



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017
& ANSI/NCSL Z540-1-1994

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CALIBRATION

Valid To: January 31, 2023

Certificate Number: 1625.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations^{1,11}:

I. Chemical

Parameter/Equipment	Range	CMC ² (±)	Comments
Conductivity Meter/Probe Calibration ³ – Discrete Points	10 µS 100 µS 1000 µS 10 000 µS 100 000 µS	0.42 µS 2.5 µS 4.8 µS 66 µS 410 µS	Conductivity solutions
pH Meter/Probe Calibration ³	(4, 7, 10) pH	0.027 pH	pH buffer
	(0 to 14) pH	0.034 pH	Comparison to pH meter

II. Dimensional

Parameter/Equipment	Range	CMC ² (±)	Comments
Angle Blocks ³	(0.25 to 60)°	0.0054°	Gage blocks, sine bar, electronic probe

Parameter/Equipment	Range	CMC ^{2, 5, 10} (±)	Comments
Calipers ³	Up to 12 in (12 to 72) in	540 μin 980 μin	Gage blocks
Cylindrical Diameter ³ – Measure & Measuring Equipment			
Outside	Up to 5 in (5 to 18) in (18 to 24) in	26 μin + 0.43 μin/in 110 μin 290 μin	Measuring machine, plug gage Height gage
Inside	(0.5 to 2.5) in (2.5 to 6) in (6 to 24) in	38 μin + 0.56 μin/in 39 μin + 1.6 μin/in 290 μin	Measuring machine, ring gage Height gage
Cylindrical Squares – Squareness	(4 to 20) in	17 μin	Electronic probe
Dial, Digital, & Test Indicators ³	Up to 4 in	11 μin/in + 0.87 μin + 0.6R	Gage blocks
Flatness ³ – Measure & Measuring Equipment	Up to 2 in diameter Up to 10 in length	4 μin 35 μin	Optical flat Electronic probe
Gage Blocks	Up to 1 in (1 to 2) in 3 in 4 in	3 μin + 0.5 μin/in 3.4 μin 5.6 μin 5.3 μin	Dimensional comparator
Gage Block Comparator – Force	Up to 200 μin (0 to 1.47) N	3.4 μin 0.089 N	Gage blocks Correx force gage

Parameter/Equipment	Range	CMC ^{2,5} (\pm)	Comments
Height/Depth Gages ³	Up to 24 in (24 to 72) in	(21 + 7L) μ in 150 μ in + 16 μ in/in	Gage blocks
Length Standards ³	Up to 18 in (18 to 48) in	13 μ in + 10 μ in/in 42 μ in + 5.5 μ in/in	Measuring machine, gage blocks
Levels ³ – Bubble Vial	---	0.62R	Gage blocks
Levels – Electronic Level Systems	---	3.7 arc seconds	Gage blocks
Micrometers ³ –	Up to 3 in (3 to 48) in	20 μ in + 12 μ in/in 64 μ in + 1.5 μ in/in	Gage blocks
Micrometer Heads	Up to 2 in	8.2 μ in	Electronic probe
Laser Micrometers	Up to 2 in	37 μ in	Pin/plug gages
Bore Micrometers	(0.25 to 5) in	8.5 μ in/in + 60 μ in	Ring gages
Bench Micrometers	Up to 12 in	17 μ in	Gage blocks
Optical Comparators ³ –			
Length	Up to 11.8 in Up to 24 in	170 μ in 300 μ in	Glass artifact
Radius/Diameter Angle	Up to 1 in (0 to 360) $^{\circ}$	500 μ in 0.014 $^{\circ}$	
Magnification	10x 20x 31.25x 50x 62.5x 100x	700 μ in 580 μ in 520 μ in 380 μ in 360 μ in 340 μ in	Glass artifact & glass magnification scale
Protractors ³	(0 to 90) $^{\circ}$	0.012 $^{\circ}$	Gage blocks/sine plate

Parameter/Equipment	Range	CMC ^{2, 5, 10} (\pm)	Comments
Parallel Measurements ³ – Measure & Measuring Equipment	Up to 1 in diameter	5.7 μ in	Optical parallels
	Up to 10 in length	38 μ in	Electronic probe
Rulers ³	(0 to 72) in (0 to 1000) mm (1000 to 1800) mm	0.017 in 0.50 mm 0.55 mm	Ruler
Sine Bars –			
Length	(5 to 10) in	60 μ in	UMM
Parallelism	(5 to 10) in	38 μ in	Electronic probe
Surface Finish Meters ³ – Profilometers	(12 to 122) Ra	2.1 μ in + 0.01 μ in/ μ in	Roughness specimens
Spherical Diameter – Measure & Measuring Equipment	Up to 5 in	23 μ in + 1.2 μ in/in	UMM
Surface Plates ³ –			
Flatness	Up to 107 diagonal in	(23 + 0.69D) μ in	Electronic level system D = diagonal inches
Repeatability	Up to 0.015 in	38 μ in	Repeatability gage
Taper Thread Plug ³ –			
Pitch Diameter	(4 to 80) TPI	130 μ in	Gage blocks, thread wires, measuring machine
Major Diameter	Up to 2 in	90 μ in	
Notch Length	Up to 2 in	100 μ in	Height gage

Parameter/Equipment	Range	CMC ² (±)	Comments
Thickness Gages ³	(0.001 to 0.06) in	19 μin + 0.000 31 in/in	Thickness films & gage blocks
Thread Plugs ³ – Simple Pitch Diameter Major Diameter	(4 to 80) TPI Up to 4 in	130 μin 75 μin	Gage blocks, thread wires, measuring machine
Adjustable Thread Rings ^{3,9}	Up to 1.5 in	X (Set Plug Tolerance)	Set using master plug gages. ASME/ANSI B1.2-1983 & ASME/ANSI B1.3-2007
Thread Wires – Inch Metric	(4 to 80) TPI (0.2 to 10) pitch	27 μin 0.69 μm	UMM
Torque Arms	(2 to 8) in (8 to 24) in (24 to 48) in	220 μin 0.0010 in 0.000 99 in	Dimensional comparison
Wire Cloth & Sieves	(0.020 to 12.5) mm	6.9 μm	Optical comparator

III. Dimensional Testing/Calibration¹

Parameter/Equipment	Range	CMC ^{2, 10} (±)	Comments
Angle ^{3, 7} – Measure	(0 to 360)°	0.039°	Optical comparator
Diameter/Radius ^{3, 7} – Measure	Up to 6 in	0.000 39 in	Optical comparator
One Dimensional Length ^{3, 7} – Measure	Up to 12 in (12 to 72) in	0.000 33 in 0.012 in	Optical comparator Steel ruler
	Up to 300 mm (300 to 1800) mm	0.0083 mm 0.59 mm	Optical comparator Steel ruler

IV. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC ^{2, 4} (±)	Comments
AC Current – Generate (0.02 to 220) µA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.027 % + 20 nA 0.016 % + 16 nA 0.013 % + 9.5 nA 0.027 % + 21 nA 0.10 % + 83 nA	Fluke 5720A
(0.22 to 2.2) mA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.022 % + 190 nA 0.0065 % + 500 nA 0.013 % + 43 nA 0.019 % + 210 nA 0.10 % + 0.87 µA	
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.027 % + 710 nA 0.016 % + 590 nA 0.013 % + 430 nA 0.016 % + 2.3 µA 0.11 % + 6.1 µA	

Parameter/Range	Frequency	CMC ^{2, 4} (±)	Comments
AC Current – Generate (cont)			
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.019 % + 28 µA 0.012 % + 17 µA 0.013 % + 3.1 µA 0.017 % + 16 µA 0.082 % + 77 µA	Fluke 5720A
(0.22 to 2.2) A	(0.02 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.028 % + 52 µA 0.041 % + 240 µA 0.69 % + 720 µA	
(2.2 to 11) A	(0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.025 % + 3.9 mA 0.068 % + 5.1 mA 0.30 % + 13 mA	Fluke 5725A
AC Current ³ – Generate			
(29 to 330) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.24 % + 120 nA 0.18 % + 120 nA 0.15 % + 120 nA 0.35 % + 170 nA 0.93 % + 230 nA 1.9 % + 460 nA	Fluke 5520A
(0.33 to 3.3) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.23 % + 280 nA 0.15 % + 220 nA 0.12 % + 170 nA 0.24 % + 230 nA 0.58 % + 350 nA 1.2 % + 690 nA	
(3.3 to 33) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.21 % + 3.3 µA 0.11 % + 2.5 µA 0.049 % + 2.4 µA 0.096 % + 2.4 µA 0.24 % + 3.5 µA 0.47 % + 4.7 µA	
(33 to 330) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.20 % + 70 µA 0.11 % + 28 µA 0.048 % + 24 µA 0.12 % + 58 µA 0.24 % + 120 µA 0.47 % + 240 µA	
(0.33 to 1.1) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.21 % + 190 µA 0.059 % + 120 µA 0.7 % + 1.2 mA 2.9 % + 5.8 mA	

Parameter/Range	Frequency	CMC ^{2, 4} (±)	Comments
AC Current ³ – Generate (cont)			
(1.1 to 3) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.21 % + 190 µA 0.07 % + 120 µA 0.70 % + 1.2 mA 2.9 % + 5.8 mA	Fluke 5520A
(3 to 11) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.057 % + 4.6 mA 0.094 % + 5.6 mA 0.34 % + 13 mA	
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.14 % + 7 mA 0.17 % + 7.7 mA 3.4 % + 14 mA	
(20.5 to 150) A	(45 to 65) Hz (65 to 440) Hz	0.65 % + 0.58 A 1.2 % + 0.58 A	Fluke 5520A & 50 turn coil
(150 to 1000) A	(45 to 65) Hz (65 to 440) Hz	0.70 % + 0.058 A 1.2 % + 0.058 A	
AC Current – Measure			
(0 to 200) µA	(1 to 10) Hz (0.01 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.034 % + 25 nA 0.032 % + 26 nA 0.076 % + 28 nA 0.46 % + 39 nA	Fluke 8508A
(0.2 to 2) mA	(1 to 10) Hz (0.01 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.032 % + 300 nA 0.024 % + 550 nA 0.074 % + 280 nA 0.46 % + 470 nA	
(2 to 20) mA	(1 to 10) Hz (0.01 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.034 % + 2.4 µA 0.033 % + 2.4 µA 0.072 % + 3.2 µA 0.46 % + 2.7 µA	
(20 to 200) mA	(1 to 10) Hz (0.01 to 10) kHz (10 to 30) kHz	0.03 % + 36 µA 0.028 % + 29 µA 0.068 % + 28 µA	
(0.2 to 2) A	(0.01 to 2) kHz (2 to 10) kHz (10 to 30) kHz	0.067 % + 310 µA 0.081 % + 240 µA 0.35 % + 320 µA	
(2 to 20) A	(0.01 to 2) kHz (2 to 10) kHz	0.084 % + 4.6 mA 0.28 % + 5.6 mA	

Parameter/Range	Frequency	CMC ^{2, 4} (±)	Comments	
AC Current – Measure (cont) (20 to 100) A	40 Hz to 1 kHz	0.68 %	Valhalla 2575A with DMM	
AC Current ³ – Measure (0 to 100) µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 1) kHz	0.46 % + 42 nA 0.17 % + 41 nA 0.068 % + 38 nA 0.068 % + 38 nA	HP 3458A, opt 002	
(0.1 to 1) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.45 % + 360 nA 0.17 % + 310 nA 0.066 % + 280 nA 0.033 % + 280 nA		
(1 to 10) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.45 % + 3.6 µA 0.17 % + 3.0 µA 0.066 % + 2.8 µA 0.033 % + 2.8 µA		
(10 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.42 % + 71 µA 0.17 % + 32 µA 0.066 % + 28 µA 0.033 % + 28 µA		
(0.1 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.46 % + 320 µA 0.18 % + 320 µA 0.089 % + 320 µA 0.12 % + 280 µA		
(1 to 100) A	40 Hz to 1 kHz	0.68 %		Valhalla 2575A with DMM
(100 to 1000) A	(10 to 100) Hz (100 to 500) Hz	2.4 % + 0.60 A 3.0 % + 0.64 A		Fluke 376 clamp

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
AC Power ³ – Generate			
Watts ($\Phi = 0^\circ$) (10 to 65 Hz)			
(3.3 to 9) mA	(0.11 to 3.0) mW (0.001 to 9) W	0.089 % 0.082 %	Fluke 5520A
(9 to 33) mA	(0.30 to 10) mW (0.003 to 33) W	0.13 % 0.13 %	Note: CMC is higher if Φ is non-zero or if frequency is greater than 65 Hz. (Upper frequency limit: 30 kHz)
(33 to 90) mA	(1 to 30) mW (0.01 to 90) W	0.089 % 0.082 %	
(90 to 330) mA	(3.0 to 100) mW (0.03 to 300) W	0.11 % 0.1 %	
(0.33 to 0.9) A	(11 to 300) mW (0.11 to 900) W	0.087 % 0.081 %	
(0.9 to 2.2) A	(30 to 720) mW (0.30 to 2000) W	0.09 % 0.084 %	
(2.2 to 4.5) A	(0.08 to 1.4) W (0.73 to 4500) W	0.16 % 0.16 %	
(4.5 to 20.5) A	(0.15 to 6.7) W (1.5 to 20 000) W	0.18 % 0.18 %	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage – Generate			
(0.005 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.058 % + 5.2 μV 0.022 % + 5.2 μV 0.011 % + 5.2 μV 0.038 % + 5.3 μV 0.087 % + 8.1 μV 0.12 % + 15 μV 0.18 % + 29 μV 0.36 % + 29 μV	Fluke 5700A
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.059 % + 5.9 μV 0.023 % + 5.8 μV 0.012 % + 5.8 μV 0.039 % + 5.9 μV 0.088 % + 8.1 μV 0.12 % + 16 μV 0.18 % + 30 μV 0.34 % + 37 μV	
(22 to 220) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.059 % + 16 μV 0.023 % + 10 μV 0.012 % + 10 μV 0.018 % + 62 μV 0.057 % + 130 μV 0.12 % + 38 μV 0.18 % + 41 μV 0.37 % + 93 μV	
(0.22 to 2.2) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.052 % + 130 μV 0.016 % + 48 μV 75 μV/V + 13 μV 30 μV/V + 710 μV 0.016 % + 380 μV 0.046 % + 160 μV 0.12 % + 420 μV 0.23 % + 1.0 mV	

Parameter/Range	Frequency	CMC ^{2,4} (\pm)	Comments
AC Voltage – Generate (cont)			
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.052 % + 1.2 mV 0.017 % + 380 μ V 75 μ V/V + 160 μ V 0.011 % + 830 μ V 0.025 % + 480 μ V 0.053 % + 1.8 mV 0.14 % + 5.0 mV 0.3 % + 10 mV	Fluke 5700A
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.053 % + 11 mV 0.017 % + 3.9 mV 85 μ V/V + 1.3 mV 0.023 % + 4.2 mV 0.053 % + 9.5 mV 0.17 % + 110 mV 0.53 % + 110 mV 1.3 % + 220 mV	
(220 to 1100) V	(15 to 50) Hz (0.050 to 1) kHz	0.043 % + 19 mV 80 μ V/V + 9.3 mV	
AC Voltage ³ – Generate			
(1 to 33) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.052 % + 33 μ V 20 μ V/V + 100 μ V 24 μ V/V + 120 μ V 0.04 % + 70 μ V 0.27 % + 80 μ V 0.81 % + 110 μ V	Fluke 5520A
(33 to 330) mV	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.036 % + 11 μ V 0.015 % + 19 μ V 31 μ V/V + 250 μ V 0.019 % + 140 μ V 0.078 % + 100 μ V 0.24 % + 87 μ V	
(0.33 to 3.3) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.036 % + 60 μ V 0.017 % + 130 μ V 50 μ V/V + 1.9 mV 0.016 % + 1.2 mV 0.074 % + 430 μ V 0.28 % + 810 μ V	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage ³ – Generate (cont)			
(3.3 to 33) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.036 % + 790 μV 0.018 % + 710 μV 0.028 % + 720 μV 0.041 % + 740 μV 0.11 % + 1.9 mV	Fluke 5520A
(33 to 330) V	45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.023 % + 3.1 mV 0.024 % + 7.2 mV 0.029 % + 11 mV 0.032 % + 20 mV 0.23 % + 63 mV	
(330 to 1020) V	45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.035 % + 20 mV 0.029 % + 20 mV 0.033 % + 32 mV	
AC Voltage – Measure			
(0 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.2 % + 1.6 μV 0.086 % + 1.5 μV 0.049 % + 1.6 μV 0.094 % + 2.4 μV 0.14 % + 3.0 μV 0.26 % + 4.9 μV 0.27 % + 9.4 μV 0.41 % + 9.5 μV	Fluke 5790A
(2.2 to 7) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.098 % + 1.5 μV 0.043 % + 1.5 μV 0.025 % + 1.5 μV 0.047 % + 2.3 μV 0.070 % + 2.9 μV 0.14 % + 4.6 μV 0.15 % + 9.2 μV 0.27 % + 9.3 μV	
(7 to 22) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.033 % + 1.7 μV 0.022 % + 1.6 μV 0.013 % + 1.6 μV 0.023 % + 2.7 μV 0.036 % + 3.1 μV 0.095 % + 4.6 μV 0.10 % + 9.2 μV 0.20 % + 9.2 μV	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage – Measure (cont)			
(22 to 70) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.029 % + 2.6 μV 0.015 % + 1.8 μV 81 μV/V + 1.8 μV 0.016 % + 2.3 μV 0.033 % + 2.9 μV 0.064 % + 4.7 μV 0.084 % + 9.3 μV 0.13 % + 9.3 μV	Fluke 5790A
(70 to 220) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.025 % + 1.8 μV 0.010 % + 1.8 μV 47 μV/V + 1.9 μV 87 μV/V + 2.7 μV 0.019 % + 4.9 μV 0.032 % + 5.0 μV 0.045 % + 9.5 μV 0.12 % + 9.6 μV	
(220 to 700) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.022 % + 22 μV 83 μV/V + 11 μV 24 μV/V + 18 μV 41 μV/V + 23 μV 59 μV/V + 35 μV 63 μV/V + 0.28 mV 0.014 % + 0.28 mV 0.080 % + 0.28 mV	
(0.7 to 2.2) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.020 % + 69 μV 58 μV/V + 55 μV 14 μV/V + 50 μV 37 μV/V + 49 μV 58 μV/V + 67 μV 0.010 % + 0.34 mV 0.019 % + 0.35 mV 0.092 % + 0.36 mV	
(2.2 to 7) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.022 % + 92 μV 67 μV/V + 96 μV 26 μV/V + 23 μV 57 μV/V + 16 μV 92 μV/V + 16 μV 0.023 % + 50 μV 0.029 % + 1.7 mV 0.12 % + 1.5 mV	

Parameter/Range	Frequency	CMC ^{2,4} (\pm)	Comments
AC Voltage – Measure (cont)			
(7 to 22) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.023 % + 40 μ V 77 μ V/V + 71 μ V 32 μ V/V + 17 μ V 54 μ V/V + 67 μ V 89 μ V/V + 120 μ V 0.023 % + 40 μ V 0.046 % + 190 μ V 0.14 % + 430 μ V	Fluke 5790A
(22 to 70) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.023 % + 290 μ V 79 μ V/V + 150 μ V 36 μ V/V + 130 μ V 66 μ V/V + 69 μ V 0.011 % + 120 μ V 0.022 % + 0.86 mV 0.047 % + 0.75 mV 0.14 % + 0.58 mV	
(70 to 220) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	0.023 % + 460 μ V 80 μ V/V + 550 μ V 37 μ V/V + 330 μ V 79 μ V/V + 320 μ V 0.011 % + 260 μ V 0.023 % + 2.8 mV 0.058 % + 1.0 mV	
(220 to 700) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.023 % + 4.3 mV 0.011 % + 4.3 mV 44 μ V/V + 4.5 mV 0.014 % + 5.3 mV 0.058 % + 2.2 mV	
(700 to 1000) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.023 % + 4.2 mV 0.011 % + 4.2 mV 45 μ V/V + 2.0 mV 0.015 % + 2.0 mV 0.058 % + 6.9 mV	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage ³ – Measure			
(0 to 10) mV	(1 to 40) Hz (0.04 to 1) kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.034 % + 3.7 μV 0.023 % + 1.5 μV 0.034 % + 1.5 μV 0.12 % + 1.8 μV 0.58 % + 1.8 μV 4.6 % + 4.4 μV	HP 3458A, opt 002
(10 to 100) mV	(1 to 40) Hz (0.04 to 1) kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	59 μV/V + 9.0 μV 58 μV/V + 6.1 μV 0.014 % + 5.6 μV 0.032 % + 5.8 μV 0.052 % + 62 μV 0.25 % + 140 μV 1.1 % + 160 μV	
(0.1 to 1) V	(1 to 40) Hz (0.04 to 1) kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	55 μV/V + 110 μV 70 μV/V + 40 μV 0.015 % + 39 μV 91 μV/V + 710 μV 0.065 % + 380 μV 0.32 % + 400 μV 1.2 % + 270 μV	
(1 to 10) V	(1 to 40) Hz (0.04 to 1) kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	54 μV/V + 1.1 mV 65 μV/V + 480 μV 0.015 % + 400 μV 0.029 % + 890 μV 0.09 % + 530 μV 0.34 % + 2.2 mV 1.2 % + 2.8 mV	
(10 to 100) V	(1 to 40) Hz (0.04 to 1) kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.021 % + 7.7 mV 0.022 % + 4.0 mV 0.022 % + 3.9 mV 0.04 % + 3.9 mV 0.14 % + 4.8 mV 0.46 % + 15 mV 1.8 % + 17 mV	
(100 to 700) V	(1 to 40) Hz (0.04 to 1) kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.046 % + 55 mV 0.045 % + 37 mV 0.068 % + 38 mV 0.14 % + 43 mV 0.35 % + 43 mV	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage ³ – HV Measure (1 to 10) kV (10 to 35) kV (35 to 100) kV	60 Hz 60 Hz 60 Hz	0.25 V + 4.6 mV/V 0.25 V + 4.8 mV/V 4.9 V + 4.9 mV/V	Vitrek 4700
AC Voltage Flatness – Measure (0.005 to 7) V (0.005 to 5.5) V	10 Hz to 30 MHz (10 to 1100) MHz	0.47 % 1.6 %	Fluke 5790A Power meter & power sensors
Capacitance ³ – Generate Synthesized Capacitance (0.19 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF (0.33 to 1.1) μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF (0.33 to 1.1) mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	(0.01 to 10) kHz (0.01 to 10) kHz (0.01 to 3) kHz (0.01 to 1) kHz (0.01 to 1) kHz (0.01 to 1) kHz (0.01 to 1) kHz (10 to 600) Hz (10 to 300) Hz (10 to 150) Hz (10 to 120) Hz (10 to 80) Hz (0 to 50) Hz (0 to 20) Hz (0 to 6) Hz (0 to 2) Hz (0 to 0.6) Hz (0 to 0.2) Hz	0.58 % + 12 pF 0.58 % + 12 pF 0.57 % + 12 pF 0.28 % + 14 pF 0.29 % + 120 pF 0.28 % + 140 pF 0.28 % + 390 pF 0.28 % + 1.4 nF 0.28 % + 3.9 nF 0.27 % + 15 nF 0.28 % + 43 nF 0.43 % + 170 nF 0.49 % + 480 nF 0.51 % + 1.4 μF 0.49 % + 5 μF 0.37 % + 36 μF 0.83 % + 49 μF 0.11 % + 360 μF	Fluke 5520A

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
Capacitance ³ – Generate (cont)			
Discrete Capacitance Points			
1 pF	1 kHz	0.85 fF	Agilent 16380A standard capacitors
10 pF	1 kHz	1.6 fF	
100 pF	1 kHz	6.5 fF	
1000 pF	1 kHz	54 fF	
1 nF	100 Hz	99 fF	Genrad 1409 series standard capacitors
2 nF	100 Hz	0.28 pF	
10 nF	100 Hz	1.0 pF	
100 nF	100 Hz	10 pF	
200 nF	100 Hz	21 pF	
1 µF	100 Hz	0.12 nF	
1 nF	120 Hz	0.24 pF	
2 nF	120 Hz	0.28 pF	
10 nF	120 Hz	1.0 pF	
100 nF	120 Hz	10 pF	
200 nF	120 Hz	21 pF	
1 µF	120 Hz	0.12 nF	
1 nF	1 kHz	57 fF	
2 nF	1 kHz	0.28 pF	
10 nF	1 kHz	1.0 pF	
100 nF	1 kHz	10 pF	
200 nF	1 kHz	21 pF	
1 µF	1 kHz	0.12 nF	
1 nF	10 kHz	57 fF	
2 nF	10 kHz	0.28 pF	
10 nF	10 kHz	1.0 pF	
100 nF	10 kHz	10 pF	
200 nF	10 kHz	21 pF	
1 µF	10 kHz	0.12 nF	
1 nF	100 kHz	55 fF	
2 nF	100 kHz	0.33 pF	
10 nF	100 kHz	1.5 pF	
100 nF	100 kHz	10 pF	
200 nF	100 kHz	22 pF	
1 µF	100 kHz	0.16 pF	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
Capacitance ³ – Measure (1 to 10) pF (10 to 100) pF (0.1 to 10) nF (10 to 100) nF (0.1 to 1) μF (1 to 10) μF (10 to 100) μF (0.1 to 1) mF (1 to 10) mF (10 to 100) mF (0.1 to 1) mF (1 to 10) mF (10 to 110) mF	10 kHz 1 kHz 1 kHz 1 kHz 1 kHz 100 Hz 100 Hz 100 Hz 100 Hz 100 Hz DC DC DC	0.12 % + 0.012 pF 0.058 % + 0.12 pF 0.057 % + 0.33 pF 0.058 % + 1.2 pF 0.059 % + 5.8 pF 0.049 % + 1.1 nF 0.063 % + 1.2 nF 0.12 % + 5.8 nF 0.64 % + 58 nF 5.8 % + 0.58 μF 0.014 % 0.014 % 0.017 %	GenRad 1692 RLC digibridge Charge technique using DC source & voltmeter
Conductivity Simulation ³ – Generate	Up to 1 μS 1 μS to 10 mS	0.015 μS 16 μS	ESI DB 877 decade resistor
DC Current – Generate	(0 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 (20.5 to 100) A (100 to 150) A (150 to 1000) A	41 μA/A + 7.1 nA 35 μA/A + 8.5 nA 35 μA/A + 54 nA 47 μA/A + 850 nA 64 μA/A + 31 μA 0.040 % + 570 μA 0.63 % + 0.12 A 0.65 % + 0.01 A 0.65 % + 0.13 A	Fluke 5720A Fluke 5725A Valhalla 2575A with DMM Fluke 5520A & 50 turn coil

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
DC Current ³ – Generate	(0 to 330) µA (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA (0.33 to 1.1) A (1.1 to 3) A (3 to 11) A (11 to 20.5) A	0.018 % + 24 nA 0.012 % + 65 nA 0.012 % + 440 nA 0.01 % + 8.5 µA 0.023 % + 51 µA 0.04 % + 200 µA 0.055 % + 920 µA 0.11 % + 3.0 mA	Fluke 5520A
	(20.5 to 100) A (100 to 1000) A	0.60 % + 0.25 A 0.63 % + 0.6 A	Fluke 5520A & 50 turn coil
DC Current – Measure	(0 to 200) µA (0.2 to 2) mA (2 to 20) mA (20 to 200) mA (0.2 to 2) A (2 to 20) A	14 µA/A + 660 pA 15 µA/A + 5.0 nA 16 µA/A + 53 nA 43 µA/A + 200 nA 0.019 % + 28 µA 0.058 % + 1.9 mA	Fluke 8508A
	(20 to 100) A	0.62 % + 0.26 A	Valhalla 2575A with DMM
	(100 to 1000) A	2.4 % + 0.74 A	Fluke 376 clamp
DC Current ³ – Measure	(0 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	20 µA/A + 1.5 nA 22 µA/A + 7.9 nA 22 µA/A + 81 nA 39 µA/A + 790 nA 0.011 % + 37 µA	HP 3458A, opt 002
	(1 to 10) A	23 mA	Fluke 45
	(10 to 1000) A	2.4 % + 0.74 A	Fluke 376 clamp

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
DC Power ³ – Generate			
(0.33 to 3.3) mA	(0.011 to 1.1) mW (0.11 to 11) mW (1.1 to 110) mW (0.011 to 1.1) W (0.11 to 3.3) W	0.043 % 94 μW/W 94 μW/W 95 μW/W 80 μW/W	Fluke 5520
(3.3 to 33) mA	(0.11 to 11) mW (1.1 to 110) mW (0.011 to 1.1) W (0.11 to 11) W (1.1 to 33) W	0.043 % 90 μW/W 90 μW/W 91 μW/W 76 μW/W	
(33 to 330) mA	(1.1 to 110) mW (0.011 to 1.1) W (0.11 to 11) W (1.1 to 110) W (11 to 330) W	0.043 % 91 μW/W 91 μW/W 92 μW/W 77 μW/W	
(0.33 to 3) A	(11 to 990) mW (0.11 to 9.9) W (1.1 to 99) W (11 to 990) W (0.11 to 3) kW	0.05 % 0.028 % 0.028 % 0.028 % 0.027 %	
(3 to 20.5) A	(0.099 to 6.7) W (0.99 to 6.7) W (9.9 to 670) W (0.099 to 6.8) kW (0.99 to 20.9) kW	0.082 % 0.071 % 0.071 % 0.071 % 0.07 %	
DC Voltage ³ – 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	8.0 μV/V + 650 nV 4.2 μV/V + 950 nV 3.0 μV/V + 3.3 μV 3.0 μV/V + 5.3 μV 3.8 μV/V + 180 μV 5.4 μV/V + 730 μV	Fluke 5720A
Fixed Point	10 V	1.0 μV/V	Fluke 732A
DC Voltage ³ – HV Generate	(1 to 50) kV	2.3 % of rdg	HV source with divider

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
DC Voltage ³ – Measure	(0 to 200) mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1050) V	5.9 μV/V + 130 nV 3.6 μV/V + 480 nV 3.6 μV/V + 4.7 μV 5.3 μV/V + 50 μV 5.2 μV/V + 760 μV	Fluke 8508A
Fixed Point	10 V	1 μV/V	Fluke 732A
DC Voltage ³ – HV Measure	(1 to 10) kV (10 to 35) kV (35 to 100) kV	0.18 V + 0.49 mV/V 0.18 V + 0.72 mV/V 0.96 V + 1.2 mV/V	Vitrek 4700 with HVL35, HVL100
Inductance ³ – Generate			
100 mH, 1 H, 10 H 100 μH to 1 H	(100, 120) Hz (1, 10) kHz	0.024 % + 2.2 μH 0.057 % + 1.6 μH	Genrad 1482 series standard inductors
Inductance ³ – Measure			
(0.002 to 10) H	(100, 120) Hz	0.26 % + 580 nH	Genrad 1482 series standard inductors
(0.002 to 10) H	(1, 10) kHz	0.27 % + 480 nH	Genrad 1692 RLC digibridge
Oscilloscope –			
Amplitude DC 50 Ω 1 MΩ	(0 to 6.6) V (0 to 130) V	0.29 % + 49 μV 0.058 % + 48 μV	Fluke 5520A- SC1100
Amplitude Square Wave 50 Ω 1 MΩ	1 mV to 6.6 V _(p-p) 1 mV to 130 V _(p-p)	0.29 % + 49 μV 0.12 % + 48 μV	
Leveled Sine Wave Amplitude (50 kHz Ref)	50 kHz reference 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	3.0 % + 0.34 mV 4.5 % + 0.35 mV 5.0 % + 0.36 mV 7.2 % + 0.36 mV 8.3 % + 0.31 mV	
Time Marker	5 s to 50 ms 20 s to 2 ns	(30 + 1200t) μs/s 5.0 μs/s	t = time in seconds

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Pulse Characterization – Transition (Rise) Time – Generate Transition (Rise / Fall) Time – Measure	1 kHz to 2 MHz Nominal 250 ps (2 to 10) MHz Nominal 300 ps 17.5 ps to 1 μs	53 ps 53 ps 24 ps	Fluke 5520A- SC1100 Tek 11801B with SD 26 sampling head
pH Simulation ³ – Generate	(0 to 14) pH units	0.0032 pH	Fluke 700 series process calibrator
Phase ³ – Generate (0 to 999.999)°	0.02 Hz to 6.25 kHz (6.25 to 50) kHz (50 to 100) kHz	0.015° 0.031° 0.06°	Clark Hess 5000
Phase ³ – Measure (0 to 360)° (-180 to 180)°	(0.02 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.06° 0.063° 0.0023 <i>f</i> – 0.050°	Clark Hess 6000 <i>f</i> = frequency in kHz

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Resistance – Generate, Discrete Resistance Points	0 Ω 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	47 μΩ 93 μΩ 0.18 mΩ 0.24 mΩ 0.46 mΩ 1.1 mΩ 2.0 mΩ 8.8 mΩ 17 mΩ 88 mΩ 0.17 Ω 1.1 Ω 2.0 Ω 24 Ω 40 Ω 360 Ω 890 Ω 12 kΩ	Fluke 5720A
	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ	0.48 μΩ/Ω 3 μΩ/Ω 2.7 μΩ/Ω 0.75 μΩ/Ω 2.7 μΩ/Ω	Fluke 742A
Resistance ³ – Generate, Synthesized Resistance Points	(0 to 11) Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (0.33 to 1.1) kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 33) kΩ (33 to 110) kΩ (110 to 330) kΩ (0.33 to 1.1) MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (0.33 to 1.1) GΩ	46 μΩ/Ω + 1.2 mΩ 35 μΩ/Ω + 1.8 mΩ 25 μΩ/Ω + 3.2 mΩ 29 μΩ/Ω + 4.2 mΩ 29 μΩ/Ω + 6.6 mΩ 29 μΩ/Ω + 41 mΩ 27 μΩ/Ω + 100 mΩ 29 μΩ/Ω + 400 mΩ 27 μΩ/Ω + 1.0 Ω 35 μΩ/Ω + 3.5 Ω 32 μΩ/Ω + 9.6 Ω 66 μΩ/Ω + 50 Ω 0.014 % + 250 Ω 0.027 % + 3.9 kΩ 0.052 % + 12 kΩ 0.35 % + 130 kΩ 1.7 % + 1.9 MΩ	Fluke 5520A
Resistance ³ – Measure	(0 to 2) Ω (2 to 20) Ω (20 to 200) Ω (0.2 to 2) kΩ (2 to 20) kΩ (20 to 200) kΩ (0.2 to 2) MΩ (2 to 20) MΩ	18 μΩ/Ω + 7.2 μΩ 13 μΩ/Ω + 25 μΩ 12 μΩ/Ω + 59 μΩ 11 μΩ/Ω + 730 μΩ 10 μΩ/Ω + 6.2 mΩ 8.6 μΩ/Ω + 120 mΩ 6.3 μΩ/Ω + 17 Ω 22 μΩ/Ω + 120 Ω	Fluke 8508A

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Resistance ³ – Measure (cont)	(20 to 200) MΩ (0.2 to 2) GΩ	70 μΩ/Ω + 12 kΩ 0.061 % + 1.2 MΩ	Fluke 8508A
RTD Indicators ³ – Pt 385, 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 (630 to 800) °C	0.060 °C 0.059 °C 0.083 °C 0.11 °C 0.12 °C 0.14 °C 0.27 °C	Fluke 5520A
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	0.048 °C 0.048 °C 0.048 °C 0.060 °C 0.15 °C 0.16 °C 0.17 °C 0.19 °C	
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	0.048 °C 0.060 °C 0.060 °C 0.071 °C 0.095 °C 0.095 °C 0.11 °C 0.13 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
RTD Indicators ³ – (cont)			
Pt 385, 1 kΩ	(-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	0.036 °C 0.036 °C 0.048 °C 0.060 °C 0.071 °C 0.083 °C 0.083 °C 0.28 °C	Fluke 5520A
PtNi 385, 120 Ω	(-80 to 0) °C (0 to 100) °C (100 to 260) °C	0.095 °C 0.095 °C 0.017 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.048 °C 0.048 °C 0.060 °C 0.071 °C 0.083 °C 0.095 °C 0.11 °C 0.12 °C 0.28 °C	
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	0.060 °C 0.060 °C 0.083 °C 0.11 °C 0.12 °C 0.15 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.36 °C	
Thermocouple Indicators ³ –			
Type B	(600 to 800) °C (800 to 1000) °C (1000 to 1550) °C (1550 to 1820) °C	0.52 °C 0.41 °C 0.37 °C 0.4 °C	Fluke 5520A
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.36 °C 0.32 °C 0.37 °C 0.59 °C 0.98 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Thermocouple Indicators ³ – (cont)			
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.59 °C 0.21 °C 0.19 °C 0.21 °C 0.26 °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	0.33 °C 0.21 °C 0.18 °C 0.22 °C 0.28 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.4 °C 0.23 °C 0.21 °C 0.32 °C 0.47 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.47 °C 0.27 °C 0.24 °C 0.23 °C 0.33 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.67 °C 0.43 °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	0.56 °C 0.44 °C 0.45 °C 0.55 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.74 °C 0.29 °C 0.21 °C 0.19 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.66 °C 0.33 °C	

V. Fluid Quantities

Parameter/Equipment	Range ⁸	CMC ^{2, 5, 8} (±)	Comments
Refractometers – Brix	1.332 99 n _D 1.336 59 n _D 1.344 01 n _D 1.355 68 n _D 1.399 86 n _D 1.464 58 n _D 1.516 55 n _D	0.000 044 n _D 0.000 045 n _D 0.000 046 n _D 0.000 052 n _D 0.000 052 n _D 0.000 084 n _D 0.000 084 n _D	Standard solutions
Salt (NaCl)	(0 to 50) % NaCl solution	0.026 % NaCl solution	
Viscosity Meter Calibration ³	Up to 33 % of Scale (33 to 66) % of Scale (66 to 100) % of Scale	2.7 % 1.8 % 1.7 %	Viscosity oils
Viscosity Dip Cups ³ – Efflux Time	(0 to 100) mm ² /s (100 to 1000) mm ² /s	1.8 % 1.3 %	Viscosity oils
Volumetric Flow ³ – Flowmeters			
Gas	(1 to 250) sccm (0.02 to 6) slpm (2 to 30) slpm	0.016 sccm + 1.5 % 0.01 slpm + 1.1 % 0.035 slpm + 1.2 %	Comparison to flow standards

VI. Mechanical

Parameter/Equipment	Range	CMC ^{2, 5, 10} (±)	Comments
Durometer Calibrators – Beam Type	Type A Type D	0.014 % 0.012 %	Optical comparator & mass comparator
Force – Compression & Tension, Measure & Measuring Equipment	(200 to 5000) lbf (5000 to 20 000) lbf (20 000 to 60 000) lbf	1.2 lbf 4.6 lbf 15 lbf	Morehouse 1000 series proving rings

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Verification of Rockwell Hardness Testers ³ (cont)	HRRW: Low Medium High HRSW: Low High HR15N: Low Medium High HR30N: Low Medium High HR45N: Low Medium High HR15T: Low Medium High HR30T: Low Medium High HR45T: Low Medium High	0.76 HRRW 0.61 HRRW 0.93 HRRW 0.93 HRSW 0.42 HRSW 1.2 HR15N 1.2 HR15N 1.2 HR15N 1.2 HR30N 1.2 HR30N 1.2 HR30N 1.2 HR45N 1.2 HR45N 1.2 HR45N 1.2 HR15T 1.2 HR15T 1.2 HR15T 1.3 HR30T 1.2 HR30T 1.2 HR30T 1.3 HR45T 1.3 HR45T 1.2 HR45T	Indirect verification per ASTM E18
Indirect Verification of Brinell Hardness Testers at Test Condition(s) ³ – 10/500/15	(50 to 70) HBW (80 to 101) HBW	2.5 HBW 3.7 HBW	Indirect verification method per ASTM E10

Parameter/Equipment	Range	CMC ^{2,5,10} (±)	Comments
Indirect Verification of Brinell Hardness Testers at Test Condition(s) ³ – (cont) 10/3000/15	239 HBW 349 HBW 416 HBW	8.4 HBW 13 HBW 15 HBW	Indirect verification method per ASTM E10
Indirect Verification of Microindentation Hardness Testers ³ – (Knoop & Vickers)	(250 to 650) HK >650 HK (240 to 600) HV >600 HV	16 HK 38 HK 13 HV 37 HV	Indirect verification method per ASTM E92
Linear Velocity ³ – Measuring Equipment	Up to 50 mm/min (50 to 1000) mm/min	0.34 % + 0.14 mm/min 2.0 %	Linear scale & stopwatch
Mass – Measure, Fixed Points	50 kg 30 kg 20 kg 10 kg 5 kg 3 kg 2 kg 1 kg 500 g 300 g 200 g 100 g 50 g 30 g 20 g 10 g 5 g 3 g 2 g 1 g 500 mg 300 mg	84 mg 40 mg 32 mg 14 mg 7.8 mg 4.8 mg 3.3 mg 2.0 mg 1.5 mg 1.4 mg 310 µg 160 µg 78 µg 47 µg 31 µg 17 µg 10 µg 5.7 µg 5.3 µg 8.2 µg 4.7 µg 3.3 µg	Double substitution with air buoyancy correction; Class E2 mass standards; Sartorius CC50, RC210P, A&D MC-6100, CC50002

Parameter/Equipment	Range	CMC ^{2, 5, 10} (±)	Comments
Mass – Measure, Fixed Points (cont)	200 mg 100 mg 50 mg 30 mg 20 mg 10 mg 5 mg 3 mg 2 mg 1 mg	6.9 µg 4.9 µg 4.3 µg 4.4 µg 2.8 µg 2.8 µg 2.8 µg 2.8 µg 2.7 µg 2.7 µg	Double substitution with air buoyancy correction; Class E2 mass standards; Sartorius CC50, RC210P, A&D MC-6100, CC50002
Mass ³ – Measure	(0.2 to 3000) g (3 to 34) kg	0.014 % + 0.071 g 0.055 % + 0.50 g	ASTM class 6/7, OIML Class M2/M3, NIST Class F by single substitution
Pressure – Pneumatic Gauge, Negative Gauge, & Absolute	(0.0 to 0.2) psi (0.2 to 1000) psi	0.000 73 psi 0.0025 %	Fluke 6270A Ruska 2465
Gauge Only	(1000 to 15 000) psig	0.0075 %	Ruska 2475
Hydraulic	(2 to 20 000) psig	0.0075 %	Ruska 2485
Pressure ³ – Pneumatic Gauge, Negative Gauge, & Absolute	(0 to 2) inH ₂ O	0.0021 inH ₂ O	Microtector
Pressure – Gauge & Absolute	(2 to 20) inH ₂ O (20 to 40) inH ₂ O	0.18 inH ₂ O 0.24 inH ₂ O	Pressure transducers
Pressure – Gauge Only	(-14 to 30) psig (30 to 100) psig (100 to 500) psig (500 to 1000) psig (1000 to 5000) psig (5000 to 10 000) psig	0.038 psig 0.062 psig 0.33 psig 0.60 psig 1.8 psig 6.7 psig	

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Scales & Balances ³	(1 to 200) g (200 to 1000) g (1 to 3) kg (3 to 5) kg (5 to 15) kg (15 to 34) kg (75 to 250) lb (250 to 1000) lb (1000 to 3000) lb (3000 to 12 000) lb	25 µg + 3.1 µg/g 1.1 mg + 2.6 µg/g 770 µg + 2.7 µg/g 0.60 g 1.8 g 4.3 g 0.17 lb 0.20 lb 0.38 lb 7.4 lb	Certified weights, NIST Handbook 44 E2, Class 1
Tachometers ³ –			
Contact	Up to 2000 rpm	0.08 rpm + 0.06 %	Tachometer test station signal generator
Strobo	Up to 500 rpm (500 to 20 000) rpm	0.013 rpm 0.054 rpm	
Photo	Up to 500 rpm (500 to 99 999) rpm	0.0091 rpm 0.0076 rpm	
Torque Transducers	(4 to 80) in·ozf (5 to 60) in·lbf (5 to 250) ft·lbf (250 to 1000) ft·lbf	0.046 % 0.035 % 0.068 % 0.032 %	Torque arms & Class F weights
Torque Wrenches, Tools ³	(8 to 80) in·ozf (5 to 20) in·lbf (20 to 50) in·lbf (50 to 250) in·lbf (20 to 100) ft·lbf (100 to 250) ft·lbf (100 to 1000) ft·lbf	0.23 in·ozf 0.025 in·lbf 0.061 in·lbf 0.86 in·lbf 0.17 ft·lbf 1.0 ft·lbf 1.2 ft·lbf	Torque transducers
Volume –Volumetric Apparatus (Beakers, Cylinders, Flasks, etc.)	Up to 4000 mL (4000 to 19 000) mL	0.01 % 0.026 %	Balance & weights

VII. Optical Quantities

Parameter/Equipment	Range	CMC ² (±)	Comments
Gloss Meters ³	20° 60° 85°	0.63 GU 0.42 GU 0.44 GU	Gloss standards
Gloss Tiles ³	20° 60° 85°	0.67 GU 0.48 GU 0.50 GU	Comparison to gloss standards

VIII. Rubber & Plastics Industry Specific Equipment

Parameter/Equipment	Range	CMC ² (±)	Comments
Capillary Rheometers – Polymeric ³ (Plastic)			ASTM D 3835 – excludes surface roughness, hardness of piston
Barrel Inside Diameter & Uniformity	(6.35 to 19) mm	0.0069 mm	Bore micrometer
Piston Tip Diameter & Length, Capillary Bore Length	(9 to 25.4) mm	0.0028 mm	Micrometer
Temperature Accuracy	(180 to 300) °C	0.088 °C	Digital thermometer
Capillary Rheometers ³ – Rubber			ASTM D 5099
Barrel Inside Diameter & Uniformity	(9 to 22) mm	0.0069 mm	Bore micrometer
Piston Tip Diameter & Length, Capillary Bore Length	(9 to 25.4) mm	0.0028 mm	Micrometer

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Capillary Rheometers ³ – Rubber (cont)			ASTM D 5099
Temperature Accuracy	(10 to 190) °C	0.088 °C	Digital thermometer
Crosshead Speed	(0 to 25.4) mm/min	0.048 mm/min	Dial indicator/stopwatch
Force	(0 to 5000) lbf	32 lbf	Load cell
Pressure	(0 to 10 000) psi	24 psi	Deadweight pressure tester
Direct Verification of Durometers – Types A, B, C, D, DO, E, M, O, OO, OOO, OOO-S			ASTM D2240
Indenter Extension & Shape –			
Diameter	(0 to 25) mm	0.0041 mm	Optical inspection under magnification
Radius	(0 to 25) mm	0.0097 mm	
Angle	(0 to 90)°	0.031°	
Extension	(0 to 25) mm	0.0069 mm	
Indenter Display	(0 to 100) Duro	0.58R + 12 µDuro	Gage blocks
Spring Calibration – Force			
Types A, B, E, & O	(0 to 100) Duro	0.63 Duro	Durometer calibrator
Types C, D, & DO	(0 to 100) Duro	0.61 Duro	
Types OO & OOO	(0 to 100) Duro	1.5 Duro	Balance
Type OOO-S	(0 to 100) Duro	1.3 Duro	
Type M	(0 to 100) Duro	1.9 Duro	
Durometer Test Blocks	Types A & D	1.4 Duro	Durometer

Parameter/Equipment	Range	CMC ² (±)	Comments
Extruders ³ –			
Temperature Controller Accuracy (T/C)	(0 to 350) °C	1.5 °C	TC calibrator
Thermocouple Accuracy	(0 to 350) °C	1.2 °C	Master temp probe & dry block calibrator
Screw Speed	(6 to 1000) rpm	2.1 rpm	Tachometer
Pressure	(2 to 30) psi (30 to 100) psi (100 to 500) psi (500 to 1000) psi (1000 to 5000) psi (5000 to 10 000) psi	0.038 psi 0.062 psi 0.33 psi 0.60 psi 1.8 psi 6.7 psi	Pressure transducer
Timer Accuracy	(0 to 7200) s	0.72 s	Comparison to stopwatch
Extrusion Plastometers ^{3,6} –			ASTM D1238
Cylinder Bore	Up to 2 in	0.000 28 in	
Piston Measurements	Up to 2 in	0.000 30 in	
Temperature	(0 to 400) °C	0.12 °C	
Load to 3 kg	Up to 3 kg (3 to 20) kg	0.35 g 2.4 g	
Timing	(0 to 7200) s	0.36 s	
Rubber Press ³ – Laboratory, Compression, Injection, Transfer			ASTM D 3182 ISO 2393
Closing Force	(0 to 2000) lbf (2000 to 30 000) lbf (30 000 to 100 000) lbf (100 000 to 200 000) lbf	24 lbf 41 lbf 200 lbf 390 lbf	
Temperature Uniformity	(50 to 350) °C	0.42 °C	
Parallelism	(0.001 to 0.01) in/ft	0.0028 in/ft	

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Injection Molders ³ –			
Temperature Controller Accuracy (T/C)	(0 to 350) °C	1.5 °C	TC calibrator
Thermocouple Accuracy	(0 to 350) °C	1.2 °C	Master temp probe & dry block calibrator
Screw Speed	(6 to 1000) rpm	2.1 rpm	Tachometer
Pressure	(2 to 30) psi (30 to 100) psi (100 to 500) psi (500 to 1000) psi (1000 to 5000) psi (5000 to 10 000) psi	0.038 psi 0.062 psi 0.33 psi 0.60 psi 1.8 psi 6.7 psi	Pressure transducer
Plunger Linear Displacement	(0 to 300) mm (0.3 to 1.8) m	0.1 mm 2.1 mm	Comparison to length standards
Plunger Speed	(0 to 900) mm/min	0.41 % + 2.1 mm/min	Length standards/stopwatch
Timer Accuracy	(0 to 7200) s	0.72 s	Comparison to stopwatch
Mooney Viscometers ³ , Stress Relaxation –			ASTM D 1646
Mooney Torque	(0 to 200) Mooney Units	0.098 Mooney Units	Class F weights
Rotor rpm	(0.01 to 100) rpm	0.36 %	Optical encoder
Die Temperature	(0 to 400) °F	0.40 °F	ASTM D 1349 RTD with indicator
Die Closing Force	(500 to 2700) lbf	38 lbf	Load cell with indicator
Rotor Dimensions	Up to 2 in	0.000 086 in	Micrometers

Parameter/Equipment	Range	CMC ^{2,5} (±)	Comments
Oscillating Disk Rheometers ³ –			ASTM D2084, ISO 3417
Torque	(0 to 200) in·lbf	0.33 in·lbf	OD torsion standard
Oscillatory Amplitude	(-90 to 90)° arc	0.0062° arc	Optical encoder
Die Temperature	(0 to 400) °F	0.40 °F	ASTM D 1349 RTD with indicator
Die Closing Force	(500 to 2700) lbf	38 lbf	ASTM E 4 Load cell with indicator
Rotor Dimensions	(0 to 2) in	0.000 086 in	Measured at test temperatures with micrometers
Disk Oscillation	1.67 Hz	0.46 %	
Rotorless Cure Meters, Moving Die Rheometers, Rubber Process Analyzers ³ –			ASTM D 5289, ASTM D 6204, ASTM D6601
Torque	(0 to 200) in·lbf	0.29 in·lbf	MD torsion standard (Dynamic)
Oscillatory Amplitude	(-90 to 90)° arc	0.0064° arc	ASTM D 1349
Die Temperature	(0 to 400) °F	0.40 °F	Thermocouple or RTD with indicator
Die Closing Force	≥1820 lbf	38 lbf	Load cell with indicator
Torque Standards (Torsion Springs), MDR, ODR	Torque up to 200 lbf·in (peak-peak) 10° (peak-peak)	0.27 in·lbf 0.0062° arc	Torque standard calibration system

IX. Thermodynamics

Parameter/Equipment	Range	CMC ^{2, 5, 10} (±)	Comments
Dew/Frost Point – Measuring Equipment	(-25 to 0) °C (0 to 65) °C	0.18 °C 0.16 °C	Dew point generator Thunder Scientific 2500
Humidity – Measure & Measuring Equipment	(10 to 95) % RH (10 to 95) % RH	1.0 % RH 1.0 % RH	Chilled mirror Thunder Scientific 2500
Humidity ³ – Measure & Measuring Equipment	(10 to 90) % RH	2.9 % RH	Vaisala probe
IR Temperature ³ – Measuring Equipment	Ambient to 300 °C (300 to 800) °C	8.5 mK/K +1.3 K 11.7 mK/K +1.3 K	Mikron M316 ε = 0.99 λ = (8 to 14) μm Williamson Blackbody ε = 0.995 λ = (1 to 4) μm
IR Temperature ³ – Measure Blackbody Sources	Ambient to 300 °C (300 to 890) °C	8.5 mK/K +1.3 K 11.7 mK/K +1.3 K	Blackbody source, IR thermometer
Ovens ³ – Temperature Uniformity	Up to 1000 °C	4.0 °C	ASTM E145, ASTM A991, AMS 2750, HP 34970
System Accuracy	Up to 420 °C (420 to 1000) °C	0.59 °C 2.8 °C	RTD TC
Time Constant	(5 to 800) s	5.8 s	Fluke 54 II
Ventilation Rate	(5 to 300) Air changes/hr	3.4 % of Air changes/hr	ASTM E145

Parameter/Equipment	Range	CMC ^{2,10} (\pm)	Comments	
Temperature ³ – Measure, Temperature Baths, Dry Wells	Temperature Uniformity			
		(-196 to 150) °C	27 mK	PRT, digital thermometer
		(0 to 30) °C	15 mK	SPRT, digital thermometer
Temperature Accuracy	(-196 to 0) °C (0 to 660) °C (660 to 1000) °C (1000 to 1450) °C	6.6 mK 13 μ K/K + 4.9 mK 0.74 K 1.8 mK/K + 0.45 K	Characterized S thermocouple ¹²	
Temperature ³ – Measuring, Equipment, TC/RTD Probes, LIG Thermometers		0.01 °C	4.9 mK	Triple point of water, reference probe
		(-80 to 0) °C	12 mK	Comparison to reference probe and temperature baths
		(0 to 150) °C	14 mK	
		(150 to 300) °C	26 mK	
		(300 to 400) °C	28 mK	
	(400 to 1000) °C (1000 to 1200) °C	3 K 1.2 mK/K + 2.4 K	Drywell and S thermocouple ¹²	

X. Time and Frequency

Parameter/Equipment	Range	CMC ^{2,10} (\pm)	Comments
Frequency ³ – Measuring Equipment	Up to 18 GHz	11 pHz/Hz + 0.58R	GPS disciplined receiver and signal generator R is the resolution of the unit under test
Frequency ³ – Measure	0.01 Hz to 18 GHz	11 pHz/Hz + 0.58R	EIP 545 and HP 5335A electronic counters R is the resolution of the unit under test

Parameter/Equipment	Range	CMC ² (±)	Comments
Timers/Stop Watches	(1 to 28 800) s	0.06 s/day	Timometer
Timers/Stop Watches ³	(1 to 28 800) s	0.049 s	Electronic counter
Tuning Fork ³	20 Hz to 22 kHz	1.2 mHz/Hz	Electronic counter

¹ This laboratory offers commercial dimensional testing/calibration service and field calibration service.

² 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.

³ This laboratory performs field calibration activities for these parameters. 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 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. CMCs 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.

⁵ In the statement of CMC, L is the length of the unit under test in inches. R is the resolution of the unit under test in microinches, and percentages are percentage of reading, unless otherwise indicated.

⁶ Using ASTM D1238 at 0 °C to 400 °C Temp, (0 to 20) kg force, and (0 to 2) in length.

⁷ This laboratory meets R205 – *Specific Requirements: Calibration Laboratory Accreditation Program* for the types of dimensional tests listed above and is considered equivalent to that of a calibration certificate.

⁸ The unit of n_D is defined as the following: 'n' indicates the refractive index and 'D' indicates the value was measured at the yellow doublet sodium D-line (wavelength: approx 589 nm).

⁹ Adjustable thread rings are set to applicable specifications using calibrated master set plug gages.

¹⁰ 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.

¹¹ This scope meets A2LA's *P112 Flexible Scope Policy*.

¹² Traceability above 960 °C is based on consensus.

MECHANICAL TESTING

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

Test Method:

Test Description:

ASTM D1646

Rubber – Viscosity, Stress Relaxation, and Pre-Vulcanization Characteristics (Mooney Viscometer)

ASTM D2084

Rubber Property – Vulcanization Using Oscillating Disk Cure Meter, Excluding Hardness

ASTM D5289

Rubber Property – Vulcanization Using Rotorless Cure Meters

ASTM D6204

Rubber – Measurement of Unvulcanized Rheological Properties Using Rotorless Shear Rheometers

ASTM D6601

Rubber Properties – Measurement of Cure and After-Cure Dynamic Properties Using a Rotorless Shear Rheometer

ASTM D8059

Rubber Compounds – Measurement of Unvulcanized Dynamic Strain Softening (Payne Effect) Using Sealed Cavity Rotorless Shear Rheometers



Accredited Laboratory

A2LA has accredited

RICHARD J. BAGAN, INC. A.K.A. MONTECH USA

Columbia City, IN

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 the requirements of ANSI/NC SL Z540-1-1994 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 April 2017).



Presented this 12th day of April 2021.

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

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1625.01
Valid to January 31, 2023

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