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, 2019 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 calibrations[1]:

I. Chemical

Parameter/Equipment	Range	CMC[2] (±)	Comments
pH – Measuring Equipment[3, 8]	(4, 7, 10) Units	0.016 Units	Buffer solutions
Electrolytic Conductivity – Measuring Equipment	≈ 10 µS/cm ≈ 100 µS/cm ≈ 1000 µS/cm ≈ 10 000 µS/cm	0.73 µS/cm 2.4 µS/cm 23 µS/cm 0.23 mS/cm	Conductivity solutions

II. Dimensional

Parameter/Equipment	Range	CMC[2] (±)	Comments
Angle – Measure[8]	Up to 60º	5.8”	Gage blocks & sine bar

Parameter/Equipment	Range	CMC[2, 5, 6, 7] (±)	Comments
Angle – Measuring Equipment[8]	5º, 15º, 30º, 45º	5.2”	Angle blocks
Bore Gages, Bore Micrometers & Holtests[3, 8]	Up to 20 in	2.3 µin/in + 28 µin	Plain ring gages
Chamfer Gages[3, 8]	Up to 1 in (1 to 2) in	350 µin 410 µin	Master chamfer rings
Coordinate Measuring Machines[3, 8] –			
Repeatability	Sphere	23 µin	Sphere
Linear Accuracy	Up to 24 in	1.4 µin/in + 71 µin	Step gage
Squareness	Up to 24 in	31 µin	Ball bar
Volumetric Performance	600 mm	140 µin	Ball bar
Crimping Tools –			
Crimp Height	Up to 0.5 in	0.0002 in	Pin gages
Pull Test	Up to 288 lbf	0.023 %	Weights & customer-supplied cables & crimps
Diameter, External[8, 9] –			
Cylindrical Gauging – Pin, Thread/Gear Wire & Plug Gages, Datum Spheres, Steel Balls	Up to 20 in Up to 4 in[9]	2.2 µin/in + 9.2 µin 16 µin[9]	ULM THV w/ gage blocks
Diameter, Internal[8] – Plain Ring Gages	(0.02 to 0.13) in (0.13 to 0.8) in (0.8 to 20) in	2.2 µin/in + 33 µin 16 µin 2.2 µin/in + 16 µin	ULM w/ ruby balls Ring comparator ULM w/ gage blocks
Flatness[8, 9]	3”	3.5 µin	Optical flat

Parameter/Equipment	Range	CMC[2, 5, 6, 7] (±)	Comments
Gage Blocks	(0.005 to 4) in (4 to 20) in	1.9 µin/in + 2.3 µin 2.3 µin/in + 4.0 µin	Comparison to gage blocks
Hand Tools[3, 8] – Indicators Micrometers Depth Gages Height Gages Calipers	Up to 1 in (1 to 6) in (1 to 72) in (1 to 72) in (1 to 72) in (1 to 120) in	2.9 µin/in + 5.8 µin	Gage blocks
Height Master[3, 8] – Micrometer Head Block Pitch	 Up to 2 in Up to 24 in	 17 µin 3 µin/in + 45 µin	 Gage blocks
Laser Trackers – Displacement	Up to 40 m	6.2 µm/m + 15 µm	72 in Length bar
Length Measurement [8] – 1D 2D Volumetric	 Up to 24 in X to Y 24 in x 24 in X to Z or Y to Z 24 in x 20 in 20 in x 20 in x 24 in	 230 µin 350 µin 390 µin 700 µin	 CMM
Length Measurement[8]– Length Fixtures, Glass Scales, Loupes, Magnification	 Up to 1 in (1 to 6) in (6 to 12) in (12 to 144) in	 200 µin 280 µin 490 µin 9.2 µin/in + 380 µin	 Optical comparator
Length Measurement[3, 8]	Up to 40 in	1.6 µin/in	Optodyne LDDM

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Length Standards[3, 8]	Up to 20 in (20 to 80) in Up to 4 in[9]	2.2 µin/in + 8.0 µin 1.8 µin/in + 15 µin 16 µin[9]	ULM Gage blocks & height comparator THV w/ gage blocks
Optical Comparators[3, 8] – Linear Travel Magnification	 Up to 30 in 10x to 100x	 120 µin 0.017 %	 Glass scales & balls
Profilometers[3, 8]	≈ 16 PRS ≈ 120 PRS	2.7 µin 4.8 µin	Surface finish standards
Radius Gages[8]	Up to 1 in (1 to 6) in (6 to 12) in	250 µin 350 µin 600 µin	Optical comparator
Sieves & Sieve Cloths[8]	20 µm to 26.5 mm	4.6 µm/mm + 2.6 µm	ASTM E11 w/ optical comparator
Squareness[8]	90º	8.8 µin/in + 10 µin	Master square
Steel Rules[8]	Up to 120 in	(120 + 10*L*) µin	Optical comparator & glass scale
Steel Tapes[3, 8]	Up to 100 ft	0.05 in	Master tapes
Straight Edges/Parallels[8]	Up to 60 in	3.9 µin/in + 25 µin	Gage blocks w/indicator
Surface Finish Standards[3, 8]	≈ 16 PRS ≈ 120 PRS > 120 PRS	3.0 µin 5.2 µin 4.4 µin + 12 %	Surface finish standards w/ profilometer

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Surface Plates[3] –			
Overall Flatness	Up to 170 in diagonal	1.5*D* µin	Laser
Repeat Readings	Up to 0.0002 inch	28 µin	Repeat-A-Meter
Thread Gauging, External [8] –			
Plug Gages, Discs	Up to 1 in	23 µin	ULM
Major Diameter	(>1 to 8) in	3.0 µin/in + 13 µin	Gage blocks, contact method
Pitch Diameter Up to 8 in	29 º 55 º 60 º	6.1 µin/in + 72 µin 6.1 µin/in + 81 µin 14 µin/in + 120 µin	Master wires
National Pipe (NPT) Pitch Diameter	Up to 3 in	18 µin/in + 72 µin	
Step	Up to 4 in	41 µin	
Thread Gauging, Internal [8] –			
Ring Gages Minor Diameter	Up to 0.5 in	350 µin	Hole micrometer, pins
	Up to 3.2 in	(180 + 17*L*) µin	Master ring
Pitch Diameter Up to 8 in (Adj.)	29° 7/45°, 55 º, 60°	(200 + 55*L*) µin (160 + 45*L*) µin	Master plug set (functional fit only)
(1.1 to 12) (Fixed)	29°,7/45°, 55 º, 60°	(70 + 2.2*L*) µin	T-ball measurements

III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC[2, 5, 6, 7] (±)	Comments
DC Voltage[3, 8] – Generate	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	6.8 µV/V + 0.40 µV 3.7 µV/V + 0.80 µV 4.9 µV/V + 3.0 µV 4.9 µV/V + 4.3 µV 3.7 µV/V + 48 µV 4.7 µV/V + 0.48 mV	Fluke 5720A
DC Voltage[3, 8] – Generate, Fixed Points	10 V	1.3 µV/V	Fluke 732B
DC Voltage – Generate & Measure[3,8]	Up to 1000 V	2.1 µV/V	Fluke 732B w/ 720A & Agilent 3458A
DC Voltage – Measure[3, 8]	Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V	9.5 µV/V + 0.37 µV 6.1 µV/V + 0.37 µV 5.8 µV/V + 0.60 µV 8.7 µV/V + 37 µV 8.7 µV/V + 0.12 mV	Agilent 3458A
DC High Voltage[3, 8] – Measure	(1 to 60) kV	0.13 %	Ross VD60 w/ HP 8842A
DC Current[3, 8] – Generate	Up to 200 pA (0.2 to 200) nA Up to 220 µA (0.22 to 2.2) mA (2.2 to 22) mA (22 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 (2 to 20) A (20 to 120) A 120 A to 5 kA	1.9 % + 13 fA 0.35 % + 13 fA 35 µA/A + 6.0 nA 31 µA/A + 7.0 nA 30 µA/A + 41 nA 41 µA/A + 0.71 µA 77 µA/A + 12 µA 0.034 % + 0.48 mA 0.10 % + 0.91 A 0.58 % + 0.16 A 0.60 % + 0.58 A 0.04 % 0.06 % 0.9 %	Keithley 617 & voltage source Fluke 5720A Fluke 5520A Fluke 5520A w/ coil Fluke 5522A, 52120A w/ coil

Parameter/Equipment	Range	CMC[2, 5, 6, 7] (±)	Comments
DC Current[3, 8] – Measure	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 (0.1 to 1) A (1 to 10) A (10 to 100) A (100 to 300) A (300 to 1200) A	1.9 % + 13 fA 0.35 % + 13 fA 17 µA/A + 0.80 nA 17 µA/A + 5.0 nA 17 µA/A + 50 nA 31 µA/A + 0.50 µA 0.010 % + 10 µA 0.31 mA 0.012 % 56 µA/A 0.05 %	Keithley 617 Agilent 3458A w/ L&N 4222 w/ L&N 4361 w/ L&N 4363 w/ RAM shunt
Resistance[3, 8] – Generate	Up to 10.9999 Ω (11 to 32.9999) Ω (33 to 109.9999) Ω (110 to 329.9999) Ω (0.33 to 1.099 999) kΩ (1.1 to 3.299 999) kΩ (3.3 to 10.99 999) kΩ (11 to 32.99 999) kΩ (33 to 109.999) kΩ (110 to 329.999) kΩ (0.33 to 1.099 99) MΩ (1.1 to 3.299 00) MΩ (3.3 to 10.9999) MΩ (11 to 32.9999) MΩ (33 to 109.9999) MΩ (110 to 329.9999) MΩ (330 to 1100) MΩ	40 µΩ/Ω + 1.0 mΩ 30 µΩ/Ω + 2.0 mΩ 28 µΩ/Ω + 2.0 mΩ 28 µΩ/Ω + 4.0 mΩ 28 µΩ/Ω + 13 mΩ 28 µΩ/Ω + 13 mΩ 28 µΩ/Ω + 30 mΩ 28 µΩ/Ω + 0.30 Ω 28 µΩ/Ω + 0.30 Ω 32 µΩ/Ω + 2.0 Ω 32 µΩ/Ω + 2.2 Ω 60 µΩ/Ω + 39 Ω 0.013 % + 63 Ω 0.025 % + 2.5 kΩ 0.050 % + 3.0 kΩ 0.30 % + 0.10 MΩ 1.5 % + 0.50 MΩ	Fluke 5520A, 4-wire Fluke 5520A, 2-wire

Parameter/Equipment	Range	CMC[2, 5, 6, 7] (±)	Comments
Resistance[3, 8] – Measure Fixed Points	0.05 mΩ 0.1 mΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω (1.9, 10) Ω 100 Ω 1 kΩ 10 kΩ 19 kΩ 100 kΩ 1 MΩ 10 MΩ 19 MΩ 0 Ω 1 Ω 1.9 Ω 10, 19 Ω 100, 190 Ω 1, 1.9 kΩ 10, 19 kΩ 100, 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	0.30 % 0.29 % 93 μΩ/Ω 65 μΩ/Ω 75 μΩ/Ω 6.9 μΩ/Ω 7.2 μΩ/Ω 4.7 μΩ/Ω 6.9 μΩ/Ω 5.2 μΩ/Ω 6.1 μΩ/Ω 6.8 μΩ/Ω 8.7 μΩ/Ω 15 μΩ/Ω 19 μΩ/Ω 41 μΩ 80 μΩ/Ω + 6.3 μΩ 80 μΩ/Ω + 11 μΩ 21 μΩ/Ω + 120 μΩ 21 μΩ/Ω + 1.2 mΩ 7.5 μΩ/Ω + 58 mΩ 7.5 μΩ/Ω + 0.58 Ω 9 μΩ/Ω + 0.9 Ω 15 μΩ/Ω + 5 Ω 16 μΩ/Ω + 13 Ω 31 μΩ/Ω + 70 Ω 39 μΩ/Ω + 0.16 kΩ 95 μΩ/Ω + 0.84 kΩ	Shunts Standard resistors L&N Fluke 742A Fluke 5720A
Resistance[3, 8] – Measure	Up 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 (10 to 100) MΩ (0.1 to 1) GΩ	18 μΩ/Ω + 58 μΩ 12 μΩ/Ω + 0.58 mΩ 9.5 μΩ/Ω + 5.8 mΩ 9.5 μΩ/Ω + 58 mΩ 9.7 μΩ/Ω + 0.58 Ω 15 μΩ/Ω + 2.3 Ω 58 μΩ/Ω + 0.12 kΩ 0.058 % + 1.2 kΩ 0.59 % + 12 kΩ	Agilent 3458A

Parameter/Equipment	Range	CMC[2] (±)	Comments
Resistance[3, 8] – Measure	(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	60 μΩ/Ω 16 μΩ/Ω 13 μΩ/Ω 14 μΩ/Ω 14 μΩ/Ω 4.8 μΩ/Ω 4.8 μΩ/Ω 4.8 μΩ/Ω 7.2 μΩ/Ω 10 μΩ/Ω 13 μΩ/Ω 19 μΩ/Ω	Resistance transfer method using Fluke reference resistors

AC Voltage – Measure[3] w/ Fluke 5790A

	Frequency								
Voltage	*9.5 Hz*	*(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*
2.2 mV		0.15%	0.066%	0.038%	0.073%	0.140%	0.270%	0.30%	0.50%
7 mV		0.061%	0.018%	0.013%	0.025%	0.052%	0.100%	0.15%	0.29%
22 mV		0.032%	0.018%	0.016%	0.022%	0.049%	0.099%	0.14%	0.29%
70 mV	0.26%	0.027%	0.013%	0.012%	0.019%	0.044%	0.078%	0.12%	0.26%
220 mV	0.26%	0.025%	0.010%	0.008%	0.018%	0.043%	0.076%	0.12%	0.26%
700 mV	0.55%	0.025%	0.009%	0.005%	0.008%	0.011%	0.035%	0.091%	0.55%
2.2 V	0.55%	0.024%	0.009%	0.005%	0.008%	0.012%	0.036%	0.092%	0.55%
7 V	0.14%	0.024%	0.009%	0.004%	0.008%	0.011%	0.033%	0.10%	0.14%
22 V	0.15%	0.024%	0.009%	0.004%	0.008%	0.012%	0.034%	0.10%	0.16%
70 V		0.024%	0.009%	0.005%	0.008%	0.015%	0.081%	0.42%	0.70%
220V		0.029%	0.010%	0.005%	0.009%	0.016%	0.082%	0.42%	
700 V			0.027%	0.013%	0.041%	0.140%			
1000 V			0.028%	0.013%	0.039%				

AC Voltage Flatness[3] – Measure @ 50 Ω w/ Fluke 5790A[8]

		Frequency			
V_{P-P}	*V_{RMS}*	*10 Hz to 50 kHz*	*50 kHz to 1 MHz*	*(1 to 10) MHz*	*(10 to 30) MHz*
0.005 V	0.00177 V	0.092%	0.21%	0.27%	0.27%
0.0075 V	0.002655 V	0.092%	0.21%	0.27%	0.27%
0.01 V	0.00354 V	0.095%	0.21%	0.28%	0.27%
0.025 V	0.00885 V	0.092%	0.21%	0.27%	0.27%
0.04 V	0.01416 V	0.092%	0.21%	0.26%	0.26%
0.07 V	0.02478 V	0.092%	0.21%	0.26%	0.26%
0.1 V	0.0354 V	0.095%	0.21%	0.26%	0.26%
0.25 V	0.0885 V	0.092%	0.21%	0.26%	0.26%
0.4 V	0.1416 V	0.093%	0.21%	0.23%	0.23%
0.8 V	0.2832 V	0.092%	0.19%	0.23%	0.23%
1.2 V	0.4248 V	0.092%	0.19%	0.23%	0.23%
3.4 V	1.2036 V	0.093%	0.19%	0.22%	0.22%
5.5 V	1.947 V	0.092%	0.19%	0.22%	0.22%

Parameter/Range	Frequency	CMC[2, 7] (±)	Comments
Capacitance[3, 8] – Measure			
(1 to 10) pF	(0.1 to 10) kHz	0.77 %	QuadTech 1689M
(10 to 100) pF		0.31 %	
(100 to 1000) pF		0.13 %	CMC is stated at 1 kHz[10]
(1 to 10) nF		0.14 %	
(10 to 100) nF		0.14 %	
(100 to 1000) nF		0.16 %	
(1 to 10) µF		0.13 %	
(10 to 100) µF		0.21 %	
(100 to 1000) µF		0.50%	

Parameter/Range	Frequency	CMC[2, 4, 5, 7] (±)	Comments
Capacitance[3, 8] – Generate			
(0.10 to 3.299) nF	10 Hz to 10 kHz	0.51 % + 12 pF	Fluke 5520A
(0.33 to 10.999) nF	(10 to 1000) Hz	0.26 % + 12 pF	
(11 to 109.999) nF	(10 to 1000) Hz	0.26 % + 0.12 nF	
(110 to 329.99) nF	(10 to 1000) Hz	0.26 % + 0.31 nF	
(0.33 to 1.0999) μF	(10 to 600) Hz	0.26 % + 1.2 nF	
(1.1 to 3.2999) μF	(10 to 300) Hz	0.26 % + 3.1 nF	
(3.3 to 10.999) μF	(10 to 150) Hz	0.26 % + 12 nF	
(11 to 32.999) μF	(10 to 120) Hz	0.42 % + 31 nF	
(33 to 109.99) μF	(10 to 80) Hz	0.46 % + 0.12 μF	
(110 to 329.99) μF	Up to 50 Hz	0.46 % + 0.31 μF	
(0.33 to 1.0999) mF	Up to 20 Hz	0.46 % + 1.2 μF	
(1.1 to 3.2999) mF	Up to 6 Hz	0.46 % + 3.1 μF	
(3.3 to 10.999) mF	Up to 2 Hz	0.46 % + 12 μF	
(11 to 32.999) mF	Up to 0.6 Hz	0.78 % + 31 μF	
(33 to 110) mF	Up to 0.2 Hz	1.2 % + 0.12 mF	
Fixed Points[3]			
1 pF	1 kHz to 13 MHz	0.37 % + 0.6*R*	Agilent 16381A
10 pF	1 kHz to 13 MHz	0.040 % + 0.6*R*	Agilent 16382A
100 pF	1 kHz to 13 MHz	0.067 % + 0.6*R*	Agilent 16383A
1000 pF	1 kHz to 13 MHz	0.33 % + 0.6*R*	Agilent 16384A
(10, 100, 1000) nF	120 Hz to 100 kHz	0.010 % + 0.6*R*	Agilent 16380C
Inductance[3, 8] – Measure			
1 μH to 10 H	(0.1 to 1) kHz	0.13 % + 0.1 μH	QuadTech 1689M CMC is stated at 1 kHz[10]
Inductance[3] – Generate			
Fixed Points			
100 μH	400 Hz, 1 kHz	1.2 %	General radio 1482 series
1 mH		0.13 %	
10 mH		0.083 %	
100 mH		0.083 %	
1 H		0.083 %	
10 H		0.17 %	

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
AC Voltage[3, 8] – 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	0.022 % + 4.0 µV 85 µV/V + 4.0 µV 75 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
(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	0.022 % + 4.0 µV 85 µV/V + 4.0 µV 75 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	
(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	0.022 % + 12 µV 85 µV/V + 7.0 µV 75 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 % + 82 µV 85 µV/V + 82 µV 40 µV/V + 82 µV 70 µV/V + 82 µV 0.011 % + 82 µV 0.034 % + 82 µV 0.090 % + 0.22 mV 0.15 % + 0.31 mV	

Parameter/Range	Frequency	CMC[2, 5, 7] (±)	Comments
AC Voltage[3, 8] – Generate (cont.)			
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.022 % + 0.40 mV 80 µV/V + 0.15 mV 40 µV/V + 50 µV 70 µV/V + 0.10 mV 95 µV/V + 0.20 mV 0.026 % + 0.60 mV 0.090 % + 2.0 mV 0.13 % + 3.2 mV	Fluke 5720A
(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 + 0.61 mV 75 µV/V + 1.0 mV 0.013 % + 2.5 mV 0.080 % + 16 mV 0.42 % + 40 mV 0.70 % + 80 mV	* 220 V range subject to 2.2E7 V-Hz limitation
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	80 µV/V + 4.1 mV 0.013 % + 6.1 mV 0.036 % + 11 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (500 to 1000) KHz	0.036 % + 11 mV 0.080 % + 45 mV 0.13 % + 83 mV 0.42 % + 91 mV 0.70 % + 1.1 V	
AC High Voltage[3, 8] – Measure			
(1 to 42) kVrms	60 Hz	0.30 %	Ross VD60 w/ HP 8842[a]

Parameter/Range	Frequency	CMC[2, 5, 6, 7] (±)	Comments
AC Current[3, 8] – Generate			
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 % + 36 nA 0.011 % + 36 nA 0.025 % + 0.11 µA 0.090 % + 0.65 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	0.023 % + 0.41 µA 0.014 % + 0.36 µA 0.011 % + 0.36 µA 0.025 % + 0.56 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 % + 4.0 µA 0.011 % + 3.0 µA 0.018 % + 4.0 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 % + 0.16 mA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.040 % + 0.19 mA 0.085 % + 0.39 mA 0.33 % + 0.75 mA	
(11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.12 % + 5.1 mA 0.15 % + 5.1 mA 3.0 % + 5.1 mA	Fluke 5520A
(16.5 to 150) A (150 to 1000) A	(45 to 65) Hz (45 to 65) Hz	0.37 % + 0.029 A 1.0 % + 0.031 A	Fluke 5520A w/ coil
(16.5 to 150) A (150 to 1000) A	(65 to 440) Hz (65 to 440) Hz	1.0 % + 0.031 A 0.95 % + 0.12 A	

Parameter/Range	Frequency	CMC[2, 5, 6, 7] (±)	Comments
AC Current[3, 8] – Generate (cont.)			
Up to 20 A	(10 to 65) Hz (65 to 300) Hz 300 Hz to 1 kHz	0.62 % 0.49 % 0.38 %	Fluke 52120A
(20 to 120) A	(10 to 65) Hz (65 to 300) Hz 300 Hz to 1 kHz	0.29 % 0.29 % 0.29 %	
120 A to 6 kA	(10 to 65) Hz (65 to 300) Hz 300 Hz to 1 kHz	0.97 % 0.95 % 0.94 %	Fluke 52120A w/ coil
AC Current[3, 8] – Measure			
10 µA to 20A	10 Hz to 10 kHz	0.013 %	Fluke 5790A w/A40s
(5 to 100) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 5 kHz	0.46 % + 35 nA 0.15 % + 30 nA 0.060 % + 30 nA	Agilent 3458A
(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 (20 to 50) kHz (50 to 100) kHz	0.40 % + 0.20 µA 0.15 % + 0.20 µA 0.060 % + 0.20 µA 0.030 % + 0.20 µA 0.060 % + 0.20 µA 0.40 % + 0.40 µA 0.55 % + 1.5 µA	
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.40 % + 2.0 µA 0.15 % + 2.0 µA 0.060 % + 2.0 µA 0.030 % + 2.0 µA 0.060 % + 2.0 µA 0.40 % + 4.0 µA 0.55 % + 15 µA	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz	0.40 % + 0.02 mA 0.15 % + 0.02 mA 0.06 % + 0.02 mA	

Parameter/Range	Frequency	CMC[2, 4, 6, 7] (±)	Comments
AC Current[3, 8] – Measure (cont.)			
(10 to 100) mA	100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.03 % + 0.02 mA 0.06 % + 0.02 mA 0.40 % + 0.04 mA 0.55 % + 0.04 mA	Agilent 3458A
(0.1 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	0.40 % + 0.2 mA 0.160 % + 0.2 mA 0.080 % + 0.2 mA 0.10 % + 0.2 mA 0.30 % + 0.2 mA 1.0 % + 0.4 mA	
AC Resistance[3, 8] – Generate			
0.1 Ω 1 Ω 10 Ω (0.1, 1, 10, 100) kΩ	DC to 13 MHz	1.2 % + 0.6*R* 0.12 % + 0.6*R* 0.11 % + 0.6*R* 0.032 % + 0.6*R*	Agilent 16074A AC

Parameter/Range	Frequency	CMC[2, 5, 6, 7] (±)	Comments
Oscilloscopes[3, 8] –			
Risetime – Generate	10 Hz to 2 MHz (420 to 540) ps	20 ps	Fluke 9500B with 9510 Active Head
	10 Hz to 2 MHz (125 to 175) ps	17 ps	Fluke 9500B with 9530 Active Head
	10 Hz to 1 MHz (59 to 81) ps	14 ps	Fluke 9500B with 9560 Active Head
	10 Hz to 1 MHz (13 to 17) ps	8.3 ps	Tektronix, Step Gen. 067-1338-00
Risetime – Measure	7 ps to 540 ps	8 ps	Tektronix 80E01
Bandwidth (Flatness)	50 kHz to 300 MHz (300 to 550) MHz (0.55 to 1.1) GHz (0.11 to 3.2) GHz (3.2 to 6.0) GHz	3.4 % 3.5 % 4.4 % 5.3 % 5.6 %	Fluke 9500A
	100 kHz to 4.2 GHz (4.2 to 18) GHz (18 to 26.5) GHz (26.5 to 50) GHz	1.4 % 1.9 % 3.0 % 4.1 %	Signal generator w/ power sensor
Phase Angle[3, 8, 11] – Generate			
(0.0 to 360)º (0.05 to 120) V	(1 to 1000) Hz (1.01 to 6.25) kHz (6.26 to 50) kHz (50.01 to 100) kHz	6.2 mº 12 mº 17 mº 46 mº	Clarke-Hess 5500, mº = milli degree
Phase Angle[3, 8] – Measure			
(0.0 to 360)º (0.01 to 120) V	20 Hz to 10 kHz (10 to 40) kHz (40 to 100) kHz	81 mº 0.29º 0.98º	Krohn-Hite 6500

Parameter/Range	Frequency	CMC[2, 5, 6, 7] (±)	Comments
Distortion[3, 8]	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.4 dB	Agilent 8903A
	100 kHz to 2.5 GHz	1.8 dB	Agilent E4448A
	(2.5 to 26.5) GHz	2.6 dB	Agilent E4448A

Parameter/Equipment	Range	CMC[2, 5, 6, 7] (±)	Comments
Thermocouple[3] – Indicating Systems & Measure			
Type B	(600 to 800) °C (800 to 1550) °C (1550 to 1820) °C	0.35 °C 0.28 °C 0.22 °C	Fluke 7526A
Type C	(0 to 1000) °C (1000 to 1800) °C (1800 to 2000) °C (2000 to 2316) °C	0.16 °C 0.23 °C 0.26 °C 0.35 °C	
Type E	(-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 600) °C (600 to 1000) °C	0.25 °C 0.12 °C 0.09 °C 0.08 °C 0.1 °C	
Type J	(-210 to -100) °C (-100 to 800) °C (800 to 1200) °C	0.14 °C 0.09 °C 0.1 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Thermocouple[3] – Indicating Systems & Measure (cont.)			
Type K	(-250 to -200) °C (-200 to -100) °C (-100 to 500) °C (500 to 800) °C (800 to 1372) °C	0.46 °C 0.16 °C 0.1 °C 0.1 °C 0.13 °C	Fluke 7526A
Type L	(-200 to -100) °C (-100 to 900) °C	0.1 °C 0.09 °C	
Type N	(-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 100) °C (100 to 800) °C (800 to 1300) °C	0.73 °C 0.23 °C 0.12 °C 0.11 °C 0.1 °C 0.12 °C	
Type R	(-50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1000) °C (1000 to 1600) °C (1600 to 1767) °C	0.55 °C 0.45 °C 0.39 °C 0.28 °C 0.22 °C 0.21 °C 0.19 °C 0.23 °C	
Type S	(-50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 400) °C (400 to 600) °C (600 to 1000) °C (1000 to 1600) °C (1600 to 1767) °C	0.51 °C 0.43 °C 0.38 °C 0.29 °C 0.23 °C 0.22 °C 0.22 °C 0.26 °C	
Type T	(-250 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 200) °C (200 to 400) °C	0.35 °C 0.16 °C 0.11 °C 0.09 °C 0.09 °C	
Type U	(-200 to 0) °C (0 to 200) °C (200 to 600) °C	0.16 °C 0.1 °C 0.1 °C	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Electrical Calibration of RTDs[3] – Generate			
Pt 385, 100 Ω	(-200 to -80) °C (-80 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 800) °C	0.013 °C 0.02 °C 0.024 °C 0.026 °C 0.033 °C 0.038 °C	Fluke 7526A
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	0.013 °C 0.015 °C 0.017 °C 0.022 °C 0.026 °C 0.032 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.01 °C 0.013 °C 0.015 °C 0.017 °C 0.022 °C 0.026 °C 0.031 °C 0.033 °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 630) °C	0.053 °C 0.056 °C 0.06 °C 0.06 °C 0.069 °C 0.071 °C 0.088 °C	
Pt 385, 500 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.026 °C 0.028 °C 0.034 °C 0.038 °C 0.045 °C	
Pt 385, 1000 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.015 °C 0.018 °C 0.024 °C 0.026 °C 0.033 °C	

Parameter/Equipment	Range[7]	CMC[2, 7] (±)	Comments
Electrical Calibration of RTDs[3] – Generate (cont.)			
Ni 385, 120 Ω	(-80 to 260) °C	0.009 °C	Fluke 7526A
Cu 427, 10 Ω	(-100 to 260) °C	0.11 °C	
SPRT	(-200 to 660) °C	0.06 °C	
Electrical Conductivity Meters (IACS)	18 % 27 % 30 % 45 % 60 %	0.16 % 0.22 % 1.0 % 1.0 % 1.0 %	Conductivity standards

IV. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC[2, 7] (±)	Comments
Power Meter[3, 8] – Power Reference, @ 1 mW	50 MHz	1.9 %	Agilent 432A w/ 478A
Relative Power (Tuned RF Level) [3, 8] – Measure			
100 kHz to 50 GHz	(0 to -10) dB (-10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -70) dB (-70 to -80) dB (-80 to -90) dB (-90 to -100) dB (-100 to -110) dB (-110 to -120) dB (-120 to -130) dB	0.018 dB 0.019 dB 0.019 dB 0.056 dB 0.056 dB 0.057 dB 0.057 dB 0.094 dB 0.094 dB 0.095 dB 0.096 dB 0.096 dB 0.097 dB	Agilent E4448A

Parameter/Range	Frequency	CMC[2, 7] (±)	Comments
Absolute Power[3, 8] – Measure			Agilent N5532S system
(-30 to -50) dBm (-50 to -60) dBm (-60 to -68) dBm	10 MHz to 18 GHz	1.3 % 2.6 % 15 %	Power sensor, N Type w/ power meter
(-30 to +10) dBm	100 kHz to 4.2 GHz (4.2 to 18) GHz (18 to 26.5) GHz (26.5 to 50) GHz	3.3 % 3.5 % 4.2 % 5.0 %	3.5 mm 2.4 mm
(+10 to +20) dBm	100 kHz to 4.2 GHz (4.2 to 18) GHz (18 to 26.5) GHz (26.5 to 50) GHz	5.9 % 6.0 % 6.5 % 7.0 %	3.5 mm 2.4 mm
VSWR[3, 8]	5 MHz to 2 GHz (2 to 12.5) GHz (12.5 to 18) GHz (18 to 26.5) GHz	0.11 dB 0.53 dB 0.85 dB 1.2 dB	E4448A w/ Krytar / Wiltron SWR bridges
Frequency Modulation[3, 8] – Measure			
Mod Rate: 20 Hz to 10 kHz Dev.: 200 Hz to 40 kHz (ß > 0.2)	250 kHz to 10 MHz	1.0 %	E4448A opt 233
Mod Rate: 50 Hz to 200 kHz Dev.: 250 Hz to 400 kHz (ß > 0.2)	10 MHz to 6.6 GHz (6.6 to 13.2) GHz (13.2 to 31.15) GHz (31.15 to 50) GHz	1.0 % 1.0 % 1.0 % 1.0 %	ß is the ratio of the frequency deviation to the modulation rate

Parameter/Range	Frequency	CMC[2, 7] (±)	Comments
Amplitude Modulation[3, 8] – Measure			
Depth:			
(5 to 99) %	100 kHz to 10 MHz	0.75 %	E4448A opt 233
(5 to 20) %	10 MHz to 3 GHz	2.5 %	
(20 to 99) %	10 MHz to 3 GHz	0.50 %	
(5 to 20) %	(3 to 26.5) GHz	4.5 %	
(20 to 99) %	(3 to 26.5) GHz	1.5 %	
(5 to 20) %	(26.5 to 31.15) GHz	6.8 %	
(20 to 99) %	(26.5 to 31.15) GHz	1.9 %	
(5 to 20) %	(31.15 to 50) GHz	2.6 %	
(20 to 99) %	(31.15 to 50) GHz	6.0 %	
Phase Modulation[3, 8] –			
Mod Rate: (0.2 to 20) kHz			
0.3 rad < Dev ≤ 0.7 rad	100 kHz to 6.6 GHz	3.0 %	E4448A opt 233
Dev > 0.7 rad		1.0 %	
0.6 rad < Dev ≤ 2.0 rad	(6.6 to 13.2) GHz	3.0 %	
Dev > 2.0 rad		1.0 %	
1.2 rad < Dev ≤ 4.0 rad	(13.2 to 26.5) GHz	3.0 %	
Dev > 4.0 rad		1.0 %	
1.3 rad < Dev ≤ 4.0 rad	(26.5 to 31.5) GHz	3.0 %	
Dev > 4.0 rad		1.0 %	
2.4 rad < Dev ≤ 8.0 rad	(31.5 to 50) GHz	3.0 %	
Dev > 8.0 rad		1.0 %	
Transmission[3, 8] S_{12}/S_{21} – Measure			
Linear Phase	Type-N Connectors	(± 0.76 to ± 39)°	Agilent N5230A VNA w/ 85032B calibration kit
Linear Mag.	30 kHz to 2 GHz	(± 0.11 to ± 8.2) dB	
Linear Phase		(± 2.1 to ± 15)°	
Linear Mag.	(2 to 6) GHz	(± 0.25 to ± 1.9) dB	

Parameter/Range	Frequency	CMC[2] (±)	Comments
Reflection[3, 8] S_{11}/S_{22} – Measure			
Linear Phase Linear Mag.	Type-N Connectors 30 kHz to 2 GHz	(± 2.4 to ± 13)° (± 0.33 to ± 0.36) dB	Agilent N5230A VNA w/ 85032B calibration kit
Linear Phase Linear Mag.	(2 to 6) GHz	(± 12 to ± 35)° (± 1.1 to ± 1.6) dB	
Single Side-Band Phase Noise[3, 8] – Measure			
Noise Floor:	Carrier: 1 MHz to 50 GHz Offset Freq:		
-110 dB	10 Hz	1.5 dB	Agilent E4448A option 226
-110 dB	100 Hz	1.5 dB	
-130 dB	1 kHz	1.5 dB	
-140 dB	10 kHz	1.5 dB	
-150 dB	100 kHz	1.5 dB	
-155 dB	1 MHz	1.5 dB	
-155 dB	10 MHz	1.5 dB	
-155 dB	100 MHz	1.5 dB	

V. Fluid Quantities

Parameter/Equipment	Range	CMC[2, 7] (±)	Comments
Gas Flow	Up to 1 sccm (1 to 10) sccm (10 to 100) sccm (0.1 to 1) slm (1 to 10) slm (10 to 100) slm	0.24 % + 0.006 sccm 0.33 % + 0.006 sccm 0.27 % + 0.006 sccm 0.27 % + 0.0006 slm 0.27 % + 0.006 slm 0.65 % + 0.006 slm	Flow standards
Liquid Flow	0.1 mL/min (0.5 to 20) mL/min	2 % + 0.6 µL/min 0.84 % + 0.6 µL/min	Comparator, stopwatch, distilled water – gravimetric method

Parameter/Equipment	Range	CMC[2, 7] (±)	Comments
Viscosity[3] – Ford, Dip & Other Viscosity Cups	Cup Nos. 1 through 5	2.8 %	ASTM D1200-94, D4212-93, ISO 2431
Volumetric Glassware & Volumetric Apparatus	10 mL 25 mL 50 mL 100 mL 250 mL 500 mL 1 L 2.5 L 5 L 10 L 15 L 20 L	0.0098 mL 0.024 mL 0.049 mL 0.098 mL 0.24 mL 0.49 mL 0.98 mL 2.4 mL 4.8 ml 9.8 mL 15 mL 20 mL	Gravimetric method w/ electronic balance & thermometer

VI. Magnetic Quantities

Parameter/Equipment	Range	CMC[2] (±)	Comments
DC Gauss Meters[3, 8]	10 G 20 G	0.62 G 0.62 G	R.B. Annis Gauss standards

VII. Mechanical

Parameter/Equipment	Range	CMC[2] (±)	Comments
Mass Measurement[8]	Up to 30 g (30 to 160) g (160 to 620) g 620 g to 4 kg (4 to 5) kg (5 to 10) kg (10 to 20) kg (20 to 50) kg	0.12 mg 0.55 mg 3.2 mg 34 mg 66 mg 76 mg 0.23 g 0.41 g	Direct weighing Substitution method Class 1 mass Class 3 mass

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Balances[3, 8]	(1 to 10) mg (10 to 100) mg (0.1 to 1) g (1 to 10) g (10 to 3200) g (3.2 to 22) kg (22 to 55) kg	0.045 % + 0.6*R* 0.089 % + 0.6*R* 0.020 % + 0.6*R* 0.000 40 % + 0.6*R* 0.000 28 % + 0.6*R* 0.001 % + 0.6R 0.001 % + 0.6R	Class 1 weights Class 3 weights
Scales[3, 8]	Up to 1000 lb Up to 4800 lb	0.023 % 0.10 %	Class F weights
Force[3]	Up to 1400 lbf (1 to 2) klbf (2 to 5) klbf (5 to 10) klbf (10 to 25) klbf	0.023 % 4.6 lbf 4.8 lbf 5.2 lbf 10 lbf	Deadweight Load cells
Torque[3] – Tools Transducers	 (0.5 to 215) ozf·in 5 lbf·in to 250 ft·lbf (250 to 1000) ft·lbf (2 to 100) in·ozf (6 to 250) in·lbf (20 to 250) ft·lbf (250 to 1000) ft·lbf	 0.51 % 0.30 % + 0.6*R* 0.24 % + 0.6*R* 0.030 % + 0.05 in·ozf 0.030 % + 0.12 in·lbf 0.030 % + 0.08 ft·lbf 0.030 % + 0.20 ft·lbf	 Torque tester Torque arm & weights
Pressure[3, 8]	(0.5 to 23) psia (23 to 1015) psia (1000 to 5000) psig (5000 to 10 000) psig (10 to 30) kpsi	0.01 % + 0.000 03 psi 0.010 % + 0.6*R* 0.035 % + 2.5 psig 0.035 % + 8.3 psig 25 psi	Pressure calibration system Pressure calibrator Pressure calibrator with Fluke 700 series Heise 901A

Parameter/Equipment	Range	CMC[2, 4, 7] (±)	Comments
Indirect Verification of Rockwell Hardness Testers[3]	HRA: Low Medium High HRBW: Low Medium High HRC: Low Medium High HREW: Low Medium High HRRW: Medium High HR15N: Low Medium High HR15TW: Low Medium High HR30N: Low Medium High HR30TW: Low Medium High	 0.43 HRA 0.35 HRA 0.18 HRA 0.58 HRBW 0.63 HRBW 0.48 HRBW 1.0 HRC 0.47 HRC 0.34 HRC 1.1 HREW 0.83 HREW 1.1 HREW 0.44 HRRW 0.31 HRRW 0.89 HR15N 0.77 HR15N 0.22 HR15N 0.89 HR15TW 0.77 HR15TW 0.22 HR15TW 0.61 HR30N 0.66 HR30N 0.91 HR30N 0.78 HR30TW 0.69 HR30TW 0.35 HR30TW	ASTM E18 Hardness blocks

Parameter/Equipment	Range	CMC[2] (±)	Comments
Indirect Verification of Rockwell Hardness Testers[3] (cont)	HR45N: Low Medium High HR45T: Low Medium High	 0.84 HR45N 0.51 HR45N 0.54 HR45N 0.79 HR45T 0.43 HR45T 0.47 HR45T	ASTM E18 Hardness blocks
Indirect Verification of Brinell Hardness Testers at Test Conditions[3]	≤263 HBW >263 to 591 HBW	2.6 HBW 7.1 HBW	ASTM E10
Equotip (Leeb) Testers[3]	≈800 LD	18 LD	ASTM A956
Durometer Calibration[3] – Spring Force	 A, B, O, D, C, DO scales	 0.60 pts	 Shore durocalibrator w/ calibrated weights

VIII. Optical Quantities

Parameter/Equipment	Range	CMC[2] (±)	Comments
Gloss Meters[8]	20° 60° 85°	1.4 GU 1.3 GU 1.3 GU	Gloss standards
Gloss Standards[8]	20°, 60°, 85°	1.5 GU	Gloss standards w/ gloss meter

IX. Thermodynamics

Parameter/Equipment	Range	CMC[2 7] (±)	Comments
Temperature – Measuring Equipment[3, 8]	-78 °C	0.0036 % + 0.071 ºC	Hart 5628 PRT, Chub 1529, isopropanol/dry ice slurry
	(-25 to 425) °C	0.0037 % + 0.044 ºC	Hart 5628 PRT, Chub 1529, temperature baths / blocks
Temperature[3, 8] – Measure	(-196 to 660) ºC	0.003 % + 0.041 ºC	Hart 5628 PRT & 1529 indicator
	(-40 to 1000) ºC	0.34 % + 1.4 ºC	Fluke 743B w/ Type K themocouple
Infrared Thermometers[3,8]	(-15 to 120) ºC (35 to 500) ºC	0.36 % + 0.7 ºC 0.35 % + 0.5 ºC	Hart 4180 black body Hart 4181 black body ε = 0.9 to 1.0 λ = (8 to 14) µm
Relative Humidity[3, 8] – Measuring Equipment	(10 to 95) % RH	0.7 % RH	Thunder Scientific 2500
Relative Humidity[3, 8] – Measure	(10 to 90) % RH (15 to 25) ºC	1.2 % RH	Vaisala HM70 / HMP 77

X. Time & Frequency

Parameter/Equipment	Frequency	CMC[2, 4] (±)	Comments
Frequency[3]	10 MHz	4.4 pHz/Hz + 0.6*R*	GPS receiver
Frequency – Measuring Equipment[3]	1 mHz to 50 GHz	4.4 pHz/Hz + 0.1 mHz	GPS receiver w/ generator
Frequency – Measure[3]	0.001 Hz to 50 GHz	4.4 pHz/Hz + 0.1 mHz	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 location listed on page 1 of this scope of accreditation which is covered by either footnote 3 or 9.

[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, and RH is the relative humidity.

[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.

[8] Uncertainty components that can be reasonably attributed to the Unit Under Test have not been utilized in the calculation of the CMC value for this measurement parameter.

[9] Parameters performed at satellite lab that are not covered by footnote 3.

[10] CMM at intermediate values is calculated using the Manufacturers Limits of Error Calculator

[11] The CMC claim is smaller than that of the expanded uncertainty claim for NIST as listed in the BIPM Key Comparison Database for the stated parameter. However, while the lab is performing a "Phase Angle – Generate" calibration, they are using a different method and are working with different parameters than NIST. A2LA has evaluated the laboratory's CMC claim and has verified this information to be correct and appropriate.

Accredited Laboratory

A2LA has accredited

TRESCAL, INC.

Irving, TX

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994, ANSI/NCSL Z540.3-2006 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 8 January 2009*).

Presented this 16th day of August 2017.

President and CEO
For the Accreditation Council
Certificate Number 2516.01
Valid to March 31, 2019

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