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

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CALIBRATION

Valid To: January 31, 2027 Certificate Number: 1625.01

In recognition of the successful completion of the A2LA evaluation process (including an assessment of the organization's compliance with R205 – A2LA's Calibration Program Requirements), 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 1.2 µS 4.3 µS 46 µS 410 µS	Conductivity solutions
pH Meter/Probe Calibration[3]	(4, 7, 10) pH Up to 14 pH	0.03 pH 0.03 pH	pH buffer Comparison to pH meter

II. Dimensional

Parameter/Equipment	Range	CMC[2] (±)	Comments
Angle Blocks[3]	(0.25 to 60)°	0.005°	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) in (2 to 4) in (4 to 6) in (6 to 24) in	29 µin + 0.80 µin/in 32 µin + 1.4 µin/in 33 µin + 1.8 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 0.35 in Up to 1 in Up to 4 in	6.6 µin + 0.58R 7.8 µin + 0.58R 2.5 µin/in + 5.0 µin + 0.58R	Gage blocks
Flatness[3] – Measure & Measuring Equipment	Up to 4 in diameter Up to 10 in length	4 µin 31 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 –	Up to 200 µin	3.4 µin	Gage blocks
Force	Up to 1.47 N	0.09 N	Correx force gage

Parameter/Equipment	Range	CMC[2, 5] (±)	Comments
Height/Depth Gages[3]	Up to 24 in (24 to 72) in	(1.8 + 4.8*L*) µin 150 µin + 16 µin/in	Gage blocks
Length Standards[3]	Up to 18 in (18 to 48) in	13 µin + 10 µin/in 42 µin + 5.5 µin/in	Measuring machine, gage blocks
Levels[3] – Bubble Vial	---	0.62*R*	Gage blocks
Levels – Electronic Level Systems	---	3.7 arc seconds	Gage blocks and sine bar
Micrometers[3] – Micrometer Heads Laser Micrometers Bore Micrometers Bench Micrometers 	Up to 3 in (3 to 48) in Up to 2 in Up to 2 in (0.2 to 0.5) in (0.5 to 1.4) in (1.4 to 2.5) in (2.5 to 4.5) in (4.5 to 6) in Up to 1 in (>1 to 5) in (>5 to 12) in	20 µin + 12 µin/in 64 µin + 1.5 µin/in 8.2 µin 17 µin 47 µin 66 µin 76 µin 86 µin 99 µin 17 µin 28 µin 46 µin	Gage blocks Electronic probe Pin/plug gages Ring gages Gage blocks
Optical Comparators, Microscopes[3] – Length Radius/Diameter Angle	 Up to 3 in (3 to 9) in (9 to 16) in (16 to 24) in Up to 1 in Up to 360 °	 250 µin 210 µin 140 µin 150 µin 200 µin 0.03°	 Glass artifact Glass artifact & glass magnification scale

Parameter/Equipment	Range	CMC[2, 5, 10] (±)	Comments
Optical Comparators, Microscopes[3] – cont. Magnification	10x 20x 31.25x 50x 62.5x 100x	700 µin 580 µin 520 µin 380 µin 360 µin 340 µin	Glass artifact & glass magnification scale
Protractors[3]	Up to 90 °	0.001°	Gage blocks/sine plate
Parallel Measurements[3] – Measure & Measuring Equipment	Up to 1 in diameter Up to 10 in length	5.7 µin 34 µin	Optical parallels Electronic probe
Rulers[3]	Up to 72 in Up to 1000 mm (1000 to 1800) mm	0.02 in 0.50 mm 0.55 mm	Ruler
Sine Bars – Length Parallelism	 (5 to 10) in (5 to 10) in	 60 µin 34 µin	 UMM Electronic probe
Surface Finish Meters[3] – Profilometers	(12 to 122) Ra	2.1 µin + 0.01 µin/µin	Roughness specimens
Spherical Diameter – Measure & Measuring Equipment	Up to 5 in	23 µin + 1.2 µin/in	UMM
Spherical Diameter[3] –	Up to 6 in	200 µin	Micrometer
Surface Plates[3] – Flatness Repeatability	 Up to 107 diagonal in Up to 0.015 in	 $(3.1\sqrt{D} + 170)$ µin 38 µin	 Electronic level system D = diagonal inches Repeatability gage

Parameter/Equipment	Range	CMC[2] (±)	Comments
Taper Thread Plug[3] –			
Pitch Diameter	(4 to 80) TPI	130 µin	Gage blocks, thread wires, measuring machine
Major Diameter	Up to 2 in	90 µin	
Notch Length	Up to 2 in	100 µin	Height gage
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	(4 to 80) TPI	95 µin	Gage blocks, thread wires, measuring machine
Major Diameter	Up to 1 in (1 to 1.5) in (1.5 to 4) in	35 µin 38 µin 150 µin	
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	(4 to 80) TPI	27 µin	UMM
Metric	(0.2 to 10) pitch	0.69 µm	
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/Calibration[1]

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Angle[3, 7] – Measure	Up 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 Up to 300 mm (300 to 1800) mm	0.000 33 in 0.01 in 0.008 mm 0.6 mm	Optical comparator Steel ruler Optical comparator Steel ruler

IV. Electrical – DC/Low Frequency

Parameter/Equipment	Frequency	CMC[2, 10] (±)	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	0.03 % + 20 nA 0.02 % + 15 nA 0.01 % + 9.5 nA 0.03 % + 21 nA 0.1 % + 82 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	0.02 % + 150 nA 0.007 % + 480 nA 0.01 % + 42 nA 0.02 % + 190 nA 0.1 % + 0.86 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	0.03 % + 570 nA 0.02 % + 510 nA 0.01 % + 420 nA 0.02 % + 2.0 µA 0.11 % + 5.9 µA	
(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	0.02 % + 24 µA 0.01 % + 15 µA 0.01 % + 3.0 µA 0.02 % + 12 µA 0.09 % + 58 µA	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Current – Generate (cont)			
(0.22 to 2.2) A	(20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.02 % + 150 µA 0.03 % + 45 µA 0.04 % + 180 µA 0.7 % + 290 µA	Fluke 5720A
(2.2 to 11) A	(0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.03 % + 3.3 mA 0.08 % + 3.8 mA 0.34 % + 7.5 mA	Fluke 5725A
(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	0.23 % + 120 nA 0.18 % + 110 nA 0.14 % + 120 nA 0.35 % + 170 nA 0.93 % + 220 nA 1.8 % + 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 % + 210 nA 0.15 % + 150 nA 0.12 % + 110 nA 0.28 % + 110 nA 0.59 % + 270 nA 1.2 % + 690 nA	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Current[3] – Generate (cont)			
(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 % + 2.2 µA 0.10 % + 3.6 µA 0.05 % + 2.2 µA 0.09 % + 2.3 µA 0.23 % + 3.5 µA 0.46 % + 4.6 µA	Fluke 5520A
(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) kH	0.20 % + 45 µA 0.10 % + 32 µA 0.05 % + 22 µA 0.12 % + 50 µA 0.23 % + 120 µA 0.46 % + 230 µA	
(0.33 o 1.1) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.10 % + 27 µA 0.05 % + 23 µA 0.11 % + 62 µA 0.24 % + 110 µA	
(1.1 to 3) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.21 % + 130 µA 0.08 % + 100 µA 0.69 % + 1.2 mA 2.9 % + 5.4 mA	
(3 to 11) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.06 % + 3.9 mA 0.1 % + 4.7 mA 3.5 % + 160 µA	
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.14 % + 6.2 mA 0.17 % + 6.8 mA 3.4 % + 16 mA	
(20.5 to 55) A	(45 to 65) Hz (65 to 440) Hz	0.65 % + 460 µA 1.1 % + 20 mA	
(55 to 150) A	(45 to 65) Hz (65 to 440) Hz	0.65 % + 1.1 mA 1.1 % + 40 mA	
(150 to 550) A	(45 to 65) Hz (65 to 100) Hz (100 to 440) Hz	0.65 % + 20 mA 1.1 % + 160 mA 1.1 % + 190 mA	
(550 to 1025) A	(45 to 65) Hz (65 to 440) Hz	0.66 % + 85 mA 1.1 % + 570 mA	Fluke 5520A & 50 turn coil

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Current – Measure			
(0 to 200) µA	(1 to 10) Hz (0.01 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.03 % + 25 nA 0.03 % + 26 nA 0.08 % + 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	0.03 % + 300 nA 0.02 % + 550 nA 0.07 % + 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	0.03 % + 2.4 µA 0.03 % + 2.4 µA 0.07 % + 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 0.03 % + 29 µA 0.07 % + 28 µA	
(0.2 to 2) A	(0.01 to 2) kHz (2 to 10) kHz (10 to 30) kHz	0.07 % + 310 µA 0.08 % + 240 µA 0.4 % + 320 µA	
(2 to 20) A	(0.01 to 2) kHz (2 to 10) kHz	0.08 % + 4.6 mA 0.28 % + 5.6 mA	
(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 0.07 % + 38 nA 0.07 % + 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 0.07 % + 280 nA 0.03 % + 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 0.07 % + 2.8 µA 0.03 % + 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 0.07 % + 28 µA 0.03 % + 28 µA	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Current[3] – Measure (cont)			
(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 0.09 % + 320 µA 0.12 % + 280 µA	HP 3458A, opt 002
(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
AC Power[3] – Generate			
Watts (Φ = 0°) (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 Note: CMC is higher if Φ is non-zero or if frequency is greater than 65 Hz. (Upper frequency limit: 30 kHz)
(9 to 33) mA	(0.30 to 10) mW (0.003 to 33) W	0.13 % 0.13 %	
(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 % 0.10 %	
(0.33 to 0.9) A	(11 to 300) mW (0.11 to 900) W	0.087 % 0.081 %	
AC Power[3] – Generate (cont)			
(0.9 to 2.2) A	(30 to 720) mW (0.30 to 2000) W	0.090 % 0.084 %	Fluke 5520A Note: CMC is higher if Φ is non-zero or if frequency is greater than 65 Hz. (Upper frequency limit: 30 kHz)
(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/Equipment	Frequency	CMC[2, 10] (±)	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	0.03 % + 4.6 µV 0.01 % + 4.6 µV 0.01 % + 4.6 µV 0.02 % + 4.7 µV 0.05 % + 5.8 µV 0.10 % + 12 µV 0.15 % + 23 µV 0.31 % + 23 µV	Fluke 5720A
(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	0.03 % + 4.6 µV 0.01 % + 4.6 µV 88 µV/V + 4.6 µV 0.02 % + 4.7 µV 0.05 % + 5.8 µV 0.10 % + 13 µV 0.14 % + 23 µV 0.27 % + 30 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	0.03 % + 8.3 µV 0.01 % + 8.1 µV 87 µV/V + 8.3 µV 0.01 % + 5.8 µV 0.03 % + 120 µV 0.09 % + 28 µV 0.14 % + 30 µV 0.30 % + 45 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	0.03 % + 69 µV 89 µV/V + 31 µV 46 µV/V + 11 µV 15 µV/V + 690 µV 56 µV/V + 350 µV 0.04 % + 93 µV 0.11 % + 210 µV 0.18 % + 300 µV	
(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	0.03 % + 670 µV 92 µV/V + 230 µV 46 µV/V + 80 µV 64 µV/V + 640 µV 0.01 % + 280 µV 0.03 % + 630 µV 0.11 % + 1.8 mV 0.15 % + 4.0 mV	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Voltage – Generate (cont)			
(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	0.03 % + 4.9 mV 92 µV/V + 2.4 mV 55 µV/V + 790 µV 88 µV/V + 1.3 mV 0.02 % + 3.3 mV 0.09 % + 19 mV 0.50 % + 41 mV 0.83 % + 87 mV	Fluke 5720A
(220 to 1100) V	(15 to 40) Hz (0.040 to 1) kHz (1 to 20) kHz (20 to 30) kHz	0.03 % + 16 mV 95 µV/V + 4.2 mV 0.02 % + 5.3 mV 0.04 % + 16 mV	
(220 to 750) V	(30 to 50) kHz (50 to 100) kHz	0.04 % + 10 mV 0.15 % + 68 mV	Fluke 5720A and Fluke 5725A
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	0.05 % + 33 µV 20 µV/V + 100 µV 24 µV/V + 120 µV 0.04 % + 70 µV 0.27 % + 80 µV 0.81 % + 110 µV	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	0.04 % + 11 µV 0.02 % + 19 µV 31 µV/V + 250 µV 0.02 % + 140 µV 0.08 % + 100 µV 0.24 % + 87 µV	
(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	0.04 % + 60 µV 0.02 % + 130 µV 50 µV/V + 1.9 mV 0.02 % + 1.2 mV 0.07 % + 430 µV 0.28 % + 810 µV	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	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	0.04 % + 790 µV 0.02 % + 710 µV 0.03 % + 720 µV 0.04 % + 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	0.02 % + 3.1 mV 0.02 % + 7.2 mV 0.03 % + 11 mV 0.03 % + 20 mV 0.23 % + 63 mV	
(330 to 1020) V	45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.04 % + 20 mV 0.03 % + 20 mV 0.03 % + 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 0.09 % + 1.5 µV 0.05 % + 1.6 µV 0.09 % + 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	0.1 % + 1.5 µV 0.04 % + 1.5 µV 0.03 % + 1.5 µV 0.05 % + 2.3 µV 0.07 % + 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	0.03 % + 1.7 µV 0.02 % + 1.6 µV 0.01 % + 1.6 µV 0.02 % + 2.7 µV 0.04 % + 3.1 µV 0.1 % + 4.6 µV 0.1 % + 9.2 µV 0.2 % + 9.2 µV	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Voltage – Measure (cont)			Fluke 5790A
(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	0.03 % + 2.6 µV 0.02 % + 1.8 µV 81 µV/V + 1.8 µV 0.02 % + 2.3 µV 0.03 % + 2.9 µV 0.06 % + 4.7 µV 0.08 % + 9.3 µV 0.13 % + 9.3 µV	
(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	0.03 % + 1.8 µV 0.01 % + 1.8 µV 47 µV/V + 1.9 µV 87 µV/V + 2.7 µV 0.02 % + 4.9 µV 0.03 % + 5.0 µV 0.05 % + 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 0.08 % + 0.28 mV	Fluke 5790A
(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	0.02 % + 69 µV 58 µV/V + 55 µV 14 µV/V + 50 µV 37 µV/V + 49 µV 58 µV/V + 67 µV 0.01 % + 0.34 mV 0.02 % + 0.35 mV 0.09 % + 0.36 mV	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Voltage – Measure (cont)			
(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	0.02 % + 92 µV 67 µV/V + 96 µV 26 µV/V + 23 µV 57 µV/V + 16 µV 92 µV/V + 16 µV 0.02 % + 50 µV 0.03 % + 1.7 mV 0.12 % + 1.5 mV	Fluke 5790A
(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	0.02 % + 40 µV 77 µV/V + 71 µV 32 µV/V + 17 µV 54 µV/V + 67 µV 89 µV/V + 120 µV 0.02 % + 40 µV 0.05 % + 190 µV 0.14 % + 430 µV	
(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	0.02 % + 290 µV 79 µV/V + 150 µV 36 µV/V + 130 µV 66 µV/V + 69 µV 0.01 % + 120 µV 0.02 % + 0.86 mV 0.05 % + 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	0.02 % + 460 µV 80 µV/V + 550 µV 37 µV/V + 330 µV 79 µV/V + 320 µV 0.01 % + 260 µV 0.02 % + 2.8 mV 0.056 % + 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	0.02 % + 4.3 mV 0.01 % + 4.3 mV 44 µV/V + 4.5 mV 0.01 % + 5.3 mV 0.06 % + 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	0.02 % + 4.2 mV 0.01 % + 4.2 mV 45 µV/V + 2.0 mV 0.02 % + 2.0 mV 0.06 % + 6.9 mV	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	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	0.03 % + 3.7 µV 0.02 % + 1.5 µV 0.03 % + 1.5 µV 0.1 % + 1.8 µV 0.6 % + 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 0.01 % + 5.6 µV 0.03 % + 5.8 µV 0.05 % + 62 µV 0.3 % + 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 0.07 % + 380 µV 0.3 % + 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 0.02 % + 400 µV 0.03 % + 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	0.02 % + 7.7 mV 0.02 % + 4.0 mV 0.02 % + 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	0.05 % + 55 mV 0.05 % + 37 mV 0.07 % + 38 mV 0.14 % + 43 mV 0.35 % + 43 mV	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Voltage[3] – HV Measure			
(1 to 10) kV	60 Hz	0.16 % - 0.20 V	Vitrek 4700 with HVL35, HVL100
(10 to 35) kV	60 Hz	0.16 % - 5.8 V	
(35 to 100) kV	60 Hz	0.20 % - 15 V	
AC Voltage Flatness – Measure			
(0.005 to 7) V	10 Hz to 30 MHz	0.47 %	Fluke 5790A
(0.005 to 5.5) V	(10 to 1100) MHz	1.6 %	Power meter & power sensors
Capacitance[3] – Generate			
Synthesized Capacitance			
(0.19 to 0.4) nF	(0.01 to 10) kHz	0.58 % + 12 pF	Fluke 5520A
(0.4 to 1.1) nF	(0.01 to 10) kHz	0.58 % + 12 pF	
(1.1 to 3.3) nF	(0.01 to 3) kHz	0.57 % + 12 pF	
(3.3 to 11) nF	(0.01 to 1) kHz	0.28 % + 14 pF	
(11 to 33) nF	(0.01 to 1) kHz	0.29 % + 120 pF	
(33 to 110) nF	(0.01 to 1) kHz	0.28 % + 140 pF	
(110 to 330) nF	(0.01 to 1) kHz	0.28 % + 390 pF	
(0.33 to 1.1) µF	(10 to 600) Hz	0.28 % + 1.4 nF	
(1.1 to 3.3) µF	(10 to 300) Hz	0.28 % + 3.9 nF	
(3.3 to 11) µF	(10 to 150) Hz	0.27 % + 15 nF	
(11 to 33) µF	(10 to 120) Hz	0.28 % + 43 nF	
(33 to 110) µF	(10 to 80) Hz	0.43 % + 170 nF	
(110 to 330) µF	(0 to 50) Hz	0.49 % + 480 nF	
(0.33 to 1.1) mF	(0 to 20) Hz	0.51 % + 1.4 µF	
(1.1 to 3.3) mF	(0 to 6) Hz	0.49 % + 5.0 µF	
(3.3 to 11) mF	(0 to 2) Hz	0.37 % + 36 µF	
(11 to 33) mF	(0 to 0.6) Hz	0.83 % + 49 µF	
(33 to 110) mF	(0 to 0.2) Hz	0.11 % + 360 µF	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
Capacitance[3] – Generate (cont)			Fluke 5520A
Discrete Capacitance Points			
1 pF	1 kHz	0.85 fF	
10 pF	1 kHz	1.6 fF	
100 pF	1 kHz	6.5 fF	
1000 pF	1 kHz	54 fF	
1 nF	(20 to 70) Hz 70 Hz to 100 kHz	1.8 % 0.55 %	Agilent 16380A standard capacitors
2 nF	(20 to 40) Hz 40 Hz to 100 kHz	1.0 % 0.55 %	Genrad 1409 series standard capacitors
10 nF	20 Hz to 100 kHz	0.31 %	
100 nF	20 Hz to 50 kHz	0.17 %	
200 nF	20 Hz to 10 kHz	0.16 %	
1000 nF	20 Hz to 30 kHz	0.34 %	
Capacitance[3] – Measure			
(1 to 10) pF	(10 to 100) kHz 100 kHz to 1 MHz	1.0 % 0.34 %	Keysight E4980AL
(10 to 100) pF	(1 to 10) kHz 10 kHz to 1 MHz	1.2 % 0.15 %	
(100 to 1000) pF	(100 to 1000) Hz 1 kHz to 1 MHz	1.9 % 0.17 %	
(1 to 10) nF	(20 to 100) Hz 100 Hz to 1 MHz	1.5 % 0.28 %	
(10 to 100) nF	20 Hz to 1 MHz	0.24 %	
(100 to 1000) nF	20 Hz to 1 MHz	0.11 %	
(1 to 10) µF	20 Hz to 1 MHz	0.31 %	
(10 to 100) µF	20 Hz to 100 kHz 100 kHz to 1 MHz	0.33 % 2.6 %	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
Capacitance[3] – Measure (cont)			
(100 to 1000) µF	(20 to 1000) Hz (1 to 100) kHz	0.16 % 2.8 %	Keysight E4980AL
(1 to 10) mF	(20 to 125) Hz (125 to 1000) Hz	0.32 % 0.55 %	
(10 to 100) mF	(20 to 125) Hz	1.2 %	
(100 to 1000) mF	20 Hz	4.2 %	
Capacitance[3] – Measure			
(0.1 to 1) mF (1 to 10) mF (10 to 110) mF	DC DC DC	0.01 % 0.01 % 0.02 %	Charge technique using DC source & voltmeter
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	41 µA/A + 7.1 nA 35 µA/A + 8.5 nA 35 µA/A + 54 nA 47 µA/A + 850 nA 67 µA/A + 24 µA	Fluke 5720A
	(2.2 to 11) A	0.04 % + 570 µA	Fluke 5725A
	(11 to 20.5) A	0.11 % + 2.0 mA	Fluke 5520A & 50 turn coil
	(20.5 to 100) A	0.63 % + 0.12 A	Valhalla 2575A with DMM
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	0.02 % + 24 nA 0.01 % + 69 nA 0.01 % + 360 nA 0.01 % + 5.3 µA 0.02 % + 200 µA 0.04 % + 85 µA 0.06 % + 690 µA 0.11 % + 1.9 mA	Fluke 5520A Fluke 5520A
	(20.5 to 100) A (100 to 1000) A	0.58 % + 0.16 A 0.59 % + 0.55 A	Fluke 5520A & 50 turn coil

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
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 (20 to 100) A (100 to 1000) A	14 µA/A + 660 pA 15 µA/A + 5.0 nA 16 µA/A + 53 nA 43 µA/A + 200 nA 0.02 % + 28 µA 0.06 % + 1.9 mA 0.62 % + 0.26 A 2.4 % + 0.74 A	Fluke 8508A Valhalla 2575A with DMM 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 (1 to 10) A (10 to 1000) 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 23 mA 2.4 % + 0.74 A	HP 3458A, opt 002 Fluke 45 Fluke 376 clamp
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	0.04 % 94 µW/W 94 µW/W 95 µW/W 80 µW/W	Fluke 5520A
(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	0.04 % 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	0.04 % 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 % 0.03 % 0.03 % 0.03 % 0.03 %	

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
DC Power[3] – Generate (cont)			
(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 % 0.070 %	Fluke 5520A
DC Voltage – 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
DC Voltage[3] – Generate	(0 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1020) V	23 µV/V + 1.3 µV 13 µV/V + 2.2 µV 14 µV/V + 24 µV 21 µV/V + 190 µV 21 µV/V + 2.0 mV	Fluke 5520A
Fixed Point[3]	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
DC Voltage – 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
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	5.4 µV/V + 400 nV 4.4 µV/V + 600 nV 4.4 µV/V + 2.7 µV 6.7 µV/V + 58 µV 5.9 µV/V + 1.3 mV	HP 3458A
Fixed Point[3]	10 V	1 µV/V	Fluke 732A with Keithley 182 and Dataproof 160A

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
DC Voltage[3] – HV Measure	(1 to 10) kV (10 to 35) kV (35 to 100) kV	0.05 % - 0.35 V 0.09 % - 5.6 V 0.16 % - 37 V	Vitrek 4700 with HVL35, HVL100
Oscilloscope[3] –			
Amplitude DC 50 Ω 1 MΩ	 (0 to 6.6) V (0 to 130) V	 0.29 % + 49 µV 0.06 % + 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 + 1200*t*) µs/s 5.0 µs/s	*t* = time in seconds
Inductance[3] – Generate			
2 mH	(20 to 60) Hz 60 Hz to 10 kHz	1.8 % 0.60 %	Genrad 1482 series standard inductors
100 mH	20 Hz to 10 kHz	0.31 %	
1 H	20 Hz to 10 kHz	0.31 %	
10 H	20 Hz to 1 kHz	0.34 %	
Inductance[3] – Measure			
(100 to 1000) nH	(100 to 300) kHz 300 kHz to 1 MHz	0.75 % 0.27 %	Keysight E4980AL
(1 to 10) µH	(10 to 100) kHz 100 kHz to 1 MHz	0.89 % 0.12 %	

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Inductance[3] – Measure (cont)			Keysight E4980AL
(10 to 100) µH	(1 to 10) kHz 10 kHz to 1 MHz	1.3 % 0.13 %	
(100 to 1000) µH	10 Hz to 1 kHz 1 kHz to 1 MHz	2.8 % 0.18 %	
(1 to 10) mH	(20 to 125) Hz 125 Hz to 1 MHz	2.7 % 0.24 %	
(10 to 100) mH	(20 to 100) Hz 100 Hz to 1 MHz	0.64 % 0.16 %	
(100 to 1000) mH	20 Hz to 300 kHz 300 kHz to 1 MHz	0.15 % 0.4 %	
(1 to 10) H	20 Hz to 100 kHz 100 kHz to 1 MHz	0.11 % 3.5 %	
(10 to 100) H	20 Hz to 10 kHz (10 to 100) kHz	0.1 % 0.41 %	
Pulse Characterization –			
Transition (Rise / Fall) Time – Measure	1 kHz to 2 MHz Nominal 250 ps	53 ps	Fluke 5520A-SC1100
	(2 to 10) MHz Nominal 300 ps	53 ps	
Phase – Generate			
(0 to 999.999)°	0.02 Hz to 6.25 kHz (6.25 to 50) kHz (50 to 100) kHz	0.02° 0.03° 0.06°	Clark Hess 5000
Phase – Measure			
(0 to 360)° (-180 to 180)°	(0.02 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.06° 0.06° 0.002*f* – 0.05°	Clark Hess 6000 *f* = frequency in kHz

Parameter/Equipment	Range	CMC[2, 10] (±)	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 0.2 mΩ 0.2 mΩ 0.5 mΩ 1.1 mΩ 2.0 mΩ 8.8 mΩ 17 mΩ 88 mΩ 0.2 Ω 1.1 Ω 2.0 Ω 24 Ω 40 Ω 360 Ω 890 Ω 12 kΩ	Fluke 5720A
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 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ	45 µΩ/Ω + 1.2 mΩ 34 µΩ/Ω + 1.8 mΩ 26 µΩ/Ω + 3.0 mΩ 30 µΩ/Ω + 3.5 mΩ 31 µΩ/Ω + 4.0 mΩ 30 µΩ/Ω + 34 mΩ 30 µΩ/Ω + 59 mΩ 30 µΩ/Ω + 340 mΩ 30 µΩ/Ω + 590 mΩ 35 µΩ/Ω + 3.0 Ω 35 µΩ/Ω + 5.4 Ω 68 µΩ/Ω + 41 Ω 0.01 % + 140 Ω 0.03 % + 3.6 kΩ 0.06 % + 6.0 kΩ 0.35 % + 110 kΩ 1.7 % + 870 kΩ 0.48 µΩ/Ω 3.0 µΩ/Ω 2.7 µΩ/Ω 0.75 µΩ/Ω 2.7 µΩ/Ω	Fluke 5520A Fluke 742A

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Resistance – 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 (20 to 200) MΩ (0.2 to 2) GΩ	19 μΩ/Ω + 4.4 μΩ 11 μΩ/Ω + 16 μΩ 8.9 μΩ/Ω + 55 μΩ 8.9 μΩ/Ω + 500 μΩ 8.9 μΩ/Ω + 5.5 mΩ 9.1 μΩ/Ω + 59 mΩ 11 μΩ/Ω + 1.2 Ω 20 μΩ/Ω + 110 Ω 70 μΩ/Ω + 12 kΩ 0.06 % + 1.2 MΩ	Fluke 8508A
Resistance[3] – Measure	(0 to 12) Ω (12 to 120) Ω (0.12 to 1.2) kΩ (1.2 to 12) kΩ (12 to 120) kΩ (0.12 to 1.2) MΩ (1.2 to 12) MΩ (12 to 120) MΩ (0.12 to 1.2) GΩ	18 μΩ/Ω + 58 μΩ 13 μΩ/Ω + 730 μΩ 12 μΩ/Ω + 430 μΩ 12 μΩ/Ω + 4.0 mΩ 12 μΩ/Ω + 39 mΩ 18 μΩ/Ω + 2.2 Ω 58 μΩ/Ω + 120 Ω 0.06 % + 1.3 kΩ 0.58 % + 7.0 kΩ	HP 3458A
AC Resistance			
(0.05 to 0.1) Ω	(125 to 1000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	3.7 % 2.1 % 1.5 % 1.3 % 1.2 % 1.4 %	Keysight E4980AL
(0.1 to 1) Ω	(20 to 125) Hz (125 to 1000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	3.7 % 1.8 % 1.1 % 0.84 % 0.69 % 0.68 % 0.90 %	
(1 to 10) Ω	(20 to 125) Hz (125 to 1000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	0.92 % 0.49 % 0.46 % 0.34 % 0.39 % 0.39 % 0.91 %	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Resistance (cont)			Keysight E4980AL
(10 to 100) Ω	(20 to 125) Hz	0.39 %	
	(125 to 1000) Hz	0.35 %	
	(1 to 10) kHz	0.31 %	
	(10 to 100) kHz	0.34 %	
	(100 to 300) kHz	0.85 %	
	(0.3 to 1) MHz	0.86 %	
	(1 to 2) MHz	0.91 %	
(100 to 300) Ω	(20 to 125) Hz	0.87 %	
	(125 to 1000) Hz	0.30 %	
	(1 to 10) kHz	0.31 %	
	(10 to 100) kHz	0.85 %	
	(100 to 300) kHz	0.85 %	
	(0.3 to 1) MHz	0.85 %	
	(1 to 2) MHz	0.87 %	
(0.3 to 1) kΩ	(20 to 125) Hz	0.16 %	
	(125 to 1000) Hz	0.30 %	
	(1 to 10) kHz	0.30 %	
	(10 to 100) kHz	0.85 %	
	(100 to 300) kHz	0.85 %	
	(0.3 to 1) MHz	0.85 %	
	(1 to 2) MHz	0.87 %	
(1 to 3) kΩ	(20 to 125) Hz	0.33 %	
	(125 to 1000) Hz	0.30 %	
	(1 to 10) kHz	0.85 %	
	(10 to 100) kHz	0.85 %	
	(100 to 300) kHz	0.85 %	
	(0.3 to 1) MHz	0.85 %	
	(1 to 2) MHz	0.87 %	
(3 to 10) kΩ	(20 to 125) Hz	0.33 %	
	(125 to 1000) Hz	0.30 %	
	(1 to 10) kHz	0.85 %	
	(10 to 100) kHz	0.85 %	
	(100 to 300) kHz	0.85 %	
	(0.3 to 1) MHz	0.85 %	
	(1 to 2) MHz	0.90 %	

Parameter/Equipment	Frequency	CMC[2, 10] (±)	Comments
AC Resistance (cont)			
(10 to 30) kΩ	(20 to 125) Hz (125 to 1000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	0.33 % 0.85 % 0.85 % 0.85 % 0.86 % 0.86 % 0.91 %	Keysight E4980AL
(30 to 100) kΩ	(20 to 125) Hz (125 to 1000) Hz (1 to 10) kHz (10 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	0.34 % 0.85 % 0.85 % 0.85 % 0.87 % 0.87 % 0.94 %	
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	0.06 °C 0.06 °C 0.08 °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	0.05 °C 0.05 °C 0.05 °C 0.06 °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	0.05 °C 0.06 °C 0.06 °C 0.07 °C 0.1 °C 0.1 °C 0.11 °C 0.13 °C	

Parameter/Equipment	Range	CMC[2, 10] (±)	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	0.04 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.08 °C 0.08 °C 0.28 °C	Fluke 5520A
PtNi 385, 120 Ω (Ni 120)	(-80 to 0) °C (>0 to 100) °C (>100 to 260) °C	0.1 °C 0.1 °C 0.02 °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	0.05 °C 0.05 °C 0.06 °C 0.07 °C 0.08 °C 0.1 °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	0.06 °C 0.06 °C 0.08 °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 0.36 °C 0.40 °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, 10] (±)	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	0.40 °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 0.48 °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 1.466 01 n_D 1.536 79 n_D	0.000 04 n_D 0.000 05 n_D 0.000 05 n_D 0.000 05 n_D 0.000 05 n_D 0.000 08 n_D 0.000 08 n_D	Standard solutions
Salt (NaCl)	(0 to 50) % NaCl solution	0.03 % NaCl solution	
Viscosity Meter Calibration[3]	(1 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	(1 to 100) mm²/s (100 to 1000) mm²/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	0.02 sccm + 1.5 % 0.01 slpm + 1.1 % 0.04 slpm + 1.2 %	Comparison to flow standards
Liquid	0 to 34 lpm	0.17 % + 0.19 lpm	Measured weight over time
Volume –Volumetric Apparatus (Beakers, Cylinders, Flasks, etc.)	(1 to 4000) mL (4000 to 19 000) mL	0.01 % 0.03 %	Balance & weights

VI. Mechanical

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Durometer Calibrators –			
Beam Type	Type A Type D	0.03 Duro 0.03 Duro	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	2.0 lbf 8.0 lbf 25 lbf	Morehouse 1000 series proving rings
Force[3] – Compression & Tension, Measure & Measuring Equipment	Up to 2.5 N (2.5 to 50) N (11.2 to 50) lbf (50 to 500) lbf (500 to 2000) lbf (2000 to 30 000) lbf	0.001 N 0.01 N 1.6E-4 lbf/lbf + 0.0015 lbf (1.3E-7·F^2 + 1.2E-4·F + 4.2E-3) lbf 3.0 lbf 21 lbf	Deadweights, load cells F is the applied force in lbf
Measure Only – Compression Only	(30 000 to 200 000) lbf	130 lbf	Load cell
Extensometers[3]	Up to 20 in	2.3 µin/in + 8.5 µin	Measuring machine, gage blocks, micrometer, bench micrometer, linear encoder, extension rod
Indirect Verification of Rockwell Hardness Testers[3]	HRA: Low Medium High HRBW: Low Medium High HRC: Low Medium High	 0.53 HRA 0.52 HRA 0.64 HRA 1.8 HRBW 1.3 HRBW 1.2 HRBW 0.98 HRC 1.2 HRC 0.73 HRC	Indirect verification per ASTM E18

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Indirect Verification of Rockwell Hardness Testers[3] (cont)	HRD: Low Medium High HRF: Low Medium High HRG: Low Medium High HRRW: Low Medium High HRSW: Low High HR15N: Low Medium High HR30N: Low Medium High HR45N: Low Medium High HR15T: Low Medium High	 0.77 HRD 0.86 HRD 0.36 HRD 1.0 HRF 0.92 HRF 0.67 HRF 1.2 HRG 1.1 HRG 0.40 HRG 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	Indirect verification per ASTM E18

Parameter/Equipment	Range	CMC[2, 5, 10] (±)	Comments
Indirect Verification of Rockwell Hardness Testers[3] (cont)	HR30T: Low Medium High HR45T: Low Medium High	 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 10/3000/15	 (50 to 70) HBW (80 to 101) HBW 239 HBW 349 HBW 416 HBW	 2.5 HBW 3.7 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	(1 to 10) mm/min (10 to 450) mm/min (450 to 1020) mm/min	1.1 % + 0.0011 mm/min 0.39 % + 0.023 mm/min 1.3 % - 4.7 mm/min	Linear scale & stopwatch
Mass – Measure, Fixed Points	30 kg 20 kg 10 kg 5 kg 3 kg 2 kg 1 kg 500 g 300 g 200 g 100 g 50 g	7.3 mg 6.3 mg 5.4 mg 2.7 mg 2.6 mg 2.6 mg 2.6 mg 2.6 mg 2.6 mg 59 µg 48 µg 15 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)	30 g 20 g 10 g 5 g 3 g 2 g 1 g 500 mg 300 mg 200 mg 100 mg 50 mg 30 mg 20 mg 10 mg 5 mg 3 mg 2 mg 1 mg	14 µg 8.9 µg 8.3 µg 6.4 µg 6.1 µg 5.7 µg 5.6 µg 5.5 µg 5.7 µg 5.5 µg 5.5 µg 5.5 µg 6.0 µg 5.6 µg 5.6 µg 5.4 µg 5.7 µg 5.4 µg 5.4 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	Up to 0.2 psi (0.2 to 1000) psi	0.000 73 psi 0.003 %	Fluke 6270A Ruska 2465
Gauge Only	(1000 to 15 000) psig	0.008 %	Ruska 2475
Hydraulic	(2 to 20 000) psig	0.008 %	Ruska 2485
Pressure[3] – Pneumatic Gauge, Negative Gauge, & Absolute	Up to 2 inH_2O	0.002 inH_2O	Microtector
Pressure – Gauge & Absolute	Up to 1 inH_2O Up to 4 inH_2O Up to 20 inH_2O (-20 to 20) inH_2O Up to 40 inH_2O	0.007 inH_2O 0.08 inH_2O 0.12 inH_2O 0.35 inH_2O 0.23 inH_2O	Manometers

Parameter/Equipment	Range	CMC[2,5,10] (±)	Comments
Pressure[3] – Pneumatic Gauge, Negative Gauge, & Absolute cont.			
Pressure – Gauge Only	(-15 to 15) psig (15 to 30) psig (30 to 100) psig (100 to 500) psig (500 to 1000) psig (1000 to 10 000) psig	0.02 psig 0.03 psig 0.06 psig 0.29 psig 0.62 psig 4.6 psig	Pressure transducers
Scales & Balances[3]	(0.01 to 1) g (1 to 200) g (0.2 to 2) kg (2 to 11) kg (25 to 3000) lb (3000 to 12 000) lb	120 µg/g + 29 µg 4.6 µg/g + 130 µg 6.4 µg/g + 1.0 µg 110 µg/g + 40 mg 0.01 % 2.1 lb	Certified weights, NIST Handbook 44 E2, Class 1
Tachometers[3] –			
Contact	(50 to 100) rpm (100 to 500) rpm (500 to 1000) rpm (1000 to 1500) rpm (1500 to 2000) rpm	1.2 rpm 2.2 rpm 0.86 rpm + 0.026 % 0.84 rpm + 0.035 % 5.1 rpm	Tachometer test station signal generator
Strobo	Up to 500 rpm (500 to 20 000) rpm	0.01 rpm 0.05 rpm	
Photo	Up to 500 rpm (500 to 3000) rpm (3000 to 9000) rpm (9000 to 99 999) rpm	0.009 rpm 0.008 rpm 0.48 rpm 3.0 rpm	
Torque Transducers	(4 to 80) ozf·in (5 to 60) lbf·in (5 to 250) lbf·ft (250 to 1000) lbf·ft	0.05 % 0.04 % 0.07 % 0.03 %	Torque arms & Class F weights

Parameter/Equipment	Range	CMC[2,5,10] (±)	Comments
Torque Wrenches, Tools[3]	(8 to 80) ozf·in (5 to 20) lbf·in (20 to 50) lbf·in (50 to 250) lbf·in (20 to 100) lbf·ft (100 to 250) lbf·ft (100 to 1000) lbf·ft	0.23 ozf·in 0.03 lbf·in 0.06 lbf·in 0.9 lbf·in 0.2 lbf·ft 1.0 lbf·ft 1.2 lbf·ft	Torque transducers

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	0.007 mm	Bore micrometer
Piston Tip Diameter & Length, Capillary Bore Length	(9 to 25.4) mm	0.003 mm	Micrometer
Temperature Accuracy	(180 to 300) °C	0.09 °C	Digital thermometer

Parameter/Equipment	Range	CMC[2] (±)	Comments
Capillary Rheometers[3] – Rubber			ASTM D 5099
Barrel Inside Diameter & Uniformity	(9 to 22) mm	0.007 mm	Bore micrometer
Piston Tip Diameter & Length, Capillary Bore Length	(9 to 25.4) mm	0.003 mm	Micrometer
Temperature Accuracy	(10 to 190) °C	0.09 °C	Digital thermometer
Crosshead Speed	Up to 25.4 mm/min	0.05 mm/min	Dial indicator/stopwatch
Force	Up to 5000 lbf	32 lbf	Load cell
Pressure	Up 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
Indentor Extension & Shape –			
Diameter	Up to 25 mm	0.004 mm	Optical inspection under magnification
Radius	Up to 25 mm	0.01 mm	
Angle	Up to 90°	0.03°	
Extension	Up to 25 mm	0.007 mm	
Indentor Display	(0 to 100) Duro	0.58*R* + 12 µDuro	Gage blocks
Spring Calibration – Force			
Types A, B, E, & O Types C, D, & DO	(0 to 100) Duro (0 to 100) Duro	0.63 Duro 0.61 Duro	Durometer calibrator
Types OO & OOO Type OOO-S Type M	(0 to 100) Duro (0 to 100) Duro (0 to 100) Duro	1.5 Duro 1.3 Duro 1.9 Duro	Balance

Parameter/Equipment	Range	CMC[2] (±)	Comments
Durometer Test Blocks	Types A & D	1.4 Duro	Durometer
Extruders[3] –			
Temperature Controller Accuracy (T/C)	(0 to 350) °C	1.5 °C	TC calibrator
Thermocouple Accuracy	(0 to 350) °C	0.96 °C	Drywell
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	0.04 psi 0.06 psi 0.33 psi 0.60 psi 1.8 psi 6.7 psi	Pressure transducer
Timer Accuracy	Up 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	Up to 7200 s	0.36 s	
Rapid Plastimeter RP3000[3] –			ASTM D3194 ISO 2007
Plate Diameter	(7 to 15) mm	0.04 mm	
Effective Depth	Up to 10 mm	0.04 mm	
Platen Temperature	Ambient to 200 °C	0.23 °C	
Timer	Up to 1 min	0.36 s	
Sample Load	Up to 200 N	1.6 N	
Platen Gap	Up to 10 mm	0.004 mm	

Parameter/Equipment	Range	CMC[2] (±)	Comments
Rubber Press[3] – Laboratory, Compression, Injection, Transfer			ASTM D 3182 ISO 2393
Closing Force	(0 to 2000) lbf (2 to 30) klbf (30 to 100) klbf (100 to 200) klbf (200 to 400) klbf	24 lbf 41 lbf 200 lbf 390 lbf 1.7 klbf	
Temperature Uniformity	(50 to 350) °C	0.42 °C	
Parallelism	(0.001 to 0.01) in/ft	0.0028 in/ft	
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	0.04 psi 0.06 psi 0.33 psi 0.60 psi 1.8 psi 6.7 psi	Pressure transducer
Plunger Linear Displacement	Up to 300 mm (0.3 to 1.8) m	0.1 mm 2.1 mm	Comparison to length standards
Plunger Speed	Up to 900 mm/min	0.41 % + 2.1 mm/min	Length standards/stopwatch
Timer Accuracy	Up to 7200 s	0.72 s	Comparison to stopwatch

Parameter/Equipment	Range	CMC[2] (±)	Comments
Mooney Viscometers[3], Stress Relaxation –			ASTM D 1646
Mooney Torque	Up to 200 Mooney Units	1.6 Mooney Units	Butyl IRM-241
Rotor rpm	2 rpm	0.000 055 RPM	Frequency counter
Die Temperature	(0 to 230) °C	0.23 °C	RTD with indicator
Die Closing Force	Up to 5000 lbf	41 lbf	Load cell with indicator
Rotor Diameter	1.2 in, 1.5 in	0.000 17 in	Micrometers
Rotor Thickness	0.218 in	0.000 16 in	
Oscillating Disk Rheometers[3]			ASTM D2084, ISO 3417
Torque	Up to 200 lbf·in	0.33 lbf·in	OD torsion standard
Die Temperature	(0 to 230) °C	0.23 °C	ASTM D 1349 RTD with indicator
Die Closing Force	Up to 5000 lbf	41 lbf	Load cell with indicator
Rotor Dimensions	1.4 in	0.000 19 in	Micrometers
Disk Oscillation	1.67 Hz	0.000 071 Hz	Frequency counter

Parameter/Equipment	Range	CMC[2] (±)	Comments
Rotorless Cure Meters, Moving Die Rheometers, Rubber Process Analyzers[3] –			ASTM D 5289, ASTM D 6204, ASTM D6601
Torque	Up to 200 lbf·in	0.29 lbf·in	MD torsion standard (Dynamic)
Die Temperature	(0 to 230) °C	0.23 °C	ASTM D 1349
Temperature Stability	(0 to 230) °C	0.09 °C	Thermocouple or RTD with indicator
Die Closing Force	Up to 5000 lbf	41 lbf	Load cell with indicator
Die Gap	Up to 1 in	0.000 16 in	Micrometer
Die Diameter	Up to 2 in	0.0016 in	Caliper
Die Oscillation	(0.02 to 50) Hz	0.020 % 0.0030 Hz	Tachometer
Torque Standards (Torsion Springs), MDR, ODR	Torque up to 200 lbf·in (peak-peak) 10° (peak-peak)	0.27 lbf·in 0.006° arc	Torque standard calibration system

IX. Thermodynamics

Parameter/Equipment	Range	CMC[2, 5, 10] (±)	Comments
Humidity – Measure & Measuring Equipment	(10 to 95) % RH	1.0 % RH	Thunder Scientific 2500
Humidity[3] – Measure & Measuring Equipment	(10 to 90) % RH	2.6 % RH	Vaisala probe

Parameter/Equipment	Range	CMC[2, 5, 10] (±)	Comments
IR Temperature[3] – Measuring Equipment	Ambient to 100 °C (100 to 780) °C (780 to 890) °C	1.3 °C 12 mK/°C + 0.14 °C 11 mK/°C + 0.48 °C	Mikron M316 Ɛ = 0.99 λ = (8 to 14) µm Williamson Blackbody Ɛ = 0.995 λ = (1 to 4) µm
IR Temperature[3] – Measure Blackbody Sources	Ambient to 100 °C (100 to 780) °C (780 to 890) °C	1.3 °C 12 mK/°C + 0.14 °C 11 mK/°C + 0.48 °C	Blackbody source, IR thermometer
Ovens[3] – Temperature Uniformity	Up to 1000 °C	1.5 °C	ASTM E145 ASTM D5423 ASTM D 5374 AMS 2750 ASTM A991
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, 5, 10] (±)	Comments
Temperature[3] – Measure, Temperature Baths, Dry Wells			
Temperature Uniformity	(-196 to 660) °C	3.3 mK	SPRT, Thermometry Bridge
Temperature Accuracy	(-196 to 660) °C (660 to 961) °C	5.9 mK 0.74 °C	Characterized S thermocouple
Temperature – Measuring Equipment, SPRTs, PRTs			
ITS-90 Fixed Points	0.01 °C 156.598 °C 231.928 °C 419.527 °C 660.323 °C	0.005 °C 0.004 °C 0.004 °C 0.004 °C 0.004 °C	TPW Cell Indium Cell Tin Cell Zinc Cell Aluminum Cell
Temperature – Measuring, Equipment, TC/RTD Probes, LIG Thermometers	-196 °C (-80 to 0) °C (0 to 25) °C (25 to 150) °C (150 to 200) °C (200 to 300) °C (300 to 420) °C	6.6 mK 13 mK 12 mK 16 mK 26 mK 32 mK 0.14 °C	LN2 Comparison SPRT, Thermometry Bridge and temperature baths
Temperature[3] – Measuring, Equipment, TC/RTD Probes, LIG Thermometers	(-40 to 350) °C (350 to 650) °C (650 to 961) °C	0.87 °C 5.8 mK/°C - 0.87 °C 3 °C	Drywells

X. Time and Frequency

Parameter/Equipment	Range	CMC[2, 10] (±)	Comments
Frequency[3] – Measuring Equipment	Up to 18 GHz	11 pHz/Hz + 0.58*R*	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 + 0.58*R*	EIP 545 and HP 5335A electronic counters *R* is the resolution of the unit under test
Timers/Stop Watches	(1 to 28 800) s	0.060 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	1.4 Hz	Electronic counter
Radar Guns[3] K Band X Band	 2521 Hz (35 mph) 4681 Hz (65 mph) 1099 Hz (35 mph) 2511 Hz (80 mph)	 1.4 Hz 1.4 Hz 1.4 Hz 1.4 Hz	Tuning forks

[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*.

Accredited Laboratory

A2LA has accredited

RICHARD J. BAGAN, INC. D.B.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/NCSL 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 6th day of March 2025.

Mr. Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1625.01
Valid to January 31, 2027

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