



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

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CALIBRATION

Valid To: March 31, 2019

Certificate Number: 2046.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations<sup>1</sup>:

I. Acoustical Quantities

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Sound Pressure Level <sup>3</sup>	94 dB 114 dB	0.34 dB 0.56 dB	Sound level calibrator

II. Chemical Quantities

Parameter/Equipment	Range	CMC <sup>2, 4, 5</sup> (±)	Comments
pH <sup>3</sup> – Measuring Equipment	(4.01, 7.00, 10.0) pH	0.015 pH units + 0.60R	Standard solutions w/comparison probe
	(0 to 14) pH	0.015 pH units + 0.60R	Fluke 5520A
Conductivity <sup>3</sup> – Measuring Equipment	100 µS to 100 mS	1.2 % + 0.60R	Standard solutions w/comparison probe

### III. Dimensional

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Micrometers & Calipers <sup>3</sup>	Up to 2 in (2 to 8) in (8 to 16) in (16 to 24) in	4.4L + 3.2 μin + 0.6R 4.7L + 4.3 μin + 0.6R 5L + 5.3 μin + 0.6R 4.8L + 4.2 μin + 0.6R	Gage blocks (Grade 1)
Gage Blocks	(Up to 13) in	(1.6L + 2.9) μin	Pratt & Whitney Labmaster™
Height Gages <sup>3</sup>	Up to 2 in (2 to 8) in (8 to 16) in (16 to 24) in	4.4L + 15 μin + 0.6R 4.7L + 16 μin + 0.6R 5L + 16 μin + 0.6R 4.8L + 16 μin + 0.6R	Gage blocks (Grade 1)
Profilometers <sup>3</sup> – Fixed Points	16 μin 119.3 μin	3.8 μin 3.7 μin	Taylor Hobson surface standard blocks
Ring Gages	Up to 14 in	(5 + 1.6D) μin	Pratt & Whitney Labmaster™
Pin Gages	Up to 6 in	(1.9 + 1.6D) μin	Pratt & Whitney Labmaster™

### IV. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2,5,6</sup> (±)	Comments
DC Voltage <sup>3</sup> – Generate	(0 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  (1000 to 10 000) V (10 000 to 40 000) V	9.0 μV/V + 0.40 μV 5.3 μV/V + 0.70 μV 3.6 μV/V + 2.5 μV 3.6 μV/V + 4.0 μV 5.1 μV/V + 40 μV 6.7 μV/V + 400 μV  0.015 % 0.041 %	Fluke 5720A       HV supply w/source voltage monitored under measure

Parameter/Equipment	Range	CMC <sup>2,5,6</sup> ( $\pm$ )	Comments
Fixed Points (In Steps)	100 mV 1 V 10 V 100 V 1000 V	3.5 $\mu$ V/V 3.5 $\mu$ V/V 3.5 $\mu$ V/V 3.5 $\mu$ V/V 3.5 $\mu$ V/V	Ratio metric techniques Fluke 752A, Fluke 10 DC reference standard
DC Voltage <sup>3</sup> – Measure	(0 to 200) mV 200 mV to 2 V (2 to 20) V (20 to 200) V (200 to 1000) V  (1 to 10) kV  (10 to 35) kV (35 to 100) kV	7.8 $\mu$ V/V + 0.10 $\mu$ V 4.4 $\mu$ V/V + 0.40 $\mu$ V 3.6 $\mu$ V/V + 4.0 $\mu$ V 5.4 $\mu$ V/V + 40 $\mu$ V 8.2 $\mu$ V/V + 0.50 mV  0.012 %  0.045 % 0.057 %	Fluke 8508A  Voltage divider & precision DMM  Precision high voltage meter
DC Current <sup>3</sup> – Measure	(0 to 200) $\mu$ A 200 $\mu$ A to 2.0 mA (2.0 to 20) mA (20 to 200) mA 200 mA to 2 A (2 to 20) A  (20 to 100) A (100 to 1000) A (1000 to 3000) A	13 $\mu$ A/A + 400 pA 13 $\mu$ A/A + 4.0 nA 14 $\mu$ A/A + 40 nA 38 $\mu$ A/A + 800 nA 0.018 % + 16 $\mu$ A 0.040 % + 400 $\mu$ A  0.054 % 0.26 % 0.30 %	Fluke 8508A  Various current shunts
DC Current <sup>3</sup> – Generate	10 fA to 1 pA (1 to 10) pA (10 to 100) pA 100 pA to 1 nA (1 to 10) nA (10 to 100) nA 100 nA to 110 $\mu$ A  (110 to 220) $\mu$ A 220 $\mu$ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A	2.9 % 1.8 % 1.8 % 1.8 % 1.8 % 1.7 % 1.6 %  49 $\mu$ A/A + 6.0 nA 37 $\mu$ A/A + 7.0 nA 38 $\mu$ A/A + 40 nA 48 $\mu$ A/A + 0.70 $\mu$ A 83 $\mu$ A/A + 12 $\mu$ A	Pico ampere source  Fluke 5720A

Parameter/Equipment	Range	CMC <sup>2,5,6</sup> (±)	Comments
DC Current <sup>3</sup> – Generate (cont)	(2.2 to 11) A	0.040 % + 480 µA	Fluke 5725A amplifier
	(11 to 20) A	0.011 % + 1.0 mA	Fluke 52120A
	(20 to 120) A	90 µA/A + 6.0 mA	
	(120 to 1000) A (1000 to 5000) A	0.26 % 0.56 %	1 kA shunt Fluke 52120A w/current coils

Parameter/Range	Frequency	CMC <sup>2,5,6</sup> (±)	Comments
AC Voltage <sup>3</sup> – Generate  Up to 2.2 mV	(10 to 20) Hz	0.026 % + 4.0 µV	Fluke 5720A
	(20 to 40) Hz	0.015 % + 4.0 µV	
	40 Hz to 20 kHz	0.013 % + 4.0 µV	
	(20 to 50) kHz	0.023 % + 4.0 µV	
(50 to 100) kHz	0.051 % + 5.0 µV		
(100 to 300) kHz	0.11 % + 10 µV		
(300 to 500) kHz	0.14 % + 20 µV		
(0.5 to 1) MHz	0.27 % + 20 µV		
(2.2 to 22) mV	(10 to 20) Hz	0.027 % + 4.0 µV	
	(20 to 40) Hz	0.013 % + 4.0 µV	
	40 Hz to 20 kHz	0.013 % + 4.0 µV	
	(20 to 50) kHz	0.023 % + 4.0 µV	
	(50 to 100) kHz	0.057 % + 5.0 µV	
	(100 to 300) kHz	0.11 % + 10 µV	
	(300 to 500) kHz	0.15 % + 20 µV	
	(0.5 to 1) MHz	0.30 % + 20 µV	
(22 to 220) mV	(10 to 20) Hz	0.025 % + 12 µV	
	(20 to 40) Hz	95 µV/V + 7.0 µV	
	40 Hz to 20 kHz	0.012 % + 7.0 µV	
	(20 to 50) kHz	0.022 % + 7.0 µV	
	(50 to 100) kHz	0.048 % + 17 µV	
	(100 to 300) kHz	0.094 % + 20 µV	
	(300 to 500) kHz	0.14 % + 25 µV	
	(0.5 to 1) MHz	0.28 % + 45 µV	
220 mV to 2.2 V	(10 to 20) Hz	0.025 % + 40 µV	
	(20 to 40) Hz	95 µV/V + 15 µV	
	(40 to 20 000) Hz	51 µV/V + 8.0 µV	
	(20 to 50) kHz	78 µV/V + 10 µV	
	(50 to 100) kHz	0.013 % + 30 µV	
	(100 to 300) kHz	0.044 % + 80 µV	
	(300 to 500) kHz	0.10 % + 200 µV	
	(0.5 to 1) MHz	0.19 % + 300 µV	

Parameter/Range	Frequency	CMC <sup>2, 5, 6</sup> (±)	Comments
AC Voltage <sup>3</sup> – Generate (cont)			
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.025 % + 400 μV 95 μV/V + 150 μV 50 μV/V + 50 μV 78 μV/V + 100 μV 0.012 % + 200 μV 0.031 % + 600 μV 0.10 % + 2.0 mV 0.19 % + 3.2 mV	Fluke 5720A
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz (40 to 20 000) Hz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.025 % + 4.0 mV 94 μV/V + 1.5 mV 57 μV/V + 600 μV 83 μV/V + 1.0 mV 0.018 % + 2.5 mV 0.091 % + 16 mV 0.44 % + 40 mV 0.80 % + 80 mV	Subject to 2.2 E <sup>7</sup> V-Hz limitation
(220 to 1100) V	(15 to 50) Hz (0.05 to 1) kHz	0.031 % + 16 mV 77 μV/V + 3.5 mV	
1100 V	40 Hz to 1.0 kHz (1 to 20) kHz (20 to 30) kHz	90 μV/V + 4.0 mV 0.017 % + 6.0 mV 0.06 % + 11 mV	5725A amplifier
750 V	(30 to 50) kHz (50 to 100) kHz	0.060 % + 11 mV 0.23 % + 45 mV	5725A amplifier
AC Voltage <sup>3</sup> – Measure			
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 (0.5 to 1) MHz	0.17 % + 1.3 μV 0.076 % + 1.3 μV 0.044 % + 1.3 μV 0.083 % + 2.0 μV 0.12 % + 2.5 μV 0.23 % + 4.0 μV 0.25 % + 8.0 μV 0.36 % + 8.0 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	0.087 % + 1.3 μV 0.038 % + 1.3 μV 0.022 % + 1.3 μV 0.041 % + 2.0 μV 0.061 % + 2.5 μV 0.12 % + 4.0 μV 0.13 % + 8.0 μV 0.20 % + 8.0 μV	

Parameter/Range	Frequency	CMC <sup>2, 5, 6</sup> (±)	Comments
AC Voltage <sup>3</sup> – 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	0.030 % + 1.3 μV 0.018 % + 1.3 μV 0.011 % + 1.3 μV 0.021 % + 2 μV 0.032 % + 2.5 μV 0.083 % + 4.0 μV 0.088 % + 8.0 μV 0.14 % + 8.0 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	0.021 % + 1.5 μV 0.011 % + 1.5 μV 72 μV/V + 1.5 μV 0.012 % + 2.0 μV 0.026 % + 2.5 μV 0.048 % + 4.0 μV 0.060 % + 8.0 μV 0.092 % + 8.0 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	0.019 % + 1.5 μV 83 μV/V + 1.5 μV 59 μV/V + 1.5 μV 93 μV/V + 2.0 μV 0.020 % + 2.5 μV 0.030 % + 4.0 μV 0.039 % + 8.0 μV 0.084 % + 8.0 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	0.018 % + 1.5 μV 67 μV/V + 1.5 μV 34 μV/V + 1.5 μV 60 μV/V + 2.0 μV 86 μV/V + 2.5 μV 0.020 % + 4.0 μV 0.028 % + 8.0 μV 0.077 % + 8.0 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	0.017 % 57 μV/V 22 μV/V 54 μV/V 75 μV/V 0.017 % 0.024 % 0.071 %	

Parameter/Range	Frequency	CMC <sup>2,5,6</sup> (±)	Comments	
AC Voltage <sup>3</sup> – 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	0.017 % 59 μV/V 23 μV/V 55 μV/V 81 μV/V 0.019 % 0.034 % 0.094 %	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	0.017 % 58 μV/V 27 μV/V 56 μV/V 81 μV/V 0.020 % 0.034 % 0.095 %		
(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	0.017 % 59 μV/V 33 μV/V 67 μV/V 98 μV/V 0.021 % 0.036 % 0.095 %		
(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	0.017 % 60 μV/V 31 μV/V 81 μV/V 0.011 % 0.021 % 0.041 %		
(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	0.018 % 85 μV/V 44 μV/V 0.012 % 0.040 %		
(700 to 1000) V	(20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	82 μV/V 40 μV/V 0.012 % 0.040 %		
(1 to 10) kV	(0.01 to 1) Hz (1 to 200) Hz (200 to 450) Hz	0.14 % 0.14 % 0.41 %		Precision high voltage meter



Parameter/Range	Frequency	CMC <sup>2, 5, 6</sup> (±)	Comments
AC Voltage <sup>3</sup> – Measure (cont)			
(10 to 30) kV	(0.01 to 1) Hz (1 to 200) Hz (200 to 450) Hz	0.14 % 0.08 % 0.52 %	Precision high voltage meter
(30 to 70) kV	(0.01 to 1) Hz (1 to 70) Hz (70 to 200) Hz	0.32 % 0.15 % 1.1 %	
(70 to 100) kV	(50 to 60) Hz	0.66 %	AC voltage standard w/voltage divider & precision DMM
AC Current <sup>3</sup> – 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	0.026 % + 16 nA 0.017 % + 10 nA 0.014 % + 8.0 nA 0.029 % + 12 nA 0.11 % + 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	0.026 % + 40 nA 0.017 % + 35 nA 0.013 % + 35 nA 0.021 % + 110 nA 0.11 % + 650 nA	
(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	0.026 % + 400 nA 0.017 % + 350 nA 0.013 % + 350 nA 0.021 % + 550 nA 0.11 % + 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	0.026 % + 4.0 µA 0.017 % + 3.5 µA 0.013 % + 2.5 µA 0.021 % + 3.5 µA 0.11 % + 10 µA	
220 mA to 2.2 A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.028 % + 35 µA 0.046 % + 80 µA 0.71 % + 160 µA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.046 % + 170 µA 0.095 % + 380 µA 0.36 % + 750 µA	



Parameter/Range	Frequency	CMC <sup>2, 5, 7</sup> (±)	Comments
AC Current <sup>3</sup> – Generate (cont)			
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.11 % + 5.0 mA 0.12 % + 5.0 mA 2.4 % + 5.0 mA	Fluke 5720A w/5725 amplifier
(20.5 to 100) A	1 kHz 10 kHz 30 kHz 100 kHz	84 µA/A 0.012 % 0.013 % 0.024 %	Fluke A40B-100A
(100 to 550) A	(45 to 440) Hz	0.36 %	Fluke 5520A w/coil
(550 to 3000) A	10 Hz to 1 kHz	0.56 %	Fluke 52120A w/current coils
(3 to 6) kA	10 Hz to 1 kHz	0.56 %	
AC Current <sup>3</sup> – Measure			
Up to 200 µA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.034 % + 20 nA 0.035 % + 20 nA 0.068 % + 20 nA 0.57 % + 20 nA	Fluke 8508A
200 µA to 2 mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.033 % + 200 nA 0.029 % + 200 nA 0.066 % + 200 nA 0.40 % + 200 nA	
(2 to 20) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.034 % + 2.0 µA 0.030 % + 2.0 µA 0.066 % + 2.0 µA 0.40 % + 2.0 µA	
(20 to 200) mA	(1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	0.033 % + 20 µA 0.026 % + 20 µA 0.061 % + 20 µA	
200 mA to 2 A	10 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz	0.061 % + 200 µA 0.072 % + 200 µA 0.30 % + 200 µA	
(2 to 20) A	10 Hz to 2 kHz (2 to 10) kHz	0.091 % + 2.4 mA 0.26 % + 2.4 mA	

Parameter/Range	Frequency	CMC <sup>2, 4, 5, 6</sup> (±)	Comments
AC Current <sup>3</sup> – Measure (cont)			
(20 to 100) A (100 to 1000) A	(0 to 100) Hz (0 to 100) Hz	0.054 % 0.30 %	Fluke 8508A
(1 to 1.2) kA (1.2 to 3) kA	(0 to 100) Hz (0 to 100) Hz	0.17 % 0.30 %	Various current shunts
Resistance <sup>3</sup> – Generate			
Fixed Points	0.001 Ω 0.01 Ω 0.1 Ω	0.056 % 0.049 % 0.040 %	Short current shunt
	1.0 Ω	0.17 μΩ/Ω	Fluke 742A-1
	100 Ω	0.80 μΩ/Ω	Fluke 742-100
	10 kΩ	0.33 μΩ/Ω	Fluke 742A-10k
	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	98 μΩ/Ω + 40 μΩ 98 μΩ/Ω + 40 μΩ 26 μΩ/Ω + 40 μΩ 26 μΩ/Ω + 40 μΩ 11 μΩ/Ω + 40 μΩ 11 μΩ/Ω + 40 μΩ 9.0 μΩ/Ω 9.0 μΩ/Ω 9.0 μΩ/Ω 9.0 μΩ/Ω 12 μΩ/Ω 12 μΩ/Ω 21 μΩ/Ω 22 μΩ/Ω 41 μΩ/Ω 49 μΩ/Ω 0.011 %	Fluke 5720A
	(1.00 to 1000) MΩ (1000 to 10 000) MΩ (10 to 100) GΩ	0.24 % 0.70 % 1.5 %	Biddle 72-6346-1
Fixed Points	10 MΩ 100 MΩ 1 GΩ 10 GΩ 100 GΩ 1 TΩ	0.14 % 0.14 % 0.14 % 0.16 % 0.59 % 2.1 %	Keithley 5155-7 Keithley 5155-8 Keithley 5155-9 Keithley 5155-10 Keithley 5155-11 Keithley 5155-12



Parameter/Equipment	Range	CMC <sup>2, 5, 6</sup> (±)	Comments
Resistance <sup>3</sup> – Measure	(0 to 0.25) Ω (0.25 to 4.0) Ω (2.5 to 40) Ω (0 to 25) Ω (25 to 400) Ω (400 to 1000) Ω (1 to 25) kΩ (25 to 40) kΩ (40 to 100) kΩ (100 to 500) kΩ	60 μΩ/Ω 47 μΩ/Ω 24 μΩ/Ω 8.7 μΩ/Ω 7 μΩ/Ω 13 μΩ/Ω 15 μΩ/Ω 14 μΩ/Ω 41 μΩ/Ω 0.015 %	Hart Scientific 1590
	(2 to 20) kΩ (20 to 200) kΩ (0.2 to 2) MΩ (2 to 20) MΩ (20 to 200) MΩ (0.2 to 2) GΩ	7.7 μΩ/Ω + 5.0 mΩ 8 μΩ/Ω + 50 mΩ 10 μΩ/Ω + 1.0 Ω 23 μΩ/Ω + 100 Ω 77 Ω/Ω + 10 kΩ 0.063 % + 1.0 MΩ	Fluke 8508A
	(2 to 100) GΩ (100 to 1000) GΩ	0.55 % 0.54 %	Quadtech 1865
Harmonic Distortion – Measure  20 Hz to 20 kHz	2 <sup>nd</sup> Harmonic 3 <sup>rd</sup> Harmonic 4 <sup>th</sup> Harmonic 5 <sup>th</sup> Harmonic 6 <sup>th</sup> Harmonic  Total Harmonic Distortion	2.0 dB 2.0 dB 2.0 dB 2.0 dB 2.0 dB  0.12 % <i>THD</i>	Keithley 2016-P
Capacitance <sup>3</sup> – Generate, Fixed Points  1 kHz	1000 pF 100 pF	14 μF/F 16 μF/F	GenRad 1404-A GenRad 1404-B
Electrical Calibration of Thermocouples <sup>3</sup> – Generate & Measure  Type B	(600 to 800) °C (800 to 1000) °C (1000 to 1550) °C (1550 to 1820) °C	0.34 °C 0.26 °C 0.23 °C 0.26 °C	Fluke 5520A



Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouples <sup>3</sup> – Generate & Measure (cont)			
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.23 °C 0.20 °C 0.24 °C 0.39 °C 0.66 °C	Fluke 5520A
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.39 °C 0.13 °C 0.11 °C 0.13 °C 0.16 °C	
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.21 °C 0.13 °C 0.11 °C 0.13 °C 0.18 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.26 °C 0.14 °C 0.12 °C 0.20 °C 0.31 °C	
Type L	(-200 to -100) °C (-100 to 800) °C (800 to 900) °C	0.29 °C 0.20 °C 0.14 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.31 °C 0.17 °C 0.15 °C 0.14 °C 0.21 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.44 °C 0.27 °C 0.26 °C 0.31 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.37 °C 0.28 °C 0.29 °C 0.36 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.49 °C 0.19 °C 0.13 °C 0.11 °C	



Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouples <sup>3</sup> – Generate & Measure (cont)			
Type U	(-200 to 0) °C (0 to 600) °C	0.44 °C 0.21 °C	Fluke 5520A
Electrical Calibration of RTDs <sup>3</sup> – Measure & Generate			
Type 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	0.047 °C 0.055 °C 0.075 °C 0.078 °C 0.11 °C 0.18 °C	Fluke 5520A 4 wire compensation
Type Pt 3926, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.045 °C 0.056 °C 0.071 °C 0.081 °C 0.093 °C	
Type 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	0.19 °C 0.034 °C 0.042 °C 0.049 °C 0.062 °C 0.063 °C 0.072 °C 0.078 °C 0.18 °C	
Type Pt 385, 200 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.047 °C 0.034 °C 0.039 °C 0.047 °C 0.093 °C 0.10 °C 0.11 °C 0.12 °C	
Type Pt 385, 500 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.039 °C 0.041 °C 0.042 °C 0.049 °C 0.064 °C 0.064 °C 0.085 °C 0.085 °C	



Parameter/Equipment	Range	CMC <sup>2, 5, 6</sup> (±)	Comments
Electrical Calibration of RTDs <sup>3</sup> – Measure & Generate (cont)			
Type Pt 385, 1000 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.035 °C 0.027 °C 0.035 °C 0.042 °C 0.047 °C 0.056 °C 0.060 °C 0.18 °C	Fluke 5520A 4 wire compensation
Type PtNi, 120 Ω (Ni 120)	(-80 to 0) °C (0 to 100) °C (100 to 260) °C	0.063 °C 0.063 °C 0.11 °C	
Type Cu 427, 10 Ω	(-100 to 260) °C	0.23 °C	
DC Power <sup>3</sup> – Measuring Equipment			
33 mV to 1020 V	(0.33 to 330) mA (0.33 to 3) A (3 to 20.5) A	0.018 % 0.017 % 0.054 %	Fluke 5520A

Parameter/Range	Frequency	CMC <sup>2, 5, 6</sup> (±)	Comments
Capacitance <sup>3</sup> – Generate			
1 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	45 μF/F 91 μF/F 0.023 % 0.042 % 0.064 % 0.089 % 0.25 % 0.37 %	HP 1638XX standard capacitor
10 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	39 μF/F 39 μF/F 40 μF/F 44 μF/F 47 μF/F 57 μF/F 0.013 % 0.016 %	

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
Capacitance <sup>3</sup> – Generate (cont)			
100 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	39 μF/F 40 μF/F 48 μF/F 68 μF/F 94 μF/F 0.014 % 0.033 % 0.051 %	HP 1638XX standard capacitor
1000 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	41 μF/F 64 μF/F 0.015 % 0.028 % 0.044 % 0.061 % 0.19 % 0.28 %	
Fixed Points			
0.001 μF	20 Hz to 1 kHz	1.2 pF	GenRad 1409 series
0.01 μF	20 Hz to 1 kHz	13 pF	
0.1 μF	20 Hz to 1 kHz	120 pF	
1.0 μF	20 Hz to 1 kHz	1.1 nF	
0.02 μF	20 Hz to 1 kHz	23 pF	
0.005 μF	20 Hz to 1 kHz	7.1 pF	
0.05 μF	20 Hz to 1 kHz	56 pF	
(0.19 to 0.3999) nF	10 Hz to 10 kHz	0.51 % + 0.010 nF	Fluke 5520A
(0.4 to 1.0999) nF	10 Hz to 10 kHz	0.51 % + 0.010 nF	
(1.1 to 3.29) nF	10 Hz to 3 kHz	0.51 % + 0.010 nF	
(3.3 to 10.9) nF	10 Hz to 1 kHz	0.27 % + 0.010 nF	
(11 to 32.9999) nF	10 Hz to 1 kHz	0.27 % + 0.10 nF	
(33 to 109.9) nF	10 Hz to 1 kHz	0.27 % + 0.10 nF	
(110 to 329.999) nF	10 Hz to 1 kHz	0.27 % + 0.30 nF	
(0.33 to 1.09) μF	(10 to 600) Hz	0.27 % + 1.0 nF	
(1.1 to 3.29999) μF	(10 to 300) Hz	0.27 % + 3.0 nF	
(3.3 to 10.9999) μF	(10 to 150) Hz	0.27 % + 10 nF	
(11 to 32.9999) μF	(10 to 120) Hz	0.41 % + 30 nF	
(33 to 109.999) μF	(10 to 80) Hz	0.46 % + 100 nF	
(110 to 329.999) μF	(10 to 50) Hz	0.46 % + 300 nF	
(0.3 to 1.09999) mF	(10 to 20) Hz	0.46 % + 1.0 μF	
(1.1 to 3.2999) mF	(0 to 6) Hz	0.46 % + 3.0 μF	
(3.3 to 10.9999) mF	(0 to 2) Hz	0.46 % + 10 μF	
(11 to 32.9999) mF	(0 to 0.6) Hz	0.76 % + 30 μF	
(33 to 110) mF	(0 to 0.2) Hz	1.1 % + 100 μF	



Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
Capacitance <sup>3</sup> – Measure			
1 pF	(0.1 to 1) kHz (1 to 10) kHz	12 % 1.2 %	Agilent E4980A
10 pF	(20 to 1000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 2) MHz	12 % 1.2 % 0.13 % 0.35 %	
100 pF	(20 to 100) Hz (0.1 to 1) kHz 1.0 kHz to 2 MHz	12 % 1.2 % 0.12 %	
1 nF	(20 to 100) Hz 100 Hz to 1 MHz (1 to 2) MHz	1.2 % 0.12 % 0.36 %	
10 nF	(20 to 100) Hz 100 Hz to 100 kHz 100 kHz to 2 MHz	0.35 % 0.12 % 0.35 %	
100 nF	20 Hz to 10 kHz 10 kHz to 2 MHz	0.12 % 0.35 %	
1.0 µF	20 Hz to 10 kHz 10 kHz to 2 MHz	0.12 % 0.35 %	
10.0 µF	(20 to 1000) Hz (1 to 100) kHz (0.1 to 2) MHz	0.12 % 0.35 % 1.2 %	
100.0 µF	100 Hz to 10 kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 2) MHz	0.35 % 1.2 % 7.0 % 12 %	
1.0 mF	(20 to 1000) Hz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz	0.35 % 1.2 % 7.0 % 12 %	
10 mF	(20 to 100) Hz (0.1 to 1) kHz (1 to 10) kHz (10 to 100) kHz	0.81 % 1.2 % 9.3 % 12 %	
100 mF	(20 to 100) Hz 100 Hz to 10 kHz	5.8 % 12 %	





Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
Inductance <sup>3</sup> – Generate @ 1000 Hz, Generate Equipment	100 µH to 1.111 H (100 µH Steps)	2.4 %	GenRad 1490-F decade inductance box
Fixed Points	200 µH 500 µH 1 mH 5 mH 10 mH 50 mH 500 mH 2 H	0.15 % 0.15 % 0.15 % 0.15 % 0.15 % 0.15 % 0.15 % 0.15 %	GenRad 1482-x standard inductors
Inductance <sup>3</sup> – Measure			Agilent E4980A
1 pH to 1 mH	(20 to 100) Hz (0.1 to 1) kHz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 2) MHz	0.35 % 0.12 % 0.12 % 0.12 % 0.12 % 0.41 %	
(1 to 10) mH	(20 to 100) Hz (0.1 to 1) kHz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 2) MHz	0.35 % 0.12 % 0.14 % 0.12 % 0.12 % 1.7 %	
(10 to 100) mH	(20 to 100) Hz (0.1 to 1) kHz (1 to 10) kHz	0.35 % 0.12 % 0.12 %	
100 mH to 1 H	(20 to 100) Hz (0.1 to 1) kHz (1 to 10) kHz	0.12 % 0.12 % 0.12 %	
(1 to 10) H	(20 to 100) Hz (0.1 to 1) kHz	0.12 % 0.12 %	
ESD Simulator – Measure			
Contact Discharge (positive & negative)	(0 to 6) kV	1.2 %	Brandenberg 139
Rise Time	1.0 ns	52 ps	Tektronix TDS 684B, CTC-3 IES Target
30 nS Current	(2.8 to 20.8) A	2.1 %	IEC 61000-4-5



Parameter/Range	Frequency	CMC <sup>2,6</sup> (±)	Comments
Oscilloscopes <sup>3</sup> – Voltage (50 Ω <sub>pk-pk</sub> )	(1 to 556) mV 556 mV to 5.56 V	0.078 % + 10 μV 0.78 % + 10 μV	Fluke 9500B w/Fluke Active Heads 9630 & 9560
Sweep Time	9 ns to 55 s	2.3 μs/s	
Rise Time	150 ps to 100 ms	16 ps	
Bandwidth	0.1 Hz to 6.0 GHz	4.4 % flatness	
Phase Angle <sup>3</sup> – Generate 0° to 360°	(10 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.079° 0.19° 0.39° 2.0° 3.9° 7.8°	Fluke 5520A

V. Electrical – Microwave/RF

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
AC Power <sup>3</sup> – Measuring Equipment			
(33 to 330) mV Power Factor = 1	(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA (330 to 900) mA 900 mA to 2.2 A (2.2 to 4.5) A (4.5 to 20.5) A	0.15 % 0.11 % 0.15 % 0.14 % 0.16 % 0.16 % 0.14 % 0.15 %	Fluke 5520A frequency (45 to 65) Hz
330 mV to 1020 V Power Factor = 1	(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA (330 to 900) mA 900 mA to 2.2 A (2.2 to 4.5) A (4.5 to 20.5) A	0.13 % 0.10 % 0.13 % 0.10 % 0.15 % 0.13 % 0.14 % 0.11 %	

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
Attenuation <sup>3</sup> – Measure  2.5 MHz to 26.5 GHz	(0 to 10) dBm (-10 to 0) dBm (-20 to -10) dBm (-30 to -20) dBm (-40 to -30) dBm (-50 to -40) dBm (-60 to -50) dBm (-70 to -60) dBm (-80 to -70) dBm (-90 to -80) dBm (-100 to -90) dBm (-110 to -100) dBm (-120 to -110) dBm (-127 to -120) dBm	0.10 dB 0.10 dB 0.13 dB 0.15 dB 0.17 dB 0.20 dB 0.22 dB 0.24 dB 0.27 dB 0.29 dB 0.31 dB 0.33 dB 0.39 dB 0.61 dB	HP 8902A, Agilent 11793A
Tuned RF Power <sup>3</sup> – Relative Measure  2.5 MHz to 26.5 GHz	(0 to 10) dBm (-10 to 0) dBm (-20 to -10) dBm (-30 to -20) dBm (-40 to -30) dBm (-50 to -40) dBm (-60 to -50) dBm (-70 to -60) dBm (-80 to -70) dBm (-90 to -80) dBm (-100 to -90) dBm (-110 to -100) dBm (-120 to -110) dBm (-127 to -120) dBm	0.10 dB 0.10 dB 0.13 dB 0.15 dB 0.17 dB 0.20 dB 0.22 dB 0.24 dB 0.27 dB 0.29 dB 0.31 dB 0.33 dB 0.39 dB 0.61 dB	HP 8902A, Agilent 11793A



Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
Tuned RF Power <sup>3</sup> – Absolute Measure  2.5 MHz to 26.5 GHz	(0 to +10) dBm (-10 to 0) dBm (-20 to -10) dBm (-30 to -20) dBm (-40 to -30) dBm (-50 to -40) dBm (-60 to -50) dBm (-70 to -60) dBm (-80 to -70) dBm (-90 to -80) dBm (-100 to -90) dBm (-110 to -100) dBm (-120 to -110) dBm (-127 to -120) dBm	0.17 dB 0.17 dB 0.19 dB 0.22 dB 0.24 dB 0.26 dB 0.28 dB 0.31 dB 0.33 dB 0.35 dB 0.37 dB 0.40 dB 0.45 dB 0.67 dB	HP 8902A, Agilent 11793A
RF Power <sup>3</sup> – Measure  (-120 to 30) dBm	100 kHz to 26 GHz	0.17 dBm	HP 8902A
RF Power – 1 mW	(0.01 to 10) MHz (0.01 to 10) GHz (10 to 18) GHz	0.93 % 1.3 % 1.6 %	Tegam F1130A, 1830A
Calibration Factor	(0.10 to 0.20) MHz (0.30 to 40) MHz (0.05 to 2.0) GHz (2.1 to 3.6) GHz (3.7 to 4.6) GHz (4.8 to 10) GHz (12 to 18) GHz	0.65 % 0.58 % 0.57 % 0.59 % 0.61 % 0.66 % 0.78 %	Tegam F1130A, 1830A
Reflection Co-efficient	9.0 kHz to 0.40 GHz	4.9 %	VNA



Parameter/Range	Frequency	CMC <sup>2, 5</sup> (±)	Comments
AM Modulation –			
Rate: (0.05 to 10) kHz Depth: 5.0 % to 99 %	(0.15 to 10) MHz	0.024 AM + 0.10 %	HP8902A
Rate: (0.02 to 10) kHz Depth: Up to 99 %	(0.15 to 10) MHz	0.036 AM + 0.10 %	
Rate: (0.05 to 50) kHz Depth: 5.0 % to 99 %	(0.01 to 1.3) GHz	0.013 AM + 0.10 %	
Rate: 20 Hz to 0.10 MHz Depth: Up to 99%	(0.01 to 1.3) GHz	0.036 AM + 0.10 %	
Rate: (0.05 to 50) kHz Depth: 5.0 % to 99%	(1.3 to 26.5) GHz	0.018 AM + 0.10 %	
Rate: 20 Hz to 0.10 MHz Depth: Up to 99 %	(0.01 to 26.5) GHz	0.036 AM + 0.10 %	
FM Modulation –			
Rate: (0.02 to 10) kHz Deviation: ≤ 40 kHz	(0.25 to 10) MHz: Up to 4.0 kHz <sub>peak</sub> FM (4.0 to 40) kHz <sub>peak</sub> FM	0.023 FM + 1.0 Hz <sub>peak</sub> 0.023 FM + 10 Hz <sub>peak</sub>	HP8902A
Rate: 50 Hz to 0.10 MHz Deviation: ≤ 400 kHz	(0.01 to 1.3) GHz: Up to 4.0 kHz <sub>peak</sub> FM (4.0 to 40) kHz <sub>peak</sub> FM (0.04 to 0.40) MHz <sub>peak</sub> FM	0.012 FM + 1.0 Hz <sub>peak</sub> 0.012 FM + 10 Hz <sub>peak</sub> 0.012 FM + 0.01 kHz <sub>peak</sub>	
Rate: 50 Hz to 0.10 MHz Deviation: ≤ 400 kHz	(0.01 to 27) GHz: Up to 4.0 kHz <sub>peak</sub> FM (4.0 to 40) kHz <sub>peak</sub> FM (0.04 to 0.40) MHz <sub>peak</sub> FM	0.012 FM + 1.0 Hz <sub>peak</sub> 0.012 FM + 10 Hz <sub>peak</sub> 0.012 FM + 0.01 kHz <sub>peak</sub>	
Rate: 20 Hz to 0.20 MHz Deviation: ≤ 400 kHz	(0.01 to 1.3) GHz: Up to 4.0 kHz <sub>peak</sub> FM (4.0 to 40) kHz <sub>peak</sub> FM (0.04 to 0.40) MHz <sub>peak</sub> FM	0.058 FM + 1.0 Hz <sub>peak</sub> 0.058 FM + 10 Hz <sub>peak</sub> 0.058 FM + 0.01 kHz <sub>peak</sub>	
Rate: 20 Hz to 0.20 MHz Deviation: ≤ 400 kHz	(0.01 to 27) GHz: Up to 4.0 kHz <sub>peak</sub> FM (4.0 to 40) kHz <sub>peak</sub> FM (0.04 to 0.40) MHz <sub>peak</sub> FM	0.058 FM + 1.0 Hz <sub>peak</sub> 0.058 FM + 10 Hz <sub>peak</sub> 0.058 FM + 0.01 kHz <sub>peak</sub>	

Parameter/Range	Frequency	CMC <sup>2,5</sup> (±)	Comments
Phase Modulation Rate: (0.20 to 10) kHz Rate: (0.20 to 20) kHz Rate: (0.20 to 20) kHz	(0.15 to 10) MHz (0.01 to 1.3) GHz (1.3 to 27) GHz	0.046 PM + 0.010 rad 0.035 PM + 0.010 rad 0.035 PM + 0.010 rad	HP8902A

#### VI. Fluid

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Volume – Pipettes	(0 to 100) µL (100 to 500) µL (0.5 to 1) mL (1 to 5) mL	0.014 % + 0.60R 40 µL/L + 0.60R 32 µL/L + 0.60R 29 µL/L + 0.60R	Gravimetric calibration using Sartorius balance & ANSI/ASTM E617 Class 1 weights

#### VII. Fluid Quantities

Parameter/Equipment	Range	CMC <sup>2,4,5</sup> (±)	Comments
Mass Flow	(5 to 50) SCCM (100 to 1000) SCCM  (1 to 10) SLPM (3 to 50) SLPM (50 to 300) SLPM (120 to 1200) SLPM (400 to 4000) SLPM	0.24 % + 0.60R 0.26 % + 0.60R  0.29 % + 0.60R 0.25 % + 0.60R 0.25 % + 0.60R 0.25 % + 0.60R 0.25 % + 0.60R	DHI molbox w/molbloc
Viscosity Meters <sup>3</sup>	100 cps 12 500 cps 100 000 cps	(0.28 + 0.60R) cps (0.44 + 0.60R) cps (480 + 0.60R) cps	Cannon / Brookfield standard solutions

## VIII. Mechanical

Parameter/Equipment	Range	CMC <sup>2, 4, 5</sup> ( $\pm$ )	Comments
Viscosity Meters <sup>3</sup>	100 cps 100 000 cps	(0.28 + 0.60R) cps (480 + 0.60R) cps	Cannon standard solutions
Pressure <sup>3</sup> – Measuring Equipment, Hydraulic & Pneumatic	(2 to 700) psig	0.002 %	Ruska 2465A w/2460-706
	(700 to 1100) psig (1100 to 5800) psig (5800 to 10 100) psig (10 100 to 16 000) psig	76 $\mu$ Pa/Pa + 2.5 Pa 78 $\mu$ Pa/Pa + 13 Pa 84 $\mu$ Pa/Pa + 50 Pa 87 $\mu$ Pa/Pa + 50 Pa	DHI PG 7202 w/PC-7200-100 w/PC-7200-500 w/PC-7200-2
	(16 000 to 20 000) psig (20 000 to 40 000) psig	12 psi 42 psi	Additel pressure gauges
	(0 to 23.2) psia	0.013 %	DHI RPM4
Mass <sup>3</sup>	(0 to 6) g (0 to 500) g (0 to 1000) g (0 to 40) kg	16 $\mu$ g 25 $\mu$ g 2.9 mg 83 mg	Sartorius CCE6 Sartorius CC-500 Sartorius CCE-1201 Sartorius CC-30002
Scales & Balances <sup>3</sup>	40 kg 30 kg 20 kg 10 kg 5 kg 1 kg 500 g 200 g 100 g 50 g 20 g 10 g 5 g 1 g 500 mg 100 mg 10 mg 1 mg	190 mg + 0.60R 130 mg + 0.60R 46 mg + 0.60R 62 mg + 0.60R 58 mg + 0.60R 3.0 mg + 0.60R 1.6 mg + 0.60R 0.57 mg + 0.60R 0.28 mg + 0.60R 140 $\mu$ g + 0.60R 88 $\mu$ g + 0.60R 62 $\mu$ g + 0.60R 41 $\mu$ g + 0.60R 41 $\mu$ g + 0.60R 18 $\mu$ g + 0.60R 18 $\mu$ g + 0.60R 18 $\mu$ g + 0.60R 18 $\mu$ g + 0.60R	Reference weights

Parameter/Equipment	Range	CMC <sup>2, 4, 5</sup> (±)	Comments
Torque <sup>3</sup> – Measure Wrenches, Screwdrivers & Watches	(4 to 8) in·ozf (8 to 40) in·ozf (2.5 to 10) in·lbf (10 to 50) in·lbf (50 to 250) in·lbf (250 to 750) in·lbf (62.5 to 250) ft·lbf (250 to 1000) ft·lbf	1.2 % 0.63 % 0.57 % 0.77 % 0.63 % 0.65 % 1.2 % 0.71 %	Torque mate 2000
Torque – Measuring Equipment Transducers	(4 to 40) in·ozf (2.5 to 50) in·lbf (50 to 180) in·lbf (15 to 250) ft·lbf (250 to 1000) ft·lbf	0.058 % 0.055 % 0.042 % 0.044 % 0.085 %	Lever arms & traceable hanging weights
RPM <sup>3</sup> – Measure	(1 to 3000) RPM	0.11 RPM	Frequency counter w/IR Sensor
RPM <sup>3</sup> – Generate  Optical	(1 to 100 000) RPM	0.17 RPM + 0.60R	Fluke 5520A
RPM <sup>3</sup> – Contact Meters	(1 to 3000) RPM	0.11 RPM + 0.60R	Frequency counter/motor
Air Velocity – Measuring Equipment	(25 to 7500) fpm	1.2 %	Wind tunnel & omega differential pressure sensor, model WT4401S
Accelerometers <sup>3</sup>	160 Hz  10 Hz to 4 kHz (4 to 7) kHz (7 to 12.8) kHz	0.61 %  0.68 % 0.79 % 1.4 %	Reference accelerometer
Force – Measure Tension & Compression	(0 to 2500) lbf (2500 to 30 000) lbf  (25 000 to 60 000) lbf	0.34 lbf 3.3 lbf  720 lbf	Morehouse tension & compression  Tinius Olsen Super-L w/computer display



Parameter/Equipment	Range	CMC <sup>2, 4, 5</sup> (±)	Comments
“Direct Verification” of Durometers <sup>3</sup> – Spring Force Indenter Display	A, B, O, D, C, DO scales (0 to 100) duro units	0.52 duro points 0.58 duro units	Durocalibrator Gage blocks
Magnetics – Gauss Meters	54.8 Gauss 995.8 Gauss 4940 Gauss	0.20 Gauss 2.9 Gauss 9.5 Gauss	MII F343-50 MII F062-1K MII F062-5K

#### IX. Optical Radiation

Parameter/Equipment	Range	CMC <sup>2, 5</sup> (±)	Comments
Photometric – Measure <sup>3</sup>	(1 to 10 000) fc	4.7 %	Radiometer

#### X. Thermodynamic

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Temperature – Measuring Equipment, Fixed Points	0.01 °C	0.0017 °C	Triple point water cell
	29.7646 °C	0.0047 °C	Melting point of Gallium cell



Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Dew Point <sup>3</sup>	(-20 to 60) °C	0.10 °C	Thunder Scientific 1200/2500
Infrared Thermometers – Hart Furnace	(-15 to 0) °C (0 to 100) °C (100 to 120) °C (120 to 200) °C (200 to 350) °C (350 to 500) °C  (500 to 1 200) °C	1.2 °C 1.4 °C 1.3 °C 2.1 °C 2.5 °C 2.9 °C  8.1 °C	Fluke 4181 / 4180  ε = 0.9 to 1.0 λ = (8 to 14) μm  Fluke 9150 furnace w/Hart 1529 & Type S thermocouple
Temperature <sup>3</sup> – Measure	(-80 to 110) °C  (110 to 550) °C (550 to 1 200) °C	0.011 °C + 0.60R  0.042 °C + 0.60R 0.59 °C + 0.60R	Fluke 7381 precision bath w/Hart 1590 & 5698 SPRT  Isotech medusa furnace, Fluke 9150 furnace w/Hart 1529 & Type S thermocouple
Humidity <sup>3</sup> – Measuring Equipment	(10 to 95) % RH	0.51 %	Thunder Scientific 2500
Humidity – Measure <sup>3</sup>	(0 to 90) % RH (90 to 100) % RH (-40 to 180) °C	1.7 % RH 1.8 % RH (1.5 + 0.015X) % RH	Vaisala HumiCap (on-site only) X = reading

XI. Time & Frequency

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Frequency <sup>3</sup> – Measure Equipment	0.05 Hz to 10 MHz 10 MHz to 4 GHz (4 to 26) GHz	15 parts in 10 <sup>12</sup> Hz/Hz 21 parts in 10 <sup>12</sup> Hz/Hz 27 parts in 10 <sup>12</sup> Hz/Hz	GPS reference
Frequency – Measure	0.05 Hz to 2.7 GHz (2.7 to 20) GHz	25 parts in 10 <sup>12</sup> Hz/Hz 60 parts in 10 <sup>12</sup> Hz/Hz	Frequency counters w/external reference
Stopwatches & Timers	Up to 24 hr	0.05 sec/day + 0.60R	Timometer

XII. Device Specific Parameters

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
ESD Simulator – Contact Discharge (positive & negative)	(0 to 8) kV	1.0 %	Brandenberg 139
Rise Time	(0.7 to 1) ns	0.12 ns	Tektronix TDS 684B, CTC-3 IES Target
30 nS Current	(2.8 to 20.8) A	1.8 %	IEC 61000-4-2 (2001-04)
60 nS Current	(1 to 10) A	1.8 %	
EFT/Burst Generator <sup>3</sup> – Voltage (±)	10 V to 6 kV	2.5 %	EN 6200-4-4 (2012) IEC 61000-4-6 (2009)
Rise Time	5 ns ± 30 %	0.81 ns	
Impulse Duration	50 ns ± 30 %	0.81 ns	
Burst Duration	15 ms ± 20 %	0.81 ns	Tektronix TDS 3052, Haefely PAT 50 / 1000 probes
Burst Period	300 ms ± 20 %	0.81 ns	
Repetition Rate 0.125 kV	5 kHz ± 20 %	1.2 Hz	
0.25 kV	5 kHz ± 20 %	1.2 Hz	
0.25 kV	5 kHz ± 20 %	1.2 Hz	
1.0 kV	5 kHz ± 20 %	1.2 Hz	
2.0 kV	2.5 kHz ± 20 %	1.2 Hz	Tektronix TDS 3052

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
CDN –			
Phase			
-6 dBm	(-0.8 to 0.8)°	0.039°	CISPR 16-1-2 (2006), IEC 61000-4-6 (2009) HP 8751A, Verification kit
-10 dBm	(-0.12 to 0.12)°	0.035°	
-30 dBm	(-0.12 to 0.12)°	0.024°	
-40 dBm	(-0.12 to 0.12)°	0.12°	
-50 dBm	(-0.12 to 0.12)°	0.14°	
-60 dBm	(-0.3 to 0.3)°	0.70°	
Impedance	(5 to 100) Hz	6.9 %	Boonton 9242 RF Voltmeter, 952001 sensor
	100 Hz to 1 MHz	1.4 %	
	(1 to 300) MHz	0.66 %	
	(300 to 500) MHz	0.70 %	
Coupling Factor	10 kHz to 500 MHz	0.38 dB	
Current Probe – Transfer Impedance	10 kHz to 100 MHz 100 MHz to 1 GHz (1 to 1.2) GHz	0.25 dB 0.57 dB 1.3 dB	CISPR 16-1-2 (2006) Boonton 9242 with Boonton 952001B probes
LISN <sup>3</sup> –			
Insertion Loss	9 kHz to 1 GHz	0.38 dB	CISPR 16-1-2 (2006-08) HP8751A, HP8753C Verification kit
Impedance	9 kHz to 1 GHz	4.9 %	
Phase	9 kHz to 1 GHz	2.8 °	

<sup>1</sup> This laboratory offers commercial calibration service and field calibration service.

<sup>2</sup> Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of  $k = 2$ . The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

<sup>3</sup> 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.

<sup>4</sup> In the statement of CMC;  $L$  is the numerical value of the nominal length of the device measured in inches;  $R$  is the numerical value of the resolution of the device in its respective units;  $D$  is the diameter of the device in inches

<sup>5</sup> In the statement of CMC, percentages are read as percent of reading/output, unless otherwise noted.

<sup>6</sup> The stated measured values are determined using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure or generate the measured value in the ranges indicated. CMC are expressed as either a specific value that covers the full range or as a fraction or percent of the reading plus a fixed floor specification.



## Accredited Laboratory

A2LA has accredited

# BROADVIEW INSTRUMENTATION SERVICES, INC.

*Valley View, OH*

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/NCSLI Z540-1-1994 and the requirements of ANSI/NCSLI Z540.3 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 20<sup>th</sup> day of June 2017.

A handwritten signature in black ink, written over a horizontal line.

President and CEO  
For the Accreditation Council  
Certificate Number 2046.01  
Valid to March 31, 2019

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