



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

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CALIBRATION

Valid To: May 31, 2012

Certificate Number: 1022.03

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

I. Chemical

Parameter/Equipment	Range	CMC ² (±)	Comments
pH Measuring Equipment ³	(4, 7, 10) units	0.016 units	Buffer solutions
Electrolytic Conductivity Measuring Equipment ³	10 µS/cm 100 µS/cm 1000 µS/cm 10 000 µS/cm	0.52 µS/cm 2.4 µS/cm 23 µS/cm 230 µS/cm	Conductivity solutions

II. Dimensional

Parameter/Equipment	Range	CMC ^{2, 5} (±)	Comments
Length Standards ³	(0.5 to 24) in	14 µin/in + 28 µin	Gage blocks and height comparator
Linear Displacement Measuring Equipment ³	(0 to 24) in (1 to 91) ft	60 µin/in + 0.0027 in 0.007 % + 0.05 ft	Mitutoyo 574-210 Starrett C530-CI

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Plain, External Diameter ³	(0.003 to 0.5 in)	31 μin	Laser micrometer
Calipers ³	(0.0005 to 72) in	6 μin/in	Gage blocks
Indicators ³	(0.0005 to 6) in	6 μin/in	Gage blocks
Micrometers ³	(0.001 to 72) in	6 μin/in	Gage blocks
Height Gages ³	(0.001 to 48) in	6 μin/in	Gage blocks
Angle ³ – Measuring Equipment	Up to 360°	7.1”	Angle encoder
Angle – Measuring Equipment	(0 to 60)° 90° ± 3’	8.7” 2.8”	Gage blocks, sine bar Cylinder square
Optical Comparators ³ – Linear Travel	Up to 30 in	120 μin	Comparison to master scales
Magnification	10x to 100x	0.11 %	Magnification checker and spheres
Flatness ³	Up to 3 in diameter (3 to 6) in diameter	5.6 μin 4.6 μin	Optical flats
Steel Tapes	(1 to 100) ft	0.08 in	Master tape

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III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 5, 6, 7} (±)	Comments
DC Voltage ³ – Measure and Generate	(0 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V	9 μV/V + 0.4 μV 5.4 μV/V + 0.4 μV 4.1 μV/V + 0.7 μV 6.3 μV/V + 36 μV 7.3 μV/V + 160 μV	Agilent 3458A opt 002 with Fluke 5700A
DC Voltage – Measure, Fixed Points	1.018 V 10 V	3.7 μV 11 μV	Fluke 732B
DC Voltage ³ – Generate	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	4.2 μV/V + 0.62 μV 4.6 μV/V + 1.8 μV 5.1 μV/V + 5 μV 5.8 μV/V + 12 μV 7.1 μV/V + 0.11 mV 4.8 μV/V + 0.62 mV	Fluke 5700A
DC High Voltage ³ – Measure Generate	(1 to 60) kV (1 to 40) kV	0.13 % 0.13 %	Ross divider and DVM
DC Current ³ – Generate	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 (11 to 100) A (100 to 1000) A	47 μA/A + 9.2 nA 48 μA/A + 10 nA 48 μA/A + 94 nA 60 μA/A + 1 μA 76 μA/A + 29 μA 0.04 % + 0.56 mA 0.16 % + 0.87 mA 0.16 % + 0.4 mA 0.3 % + 60 mA	Fluke 5700A Fluke 5520A Fluke 5700/5220A Fluke 5500A/coil

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Parameter/Equipment	Range	CMC ^{2, 5, 6, 7} (\pm)	Comments
DC Current ³ – Measure	(10 to 100) μ A (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 1200) A	19 μ A/A + 1 nA 19 μ A/A + 6 nA 21 μ A/A + 60 nA 40 μ A/A + 0.6 μ A 120 μ A/A + 12 μ A 0.31 mA 33 μ A/A 0.5 %	Agilent 3458A opt 002 w/ L&N 4222 w/ L&N 4361 w/ RAM shunt
Resistance – Generate ³	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 (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	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 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, 4-wire Fluke 5520A, 2-wire
DC Resistance – Generate, Fixed Values	0.1 Ω (1, 1.9, 10) Ω 100 Ω , 1 k Ω (10, 19) k Ω 100 k Ω 1 M Ω 10 M Ω 19 M Ω	12 parts in 10 ⁶ 9 $\mu\Omega/\Omega$ 7 $\mu\Omega/\Omega$ 5 $\mu\Omega/\Omega$ 7 $\mu\Omega/\Omega$ 11 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$ 23 $\mu\Omega/\Omega$	L&N 4015-B Fluke 742A series fixed resistors
DC Resistance ³ – Generate, Fixed Values	1 Ω 1.9 Ω 10 Ω 19 Ω (100, 190) Ω 1 k Ω 1.9 k Ω (10, 19) k Ω (100, 190) k Ω	0.011 % 0.06 % 33 $\mu\Omega/\Omega$ 31 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$ 14 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$ 13 $\mu\Omega/\Omega$ 16 $\mu\Omega/\Omega$	Fluke 5700A

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Parameter/Equipment	Range	CMC ^{2, 5, 6, 7} (\pm)	Comments
DC Resistance ³ – Generate, Fixed Values (cont)	1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω	22 $\mu\Omega/\Omega$ 23 $\mu\Omega/\Omega$ 43 $\mu\Omega/\Omega$ 55 $\mu\Omega/\Omega$ 0.014 %	Fluke 5700A
	1 G Ω 10 G Ω 100 G Ω	0.11 % 2.3 % 3.7 %	Keithley resistors
DC Resistance ³ – Measure	(0 to 10) Ω (10 to 100) Ω (100 to 1000) Ω (1 to 10) k Ω (10 to 100) k Ω (100 to 1000) k Ω (1 to 10) M Ω (10 to 100) M Ω (0.1 to 1) G Ω	26 $\mu\Omega/\Omega$ + 64 $\mu\Omega$ 17 $\mu\Omega/\Omega$ + 0.59 m Ω 12 $\mu\Omega/\Omega$ + 0.64 m Ω 18 $\mu\Omega/\Omega$ + 6.4 m Ω 13 $\mu\Omega/\Omega$ + 64 m Ω 20 $\mu\Omega/\Omega$ + 2.4 Ω 67 $\mu\Omega/\Omega$ + 120 Ω 0.063 % + 1.2 k Ω 0.7 % + 12 k Ω	Agilent 3458A
	(1 to 1000) G Ω	0.46 %	Keithley 487
DC Resistance – Measure	(0.1 to 1) Ω (1 to 1.9) Ω (1.9 to 10) Ω (10 to 100) Ω (0.1 to 1) k Ω (1 to 10) k Ω (10 to 19) k Ω (19 to 100) k Ω (0.1 to 1) M Ω (1 to 10) M Ω (10 to 19) M Ω (19 to 100) M Ω	60 $\mu\Omega/\Omega$ 16 $\mu\Omega/\Omega$ 13 $\mu\Omega/\Omega$ 14 $\mu\Omega/\Omega$ 14 $\mu\Omega/\Omega$ 4.8 $\mu\Omega/\Omega$ 4.8 $\mu\Omega/\Omega$ 4.9 $\mu\Omega/\Omega$ 7.3 $\mu\Omega/\Omega$ 10 $\mu\Omega/\Omega$ 13 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$	Agilent 3458A and 742A series resistors

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Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
AC Voltage ³ – Generate			
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	0.14 % + 8.8 μV 0.06 % + 5.4 μV 0.033 % + 5.4 μV 0.063 % + 5.4 μV 0.095 % + 8.5 μV 0.18 % + 14 μV 0.21 % + 27 μV 0.38 % + 27 μV	Fluke 5700A
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	0.05 % + 10 μV 0.02 % + 10 μV 0.01 % + 7 μV 0.02 % + 8 μV 0.03 % + 11 μV 0.07 % + 19 μV 0.11 % + 37 μV 0.29 % + 41 μV	
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	0.048 % + 12 μV 0.02 % + 8 μV 59 μV/V + 8 μV 0.01 % + 8 μV 0.022 % + 23 μV 0.039 % + 23 μV 0.09 % + 31 μV 0.27 % + 98 μV	
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	0.048 % + 78 μV 0.024 % + 23 μV 0.019 % + 5 μV 0.021 % + 16 μV 0.025 % + 62 μV 0.039 % + 120 μV 0.088 % + 0.31 mV 0.18 % + 0.78 mV	

Peter Meyer

Parameter/Range	Frequency	CMC ^{2, 6, 7} (±)	Comments
AC Voltage ³ – Generate (cont)			
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	0.047 % + 0.8 mV 0.015 % + 0.25 mV 0.004 % + 0.07 mV 0.009 % + 0.17 mV 0.018 % + 0.32 mV 0.045 % + 1.4 mV 0.11 % + 4 mV 0.23 % + 7.1 mV	Fluke 5700A
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	0.024 % + 4.1 mV 0.016 % + 2.4 mV 0.005 % + 0.9 mV 0.01 % + 0.8 mV 0.027 % + 7.9 mV 0.12 % + 78 mV 0.41 % + 86 mV	
750 V	(30 to 50) kHz (50 to 100) kHz	0.03 % + 11 mV 0.11 % + 37 mV	w/ Fluke 5725A
1100 V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	69 µV/V + 4.1 mV 0.01 % + 6.8 mV 0.03 % + 11 mV	w/ Fluke 5725A
AC Voltage ³ – Measure			
(0.01 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 4.6 % + 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 (0.3 to 1) MHz (1 to 2) MHz	95 µV/V + 47 µV/V 92 µV/V + 24 µV/V 0.017 % + 24 µV/V 0.035 % + 24 µV/V 0.093 % + 24 µV/V 0.35 % + 0.012 % 1.2 % + 0.012 % 1.8 % + 0.012 %	

Peter Mlyns

Parameter/Range	Frequency	CMC ^{2,5,7} (\pm)	Comments
AC Voltage ³ – Measure (cont)			
(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 (0.3 to 1) MHz	0.024 % + 4.7 mV 0.024 % + 2.3 mV 0.024 % + 2.3 mV 0.041 % + 2.3 mV 0.14 % + 2.3 mV 0.47 % + 12 mV 1.8 % + 12 mV	Agilent 3458A opt 002
(100 to 707) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.047 % + 47 mV 0.047 % + 23 mV 0.07 % + 23 mV 0.14 % + 23 mV 0.35 % + 23 mV	
AC High Voltage ³ – Measure			
(1 to 42) kV	60 Hz	0.32 %	Ross divider and DVM
AC Resistance – Generate, Fixed Values			
0.1 Ω	100 Hz 1 kHz	0.15 % 0.14 %	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 k Ω	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 %	

Peter Meyer

Parameter/Range	Frequency	CMC ^{2,5,6} (±)	Comments
AC Resistance – Generate, Fixed Values (cont)			
10 kΩ	5 Hz 10 Hz 50 Hz to 1 MHz	0.56 % 0.19 % 0.073 %	16074A AC resistance standards
100 kΩ	5 Hz 10 Hz 50 Hz to 100 kHz	0.43 % 0.32 % 0.07 %	
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 (10 to 30) kHz	0.06 % + 25 nA 0.031 % + 20 nA 0.012 % + 16 nA 0.05 % + 40 nA 0.14 % + 80 nA 1.8 % + 0.46 μA	Fluke 5700A/5725A Fluke 5520A
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 (10 to 30) kHz	0.06 % + 40 nA 0.031 % + 35 nA 0.012 % + 35 nA 0.05 % + 0.4 μA 0.14 % + 0.8 μA 1.2 % + 0.69 μA	Fluke 5700A/5725A Fluke 5520A
(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 (10 to 30) kHz	0.06 % + 0.4 μA 0.031 % + 0.35 μA 0.012 % + 0.35 μA 0.05 % + 4 μA 0.14 % + 8 μA 0.46 % + 4.6 μA	Fluke 5700A/5725A Fluke 5520A
(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 (10 to 30) kHz	0.06 % + 4 μA 0.031 % + 3.5 μA 0.012 % + 3.5 μA 0.05 % + 40 μA 0.14 % + 80 μA 0.46 % + 0.23 mA	Fluke 5700A/5725A Fluke 5520A

Peter Mlynski

Parameter/Range	Frequency	CMC ^{2, 4, 5, 6, 7} (\pm)	Comments
AC Current ³ – Generate (cont)			
220 mA to 2.2 A	(10 to 20) Hz 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.18 % + 0.1 mA 0.055 % + 35 μ A 0.065 % + 80 μ A 0.75 % + 0.16 mA	Fluke 5700A/5725A
(2.2 to 11) A	(10 to 30) kHz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.46 % + 0.23 mA 0.04 % + 0.17 mA 0.085 % + 0.38 mA 0.33 % + 0.75 mA	Fluke 5520A Fluke 5700A/5725A
(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 3.6 % + 5.8 mA	Fluke 5520A
AC Current ³ – Measure			
(5 to 100) μ A	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz	0.46 % + 0.035 μ A 0.18 % + 0.035 μ A 0.07 % + 0.035 μ A	Agilent 3458A
(0.1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.46 % + 0.024 μ A 0.18 % + 0.024 μ A 0.07 % + 0.024 μ A 0.036 % + 0.024 μ A	
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.46 % + 0.085 μ A 0.18 % + 0.085 μ A 0.07 % + 0.085 μ A 0.036 % + 0.085 μ A	
(0.1 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.46 % + 0.82 μ A 0.19 % + 0.82 μ A 0.093 % + 0.82 μ A 0.12 % + 0.82 μ A	
100 mA to 20 A	DC to 5 kHz	0.036 % + 0.14 %*F	w/ Fluke Y5020 shunt
Capacitance ³ – Generate			
100 pF to 1.1 μ F	1 kHz	0.03 %	GenRad 1423-A capacitance decade

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Parameter/Range	Frequency	CMC ^{2, 5} (±)	Comments
Capacitance – Generate, Fixed Values			
(1, 10, 100) pF & 1 nF	1 kHz to 13 MHz	360 μF/F	Standard capacitors
(10, 100) nF & 1 μF	120 Hz to 1 kHz	370 μF/F	
Capacitance ³ – Measure			
1 pF	500 Hz to 5 kHz (5 to 100) kHz	12 % + 0.6 pF 1.2 %	Fluke PM6304C
10 pF	(150 to 500) Hz 500 to 5 kHz (5 to 20) kHz (20 to 100) kHz	12 % 1.2 % 0.12 % 0.46 %	
100 pF	(50 to 250) Hz 250 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz	12 % 1.2 % 0.12 % 0.46 %	
1 nF	(50 to 250) Hz 250 Hz to 20 kHz (20 to 100) kHz	1.2 % 0.12 % 0.46 %	
10 nF	(50 to 500) Hz 500 Hz to 2 kHz (2 to 20) kHz (20 to 100) kHz	0.12 % 0.06 % 0.12 % 0.46 %	
100 nF	(50 to 150) Hz 150 Hz to 2 kHz (2 to 20) kHz (20 to 100) kHz	0.12 % 0.06 % 0.12 % 0.46 %	
1 μF	50 Hz to 2 kHz (2 to 20) kHz (20 to 100) kHz	0.06 % 0.12 % 0.46 %	
10 μF	(50 to 1500) Hz (1.5 to 15) kHz (15 to 50) kHz (50 to 100) kHz	0.06 % 0.12 % 1.2 % 12 %	

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Parameter/Range	Frequency	CMC ^{2, 5} (±)	Comments
Capacitance ³ – Measure (cont)			
100 µF	(50 to 1500) Hz (1.5 to 15) kHz (15 to 50) kHz	0.12 % 1.2 % 12 %	Fluke PM6304C
(100 to 200) µF (200 to 300) µF (0.33 to 110) mF	Direct Current Direct Current Direct Current	0.09 % 0.052 % 0.045 %	Time-charge method with Fluke 5700A and Agilent 3458A
Inductance ³ – Generate, Fixed Values			
100 µH 10 mH 100 mH 10 H	400 Hz, 1 kHz	0.13 % 0.06 % 0.09 % 0.09 %	Standard inductors
Inductance ³ – Measure			
1 µH	500 Hz to 1.5 kHz (50 to 100) kHz	12 % 1.2 %	Fluke PM6304C
10 µH	(250 to 500) Hz 500 Hz to 20 kHz (20 to 100) kHz	12 % 1.2 % 0.46 %	
100 µH	(75 to 250) Hz (250 to 1500) Hz (1.5 to 20) kHz (20 to 100) kHz	12 % 1.2 % 0.12 % 0.46 %	
1 mH	(50 to 75) Hz (75 to 250) Hz 250 Hz to 20 kHz (20 to 100) kHz	12 % 1.2 % 0.12 % 0.46 %	

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Parameter/Range	Frequency	CMC ^{2, 5} (±)	Comments
Inductance ³ – Measure (cont)			
10 mH	(50 to 75) Hz (75 to 250) Hz 250 Hz to 2 kHz (2 to 20) kHz (20 to 100) kHz	1.2 % 0.12 % 0.06 % 0.12 % 0.46 %	Fluke PM6304C
100 mH	(50 to 75) Hz 75 Hz to 2 kHz (2 to 20) kHz (20 to 100) kHz	0.12 % 0.06 % 0.12 % 0.46 %	
1 H	50 Hz to 2 kHz (2 to 20) kHz (20 to 100) kHz	0.06 % 0.12 % 0.46 %	
10 H	(50 to 250) Hz 250 Hz to 20 kHz (20 to 100) kHz	0.06 % 0.12 % 1.2 %	
100 H	(50 to 2500) Hz (2.5 to 15) kHz (15 to 75) kHz	0.12 % 1.2 % 12 %	
1000 H	(50 to 250) Hz 250 Hz to 2.5 kHz (2.5 to 15) kHz	0.12 % 1.2 % 12 %	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouples ³ – Generate			
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	Fluke 5520A
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	

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Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouples ³ – Generate (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 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 1757) °C	0.57 °C 0.35 °C 0.33 °C 0.4 °C	
Type S	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 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	0.05 °C 0.07 °C 0.08 °C 0.09 °C 0.10 °C 0.21 °C	Fluke 5520A; 4-wire compensation
Pt 3926, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.05 °C 0.07 °C 0.09 °C 0.10 °C 0.12 °C	

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Parameter/Equipment	Range	CMC ^{2,5} (±)	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 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.08 °C 0.09 °C 0.10 °C 0.23 °C	Fluke 5520A; 4-wire compensation
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	0.04 °C 0.05 °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	0.04 °C 0.05 °C 0.06 °C 0.08 °C 0.09 °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	0.03 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.23 °C	
Ni 120, 120 Ω	(-80 to 100) °C (100 to 300) °C	0.08 °C 0.14 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.3 °C	
Thermocouple ³ – Indicating Systems & Measure	E, J, K, T, R, S	0.053 % + 0.03 °C 0.053 % + 0.3 °C	Agilent 3458A w/ Fluke 5520A

Peter Meyer

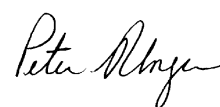
Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Phase Angle ³ – Measuring Equipment	(1 to 1000) Hz 1001 Hz to 6.25 kHz (6.26 to 50) kHz (50.01 to 100) kHz	0.007° 0.013° 0.03° 0.059°	Clark Hess model 5000
Phase Angle ³ – Measure	Up to 180°	0.059°	Krohn-Hite 6500
pH Measuring Equipment ³	Up to 14 units	0.016 %	Fluke 5500A
Total Harmonic Distortion ³	20 Hz to 20 kHz (20 to 100) kHz	1.1 dB 2.0 dB	Agilent 8903A
Risetime ³ – Generate	Single Sided	150 ps ± 35 ps	Fluke 5820A

Parameter/Equipment	Frequency	CMC ^{2,5} (±)	Comments
Oscilloscopes ³ –			
Risetime – Measure	Up to 50 GHz	< 8 ps ± 3 ps	Tek TDS-8200 w/ 80E01
Risetime – Generate	Single Sided	< 180 ps ± 100 ps	Fluke 5820A
Bandwidth	50 kHz to 2.1 GHz	1.3 %	Fluke 5820A
	(2.1 to 4.2) GHz	0.31 dB	Agilent 8340A with: 8482A, 11667A
	(4.2 to 18) GHz	0.74 dB	8481A, 11667A
	(18 to 26.5) GHz	0.84 dB	8485A, 11667B

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IV. Electrical – RF/Microwave – Signal Generators, Spectrum Analyzers, Network Analyzers, Power Sensors

Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
Power Meter ³ – Power Reference @ 1 mW	50 MHz	1.9 % + <i>M</i>	Power transfer using Agilent 432A, 478A-H76
Power Sensor Calibration Factor ³ – (-30 to +20) dBm	100 kHz to 4.2 GHz	1.6 %	Agilent 438A with: 8482-H84
	10 MHz to 14 GHz (14 to 18) GHz	1.6 % 1.8 %	8481A-H84
	(2 to 18) GHz (18 to 26.5) GHz	1.9 % 2.8 %	8485A-H84
Amplitude Modulation ³ – Carrier: (0.15 to 10) MHz Depth: Up to 99 %	(20 to 50) Hz 50 Hz to 100 kHz	3.5 % 2.5 %	Agilent 8902A
Carrier: 10 MHz to 1.3 GHz Depth: Up to 99 %	(20 to 50) Hz 50 Hz to 100 kHz	1.4 % 3.5 %	
Frequency Modulation ³ – Carrier: 250 kHz to 10 MHz Dev: Up to 40 kHz	20 Hz to 10 kHz	2.5 %	Agilent 8902A
Carrier: 10 MHz to 1.3 GHz Dev: Up to 400 kHz	(20 to 50) Hz 50 Hz to 100 kHz (100 to 200) kHz	5.9 % 1.4 % 5.9 %	
Phase Modulation ³ – Carrier: 150 kHz to 10 MHz	200 Hz to 10 kHz	4.7 %	Agilent 8902A
Carrier: 10 MHz to 1.3 GHz	200 Hz to 20 kHz	3.6 %	



Parameter/Range	Frequency	CMC ^{2,4,5} (±)	Comments
Relative Power ³ – Measure (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	10 MHz to 26.5 GHz	0.06 dB 0.07 dB 0.07 dB 0.11 dB 0.11 dB 0.12 dB 0.13 dB 0.19 dB 0.19 dB 0.35 dB	Agilent 8902A
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 100 kHz to 4.2 GHz (4.2 to 18) GHz (18 to 26.5) GHz	2.7 % + <i>M</i> 1.9 % + <i>M</i> 3.1 % + <i>M</i> 2.6 % + <i>M</i> 4 % + <i>M</i> 4.3 % + <i>M</i> 4.3 % + <i>M</i>	Agilent E4448A or 438A: 8484A, N-type 8482A, N-type 8481A, N-type 8485A, 3.5 mm 8482A, N-type 8481A, N-type 8485A, 3.5 mm
VSWR ³	5 MHz to 2 GHz (2 to 12.5) GHz (12.5 to 18) GHz	0.62 dB 0.72 dB 1.4 dB	Agilent 8902A measuring receiver w/ Wiltron SWR bridges (Agilent E4440A)
Reflection 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.	(± 0.948 to ± 7.75)° (± 0.018 to ± 0.031) dB (± 3.9 to ± 9.5)° (± 0.026 to ± 0.048) dB	Agilent 8753D VNA w/ 85032B Cal kit

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Parameter/Range	Frequency	CMC ² (±)	Comments
Transmission S ₁₂ /S ₂₁ – Measure, Type-N connectors			
30 kHz to 2 GHz	Linear Phase Linear Mag.	(± 0.61 to ± 45)° (± 0.11 to ± 9.5) dB	Agilent 8753D VNA w/ 85032B Cal kit
(2 to 6) GHz	Linear Phase Linear Mag.	(± 0.60 to ± 45)° (± 0.12 to ± 9.5) dB	
Single Side Band-Phase Noise – Measure			
Carrier: 1 MHz to 26.5 GHz	Noise Floor: (approximately)		Agilent E4440A Opt 226
Offset Freq:			Noise floor for any given frequency may be degraded due to SSB noise floor of the reference generator
10 Hz	-80 dB	3.0 dB	
100 Hz	-95 dB	2.2 dB	
1 kHz	-110 dB	1.1 dB	
10 kHz	-118 dB	0.76 dB	
100 kHz	-118 dB	0.87 dB	
1 MHz	-118 dB	0.46 dB	
10 MHz	-145 dB	0.46 dB	
100 MHz	-150 dB	0.46 dB	

V. Fluid Quantities

Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
Hydrometers ³	(0.7 to 1.2) sp. gr. (1.2 to 2.0) sp. gr.	0.0007 sp. gr. 0.0012 sp. gr.	ASTM E126; by comparison using reference hydrometer
Volume ³ – To Contain	(0 to 4000) mL (4 to 30) L	0.05 mL + 0.6R 0.37 mL + 0.6R	Gravimetric/ electronic balances
Viscosity ³ – Ford, Dip and Other Viscosity Cups	Cup Nos. 1 through 5	2.8 %	ASTM D1200-94, D4212-93, ISO-2431

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VI. Mechanical

Parameter/Equipment	Range	CMC ^{2,4,5} (\pm)	Comments
Mass Measurement ³	(30 to 4000) g (4 to 31) kg	0.04 g 0.3 g	Electronic balance, Class 6 limited
Balances ³	(0.001 to 7.4) kg 1 mg to 220 g 1 mg to 220 g	2.6 $\mu\text{g/g} + 0.6R$ 5 $\mu\text{g/g} + 0.6R$ 10 $\mu\text{g/g} + 0.6R$	Handbook 44 with: Class 1 weights Class 2 weights Class 3 weights
Scales ³	2 mg to 38 kg 0.1 oz to 3700 lb	0.01 % + 0.6R 90 $\mu\text{lb/lb} + 0.6R$	Handbook 44 with: Class F weights Class 6 weights
Torque Tools ³	(20 to 160) ozf·in (10 to 100) lbf·in (8 to 30) lbf·ft (30 to 300) lbf·ft	0.42 % + 0.01 ozf·in 0.17 % 0.21 % + 0.02 lbf·ft 0.24 %	AKO TSD-650-P torque transducer calibration system
Pressure ³ – Gages and Transducers	(0 to 2) inH ₂ O (-14.5 to 1000) psi (0.5 to 1000) psia (100 to 10 000) psi	0.005 inH ₂ O + 0.6R 0.018 % 0.018 % + 0.03 psia 0.1 % + 0.2 psi	Dwyer hook gauge DPI 515 Ametek dead weight tester
Direct Verification of Durometers ³ – Spring Force Indenter Shape	A, B, O, D, C, DO scales	0.6 points Pass/Fail	ASTM D2240 using: Shore durocalibrator Microscope

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Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Verification of Rockwell Hardness Testers ³	HRBW: Low Mid High HRC: Low Mid High HREW: Low High HR30N: Low Mid High HR30TW: Low High	0.67 HRBW 0.67 HRBW 0.67 HRBW 0.43 HRC 0.54 HRC 0.53 HRC 0.20 HREW 0.20 HREW 0.2 HR30N 0.5 HR30N 0.3 HR30N 1.2 HR30TW 0.2 HR30TW	ASTM E18 w/ traceable blocks
Extrusion Plastometer ³ –			ASTM D1238 using:
Piston Diameter	---	69 µin	Micrometer
Cylinder/Bore Dia.	---	120 µin	Micrometer
Timer	---	0.0023 s	Counter
Mass	---	0.04 g	Digital balance
Switch Travel	---	0.0016 in	Caliper
Temperature	< 300 °C	0.028 °C	PRT
	≥ 300 °C	0.037 °C	

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VII. Thermodynamics – Baths, Calibrators, Chambers, Furnaces, Ovens, Psychrometers, Recorders, Thermometers


Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Temperature ³ – Measure	(-197 to 660) °C	0.0036 % + 0.012 °C	Hart 5628 with 1502
Temperature Measuring Equipment ³	(-80 to -45) °C (-45 to 140) °C (140 to 660) °C	0.15 °C 0.0037 % + 0.014 °C 0.0037 % + 0.044 °C	Hart 5628 with 1502; w/ 9107 w/ 9127
Infrared Measuring Equipment ³	(-30 to 150) °C	0.5 °C	Hart 9133
Relative Humidity – Measure ³	(15 to 95) % RH	1.3 % RH	Thunder 5A-1MP psychrometer

VIII. Time & Frequency – Timers, Stopwatches, Counters

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Frequency Measuring Equipment ³	1 mHz to 50 GHz	1.2 parts in 10 ¹⁰ + 0.6R	Symmetricon 8040 Rb oscillator and 3325B or PSG E4438C
Frequency ³ – Measure	1 mHz to 40 GHz	1.2 parts in 10 ¹⁰ + 0.6R	Symmetricon 8040 Rb oscillator locked to 53132A, 53152B or E44458A

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. CMC's 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 numerical value of the nominal diameter of the device measured in inches; R is the numerical value of the resolution of the device in its respective units; F is the frequency in kHz; M is the source of mismatch uncertainty.
- ⁵ In the statement of CMC, percentages are read as percent of reading/output, unless otherwise noted.
- ⁶ The measurands stated are generated with the Fluke 732B, 742A, 5500A and 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.
- ⁷ 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 floor specification or a fraction of the range.

