



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

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CALIBRATION

Valid To: October 31, 2016

Certificate Number: 1078.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations<sup>1,9</sup>:

I. Acoustical Quantities

Parameter/Equipment	Range	CMC <sup>2,8</sup> (±)	Comments
Sound Level	(0 to 140) dB	0.16 dB + 0.032 %	Piston phone
	(0 to 140) dB	0.32 dB	Sound level calibrator
Sound Level <sup>3</sup>	(0 to 140) dB	0.6 dB	Sound level calibrator

II. Chemical

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Conductivity Meters	10 µS/cm 100 µS/cm 1000 µS/cm 1400 µS/cm 10 000 µS/cm	0.68 µS/cm + 0.6R 1.2 µS/cm + 0.6R 4.5 µS/cm + 0.6R 6.9 µS/cm + 0.6R 55 µS/cm + 0.6R	Conductivity solutions
pH Meters <sup>3</sup>	4 pH 7 pH 10 pH	0.014 pH 0.014 pH 0.014 pH	Standard buffers

III. Dimensional

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Angle Blocks	0° to 90°	5'' + 10 parts in 10 <sup>6</sup>	Measuring machine
Angle Plates <sup>3</sup>	Up to 30 in	(120 + 6H) μin	Gage amp. probe, indi-square and test indicator
Arbor – Straightness	Up to 24 in	(35 + 9L) μin	Gage amp w/probe
Bench Center – Center Parallelism Base Flatness & Base Parallelism	Up to 24 in Up to 24 in	(68 + 4L) μin (62 + 2.5L) μin	Gage amp w/probe
Benchmics <sup>3</sup>	Up to 2 in	30 μin	Gage blocks
Bore Gages <sup>3</sup>	Up to 12 in	10 μin/in + 0.6R	Gage blocks
Box Parallels – Parallelism Squareness	5 in × 10 in × 10 in	(12 + 20H) μin (18 + 20H) μin	Gage amp w/probe, cylindrical square
Calipers <sup>3</sup> (Including Intertest, Oditest, Snap Jaw and other OD Calipers) –  Resolution 0.0001 in  Resolution 0.0005 in  Resolution 0.001 in	Up to 2 in (2 to 12) in  Up to 24 in (24 to 60) in  Up to 30 in (30 to 100) in	78 μin 70 μin + 4 μin/in  450 μin 340 μin + 3.7 μin/in  840 μin 700 μin + 3.4 μin/in	Gage blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Chamfer Gages/Hole Gages <sup>3</sup>	Up to 12 in	20 μin + 0.6R	Cylindrical rings
Clinometers and Inclinometers	Up to 360°	16'' + 0.6R	Sine bar/gage blocks
CMMs <sup>3</sup> –			
Length Error (E <sub>L</sub> ) Linear Volumetric	Up to 52 in	38 μin + 5.2 μin/in 58 μin + 8.1 μin/in	ASME B89.4.1.10360.2
Length Error (E <sub>150</sub> )	Up to 52 in	38 μin + 5.2 μin/in	
Repeatability Range (R <sub>0</sub> )	----	---	
Length	Up to 114 in on each axis	38 μin + 5.2 μin/in	ASME B89.4.1.2000
Volume	Up to 36 in for shortest axis	82 μin + 13 μin/in	
Probing Analysis Bi-directional	---	2 μm (40 + 10L) μin	Ball bar Test probe
Coating Thickness Shims/Precision Shims	25 μin to 0.5 in	19 μin + 82 μin/in	Heidenhain-Certo CT 6001
Concentricity Gage	N/A	130 μin + 8 μin/in	Indicator, bench center
Cylindrical Plugs <sup>3</sup>	Up to 4 in (4 to 20) in	4 μin + 5 μin/in 4 μin + 5.4 μin/in	ULM
Cylindrical Rings <sup>3</sup>	(0.1 to 18) in (18 to 36) in	(7.5 + 2D) μin (50 + 3D) μin	ULM, gage blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Cylindrical Squares	Up to 12 in	$(13 + 9H) \mu\text{in}$	Gage amp w/probe; <i>H</i> is the height of the cylinder from the base in inches.
External Spline Gages <sup>3</sup> – Measurement Over Pins Circular Tooth Thickness Major Diameter	Up to 8 in	$(170 + 28D) \mu\text{in}$ $(110 + 16L) \mu\text{in}$ $(28 + 12D) \mu\text{in}$	UMM Optical comparator UMM
Feeler/Thickness Gage <sup>3</sup>	Up to 0.2 in	36 $\mu\text{in}$	UMM
Fixed Gaging  Screw Pitch Gages, Drill Gages, Taper Gages, Center Gages, Sheet and Wire Gages, Angle Gages	--- ---	$(110 + 16L) \mu\text{in}$ (length measures) 54"	Measuring machine/optical comparator
Gage Amplifier and Probe(s) <sup>3</sup>  Single Probe Dual Probe	--- ---	8.9 $\mu\text{in}$ 2.1 $\mu\text{in}$	Gage blocks Gage blocks
Gage Balls	Up to 4 in	$(32 + 1.5D) \mu\text{in}$	Universal measuring machine (UMM)
Gage Blocks	Up to 4 in (4 to 20) in	$(3.1 + 3.2L) \mu\text{in}$ $(3.3 + 3.2L) \mu\text{in}$	Gage blocks and comparator
Groove Micrometers <sup>3</sup>	Up to 4 in	18 $\mu\text{in/in} + 0.6R$	Gage blocks
Height Gage <sup>3</sup>	Up to 48 in	10 $\mu\text{in/in} + 0.6R$	Gage blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Height Measures <sup>3</sup>	Up to 24 in	13 µin/in + 94 µin	Height gage
Indicators <sup>3</sup> –			
Dial	Up to 8 in	10 µin/in + 0.6R	Indicator calibrator
Test	Up to 0.060 in	0.0001 in	
Indicator Calibrator <sup>3</sup>	----	12 µin + 0.6R	Gage blocks, amp w/probe
Laser Distance Meters	Up to 6.1 m	4.6 µm/m + 120 µm	ULM
Length Standards <sup>3</sup> –			
CROBLOX	Up to 4 in (4 to 20) in	4 µin + 2.2 µin/in 4 µin + 2.4 µin/in	ULM, gage blocks
Ceramic	Up to 4 in (4 to 20) in	4 µin + 2.7 µin/in 4 µin + 3 µin/in	
Steel	Up to 4 in (4 to 20) in	4 µin + 5 µin/in 4 µin + 5.4 µin/in	
	(20 to 120) in	3.7 µin/in + 14 µin	ULM
Levels (Machinist) <sup>3</sup>	Up to 96 in	0.00019 in/ft	Sine plate
Linear Measure <sup>3</sup>	(Up to 24) in	94 µin + 13 µin/in	Height gage
Linear Measure	(Up to 30) in	(330 + 5.8L) µin	CMM
Linear Measurement of Machine Tools <sup>3</sup>	Up to 20 ft	1.5 µin/in + 0.58 µin	Laser

Parameter/Equipment	Range	CMC <sup>2, 4, 8</sup> (±)	Comments
Linear Scales/Reticles and Stage Micrometers –			
2D	Up to 12 in	(115 + 15L) μin	Vision system
1D	Up to 30 in	9.9 μin + 1.5 μin/in	Gitterperioden interferometer
Micrometers <sup>3</sup> –			
Inside	Up to 294 in	10 μin/in + 0.6R	Gage blocks
Depth	Up to 12 in	10 μin/in + 0.6R	
Tri-Bores	Up to 6 in	10 μin/in + 0.6R	
Outside	Up to 42 in	10 μin/in + 0.6R	
Groove	Up to 4 in	18 μin/in + 0.6R	
Microscopes <sup>3</sup> –			
Reticule Magnification	Up to 25 mm Up to 1000x	23 μm 2.4 %	Stage micrometer
Optical Comparator <sup>3</sup> –			
Linear	Up to 12 in	0.0002 in	Glass scale Calibration sphere Calibration sphere
Angle	0° to 360°	2'	
Magnification	10x, 20x, 50x, 62.5x, 100x, 200x	0.00012 in	
Optical Flats	Up to 8 in	2.8 μin	Reference flat and monochromatic light source
Parallels <sup>3</sup> –			
Steel	1.5 in × 6 in	(10 + 6L) μin	Gage amp w/probe; L is the distance between the parallel surfaces.
Granite	8 in × 48 in	(10 + 3.6L) μin	

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Pitch Micrometer Standards –			
Length	Up to 12 in	(22 + 6L) μin	UMM
Angle	Up to 60°	54”	Vision system
Precision Diameter Tapes	Up to 48 in (48 to 96) in (96 to 780) in	200 μin + 4 μin/in 560 μin + 1.4 μin/in 0.0013 in + 6 μin/in	Setting discs, ULM
Profilometers <sup>3</sup>	120 μin Ra	2.8 μin	Roughness specimen
Protractor – Digital and Mechanical <sup>3</sup>	0° to 180°	0.0076°	Sine bar and gage blocks
Radius Gage	Up to 5 in	0.00015 in	Optical comparator
Riser Blocks and Stands	Up to 24 in	(13 + 8H) μin	Gage amplifier with probe
Roundness Testers <sup>3</sup> –			
Coning Error	---	11 μin	Test ball and riser cylinder
Axial Error	---	11 μin	Test ball
Radial Accuracy	---	11 μin	Test ball
Z-Axis straightness	(0.1 to 12) in	(14 + 12H) μin	Cylindrical square; In the CMC, <i>H</i> is the height of the cylinder from the base in inches.
Rules/Scales <sup>3</sup>	Up to 100 in	(86 + 16L) μin	UMM

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Sine Plates/Bars <sup>3</sup> –  Flatness/Parallelism & Parallelism Cylinder to Base  Angle Calibration Center of Rolls	Up to 20 in  0° to 90° Up to 20 in	50 μin  0.00045° 16 μin/in	Gage amp w/probe, angle blocks and gage blocks
Snap Gages <sup>3</sup>	Up to 20 in	88 + 13 Lμ”	Box parallel with gage amp and probe
Squares <sup>3</sup> –  Master  Granite  Steel	Up to 30 in  Up to 30 in  Up to 30 in	(56 + 5H) μin  (42 + 6H) μin  (42 + 6H) μin	Gage amp and probe  Indi-square and test indicator  Master square and gage blocks
Straightness and Straight Edges <sup>3</sup>	Up to 60 in	(10 + 14L) μin	Gage amplifier w/probe
Step Gages	Up to 50 in	9.7 μin + 3.1 μin/in	Gage amp and probe, gage blocks
Surface Plates <sup>3</sup> –  Flatness  Repeatability	18 in x 24 in to 72 in x 144 in  Up to 72 in x 144 in	8√D μin  34 μin	Electronic levels D is the length of the plate diagonal in inches.  Repeat-o-meter



Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Surface Roughness <sup>3</sup>	(15 to 150) $\mu\text{in Ra}$	3.4 $\mu\text{in}$	Verification of specimens per ASME B46.1 Type C using profilometers; Ra is the resolution of the profilometers in microinches.
Tape Measures <sup>3</sup>	Up to 300 ft	(0.026 + 0.6R) in	UMM
Tapered Plugs <sup>3</sup> – Simple Pitch Diameter Notch Height	Up to 18 in Up to 18 in	(100 + 12D) $\mu\text{in}$ 13 $\mu\text{in/in}$ + 94 $\mu\text{in}$	Thread wires/UMM Height measuring machine
Tapered Rings <sup>3</sup> – Simple Pitch Diameter Taper Standoff and Thickness Functional Diameter	Up to 18 in Up to 18 in Up to 18 in Up to 2 in	300 $\mu\text{in}$ 400 $\mu\text{in}$ 120 $\mu\text{in}$ (300 + 8D) $\mu\text{in}$	NPT master plug, UMM NPT master plug NPT master plug and height measuring machine
Thickness Gages <sup>3</sup> – Dial and Digital	Up to 1 in	19 $\mu\text{in}$ + 0.6R	Gage blocks
Thread Micrometers <sup>3</sup> (Screw Thread, Pitch, Point)	Up to 4 in	10 $\mu\text{in}$ + 0.6R	Pitch standard
Thread Plugs <sup>3</sup> – Simple Pitch Diameter Major Diameter	Up to 20 in Up to 4 in (4 to 20) in	82 $\mu\text{in}$ + 6.8 $\mu\text{in/in}$ 4 $\mu\text{in}$ + 5 $\mu\text{in/in}$ 4 $\mu\text{in}$ + 5.4 $\mu\text{in/in}$	3-wire method ULM, gage blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Thread Rings <sup>3</sup> – Simple Pitch Diameter Minor Diameter	Up to 18 in Up to 2 in	300 μin (70 + 13D) μin	UMM
Functional Diameter Minor Diameter	Up to 18 in (2 to 18) in	(300 + 8D) μin (300 + 11D) μin	w/ set plug
Thread Wires	Up to 0.5 in	(8.5 + 7D) μin	UMM, gage blocks
Universal Measuring Machines <sup>3</sup> (UMMs) – English	Up to 4 in (4 to 24) in	1.5 μin + 1.2 μin/in 1.3 μin + 1.8 μin/in	Gage blocks
Metric	Up to 100 mm	0.04 μm + 0.0015 μm/mm	
V-Blocks – Parallelism Side	8 in × 8 in × 8 in	14 μin	Gage amplifier w/probe
V		20 μin	Cylindrical square
Squareness		(37 + 11H) μin	Cylindrical plug
Vision Systems <sup>3</sup> – X-Y Linear Accuracy	Up to 24 in	(110 + 13L) μin	Glass scale
Z-Axis Linear Accuracy	Up to 20 in	(74 + 11L) μin	Gage blocks
Wire Crimpers <sup>3</sup> – Crimp Height	---	0.0024 in	Micrometer
Crimping Chamber		(10 + 19D) μin	Pin; D is the diameter of the pin.
Ratchet Inspection		120 μin	Feeler gage

IV. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC <sup>2,7</sup> (±)	Comments
AC Current – Generate & Measure			
	(10 to 300) $\mu$ A	10 Hz 0.018 % + 30 pA 20 Hz 67 $\mu$ A/A + 30 pA 30 Hz 42 $\mu$ A/A + 30 pA 40 Hz 37 $\mu$ A/A + 30 pA 55 Hz 37 $\mu$ A/A + 30 pA 100 Hz 38 $\mu$ A/A + 30 pA 300 Hz 38 $\mu$ A/A + 30 pA 400 Hz 38 $\mu$ A/A + 30 pA 500 Hz 38 $\mu$ A/A + 30 pA 1 kHz 38 $\mu$ A/A + 30 pA 3 kHz 46 $\mu$ A/A + 30 pA 5 kHz 46 $\mu$ A/A + 30 pA 10 kHz 46 $\mu$ A/A + 30 pA 20 kHz 63 $\mu$ A/A + 30 pA 30 kHz 80 $\mu$ A/A + 30 pA	Fluke 5790A, 5700A/EP, A40, standard resistors
	(0.3 to 3) mA	10 Hz 0.017 % + 300 pA 20 Hz 61 $\mu$ A/A + 300 pA 30 Hz 30 $\mu$ A/A + 300 pA 40 Hz 30 $\mu$ A/A + 300 pA 55 Hz 30 $\mu$ A/A + 300 pA 100 Hz 30 $\mu$ A/A + 300 pA 300 Hz 30 $\mu$ A/A + 300 pA 400 Hz 30 $\mu$ A/A + 300 pA 500 Hz 30 $\mu$ A/A + 300 pA 1 kHz 30 $\mu$ A/A + 300 pA 3 kHz 30 $\mu$ A/A + 300 pA 5 kHz 31 $\mu$ A/A + 300 pA 10 kHz 30 $\mu$ A/A + 300 pA 20 kHz 45 $\mu$ A/A + 300 pA 30 kHz 48 $\mu$ A/A + 300 pA	
(3 to 10) mA	10 Hz 0.017 % + 1 nA 20 Hz 69 $\mu$ A/A + 1 nA 40 Hz 38 $\mu$ A/A + 1 nA 400 Hz 36 $\mu$ A/A + 1 nA 1 kHz 35 $\mu$ A/A + 1 nA 5 kHz 36 $\mu$ A/A + 1 nA 10 kHz 36 $\mu$ A/A + 1 nA 20 kHz 36 $\mu$ A/A + 1 nA 50 kHz 60 $\mu$ A/A + 1 nA		

Parameter/Range	Frequency	CMC <sup>2,7</sup> (±)	Comments
AC Current – Generate & Measure (cont)			
(10 to 20) mA	10 Hz	0.017 % + 2 nA	Fluke 5790A, 5700A/EP, A40, standard resistors
	20 Hz	69 μA/A + 2 nA	
	40 Hz	38 μA/A + 2 nA	
	400 Hz	36 μA/A + 2 nA	
	1 kHz	35 μA/A + 2 nA	
	5 kHz	36 μA/A + 2 nA	
	10 kHz	36 μA/A + 2 nA	
	20 kHz	36 μA/A + 2 nA	
	50 kHz	64 μA/A + 2 nA	
(20 to 30) mA	10 Hz	0.017 % + 3 nA	
	20 Hz	69 μA/A + 3 nA	
	40 Hz	38 μA/A + 3 nA	
	400 Hz	36 μA/A + 3 nA	
	1 kHz	35 μA/A + 3 nA	
	5 kHz	36 μA/A + 3 nA	
	10 kHz	36 μA/A + 3 nA	
	20 kHz	36 μA/A + 3 nA	
	50 kHz	64 μA/A + 3 nA	
(30 to 50) mA	10 Hz	0.017 % + 5 nA	
	20 Hz	69 μA/A + 5 nA	
	40 Hz	38 μA/A + 5 nA	
	400 Hz	36 μA/A + 5 nA	
	1 kHz	35 μA/A + 5 nA	
	5 kHz	36 μA/A + 5 nA	
	10 kHz	36 μA/A + 5 nA	
	20 kHz	36 μA/A + 5 nA	
	50 kHz	64 μA/A + 5 nA	
(50 to 100) mA	10 Hz	0.017 % + 60 nA	
	20 Hz	70 μA/A + 60 nA	
	40 Hz	38 μA/A + 60 nA	
	400 Hz	36 μA/A + 60 nA	
	1 kHz	35 μA/A + 60 nA	
	5 kHz	36 μA/A + 60 nA	
	10 kHz	36 μA/A + 60 nA	
	20 kHz	40 μA/A + 60 nA	
	50 kHz	68 μA/A + 60 nA	
(100 to 200) mA	10 Hz	0.017 % + 120 nA	
	20 Hz	72 μA/A + 120 nA	
	40 Hz	38 μA/A + 120 nA	
	400 Hz	36 μA/A + 120 nA	
	1 kHz	35 μA/A + 120 nA	
	5 kHz	36 μA/A + 120 nA	
	10 kHz	36 μA/A + 120 nA	
	20 kHz	40 μA/A + 120 nA	
	50 kHz	68 μA/A + 120 nA	

Parameter/Range	Frequency	CMC <sup>2,7</sup> (±)	Comments
AC Current – Generate & Measure (cont)			
(200 to 300) mA	10 Hz	0.017 % + 180 nA	Fluke 5790A, 5700A/EP, A40, standard resistors
	20 Hz	72 µA/A + 180 nA	
	40 Hz	38 µA/A + 180 nA	
	400 Hz	36 µA/A + 180 nA	
	1 kHz	35 µA/A + 180 nA	
	5 kHz	36 µA/A + 180 nA	
	10 kHz	36 µA/A + 180 nA	
	20 kHz	40 µA/A + 180 nA	
	50 kHz	72 µA/A + 180 nA	
(300 to 500) mA	10 Hz	0.017 % + 300 nA	
	20 Hz	72 µA/A + 300 nA	
	40 Hz	38 µA/A + 300 nA	
	400 Hz	36 µA/A + 300 nA	
	1 kHz	35 µA/A + 300 nA	
	5 kHz	36 µA/A + 300 nA	
	10 kHz	36 µA/A + 300 nA	
	20 kHz	40 µA/A + 300 nA	
	50 kHz	72 µA/A + 300 nA	
(0.5 to 1) A	10 Hz	0.018 % + 6 µA	
	20 Hz	72 µA/A + 6 µA	
	40 Hz	42 µA/A + 6 µA	
	400 Hz	40 µA/A + 6 µA	
	1 kHz	39 µA/A + 6 µA	
	5 kHz	40 µA/A + 6 µA	
	10 kHz	40 µA/A + 6 µA	
	20 kHz	52 µA/A + 6 µA	
	50 kHz	0.011 % + 6 µA	
(1 to 2) A	10 Hz	0.018 % + 12 µA	
	20 Hz	75 µA/A + 12 µA	
	40 Hz	42 µA/A + 12 µA	
	400 Hz	40 µA/A + 12 µA	
	1 kHz	40 µA/A + 12 µA	
	5 kHz	40 µA/A + 12 µA	
	10 kHz	40 µA/A + 12 µA	
	20 kHz	53 µA/A + 12 µA	
	50 kHz	0.011 % + 12 µA	
(2 to 3) A	10 Hz	0.019 % + 18 µA	
	20 Hz	82 µA/A + 18 µA	
	40 Hz	58 µA/A + 18 µA	
	400 Hz	57 µA/A + 18 µA	
	1 kHz	57 µA/A + 18 µA	
	5 kHz	57 µA/A + 18 µA	
	10 kHz	57 µA/A + 18 µA	
	20 kHz	61 µA/A + 18 µA	
	50 kHz	0.012 % + 18 µA	

Parameter/Range	Frequency	CMC <sup>2,7</sup> ( $\pm$ )	Comments
AC Current – Generate & Measure (cont)			
(3 to 5) A	10 Hz 20 Hz 40 Hz 400 Hz 1 kHz 5 kHz 10 kHz 20 kHz 50 kHz	0.019 % + 30 $\mu$ A 85 $\mu$ A/A + 30 $\mu$ A 58 $\mu$ A/A + 30 $\mu$ A 57 $\mu$ A/A + 30 $\mu$ A 57 $\mu$ A/A + 30 $\mu$ A 57 $\mu$ A/A + 30 $\mu$ A 57 $\mu$ A/A + 30 $\mu$ A 71 $\mu$ A/A + 30 $\mu$ A 0.017 % + 30 $\mu$ A	Fluke 5790A, 5700A/EP, A40, standard resistors
(5 to 10) A	10 Hz 20 Hz 40 Hz 400 Hz 1 kHz 5 kHz 10 kHz 20 kHz 50 kHz	200 $\mu$ A/A + 60 $\mu$ A 110 $\mu$ A/A + 60 $\mu$ A 73 $\mu$ A/A + 60 $\mu$ A 72 $\mu$ A/A + 60 $\mu$ A 72 $\mu$ A/A + 60 $\mu$ A 72 $\mu$ A/A + 60 $\mu$ A 72 $\mu$ A/A + 60 $\mu$ A 90 $\mu$ A/A + 60 $\mu$ A 0.013 % + 60 $\mu$ A	
(10 to 20) A**	10 Hz 20 Hz 40 Hz 400 Hz 1 kHz 5 kHz 10 kHz 20 kHz 50 kHz	0.022 % + 120 $\mu$ A 0.013 % + 120 $\mu$ A 86 $\mu$ A/A + 120 $\mu$ A 85 $\mu$ A/A + 120 $\mu$ A 85 $\mu$ A/A + 120 $\mu$ A 85 $\mu$ A/A + 120 $\mu$ A 85 $\mu$ A/A + 120 $\mu$ A 0.011 % + 120 $\mu$ A 0.016 % + 120 $\mu$ A	** Measure Only
50 Turn Coils (Effective Current Transfer Ratio)	25 Turn Amps, 50 Hz, 400 Hz 500 Turn Amps, 50 Hz, 400 Hz 800 Turn Amps, 400 Hz 1000 Turn Amps, 50 Hz	0.11 % of ratio 0.12 % of ratio 0.14 % of ratio 0.14 % of ratio	Comparison to standard coil
AC Current – Generate			
Turn Amps (20 to 120) A (120 to 6000) A	(50 to 400) Hz	0.055 % + 0.6A 0.80 % - 1.6A	Fluke 55120A w/ 52120-3k and 52120- 6k coils
(20 to 120) A	1000 Hz	0.24 % + 0.24A	

Parameter/Range	Frequency	CMC <sup>2,5,6</sup> (±)	Comments
AC Current – Generate <sup>3</sup> (cont)  (11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.094 % + 3.9 mA 0.12 % + 3.9 mA 2.4 % + 3.9 mA	Fluke 5520A
AC Current – Measure <sup>3</sup>  (0 to 100) µA  (0.1 to 1) mA  (1 to 10) mA  (10 to 100) mA  (0.1 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz  (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz  (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz  (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz  (10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	0.27 % + 20 nA 0.11 % + 20 nA 0.042 % + 20 nA 0.042 % + 20 nA  0.27 % + 0.14 µA 0.11 % + 0.14 µA 0.042 % + 0.14 µA 0.023 % + 0.14 µA 0.042 % + 0.14 µA 0.27 % + 0.27 µA 0.37 % + 1 µA  0.27 % + 1.4 µA 0.11 % + 1.4 µA 0.042 % + 1.4 µA 0.023 % + 1.4 µA 0.042 % + 1.4 µA 0.27 % + 2.7 µA 0.37 % + 10 µA  0.27 % + 14 µA 0.11 % + 14 µA 0.042 % + 14 µA 0.023 % + 14 µA 0.042 % + 14 µA 0.27 % + 27 µA 0.37 % + 100 µA  0.27 % + 140 µA 0.11 % + 140 µA 0.057 % + 140 µA 0.070 % + 140 µA 0.21 % + 140 µA 0.67 % + 270 µA	Agilent/HP 3458A

Parameter/Range	Frequency	CMC <sup>2,6</sup> (±)	Comments
AC Current – Measure <sup>3</sup> (cont)			
(1 to 2) A	10 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz	0.057 % + 190 µA 0.068 % + 190 µA 0.25 % + 1.4 µA	Fluke 8508
(2 to 20) A	10 Hz to 2 kHz (2 to 10) kHz	0.072 % + 1.9 mA 0.20 % + 1.9 mA	Fluke 8508
50 A to 1 kA	60 Hz	2.0 %	Fluke 337
AC Power <sup>3</sup> – PF = 1			
(29 to 330) µA (0.33 to 3.3) mA 3.3 mA to 3.3 A	(10 to 20) Hz 1 mV to 33 V	0.19 % 0.17 % 0.15 %	Fluke 5520A
(29 to 330) µA (0.33 to 3.3) mA (3.3 to 330) mA 330 mA to 3 A	(20 to 45) Hz 1 mV to 33 V	0.15 % 0.11 % 0.080 % 0.15 %	
(29 to 330) µA (0.33 to 3.3) mA (3.3 to 330) mA 330 mA to 1.1 A (1.1 to 3) A (3 to 11) A (11 to 20.5) A	(45 to 100) Hz 1 mV to 1020 V	0.13 % 0.088 % 0.041 % 0.052 % 0.054 % 0.065 % 0.12 %	
(29 to 330) µA (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3) A (3 to 11) A (3 to 20.5) A	100 Hz to 1 kHz 1 mV to 1020 V	0.13 % 0.088 % 0.041 % 0.041 % 0.052 % 0.054 % 0.095 % 0.14 %	
(29 to 330) µA (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A	(1 to 5) kHz 1 mV to 1020 V	0.28 % 0.17 % 0.070 % 0.092 % 0.54 %	



Parameter/Range	Frequency	CMC <sup>2, 6, 7</sup> (±)	Comments
AC Power <sup>3</sup> – PF = 1 (cont)			
(1.1 to 3) A (3 to 11) A (11 to 20.5) A	(1 to 5) kHz 1 mV to 1020 V	0.26 % 2.4 % 2.4 %	Fluke 5520A
(29 to 330) µA (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3) A	(5 to 10) kHz 1 mV to 1020 V	0.67 % 0.40 % 0.17 % 0.18 % 2.3 % 2.1 %	
(29 to 330) µA (0.33 to 3.3) mA (3.3 to 330) mA	(10 to 30) kHz 1 mV to 330 V	1.3 % 0.79 % 0.32 %	
AC Voltage – Measure & Generate <sup>3</sup>			
(0.6 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.14 % + 1.1 µV 0.062 % + 1.1 µV 0.040 % + 1.1 µV 0.067 % + 1.6 µV 0.097 % + 2.0 µV 0.19 % + 3.2 µV 0.19 % + 6.3 µV 0.31 % + 6.3 µV	Fluke 5790A, 5720A
(2.2 to 7) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.068 % + 1.1 µV 0.032 % + 1.1 µV 0.021 % + 1.1 µV 0.034 % + 1.6 µV 0.049 % + 2.0 µV 0.096 % + 3.2 µV 0.11 % + 6.3 µV 0.19 % + 6.3 µV	
(7 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 1.1 µV 0.016 % + 1.1 µV 0.0096 % + 1.1 µV 0.018 % + 1.6 µV 0.026 % + 2.0 µV 0.066 % + 3.2 µV 0.074 % + 6.3 µV 0.14 % + 6.3 µV	

Parameter/Range	Frequency	CMC <sup>2,7</sup> (±)	Comments
AC Voltage – Measure & Generate <sup>3</sup> (cont)			
(22 to 70) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.022 % + 1.2 μV 0.012 % + 1.2 μV 0.0071 % + 1.2 μV 0.012 % + 1.6 μV 0.025 % + 2.0 μV 0.048 % + 3.2 μV 0.063 % + 6.3 μV 0.096 % + 6.3 μV	Fluke 5790A, 5720A
(70 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.017 % + 1.2 μV 0.0076 % + 1.2 μV 0.0037 % + 1.2 μV 0.0058 % + 1.6 μV 0.013 % + 2.0 μV 0.022 % + 3.2 μV 0.031 % + 6.3 μV 0.079 % + 6.3 μV	
(220 to 700) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.017 % + 1.2 μV 0.0061 % + 1.2 μV 0.0029 % + 1.2 μV 0.0046 % + 1.6 μV 0.0063 % + 2.0 μV 0.017 % + 4.3 μV 0.025 % + 6.3 μV 0.074 % + 6.3 μV	
(0.7 to 2.2) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.018 % 0.0061 % 0.0022 % 0.004 % 0.0057 % 0.015 % 0.023 % 0.074 %	
(2.2 to 7) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.016 % 0.0054 % 0.0024 % 0.0041 % 0.0065 % 0.018 % 0.035 % 0.097 %	

Parameter/Range	Frequency	CMC <sup>2,7</sup> (±)	Comments
AC Voltage – Measure & Generate <sup>3</sup> (cont)			
(7 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.016 % 0.0057 % 0.0030 % 0.0039 % 0.0065 % 0.018 % 0.033 % 0.097 %	Fluke 5790A, 5720A
(22 to 70) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.016 % 0.0058 % 0.0034 % 0.0050 % 0.0075 % 0.016 % 0.032 % 0.09 %	
(70 to 220) V*	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	0.016 % 0.0058 % 0.0034 % 0.0056 % 0.0080 % 0.017 % 0.039 %	* Subject to 2.2 x 10 <sup>7</sup> V-Hz limitation
(220 to 700) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.016 % 0.0080 % 0.0038 % 0.011 % 0.040 %	Fluke 5790A, 5720A, 5725A
(700 to 1000) V**	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.016 % 0.0080 % 0.0036 % 0.011 % 0.040 %	** Measure only

Parameter/Range	Frequency	CMC <sup>2, 5</sup> (±)	Comments
AC High Voltage – Measure <sup>3</sup>  (1 to 5) kV (5 to 35) kV (35 to 75) kV	(50 to 60) Hz	0.2 % + 1 V 0.4 % + 65 V 0.4 % + 49 V	Vitrek 4700A
AC High Voltage – Generate <sup>3</sup>  (1 to 5) kV	60 Hz	0.24 % + 1 V	Assoc. res. 3565D
AC Voltage – Measure <sup>3</sup> ≤ 2 MHz  (0 to 10) mV  (10 to 100) mV  (0.1 to 1) V  (1 to 10) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz  (1 to 40) Hz 40Hz to 1kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz  (1 to 40) Hz 40 Hz to 1kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz  (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.023 % + 2 μV 0.018 % + 0.74 μV 0.026 % + 0.74 μV 0.069 % + 0.74 μV 0.34 % + 0.74 μV 2.7 % + 1.4 μV  0.033 % + 2.7 μV 0.014 % + 1.4 μV 0.019 % + 1.4 μV 0.037 % + 1.4 μV 0.067 % + 1.4 μV 0.22 % + 6.7 μV 0.68 % + 6.7 μV 1.1 % + 6.7 μV  0.0047 % + 27 μV 0.0047 % + 14 μV 0.0094 % + 14 μV 0.020 % + 14 μV 0.054 % + 14 μV 0.20 % + 67 μV 0.67 % + 67 μV 1.1 % + 67 μV  0.0077 % + 0.27 mV 0.0062 % + 0.14 mV 0.0099 % + 0.14 mV 0.021 % + 0.14 mV 0.054 % + 0.14 mV 0.21 % + 0.67 mV 0.67 % + 0.67 mV 1.1 % + 0.67 mV	Agilent/HP 3458A

Parameter/Range	Frequency	CMC <sup>2, 5, 7, 8</sup> (±)	Comments
AC Voltage – Measure <sup>3</sup> (cont) ≤ 2 MHz  (10 to 100) V      (100 to 700) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz  (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.025 % + 2.7 mV 0.016 % + 1.4 mV 0.014 % + 1.4 mV 0.025 % + 1.4 mV 0.082 % + 1.4 mV 0.27 % + 6.7 mV 1.1 % + 6.7 mV  0.033 % + 27 mV 0.027 % + 14 mV 0.041 % + 14 mV 0.081 % + 14 mV 0.21 % + 14 mV	Agilent/HP 3458A
Capacitance – Measure <sup>3</sup>  1 pF 10 pF 100 pF to 1 μF  (0.7 to 110) mF  10 pf to 0.1 F	1 kHz  DC  12 Hz to 2 MHz	10 μF/F 13 μF/F 14 μF/F  0.012 %  See Table IV.a	AH2500A  5700A w/ 3458A, charge method  1689M , Quad tech 7600
Capacitance – Generate <sup>3</sup> , Fixed Points  100 pF 0.001 μF 0.002 μF (0.01, 0.02, 0.05) μF (0.1, 0.5, 1) μF	100 Hz, 1 kHz	0.054 % 0.068 % 0.056 % 0.055 % 0.055 %	Standard capacitors

Table IV.a: CMC (in %) for Capacitance measured with 1689M and 7600 LCR Meter, Fixed Points

	10 pF	100 pF	1 nF	10 nF	100 nF	1 $\mu$ F	10 $\mu$ F	100 $\mu$ F	0.001 F	0.01 F	0.1 F
12 Hz			3.1	5	1.5	0.79	0.93	0.14	0.11	0.46	4.5
20 Hz			1.9	3	0.63	0.48	0.49	0.11	0.11	0.76	
50 Hz		3.8	0.39	0.47	0.25	0.11	0.16	0.058	0.11	0.94	
100 Hz		1.4	0.16	0.21	0.15	0.047	0.067	0.047	0.16	1.4	
200 Hz		0.71	0.081	0.12	0.095	0.047	0.047	0.047	0.29	2.8	
500 Hz	1.9	0.2	0.035	0.042	0.058	0.035	0.035	0.058	0.48	4.4	
1 kHz	0.48	0.058	0.024	0.024	0.024	0.024	0.024	0.058	0.48	4.7	
2 kHz	0.71	0.081	0.047	0.035	0.035	0.041	0.035	0.17	1.2		
5 kHz	0.66	0.083	0.056	0.047	0.047	0.056	0.08	0.32	2.8		
10 kHz	0.42	0.07	0.056	0.055	0.055	0.06	0.11	0.6			
20 kHz	0.035	0.024	0.048	0.057	0.058	0.068	0.18	1.3			
50 kHz	0.024	0.024	0.066	0.066	0.07	0.11	0.46	4.1			
100 kHz	0.024	0.03	0.08	0.081	0.091	0.2	1.2				
200 kHz	0.27	0.11	0.11	0.12	0.15	0.46	3.7				
500 kHz	0.43	0.4	0.2	0.38	0.38	2.1					
1 MHz	0.36	0.35	0.35	0.41	1.1						
2 MHz	0.65	0.64	0.66	0.9	3.4						

Parameter/Equipment	Range	CMC <sup>2,7</sup> ( $\pm$ )	Comments
DC Power <sup>3</sup> – 33 mV to 1020 V	330 $\mu$ A to 330 mA 330 mA to 3 A (3 to 20.5) A	0.068 % 0.07 % 0.12 %	Fluke 5520A

Parameter/Equipment	Range	CMC <sup>2, 5, 6, 8</sup> (±)	Comments
DC Current <sup>3</sup> –  Generate and Measure	(0 to 100) nA (0.1 to 1) μA (1 to 10) μA  (10 to 100) μA (0.1 to 1 mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 2) A (2 to 10) A (10 to 20) A  (20 to 100) A (100 to 300) A (300 to 1000) A	30 μA/A + 0.27 nA 19 μA/A + 0.27 nA 17 μA/A + 0.067 nA  5.2 μA/A + 0.01 nA 4.9 μA/A + 0.1 nA 5.1 μA/A + 1 nA 5.6 μA/A + 60 nA 7.3 μA/A + 6 μA 8.9 μA/A + 12 μA 31 μA/A + 6 μA 31 μA/A + 12 μA  27 μA/A + 18 μA/°C 0.011 % + 18 μA/°C 0.077 % + 18 μA/°C	Fluke 3458A/HFL, current source, standard resistors/current shunts
Generate Only Turn Amps	(25 to 100) A (100 to 1500) A	0.09 % 0.52 %	Fluke 52120A w/52120-3k and 52120-6k coils
DC Voltage – Generate, Fixed Points	100 mV  1 V  10 V 19 V  100 V  1000 V	0.82 μV/V  0.63 μV/V  0.55 μV/V 1.1 μV/V  0.63 μV/V  0.82 μV/V	Fluke 732B, 752A, HP 34420A  Fluke 732B, 752A, HP 34420A  Fluke 732B  Fluke 732B, 720A, 752A, HP 34420A  Fluke 732B, 752A, HP 34420A  Fluke 732B, 752A, HP 34420A
DC Voltage – Generate	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	5.6 μV/V + 0.39 μV 3.2 μV/V + 0.63 mV 2.4 μV/V + 2.4 μV 2.4 μV/V + 3.9 μV 3.2 μV/V + 39 μV 4.8 μV/V + 390 μV	Fluke 5700A/EP

Parameter/Equipment	Range	CMC <sup>2, 5, 8</sup> ( $\pm$ )	Comments
DC Voltage – Measure <sup>3</sup>	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V	3.0 $\mu$ V/V + 0.21 $\mu$ V 2.1 $\mu$ V/V + 0.21 $\mu$ V 2.1 $\mu$ V/V + 0.34 $\mu$ V 3.5 $\mu$ V/V + 21 $\mu$ V 3.7 $\mu$ V/V + 74 $\mu$ V	Agilent/HP 3458A
DC High Voltage – Measure <sup>3</sup>	(1 to 6) kV (6 to 35) kV (35 to 100) kV	0.2 % + 1 V 0.4 % + 26 V 0.4 % + 140 V	Vitrek 4700A
DC High Voltage – Generate <sup>3</sup>	(1 to 6) kV	0.21 % + 1.1 V	Assoc. res. 3565D monitored with Vitrek 4700A
Edge Characteristics – Amplitude	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V	3.0 $\mu$ V/V + 0.21 $\mu$ V 2.1 $\mu$ V/V + 0.21 $\mu$ V 2.1 $\mu$ V/V + 0.34 $\mu$ V 3.5 $\mu$ V/V + 21 $\mu$ V	Agilent/HP 3458A/HFL
Electrical Calibration of RTD Indicating Devices <sup>3</sup> –			
Pt 385, 100 $\Omega$	-200 °C to 0 °C 0 °C to 100 °C 100 °C to 300 °C 300 °C to 400 °C 400 °C to 630 °C 630 °C to 800 °C	0.05 °C 0.07 °C 0.09 °C 0.1 °C 0.12 °C 0.14 °C	Fluke 5520A
Pt 3926, 100 $\Omega$	-200 °C to 0 °C 0 °C to 100 °C 100 °C to 300 °C 300 °C to 400 °C 400 °C to 630 °C	0.05 °C 0.07 °C 0.09 °C 0.1 °C 0.26 °C	
PtNi 385, 120 $\Omega$	-80 °C to 100 °C 100 °C to 260 °C	0.08 °C 0.16 °C	



Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of RTD Indicating Devices <sup>3</sup> (cont) –			
Pt 385, 200 Ω	-200 °C to 100 °C 100 °C to 260 °C 260 °C to 300 °C 300 °C to 400 °C 400 °C to 600 °C 600 °C to 630 °C	0.04 °C 0.05 °C 0.12 °C 0.13 °C 0.14 °C 0.16 °C	Fluke 5520A
Pt 385, 500 Ω	-200 °C to -80 °C -80 °C to 100 °C 100 °C to 260 °C 260 °C to 400 °C 400 °C to 600 °C 600 °C to 630 °C	0.04 °C 0.05 °C 0.06 °C 0.08 °C 0.09 °C 0.11 °C	
Pt 385, 1000 Ω	-200 °C to 0 °C 0 °C to 100 °C 100 °C to 260 °C 260 °C to 300 °C 300 °C to 600 °C 600 °C to 630 °C	0.03 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.23 °C	
Pt 3916, 100 Ω	-200 °C to -190 °C -190 °C to -80 °C -80 °C to 0 °C 0 °C to 100 °C 100 °C to 260 °C 260 °C to 300 °C 300 °C to 400 °C 400 °C to 600 °C 600 °C to 630 °C	0.25 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.08 °C 0.09 °C 0.10 °C 0.23 °C	
Electrical Calibration of Thermocouple Indicating Devices <sup>3</sup> –			
Type E	-250 °C to -100 °C -100 °C to -25 °C -25 °C to 350 °C 350 °C to 650 °C 650 °C to 1000 °C	0.5 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °C	Fluke 5520A

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouple Indicating Devices <sup>3</sup> – (cont)			
Type J	-210 °C to -100 °C -100 °C to -30 °C -30 °C to 150 °C 150 °C to 760 °C 760 °C to 1200 °C	0.28 °C 0.16 °C 0.14 °C 0.17 °C 0.23 °C	Fluke 5520A
Type K	-200 °C to -100 °C -100 °C to -25 °C -25 °C to 120 °C 120 °C to 1000 °C 1000 °C to 1372 °C	0.34 °C 0.18 °C 0.16 °C 0.26 °C 0.40 °C	
Type S	0 °C to 250 °C 250 °C to 1000 °C 1000 °C to 1400 °C 1400 °C to 1767 °C	0.47 °C 0.36 °C 0.37 °C 0.46 °C	
Type T	-250 °C to -150 °C -150 °C to 0 °C 0 °C to 120 °C 120 °C to 400 °C	0.63 °C 0.24 °C 0.16 °C 0.14 °C	

Parameter/Range	Frequency	CMC <sup>2, 8</sup> (±)	Comments	
High Frequency Capacitance, Fixed Points <sup>3</sup> –	1 pF	1 kHz	73 parts in 10 <sup>6</sup>	Agilent/HP 16380A series capacitors
		1 MHz	0.01 %	
		2 MHz	0.023 %	
		3 MHz	0.041 %	
		4 MHz	0.063 %	
		5 MHz	0.088 %	
		10 MHz	0.26 %	
		13 MHz	0.38 %	
	10 pF	1 kHz	62 parts in 10 <sup>6</sup>	
		(1, 2) MHz	62 parts in 10 <sup>6</sup>	
		3 MHz	64 parts in 10 <sup>6</sup>	
		4 MHz	67 parts in 10 <sup>6</sup>	
		5 MHz	72 parts in 10 <sup>6</sup>	
		10 MHz	0.013 %	
		13 MHz	0.017 %	
	100 pF	1 kHz	61 parts in 10 <sup>6</sup>	
		1 MHz	62 parts in 10 <sup>6</sup>	
		2 MHz	68 parts in 10 <sup>6</sup>	
		3 MHz	82 parts in 10 <sup>6</sup>	
		4 MHz	0.01 %	
		5 MHz	0.014 %	
		10 MHz	0.034 %	
		13 MHz	0.049 %	
	1000 pF	1 kHz	63 parts in 10 <sup>6</sup>	
		1 MHz	80 parts in 10 <sup>6</sup>	
		2 MHz	0.016 %	
		3 MHz	0.028 %	
		4 MHz	0.046 %	
		5 MHz	0.064 %	
		10 MHz	0.2 %	
		13 MHz	0.29 %	

Parameter/Range	Frequency	CMC <sup>2, 8</sup> (±)	Comments
High Frequency Capacitance, Fixed Points <sup>3</sup> (cont) –			
0.01 µF	(0.12, 1, 10, 100) kHz	63 parts in 10 <sup>6</sup>	Agilent/HP 16380A series capacitors
0.1 µF	(0.12, 1, 10, 100) kHz	63 parts in 10 <sup>6</sup>	
1 µF	0.12 kHz (1, 10) kHz 100 kHz	69 parts in 10 <sup>6</sup> 63 parts in 10 <sup>6</sup> 85 parts in 10 <sup>6</sup>	
Inductance <sup>3</sup> –			
Measure (12 Hz to 2 MHz)	0.1 µH to 10 H	See Table IV.b	LCR meters
Generate – Fixed Points	100 µH (1, 5, 10, 100) mH (1, 2, 5) H	0.026 % 0.011 % 0.011 %	Standard inductors

Table IV.b: Inductance Measure CMC (in %) measured with 1689M and 7600 LCR Meters

Freq.	0.1 µH	1 µH	10 µH	100 µH	1 mH	10 mH	100 mH	1 H	5 H	10 H
12 Hz						0.81	1.3	1.1	1.1	1.1
20 Hz					4.8	0.49	0.71	0.58	0.56	0.56
50 Hz					0.97	0.11	0.17	0.26	0.26	0.26
100 Hz				3.6	0.37	0.048	0.069	0.11	0.16	0.16
200 Hz				1.8	0.19	0.048	0.048	0.058	0.11	0.085
500 Hz			4.8	0.49	0.060	0.036	0.036	0.036	0.051	0.036
1 kHz			1.2	0.13	0.024	0.024	0.024	0.024	0.024	0.024
2 kHz			0.90	0.13	0.036	0.042	0.036	0.036	0.048	0.048
5 kHz		3.2	0.37	0.084	0.048	0.062	0.062	0.055	0.079	0.096
10 kHz		1.7	0.22	0.079	0.064	0.062	0.064	0.069	0.097	0.26
20 kHz		0.94	0.15	0.074	0.066	0.066	0.067	0.081	0.030	0.048
50 kHz	4.7	0.54	0.12	0.080	0.075	0.075	0.16	0.50	0.058	0.11
100 kHz	3.4	0.42	0.13	0.095	0.091	0.092	0.21	1.9	0.11	0.20
200 kHz	2.7	0.38	0.15	0.13	0.13	0.13	0.68	4.6		
500 kHz	2.4	0.44	0.25	0.23	0.46	0.50	1.9			
1 MHz	2.5	0.60	0.41	0.40	0.40	0.96				
2 MHz	2.7	0.92	0.75	0.73	0.76	4.3				

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
Phase – Generate			
5 Vrms (Voltage Ratio = 1)	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 200) kHz	6.6 m° 5.2 m° 13 m° 21 m°	Clark-Hess 5500-2 Ratio= ratio of the larger voltage divided by the smaller voltage
50 m to 100 Vrms	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 200) kHz	(6.5 + (0.05 · Ratio))m° (11 + (0.1 · Ratio))m° (19 + (0.15 · Ratio))m° (41 + (0.4 · Ratio))m°	
(100 to 120) Vrms	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 200) kHz	(15 + (0.1 · Ratio))m° (21 + (0.2 · Ratio))m° (31 + (0.3 · Ratio))m° (81 + (1 · Ratio))m°	
(0.1 to 100) Vrms	1 Hz to 1 kHz (1.001 to 6.25) kHz (6.25 to 50) kHz (50.01 to 100) kHz	13 m° 13 m° 20 m° 42 m°	
Phase – Measure			
(0.01 to 0.1) Vrms	10 Hz to 10 kHz (10 to 50) kHz (50 to 100) kHz	0.21° 0.36° 0.71°	KH 6620 phase meter
(0.1 to 120) Vrms	10 Hz to 50 kHz (50 to 100) kHz	0.054° 0.036°	

Parameter/Equipment	Range	CMC <sup>2,6</sup> ( $\pm$ )	Comments
Oscilloscope Calibration <sup>3</sup> –			
Squarewave Signal 50 $\Omega$ at 1 kHz Source	(1 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 1100) V	0.27 % + 42 $\mu$ V 0.27 % + 130 $\mu$ V 0.27 % + 1.2 mV 0.27 % + 12 mV	Fluke 5520A/SC1100 scope option
Squarewave Signal 1 M $\Omega$ at 1 kHz Source	(1 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 1100) V	0.15 % + 42 $\mu$ V 0.15 % + 130 $\mu$ V 0.15 % + 1.2 mV 0.15 % + 12 mV	
Leveled Sine Wave Flatness (relative to 50 kHz)	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	1.5 % + 110 $\mu$ V 2 % + 110 $\mu$ V 4 % + 110 $\mu$ V 5 % + 110 $\mu$ V	
Period	1 ns to 20 ms 50 ms 100 ms 200 ms 500 ms 1 s 2 s 5 s	2.0 parts in 10 <sup>6</sup> 59 parts in 10 <sup>6</sup> 97 parts in 10 <sup>6</sup> 180 parts in 10 <sup>6</sup> 410 parts in 10 <sup>6</sup> 800 parts in 10 <sup>6</sup> 1600 parts in 10 <sup>6</sup> 3900 parts in 10 <sup>6</sup>	
Rise Time – Generate	12.8 ps	3.9 ps	Tektronix 067-1338-00
Rise Time – Measure	> 5.4ps	5.4 ps	Tektronix TDS8000 with 80E03
Resistance – Generate, Fixed Points <sup>3</sup>	100 $\mu$ $\Omega$  1 m $\Omega$ 10 m $\Omega$ 0.1 $\Omega$  1 $\Omega$ 10 $\Omega$ 100 $\Omega$ 1 k $\Omega$ 10 k $\Omega$ 19 k $\Omega$ 100 k $\Omega$ 1 M $\Omega$ 10 M $\Omega$ 100 M $\Omega$ 1 G $\Omega$	29 $\mu$ $\Omega$ / $\Omega$  14 $\mu$ $\Omega$ / $\Omega$ 9.5 $\mu$ $\Omega$ / $\Omega$ 6.5 $\mu$ $\Omega$ / $\Omega$  4.6 $\mu$ $\Omega$ / $\Omega$ 4.2 $\mu$ $\Omega$ / $\Omega$ 2.3 $\mu$ $\Omega$ / $\Omega$ 2.5 $\mu$ $\Omega$ / $\Omega$ 1.6 $\mu$ $\Omega$ / $\Omega$ 4.7 $\mu$ $\Omega$ / $\Omega$ 3.3 $\mu$ $\Omega$ / $\Omega$ 4.5 $\mu$ $\Omega$ / $\Omega$ 9.0 $\mu$ $\Omega$ / $\Omega$ 22 $\mu$ $\Omega$ / $\Omega$ 22 $\mu$ $\Omega$ / $\Omega$	Norma 80  L&N 4222B L&N 4223B  L&N resistors  Fluke 742A, standard resistors

Parameter/Equipment	Range	CMC <sup>2, 8</sup> (±)	Comments
Resistance – Generate, Fixed Points <sup>3</sup> (cont)	10 GΩ 100 GΩ 1 TΩ 10 TΩ	0.13 % 0.22 % 0.34 % 1.2 %	IET high resistance standard
Resistance – Measure, DC	100 μΩ 100 μΩ to 1 mΩ (1 to 10) mΩ (10 to 100) mΩ (0.1 to 1) Ω  (0 to 2) Ω (2 to 20) Ω (20 to 200) Ω 200 Ω to 2 kΩ (2 to 20) kΩ (20 to 200) kΩ 200 kW to 2 MΩ (2 to 20) MΩ (20 to 200) MΩ 200 MΩ to 2 GΩ (2 to 20) GΩ  100 MΩ to 1 GΩ (1 to 10) GΩ (10 to 100) GΩ 100 GΩ to 1 TΩ (1 to 10) TΩ (10 to 100) TΩ	85 μΩ/Ω + 0.48 nΩ 12 μΩ/Ω + 4.8 nΩ 9.2 μΩ/Ω + 4.8 nΩ 5.4 μΩ/Ω + 48 nΩ 2.6 μΩ/Ω + 0.48 μΩ  3.4 μΩ/Ω + 4.4 μΩ 2.1 μΩ/Ω + 15 μΩ 2.6 μΩ/Ω + 33 μΩ 2.5 μΩ/Ω + 0.33 mΩ 1.5 μΩ/Ω + 3.3 mΩ 2.3 μΩ/Ω + 33 mW 4.4 μΩ/Ω + 1.1 Ω 4.4 μΩ/Ω + 11 Ω 8.3 μΩ/Ω + 110 Ω 28 μΩ/Ω + 110 kΩ 0.21 % + 1.1 MΩ  0.081 % 0.12 % 0.24 % 0.35 % 0.59 % 1.2 %	Stable current source, 3458A/HFL, standard resistors  Fluke 8508A and standard resistors  6500A
Resistance – Measure, AC	10 Hz to 2 MHz	See Table IV.c	LCR meters

Table IV.c: AC Resistance Measure CMC (in %) measured with LCR Meters

	0.1 $\Omega$	1 $\Omega$	10 $\Omega$	100 $\Omega$	1 k $\Omega$	10 k $\Omega$	100 k $\Omega$	200 k $\Omega$	500 k $\Omega$	1 M $\Omega$
12 Hz		0.60	0.11	0.11	0.11	0.11	0.11	1.7		
20 Hz		0.60	0.11	0.11	0.11	0.11	0.11	0.85	2.8	4.6
50 Hz	3.1	0.31	0.058	0.058	0.058	0.058	0.058	0.38	1.3	2.0
100 Hz	2.3	0.23	0.047	0.047	0.047	0.047	0.047	0.23	0.70	1.2
200 Hz	2.3	0.23	0.047	0.047	0.047	0.047	0.047	0.15	0.44	0.70
500 Hz	1.5	0.16	0.035	0.035	0.035	0.035	0.035	0.10	0.29	0.44
1 kHz	0.77	0.09	0.024	0.024	0.024	0.024	0.024	0.082	0.24	0.35
2 kHz	1.0	0.15	0.035	0.035	0.035	0.035	0.047	0.075	0.21	0.31
5 kHz	0.90	0.14	0.047	0.047	0.047	0.047	0.063	0.072	0.20	0.30
10 kHz	1.0	0.14	0.062	0.055	0.055	0.055	0.063	0.073	0.21	0.30
20 kHz	1.1	0.16	0.066	0.057	0.057	0.057	0.067	0.077	0.22	0.33
50 kHz	1.4	0.19	0.077	0.066	0.065	0.066	0.31	0.37	1.1	1.7
100 kHz	1.9	0.26	0.10	0.081	0.079	0.081	0.40	0.47	1.5	2.2
200 kHz	3.0	0.39	0.14	0.11	0.11	0.12	0.56	0.68	2.2	3.4
500 kHz		0.79	0.26	0.20	0.20	0.26	1.1	1.4	4.2	
1 MHz		1.5	0.45	0.35	0.35	0.70	1.9	2.4		
2 MHz		2.8	0.85	0.65	0.64	1.4	3.5	4.5		



V. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC <sup>2, 8</sup> (±)	Comments
Amplitude Modulation <sup>3</sup> –  AM Accuracy: (0.15 to 10) MHz 5 % to 40 % AM Depth	Rate: 50 Hz to 10 kHz Rate: 20 Hz to 10 kHz	2.3 % + 0.012 % AM 3.5 % + 0.012 % AM	Measuring receiver
40 % to 99 % AM Depth	Rate 50 Hz to 10 kHz Rate: 20 Hz to 10 kHz	2.3% + 0.12 % AM 3.5 % + 0.12 % AM	
(10 to 1300) MHz 5 % to 40 % AM Depth	Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz	1.2 % + 0.012 % AM 3.5 % + 0.012 % AM	
40 % to 99 % AM Depth	Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz	1.2 % + 0.12 % AM 3.5 % + 0.12 % AM	
(1.3 to 26.5) GHz 5 % to 40 % AM Depth	Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz	1.2 % + 0.012 % AM 3.5 % + 0.012 % AM	Measuring receiver, down converter and local oscillator
40 % to 99 % AM Depth	Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz	1.2 % + 0.12 % AM 3.5 % + 0.12 % AM	
AM Distortion: 150 kHz to 1.3 GHz	< 50 % AM Depth 50 % to 95 % AM Depth	1.1 dB 2.1 dB	Measuring receiver and distortion analyzer
(1.3 to 26.5) GHz	< 50 % AM Depth 50 % to 95 % AM Depth	1.1 dB 2.1 dB	
AM Flatness: (0.01 to 26.5) GHz 20 % to 80 % AM Depth	Rate: 90 Hz to 10 kHz	0.31 %	Measuring receiver
Distortion Accuracy – Measure <sup>3</sup>  (0 to -70) dB	(2 to 20) Hz	0.43 dB	Low frequency signal analyzer
(0 to -99.9) dB (0 to -99.9) dB	20 Hz to 20 kHz (20 to 100) kHz	1.1 dB 2.1 dB	Distortion analyzer

Parameter/Range	Frequency	CMC <sup>2, 8</sup> (±)	Comments
<p>Frequency Modulation<sup>3</sup> –</p> <p>FM Accuracy (0.15 to 10) MHz &lt; 4 kHz FM peak Dev. &lt; 40 kHz FM peak Dev.</p> <p>(10 to 1300) MHz &lt; 400 kHz FM pk Dev.</p> <p>(1.3 to 26.5) GHz &lt; 400 kHz FM pk Dev.</p> <p>FM Distortion 400 kHz to 10 MHz Rate: 20 Hz to 10 kHz</p> <p>10 MHz to 26.5 GHz Rate: 20 Hz to 100 kHz</p> <p>Residual FM Carrier Frequency (<i>f</i>) &lt; 100 MHz (100 to 1300) MHz (1.3 to 6.2) GHz (6.2 to 12.4) GHz (12.4 to 18) GHz</p>	<p>Rate:</p> <p>20 Hz to 10 kHz 20 Hz to 10 kHz</p> <p>50 Hz to 100 kHz 20 Hz to 200 kHz</p> <p>50 Hz to 100 kHz 20 Hz to 200 kHz</p> <p>&lt; 10 kHz FM Deviation</p> <p>&lt; 100 kHz FM Deviation</p> <p>Bandwidth: 50 Hz to 3 kHz 50 Hz to 3 kHz 50 Hz to 3 kHz 50 Hz to 3 kHz 50 Hz to 3 kHz</p>	<p>2.4 % + 1.2 Hz 2.4 % + 12 Hz</p> <p>1.3 % + 120 Hz 5.8 % + 240 Hz</p> <p>1.3 % + 120 Hz 5.8 % + 100 Hz</p> <p>0.15 %</p> <p>0.15 %</p> <p>1 Hz (rms) 0.4 Hz + (6 x 10<sup>-9</sup>) <i>f</i> 17 Hz 33 Hz 49 Hz</p>	<p>Measuring receiver</p> <p>Measuring receiver and distortion analyzer</p> <p>Measuring receiver</p>
<p>Phase Modulation<sup>3</sup> –</p> <p>(0.15 to 10) MHz &lt; 40 Radians (peak) &lt; 400 Radians (peak)</p> <p>(10 to 1300) MHz &lt; 4 Radians (peak) &lt; 40 Radians (peak) &lt; 400 Radians (peak)</p> <p>(1.3 to 26.5) GHz &lt; 4 Radians (peak) &lt; 40 Radians (peak) &lt; 400 Radians (peak)</p>	<p>Rate: 200 Hz to 10 kHz</p> <p>Rate: 200 Hz to 20 kHz</p> <p>Rate: 200 Hz to 20 kHz</p>	<p>4.7 % + 0.012 rad 4.7 % + 0.12 rad</p> <p>5.2 % + 0.0012 rad 3.5 % + 0.012 rad 3.5 % + 0.12 rad</p> <p>3.7 % + 0.0012 rad 3.5 % + 0.012 rad 3.5 % + 0.12 rad</p>	<p>Measuring receiver</p> <p>Measuring receiver, down converter and local oscillator</p>

Parameter/Range	Frequency	CMC <sup>2, 8</sup> ( $\pm$ )	Comments
Range Calibration (Power Meters) <sup>3</sup> –  Zero Set Instrument Accuracy	3 $\mu$ W 10 $\mu$ W 30 $\mu$ W (100, 300) $\mu$ W (1, 2) mW (10, 30, 100) mW	0.25 % + 6.2 nW 1.6 % 0.46 % 0.28 % 0.26 % 0.28 % 0.30 %	Range calibrator, Agilent 11683A or Agilent 8477A
RF Power Level <sup>3</sup> – Generate			
Absolute	0 dBm @ 50 MHz	0.11 dB + <i>M</i>	Signal generator, power splitter, attenuator, standard sensors, and power meter
	+20 to - 20 dBm 0.1 MHz to 26.5 GHz	0.12 dB + <i>M</i>	
	-20 to -127 dBm 0.9 MHz to 1.3 GHz	0.18 dB + <i>M</i>	
	-20 to -100 dBm (1.3 to 26.5) GHz	0.18 dB + <i>M</i>	
Relative (Power Sensor Calibration Factors)	100 kHz 300 kHz 1 MHz 3 MHz 10 MHz 30 MHz 100 MHz 300 MHz 500 MHz	0.84 % + <i>M</i> 0.53 % + <i>M</i> 0.47 % + <i>M</i> 0.47 % + <i>M</i> 0.45 % + <i>M</i> 0.45 % + <i>M</i> 0.55 % + <i>M</i> 0.62 % + <i>M</i> 0.62 % + <i>M</i>	Signal generator, power splitter, attenuator, standard sensors, and power meter. Referenced to, 1 mW  UUT Mismatch uncertainty ( <i>M</i> )
Relative (Power Sensor Calibration Factors)	1 GHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz 7 GHz 8 GHz 9 GHz 10 GHz 11 GHz 12 GHz 13 GHz 14 GHz 15 GHz	0.67 % + <i>M</i> 0.78 % + <i>M</i> 0.95 % + <i>M</i> 1.1 % + <i>M</i> 1.2 % + <i>M</i> 1.2 % + <i>M</i> 1.2 % + <i>M</i> 1.2 % + <i>M</i> 1.6 % + <i>M</i> 1.7 % + <i>M</i> 2.2 % + <i>M</i> 1.8 % + <i>M</i> 1.8 % + <i>M</i> 1.9 % + <i>M</i> 2.2 % + <i>M</i>	Signal generator, power splitter, attenuator, standard sensors, and power meter. Referenced to, 1 mW  UUT Mismatch uncertainty ( <i>M</i> )

Parameter/Range	Frequency	CMC <sup>2, 8</sup> ( $\pm$ )	Comments
RF Power Level <sup>3</sup> – Generate (cont)			
Relative (Power Sensor Calibration Factors)	16 GHz 17 GHz 18 GHz 19 GHz 20 GHz 21 GHz 22 GHz 23 GHz 24 GHz 25 GHz 26 GHz 26.5 GHz	2.2 % + <i>M</i> 1.8 % + <i>M</i> 2.9 % + <i>M</i> 4.1 % + <i>M</i> 5.2 % + <i>M</i> 4.7 % + <i>M</i> 3.5 % + <i>M</i> 2.8 % + <i>M</i> 3.1 % + <i>M</i> 3.9 % + <i>M</i> 3.9 % + <i>M</i> 3.9 % + <i>M</i>	Signal generator, power splitter, attenuator, standard sensors, and power meter. Referenced to, 1 mW  UUT Mismatch uncertainty ( <i>M</i> )
RF Power Level <sup>3</sup> – Measure			
Absolute	0 dBm @ 50 MHz  +45 to 20 dBm 0.1 MHz to 4.2 GHz  +20 to - 20 dBm 0.1 MHz to 26.5 GHz  -20 to -127 dBm 0.9 MHz to 1.3 GHz  -20 to -100 dBm (1.3 to 26.5) GHz	0.04 dB + <i>M</i>  0.06 dB + <i>M</i>  0.05 dB + <i>M</i>  0.15 dB + <i>M</i>  0.15 dB + <i>M</i>	8478B, 432A  8482B, power meter  8482A, 8481A, 8485A, power meter  11722A, 8902A  11792A, 8902A 11793A, E8244A  UUT Mismatch uncertainty ( <i>M</i> )

Parameter/Range	Frequency	CMC <sup>2,8</sup> (±)	Comments
RF Power Level <sup>3</sup> – Measure, Relative (cont)			
0 dB	+ 10 to -100 dBm 0.9 MHz to 26.5 GHz	0.01 dB + <i>M</i>	11722A, 11792A 8902A, 11793A, E8244A
-10 dB		0.04 dB + <i>M</i>	
-20 dB		0.04 dB + <i>M</i>	
-30 dB		0.04 dB + <i>M</i>	
-40 dB		0.08 dB + <i>M</i>	
-50 dB		0.08 dB + <i>M</i>	
-60 dB		0.08 dB + <i>M</i>	
-70 dB		0.08 dB + <i>M</i>	
-80 dB		0.10 dB + <i>M</i>	
-90 dB		0.10 dB + <i>M</i>	
-100 dB		0.10 dB + <i>M</i>	11722A, 8902A
-110 dB	-100 to -127dBm	0.10 dB + <i>M</i>	UUT Mismatch
-120 dB	0.9 MHz to 1.3 GHz	0.12 dB + <i>M</i>	uncertainty ( <i>M</i> )
-127 dB		0.19 dB + <i>M</i>	
Power Sensors, Fixed Points <sup>3</sup>	100 kHz 300 kHz 1 MHz (10, 30, 50) MHz 100 MHz (0.3, 0.5, 1) MHz 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz 7 GHz 8 GHz 9 GHz 10 GHz 11 GHz (12, 12.4) GHz 13 GHz 14 GHz 15 GHz 16 GHz 17 GHz 18 GHz 19 GHz 20 GHz 21 GHz 22 GHz 23 GHz 24 GHz 25 GHz 26 GHz 26.5 GHz	2.8 % 0.98 % 0.93 % 0.92 % 0.77 % 0.83 % 0.85 % 0.88 % 0.87 % 1.1 % 1.1 % 1.1 % 1.1 % 1.3 % 1.4 % 1.7 % 1.4 % 1.3 % 1.4 % 1.4 % 1.7 % 1.7 % 1.7 % 1.4 % 2.1 % 3.2 % 3.5 % 3.5 % 2.6 % 2.4 % 2.5 % 2.6 % 2.9 % 2.9 %	Signal generator, power splitter, attenuator, standard sensors, and power meter referenced to 50MHz, 1μW

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
S-Parameters <sup>3</sup> – Reflection S11/22 Magnitude and Phase –			
3.5 mm – (0.01 to 1.0) lin (0 to 0.01) lin (0.01 to 0.1) lin (0.01 to 0.5) lin (0.5 to 1) lin	(1.5 to 26.5) GHz	(± 0.012 to ± 0.040) lin (± 7.4 to ± 180) deg (± 0.095 to ± 20) deg (± 0.54 to ± 2.3) deg (± 0.50 to ± 1.1) deg	Network analyzer with S-parameter test set, calibration kit, and cables
Magnitude (0 to 1) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 0.005 to ± 0.015) lin (± 0.008 to ± 0.002) lin (± 0.015 to ± 0.032) lin	
Phase (0 to 0.2) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 180 to ± 2) deg (± 180 to ± 3) deg (± 180 to ± 4.5) deg	
(0.2 to 1) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 2 to ± 1) deg (± 3 to ± 1.5) deg (± 4.5 to ± 2) deg	
7 mm – Magnitude (0 to 1) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 0.001 to ± 0.006) lin (± 0.002 to ± 0.01) lin (± 0.005 to ± 0.018) lin	
Phase (0 to 0.2) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 180 to ± 1) deg (± 180 to ± 1.5) deg (± 180 to ± 2) deg	
(0.2 to 1) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 1 to ± 0.5) deg (± 1.5 to ± 0.5) deg (± 2 to ± 1) deg	
N-Type – Magnitude (0 to 1) lin	100 kHz to 0.3 GHz (0.3 to 1.3) GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	0.0085 lin (± 0.005 to ± 0.018) lin (± 0.005 to ± 0.025) lin (± 0.01 to ± 0.05) lin	
Phase (0 to 0.2) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 180 to ± 1.5) deg (± 180 to ± 2) deg (± 180 to ± 4) deg	
(0.2 to 1) lin	300 kHz to 1.3 GHz (1.3 to 3.0) GHz (3.0 to 6.0) GHz	(± 1.5 to ± 1) deg (± 2.0 to ± 1.5) deg (± 4 to ± 3) deg	

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
S-Parameters <sup>3</sup> – Transmission S <sup>12</sup> /S <sup>21</sup> Magnitude and Phase –			
3.5 mm (0 to 20) dB	(1.5 to 26.5) GHz	(± 0.11 to ± 0.29) dB (± 1.2 to ± 12) deg	Network analyzer with S-parameter test set, calibration kit, and cables System verification with verification kit
(20 to 40) dB	(1.5 to 26.5) GHz	(± 0.13 to ± 0.68) dB (± 1.5 to ± 19) deg	
(10 to -90) dB	300 kHz to 1.3 GHz	(± 0.3 to ± 6.0) dB (± 0.25 to ± 80) deg	
	(1.3 to 3.0) GHz	(± 0.04 to ± 6.0) dB (± 0.35 to ± 90) deg	
	(3.0 to 6.0) GHz	(± 0.06 to ± 9.0) dB (± 0.67 to ± 180) deg	
7 mm (10 to -90) dB	300 kHz to 1.3 GHz	(± 0.03 to ± 5.0) dB (± 0.26 to ± 80) deg	
N-Type (10 to -90) dB	(1.3 to 3.0) GHz	(± 0.03 to ± 5.0) dB (± 0.26 to ± 90) deg	
	(3.0 to 6.0) GHz	(± 0.05 to ± 10) dB (± 0.54 to ± 180) deg	
	300 kHz to 1.3 GHz	(± 0.03 to ± 6.0) dB (± 0.2 to ± 80) deg	
(10 to -90) dB	(1.3 to 3.0) GHz	(± 0.04 to ± 6.0) dB (± 0.44 to ± 90) deg	
	(3.0 to 6.0) GHz	(± 0.1 to ± 9.0) dB (± 0.67 to ± 90) deg	

VI. Fluid Quantities

Parameter/Equipment	Range	CMC <sup>2, 4, 8</sup> ( $\pm$ )	Comments
Dynamic Viscosity <sup>3</sup>	(0 to 100 000) cP	0.83 %	Standard viscosity fluids, PRT
Flow <sup>3</sup>	2 sccm to 10 slm (10 to 1000) slm	0.26 % 0.51 %	Mass flow system
Hydrometers –  Baume Lighter than Water  (80.5 to 57) API (81 to 57)  (57 to 10) API (57 to 10)  Heavier than Water  (0.72 to 21) API (10 to -11)  (0.72 to 67)	Specific Gravity:  1.00  (0.66 to 0.75)  (0.75 to 1)  (1 to 1.17)  (1 to 1.85)	0.0058 % + 0.6R  0.0072 % + 0.6R  0.006 % + 0.6R  0.0058 % + 0.6R  0.0058 % + 0.6R	Distilled water  Petroleum based solutions  Alcohol solutions  Sulfuric acid and/or glycerine solutions  Sulfuric acid solutions
Kinematic Viscosity <sup>3</sup>	Zahn cups (1 to 5) Shell cups (1 to 6)	0.84 s + 0.24 % 0.84 s + 0.24 %	Temperature bath, viscosity oils, stopwatch
Volumetric Calibration	(0 to 200) mL 200 mL to 1 L (1 to 25) L	0.24 % + 130 nL 0.24 % + 9 $\mu$ L 0.24 % + 900 $\mu$ L	Gravimetric method



VII. Foundry-Industry Specific Calibrations

Parameter/Equipment	Range	CMC <sup>2, 4, 8</sup> (±)	Comments
AFS Clay Tester <sup>3</sup>	---	0.42 s	Stopwatch
Cone Jolt Toughness Tester <sup>3</sup> – Cam Measurement Rise In Cam Cone Weight	0.030 in 0.030 in (470 to 480) g	180 μin 200 μin 0.14 g	Micrometer feeler gage scale
Friability Tester <sup>3</sup>	60 s	0.42 s	Stopwatch
Hot Tensile Tester <sup>3</sup> – Load Temperature Gap Measure	130 psi 450 °F 0.030 in	0.38 psi 0.7 °F 200 μin	Dead weight Temperature measuring device Feeler gage
Melt Point Apparatus <sup>3</sup>	(200 to 220) °F	2.8 °F	Temperature measuring device
Mold Strength Tester <sup>3</sup>	(0 to 50) psi	0.2 % + 0.6R	Balances and weights
Moisture Teller <sup>3</sup>	(0 to 300) °F	2 °F	Temperature calibrator
Permmeter <sup>3</sup>	(0 to 200) perms	6.2 perms	Perm standard
Sand Rammer <sup>3</sup> (Compactability Tester)	---	0.0066 in + 0.6R	Impact rings
Sand Specimen Tube <sup>3</sup>	2.0 in	0.0014 in	Bore gage
Sand (Green) Strength Machine <sup>3</sup>	(0 to 500) psi	0.93 % + 0.82 psi	Master proving gage

Parameter/Equipment	Range	CMC <sup>2,4,8</sup> (±)	Comments
Sand Sieves –	125 mm to 20 µm	(3.2 + 6.9L) µm	ASTM E11, vision system
Sand Squeezer <sup>3</sup>	(0 to 10 000) psi	1.2 % + 1 psi	Pressure calibrator
Ultrasonic Cleaner/Scrubber <sup>3</sup> –  Temperature Time	18 °F 30 min	0.64 °F 0.42 s	Thermometer Stopwatch
Welders <sup>3</sup>	(0 to 50) V (0 to 50) A	1 % 1 %	Loadbank and DMM
Wet Tensile Tester <sup>3</sup> –  Load Temperature Load Rate	0.449 N/cm <sup>2</sup> (300 to 320) °F 0.05 N/cm <sup>2</sup> /s	0.002 N/cm <sup>2</sup> 0.7 °F 0.0017 N/cm <sup>2</sup> /s	Dead weight Thermometer Stopwatch

#### VIII. Mechanical

Parameter/Equipment	Range	CMC <sup>2,8</sup> (±)	Comments
Accelerometers – Shear and Charge <sup>3</sup>	(0.25 to 10) g (5 to 10 000) Hz	2.7 % 2.7 %	Accelerometer; g is the acceleration due to gravity.
Air Velocity	(100 to 4000) ft/min (4000 to 9000) ft/min	0.48 % + 5.5 ft/min 0.48 % + 40 ft/min	Flowkinetics manometer

Parameter/Equipment	Range	CMC <sup>2,4,8</sup> (±)	Comments
Cable Tensiometers/ Wire Tension Meters	(0 to 1000) lb	1.1 lb + 0.6R	Deadweights
Deadweight Testers –  Piston and Cylinder Area  Mass  Performance Test (Cross-Float)	(0 to 10 000) psi	(12 + 3D) μin  0.2 g  0.04 %	UMM  Class F weights and scales  Pressure calibrator with transducer
Durometers <sup>3</sup> –  Indenter Shape and Extension:      Durometer Spring	Types A, B, C, D, E, O and DO  Pressure foot orifice diameter  Indenter extension length  Cone angle  Tip radius  Indenter thickness  Up to 45 N	  3.2 μm  3.2 μm  1 arcmin  3.2 μm  3.2 μm  36 mN	ASTM D2240    Vision system    Durometer calibrator
Durometer Calibrator	Scales A and D	0.2 %	Scale and CMM

Parameter/Equipment	Range	CMC <sup>2,4,8</sup> ( $\pm$ )	Comments
Dynamometer and Force Rings <sup>3</sup>	(0 to 10 000) lbf	0.11 % + 0.6R	Load cells
Force Gages	(0 to 500) lbf (200 to 10 000) lbf	0.0024 % + 0.007 lbf 0.6 % + 1.2 lbf	Deadweights Load cell
Force Gages <sup>3</sup>	(0 to 250) lbf	0.12 % + 0.6R	Deadweights
Indirect Verification of Brinell Hardness Testers at Test Condition(s) <sup>3</sup> –  (3000, 1500, 500) Kg	(125 to 260) HBW	0.008d	ASTM E10  d is the mean of the n mean test diameter in millimeters.
Indirect Verification of Leeb Hardness Testers	Up to 800 HLD	7.4 HLD	Standard test block
Indirect Verification of Microindentation Hardness Testers (Knoop and Vickers) <sup>3</sup> –	Repeatability under forces P (gf):  1 ≤ P < 500  100 ≤ HK ≤ 940 100 ≤ HV ≤ 940	20 HK + 1.2 % 13 HV + 3 %	ASTM E384

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Indirect Verification of Rockwell Hardness and Rockwell Superficial Hardness Testers <sup>3</sup>	<p>HRA:  (22 to 63) HRA  (64 to 73) HRA  (74 to 83) HRA</p> <p>HRBW:  (0 to 40) HRB  (41 to 60) HRB  (61 to 80) HRB</p> <p>HRC:  (25 to 35) HRC  (40 to 55) HRC  (60 to 70) HRC</p> <p>HRE:  (57 to 63) HRE  (64 to 81) HRE  (82 to 99) HRE</p> <p>HRF:  (57 to 63) HRF  (64 to 80) HRF  (81 to 97) HRF</p> <p>HR15N:  (72 to 78) HR15N  (80 to 88) HR15N  (90 to 94) HR15N</p> <p>HR30N:  (46 to 55) HR30N  (60 to 73) HR30N  (78 to 86) HR30N</p> <p>HR45N:  (25 to 37) HR45N  (43 to 61) HR45N  (67 to 77) HR45N</p> <p>HR15T:  (61 to 67) HR15T  (70 to 77) HR15T  (80 to 91) HR15T</p> <p>HR30T:  (15 to 28) HR30T  (36 to 50) HR30T  (56 to 79) HR30T</p> <p>HR45T:  (2 to 13) HR45T  (14 to 34) HR45T  (43 to 67) HR45T</p>	<p>0.7 HRA  0.7 HRA  0.7 HRA</p> <p>0.7 HRB  0.7 HRB  0.7 HRB</p> <p>0.7 HRC  0.7 HRC  0.7 HRC</p> <p>0.7 HRE  0.7 HRE  0.7 HRE</p> <p>0.7 HRF  0.7 HRF  0.7 HRF</p> <p>0.7 HR15N  0.7 HR15N  0.7 HR15N</p> <p>0.7 HR30N  0.7 HR30N  0.7 HR30N</p> <p>0.7 HR45N  0.7 HR45N  0.7 HR45N</p> <p>0.7 HR15T  0.7 HR15T  0.7 HR15T</p> <p>0.7 HR30T  0.7 HR30T  0.7 HR30T</p> <p>0.7 HR45T  0.7 HR45T  0.7 HR45T</p>	

Parameter/Equipment	Range	CMC <sup>2,4,8</sup> (±)	Comments
Load Cells	(0 to 500) lbf (500 to 10 000) lbf	0.034 % + 0.00044 lbf 0.05 % + 0.024 lbf	Dead weights, comparison to master load cell
Load Cells <sup>3</sup>	(0 to 10 000) lbf	0.1 % + 0.002 lbf	Dead weights, comparison to master load cell
Manometers	(0 to 24) in H <sub>2</sub> O	0.00017 in H <sub>2</sub> O	Hook gage
Mass	1 mg to 50 g (50 to 220) g (220 to 400) g 400 g to 1.2 kg (1.2 to 8.2) kg (8.2 to 30) kg	17 µg 35 µg 0.14 mg 3.7 mg 12 mg 0.11 g	By comparison
Mass <sup>3</sup>	(2 to 30) kg	0.2 g	By comparison
Pressure/Vacuum Gauges <sup>3</sup>	(-15 to 1000) psi Pneumatic  (1000 to 5000) psi  (5000 to 10 000) psi	0.005 psi + 0.012 % fs  0.32 psi + 0.026 % fs  1.8 psi + 0.026 % fs	Pressure calibrator  Pressure transducers
Refractometers <sup>3</sup>	(0 to 100) %	0.02 % + 0.6R	Standard solutions
Scales <sup>3</sup>	(1 to 50) mg 51 mg to 10 g (11 to 50) g (51 to 300) g (301 to 1000) g (1 to 5) kg (5 to 30) kg	0.016 mg + 0.58R 0.03 mg + 0.58R 0.054 mg + 0.58R 0.24 mg + 0.58R 3.8 mg + 0.58R 11 mg + 0.58R 89 mg + 0.58R	Verification with mass standards

Parameter/Equipment	Range	CMC <sup>2, 4, 8</sup> ( $\pm$ )	Comments
Scales <sup>3</sup> (cont)	Up to 0.5 lb (0.5 to 1) lb (1 to 2) lb (2 to 5) lb (5 to 10) lb (10 to 20) lb (20 to 50) lb (50 to 100) lb (100 to 500) lb (500 to 1000) lb	0.000 0015 oz + 0.58R 0.000 0030 oz + 0.58R 0.000 011 oz + 0.58R 0.000 14 oz + 0.58R 0.000 34 oz + 0.58R 0.000 68 oz + 0.58R 0.000 93 oz + 0.58R 0.0043 oz + 0.58R 0.0086 oz + 0.58R 0.043 oz + 0.58R	Verification with mass standards
Scales – Proportional Testing <sup>3</sup>	Up to 750 lb (750 to 1500) lb (1500 to 3000) lb (3000 to 4500) lb (4500 to 6000) lb	0.22 lb + 0.6R 0.28 lb + 0.6R 0.36 lb + 0.6R 0.42 lb + 0.6R 0.48 lb + 0.6R	NIST Class F weights
Spring Testers <sup>3</sup> –  Force Scale	(0 to 1000) lbf	0.02 % + 0.6R	Weights, load cells; R is the resolution of the force scale of the spring tester.
Deflection Accuracy	Up to 20 in	26 $\mu$ in + 0.6R	Gage blocks; R is the resolution of the deflection scale.
Tachometers <sup>3</sup> –  Non-Contact	Up to 180 000 rpm	0.8R	Function generator, LED
Contact	Up to 5000 rpm (5000 to 15 000) rpm	0.024 % + 1.4 rpm 0.032 % + 0.84 rpm	Tachometer calibrator
Tensile Testers <sup>3</sup>	(0 to 30 000) lbf (30 000 to 50 000) lbf	0.4 % + 0.08 % fs 0.24 % + 0.02 % fs	Load cells
Torque Wrenches	Up to 1000 ft·lbf (1000 to 2000) ft·lbf  Up to 120 in·lbf	0.18 % + 0.1 ft·lbf 0.062 % + 1.3 ft·lbf  0.32 % + 0.6R	Torque calibrator

Parameter/Equipment	Range	CMC <sup>2,4,8</sup> (±)	Comments
Torque – Calibration of Torque Meters and Sensors	(0.1 to 2000) ft·lbf	0.14 %	Weights
Torque Watches <sup>3</sup>	(0.5 to 215) in·ozf	0.08 % + 0.52 in·ozf	Torque calibrator
Ultrasonic Thickness Testers <sup>3</sup>	(0 to 10) in	(800 + 13L) μin	Standard thickness specimen

#### IX. Optical Quantities

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Gloss Meters <sup>3</sup>	20° 60°, 85°	0.73 <i>GU</i> 0.54 <i>GU</i>	Gloss standards; <i>GU</i> represents gloss units.

#### X. Thermodynamics

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Dew Point	-20 °C to 60 °C	-0.44 °C + 0.6R	Thunder Scientific humidity chamber
Industrial Platinum Resistance Thermometers	-30 °C to 75 °C 75 °C to 200 °C 200 °C to 250 °C 250 °C to 300 °C	0.024 °C 0.032 °C 0.041 °C 0.047 °C	SPRT, temperature bath, resistance bridge
Infrared Thermometers – Measure <sup>3</sup>	-15 °C to 120 °C 35 °C to 500 °C 500 °C to 1100 °C	0.6 °C + 0.6R 0.8 °C + 0.6R 3.6 °C	Hart 9132 radiation source Isotech Pegasus 92R radiation source



Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Liquid-in-Glass Thermometers and Temperature Measuring Devices	-30 °C to 150 °C 150 °C to 250 °C 250 °C to 300 °C	0.02 °C + 0.6R 0.03 °C + 0.6R 0.04 °C + 0.6R	Constant temperature bath, SPRT
Relative Humidity – Measure			
Hygrometer	(10 to 95) % RH	0.7 % RH + 0.6R	Humidity generator, Thunder Scientific 2500ST
Psychrometer	5 °C to 35 °C	0.1 °C + 0.84R	Comparison to SPRT in temp bath
Temperature – Measuring Equipment <sup>3</sup>	-10 °C to 50 °C 50 °C to 650 °C	0.04 °C + 0.6R 0.045 °C + 0.6R	Dry-wells
Thermocouples and Thermocouple Wire	-80 °C to 650 °C	0.42 °C	Comparison to SPRT with Agilent 3458A

#### XI. Time & Frequency

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Frequency – Measuring Equipment	10 MHz 0.01 Hz to 200 kHz 200 kHz to 26.5 GHz	3 parts in 10 <sup>11</sup> 3 parts in 10 <sup>11</sup> + 30 nHz 3 parts in 10 <sup>11</sup>	GPS Function generator with ext. timebase Signal generator with ext. timebase
Frequency – Measure <sup>3</sup>	0.01 Hz to 5 GHz (5 to 20) GHz (20 to 26.5) GHz	25 nHz/Hz + 30 nHz 25 nHz/Hz 580 Hz	Frequency counter Spectrum analyzer

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Stopwatches & Timers <sup>3</sup>	10 s to 72 hr	28 ms + 0.6 μs/s	Function generator, frequency counter
	(2 to 960) s	0.037 s/day	Timometer

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

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

<sup>3</sup> Field calibration service is available for this calibration and this laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

<sup>4</sup> In the statement of CMC,  $L$  is the numerical value of the nominal length in inches;  $R$  is the resolution of the unit under test;  $D$  is the diameter in inches;  $H$  is the height of the unit under test (except where noted); and  $fs$  represents full scale.  $Ra$  is the numerical value of the nominal roughness of the surface measured in micrometer roughness, except where noted.

<sup>5</sup> CMC for calibrations performed in the laboratory with the Agilent/HP 3458A/HFL is based upon 90-day specifications. CMC for calibrations performed field with the Agilent/HP 3458A is based upon 1-year specifications. The measurands stated are generated with the Agilent/HP 3458A. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMC are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification. Unless otherwise noted, percentages are defined as percent of reading.

<sup>6</sup> CMC for calibrations performed with the Fluke 5520A is based upon 1-year specifications. CMC for calibrations performed with the Fluke 5720A/EP is based upon 90-day specifications. The measurands stated are generated with the Fluke 5500, 5700 and 732B series of instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMC are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification. Unless otherwise noted, percentages are defined as percent of reading.

<sup>7</sup> CMC for calibrations performed with the Fluke 5790A is based upon 1-year specifications. The measurands stated are generated with the Fluke 5700 series of instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMCs are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification. Unless otherwise noted, percentages are defined as percent of reading.

<sup>8</sup> In the statement of CMC, the value is defined as the percentage of reading, unless otherwise noted.

<sup>9</sup> This accreditation covers calibrations performed at the main laboratory listed above, and the following satellite laboratory located at 2591 S. Oakwood Road, Oshkosh, WI 54904.

Satellite Location:

PRECISION METROLOGY, INC.  
 2951 S. Oakwood Rd  
 Oshkosh, WI 54904  
 Carol Shipley Phone: 414 351 7420

CALIBRATION

I. Dimensional

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Bore Gages <sup>3</sup>	Up to 12 in	10 µin/in + 0.6R	Gage blocks
Calipers <sup>3</sup> –			Gage blocks
Resolution 0.0001 in	Up to 2 in (2 to 12) in	78 µin 70 µin + 4 µin/in	
Resolution 0.0005 in	Up to 24 in (24 to 60) in	450 µin 340 µin + 3.7 µin/in	
Resolution 0.001 in	Up to 30 in (30 to 80) in	840 µin 700 µin + 3.4 µin/in	
Chamfer Gages/Hole Gages <sup>3</sup>	Up to 12 in	(20 + 0.6R) µin	Cylindrical rings
Depth Gages	Up to 12 in	12 µin/in + 0.6R	Gage blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Dial Indicator	Up to 0.5 in (0.5 to 8) in	12 µin/in + 0.6R 12 µin/in + 0.6R	Indicator calibrator Gage blocks
Height Gage	Up to 36 in	15 µin/in + 0.6R	Reference stack
Intertest/Oditest Calipers	Up to 4 in	54 µin + 0.6R	Gage blocks
Micrometers <sup>3</sup> – Depth Groove	Up to 12 in Up to 4 in	20 µin/in + 0.6R 18 µin/in + 0.6R	Gage blocks
Micrometer – OD Micrometers	Up to 42 in	12 µin/in + 0.6R	Gage blocks
Protractor – Digital and Mechanical <sup>3</sup>	0° to 180°	0.0076°	Angle blocks
Test Indicator	Up to 0.5 in	0.0001 in	Indicator calibrator
Thickness Gages <sup>3</sup> – Dial and Digital	Up to 1 in	19 µin + 0.6R	Gage blocks
Tri-Bore Micrometers	Up to 3 in	15 µin/in + 0.6R	Cylindrical rings

## II. Mechanical

Parameter/Equipment	Range	CMC <sup>2,4,5</sup> (±)	Comments
Torque Wrenches	Up to 1000 in·lbf Up to 250 ft·lbf	0.6 % + 0.6R 0.6 % + 0.1 ft·lbf	Torque calibrator

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

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

<sup>3</sup> Field calibration service is available for this calibration and this laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

<sup>4</sup> In the statement of CMC,  $R$  is the resolution of the unit under test.

<sup>5</sup> In the statement of CMC, the value is defined as the percentage of reading, unless otherwise noted.



## *Accredited Laboratory*

A2LA has accredited

**PRECISION METROLOGY, INC.**

*Milwaukee, WI*

for technical competence in the field of

**Calibration**

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSLI Z540-1-1994 and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).



Presented this 23<sup>rd</sup> day of September 2014.

A handwritten signature in blue ink, appearing to read "J. C. Bunt".

Senior Director of Quality and Communications  
For the Accreditation Council  
Certificate Number 1078.01  
Valid to October 31, 2016  
Revised July 5, 2016

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