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

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CALIBRATION

Valid To: March 31, 2021 Certificate Number: 1277.01

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. Acoustical Quantities

Parameter/Range	Frequency	CMC[2] (±)	Comments
Microphone Acoustic Level –			
Sensitivity:			
¼ in	114 dB @ 250 Hz	0.20 dB	2900 B Larson Davis sound level calibration system (comparison method)
½ in	114 dB @ 250 Hz	0.22 dB	
1 in	114 dB @ 250 Hz	0.22 dB	
Frequency Response:			
¼ in	20 Hz to 126 kHz	0.49 dB	
½ in	20 Hz to 20 kHz	0.21 dB	
1 in	20 Hz to 20 kHz	0.20 dB	
Sound Level Calibrators –			
(94 to 114) dB	(0.25 to 1) kHz	0.27 dB	2900 B Larson Davis sound level calibration system (comparison method)

Parameter/Range	Frequency	CMC[2] (±)	Comments
Sound Level Meters – (94 to 114) dB	(0.125 to 2) kHz (0.02 to 20) kHz	0.64 dB 0.12 dB	Acoustic method Electrical method

II. Chemical

Parameter/Equipment	Range	CMC[2, 6, 10] (±)	Comments
pH – Measuring Equipment	4.01 pH unit 7.01 pH unit 10.01 pH unit	0.012 pH unit + 0.6*R* 0.016 pH unit + 0.6*R* 0.018 pH unit + 0.6*R*	Accredited solutions
Conductance – Measuring Equipment	1.015 mS/cm 1.408 mS/cm 12.85 mS/cm 111.3 mS/cm	0.0058 mS/cm + 0.6*R* 0.010 mS/cm + 0.6*R* 0.087 mS/cm + 0.6*R* 0.88 mS/cm + 0.6*R*	Accredited solutions

III. Dimensional

Parameter/Equipment	Range	CMC[2, 6] (±)	Comments
Micrometers[3]	Up to 36 in	(4.6 + 5.0*L*) µin + 0.6*R*	Gage blocks
Tri-Bore	Up to 5 in	(6.4 + 4.4*L*) µin/in	Ring gage set
Calipers[3]	Up to 36 in	(2.9 + 11*L*) µin + 0.6*R*	Gage blocks
Angle	Up to ±90 ° Up to 60 °	3.7' 0.000 048 °/°	Optical protractor Sine bar/gage blocks

Parameter/Equipment	Range	CMC[2, 6] (±)	Comments
Optical Comparators[3]– Magnification Linear Accuracy Angle	 10× to 100× (0.001 to 6) in (30/60/90/120/150)°	 420 µin 150 µin + 0.6*R* 0.0048° + 0.6*R*	 Magnification scale Glass scale
Cylindrical Gages – Pins, Plugs, Discs	 (0.003 to 4.0) in	 (13 + 1.1*L*) µin	 ULM and gage blocks
Height Gages[3, 8]	Up to 48 in	(25 + 4.9*L*) µin	Gage blocks
Indicators[3] – Dial and Digital	Up to 4 in Up to 100 mm	(1.4 + 4.5*L*) µin + 0.6*R* (54 + 7.6*L*) nm + 0.6*R*	Gage blocks
Gage Blocks	(0.01 to 4) in (0.5 to 100) mm (4 to 8) in	(1.6 + 3.7*L*) µin (89 + 3.4*L*) nm (16 + 2*L*) µin	Twin head comparison ULM
Linear Displacement	Up to 1600 in	(23 + 1.1*L*) µin	Renishaw laser system
Radius Gage	(0.005 to 5) in	0.0031 in	Optical comparator
Threaded Plug Gages – Pitch diameter (5 to 80 TPI) Major Diameter	 Up to 8 in Up to 4 in	 (31 + 1.3*L*) µin (13 + 1.1*L*) µin	 ULM, thread wires ULM and gage blocks
Thread rings – Pitch diameter (5 to 80 TPI)	 Up to 6.5 in	 (30 + 4.6*L*) µin	 ULM, Tee ball probes
Gage Balls	Up to 4 in	(11 + 3.9*L*) µin	ULM
Ring Gages	Up to 8 in	(5 + 2.4*L*) µin	ULM, master rings and gage blocks

Parameter/Equipment	Range	CMC[2, 6] (±)	Comments
Foils and Thickness Gages	Up to 8 in	(16 + 1.9*L*) µin	ULM
Linear Scales/Reticles and Stage Micrometers	Up to 12 in	0.000 63 in	Optical comparator
Durometers –	Types A,B,C,D,E,O, OO, and DO		ASTM D2240
Indenter Shape and Extension:	Indenter extension length	12 µm	Optical comparator
	Tip radius	12 µm	Optical comparator
Spring Force	All scales	0.0047 N	Dual pan balance and weights

IV. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
AC Current[3] – Generate			
(0 to 220) µA			
	(10 to 20) Hz	0.082 % + 25 nA	Fluke 5700A
	(20 to 40) Hz	0.041 % + 20 nA	
	(40 to 1000) Hz	0.017 % + 16 nA	
	(1 to 5) kHz	0.073 % + 40 nA	
	(5 to 10) kHz	0.19 % + 80 nA	
(0.22 to 2.2) mA			
	(10 to 20) Hz	0.082 % + 40 nA	
	(20 to 40) Hz	0.041 % + 20 nA	
	(40 to 1000) Hz	0.017 % + 35 nA	
	(1 to 5) kHz	0.068 % + 400 nA	
	(5 to 10) kHz	0.19 % + 800 nA	
(2.2 to 22) mA			
	(10 to 20) Hz	0.082 % + 400 nA	
	(20 to 40) Hz	0.041 % + 350 nA	
	(40 to 1000) Hz	0.017 % + 350 nA	
	(1 to 5) kHz	0.068 % + 4 µA	
	(5 to 10) kHz	0.19 % + 8 µA	

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
AC Current[3] – Generate (cont)			
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz (40 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.082 % + 4 µA 0.041 % + 3.5 µA 0.017 % + 3.5 µA 0.068 % + 40 µA 0.19 % + 80 µA	Fluke 5700A
(0.22 to 2.2) A	(20 to 1000) Hz (1 to 5) kHz (5 to 10) kHz	0.077 % + 35 µA 0.087 % + 80 µA 1 % + 160 µA	
(1.1 to 3) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.19 % + 0.1 mA 0.062 % + 0.1 mA 0.62 % + 1 mA 2.6 % + 5 mA	Fluke 5520A
(3 to 11) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.062 % + 2 mA 0.1 % + 2 mA 2.6 % + 2 mA	
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.12 % + 5 mA 0.15 % + 5 mA 3.1 % + 5 mA	
(> 20.5 to 1025) A	(45 to 65) Hz (65 to 440) Hz	0.67 % + 0.9 A 1.2 % + 0.9 A	Fluke 552XA with Fluke 5500A/coil
AC Current[3] – Measure			
(0 to 100) µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.51 % + 3 nA 0.21 % + 3 nA 0.13 % + 3 nA 0.13 % + 3 nA	HP 3458A, option II
(0.1 to 1) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz	0.49 % + 0.2 µA 0.21 % + 0.2 µA 0.1 % + 0.2 µA 0.061 % + 0.2 µA 0.085 % + 0.2 µA	
(1 to 10) mA	(10 to 20) Hz	0.49 % + 2 µA	

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
AC Current[3] – Measure (cont)			
(1 to 10) mA	(20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz	0.17 % + 2 µA 0.085 % + 2 µA 0.061 % + 2 µA 0.069 % + 2 µA	HP 3458A, option II
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz	0.49 % + 20 µA 0.18 % + 20 µA 0.078 % + 20 µA 0.061 % + 20 µA 0.085 % + 20 µA	
100 mA to 1 A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.5 % + 0.2 mA 0.24 % + 0.2 mA 0.15 % + 0.2 mA 0.18 % + 0.2 mA	
(1 to 10) A	(45 to 1000) Hz (1 to 5) kHz	0.03 % 0.08 %	HP 3458A w/ Fluke Y5020A current shunt
AC Voltage[3] – Generate			
(0 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (500 to 1000) kHz	0.095 % + 4.5 µV 0.073 % + 4.5 µV 0.073 % + 4.5 µV 0.12 % + 4.5 µV 0.15 % + 7 µV 0.21 % + 13 µV 0.3 % + 25 µV 0.54 % + 25 µV	Fluke 5700A
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (500 to 1000) kHz	0.064 % + 5 µV 0.025 % + 5 µV 0.015 % + 5 µV 0.045 % + 5 µV 0.1 % + 7 µV 0.13 % + 12 µV 0.2 % + 25 µV 0.41 % + 25 µV	

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
AC Voltage[3] – Generate (cont)			
(22 to 220) mV	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (500 to 1000) kHz	0.064 % + 13 µV 0.025 % + 8 µV 0.013 % + 8 µV 0.037 % + 8 µV 0.1 % + 25 µV 0.13 % + 25 µV 0.2 % + 35 µV 0.4 % + 80 µV	Fluke 5700A
(0.22 to 2.2) V	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (500 to 1000) kHz	0.06 % + 80 µV 0.019 % + 25 µV 0.0091 % + 6 µV 0.014 % + 16 µV 0.029 % + 70 µV 0.05 % + 130 µV 0.12 % + 350 µV 0.26 % + 850 µV	
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (500 to 1000) kHz	0.06 % + 800 µV 0.019 % + 250 µV 0.0091 % + 60 µV 0.014 % + 160 µV 0.029 % + 350 µV 0.059 % + 1.5 mV 0.15 % + 4.3 mV 0.32 % + 8.5 mV	
(22 to 220) V*	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz	0.059 % + 8 mV 0.019 % + 2.5 mV 0.0096 % + 0.8 mV 0.025 % + 3.5 mV 0.059 % + 8 mV	*220V range subject to 2.2E7 V-Hz limitation
(220 to 1100) V**	(15 to 50) Hz (50 to 1000) Hz	0.046 % + 16 mV 0.0091 % + 3.5 mV	**1100 V range subject to 250 V limitation

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
AC Voltage[3] – Measure			
(0 to 10) mV	(40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.023 % + 1.1 µV 0.035 % + 1.1 µV 0.12 % + 1.1 µV 0.58 % + 1.1 µV 4.6 % + 2 µV	HP 3458A, option II
(10 to 100) mV	(40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 1000) kHz (1 to 2) MHz	0.0087 % + 2 µV 0.017 % + 2 µV 0.035 % + 2 µV 0.093 % + 2 µV 0.35 % + 10 µV 1.2 % + 10 µV 1.7 % + 10 µV	
100 mV to 1 V	(40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 1000) kHz (1 to 2) MHz	0.0081 % + 20 µV 0.016 % + 20 µV 0.035 % + 20 µV 0.092 % + 20 µV 0.35 % + 0.1 mV 1.2 % + 0.1 mV 1.7 % + 0.1 mV	
(1 to 10) V	(40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 1000) kHz	0.0081 % + 0.2 mV 0.016 % + 0.2 mV 0.035 % + 0.2 mV 0.92 % + 0.2 mV 0.35 % + 1 mV 1.2 % + 1 mV	
(10 to 100) V	(40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.023 % + 2 mV 0.023 % + 2 mV 0.040 % + 2 mV 0.14 % + 2 mV	
(100 to 1000) V	(40 to 1000) Hz	0.51 % + 20 mV	

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
Capacitance[3] – Generate			
(0.19 to 0.4) nF	10 Hz to 10 kHz	0.58 % + 0.01 nF	Fluke 5520A
(0.4 to 1.1) nF	10 Hz to 10 kHz	0.52 % + 0.01 nF	
(1.1 to 3.3) nF	10 Hz to 3 kHz	0.52 % + 0.01 nF	
(3.3 to 11) nF	10 Hz to 1 kHz	0.28 % + 0.01 nF	
(11 to 33) nF	10 Hz to 1 kHz	0.26 % + 0.1 nF	
(33 to 110) nF	10 Hz to 1 kHz	0.26 % + 0.1 nF	
(110 to 330) nF	10 Hz to 1 kHz	0.26 % + 0.3 nF	
(0.33 to 1.1) µF	(10 to 600) Hz	0.26 % + 1 nF	
(1.1 to 3.3) µF	(10 to 300) Hz	0.26 % + 3 nF	
(3.3 to 11) µF	(10 to 150) Hz	0.26 % + 10 nF	
(11 to 33) µF	(10 to 120) Hz	0.41 % + 30 nF	
(33 to 110) µF	(10 to 80) Hz	0.46 % + 0.1 µF	
(110 to 330) µF	(10 to 50) Hz	0.47 % + 0.3 µF	
(0.33 to 1.1) mF	(0 to 20) Hz	0.46 % + 1 µF	
(1.1 to 3.3) mF	(0 to 6) Hz	0.47 % + 3 µF	
(3.3 to 11) mF	(0 to 2) Hz	0.47 % + 10 µF	
(11 to 33) mF	(0 to 0.6) Hz	0.76 % + 30 µF	
(33 to 110) mF	(0 to 0.2) Hz	1.1 % + 0.10 mF	
Oscilloscopes –			
Amplitude, DC Signal			
50 Ω Load	(-6.6 to 6.6) V	0.29 % IV + 40 µV	Fluke 5522A/SC1100
1 MΩ Load	(-130 to 130) V	0.058 % IV + 40 µV	
Amplitude, Square Wave			
50 Ω Load	±1 mV to ±6.6 V_{p-p} 10 Hz to 10 kHz	0.29 % IV + 40 µV	
1 MΩ Load	±1 mV to ±130 V_{p-p} 10 Hz to 1 kHz	0.12 % IV + 40 µV	
Time Marker into 50 Ω Load-Source	5 s to 50 ms	29 parts in 10^6 + 1000 parts in 10^6 /s	
	20 ms to 2 ns	2.9 parts in 10^6	
Leveled Sine Wave Relative to 50 kHz [5 mV to 5.5 V] p-p	50 kHz to 100 MHz	2.0 %	
	(100 to 300) MHz	2.5 %	Fluke 9500B with active head(s)
	(300 to 600) MHz	4.7 %	
	(550 to 1100) MHz	4.3 %	
	(1.1 to 3.2) GHz	5.3 %	
	(3.2 to 6.0) GHz	5.3 %	

Parameter/Equipment	Range	CMC[2, 4, 10] (±)	Comments
Oscilloscopes – (cont)			
Rise Time	10 Hz to 2 MHz (125 to 175) ps 10 Hz to 1 MHz (59 to 81) ps	20 ps 14 ps	Fluke 9500B with active head(s)
Capacitance – Fixed Points	100 pF 1 nF to 1 µF	0.059 % 0.016 %	Standard capacitors
Capacitance – Measure	10 pF to 1.1 µF	0.018 %	Gen Rad 1615A capacitance bridge
DC Current[3] – Generate	0.1 nA to 220 µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A (1.1 to 3) A (3 to 11) A (11 to 20) A	130 µA/A + 8 nA 130 µA/A + 8 nA 130 µA/A + 80 nA 150 µA/A + 0.8 µA 200 µA/A + 25 µA 0.039 % + 40 µA 0.052 % + 0.33 mA 0.1 % + 0.75 mA	Fluke 5700A Fluke 5520A
DC Current[3] – Measure	(10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 20) A	22 µA/A + 0.8 nA 21 µA/A + 5 nA 21 µA/A + 50 nA 35 µA/A + 0.5 µA 0.011 % + 10 µA 0.032 % + 0.6 mA 0.027 % + 3.3 mA	HP 3458A, option II HP 3458A w/ Fluke Y5020 shunt
DC Voltage[3] – Measure	(0 to 100) mV (0.1 to 1) V (1.0 to 10) V (10 to 100) V (100 to 1000) V	5.2 µV/V + 0.3 µV 4.1 µV/V + 0.3 µV 4.0 µV/V + 0.5 µV 6.2 µV/V + 30 µV 63 µV/V + 0.1 mV*	HP 3458A, option II *Add 12 mV/V·$(V_{in}/1000)^2$ for input >100 V

Parameter/Equipment	Range	CMC[2, 4, 10] (±)	Comments
DC Voltage[3] – Generate	(0 to 220) mV (0 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	18 µV/V + 0.6 µV 21 µV/V + 1 µV 9 µV/V + 3.5 µV 18 µV/V + 6.5 µV 20 µV/V + 80 µV 12 µV/V + 500 µV	Fluke 5700A
Inductance – Measure @ 100 Hz Fixed Values	100 µH to 5 H	0.3 %	Standard inductor set with Gen Rad 1632A bridge as transfer standard
Inductance – Generate	100 µH to 5.0 H	0.33 %	Gen Rad 1482 standard inductors
Resistance[3] – Measure	(0 to 10) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ	15 µΩ/Ω + 0.05 mΩ 13 µΩ/Ω + 0.50 mΩ 10 µΩ/Ω + 5.0 mΩ 10 µΩ/Ω + 50 mΩ 10 µΩ/Ω + 50 mΩ 16 µΩ/Ω + 2.0 Ω 52 µΩ/Ω + 100 Ω 0.051 % + 1.0 kΩ 0.5 % + 10 kΩ	HP 3458A, option II
Resistance[3] – Generate	(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 (0.50 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (330 to 1100) MΩ	46 µΩ/Ω + 0.0010 Ω 32 µΩ/Ω + 0.0015 Ω 30 µΩ/Ω + 0.0015 Ω 29 µΩ/Ω + 0.0020 Ω 29 µΩ/Ω + 0.0020 Ω 29 µΩ/Ω + 0.020 Ω 29 µΩ/Ω + 0.020 Ω 29 µΩ/Ω + 0.2 Ω 29 µΩ/Ω + 0.20 Ω 36 µΩ/Ω + 2.0 Ω 39 µΩ/Ω + 2.0 Ω 77 µΩ/Ω + 30 Ω 0.016 % + 50 Ω 0.031 % + 2.5 kΩ 0.084 % + 3.0 kΩ 0.33 % + 0.10 MΩ 1.8 % + 0.50 MΩ	Fluke 5520A

Parameter/Equipment	Range	CMC[2, 4, 10] (±)	Comments
Resistance – Generate, Fixed Values	1 and 10 mΩ	4.7 µΩ/Ω	L&N reference resistors
	(0.1, 1, 10, 100) Ω (1, 10, 100, 1000) kΩ	4.7 µΩ/Ω 4.7 µΩ/Ω	ESI SR1010 reference resistors
	0 Ω	4.8 µΩ	Copper shorting block
	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	120 µΩ 210 µΩ 340 µΩ 620 µΩ 2 mΩ 3.8 mΩ 15 mΩ 29 mΩ 140 mΩ 270 mΩ 1.6 Ω 3.1 Ω 23 Ω 48 Ω 480 Ω 1.1 kΩ 13 kΩ	Fluke 5700A
Electrical Thermocouple[3] – Generate and Measure			
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.35 °C 0.3 °C 0.36 °C 0.58 °C 0.97 °C	Fluke 5520A
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.76 °C 0.32 °C 0.25 °C 0.26 °C 0.31 °C	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Electrical Thermocouple[3] – Generate and Measure (cont)			
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.31 °C 0.19 °C 0.16 °C 0.2 °C 0.27 °C	Fluke 5520A
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.38 °C 0.21 °C 0.19 °C 0.3 °C 0.46 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.46 °C 0.25 °C 0.22 °C 0.21 °C 0.31 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.75 °C 0.48 °C 0.38 °C 0.47 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.54 °C 0.42 °C 0.4 °C 0.53 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.73 °C 0.28 °C 0.19 °C 0.16 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.65 °C 0.31 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical RTD Simulation[3] –			
Pt 385, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.058 °C 0.058 °C 0.085 °C 0.1 °C 0.12 °C 0.12 °C 0.27 °C	Fluke 5520A
Pt 3926, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.058 °C 0.058 °C 0.081 °C 0.1 °C 0.12 °C 0.14 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.29 °C 0.046 °C 0.058 °C 0.069 °C 0.081 °C 0.092 °C 0.1 °C 0.12 °C 0.27 °C	
Pt 385, 200 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.046 °C 0.046 °C 0.046 °C 0.058 °C 0.14 °C 0.15 °C 0.16 °C 0.18 °C	
Pt 385, 500 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.047 °C 0.058 °C 0.058 °C 0.069 °C 0.093 °C 0.093 °C 0.1 °C 0.13 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical RTD Simulation[3] (cont) –			
Pt 385, 1000 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.035 °C 0.035 °C 0.046 °C 0.058 °C 0.069 °C 0.081 °C 0.081 °C 0.27 °C	Fluke 5520A
PtNi 385, 120 Ω	(-80 to 0) °C (0 to 100) °C (100 to 260) °C	0.092 °C 0.092 °C 0.16 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.35 °C	

V. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
RF Absolute Power[3, 5] – Measure			
1 mW Reference	50 MHz	0.45 %	HP 8478B sensor w/ HP 432A power meter and type N connector
(-20 to +10) dBm	(0.01 to 0.05) GHz (0.05 to 1) GHz (1 to 3) GHz (3 to 7) GHz (7 to 12.4) GHz (12.4 to 15) GHz (15 to 16) GHz (16 to 18) GHz	1.3 % + 0.6 µW 1.4 % + 0.6 µW 1.7 % + 0.6 µW 2.1 % + 0.6 µW 2.7 % + 0.6 µW 3.1 % + 0.6 µW 3.3 % + 0.6 µW 3.5 % + 0.6 µW	
(-20 to +30) dBm	100 kHz to 2.6 GHz	0.13 dB	HP 11722A sensor w/ HP 8902A, HP 11793A and type N connector

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
RF Absolute Power[3, 5] – Measure (cont)	50 MHz to 18 GHz	0.10 dB	HP 11792A sensor w/ HP 8902A, HP 11793A, and APC 3.5 mm connector
RF Absolute Power[3, 5] – Generate			
Sine Wave into 50 Ω			
(10 to 3) V_{p-p}	(0.001 to 100) kHz 100 kHz to 20 MHz	0.12 dB 0.37 dB	HP 3325 synthesized function generator w/ BNC connector
2.99 V_{p-p} to 1 mV_{p-p}	0.001 Hz to 100 kHz 100 kHz to 10 MHz	0.26 dB 0.60 dB	
2.99 V_{p-p} to 100 mV_{p-p}	(10 to 20) MHz	0.60 dB	
(99.9 to 1) mV_{p-p}	(10 to 20) MHz	0.60 dB	
(13.01 to -4.99) dBm	200 Hz to 80 MHz	0.19 dB	HP3335A synthesized level generator in 2 dBm steps, w/ BNC connector
(-6.99 to -44.99) dBm	200 Hz to 80 MHz	0.21 dB	
(-46.99 to -84.99) dBm	200 Hz to 80 MHz	0.29 dB	
RF Tuned Power – Measure			
(0 to -127) dB	(2.5 to 1300) MHz	0.11 dB + 0.000 83 %	HP 11722A/11792A sensors w/ HP 8902A, 11793A converter and type N or type APC 3.5 mm connectors
(0 to -127) dB	2.5 MHz to 18 GHz	0.11 dB + 0.004 %	

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
Amplitude Modulation – Generate			
AM Flatness Carrier Frequency	Rate Frequency:		
(11 to 13.5) MHz Depth: (0 to 99) %	50 Hz to 50 kHz 20 Hz to 100 kHz	0.16 % 0.32 %	HP 11715A AM/FM test source
Amplitude Modulation – Measure			
Carrier Frequency	Rate Frequency:		
(0.15 to 10) MHz Depth: (5 to 99) % (0 to 99) %	50 Hz to 10 kHz 20 Hz to 10 kHz	3.5 % + 1 digit 4.1 % + 1 digit	HP 8902A w/ HP 11722A and 11792A sensors and HP 11793A converter
(10 to 1300) MHz Depth: (5 to 99) %	50 Hz to 50 kHz	1.6 % + 1 digit	
(1.3 to 18) GHz Depth: (5 to 99) %	50 Hz to 50 kHz	3.2 % + 1 digit	
10 MHz to 18 GHz Depth: (0 to 99) %	20 Hz to 100 kHz	4.2 % + 1 digit	
Frequency Modulation – Measure			
Carrier Frequency	Rate Frequency:		
(0.25 to 10) MHz ≤ 40 kHz Peak Deviation	20 Hz to 10 kHz	2.3 % + 1 digit	HP 8902A w/ HP 11722A and 11792A sensors and 11793A converter
10 MHz to 18 GHz ≤ 400 kHz Peak Deviation	50 Hz to 100 kHz 20 Hz to 400 kHz	3.0 % + 1 digit 6.7 % + 1 digit	

Parameter/Range	Frequency	CMC[2, 4, 10] (±)	Comments
Frequency Modulation – Generate			
FM Flatness Carrier Frequency	Rate Frequency:		
(11 to 13.5) MHz	DC to 100 kHz (100 to 200) kHz	0.33 % 0.43 %	HP 11715A AM/FM test source
(88 to 108) MHz	DC to 100 kHz (100 to 200) kHz	0.34 % 0.43 %	
(352 to 432) MHz	DC to 100 kHz (100 to 200) kHz	0.34 % 0.43 %	
Phase Modulation – Measure			
Carrier Frequency	Rate Frequency:		
(0.15 to 10) MHz	200 Hz to 10 kHz	4.8 % + 1 digit	HP 8902A w/ HP 11792A and 11722A sensors
10 MHz to 18 GHz	200 Hz to 20 kHz	4.6 % + 1 digit	
RF Volts – Measure, Fixed Points			
3 V	(1 to 10) MHz (10 to 30) MHz (30 to 50) MHz (50 to 70) MHz (70 to 80) MHz (80 to 100) MHz	0.091 % 0.11 % 0.19 % 0.30 % 0.32 % 0.38 %	HP 11049A thermal voltage converter

VI. Mechanical

Parameter/Equipment	Range	CMC[2, 4, 6, 10] (±)	Comments
Torque Wrench	(10 to 3120) in·lbf	0.24 % of IV from (10 to 100) % FS	Larson STWCS
	(0 to 1000) in·ozf	0.49 % of IV (10 to 100) % of range	Futek torque system
	(0 to 600) ft·lbf	1.8 ft·lbf (10 to 100) % of range	
Torque – Measuring Equipment			
Transducers	(0.6 to 42) ft·lbf (1.7 to 600) ft·lbf	0.032 % IV 0.042 % IV	Torque arm/dead weight
Acceleration/ Vibration – Meauring Equipment	(5 to 2000) Hz (2 to 10) kHz	1.3 % IV 1.1 % IV	Back to back comparison method
Pressure Gauges – Measuring Equipment			
Pneumatic	(-5 to 5) psig	0.0065 % IV + 0.0005 psig	Pace 6000
	(-15 to 50) psig	0.0055 % IV + 0.0033 psig	
	(-15 to 300) psig	0.0085 % IV + 0.015 psig	
	(-14.5 to 1000) psig	0.011 % IV + 0.051 psig	
Hydraulic	(1000 to 10 000) psig	0.041 %	Deadweight tester
	(0 to 10) inH_2O	0.006 in·H_2O	Meriam manometer
Absolute Pressure – Measuring Equipment and Measure	(9 to 20) psia (0.5 to 80) psia (0.5 to 330) psia (0.5 to 1030) psia	0.0058 % IV 0.0058 % IV 0.0063 % IV 0.0064 % IV	Pace 6000

Parameter/Equipment	Range	CMC[2, 4, 6] (±)	Comments
Scales and Balances[3] –	(0.5 to 629) lb	0.01 % + 0.6*R*	ASTM Class 6 weights
Analytical Balances[3]	(20 to 100) mg	0.031 mg + 0.19 mg/g	ASTM Class 1 weights
	(100 to 500) mg	0.043 mg + 0.076 mg/g	
	(1 to 10) g	0.033 mg + 0.002 mg/g	
	(10 to 100) g	0.03 mg + 0.0023 mg/g	
	(0.1 to 3) kg	0.0034 % + 0.6*R*	
Force[3, 7] – Measuring Equipment	(0.5 to 500) lbf	0.01 % IV + 0.6*R*	ASTM Class 6 weights
	(100 to 1000) lbf	0.061 % FS	Load cells
	(200 to 2000) lbf	0.050 % FS	
	(500 to 5000) lbf	0.049 % FS	
	(1000 to 10 000) lbf	0.049 % FS	
	(2500 to 25 000) lbf	0.056 % FS	
	(5000 to 50 000) lbf	0.049 % FS	
	(10 000 to 100 000) lbf	0.064 % FS	
	(50 000 to 500 000) lbf	0.05 % FS	Compression only
Rockwell Hardness[3] – Indirect Verification of Superficial Hardness Testers	HRA:		ASTM E18
	Low	0.54 HRA	
	Medium	0.43 HRA	
	High	0.32 HRA	
	HRBW:		
	Low	0.83 HRBW	
	Medium	1.0 HRBW	
	High	0.79 HRBW	
	HRC:		
	Low	0.86 HRC	
	Medium	1.0 HRC	
	High	0.44 HRC	

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Rockwell Hardness[3] – Indirect Verification of Superficial Hardness Testers (cont)	HRRW: HR15N: Low Medium High HR30N: Low Medium High HR15TW: Low Medium High HR30TW: Low Medium High	1.6 HRRW 0.99 HR15N 0.80 HR15N 0.97 HR15N 0.49 HR30N 0.78 HR30N 0.38 HR30N 0.52 HR15TW 0.59 HR15TW 0.48 HR15TW 0.97 HR30TW 0.77 HR30TW 0.57 HR30TW	ASTM E18
Universal Testing Machine, Compression Testing Machines, Tension Testing Machines[3]	(0.5 to 500) lbf (100 to 1000) lbf (200 to 2000) lbf (500 to 5000) lbf (1000 to 10 000) lbf (2500 to 25 000) lbf (5000 to 50 000) lbf (10 000 to 100 000) lbf (50 000 to 500 000) lbf	0.011 % IV 0.061 % FS 0.050 % FS 0.058 % FS 0.049 % FS 0.056 % FS 0.056 % FS 0.056 % FS 0.056 % FS	ASTM E4, load cells and dead weights tension and compression Compression only

VII. Thermodynamics

Parameter/Equipment	Range	CMC[2, 4, 10] (±)	Comments
Temperature[3] – Generate	(-40 to 150) °C (-50 to 660) °C	0.014 °C + 42 µ°C/°C 0.036 °C + 0.16 m°C/°C	Fluke 1502 w/ 5628 PRT in bath Fluke 1502 w/ 5609 PRT
Infrared Temperature[3] – Measure	(25 to 400) °C	1.9 °C + 0.001 °C/°C	Black body
Temperature[3] – Measure	(-50 to 660) °C (93 to 649) °C	0.031 °C + 72 µ°C/°C 1.4 °C + 3.3 m°C/°C	Fluke 1502 w/ 5628 PRT Type N thermocouple
Thermocouples – Types B, C, E, J, K N, R, S, T, U	(-50 to 660) °C	0.23 °C + 0.12 m°C/°C	Fluke 5520A/ Fluke 1502A/5628
RTDs –	(-50 to 660) °C	0.038 °C	HP3458A/Hart 1502A/ 5628
Relative Humidity – Generate Relative Humidity[3] – Measuring Equipment	(10 to 95) % RH 11.3 % RH 33 % RH 75.5 % RH 97.7 % RH	0.7 % RH 1.6 % RH 1.6 % RH 2.0 % RH 2.6 % RH	Thunder Scientific 2500 Vaisala HMK15
Relative Humidity[3] – Measure	(11.3 to 90) % RH (90 to 97.7) % RH	1.9 % RH 2.5 % RH	Vaisala MI70/HMP77B

VIII. Time & Frequency

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Frequency – Measuring Equipment	10 MHz	5.7 x 10^{-12} Hz/Hz	NOVAS WR 2410 GPS receiver
Frequency – Measure Period – Measure	0.01 Hz to 18 GHz 1 µs to 1000 s	1.6 x 10^{-9} Hz/Hz 1.2 x 10^{-9} s/s	NOVAS WR 2410 GPS receiver with Frequency Counter

Parameter/Equipment	Range	CMC[2] (±)	Comments
Stopwatches	24 hr (2 to 120) s	33 ms 0.039 s/day	NIST RP 960-12 Timometer

[1] This laboratory offers commercial calibration service and field calibration service.

[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, the value is defined as the percentage of reading unless otherwise indicated; IV represents *Indicated Value* and FS represents *Full Scale*.

[5] The CMCs do not include mismatch.

[6] In the statement of CMC, *L* represents the length of the unit under test in inches or millimeters, where appropriate; *R* represents the resolution of the unit under test.

[7] Greater than 100 kN, field service available only.

[8] Repeatability of the Unit Under Test has not been utilized in the calculation of the CMC value for this measurement parameter.

[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

NOVASTAR METROLOGY

Livonia, 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 10th day of April 2019.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1277.01
Valid to March 31, 2021
Revised April 15, 2019

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