60) specific gravity	0.000 25 specific gravity	By mass measurement

IV. Mechanical

Parameter/Equipment	Range	CMC ^{2, 7, 10} (±)	Comments
Mass	1 mg to 5g (5 to 10) g (10 to 100) g (100 to 200) g 200 g to 2 kg (2 to 5) kg (5 to 10) kg (10 to 30) kg	0.036 mg 0.069 mg 0.20 mg 0.45 mg 8.2 mg 17 mg 36 mg 120 mg	Single substitution
Force – Measuring Equipment (Compression & Tension)	(0.25 to 500) lbf	0.018 %	Deadweights
Force – Measuring Equipment & Measure (Compression & Tension)	(500 to 2000) lbf (2000 to 5000) lbf (5000 to 25 000) lbf (25 000 to 50 000) lbf (50 000 to 100 000) lbf	0.054 % 0.063 % 0.061 % 0.056 % 0.061 %	Load cells
Vibration – Measuring Equipment & Accelerometers	(0.5 to 1) Hz (1 to 10) Hz (10 to 100) Hz 100 Hz 100 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 15) kHz	2.2 % 1.1 % 0.67 % 0.50 % 0.68 % 1.0 % 2.0 % 3.0 %	Direct comparison to reference accelerometer, long stroke & air bearing shakers

Parameter/Equipment	Range	CMC ^{2,7} ($\pm$)	Comments
Torque Wrench ⁸	(2.5 to 20) lbf·in (20 to 100) lbf·in (8.33 to 100) lbf·in (100 to 1000) lbf·in (1000 to 4000) lbf·in (4000 to 6500) lbf·in	1.0 % + 0.0062 lbf·in 1.0 % + 0.010 lbf·in 1.0 % + 0.023 lbf·in 1.0 % + 0.23 lbf·in 1.0 % + 2.1 lbf·in 1.0 % + 2.4 lbf·in	Torque transducers
Torque Cells	(2.5 to 20) lbf·in (10 to 100) lbf·in (30 to 600) lbf·in (8 to 100) lbf·in (80 to 1000) lbf·in (1000 to 6500) lbf·in	0.052 % + 0.000 82 lbf·in 0.042 % + 0.000 55 lbf·in 0.041 % + 0.0087 lbf·in 0.040 % + 0.0033 lbf·in 0.10 % + 0.0030 lbf·in 0.060 % + 0.25 lbf·in	Moment arm/weights
Pressure – Gauge, Hydraulic	350 kPa to 16.5 MPa (50 to 2400) psi (6.9 to 83) MPa (1000 to 12 000) psi	0.0042 % + 66 Pa 0.0042 % + 0.0095 psi 0.0042 % + 68 Pa 0.0042 % + 0.0098 psi	Hydraulic piston gage
Pressure – Gauge, Pneumatic	(4 to 350) KPa (0.6 to 50) psi (20 to 3500) KPa (3 to 500) psi (40 to 7000) KPa (5.8 to 1000) psi	0.0015 % + 0.58 Pa 0.0015 % + 0.000 085 psi 0.0020 % + 1.1 Pa 0.0020 % + 0.000 16 psi 0.0021 % + 13 Pa 0.0021 % + 0.0019 psi	Fluke PG7601 pneumatic piston gage

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
Pressure – Absolute			
Hydraulic	450 kPa to 17 MPa (65 to 2415) psi	0.0042 % + 70 Pa 0.0042 % + 0.010 psi	Hydraulic piston gage
	(7 to 83) MPa (1015 to 12 015) psi	0.0042 % + 76 Pa 0.0042 % + 0.011 psi	
Pneumatic	(7 to 350) KPa (1 to 50) psi	0.0015 % + 0.71 Pa 0.0015 % + 0.000 10 psi	Fluke PG7601 pneumatic piston gage
	(50 to 3500) KPa (7.3 to 500) psi	0.0020 % + 1.2 Pa 0.0020 % + 0.000 17 psi	
	(100 to 7000) KPa (14.5 to 1000) psi	0.0021 % + 13 Pa 0.0021 % + 0.0019 psi	
Differential/Gauge (Pneumatic)	(-15 to -9) kPa (-9 to 9) kPa (9 to 15) kPa	0.012 % + 0.000 16 kPa 0.0011 kPa 0.012 % + 0.000 16 kPa	DHI PPC3 controller with BG15ks sensor
Negative Gauge Pressure	(0 to -9.3) kPa (-9.3 to -100) kPa	0.0026 kPa 0.010 % + 0.0019 kPa	DHI PPC3 controller with A200 kp sensor
	(0 to -1.35) psi (-1.35 to -15) psi	0.000 38 psi 0.010 % + 0.000 28 psi	
Tachometers ³ – Revolutions Per Minute			
Contact ⁸	(2 to 4000) fpm (1 to 2000) rpm	(0.55 + 0.000 09X) fpm 0.058 rpm	Adapter plate Keysight 33622A signal generator; X is the measured value in fpm; fpm=feet per minute
Photo/LED ⁸	(1 to 100 000) rpm	0.000 43 %	Keysight 33622A & LED

V. Optical Quantities

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
Illuminance – Light Meters	(5 to 50) fc (50 to 100) fc (100 to 500) fc (500 to 900) fc	0.70 % (0.008X - 0.10) fc (0.000 012X ² + 0.0063X + 0.11) fc (0.000 007 5X ² + 0.011X – 0.93) fc	NIST standard lamps at 2856K; X is the nominal illuminance level in foot candles (fc)
Irradiance – Ultraviolet Light Meters @ 365 nm	(200 to 8000) $\mu\text{W}/\text{cm}^2$	6.0 % + 1.2 $\mu\text{W}/\text{cm}^2$	365 nm detector system
Optical Transmission Density – Densitometer Film	(0.1 to 1) d (1 to 4) d (0.1 to 1) d (1 to 4) d	0.0046 d 0.015 d 0.0046 d 0.015 d	SRM; d = transmission density Densitometer

VI. Thermodynamics

Parameter/Equipment	Range ⁶	CMC ^{2, 7, 10} (±)	Comments
Temperature – Measuring Equipment			
Hg	-38.8344 °C	0.0015 °C	Freezing/melting point standards & SPRT
Triple Point of Water	0.01 °C	0.0012 °C	
Ga	29.7646 °C	0.0016 °C	
Sn	231.928 °C	0.0022 °C	
Zn	419.527 °C	0.0040 °C	
Liquid Nitrogen	(-194 to -197) °C	0.0027 °C	SPRT, indicator, liquid nitrogen bath
	0 °C	0.010 °C	Ice bath
Temperature – Measure ³	(-195 to -50) °C (-50 to 0) °C (0 to 100) °C (100 to 200) °C (200 to 420) °C (420 to 660) °C	0.0081 °C 0.0056 °C 0.0067 °C 0.0072 °C 0.0080 °C 0.010 °C	SPRT & indicator
Temperature – Measuring Equipment, IR Thermometers	(-15 to 0) °C (0 to 100) °C (100 to 120) °C (120 to 200) °C (200 to 350) °C (350 to 500) °C	0.65 °C 0.78 °C 0.83 °C 1.0 °C 1.8 °C 2.3 °C	Fluke 4180 IR calibrator Fluke 4181 IR calibrator
Relative Humidity ³ – Measure	(10 to 90) % RH	1.1 % RH	Vaisala HM70 & Thunder Scientific 2500
Relative Humidity – Measuring Equipment	(10 to 90) % RH	0.30 % + 0.24 % RH	Thunder Scientific 2500
Dew Point ³ – Measure	(-50 to 20) °C	0.23 °C	Chilled mirror

Parameter/Equipment	Range ⁶	CMC ^{2, 10} ($\pm$)	Comments
Dew Point – Measuring Equipment	(-15 to 30) °C	0.15 °C	Thunder Scientific 2500

VII. Time & Frequency

Parameter/Range	Frequency ⁶	CMC ^{2, 10} ($\pm$)	Comments
Frequency – Generate	10 MHz	2.7 parts in 10^{10}	Spectracom SecureSync with GPS to NIST
Frequency – Measuring Equipment ⁸	1 mHz to 3 GHz	2.7 parts in 10^{10}	Keysight 33622A & N9310 signal generators with 10 MHz distributed reference signal
Frequency – Measure ⁸	1 mHz to 6 GHz	2.7 parts in 10^{10}	Keysight 53230A frequency counter with 10 MHz distributed reference signal

¹ This laboratory offers commercial calibration service and field calibration service, where noted.

² Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

³ Field calibration service is available for this calibration. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

- ⁴ In the statement of CMC, L is the length of the unit under test in inches; R is the numerical value of the resolution of the device in its respective units.
- ⁵ The stated measured values are determined using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure or generate the measured value in the ranges indicated. CMC's are expressed as either a specific value that covers the full range or as a percent or fraction of the reading/output plus a fixed floor specification.
- ⁶ Where ranges are not specified, the CMC stated is for the cardinal points only.
- ⁷ In the statement of CMC, percentages are to be read as percent of reading, unless otherwise indicated.
- ⁸ Uncertainty contribution due to the UUT is not included.
- ⁹ This scope meets A2LA's *P112 Flexible Scope Policy*.
- ¹⁰ The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter.



Accredited Laboratory

A2LA has accredited

CONSUMERS ENERGY/LABORATORY SERVICES

Jackson, MI

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and R205 – Specific Requirements: Calibration Laboratory Accreditation Program. 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).



Presented this 28th day of September 2022.

A blue ink signature of the Vice President of Accreditation Services.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1097.01
Valid to July 31, 2024
Revised October 5, 2023

For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.