SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005
ANSI/NCSL Z540-1-1994 & ANSI/NCSL Z540.3-2006

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CALIBRATION

Valid To: March 31, 2011 Certificate Number: 2516.02

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations[1]:

I. Acoustical Quantities

Parameter/Equipment	Range	CMC[2] (±)	Comments
Sound Level Measuring Equipment[3]	114 dB (0.125, 0.25) kHz (0.5, 1, 2) kHz 94 dB @ 1 kHz	0.33 dB 0.33 dB 0.77 dB	GenRad 1562A Extech 407766
Sound Level[3] – Measure	(35 to 95) dB (75 to 130) dB	0.23 dB 0.25 dB	Extech 407736

II. Chemical

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
pH Measuring Equipment[3]	(4, 7, 10) units	0.012 units + 0.6*R*	Buffer solutions

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Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Electrolytic Conductivity Measuring Equipment[3]	10 µS/cm 1000 µS/cm 10 000 µS/cm	0.52 µS/cm + 0.6*R* 24 µS/cm + 0.6*R* 230 µS/cm + 0.6*R*	Conductivity solutions

III. Dimensional

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Bore Gages[3], Bore Micrometers[3], & Holtests[3]	Up to 1 in (>1 to 2) in (>2 to 3) in (>3 to 4) in (>4 to 6) in	71 µin/in 79 µin/in 94 µin/in 97 µin/in 640 µin/in	Gage blocks & master ring gages
Calipers[3]	Up to 24 in	13 µin/in + 0.6*R*	Gage blocks
Coordinate Measuring Machines[3] – Repeatability Linear Accuracy Squareness Volumetric Performance	 Sphere Up to 24 in Up to 24 in 600 mm	 23 µin 1.4 µin/in + 71 µin 31 µin 140 µin	ASME B89.4.10360.2-2008 Sphere Step gage Ball bar Ball bar
Depth Gages[3]	Up to 24 in	11 µin/in + 0.6*R*	Gage blocks
Height Gages[3]	Up to 24 in	15 µin/in + 0.6*R*	Gage blocks
Indicators[3]	Up to 6 in	12 µin/in + 0.6*R*	Gage blocks
Length Measurement[3]	Up to 40 in	3.3 µin/in	Optodyne LDDM
Micrometers[3]	Up to 40 in	11 µin/in + 0.6*R*	Gage blocks

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
Optical Comparators[3] –			
Linear Travel	Up to 30 in	120 µin	Comparison to master
Magnification	10x to 100x	0.12 %	
Steel Rules	Up to 24 in	(18 + 10*L*) µin	Gage blocks and eyepiece
Steel Tapes[3]	Up to 30 ft	0.12 in	Master tapes
Surface Plates[3]	Up to (72 x 144) in^2	1.4*D* µin	Laser

IV. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC[2, 5, 6, 7, 8] (±)	Comments
DC Voltage – Measure and Generate	0.1 mV to 1100 V	2.7 µV/V + 0.6 µV	Fluke 732B w/ 720A & Agilent 3458A Opt. 002
	Up to 220 mV (>0.22 to 2.2) V (>2.2 to 11) V (>11 to 22) V (>22 to 220) V (>220 to 1100) V	10 µV/V 5.6 µV/V 5.9 µV/V 7.6 µV/V 6.5 µV/V 12 µV/V	Fluke 5700A/EP w/ 5725A, HP 3458A Opt. 002
DC Voltage – Measure	(0 to 7) mV	60 µV/V + 0.04 µV	Agilent 34420A
DC Voltage[3] – Generate, Fixed Points	1 V 1.018 V 10 V	3.6 parts in 10^6 1.7 parts in 10^6 0.58 parts in 10^6	Fluke 732X series
DC High Voltage[3] – Measure	(1 to 6) kV	1 %	Fluke 80K series probe & 87 series DMM

Parameter/Equipment	Range	CMC[2, 5, 6, 8] (±)	Comments
DC Current[3] – Measure	Up to 20 pA (20 to 200) pA (0.2 to 2) nA (2 to 20) nA (20 to 200) nA (0.2 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	3.5 % 0.63 % 0.20 % 0.23 % 0.085 % 19 µA/A + 0.94 nA 18 µA/A + 5.8 nA 20 µA/A + 58 nA 38 µA/A + 0.58 µA 0.012 % + 12 µA	Keithley 617 Agilent 3458A w/ resistors
DC Current[3] – Generate	Up to 200 pA (0.2 to 200) nA Up to 100 µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (100 to 220) mA (0.22 to 2.2) A (2.2 to 11) A (11 to 20.5) A (20.5 to 150) A (150 to 1000) A	1.9 % + 0.02 pA 0.29 % + 0.02 nA 19 µA/A + 0.94 nA 18 µA/A + 5.8 nA 20 µA/A + 58 nA 38 µA/A + 0.58 µA 47 µA/A + 0.81 µA 74 µA/A + 14 µA 0.041 % + 0.56 mA 0.12 % + 16 mA 0.29 % + 75 mA 0.31 % + 0.65 A	Keithley 261, current source Fluke 5700A/EP w/ Agilent 3458A Opt. 002 Fluke 5700A/EP & 5725A Fluke 5520A Fluke 5520A w/ 50-turn coil
Resistance[3] – Generate	Up to 10.99 Ω 11 Ω to 1.099 kΩ (1.1 to 10.99) kΩ (11 to 109.99) kΩ (0.11 to 1.099) MΩ (1.1 to 3.299) MΩ (3.3 to 10.99) MΩ (11 to 32.99) MΩ (33 to 109.99) MΩ (110 to 329.99) MΩ (330 to 1100) MΩ	41 µΩ/Ω + 0.001 Ω 32 µΩ/Ω + 0.002 Ω 30 µΩ/Ω + 0.02 Ω 30 µΩ/Ω + 0.2 Ω 36 µΩ/Ω + 2.3 Ω 78 µΩ/Ω + 39 Ω 0.014 % + 52 Ω 0.026 % + 2.6 kΩ 0.052 % + 3.2 kΩ 0.31 % + 100 kΩ 1.6 % + 520 kΩ	Fluke 5520A, 4-wire Fluke 5520A, 2-wire

Parameter/Equipment	Range	CMC[2, 5, 6, 8] (±)	Comments
Resistance[3] – Generate, Fixed Points	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	95 μΩ/Ω 97 μΩ/Ω 26 μΩ/Ω 26 μΩ/Ω 12 μΩ/Ω 13 μΩ/Ω 10 μΩ/Ω 10 μΩ/Ω 10 μΩ/Ω 10 μΩ/Ω 13 μΩ/Ω 13 μΩ/Ω 21 μΩ/Ω 22 μΩ/Ω 40 μΩ/Ω 49 μΩ/Ω 0.014 %	Fluke 5700A/EP
	0.05 mΩ 0.1 mΩ 1 mΩ 10 mΩ 100 mΩ	0.43 % 0.33 % 0.03 % 0.03 % 0.03 %	Standard resistors
	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 kΩ 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 10 MΩ 19 MΩ 100 MΩ	17 parts in 10^6 33 parts in 10^6 22 parts in 10^6 12 parts in 10^6 26 parts in 10^6 28 parts in 10^6 10 parts in 10^6 12 parts in 10^6 9 parts in 10^6 8 parts in 10^6 10 parts in 10^6 16 parts in 10^6 23 parts in 10^6 30 parts in 10^6 0.014 % 0.024 %	Fluke 742A resistance standards
Resistance[3] – Measure	(0 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) kΩ (10 to 100) kΩ (100 to 1000) kΩ (1 to 10) MΩ	86 μΩ/Ω 23 μΩ/Ω 9.9 μΩ/Ω 13 μΩ/Ω 14 μΩ/Ω 16 μΩ/Ω 38 μΩ/Ω	Agilent 3458A Opt 002

Parameter/Equipment	Range	CMC[2, 4, 5, 6, 8] (±)	Comments
Resistance[3] – Measure (cont)	(10 to 100) MΩ (0.1 to 1) GΩ	0.014 % 0.038 %	Agilent 3458A Opt 002
	(0.1 to 1) Ω (1 to 1.9) Ω (1.9 to 10) Ω (10 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 to 19) kΩ (19 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ (10 to 19) MΩ (19 to 100) MΩ	61 μΩ/Ω 16 μΩ/Ω 13 μΩ/Ω 14 μΩ/Ω 14 μΩ/Ω 4.8 μΩ/Ω 4.8 μΩ/Ω 4.9 μΩ/Ω 7.3 μΩ/Ω 10 μΩ/Ω 13 μΩ/Ω 20 μΩ/Ω	Fluke 5700A/EP w/ Agilent 3458A & Fluke 742A series resistors
Inductance – Generate			
1 kHz[3]	(1 to 10) mH (10 to 100) mH (100 to 1000) mH	2.4 % + 0.6*R* 1.9 % + 0.6*R* 0.84 % + 0.6*R*	GenRad 1490-A standard inductors
Fixed Points: 400 Hz & 1 kHz	100 μH 1 mH 10 mH 100 mH 1 H	0.1 μH + 0.6*R* 0.7 μH + 0.6*R* 7.1 μH + 0.6*R* 0.07 mH + 0.6*R* 0.52 mH + 0.6*R*	GenRad 1482-B GenRad 1482-E GenRad 1482-H GenRad 1482-L GenRad 1482-P
Inductance[3] – Measure, (0.1, 0.12, 1 and 10) kHz	10 μH 100 μH 1 mH 10 mH 100 mH 1 H 10 H	2.6 % 1.1 % 0.71 % 0.71 % 0.76 % 0.87 % 0.98 %	GenRad 1659 RLC Digibridge
Capacitance[3] – Measure, (0.1, 0.12, 1 & 10) kHz	(40 to 100) pF (100 to 1000) pF (1 to 10) nF (10 to 100) nF (100 to 1000) nF (1 to 10) μF (10 to 100) μF (100 to 1000) μF (1 to 10) mF	14 % 1.1 % 0.13 % 0.13 % 0.16 % 0.15 % 4.1 % 6.4 % 8.2 %	GenRad 1659 RLC Digibridge

Parameter/Equipment	Range	CMC[2, 4, 5, 8] (±)	Comments
Capacitance[3] – Generate			
10 Hz to 10 kHz	(0.10 to 3.299) nF	0.52 % + 0.012 nF	Fluke 5520A
(10 to 1000) Hz	(0.33 to 10.999) nF	0.26 % + 0.012 nF	
(10 to 1000) Hz	(11 to 109.999) nF	0.26 % + 0.12 nF	
(10 to 1000) Hz	(110 to 329.99) nF	0.26 % + 0.31 nF	
(10 to 600) Hz	(0.33 to 1.0999) μF	0.26 % + 1.2 nF	
(10 to 300) Hz	(1.1 to 3.2999) μF	0.26 % + 3.1 nF	
(10 to 150) Hz	(3.3 to 10.999) μF	0.26 % + 12 nF	
(10 to 120) Hz	(11 to 32.999) μF	0.42 % + 31 nF	
(10 to 80) Hz	(33 to 109.99) μF	0.46 % + 0.12 μF	
To 50 Hz	(110 to 329.99) μF	0.46 % + 0.31 μF	
To 20 Hz	(0.33 to 1.0999) mF	0.46 % + 1.2 μF	
To 6 Hz	(1.1 to 3.2999) mF	0.46 % + 3.1 μF	
To 2 Hz	(3.3 to 10.999) mF	0.46 % + 12 μF	
To 0.6 Hz	(11 to 32.999) mF	0.78 % + 31 μF	
To 0.2 Hz	(33 to 110) mF	1.2 % + 120 μF	HP 16381A standard air capacitor
Fixed Points			
1 kHz to 1 MHz	1 pF	0.037 % + 0.6*R*	
2 MHz		0.043 % + 0.6*R*	
3 MHz		0.055 % + 0.6*R*	
4 MHz		0.073 % + 0.6*R*	
5 MHz		0.096 % + 0.6*R*	
10 MHz		0.26 % + 0.6*R*	
13 MHz		0.38 % + 0.6*R*	HP 16382A
1 kHz to 13 MHz	10 pF	0.040 % + 0.6*R*	HP 16383A
1 kHz to 5 MHz	100 pF	0.039 % + 0.6*R*	
10 MHz		0.052 % + 0.6*R*	
13 MHz		0.067 % + 0.6*R*	HP 16384A
1 kHz to 1 MHz	1000 pF	0.037 % + 0.6*R*	
2 MHz		0.040 % + 0.6*R*	
3 MHz		0.048 % + 0.6*R*	
4 MHz		0.062 % + 0.6*R*	
5 MHz		0.080 % + 0.6*R*	
10 MHz		0.23 % + 0.6*R*	
13 MHz		0.33 % + 0.6*R*	HP 16380C series air capacitors
120 Hz to 100 kHz	(10, 100, 1000) nF	0.010 % + 0.6*R*	

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
AC Voltage[3] – Generate			
Up to 2.2 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.025 % + 5 µV 0.010 % + 5 µV 0.009 % + 5 µV 0.021 % + 5 µV 0.053 % + 6 µV 0.11 % + 12 µV 0.14 % + 23 µV 0.29 % + 23 µV	Fluke 5700A/EP
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.025 % + 5 µV 0.01 % + 5 µV 90 µV/V + 5 µV 0.021 % + 5 µV 0.053 % + 6 µV 0.11 % + 12 µV 0.14 % + 23 µV 0.29 % + 23 µV	
(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	0.025 % + 14 µV 0.01 % + 8 µV 87 µV/V + 8 µV 0.021 % + 8 µV 0.048 % + 20 µV 0.087 % + 23 µV 0.14 % + 29 µV 0.29 % + 52 µV	
(0.22 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	0.025 % + 46 µV 90 µV/V + 17 µV 46 µV/V + 9 µV 81 µV/V + 12 µV 0.012 % + 35 µV 0.039 % + 92 µV 0.11 % + 0.23 mV 0.17 % + 0.35 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	0.025 % + 0.46 mV 92 µV/V + 0.17 mV 46 µV/V + 0.06 mV 81 µV/V + 0.12 mV 0.011 % + 0.23 mV 0.03 % + 0.7 mV 0.11 % + 2.3 mV 0.15 % + 3.7 mV	

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
AC Voltage[3] – Generate (cont)			
(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 (0.5 to 1) MHz	0.025 % + 4.6 mV 90 µV/V + 1.7 mV 54 µV/V + 0.69 mV 90 µV/V + 1.2 mV 0.015 % + 2.9 mV 0.092 % + 19 mV 0.48 % + 47 mV 0.81 % + 93 mV	Fluke 5700A/EP
(220 to 250) V	(15 to 40) Hz	0.03 % + 19 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.042 % + 13 mV 0.15 % + 52 mV	
(220 to 1100) V	(40 to 50) Hz 50 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	92 µV/V + 4.7 mV 69 µV/V + 4.0 mV 0.014 % + 6.9 mV 0.042 % + 13 mV	
AC Voltage – Measure			
(0.7 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	0.21 % + 1.6 µV 0.1 % + 1.6 µV 0.075 % + 1.6 µV 0.11 % + 2.4 µV 0.15 % + 2.9 µV 0.27 % + 4.6 µV 0.29 % + 9.2 µV 0.41 % + 9.2 µV	Fluke 5790A
(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	0.1 % + 1.6 µV 0.048 % + 1.6 µV 0.032 % + 1.6 µV 0.051 % + 2.4 µV 0.072 % + 2.9 µV 0.14 % + 4.6 µV 0.15 % + 9.2 µV 0.27 % + 9.2 µV	

Parameter/Range	Frequency	CMC[2, 5, 8] (±)	Comments
AC Voltage – Measure (cont)			
(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	0.034 % + 1.6 µV 0.023 % + 1.6 µV 0.017 % + 1.6 µV 0.025 % + 2.4 µV 0.037 % + 2.9 µV 0.094 % + 4.6 µV 0.1 % + 9.2 µV 0.2 % + 9.2 µV	Fluke 5790A
(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	0.028 % + 1.8 µV 0.014 % + 1.8 µV 80 µV/V + 1.8 µV 0.015 % + 2.4 µV 0.03 % + 2.9 µV 0.059 % + 4.6 µV 0.077 % + 9.2 µV 0.13 % + 9.2 µV	
(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	0.025 % + 1.8 µV 98 µV/V + 1.8 µV 43 µV/V + 1.8 µV 80 µV/V + 2.4 µV 0.018 % + 2.9 µV 0.029 % + 4.6 µV 0.049 % + 9.2 µV 0.12 % + 9.2 µV	
(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	0.025 % + 1.8 µV 0.011 % + 1.8 µV 43 µV/V + 1.8 µV 60 µV/V + 2.4 µV 93 µV/V + 2.9 µV 0.02 % + 4.6 µV 0.035 % + 9.2 µV 0.11 % + 9.2 µV	
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	0.024 % 78 µV/V 28 µV/V 54 µV/V 84 µV/V 0.019 % 0.036 % 0.11 %	

Parameter/Range	Frequency	CMC[2, 5, 8] (±)	Comments
AC Voltage – Measure (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	0.023 % 78 µV/V 32 µV/V 56 µV/V 94 µV/V 0.022 % 0.046 % 0.14 %	Fluke 5790A
(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	0.023 % 78 µV/V 32 µV/V 56 µV/V 96 µV/V 0.022 % 0.046 % 0.14 %	
(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	0.023 % 79 µV/V 37 µV/V 66 µV/V 0.011 % 0.023 % 0.048 % 0.14 %	
(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	0.023 % 85 µV/V 42 µV/V 84 µV/V 0.012 % 0.024 % 0.058 %	
(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	0.023 % 0.012 % 49 µV/V 0.015 % 0.058 %	

Parameter/Range	Frequency	CMC[2, 5, 6, 8] (±)	Comments
AC Voltage[3] – Measure (cont)			
(0.1 to 10) mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.035 % + 3.5 µV 0.024 % + 1.3 µV 0.035 % + 1.3 µV 0.12 % + 1.3 µV 0.58 % + 1.3 µV 4.7 % + 2.4 µV	Agilent 3458A Opt 002
10 mV to 10 V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	85 µV/V + 47 µV/V 92 µV/V + 24 µV/V 0.017 % + 24 µV/V 0.035 % + 24 µV/V 0.1 % + 24 µV/V 0.35 % + 120 µV/V 1.2 % + 120 µV/V 1.8 % + 120 µV/V	
(10 to 100) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.024 % + 4.7 mV 0.024 % + 2.4 mV 0.024 % + 2.4 mV 0.041 % + 2.4 mV 0.14 % + 2.4 mV 0.47 % + 12 mV 1.8 % + 12 mV	
(100 to 1000) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.47 % + 47 mV 0.47 % + 24 mV 0.07 % + 24 mV 0.14 % + 24 mV 0.35 % + 24 mV	
AC High Voltage[3] – Measure			
(1 to 6) kV	60 Hz	0.52 %	Fluke 80K series probes and Fluke 87 meter
AC Current – Generate			
9 µA to 220 µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	72 µA/A 73 µA/A 75 µA/A 0.023 % 0.11 %	Fluke 5700A/EP w/ 5725A

Parameter/Range	Frequency	CMC[2, 5, 6, 8] (±)	Comments
AC Current – Generate (cont)			
(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	38 µA/A 66 µA/A 50 µA/A 64 µA/A 0.012 %	Fluke 5700A/EP w/ 5725A
(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	95 µA/A 93 µA/A 100 µA/A 97 µA/A 0.059 %	
(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	66 µA/A 66 µA/A 71 µA/A 96 µA/A 0.014 %	
(0.22 to 2.2) A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.015 % 0.058 % 0.14 %	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.034 % 0.044 % 0.055 %	
(11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.14 % + 5.8 mA 0.18 % + 5.8 mA 3.5 % + 5.8 mA	Fluke 5520A
AC Current[3] – Measure			
(5 to 100) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz	0.4 % + 0.03 µA 0.15 % + 0.03 µA 0.06 % + 0.03 µA	Agilent 3458A Opt 002
100 µA to 100 mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.4 % + 200 µA/A 0.15 % + 200 µA/A 0.06 % + 200 µA/A 0.03 % + 200 µA/A	
(0.1 to 1.0) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.4 % + 0.2 mA 0.16 % + 0.2 mA 0.08 % + 0.2 mA 0.1 % + 0.2 mA	

Parameter/Range	Frequency	CMC[2, 8] (±)	Comments
AC Resistance[3] – Generate			
0.1 Ω	100 Hz 1 kHz	0.15 % 0.14 %	HP 16074A AC resistance standards
1 Ω	100 Hz 1 kHz	0.024 % 0.062 %	
10 Ω	100 Hz to 13 MHz	0.082 %	
100 Ω	5 Hz 10 Hz 50 Hz to 1 MHz 5 MHz 10 MHz 13 MHz	0.28 % 0.13 % 0.015 % 0.21 % 0.44 % 0.57 %	
1 kΩ	5 Hz 10 Hz 50 Hz to 1 MHz 5 MHz 10 MHz 13 MHz	0.60 % 0.26 % 0.061 % 0.24 % 0.57 % 0.74 %	
10 kΩ	5 Hz 10 Hz 50 Hz to 1 MHz	0.56 % 0.19 % 0.073 %	
100 kΩ	5 Hz 10 Hz 50 Hz to 100 kHz	0.43 % 0.32 % 0.07 %	
Phase Angle[3] –			
(0.0 to 999.999)º	1 Hz to 6.250 kHz (>6.25 to 50) kHz (>50 to 200) kHz	0.040° 0.068° 0.18°	Clark-Hess 5500 phase standard
Audio Distortion (THD)[3]	20 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	1.7 dB 1.7 dB 2.1 dB	HP 8903E

Parameter/Range	Frequency	CMC[2, 8] (±)	Comments
Oscilloscopes[3] –			
Rise Time	Single Sided	12 ps	Fluke 9500 w/ active heads
Bandwidth (Flatness)	0.1 Hz to 300 MHz (> 300 to 550) MHz (> 0.55 to 3) GHz (> 3 to 6) GHz	1.6 % 1.6 % 1.6 % 2.0 %	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Thermocouple[3] – Indicating Systems & Measure	E, J, K, T R, S	0.0005 °C/°C + 0.03 °C 0.0005 °C/°C + 0.2 °C	Agilent 3458A w/ DCV source
Electrical Calibration of Thermocouples[3] – Generate and Measure			
Type B	(600 to 800) °C (800 to 1000) °C (1000 to 1550) °C (1550 to 1820) °C	0.44 °C 0.34 °C 0.30 °C 0.33 °C	Fluke 5520A
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.30 °C 0.26 °C 0.31 °C 0.50 °C 0.84 °C	
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.50 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °C	
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.27 °C 0.16 °C 0.14 °C 0.17 °C 0.23 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Calibration of Thermocouples[3] – Generate and Measure (cont)			
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.33 °C 0.18 °C 0.16 °C 0.26 °C 0.40 °C	Fluke 5520A
Type L	(-200 to -100) °C (-100 to 800) °C (800 to 900) °C	0.37 °C 0.26 °C 0.17 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.57 °C 0.35 °C 0.33 °C 0.40 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.47 °C 0.36 °C 0.37 °C 0.46 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.63 °C 0.24 °C 0.16 °C 0.14 °C	
Electrical Calibration of RTDs[3] – Generate			
Pt 385, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.052 °C 0.080 °C 0.09 °C 0.11 °C 0.12 °C 0.23 °C	Fluke 5520A
Pt 3926, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.052 °C 0.071 °C 0.091 °C 0.10 °C 0.12 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Calibration of RTDs[3] – Generate (cont)			
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	0.25 °C 0.042 °C 0.052 °C 0.062 °C 0.071 °C 0.081 °C 0.091 °C 0.10 °C 0.23 °C	Fluke 5520A
Pt 385, 200 Ω	(-200 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.042 °C 0.053 °C 0.12 °C 0.13 °C 0.14 °C 0.16 °C	
Pt 385, 500 Ω	(-200 to -80) °C (-80 to 100) °C (100 to 260) °C (260 to 400) °C (400 to 600) °C (600 to 630) °C	0.042 °C 0.052 °C 0.062 °C 0.082 °C 0.092 °C 0.11 °C	
Pt 385, 1000 Ω	(-200 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C	0.034 °C 0.043 °C 0.052 °C 0.062 °C 0.072 °C 0.23 °C	
Ni 120, 120 Ω	(-80 to 100) °C (100 to 260) °C	0.081 °C 0.14 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.3 °C	

V. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC[2, 8] (±)	Comments
Power Meter[3] – Power Reference, @ 1 mW	50 MHz	1.9 %	HP 432A power meter w/ 478A thermistor sensor

Parameter/Range	Frequency	CMC[2, 4, 8] (±)	Comments
Relative Power – Measure			
(0 to -10) dBm	10 MHz to 26.5 GHz	0.05 dB	HP 8902A w/ option 050
(-10 to -20) dBm		0.05 dB	
(-20 to -30) dBm		0.06 dB	
(-30 to -40) dBm		0.10 dB	
(-40 to -50) dBm		0.10 dB	
(-50 to -60) dBm		0.11 dB	
(-60 to -70) dBm		0.13 dB	
(-70 to -80) dBm		0.19 dB	
(-80 to -90) dBm		0.19 dB	
(-90 to -100) dBm		0.34 dB	
Absolute Power – Measure			HP 437B with
(-70 to -30) dBm	10 MHz to 18 GHz	3.0 % + *M*	HP 8484A, N-type
(-30 to +10) dBm	100 kHz to 4.2 GHz	2.1 % + *M*	HP 8482A H85, N-type
	(4.2 to 18) GHz	2.6 % + *M*	HP 8481A H85, N-type
	(18 to 26.5) GHz	2.5 % + *M*	HP 8485A H85, 3.5 mm
(+10 to +20) dBm	100 kHz to 4.2 GHz	3.9 % + *M*	HP 8482A H85, N-type
	(4.2 to 18) GHz	2.0 % + *M*	HP 8481A H85, N-type
	(18 to 26.5) GHz	2.2 % + *M*	HP 8485A H85, 3.5 mm
VSWR[3]	5 MHz to 2 GHz	0.12 dB	HP 8902A measuring receiver w/ Wiltron SWR bridges
	(2 to 12.5) GHz	0.60 dB	
	(12.5 to 18) GHz	1.0 dB	
Frequency Modulation –			
Carrier: 250 kHz to 10 MHz Dev: Up to 40 kHz	20 Hz to 10 kHz	2.4 %	HP 8902A w/ option 050
Carrier: 10 MHz to 1.3 GHz Dev: Up to 400 kHz	(20 to 50) Hz	5.8 %	
	50 Hz to 100 kHz	1.2 %	
	(100 to 200) kHz	5.8 %	

Parameter/Range	Frequency	CMC[2, 8] (±)	Comments
Amplitude Modulation –			
Carrier: (0.15 to 10) MHz Depth: Up to 99 %	(20 to 50) Hz 50 Hz to 100 kHz	3.5 % 2.4 %	HP 8902A w/ option 050
Carrier: 10 MHz to 1.3 GHz Depth: Up to 99 %	(20 to 50) Hz 50 Hz to 100 kHz	3.5 % 3.5 %	
Phase Modulation –			HP 8902A w/ option 050
Carrier: 150 kHz to 10 MHz	200 Hz to 10 kHz	4.7 %	
Carrier: 10 MHz to 1.3 GHz	200 Hz to 20 kHz	3.6 %	

VI. Mechanical

Parameter/Equipment	Range	CMC[2, 4, 8] (±)	Comments
Balances[3]	 Up to 5500 g Up to 55 kg	 0.00024 % + 0.6*R* 0.002 % + 0.6*R*	Handbook 44 w/: Class 1 weights Class 3 weights
Scales[3]	Up to 4800 lb	0.021 % + 0.6*R*	Handbook 44 w/ Class F weights
Torque Tools[3] –	0.5 to 42.5 ozf·in (5 to 50) lbf·in (50 to 250) lbf·in (20 to 250) lbf·ft	6.4 % 0.86 % 0.41 % 0.35 %	Waters 6500-T3 Sturtevant-Richmont 5AC
Force Gauges[3]	Up to 250 lbf	0.27 % of full scale	Deadweights
Pressure[3]	(0.5 to 23) psia (23 to 1015) psia	0.0093 % + 0.0004 psi 0.0093 % + 0.6*R*	DHI PPC3 pressure calibrator w/ RPM4 DHI PPC3 pressure calibrator

Parameter/Equipment	Range	CMC[2] (±)	Comments
Indirect Verification of Brinell Hardness Testers at Test Conditions[3, 9] –			ASTM E10-07a with hardness test blocks and Brinell scope
10/3000/15	Repeatability:		
	≤ 263 HBW	0.028*d*	*d* is the mean of the *n* diameters in millimeters
	(> 263 to 591) HBW	0.011*d*	
	Error:		
	≤ 263 HBW	1.0 %	Uncertainty is stated as a percentage of the standardized test block hardness value
	(> 263 to 591) HBW	1.2 %	
Indirect Verification of Rockwell Hardness Testers[3]	HRBW:		ASTM E18-08 using traceable blocks through NIST
	Low	0.05 HRBW	
	Mid	0.03 HRBW	
	High	0.10 HRBW	
	HRC:		
	Low	0.43 HRC	
	Mid	0.54 HRC	
	High	0.53 HRC	
	HREW:		
	Low	0.20 HREW	
	High	0.20 HREW	
	HR30N:		
	Low	0.2 HR30N	
	Mid	0.5 HR30N	
	High	0.3 HR30N	
	HR30TW:		
	Low	1.2 HR30TW	
	High	0.2 HR30TW	

VII. Thermodynamics

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Temperature Measuring Equipment[3]	(-5 to 425) °C	0.0038 °C/°C + 0.069 ºC	Burns 3925 PRT, 1522 indicator w/ Hart 9172 & 7102 baths
Temperature[3] – Measure	(-197 to 425) ºC	0.0038 °C/°C + 0.069 ºC	Burns 3925 PRT & 1522 indicator
Infrared Thermometers[3]	(50, 100, 150) ºC	1.2 ºC + 0.6*R*	Hart 9135 black body
Relative Humidity[3] – Measure	(10 to 90 %) RH	1.6 % RH + 0.6*R*	Veriteq 5000A-RH/T data logger

VIII. Time & Frequency

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
Frequency Measuring Equipment[3]	10 MHz reference 1 mHz to <100 kHz 100 kHz to 10 MHz >10 MHz to 40 GHz	30 pHz 1.2 nHz/Hz + 0.6*R* 17 pHz/Hz + 0.6*R* 26 pHz/Hz + 0.6*R*	GPS receiver GPS receiver w/ generator
Frequency[3] – Measure	0.001 Hz to 46 GHz	26 pHz/Hz + 0.6*R*	Counter locked to 10 MHz reference

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

[2] Calibration and Measurement Capability (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. Calibration and Measurement Capabilities 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 numerical value of the nominal length of the device measured in inches; D is the length of the diagonal in inches; M is the source mismatch uncertainty; and R is the value of the resolution of the device under test.

[5] The measurands stated are generated with the Fluke 5500A & 5700A series of instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMCs are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification.

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

[7] Fluke 732B CMCs are to be read as a fraction of the reading plus one-year floor specification.

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

[9] The notation 10/3000/15 gives the conditions of the verification with "10" is the diameter of the indentor in millimeters, "3000" is the test force in kilogram-force, and "15" is the duration of force application in seconds.