



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, 2020

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^{1,10}:

I. Dimensional

Parameter/Equipment	Range	CMC ^{2, 4, 11} (\pm)	Comments
Steel Rules and Scales	Up to 60 in	0.0015 in	Renishaw ML10 laser measuring system
Step Blocks	Up to 9 in	(30 + 3.9L) μ in	Gage blocks and 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 and Micrometers ³	Up to 36 in	(9.0 + 6.0L) μ in + 0.6R	Gage blocks
Height Gages ³	Up to 36 in	(86 + 1.3L) μ in + 0.6R	Gage blocks
Length Standards	Up to 6 in (6 to 39) in	(6.4 + 4.3L) μ in (-22 + 8.9L) μ in	P&W Labmaster TM and gage blocks

II. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 5, 6, 8} (\pm)	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 μ V/V + 0.46 μ V 3.5 μ V/V + 0.74 μ V 2.5 μ V/V + 2.5 μ V 2.5 μ V/V + 4.0 μ V 3.5 μ V/V + 40 μ V 4.5 μ V/V + 400 μ V	Fluke 5720A
Fixed Point	10 V	0.40 μ 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 μ V/V + 0.49 μ V 9.2 μ V/V + 0.49 μ V 9.2 μ V/V + 5.8 μ V 12 μ V/V + 35 μ V 15 μ V/V + 0.12 mV 25 μ V/V + 0.12 mV	HP 3458A
DC High Voltage – Measure ³	(1 to 10) kV (10 to 100) kV	0.084 % 0.072 %	Agilent 34401A and divider
DC Current – Generate ³	Up to 220 μ A 220 μ A 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 μ A/A + 6.0 nA 30 μ A/A + 7.0 nA 30 μ A/A + 40 nA 40 μ A/A + 0.70 μ A 50 μ A/A + 0.70 μ A 60 μ A/A + 12 μ A 0.011 % + 12 μ A 0.034 % + 0.48 mA 0.078 % + 0.58 mA 0.20 % + 2.5 mA 0.20 % + 12 mA 0.22 % + 39 mA	Fluke 5720A Fluke 5720A, Fluke 5725A Fluke 5520A Fluke 5520A and Fluke 50 turn coil

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	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 parts in 10 ⁶ Ω 3.7 parts in 10 ⁶ Ω 1.3 parts in 10 ⁶ Ω 1.4 parts in 10 ⁶ Ω 1.1 parts in 10 ⁶ Ω 1.2 parts in 10 ⁶ Ω 1.6 parts in 10 ⁶ Ω 2.8 parts in 10 ⁶ Ω 3.7 parts in 10 ⁶ Ω 0.029 % 0.017 % 0.023 % 0.069 % 0.092 % 0.14 % 0.40 % 0.69 %	MI 6011 range extender / standard resistor and Agilent 34420A MI 6010 bridge / MI6011 range extender and standard resistors MI6010 bridge and standard resistors MI6000A high resistance bridge and standard resistors Guildline 6520 teraohmmeter

Parameter/Equipment	Range	CMC ^{2, 5, 8} (±)	Comments		
DC Resistance – Generate ³ , Fixed Points	0 Ω	40 μΩ	Fluke 5720A		
	1 Ω	82 μΩ/Ω			
	1.9 Ω	80 μΩ/Ω			
	10 Ω	21 μΩ/Ω			
	19 Ω	21 μΩ/Ω			
	100 Ω	9.0 μΩ/Ω			
	190 Ω	9.0 μΩ/Ω			
	1 kΩ	7.5 μΩ/Ω			
	1.9 kΩ	7.6 μΩ/Ω			
	10 kΩ	7.5 μΩ/Ω			
	19 kΩ	7.5 μΩ/Ω			
	100 kΩ	9.0 μΩ/Ω			
	190 kΩ	9.0 μΩ/Ω			
	1 MΩ	15 μΩ/Ω			
	1.9 MΩ	16 μΩ/Ω			
	10 MΩ	31 μΩ/Ω			
	19 MΩ	40 μΩ/Ω			
		100 MΩ		31 μΩ/Ω	Measurements International 9331G resistors
		1 GΩ		30 μΩ/Ω	
		10 GΩ	0.059 %		
	100 GΩ	0.064 %			
	1 TΩ	0.062 %			
	10 TΩ	0.060 %			
	100 TΩ	2.3 %			
Capacitance – Generate	(0.19 to 0.4) nF	0.39 % + 0.0078 nF	Fluke 5520A		
	(0.4 to 1.1) nF	0.40 % + 0.0078 nF			
	(1.1 to 3.3) nF	0.39 % + 0.0078 nF			
	(3.3 to 11) nF	0.22 % + 0.0078 nF			
	(11 to 33) nF	0.20 % + 0.078 nF			
	(33 to 110) nF	0.22 % + 0.078 nF			
	(110 to 330) nF	0.22 % + 0.23 nF			
	330 nF to 1.1 μF	0.22 % + 0.000 78 μF			
	(1.1 to 3.3) μF	0.22 % + 0.0023 μF			
	(3.3 to 11) μF	0.22 % + 0.0078 μF			
	(11 to 33) μF	0.33 % + 0.023 μF			
	(33 to 110) μF	0.36 % + 0.078 μF			
	(110 to 330) μF	0.36 % + 0.24 μF			
	330 μF to 1.1 mF	0.36 % + 0.000 78 mF			
	(1.1 to 3.3) mF	0.36 % + 0.0023 mF			
	(3.3 to 11) mF	0.36 % + 0.0078 mF			
	(11 to 33) mF	0.59 % + 0.023 mF			
(33 to 110) mF	0.86 % + 0.078 mF				
Fixed Point	1000 pF	0.0025 %	GenRad 1404-A		

Parameter/Equipment	Range	CMC ^{2, 5, 8} (±)	Comments
Capacitance – Measure	10 aF to 11.11 µF	0.012 % + 0.000 40 pF	Gen Rad 1620 capacitance measuring bridge with 1615-P1 range extension capacitor
Oscilloscopes –			
Amplitude DC			
DC Signal			
50 Ω load	(0 to ± 6.6) V	0.21 % + 31 µV	Fluke 5520A with SC1100 scope option
1 MΩ load	(0 to ± 130) V	0.046 % + 31 µV	
Amplitude – Square Wave (pk - pk)			
50 Ω Load	±1 mV to ± 6.6 V	0.20 % + 31 µV	Fluke 5520A with SC1100 scope option
1 MΩ Load	±1 mV to ± 130 V	0.081 % + 31 µV (≤ 1 kHz) 0.20 % + 31 µV (> 1 kHz)	
Leveled Sine Wave (Into 50 Ω Load)	50 kHz Reference 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	1.6 % + 300 µV 2.7 % + 300 µV 3.1 % + 300 µV 4.7 % + 300 µV 5.4 % + 300 mV	
Flatness @ 50 kHz Reference	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	1.2 % + 100 µV 1.6 % + 100 µV 3.1 % + 100 µV 3.9 % + 100 µV	
Time Marker (Into 50 Ω)	5 s to 50 ms 20 ms to 1 ns	(22 + 1000 <i>t</i>) µs/s 1.9 µs/s	<i>t</i> is the numerical value of the time in seconds
Edge Spec (Rise Time)	≤ 300 ps	(+0 ps / -78 ps)	

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 5720A
(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 + 100 μV 96 μV/V + 200 μV 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	2.2x10 ⁷ V-Hz

Parameter/Range	Frequency	CMC ^{2,5,6} (±)	Comments
AC Voltage – Generate ³ (cont)			
(220 to 250) V	(15 to 50) Hz	0.026 % + 16 mV	Fluke 5720A
(220 to 1100) V	50 Hz 50 Hz to 1 kHz	80 μV/V + 4.0 mV 63 μV/V + 3.5 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.036 % + 11 mV 0.13 % + 45 mV	Fluke 5720A Fluke 5725A
(220 to 1100) V	(1 to 20) kHz (20 to 30) kHz	0.013 % + 6.0 mV 0.036 % + 11 mV	
AC Voltage – Measure ³			
(1 to 10) mV	(1 to 40) Hz	0.035 % + 3.5 μV	HP 3458A
(10 to 100) mV	(1 to 40) Hz	88 μV/V + 4.6 μV	
100 mV to 1 V	(1 to 40) Hz	81 μV/V + 46 μV	
(1 to 10) V	(1 to 40) Hz	81 μV/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	
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 μV 0.074 % + 1.3 μV 0.042 % + 1.3 μV 0.081 % + 2.0 μV 0.12 % + 2.5 μV 0.23 % + 4.0 μV 0.26 % + 8.0 μV 0.50 % + 8.0 μV 0.11 % + 1.5 μV 0.26 % + 1.5 μV 0.45 % + 1.5 μV 1.1 % + 3.0 μV	Fluke 5790A frequencies ≥ 1 MHz are referenced to 1 kHz

Parameter/Range	Frequency	CMC ^{2, 5, 8} (±)	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 μV 0.037 % + 1.3 μV 0.021 % + 1.3 μV 0.041 % + 2.0 μV 0.061 % + 2.5 μV 0.12 % + 4.0 μV 0.14 % + 8.0 μV 0.36 % + 8.0 μV 0.11 % + 1.5 μV 0.15 % + 1.5 μV 0.26 % + 1.5 μV 0.56 % + 1.5 μV	Fluke 5790A 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 μV 0.019 % + 1.3 μV 0.011 % + 1.3 μV 0.021 % + 2.0 μV 0.031 % + 2.5 μV 0.082 % + 4.0 μV 0.10 % + 8.0 μV 0.26 % + 8.0 μV 0.11 % + 1.5 μV 0.15 % + 1.5 μV 0.26 % + 1.5 μV 0.56 % + 1.5 μV	
(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 μV 0.012 % + 1.5 μV 0.0069 % + 2.5 μV 0.013 % + 2.0 μV 0.026 % + 2.5 μV 0.053 % + 4.0 μV 0.068 % + 8.0 μV 0.13 % + 8.0 μV 0.075 % 0.15 % 0.23 % 0.53 %	

Parameter/Range	Frequency	CMC ^{2, 5, 8} (\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 5790A frequencies \geq 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 ^{2,5,8} (±)	Comments
AC Voltage – Measure ³ (cont)			
(2.2 to 7) V	(10 to 20) Hz	0.020 %	Fluke 5790A frequencies ≥ 1 MHz are referenced to 1 kHz
	(20 to 40) Hz	0.0070 %	
	40 Hz to 20 kHz	0.0029 %	
	(20 to 50) kHz	0.0053 %	
	(50 to 100) kHz	0.0088 %	
	(100 to 300) kHz	0.022 %	
	(300 to 500) kHz	0.047 %	
	(0.5 to 1) MHz	0.15 %	
	(1 to 2) MHz	0.075 %	
	(2 to 10) MHz	0.15 %	
	(10 to 20) MHz	0.23 %	
(20 to 30) MHz	0.53 %		
(7 to 22) V	(10 to 20) Hz	0.020 %	
	(20 to 40) Hz	0.0070 %	
	40 Hz to 20 kHz	0.0031 %	
	(20 to 50) kHz	0.0053 %	
	(50 to 100) kHz	0.0085 %	
	(100 to 300) kHz	0.022 %	
	(300 to 500) kHz	0.047 %	
	(0.5 to 1) MHz	0.15 %	
(22 to 70) V	(10 to 20) Hz	0.020 %	
	(20 to 40) Hz	0.0072 %	
	40 Hz to 20 kHz	0.0039 %	
	(20 to 50) kHz	0.0063 %	
	(50 to 100) kHz	0.011 %	
	(100 to 300) kHz	0.022 %	
	(300 to 500) kHz	0.051 %	
	(0.5 to 1) MHz	0.15 %	
(70 to 220) V	(10 to 20) Hz	0.020 %	
	(20 to 40) Hz	0.0072 %	
	40 Hz to 20 kHz	0.0038 %	
	(20 to 50) kHz	0.0077 %	
	(50 to 100) kHz	0.011 %	
	(100 to 300) kHz	0.026 %	
	(300 to 500) kHz	0.070 %	
(220 to 700) V	(10 to 20) Hz	0.020 %	
	(20 to 40) Hz	0.011 %	
	40 Hz to 20 kHz	0.0047 %	
	(20 to 50) kHz	0.015 %	
	(50 to 100) kHz	0.085 %	
(700 to 1000) V	(10 to 20) Hz	0.020 %	
	(20 to 40) Hz	0.011 %	
	40 Hz to 20 kHz	0.0040 %	
	(20 to 50) kHz	0.015 %	
	(50 to 100) kHz	0.085 %	

Parameter/Range	Frequency	CMC ^{2, 5, 8} (±)	Comments
AC Voltage – Measure (1 to 10) kV (10 to 50) kV	60 Hz 60 Hz	0.57 % 0.46 %	Agilent 34401A and HV divider
AC Current – Generate ³ Up to 220 µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.023 % + 16 nA 0.014 % + 10 nA 0.011 % + 8.0 nA 0.025 % + 12 nA 0.090 % + 65 nA	Fluke 5720A
220 µA 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 0.025 % + 110 nA 0.090 % + 65 nA	
(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 µA 0.014 % + 0.35 µA 0.011 % + 0.35 µA 0.018 % + 0.55 µA 0.090 % + 5.0 µA	
(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 µA 0.014 % + 3.5 µA 0.011 % + 2.5 µA 0.018 % + 3.5 µA 0.090 % + 10 µA	
220 mA to 2.2 A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.024 % + 35 µA 0.039 % + 80 µA 0.60 % + 160 µA	
(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 % + 0.39 mA 0.33 % + 0.75 mA	Fluke 5720A, 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 5520A
(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 5520A and 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/Range	Frequency	CMC ^{2, 5, 6, 8} (±)	Comments
AC Current – Measure ³			
(5 to 100) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz	0.46 % + 35 nA 0.17 % + 35 nA 0.069 % + 35 nA	HP 3458A
100 µA to 1 mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % + 0.23 µA 0.17 % + 0.23 µA 0.069 % + 0.23 µA 0.035 % + 0.23 µA	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % + 2.3 µA 0.17 % + 2.3 µA 0.069 % + 2.3 µA 0.035 % + 2.3 µA	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % + 23 µA 0.17 % + 23 µA 0.069 % + 23 µA 0.035 % + 23 µA	
100 mA to 1 A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % + 0.23 mA 0.18 % + 0.23 mA 0.092 % + 0.23 mA 0.12 % + 0.23 mA	
Phase Angle ³ –			
(0 to 360)°	(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	0.082° 0.19° 0.39° 1.9° 3.9° 7.8°	Fluke 5520A

Parameter/Equipment	Range	CMC ^{2, 8, 11} (±)	Comments
AC Energy – Generate @ (47 to 63) Hz (63 to 630) VAC	200 mA to 200 A (0 to 360)° Phase Angle	0.010 %	Radian RD-22-331 Watt-hour Standard and Radian RS-933 Watt-hour calibration system
AC Energy – Measure @ (47 to 63) Hz (63 to 630) VAC	200 mA to 200 A (0 to 360)° Phase Angle	0.0078 %	Radian RD-22-331 Watt-hour standard
Thermocouple Indicators ³ – Type J Type K Type T Type E	(-210 to 1200) °C (-200 to 1372) °C (-250 to -180) °C (-180 to 400) °C (-270 to -180) °C (-180 to 1000) °C	0.067 °C 0.069 °C 0.11 °C 0.070 °C 0.32 °C 0.075 °C	Fluke 5720A with ice bath

III. Fluid Quantities

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
Gas Flow – Air Flow Meters	(5 to 20) sccm (20 to 200) sccm (0.2 to 2) L/min (2 to 20) L/min (0.5 to 65) ft ³ /min (7.5 to 50) L/min	0.048 sccm 0.25 % 0.24 % 0.28 % 0.38 % 0.22 %	DHI molbocs Sonic venturis
Specific Gravity – Hydrometers and Density Meters	(0.60 to 1.60) specific gravity	0.000 25 specific gravity	By mass measurement

IV. Mechanical

Parameter/Equipment	Range	CMC ^{2, 8, 11} (±)	Comments
Mass	1mg 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 0.28 mg 0.45 mg 8.1 mg 14 mg 36 mg 120 mg	Single substitution
Force – Compression and Tension	(0 to 500) lbf (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	0.018 % 0.054 % 0.066 % 0.061 % 0.057 % 0.061 %	Deadweights Load cells
Vibration and 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 long stroke and air bearing shakers

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
Torque Wrench ⁹	(2.5 to 12.5) in·lbf (12.5 to 20) in·lbf	0.45 % + 0.0070 in·lbf 0.059 in·lbf	Torque transducers
	(20 to 100) in·lbf	0.24 %	
	(8 to 60) ft·lbf (60 to 100) ft·lbf	0.50 % + 0.016 ft·lbf 0.30 ft·lbf	
	(100 to 500) ft·lbf (500 to 1000) ft·lbf	0.45 % + 0.12 ft·lbf 2.5 ft·lbf	
	(1000 to 1600) ft·lbf (1600 to 2600) ft·lbf	0.58 % + 0.055 ft·lbf 0.60 %	
	(2600 to 6500) ft·lbf	16 ft·lbf	
Torque Cells	(2.5 to 20) in·lbf	0.052 % + 0.000 82 in·lbf	Moment arm/weights
	(10 to 100) in·lbf	0.042 % + 0.000 55 in·lbf	
	(10 to 100) ft·lbf	0.040 % + 0.0033 ft·lbf	
	(80 to 1000) ft·lbf	0.10 % + 0.0030 ft·lbf	
	(1000 to 6500) ft·lbf	0.060 % + 0.25 ft·lbf	
Pressure – Gauge, Hydraulic	350 kPa to 16.5 MPa (50 to 2400) psi	0.0042 % + 66 Pa 0.0042 % + 0.0095 psi	Hydraulic piston gage
	(6.9 to 83) MPa (1000 to 12 000) psi	0.0042 % + 68 Pa 0.0042 % + 0.0098 psi	
Pressure – Gauge, Pneumatic	(4 to 350) KPa (0.6 to 50) psi	0.0012 % + 0.58 Pa 0.0012 % + 0.000 085 psi	Fluke PG7601 pneumatic piston gage
	(20 to 3500) KPa (3 to 500) psi	0.0018 % + 1.1 Pa 0.0018 % + 0.000 16 psi	
	(40 to 7000) KPa (5.8 to 1000) psi	0.0019 % + 13 Pa 0.0019 % + 0.0019 psi	

Parameter/Equipment	Range	CMC ^{2, 8, 11} (±)	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)	0.0042 % + 76 Pa 0.0042 % + 0.011 psi	
Pneumatic	(7 to 350) KPa (1 to 50) psi	0.0012 % + 0.71 Pa 0.0012 % + 0.000 10 psi	Fluke PG7601 pneumatic piston gage
	(50 to 3500) KPa (7.3 to 500) psi	0.0018 % + 1.2 Pa 0.0018 % + 0.000 17 psi	
	(100 to 7000) KPa (14.5 to 1000) psi	0.0019 % + 13 Pa 0.0019 % + 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	0.022 kPa 0.010 % + 0.0019 kPa	DHI PPC3 controller with A200 kp sensor
	(0 to -1.35) psi (-1.35 to -15) psi	0.00038 psi 0.010 % + 0.000 28 psi	
Tachometers ³ – Revolutions per Minute			
Contact ⁹	(2 to 4000) fpm (1 to 2000) rpm	(0.55 + 0.000 09X) fpm 0.058 rpm	Adapter plate Agilent 33250A signal generator; X is the measured value in fpm fpm=feet per minute
Photo/LED ⁹	(1 to 100 000) rpm	0.00043 %	Agilent 33250A and LED

V. Optical Quantities

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
Illuminance – Light meters Ultraviolet Light Meters @ 365 nm	(5 to 50) fc (50 to 100) fc (100 to 500) fc (500 to 900) fc (200 to 8000) $\mu\text{W}/\text{cm}^2$	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 6.0 % + 1.2 $\mu\text{W}/\text{cm}^2$	NIST standard lamps at 2856K; X is the nominal illuminance level in foot candles (fc) 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 Densitometer; d = transmission density

VI. Thermodynamics

Parameter/Equipment	Range ⁷	CMC ^{2, 11} (±)	Comments
Temperature – Measuring Equipment SPRT Hg Triple Point of Water Ga Sn Zn	-38.8344 °C 0.01 °C 29.7646 °C 231.928 °C 419.527 °C	0.0015 °C 0.0012 °C 0.0016 °C 0.0022 °C 0.0035 °C	Freezing/melting point standards and SPRT



Parameter/Equipment	Range ⁷	CMC ^{2, 8, 11} (±)	Comments
Temperature – Measuring Equipment (cont)			
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	0.012 °C 0.0089 °C 0.0071 °C 0.0076 °C 0.0082 °C 0.0086 °C	PRT and 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 – 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
Dew Point – Measuring Equipment	(-15 to 30) °C	0.15 °C	Thunder Scientific 2500

VII. Time & Frequency

Parameter/Range	Frequency ⁷	CMC ^{2, 11} (±)	Comments
Frequency – Generate	10 MHz	2.7 parts in 10 ¹⁰	Spectracom SecureSync with GPS to NIST

Parameter/Range	Frequency	CMC ^{2, 11} (\pm)	Comments
Frequency – Measuring Equipment ⁹	1 mHz to 990 MHz	2.7 parts in 10 ¹⁰	HP 33250A and 8656A signal generators with 10 MHz distributed signal
Frequency – Measure ⁹	1 mHz to 1.3 GHz	2.7 parts in 10 ¹⁰	Agilent 53230A frequency counter with 10 MHz distributed signal reference

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 and this laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. 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 measurands stated are generated with the Fluke 5520A, 5720A, 5725A series of instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMC is expressed as either a specific value that covers the full range or as a fraction/percentage of the reading/output plus a fixed floor specification.

⁶ The measurands stated are measured with the HP 3458A. This capability is suitable for the calibration of the devices intended to generate the measurand in the ranges indicated. CMC is expressed as either a specific value that covers the full range or as a combination of the fraction/percentage of the reading/output plus a range specification.

⁷ Where ranges are not specified, the CMC stated is for the cardinal points only.

⁸ In the statement of CMC, percentages are to be read as percent of reading, unless otherwise indicated.

⁹ Uncertainty contribution due to the UUT is not included.

¹⁰ This scope meets A2LA's P112 Flexible Scope Policy.

¹¹ 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.

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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 8th day of August 2018.

A handwritten signature in black ink, written over a horizontal line.

President and CEO
For the Accreditation Council
Certificate Number 1097.01
Valid to July 31, 2020

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