



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

ELEMENT MATERIALS TECHNOLOGY DETROIT - WARREN 11 MILE<sup>3</sup>  
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CALIBRATION

Valid until: December 31, 2020

Certificate Number: 0098.13

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations<sup>1, 10</sup>:

I. Chemical

Parameter/Equipment	Range	CMC <sup>2, 7, 11</sup> ( $\pm$ )	Comments
pH – Measuring Equipment <sup>3</sup>	(4, 7, 10) units	0.025 units	Standard solutions
Conductivity – Fixed Values <sup>3</sup>	10 $\mu$ S 100 $\mu$ S 1000 $\mu$ S (1413 to 110 000) $\mu$ S	5.9 % 2.4 % 0.50 % 0.42 %	Standard solutions

II. Dimensional

Parameter/Equipment	Range	CMC <sup>2</sup> ( $\pm$ )	Comments
Optical Flats	(0.5 to 2) in	9.3 $\mu$ in	Grade 1 optical flats, monochromatic light

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Micrometers <sup>3</sup> –			
Inside	(0.2 to 20) in	(39 + 4.0L) $\mu$ in	Gage blocks
Outside	(0.001 to 6) in (6 to 36) in	(40 + 2.3L) $\mu$ in (400 + 1.6L) $\mu$ in	Gage blocks, length standards,
Spindle Pressure Spindle Torque Load	(5 to 900) kPa $\leq$ 1.8 mN	5.4 kPa 0.0037 mN	D5947
Spindle/Anvil Flatness	(0.125 to 2) in	9.9 $\mu$ in	Optical flats
Depth	(0.001 to 12) in	(75 + 39L) $\mu$ in	Gage blocks
Calipers <sup>3</sup>	(0.001 to 18) in (18 to 72) in	(71 + 21L) $\mu$ in (210 + 9.3L) $\mu$ in	Gage blocks
Length Indicators <sup>3</sup> (Dial, Test, LVDTs)	(-0.5 to 0.5) in	18 $\mu$ in	Gage blocks
	Up to 6 in (6 to 36) in	(46 + 2.3L) $\mu$ in (400 + 1.6L) $\mu$ in	Gage blocks
	Up to 1 in	150 $\mu$ in	Micrometer head
Length Indicator Calibrators	(0.00005 to 6) in	(46 + 9.3L) $\mu$ in	Gage blocks
Height Gages <sup>3</sup>	(0.001 to 24) in (24 to 36) in	(230 + 1.3L) $\mu$ in (200 + 2.4L) $\mu$ in	Gage blocks, LVDT, surface plate
Rulers <sup>3</sup>	(0.5 to 60) in (60 to 70) in	0.012 in 0.017 in	Standard rule
Tape Measure	0.5 in to 6 ft (6 to 12) ft (12 to 24) ft	0.030 in 0.032 in 0.049 in	Standard rule

Parameter/Equipment	Range	CMC <sup>2, 4</sup> (±)	Comments
Angle – Protractors, Inclinometers <sup>3</sup>	(0.01 to 45)°	0.004°	Angle sine plate, gage blocks
	30°	0.060°	Angle block set
	45°	0.070°	
	60°	0.074°	
	90°	0.13°	
Radius Gages	Up to 12 in	420 μin	Optical comparator

### III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2, 5, 6, 7, 9</sup> (±)	Comments
DC Current – Measure <sup>3</sup>	(10 to 100) nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA 100 μA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	42 μA/A + 54 pA 30 μA/A + 66 pA 30 μA/A + 190 pA 30 μA/A + 1.6 nA 30 μA/A + 12 nA 30 μA/A + 120 nA 47 μA/A + 1.2 μA 0.014 % + 19 μA	HP 3458A
	(1 to 3) A (3 to 1000) A	0.14 % + 700 μA 0.009 % + 7 mA	HP 34401 HP 3458A opt 2 w/current shunt
DC Current – Generate <sup>3</sup>	(0 to 330) μA	180 μA/A + 24 nA	Fluke 5520A
	(Up to 220) μA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (2.2 to 11) A	58 μA/A + 10 nA 58 μA/A + 19 nA 58 μA/A + 210 nA 70 μA/A + 1.7 μA 93 μA/A + 58 μA 0.042 % + 720 μA	Fluke 5700A  Fluke 5700A w/ 5725A
	(11 to 20) A	0.12 % + 2.1 mA	Fluke 5520A
	(20 to 160) A (160 to 525) A (525 to 1000) A	0.26 % + 140 mA 0.26 % + 140 mA 0.26 % + 180 mA	Fluke 5520A/Fluke 50-turn coil

Parameter/Equipment	Range	CMC <sup>2, 5, 6, 7, 9</sup> (±)	Comments
DC Voltage – Generate <sup>3</sup>	(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	9.3 μV/V + 0.86 μV 8.1 μV/V + 2.2 μV 8.1 μV/V + 17 μV 8.1 μV/V + 26 μV 9.3 μV/V + 210 μV 11 μV/V + 2.1 mV	Fluke 5700A
DC Voltage – Measure <sup>3</sup>	(0 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV	6 μV/V + 440 nV 4.7 μV/V + 640 nV 4.7 μV/V + 4.0 μV 7 μV/V + 83 μV 7 μV/V + 1.6 mV	HP 3458A opt 002

Parameter/Range	Frequency	CMC <sup>2, 9</sup> (±)	Comments
Capacitance – Generate <sup>3</sup>			
Fixed Values, 0.001 μF 0.1 μF 1 μF	1 kHz 1 kHz 1 kHz	0.12 % + 0.001 nF 0.06 % + 0.07 nF 0.06 % + 0.6 nF	Standard capacitors
Synthesized Capacitance			Fluke 5520A
(0.19 to 1.1) nF	10 Hz to 10 kHz	0.58 % + 0.014 nF	
(1.1 to 3.3) nF	10 Hz to 3 kHz	0.58 % + 0.013 nF	
(3.3 to 11) nF	10 Hz to 1 kHz	0.29 % + 0.017 nF	
(11 to 33) nF	10 Hz to 1 kHz	0.29 % + 0.12 nF	
(33 to 110) nF	10 Hz to 1 kHz	0.29 % + 0.14 nF	
(110 to 330) nF	10 Hz to 1 kHz	0.29 % + 0.42 nF	
(0.33 to 1.1) μF	(10 to 600) Hz	0.29 % + 1.4 nF	
(1.1 to 3.3) μF	(10 to 600) Hz	0.29 % + 4.0 nF	
(3.3 to 11) μF	(10 to 150) Hz	0.29 % + 15 nF	
(11 to 33) μF	(10 to 120) Hz	0.47 % + 45 nF	
(33 to 110) μF	Up to 50 Hz	0.52 % + 180 nF	
(110 to 330) μF	Up to 50 Hz	0.52 % + 510 nF	
(0.33 to 1.1) mF	Up to 20 Hz	0.52 % + 1.7 μF	
(1.1 to 3.3) mF	Up to 6 Hz	0.52 % + 3.8 μF	
(3.3 to 11) mF	Up to 2 Hz	0.52 % + 13 μF	
(11 to 33) mF	Up to 0.6 Hz	0.87 % + 40 μF	
(33 to 110) mF	Up to 0.2 Hz	1.3 % + 130 μF	

Parameter/Equipment	Range	CMC <sup>2, 5, 6, 7, 9</sup> ( $\pm$ )	Comments
Resistance – Measure <sup>3</sup>	(0 to 1) $\Omega$ (1 to 10) $\Omega$ (10 to 100) $\Omega$ 100 $\Omega$ to 1 k $\Omega$ (1 to 10) k $\Omega$ (10 to 100) k $\Omega$ 100 k $\Omega$ to 1 M $\Omega$ (1 to 10) M $\Omega$ (10 to 100) M $\Omega$ 100 M $\Omega$ to 1 G $\Omega$	18 $\mu\Omega/\Omega$ + 20 $\mu\Omega$ 18 $\mu\Omega/\Omega$ + 70 $\mu\Omega$ 15 $\mu\Omega/\Omega$ + 660 $\mu\Omega$ 12 $\mu\Omega/\Omega$ + 1.5 m $\Omega$ 16 $\mu\Omega/\Omega$ + 43 m $\Omega$ 12 $\mu\Omega/\Omega$ + 170 m $\Omega$ 18 $\mu\Omega/\Omega$ + 6.1 $\Omega$ 59 $\mu\Omega/\Omega$ + 170 $\Omega$ 0.060 % + 3.0 k $\Omega$ 0.59 % + 200 k $\Omega$	HP 3458A
Resistance – Generate <sup>3</sup>			
Fixed Values	1 $\Omega$ 1.9 $\Omega$ 10 $\Omega$ 19 $\Omega$ 100 $\Omega$ 190 $\Omega$ 1 k $\Omega$ 1.9 k $\Omega$ 10 k $\Omega$ 19 k $\Omega$ 100 k $\Omega$ 190 k $\Omega$ 1 M $\Omega$ 1.9 M $\Omega$ 10 M $\Omega$ 19 M $\Omega$ 100 M $\Omega$	120 $\mu\Omega$ 220 $\mu\Omega$ 340 $\mu\Omega$ 580 $\mu\Omega$ 2.0 m $\Omega$ 3.8 m $\Omega$ 15 m $\Omega$ 27 m $\Omega$ 130 m $\Omega$ 250 m $\Omega$ 1.6 $\Omega$ 3.0 $\Omega$ 22 $\Omega$ 43 $\Omega$ 450 $\Omega$ 1100 $\Omega$ 15 000 $\Omega$	Fluke 5700A
	(0 to 11) $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (110 to 330) $\Omega$ (0.33 to 1.1) k $\Omega$ (1.1 to 3.3) k $\Omega$ (3.3 to 11) k $\Omega$ (11 to 33) k $\Omega$ (33 to 110) k $\Omega$ (110 to 330) k $\Omega$ (0.33 to 1.1) M $\Omega$ (1.1 to 3.3) M $\Omega$ (3.3 to 11) M $\Omega$ (11 to 33) M $\Omega$ (33 to 110) M $\Omega$ (110 to 330) M $\Omega$ (0.33 to 1.1) G $\Omega$	47 $\mu\Omega/\Omega$ + 1.2 m $\Omega$ 35 $\mu\Omega/\Omega$ + 1.8 m $\Omega$ 33 $\mu\Omega/\Omega$ + 1.8 m $\Omega$ 33 $\mu\Omega/\Omega$ + 2.9 m $\Omega$ 33 $\mu\Omega/\Omega$ + 6.1 m $\Omega$ 33 $\mu\Omega/\Omega$ + 35 m $\Omega$ 33 $\mu\Omega/\Omega$ + 83 m $\Omega$ 33 $\mu\Omega/\Omega$ + 350 m $\Omega$ 33 $\mu\Omega/\Omega$ + 850 m $\Omega$ 37 $\mu\Omega/\Omega$ + 3.2 $\Omega$ 37 $\mu\Omega/\Omega$ + 7.0 $\Omega$ 70 $\mu\Omega/\Omega$ + 51 $\Omega$ 0.016 % + 230 $\Omega$ 0.029 % + 3.6 k $\Omega$ 0.058 % + 9.9 k $\Omega$ 0.35 % + 160 k $\Omega$ 1.8 % + 1.5 M $\Omega$	Fluke 5520A

Parameter/Equipment	Range	CMC <sup>2,4,9</sup> (±)	Comments
Oscilloscopes <sup>3</sup> –			
DC Signal (50 Ω Load)	0 V to ± 6.6 V	0.43 % + 47 μV	Fluke 5520A SC1100 opt
DC Signal (1 MΩ Load)	0 V to ± 130 V	1.6 % + 47 μV	
Square Wave Signal (50 Ω Load)	0 V to ± 6.6 V	0.78 % + 47 μV	
Square Wave Signal (1 MΩ Load)	0 V to ± 130 V	1.1 % + 47 μV	
Bandwidth (50 kHz Reference)	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	2.2 % + 120 μV 2.7 % + 120 μV 4.9 % + 120 μV 6.0 % + 120 μV	
Risetime Into 50 Ω	Single Sided	120 ps + 0.5R	
Timing Markers	1 ns to 50 ms/div  50 ms to 5 s/div	2.9 parts in 10 <sup>6</sup> + 0.5R  0.58 % + 0.5R	

Parameter/Range	Frequency	CMC <sup>2,5,9</sup> (±)	Comments
AC Current – Generate <sup>3</sup>			
(0 to 220) μA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.081 % + 34 nA 0.041 % + 28 nA 0.017 % + 23 nA 0.07 % + 58 nA 0.19 % + 110 nA	Fluke 5700A
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	0.081 % + 170 nA 0.041 % + 120 nA 0.017 % + 100 nA 0.07 % + 490 nA 0.19 % + 950 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	0.081 % + 2.6 μA 0.041 % + 1.4 μA 0.017 % + 1.0 μA 0.07 % + 4.9 μA 0.19 % + 9.5 μA	

Parameter/Range	Frequency	CMC <sup>2, 5, 9</sup> (±)	Comments
AC Current – Generate <sup>3</sup> (cont)			
(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	0.081 % + 27 µA 0.041 % + 14 µA 0.017 % + 13 µA 0.07 % + 49 µA 0.19 % + 100 µA	Fluke 5700A
220 mA to 2.2 A	(20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.076 % + 150 µA 0.076 % + 140 µA 0.087 % + 260 µA 0.99 % + 2.1 mA	
(2.2 to 11) A	40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.054 % + 1.2 mA 0.11 % + 1.6 mA 0.42 % + 1.6 mA	Fluke 5700A/5725A
(11 to 20) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.14 % + 7.4 mA 0.18 % + 7.4 mA 3.0 % + 8.7 mA	Fluke 5520A
(20 to 150) A	(45 to 440) Hz	0.92 % + 200 mA	Fluke 5520A w/Fluke 50-turn coil
(150 to 1000) A	(45 to 200) Hz	1.2 % + 250 mA	
AC Current – Measure <sup>3</sup>			
(5 to 100) µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.47 % + 37 nA 0.18 % + 37 nA 0.07 % + 37 nA 0.07 % + 37 nA	HP 3458A
100 µA 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	0.47 % + 250 nA 0.18 % + 250 nA 0.07 % + 250 nA 0.036 % + 250 nA 0.07 % + 250 nA 0.47 % + 470 nA 0.64 % + 1.8 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	0.47 % + 2.5 µA 0.18 % + 2.5 µA 0.07 % + 2.5 µA 0.036 % + 2.5 µA 0.07 % + 2.5 µA 0.47 % + 4.7 µA 0.64 % + 18 µA	

Parameter/Range	Frequency	CMC <sup>2, 5, 7</sup> (±)	Comments
AC Current – Measure <sup>3</sup> (cont)			
(10 to 100) 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	0.47 % + 25 µA 0.18 % + 25 µA 0.07 % + 25 µA 0.036 % + 25 µA 0.07 % + 25 µA 0.47 % + 47 µA 0.64 % + 180 µA	HP 3458A
100 mA 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	0.47 % + 260 µA 0.19 % + 260 µA 0.093 % + 260 µA 0.12 % + 260 µA 0.35 % + 260 µA 1.2 % + 480 µA	
(1 to 3) A	(3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	1.3 % + 700 µA 0.41 % + 710 µA 0.18 % + 710 µA	HP 34401
(3 to 1000) A	(40 to 400) Hz	3.7 mA/A + 2.5 mA	HP 3458A opt 2 w/shunt
AC Voltage – Measure <sup>3</sup>			
(1 to 10) mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.036 % + 4.2 µV 0.025 % + 2.7 µV 0.036 % + 2.9 µV 0.12 % + 2.9 µV 0.58 % + 3.1 µV 4.7 % + 4.4 µV	HP 3458A opt 2
(10 to 100) 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 300 kHz to 1 MHz (1 to 2) MHz	0.0082 % + 5.8 µV 0.0082 % + 3.9 µV 0.017 % + 4.2 µV 0.035 % + 4.0 µV 0.093 % + 7.4 µV 0.35 % + 17 µV 1.2 % + 52 µV 1.8 % + 52 µV	



Parameter/Range	Frequency	CMC <sup>2, 5, 6, 7, 9</sup> (±)	Comments
AC Voltage – Measure <sup>3</sup> (cont)			
100 mV to 1 V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.0082 % + 50 μV 0.0082 % + 28 μV 0.017 % + 29 μV 0.035 % + 32 μV 0.093 % + 32 μV 0.35 % + 130 μV 1.2 % + 280 μV 1.8 % + 280 μV	HP 3458A opt 2
(1 to 10) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.0082 % + 580 μV 0.0082 % + 330 μV 0.017 % + 280 μV 0.035 % + 340 μV 0.093 % + 340 μV 0.35 % + 1.3 mV 1.2 % + 3.2 mV 1.8 % + 3.2 mV	
(10 to 100) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.024 % + 5.1 mV 0.024 % + 2.9 mV 0.024 % + 3.1 mV 0.041 % + 3.4 mV 0.14 % + 4.0 mV 0.47 % + 13 mV 1.8 % + 13 mV	
(100 to 1000) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.047 % + 55 mV 0.047 % + 34 mV 0.07 % + 36 mV 0.14 % + 38 mV 0.35 % + 38 mV	

Parameter/Range	Frequency	CMC <sup>2, 6, 7</sup> (±)	Comments
AC Voltage – Generate <sup>3</sup>			
(0 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	0.064 % + 6.5 μV 0.025 % + 6.5 μV 0.013 % + 1.9 μV 0.043 % + 6.8 μV 0.099 % + 9.2 μV 0.13 % + 16 μV 0.2 % + 30 μV 0.4 % + 31 μV	Fluke 5700A
(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	0.064 % + 7.1 μV 0.025 % + 7.0 μV 0.013 % + 7.1 μV 0.043 % + 7.3 μV 0.099 % + 9.7 μV 0.13 % + 17 μV 0.2 % + 31 μV 0.4 % + 40 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	0.064 % + 21 μV 0.025 % + 15 μV 0.013 % + 13 μV 0.037 % + 16 μV 0.099 % + 34 μV 0.13 % + 42 μV 0.2 % + 52 μV 0.4 % + 150 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	0.058 % + 140 μV 0.019 % + 87 μV 87 μV/V + 61 μV 0.014 % + 64 μV 0.029 % + 110 μV 0.05 % + 250 μV 0.13 % + 470 μV 0.26 % + 1.3 mV	
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.058 % + 2.1 mV 0.019 % + 860 μV 87 μV/V + 630 μV 0.014 % + 650 μV 0.029 % + 740 μV 0.058 % + 2.5 mV 0.15 % + 5.4 mV 0.32 % + 15 mV	

Parameter/Range	Frequency	CMC <sup>2, 6, 7</sup> (±)	Comments
AC Voltage – Generate <sup>3</sup> (cont)			
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.058 % + 21 mV 0.019 % + 6.1 mV 93 μV/V + 6.3 mV 0.026 % + 9 mV 0.058 % + 14 mV 0.18 % + 110 mV 0.55 % + 110 mV 1.4 % + 230 mV	Fluke 5700A
(220 to 1100) V	(15 to 50) Hz 50 Hz to 1 kHz	0.042 % + 57 mV 99 μV/V + 44 mV	
(220 to 750) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.011 % + 23 mV 0.02 % + 19 mV 0.07 % + 45 mV 0.27 % + 110 mV	Fluke 5700A w/ 5725A
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	0.011 % + 30 mV 0.02 % + 31 mV 0.07 % + 66 mV	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of RTD Indicating Devices <sup>3</sup> –			
Pt 385, 200 Ω	(-200 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C	0.053 °C 0.064 °C 0.15 °C 0.17 °C 0.19 °C	Fluke 5520A
500 Ω	(-200 to 100) °C (100 to 260) °C (260 to 600) °C (600 to 630) °C	0.066 °C 0.078 °C 0.10 °C 0.14 °C	
1000 Ω	(-200 to 100) °C (100 to 260) °C (260 to 600) °C (600 to 630) °C	0.064 °C 0.076 °C 0.097 °C 0.28 °C	
PtNi 385 120 Ω (Ni 120)	(-80 to 100) °C (100 to 260) °C	0.085 °C 0.17 °C	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of RTD Indicating Devices <sup>3</sup> – (cont)			
Cu 427, 10 Ω	(-100 to 260) °C	0.35 °C	Fluke 5520A
Pt 385, 100 Ω	(-200 to 0) °C	0.064 °C	
	(0 to 100) °C	0.085 °C	
	(100 to 400) °C	0.12 °C	
	(400 to 630) °C	0.15 °C	
	(630 to 800) °C	0.27 °C	
Pt 3916, 100 Ω	(-200 to -190) °C	0.29 °C	
	(-190 to 0) °C	0.063 °C	
	(0 to 260) °C	0.086 °C	
	(260 to 600) °C	0.12 °C	
	(600 to 630) °C	0.27 °C	
Pt 3926, 100 Ω	(-200 to 0) °C	0.063 °C	
	(0 to 100) °C	0.085 °C	
	(100 to 400) °C	0.12 °C	
	(400 to 630) °C	0.15 °C	
Calibration of Thermocouple Indicators, Sensors and Sensing Systems <sup>3</sup> –			
Type B	(600 to 800) °C	0.53 °C	Fluke 5520A
	(800 to 1000) °C	0.43 °C	
	(1000 to 1550) °C	0.38 °C	
	(1550 to 1820) °C	0.41 °C	
Type C	(0 to 150) °C	0.37 °C	
	(150 to 650) °C	0.42 °C	
	(650 to 1000) °C	0.39 °C	
	(1000 to 1800) °C	0.60 °C	
	(180 to 2316) °C	0.98 °C	
Type E	(-250 to -100) °C	0.60 °C	
	(-100 to -25) °C	0.24 °C	
	(-25 to 350) °C	0.22 °C	
	(350 to 650) °C	0.24 °C	
	(650 to 1000) °C	0.29 °C	
Type J	(-210 to -100) °C	0.34 °C	
	(-100 to -30) °C	0.22 °C	
	(-30 to 150) °C	0.20 °C	
	(150 to 760) °C	0.22 °C	
	(760 to 1200) °C	0.29 °C	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Calibration of Thermocouple Indicators, Sensors and Sensing Systems <sup>3</sup> (cont) –			
Type K	(-200 to -100) °C (-100 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.41 °C 0.25 °C 0.33 °C 0.48 °C	Fluke 5520A
Type L	(-200 to -100) °C (-100 to 800) °C (800 to 900) °C	0.34 °C 0.26 °C 0.25 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.49 °C 0.29 °C 0.26 °C 0.26 °C 0.35 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.68 °C 0.44 °C 0.41 °C 0.49 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.57 °C 0.45 °C 0.46 °C 0.56 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.75 °C 0.31 °C 0.22 °C 0.20 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.67 °C 0.35 °C	
Type J	(-210 to 760) °C	0.069 °C	HP 3458A opt 2, junction at ice point, ice bath
Type K	(-270 to 1370) °C	0.064 °C	
Type T	(-270 to 400) °C	0.073 °C	

IV. Mechanical

Parameter/Equipment	Range	CMC <sup>2,7</sup> (±)	Comments
Force – Measuring Equipment			
Tension and Compression <sup>3</sup>	Up to 100 lbf	0.02 %	Dead weight
	Up to 100 lbf (100 to 1000) lbf (1000 to 5000) lbf (5000 to 10 000) lbf (10 000 to 30 000) lbf	0.0075 % full scale 0.0048 % full scale 0.015 % full scale 0.010 % full scale 0.0073 % full scale	Load cells
Verification of Tensile Testers <sup>3</sup> –			ASTM E4
Displacement, Position	(0.01 to 4) in (4 to 24) in (24 to 72) in	140 μin 0.0060 in 0.061 in	Digital indicator, precision rule
Crosshead Speed	(0.001 to 4) in/min (4 to 72) in/min	0.02 % 0.11 %	Stopwatch, indicator/rule;
Tensile and Compressive Force	Up to 1000 lbf	0.02 %	Dead weight
	Up to 100 lbf (100 to 1000) lbf (1000 to 5000) lbf (5000 to 10 000) lbf (10 000 to 30 000) lbf	0.0075 % full scale 0.0048 % full scale 0.015 % full scale 0.010 % full scale 0.0073 % full scale	Load cells
Verification of Extensometers <sup>3</sup> –			ASTM E83 w/
Gage Length	(0.001 to 4) in (4 to 72) in	(140 μin + 24L) μin (0.017 + 0.00055L) in	Micrometer head w/fixture; Steel rule

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Extrusion Plastometers <sup>3</sup> –  Bore Measurement Piston Land Diameter Piston Foot Length Die Orifice Weight Height of Switch  Temperature  Timer Go/No-Go Gage	(0.35 to 0.55) in (0.35 to 0.50) in (0.20 to 0.30) in (0.37 to 0.38) in (50 to 30 000) g (0.1 to 12) in  (50 to 260) °C (260 to 420) °C  (10 to 6000) s (0 to 1) in	74 μin 84 μin 84 μin 84 μin 0.27 g 460 μin  0.073 °C 0.079 °C  0.41 s 16 μin	ASTM D1238, ISO 1133
Abrasion Testers <sup>3</sup> –  Platform Speed Wheel Position Platform Flatness Arm Weight Add-on Weights Nozzle Flatness Vacuum  Wyzenbeek Oscillatory Abrasion Testers <sup>3</sup> –  Cycle Rate/Counter Specimen Tension/Force	(20 to 120) rpm (0.001 to 0.25) in ± 0.15 in (200 to 300) g (200 to 600) g (0.001 to 0.5) in Up to 94 inH <sub>2</sub> O  (80 to 100) osc/min (0.5 to 7) lbf	0.25 rpm 0.0012 in 690 μin 0.33 g 0.23 g 0.0014 in 1.2 inH <sub>2</sub> O  1.7 counts 0.082 lbf	Tachometer Caliper Indicator Load cell Balance Micrometer Vacuum gage  Stop watch Force gage

Parameter/Equipment	Range	CMC <sup>2, 4, 7</sup> (±)	Comments	
Pressure <sup>3</sup> – Measuring Equipment	Pneumatic	(0 to 5) psia 0.0031 psi (5 to 11) psia 0.0068 psi (11 to 17) psia 0.0041 psi (17 to 24) psia 0.0057 psi (24 to 60) psia 0.014 psi (60 to 150) psia 0.036 psi (150 to 715) psia 0.17 psi (715 to 1500) psia 0.35 psi	Precision pressure calibration system	
	Hydraulic	(0 to 10) psig 0.0030 psi (10 to 24) psig 0.0071 psi (24 to 60) psig 0.018 psi (60 to 135) psig 0.040 psi (135 to 700) psig 0.21 psi (700 to 1485) psig 0.43 psi  (5 to 100) psig 0.058 % applied  (100 to 10 000) psig 0.046 % applied		
Tachometers <sup>3</sup> –	Optical	(10 to 100 000) rpm	0.0006 % + 0.6R	Multifunction generator and LED  Tachometer calibrator
	Mechanical Coupled	(55 to 10 000) rpm (10 000 to 40 000) rpm	0.085 rpm (0.2 + 0.007 %) rpm	
	Linear Velocity	(175 to 188 000) in/min	0.34 in/min	
Shaft Speed – Measure <sup>3</sup>	(0.01 to 1000) rpm	0.31 rpm	Tachometer	
	(1000 to 25 000) rpm	0.69 rpm		
Magnetic Wand Insertion Probe <sup>3</sup>	(1 to 20) lbf	0.14 lbf	ASTM F2075 utilizing pull-test methods	



Parameter/Equipment	Range	CMC <sup>2,7</sup> (±)	Comments
Torque Devices <sup>3</sup> –  Transducers	(0 to 2000) ft·lbf	0.20 % applied value	Torque arm, wheels, and Class 1,5, 6 weights
Wrench	4 in·lbf to 250 ft·lbf	0.38 % applied value	CDI SureTest system
Accelerometers	Reference (100 Hz) (3 to 9.99) Hz 10 Hz to 1 kHz (1 to 2) kHz (2 to 10) kHz	0.54 % 0.59 % 0.71 % 1.2 % 2.8 %	Vibration calibration system referenced at 100 Hz or 160 Hz
Scales & Balances <sup>3</sup> –  1 mg to 11 kg	Resolution: 0.001 mg 0.01 mg 0.1 mg 1 mg 10 mg 100 mg 1 g 10 g  (0.5 to 100) lb (100 to 500) lb  (500 to 1000) lb	0.0011 mg + 0.00036 % 0.011 mg + 0.00036 % 0.11 mg + 0.00036 % 1.1 mg + 0.00036 % 11 mg + 0.00036 % 0.11g + 0.00036 % 1.1 g + 0.00036 % 11 g + 0.00036 %  0.0085 lb 0.042 lb  0.13 lb	ASTM Class 1 weights       Class 5 weights  Class 5, 6 weights using Handbook 44
Mass	(0.5, 1, 2) lb 5 lb 10 lb 20 lb 50 lb 100 lb  (0 to 12 500) g (12 500 to 22 700) g (22 700 to 64 000) g	0.0084 oz 0.012 oz 0.015 oz 0.022 oz 0.0089 oz 0.021 oz  0.19 g 1.4 g 1.5 g	Class 1, 5, 6 mass standards, substitution method using precision balance  Direct measurement with precision scales

V. Thermodynamics

Parameter/Equipment	Range	CMC <sup>2, 4, 7, 11</sup> (±)	Comments
Relative Humidity – Measuring Equipment	(10 to 90) % RH (90 to 95) % RH	0.83 % RH 1.2 % RH	Thunder Scientific two pressure humidity generator
Measure <sup>3</sup>	Up to 50 %RH (50 to 90) %RH (90 to 100) %RH	1.1 % RH 1.2 % RH 1.7 % RH	Reference Hygrometer
Temperature – Measuring Equipment <sup>3</sup>	(-80 to 180) °C  (-30 to 160) °C  (30 to 500) °C	0.13 °C + 0.082 %  0.039 °C + 0.032 %  0.12 °C + 0.046 %	PRT, thermodynamic cavity  PRT, bath  PRT, dry wells
Ovens <sup>3</sup> –			
Temperature Uniformity	(40 to 500) °C	1.4 °C	ASTM E145, ISO 188 and other standard methods
Time Constant	10 s to 60 m	38 ms + 0.6R	Stop watch
Ventilation Rate	(1 to 600) exchanges	4.9 % exchanges	Scanner, power measurement system

## VI. Time & Frequency

Parameter/Equipment	Range	CMC <sup>2, 4, 8, 11</sup> ( $\pm$ )	Comments
Frequency – Measure <sup>3</sup>	Up to 1.3 GHz	$5.6 \times 10^{-10}f$	GPS receiver, frequency counter
Frequency – Measuring Equipment <sup>3</sup>	Up to 1.0 GHz	$5.6 \times 10^{-10}f$	GPS receiver, signal generator
Timers/Stop Watches <sup>3</sup> –			
Mechanical	5 s to 72 hr	38 ms + 0.6R	Frequency counter
Electronic	0.010 s to 24 hr	270 $\mu$ s + 0.6R	

<sup>1</sup> This laboratory offers commercial calibration services as well as field calibration services, where noted.

<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 in inches unless otherwise noted.  $R$  is the resolution of the unit under test.

<sup>5</sup> Based on using the standard at the temperature the HP 3458A was calibrated ( $t_{cal} \pm 5$  °C) and a auto-calibration (ACAL) was performed within the previous 24 hours ( $\pm 1$  °C of ambient temperature). CMC is based upon 1-year specifications and is read as a fraction of the reading plus range error.

<sup>6</sup> Based on using the standard at the temperature the Fluke 5700A was calibrated ( $t_{cal} \pm 5$  °C) and assuming the instrument is zeroed at least every seven days or when the ambient temperature changes more than 5 °C. For resistance, a zero calibration is performed at least every 12 hours within  $\pm 1$  °C of use. CMC is based upon 1-year specifications and is read as a fraction or percent output plus floor specification.

<sup>7</sup> In the statement of CMC, percentages are percentage of reading, unless otherwise indicated.

<sup>8</sup> In the statement of CMC,  $f$  is the frequency and  $t$  is the time.

<sup>9</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's are expressed as either a specific value that covers the full range or as a percent or fraction of the reading plus a fixed floor specification.

<sup>10</sup> This scope meets A2LA's *P112 Flexible Scope Policy*.

<sup>11</sup> The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter.



## Accredited Laboratory

A2LA has accredited

# ELEMENT MATERIALS TECHNOLOGY DETROIT – WARREN 11 MILE

*Warren, MI*

for technical competence in the field of

## Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets 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 April 2017.)



Presented this 28<sup>th</sup> day of August 2019.

A blue ink signature of the Vice President of Accreditation Services.

Vice President, Accreditation Services  
For the Accreditation Council  
Certificate Number 0098.13 (Formerly 0038.05)  
Valid to December 31, 2020  
Revised August 20, 2020

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