



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: 2516.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations¹:

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	0.33 dB 0.33 dB	GenRad 1562A
	94 dB @ 1 kHz	0.77 dB	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 + 0.6R	Buffer solutions

Parameter/Equipment	Range	CMC ^{2,4} (\pm)	Comments
Electrolytic Conductivity Measuring Equipment ³	10 μ S/cm 1000 μ S/cm 10 000 μ S/cm	0.52 μ S/cm + 0.6R 24 μ S/cm + 0.6R 230 μ S/cm + 0.6R	Conductivity solutions

III. Dimensional

Parameter/Equipment	Range	CMC ^{2,4} (\pm)	Comments
Gage Blocks	Up to 1 in (>1 to 20) in	3 μ in (1.3 + 2L) μ in	Comparison to gage blocks
Length Standards ³	Up to 18 in (>18 to 60) in	(20 + 3.6L) μ in (35 + 4.5L) μ in	Gage blocks & height comparator
Micrometers ³	Up to 72 in	11 μ in/in + 0.6R	Gage blocks
Indicators ³	Up to 6 in	12 μ in/in + 0.6R	Gage blocks
Calipers	Up to 120 in	11 μ in/in + 0.6R	Gage blocks
Calipers ³	Up to 72 in	13 μ in/in + 0.6R	Gage blocks
Height Master ³ – Micrometer Head Block Pitch	Up to 24 in	60 μ in (45 + 3L) μ in	Gage blocks
Height Gages ³	Up to 40 in	15 μ in/in + 0.6R	Gage blocks
Depth Gages ³	Up to 24 in	11 μ in/in + 0.6R	Gage blocks
Radius Gages	Up to 12 in	190 μ in	Optical comparator

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Length Measurement – Length Fixtures, Glass Scales, Loupes, Magnification Checkers, Snap Gages, Steel Wire Gages, Weld Fillet Gages, Lead Gages, Screw Thread Pitch Gages	Up to 120 in	190 µin/in + 0.6R	Optical comparator
Length Measurement ³	Up to 40 in	1.4 µin/in	Optodyne LDDM
Bore Gages, Bore Micrometers & Holtests ³	Up to 6 in	20 µin/in + 0.6R	Gage blocks
Straight Edges/Parallels	Up to 60 in	1.6 µin/in + 22 µin	Gage blocks w/ indicator
Steel Tapes ³	Up to 100 ft	0.08 in	Master tapes
Steel Rules	Up to 120 in	(18 + 10L) µin	Optical comparator & glass scale
Sieves & Sieve Cloths	All grades, mesh sizes	190 µin/in	ASTM E11 w/ optical comparator
External Diameter – Cylindrical Gauging – Pin, Wire and Plug Gages, Gear Wires and Crimper Limit Gages Datum Spheres, Steel Balls	Up to 1 in (>1 to 12) in Up to 1 in	17 µin (12 + 4.8L) µin 12 µin	Gage blocks Gage blocks
Internal Diameter – Plain Ring Gages	(0.06 to 0.13) in (>0.13 to 0.8) in (>0.8 to 7.0) in	58 µin 23 µin (18 + 6.3L) µin	Master plain ring
Chamfer Gages ³	Up to 2 in	350 µin	Master chamfer rings

Parameter/Equipment	Range	CMC ^{2, 4, 7} (\pm)	Comments
External Thread Gauging – Plug Gages, Discs Major Diameter Pitch Diameter (80 to 4) TPI National Pipe (NPT) Pitch Diameter	Up to 1 in (>1 to 17) in 29° 55° 60° Up to 3 in	17 μ in (12 + 4.8L) μ in (90 + 11L) μ in (66 + 13L) μ in (64 + 13L) μ in 360 μ in	Gage blocks, contact method Master wires Measuring wires
Internal Thread Gauging – Ring Gages Minor Diameter Pitch Diameter 29° 60°, 55° and 7/45° National Pipe Rings (NPT) Step Height	Up to 0.5 in Up to 3.2 in Up to 8 in Up to 3 in	350 μ in (180 + 17L) μ in (200 + 55L) μ in (160 + 45L) μ in (350 + 8L) μ in	Hole micrometer, pins Master ring Master plug set (functional fit only) Gage blocks
Optical Comparators ³ – Linear Travel Magnification	Up to 30 in 10x to 100x	120 μ in 0.12 %	Comparison to master
Surface Plates ³	Up to (72 x 144) in ²	1.4D μ in	Laser
Coordinate Measuring Machines ³ – Repeatability Linear Accuracy	Sphere Up to 24 in	23 μ in 1.4 μ in/in + 71 μ in	ASME B89.4.10360.2-2008 Sphere Step gage

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Coordinate Measuring Machines ³ – (cont)			ASME B89.4.10360.2-2008
Squareness	Up to 24 in	31 μin	Ball bar
Volumetric Performance	600 mm	140 μin	Ball bar
Angle Measuring Equipment	Up to 90°	3”	Gage blocks & sine bar
Sine Bar & Plates	Up to 90°	6.7”	Gage & angle blocks
Angle Plates	Up to 18 in	(45 + 4.2L) μin	Master square
Angle Blocks & Squares	Up to 45°	8.7”	Sine plate & gage blocks

IV. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2,5,7} (±)	Comments
DC Voltage ³ – Generate and Measure	Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V*	11 μV/V + 0.4 μV 6.8 μV/V + 0.4 μV 5.5 μV/V + 0.6 μV 7.7 μV/V + 35 μV 8.7 μV/V + 0.2 mV	Fluke 5700A w/ Agilent 3458A *Add 12 μV/V _x (V _{in} /1000) ² for inputs > 100 V
DC Voltage ³ – Generate, Fixed Points	1 V 10 V	0.83 μV/V 0.80 μV/V	Fluke 732B, 752A & HP 3458A Opt 002
DC High Voltage ³ – Measure	(1 to 6) kV (6 to 20) kV (20 to 35) kV (35 to 40) kV	1.2 % 2.3 % 1.2 % 2.3 %	Fluke 80K series probe & 87III meter
DC Current ³ – Generate	Up to 200 pA (0.2 to 200) nA	1.9 % + 0.02 pA 0.29 % + 0.02 nA	Keithley 617, voltage source

Parameter/Equipment	Range	CMC ^{2, 5, 6, 7} (\pm)	Comments
DC Current ³ – Generate (cont)	Up to 100 μ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA	19 μ A/A + 0.94 nA 18 μ A/A + 5.8 nA 20 μ A/A + 58 nA 38 μ A/A + 0.58 μ A	Fluke 5700A w/ Agilent 3458A
	(100 to 220) mA (0.22 to 2.2) A (2.2 to 11) A	59 μ A/A + 0.93 μ A 92 μ A/A + 29 μ A 0.041 % + 0.56 mA	Fluke 5700A & 5725A
	(11 to 20.5) A	0.12 % + 16 mA	Fluke 5520A
	(20.5 to 150) A	0.29 % + 75 mA	Fluke 5520A w/ 50-turn coil
	(150 to 1000) A	0.31 % + 0.65 A	
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	3.5 % 0.63 % 0.20 % 0.23 % 0.085 %	Keithley 617
	(0.2 to 100) μ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	19 μ A/A + 0.94 nA 18 μ A/A + 5.8 nA 20 μ A/A + 58 nA 38 μ A/A + 0.58 μ A 0.012 % + 12 μ A	Agilent 3458A
Resistance ³ – Generate	Up to 10.99 Ω 11 Ω to 1.099 k Ω (1.1 to 10.99) k Ω (11 to 109.99) k Ω	41 $\mu\Omega/\Omega$ + 0.001 Ω 32 $\mu\Omega/\Omega$ + 0.002 Ω 30 $\mu\Omega/\Omega$ + 0.02 Ω 30 $\mu\Omega/\Omega$ + 0.2 Ω	Fluke 5520A, 4-wire
	(0.11 to 1.099) M Ω (1.1 to 3.299) M Ω (3.3 to 10.99) M Ω (11 to 32.99) M Ω (33 to 109.99) M Ω (110 to 330) M Ω (330 to 1100) M Ω	36 $\mu\Omega/\Omega$ + 2.3 Ω 78 $\mu\Omega/\Omega$ + 39 Ω 0.014 % + 52 Ω 0.026 % + 2.6 k Ω 0.052 % + 3.2 k Ω 0.31 % + 100 k Ω 1.6 % + 520 k Ω	Fluke 5520A, 2-wire
Fixed Points	(1, 1.9) Ω 10 Ω 19 Ω (100, 190) Ω	0.011 % 33 $\mu\Omega/\Omega$ 31 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$	Fluke 5700A, 742A

Parameter/Equipment	Range	CMC ^{2, 4, 5, 7} (±)	Comments
Capacitance ³ – Measure, (0.1, 0.12, 1 and 10) kHz	10 pF 100 pF 1000 pF 10 nF 100 nF 1000 nF 10 µF 100 µF	0.15 % 0.23 % 0.14 % 0.13 % 0.13 % 0.16 % 0.12 % 0.2 %	GenRad 1659 RLC Digibridge
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	
Fixed Points			
1 kHz to 1 MHz	1 pF	0.037 % + 0.6R	HP 16381A standard air capacitor
2 MHz		0.043 % + 0.6R	
3 MHz		0.055 % + 0.6R	
4 MHz		0.073 % + 0.6R	
5 MHz		0.096 % + 0.6R	
10 MHz		0.26 % + 0.6R	
13 MHz		0.38 % + 0.6R	
1 kHz to 13 MHz		10 pF	
1 kHz to 5 MHz	100 pF	0.039 % + 0.6R	HP 16383A
10 MHz		0.052 % + 0.6R	
13 MHz		0.067 % + 0.6R	
1 kHz to 1 MHz	1000 pF	0.037 % + 0.6R	HP 16384A
2 MHz		0.04 % + 0.6R	
3 MHz		0.048 % + 0.6R	
4 MHz		0.062 % + 0.6R	
5 MHz		0.08 % + 0.6R	
10 MHz		0.23 % + 0.6R	
13 MHz		0.33 % + 0.6R	

Parameter/Equipment	Range	CMC ^{2, 4, 7} (\pm)	Comments
Capacitance ³ – Generate (cont) 120 Hz to 100 kHz	(10, 100, 1000) nF	0.01 % + 0.6R	HP 16380C series air capacitors
Inductance ³ – Generate, @ 1 kHz Fixed Points, 400 Hz & 1 kHz	(1 to 10) mH (10 to 100) mH (100 to 1000) mH 100 μ H 1 mH 10 mH 100 mH 1 H	2.4 % + 0.6R 1.9 % + 0.6R 0.84 % + 0.6R 0.1 μ H + 0.6R 0.7 μ H + 0.6R 7.1 μ H + 0.6R 0.07 mH + 0.6R 0.52 mH + 0.6R	GenRad 1490A standard inductors
Inductance – Measure, @ 1 kHz	1 μ H to 100 H	0.17 %	GenRad 1659 RLC Digibridge

Parameter/Range	Frequency	CMC ^{2, 5} (\pm)	Comments
AC Voltage ³ – Generate Up to 2.2 mV (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 (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	0.05 % + 5 μ V 0.019 % + 5 μ V 0.01 % + 5 μ V 0.033 % + 5 μ V 0.075 % + 7 μ V 0.1 % + 13 μ V 0.15 % + 25 μ V 0.31 % + 25 μ V 0.05 % + 5 μ V 0.019 % + 5 μ V 0.01 % + 5 μ V 0.033 % + 5 μ V 0.075 % + 7 μ V 0.1 % + 12 μ V 0.15 % + 55 μ V 0.31 % + 25 μ V	Fluke 5700A

Parameter/Range	Frequency	CMC ^{2,5} (±)	Comments
AC Voltage ³ – Generate (cont)			
(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	0.05 % + 13 µV 0.019 % + 8 µV 0.01 % + 8 µV 0.028 % + 8 µV 0.075 % + 25 µV 0.1 % + 25 µV 0.15 % + 35 µV 0.31 % + 80 µV	Fluke 5700A
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	0.045 % + 80 µV 0.014 % + 25 µV 65 µV/V + 8 µV 0.011 % + 16 µV 0.021 % + 70 µV 0.039 % + 130 µV 0.095 % + 350 µV 0.19 % + 0.85 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	0.045 % + 0.8 mV 0.014 % + 0.25 mV 65 µV/V + 0.06 mV 0.011 % + 0.16 mV 0.021 % + 0.35 mV 0.045 % + 1.5 mV 0.12 % + 4.3 mV 0.25 % + 8.5 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	0.045 % + 8 mV 0.014 % + 2.5 mV 70 µV/V + 0.8 mV 0.019 % + 3.5 mV 0.045 % + 8 mV 0.14 % + 90 mV 0.45 % + 90 mV 1.1 % + 190 mV	
(220 to 1100) V	(40 to 50) Hz 50 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	0.036 % + 16 mV 70 µV/V + 3.5 mV 0.013 % + 6 mV 0.036 % + 11 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.036 % + 11 mV 0.13% + 45 mV	

Parameter/Range	Frequency	CMC ^{2, 6, 7} (±)	Comments
AC Voltage ³ – Measure			
(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 % + 0.012 % 1.2 % + 0.012 % 1.8 % + 0.012 %	
(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 4.2) kV	60 Hz (0 to 500) Hz (500 to 1000) Hz	1.6 % 3.1 % 3.7 %	Fluke 80K series probe & Fluke 87III meter
(4.2 to 28) kV	60 Hz	5.9 %	

Parameter/Range	Frequency	CMC ^{2, 5, 6} (±)	Comments
AC Current ³ – Generate			
(9 to 220) µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.064 % + 25 nA 0.033 % + 20 nA 0.014 % + 16 nA 0.051 % + 40 nA 0.14 % + 80 nA	Fluke 5700A/5725A
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	0.064 % + 40 nA 0.033 % + 35 nA 0.013 % + 35 nA 0.051 % + 0.4 µA 0.15 % + 0.8 µA	
(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	0.064 % + 0.40 µA 0.033 % + 0.35 µA 0.013 % + 0.35 µA 0.051 % + 4.0 µA 0.15 % + 8.0 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	0.064 % + 4.0 µA 0.033 % + 3.5 µA 0.013 % + 3.5 µA 0.051 % + 40 µA 0.15 % + 80 µA	
220 mA to 2.2 A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.056 % + 35 µA 0.066 % + 80 µA 0.75 % + 160 µA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.059 % + 0.17 mA 0.096 % + 0.38 mA 0.34 % + 0.75 mA	
(1.1 to 2.99999) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.21 % + 0.12 mA 0.071 % + 0.12 mA 0.7 % + 1.2 mA 2.9 % + 5.8 mA	Fluke 5520A
(3 to 10.9999) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.071 % + 2.4 mA 0.12 % + 2.4 mA 3.5 % + 2.4 mA	
(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	

Parameter/Range	Frequency	CMC ^{2, 4, 6, 7} (\pm)	Comments
AC Current ³ – Measure (5 to 100) μ A 100 μ A to 100 mA (0.1 to 1.0) A	 (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	 0.4 % + 0.03 μ A 0.15 % + 0.03 μ A 0.06 % + 0.03 μ A 0.4 % + 0.02 % 0.15 % + 0.02 % 0.06 % + 0.02 % 0.03 % + 0.02 % 0.4 % + 0.2 mA 0.16 % + 0.2 mA 0.08 % + 0.2 mA 0.1 % + 0.2 mA	 Agilent 3458A Opt 002
AC Resistance ³ – Generate, Fixed Points 0.1 Ω 1 Ω 10 Ω (0.1, 1, 10, 100) k Ω	 DC to 1 MHz	 1.2 % + 0.6R 0.12 % + 0.6R 0.11 % + 0.6R 0.032 % + 0.6R	 HP 16074A AC resistance standards
Oscilloscopes ³ – Risetime Bandwidth (Flatness)	 Single Sided 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz (1.1 to 4.2) GHz (4.2 to 18) GHz (18 to 26.5) GHz	 120 ps 1.8 % + 120 μ V 2.4 % + 120 μ V 4.7 % + 120 μ V 5.9 % + 120 μ V 0.24 dB 0.71 dB 0.47 dB	 Fluke 5520A w/ SC1100 HP 8340A w/: 8482A, 11667B 8481A, 11667B 8485A, 11667B
Phase Angle ³	(1 to 1000) Hz 1001 Hz to 6.25 kHz (6.26 to 50) kHz (50.01 to 100) kHz	(0.006 + 0.05D) ^o (0.012 + 0.1D) ^o (0.017 + 0.25D) ^o (0.046 + 0.5D) ^o	Clark-Hess 5500 phase standard D is the ratio between the REF & VAR output amplitudes

Parameter/Equipment	Frequency	CMC ² (±)	Comments
Audio Distortion (THD) ³	Up to 100 Hz (> 100 to 500) Hz (> 0.5 to 1) kHz (> 1 to 5) kHz (> 5 to 10) kHz (> 10 to 50) kHz (> 50 to 100) kHz (> 100 to 250) kHz	1.2 dB 1.3 dB 1.7 dB 1.4 dB 1.3 dB 1.7 dB 2.3 dB 1.7 dB	Agilent N5531S measuring receiver system
Thermocouple ³ – Indicating Systems & Measure	E, J, K, T R, S	0.5 m°C/°C + 0.03 °C 0.5 m°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 0.3 °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	0.3 °C 0.26 °C 0.31 °C 0.5 °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	0.5 °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 0.4 °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 N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.4 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °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 0.4 °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	
Type U	(-200 to 0) °C (0 to 600) °C	0.56 °C 0.27 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
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 0.08 °C 0.091 °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 0.1 °C 0.12 °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	0.25 °C 0.042 °C 0.052 °C 0.062 °C 0.071 °C 0.081 °C 0.091 °C 0.1 °C 0.23 °C	
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	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of RTDs ³ – Generate (cont)			
Pt 385, 1000 Ω	(-200 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 400) °C (400 to 600) °C (600 to 630) °C	0.034 °C 0.043 °C 0.052 °C 0.062 °C 0.077 °C 0.23 °C	Fluke 5520A
Ni 120, 120 Ω	(-80 to 100) °C (100 to 300) °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 ^{2,4,7} (±)	Comments
Power Meter ³ – Power Reference, @ 1 mW	50 MHz	1.9 %	HP 432A power meter w/ 478A thermistor sensor
Relative Power ³ – Measure (0 to -50) dB (-50 to -70) dB (-70 to -100) dB (-100 to -130) dB	10 MHz to 26.5 GHz	0.035 dB 0.088 dB 0.15 dB 0.18 dB	Agilent N5531S measuring receiver system
RF Absolute Power ³ – Measure (-70 to -30) dBm (-30 to +10) dBm (+10 to +20) dBm	10 MHz to 18 GHz 100 kHz to 4.2 GHz (4.2 to 18) GHz (18 to 26.5) GHz (26.5 to 50) GHz 100 kHz to 4.2 GHz (4.2 to 18) GHz (18 to 26.5) GHz (26.5 to 50) GHz	2.9 % + <i>M</i> 1.8 % + <i>M</i> 3.7 % + <i>M</i> 3.4 % + <i>M</i> 9.9 % + <i>M</i> 3.9 % + <i>M</i> 3.9 % + <i>M</i> 2.7 % + <i>M</i> 6.8 % + <i>M</i>	HP 437A power meter w/ sensors 8484A, N-Type 8482A, N-Type E4413A, 3.5 mm E4413A, 3.5 mm N5532A, 2.4 mm 8482A, N-Type E4413A, 3.5 mm E4413A, 3.5 mm N5532A, 2.4 mm

Parameter/Range	Frequency	CMC ^{2,4,7} (±)	Comments
Power Sensor Calibration Factor ³ – (-30 to +20) dBm	100 kHz to 4.2 GHz 10 MHz to 14 GHz (14 to 18) GHz	1.6 % 1.6 % 1.8 %	Agilent E4418B power meter 8482A-H84 sensor 8481A-H84 sensor
VSWR ³	5 MHz to 2 GHz (2 to 12.5) GHz (12.5 to 18) GHz	0.12 dB 0.6 dB 1 dB	HP 8902A measuring receiver w/ Wiltron SWR bridges
Frequency Modulation ³ – Measure Mod Rate: 20 Hz to 10 kHz Dev.: 200 Hz to 40 kHz ($\beta > 0.2$) Mod Rate: 50 Hz to 200 kHz Dev.: 250 Hz to 400 kHz ($\beta > 0.2$)	250 kHz to 10 MHz 10 MHz to 6.6 GHz (6.6 to 13.2) GHz (13.2 to 31.15) GHz (31.15 to 50) GHz	1.5 % 1.5 % 2.5 % 3.8 % 8.5 %	Agilent N5531S measuring receiver system β is the ratio of the frequency deviation to the modulation rate
Amplitude Modulation ³ – Measure Mod Rate: 50 Hz to 10 kHz Depths: (5 to 99) % Mod Rate: 50 Hz to 100 kHz Depths: (5 to 20) % Depths: (>20 to 99) %	(0.10 to 10) MHz 10 MHz to 3 GHz (3 to 26.5) GHz (26.5 to 31.15) GHz (31.15 to 50) GHz 10 MHz to 3 GHz (3 to 26.5) GHz (26.5 to 31.15) GHz (31.15 to 50) GHz	0.75 % 2.5 % 4.5 % 6.8 % 26 % 0.5 % 1.5 % 1.9 % 6 %	Agilent N5531S measuring receiver system

Parameter/Range	Frequency	CMC ^{2,7} (±)	Comments
Phase Modulation ³ – Mod Rate: (0.2 to 20) kHz 0.3 rad < Dev ≤ 0.7 rad Dev > 0.7 rad 0.6 rad < Dev ≤ 2.0 rad Dev > 2.0 rad 1.2 rad < Dev ≤ 4.0 rad Dev > 4.0 rad 1.3 rad < Dev ≤ 4.0 rad Dev > 4.0 rad 2.4 rad < Dev ≤ 8.0 rad Dev > 8.0 rad	100 kHz to 6.6 GHz (6.6 to 13.2) GHz (13.2 to 26.5) GHz (26.5 to 31.5) GHz (31.5 to 50) GHz	3 % 1 % 3 % 1 % 3 % 1 % 3 % 1 %	Agilent N5531S measuring receiver system
Transmission ³ S ₁₂ /S ₂₁ – Measure Type-N connectors 30 kHz to 2 GHz (2 to 6) GHz	Linear Phase Linear Mag. Linear Phase Linear Mag.	(± 0.77 to ± 39)° (± 0.11 to ± 8.2) dB (± 2.2 to ± 15)° (± 0.25 to ± 2.0) dB	Agilent 8753D VNA w/ 85032B calibration kit
Reflection ³ S ₁₁ /S ₂₂ – Measure Type-N connectors – 30 kHz to 2 GHz (2 to 6) GHz	Linear Phase Linear Mag. Linear Phase Linear Mag.	(± 2.4 to ± 13)° (± 0.33 to ± 0.36) dB (± 13 to ± 35)° (± 1.1 to ± 1.6) dB	Agilent 8753D VNA w/ 85032B calibration kit

Parameter/Range	Frequency	CMC ² (±)	Comments
Single Side-Band Phase Noise ³ – Measure Carrier: 50 kHz to 26.5 GHz Offset Freq: 0.01 Hz 1 Hz 10 Hz 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 10 MHz 100 MHz	Noise Floor: -70 dB -130 dB -140 dB -150 dB -160 dB -170 dB -170 dB -170 dB -170 dB -170 dB	5.8 dB 5.8 dB 5.8 dB 5.8 dB 5.8 dB 5.8 dB 5.8 dB 5.8 dB 5.8 dB 5.8 dB	Agilent N5500A opt 001 phase noise test set

VI. Mechanical

Parameter/Equipment	Range	CMC ^{2, 4, 7} (±)	Comments
Mass Measurement	30 mg to 620 g (620 to 5000) g (5 to 55) kg	0.003 g 0.026 g 0.033 g	Electronic balance, mass comparison
Balances ³	Up to 5500 g Up to 55 kg	0.00024 % + 0.6R 0.002 % + 0.6R	Handbook 44 w/ Class 1 weights Class 3 weights
Scales ³	Up to 4800 lb	0.021 % + 0.6R	Handbook 44 w/ Class F weights
Force ³	Up to 1400 lbf (0 to 2000) lbf (2 to 25) klbf (25 to 200) klbf	0.02 % + 0.6R 0.99 lbf 15 lbf 170 lbf	Deadweight Load cells

Parameter/Equipment	Range	CMC ^{2,4,7} (\pm)	Comments
Torque ³ – Tools Transducers	5 lbf·in to 200 lbf·ft (200 to 1000) lbf·ft (2 to 100) ozf·in (6 to 250) lbf·in (20 to 250) lbf·ft (250 to 1000) lbf·ft	0.3 % + 0.6 <i>R</i> 0.24 % + 0.6 <i>R</i> 0.03 % + 0.05 ozf·in 0.03 % + 0.11 lbf·in 0.03 % + 0.08 lbf·ft 0.03 % + 0.2 lbf·ft	Torque tester Torque arm and weights
Pressure ³	(0.5 to 23) psia (23 to 1015) psia (>150 to 5000) psi (>5 to 30) kpsi	0.0093 % + 0.0004 psi 0.0093 % + 0.6 <i>R</i> 0.36 % 0.11 % + 2 psi	Pressure calibration system Pressure calibrator Direct comparison
Indirect Verification of Brinell Hardness Testers at Test Conditions ³ – 10/3000/15	Repeatability: \leq 263 HBW > 263 to 591 HBW Error: \leq 263 HBW > 263 to 591 HBW	 0.028 <i>d</i> 0.011 <i>d</i> 1 % 1.2 %	ASTM E10-07a with hardness test blocks and Brinell scope <i>d</i> is the mean of the <i>n</i> diameters in millimeters Uncertainty is stated as a percentage of the standardized test block hardness value

Parameter/Equipment	Range	CMC ² (±)	Comments
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	0.1 HRBW	
	HRC:		
Low	0.43 HRC		
Mid	0.54 HRC		
High	0.53 HRC		
HREW:			
Low	0.2 HREW		
High	0.2 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, 7} (±)	Comments
Temperature Measuring Equipment ³	(-5 to 425) °C	0.0038 % + 0.0069 °C	Hart 5627 PRT, 1522 indicator w/ Hart 9172 & 7102 baths
Temperature ³ – Measure	(-197 to 425) °C	0.0038 % + 0.0069 °C	Hart 5627 PRT & 1522 indicator
Infrared Thermometers ³	(50, 100, 150) °C	1.2 °C + 0.6R	Hart 9135 black body
Relative Humidity ³ – Measure	(10 to 90) % RH	1.6 % RH + 0.6R	Veriteq 5000A-RH/T data logger

VIII. Time & Frequency

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

- ¹ This laboratory offers commercial calibration service and field calibration service. This accreditation covers calibrations performed at the main laboratory listed as well as the satellite locations listed on page 1 of this scope of accreditation.
- 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; R is the value of the resolution of the device under test; D is the length of the diagonal in inches; M is the source of mismatch uncertainty
- ⁵ The measurands stated are generated with the Fluke 5700A or 5520A 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 In the statement of CMC, percentages are percentage of reading, unless otherwise indicated.