



The American Association for Laboratory Accreditation

World Class Accreditation

# 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/NCSL 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 9<sup>th</sup> day of September 2010.



  
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President & CEO

For the Accreditation Council  
Certificate Number 1078.01  
Valid to July 31, 2012

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



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

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CALIBRATION

Valid To: July 31, 2012

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>1,8</sup>:

I. Acoustical Quantities

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Sound Level	(0 to 140) dB	0.16 dB + 0.032 % rdg	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
pH Meters	(4, 7, 10) pH units	0.01 pH units	Standard buffers
Conductivity Meters	10 µS/cm	0.64 µS/cm + 0.6R	Conductivity solutions
	100 µS/cm	1.2 µS/cm + 0.6R	
	1000 µS/cm	5.5 µS/cm + 0.6R	
	1400 µS/cm	9.2 µS/cm + 0.6R	
	10 000 µS/cm	35 µS/cm + 0.6R	

### III. Dimensional

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Gage Blocks – Steel Non-Steel	Up to 4 in (4 to 20) in Up to 4 in (4 to 20) in	(2.8 + 1.6L) μin (5.0 + 1.6L) μin (4.0 + 2.2L) μin (6.0 + 2.2L) μin	Gage blocks
Gage Balls	Up to 4 in	(18 + 4D) μin	Universal measuring machine (UMM)
Pitch Micrometer Standards – Length Angle	Up to 12 in Up to 60°	(8 + 8L) μin 54"	UMM Vision system
Length Standards <sup>3</sup>	Up to 18 in	(18 + 8L) μin	UMM
Length Standards	(18 to 120) in	(180 + 12L) μin	UMM
Indicators <sup>3</sup> – Dial Test	Up to 8 in Up to 0.060 in	(10L + 0.6R) μin 0.0001 in	Indicator calibrator
Bore Gages <sup>3</sup>	Up to 12 in	(10L + 0.6R) μin	Gage blocks
Height Gage <sup>3</sup>	Up to 48 in	(10L + 0.6R) μin	Gage blocks
Calipers <sup>3</sup>	Up to 80 in (80 to 120) in	(10L + 0.6R) μin (1200 + 0.6R) μin	Gage blocks
Groove Micrometers <sup>3</sup>	Up to 4 in	(18 + 0.6R) μin	Gage blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Micrometers <sup>3</sup> – Inside Depth Tri-Bores Outside Groove	Up to 294 in Up to 12 in Up to 6 in Up to 42 in Up to 4 in	$(14L + 0.6R)$ $\mu$ in $(20L + 0.6R)$ $\mu$ in $(10L + 0.6R)$ $\mu$ in $(10L + 0.6R)$ $\mu$ in $(18L + 0.6R)$ $\mu$ in	Gage blocks; $L$ is the measured displacement in inches.
Thread Micrometers <sup>3</sup> (Screw Thread, Pitch, Point)	Up to 4 in	$(10L + 0.6R)$ $\mu$ in	Pitch standard; $L$ is the measured displacement in inches.
Snap (Jaw) Calipers <sup>3</sup>	Up to 12 in	$(86 + 0.6R)$ $\mu$ in	Gage blocks
Intertest Calipers <sup>3</sup>	Up to 4 in	$(40 + 0.6R)$ $\mu$ in	Gage blocks
Oditest Calipers <sup>3</sup>	Up to 2 in	$(40 + 0.6R)$ $\mu$ in	Gage blocks
Snap Gages <sup>3</sup>	Up to 20 in	0.00018 in	Box parallel with gage amp and probe
Reference Stacks	50 in	$(15 + 9L)$ $\mu$ in	Gage blocks
Surface Plates <sup>3</sup> – Flatness  Repeatability	Up to 72 in $\times$ 144 in  Up to 72 in $\times$ 144 in	$8\sqrt{D}$ $\mu$ in  34 $\mu$ in	Electronic levels $D$ is the length of the plate diagonal in inches.  Repeat-o-meter
Rules/Scales <sup>3</sup>	Up to 100 in	$(86 + 16L)$ $\mu$ in	UMM
Tape Measures <sup>3</sup>	Up to 300 ft	$(0.026 + 0.6R)$ in	UMM
Benchmics <sup>3</sup>	Up to 2 in	30 $\mu$ in	Gage blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Linear Measurement of Machine Tools <sup>3</sup>	Up to 20 ft	42 μin + 0.5 μin/in	Laser
Height Measures <sup>3</sup>	Up to 24 in	(130 + 10L) μin	Height gage
Plain Ring Gages <sup>3</sup>	(0.1 to 18) in (18 to 36) in	(20 + 4D) μin (48 + 2D) μin	UMM
Plain Plug Gages <sup>3</sup>	Up to 20 in	(18 + 4D) μin	UMM
Threaded Rings <sup>3</sup> – 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	with set plug
Threaded Plug Gages <sup>3</sup> – Pitch Diameter Major Diameter	Up to 18 in Up to 18 in	(98 + 6D) μin (18 + 4D) μin	UMM, thread wires (best thread wire size)
Thread Wires	Up to 0.5 in	(16 + 4D) μin	UMM
NPT Plugs <sup>3</sup> – Pitch Diameter Taper	Up to 18 in Up to 18 in	(100 + 12D) μin (360 + 10D) μin	Thread wires/UMM Height measuring machine
NPT Rings <sup>3</sup> – 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 μin 400 μin 120 μin (300 + 8D) μin	NPT master plug, UMM NPT master plug NPT master plug and height measuring machine

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
CMMs <sup>3</sup> –			ASME B89.4.1
Length	(0 to 72) in on each axis	(42 + 5L) μin	Laser
Volume	To 36 in for shortest axis	(120 + 5L) μin	Step gage
Probing Analysis	---	2 μm	Ball bar
Bi-directional	---	50 μin	Test probe
Depth Gage <sup>3</sup>	Up to 8 in	(10L + 0.6R) μin	Gage blocks or depth mikemaster
Optical Comparator <sup>3</sup> –			
Linear	Up to 12 in	0.0002 in	Glass scale
Angle	0° to 360°	2ʹ	Calibration sphere
Magnification	10x, 20x, 50x, 62.5x, 100x, 200x	0.00012 in	Calibration sphere
Optical Flats	Up to 8 in	2.8 μin	Reference flat and monochromatic light source
Angle Plates <sup>3</sup>	Up to 30 in	(120 + 6H) μin	Gage amp. Probe, indi-square and test indicator
Angle Blocks	0° to 90°	7ʹ	Measuring machine
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, H is the height of the cylinder from the base in inches.

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Protractor – Digital and Mechanical <sup>3</sup>	0° to 180°	0.08R + 0.08°/ 180°	Angle blocks
Levels (Machinist) <sup>3</sup>	Up to 96 in	0.00019 in/ft	Sine plate
Radius Gage	Up to 5 in	0.00015 in	Optical comparator
Feeler/Thickness Gage <sup>3</sup>	Up to 0.2 in	36 $\mu$ in	UMM
Fixed Gaging – Screw Pitch Gages, Drill Gages, Taper Gages, Center Gages, Sheet and Wire Gages, Angle Gages	---	(110 + 16L) $\mu$ in (length measures) 54"	Measuring machine/optical comparator
Precision Diameter Tapes	Up to 48 in (48 to 780) in	200 $\mu$ in + 4 $\mu$ in/in 0.0013 in + 6 $\mu$ in/in	UMM
Parallels <sup>3</sup> –  Steel  Granite	1.5 in $\times$ 6 in  8 in $\times$ 48 in	(10 + 10L) $\mu$ in  (10 + 3.6L) $\mu$ in	Gage amp with probe; L is the distance between the parallel surfaces.
Box Parallels–  Parallelism Squareness	5 in $\times$ 10 in $\times$ 10 in	(12 + 20H) $\mu$ in (18 + 20H) $\mu$ in	Gage amp with probe, cylindrical square
Sine Plates/Bars <sup>3</sup> –  Flatness/Parallelism & Parallelism Cylinder to Base  Angle Calibration	Up to 20 in  0° to 90°	50 $\mu$ in  8"	Gage amp with probe and angle blocks

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Thickness Gages <sup>3</sup> – Dial and Digital	Up to 1 in	$(19 + 0.6R) \mu\text{in}$	Gage blocks
Chamfer Gages/Hole Gages <sup>3</sup>	Up to 12 in	$(20 + 0.6R) \mu\text{in}$	Cylindrical rings
Gage Amplifier and Probe <sup>3</sup>	---	$(5 + 0.6R) \mu\text{in}$	Gage blocks
Riser Blocks and Stands	Up to 24 in	$(13 + 8H) \mu\text{in}$	Gage amplifier with probe
Clinometers and Inclinometers	Up to 360°	$16'' + 0.6R$	Sine bar/gage blocks
Cylindrical Squares	Up to 12 in	$(13 + 9H) \mu\text{in}$	Gage amplifier with probe; $H$ is the height of the cylinder from the base in inches.
Squares <sup>3</sup> – Master	Up to 30in	$(56 + 5H) \mu\text{in}$	Gage amp and probe
Granite	Up to 30 in	$(42 + 6H) \mu\text{in}$	Indi-square and test indicator
Steel	Up to 30 in	$(42 + 6H) \mu\text{in}$	Master square and gage blocks
Straightness and Straight Edges	Up to 60 in	$(10 + 14L) \mu\text{in}$	Gage amplifier with probe
Straightness and Straight Edges <sup>3</sup>	Up to 60 in	$(14 + 16L) \mu\text{in}$	Gage amplifier with probe

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
V-Blocks – Parallelism Side V Squareness	8 in × 8 in × 8 in	14 μin 20 μin (37 + 11 <i>H</i> ) μin	Gage amplifier with probe Cylindrical square Cylindrical plug
Indicator Calibrator <sup>3</sup>	----	(12 + 0.6 <i>R</i> ) μin	Gage blocks, amplifier with probe
Indirect Verification of Profilometers <sup>3</sup>	20 μin <i>Ra</i> 120 μin <i>Ra</i> 400 μin <i>Ra</i>	(4.6 + 0.6 <i>R</i> ) μin (4.6 + 0.6 <i>R</i> ) μin (16 + 0.6 <i>R</i> ) μin	Roughness specimen
Surface Roughness <sup>3</sup>	(15 to 150) μin <i>Ra</i>	5 % rdg + 0.6 <i>R</i>	Verification of specimens per ASME B46.1 Type C using profilometers; <i>R</i> is the resolution of the profilometers in microinches.
Wire Crimpers <sup>3</sup> – Crimp Height Crimping Chamber Ratchet Inspection	---	0.0024 in (10 + 19 <i>D</i> ) μin 120 μin	Micrometer Pin; <i>D</i> is the diameter of the pin. Feeler gage
Microscopes <sup>3</sup> – Reticule Magnification	(0 to 25) mm Up to 1000x	23 μm 2.4 % rdg	Stage micrometer

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Concentricity Gage	N/A	130 μin + 8 μin/in	Indicator, bench center
Universal Measuring Machines <sup>3</sup> (UMMs)	Up to 20 in	(6 + 8L) μin	Gage blocks, dynamometer, optical flats
External Spline Gages <sup>3</sup> – Measurement Over Pins Circular Tooth Thickness Major Diameter	Up to 8 in	(170+ 28D) μin (110 + 16L) μin (26 + 12D) μin	UMM Optical comparator UMM
Vision Systems <sup>3</sup> – X-Y Linear Accuracy Z-Axis Linear Accuracy	Up to 24 in Up to 20 in	(110 + 13L) μin (74 + 11L) μin	Glass scale Gage blocks
Linear Scales/Reticles	Up to 12 in Up to 12 in	(17 + 7L) μin (110 + 16L) μin	Laser, optical comparator Vision system
Linear Measure	(0 to 30) in	(140 + 10L) μin	CMM
Linear Measure <sup>3</sup>	(0 to 24) in	0.00013 in	Height gage
Arbor – Straightness	(0 to 24) in	(35 + 9L) μin	Gage amp w/probe
Bench Center – Center Parallelism Base Flatness & Base Parallelism	(0 to 24) in (0 to 24) in	(68 + 4L) μin (62 + 2.5L) μin	Gage amp w/probe

IV. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2, 6</sup> (±)	Comments
DC Voltage – Generate, Fixed Points	10 V	0.7 µV/V	Fluke 732B
DC Voltage – Generate	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220V) (220 to 1100V)	7.3 µV/V + 1 µV 5.6 µV/V + 1 µV 2.5 µV/V + 3 µV 5.2 µV/V + 5 µV 5.6 µV/V + 50 µV 5 µV/V + 500 µV	Fluke 5700A/EP
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	5.9 µV/V + 0.3 nV 5.3 µV/V + 0.3 µV 4.7 µV/V + 1 µV 11 µV/V + 3 µV 22 µV/V + 1 mV	Agilent/HP 3458A
DC Voltage – Measure, Fixed Point	19 V	21 µV	Fluke 732B, 720A Agilent 34420A
DC High Voltage – Measure <sup>3</sup>	(1 to 2) kV (2 to 20) kV  (20 to 70) kV	0.05 % + 0.46 V 0.05 % + 4.6 V  0.05 % + 17 V	Vitrek 4600A  Vitrek 4670A
DC Current – Generate <sup>3</sup>	(0 to 100) nA 100 nA to 1 µA (1 to 10) µA (10 to 220) µA 220 µA to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (2.2 to 11) A  (11 to 20) A (20 to 150) A 150A to 1 kA	28 µA/A 16 µA/A 16 µA/A 35 µA/A + 6 nA 30 µA/A + 8 nA 30 µA/A + 50 nA 40 µA/A + 0.7 µA 56 µA/A + 15 µA 0.035 % + 0.48 mA  0.08 % + 0.75 mA 0.26 % 0.51 %	Fluke 5700A/EP          Fluke 5520A w/5500A coil

Parameter/Equipment	Range	CMC <sup>2, 5, 6</sup> ( $\pm$ )	Comments
DC Current – Measure <sup>3</sup>	(0 to 100) nA (0.1 to 1) $\mu$ A 1 $\mu$ A to 10 mA (10 to 100) mA (0.1 to 1) A (3 to 20) A (20 to 300) A (300 to 1000) A	51 $\mu$ A/A + 0.04 nA 28 $\mu$ A/A + 0.04 nA 20 $\mu$ A/A + 0.1 $\mu$ A 36 $\mu$ A/A + 0.5 $\mu$ A 0.012 % + 10 $\mu$ A 0.015 % + 0.16 mA 0.04 % 0.25 %	Agilent/HP 3458A  Fluke 8508  with shunts
Resistance – Measure	(0 to 10) $\Omega$ (10 to 100) $\Omega$ 100 $\Omega$ to 100 k $\Omega$ 100 k $\Omega$ to 1 M $\Omega$ (1 to 10) M $\Omega$ (10 to 100) M $\Omega$ 100 M $\Omega$ to 1 G $\Omega$ (1 to 2) G $\Omega$ (2 to 20) G $\Omega$ (20 to 200) G $\Omega$ 200 G $\Omega$ to 2 T $\Omega$	10 $\mu\Omega/\Omega$ + 50 $\mu\Omega$ 9 $\mu\Omega/\Omega$ + 0.5 m $\Omega$ 8 $\mu\Omega/\Omega$ + 50 m $\Omega$ 8 $\mu\Omega/\Omega$ + 2 $\mu\Omega$ 30 $\mu\Omega/\Omega$ + 100 $\Omega$ 0.03 % + 1 k $\Omega$ 0.3 % + 10 k $\Omega$ 0.14 % + 600 $\Omega$ 0.8 % + 600 $\Omega$ 0.8 % + 600 $\Omega$ 0.8 %	Agilent/HP 3458A and standard resistors  Fluke 8508A 6500A
Inductance <sup>3</sup> –  Measure (1 kHz)  Generate – Fixed Points	50 $\mu$ H to 10 H  100 $\mu$ H (1, 5, 10, 100) mH 1 H 2H, 5H	0.03 % rdg + 0.05 $\mu$ H  0.25 % rdg 0.1 % rdg 0.1 % rdg 0.11 % rdg	1689M RLC bridge  Standard inductors
Resistance – Generate, Fixed Points <sup>3</sup>	1 m $\Omega$ 10 m $\Omega$  0.1 $\Omega$  (1, 10, 100) $\Omega$ (1, 10) k $\Omega$ 100 k $\Omega$ 1 M $\Omega$ (10, 100) M $\Omega$ 1 G $\Omega$  10 G $\Omega$ 100 G $\Omega$ 1 T $\Omega$	0.13 % rdg 0.047 % rdg  10 $\mu\Omega/\Omega$  10 $\mu\Omega/\Omega$ 7 $\mu\Omega/\Omega$ 5 $\mu\Omega/\Omega$ 7 $\mu\Omega/\Omega$ 13 $\mu\Omega/\Omega$ 28 $\mu\Omega/\Omega$  0.21 % rdg 0.42 % rdg 2.5 % rdg	L&N 4361 L&N 4363  L&N resistors  Fluke 742A, standard resistors  IET high resistance standard

Parameter/Equipment	Range	CMC <sup>2,6</sup> (±)	Comments
DC Power <sup>3</sup> –  33 mV to 1020 V	330 µA to 330 mA 330 mA to 3 A (3 to 20.5) A	0.068 % 0.07 % 0.12 %	Fluke 5520A
Capacitance <sup>3</sup> –  Measure (1 kHz)	100 pF to 1µF  1 µF to 25 µF (25 to 100) µF 100 µF to 7 mF (7 to 33) mF (33 to 110) mF	14 µF/F  0.03 % rdg + 80 µF/F 0.03 % rdg + 80 µF/F 0.03 % rdg 0.012 % rdg	AH 2500A  1689M  Fluke 5700A/EP and Agilent 3458A
Generate – Fixed Points	100 pF 0.001 µF 0.002 µF (0.01, 0.02, 0.05) µF (0.1, 0.5, 1) µF	0.054 % rdg 0.068 % rdg 0.056 % rdg 0.055 % rdg 0.055 % rdg	Standard capacitors
Oscilloscope Calibration <sup>3</sup> – Squarewave Signal 50 Ω at 1 kHz Source	(1 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 1100) V	0.28 % + 48 µV 0.28 % + 120 µV 0.28 % + 1.2 mV 0.28 % + 12 mV	Fluke 5520A/SC1100 scope option
Squarewave Signal 1 MΩ at 1 kHz Source	(1 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 1100) V	0.12 % + 48 µV 0.12 % + 120 µV 0.12 % + 1.2 mV 0.12 % + 12 mV	
Leveled Sine Wave Amplitude	50 kHz reference 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	2 % + 300 µV 3.5 % + 300 µV 4 % + 300 µV 6 % + 300 µV 7 % + 300 µV	
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 % + 100 µV 2 % + 100 µV 4 % + 100 µV 5 % + 100 µV	
Time Marker 50 Ω Source and Period	5 s to 50 ms 20 ms to 2 ns	26 parts in 10 <sup>6</sup> + 0.07 ms	
Rise Time	≤ 300 ps	2.6 parts in 10 <sup>6</sup> + 0 / -100 ps	

Parameter/Equipment	Range	CMC <sup>2,5</sup> ( $\pm$ )	Comments
Edge Characteristics – Amplitude	100 mV to 10 VDC	6.2 parts in 10 <sup>6</sup>	Agilent/HP 3458A
Equivalent Rise Time	$\geq 20$ ps/div $< 20$ ps/div	8 ps + 0.1 % of interval 1 ps + 1 % of interval	TDS 8000, equivalent rise time determined using sine wave
Phase – Measure  (0.01 to 0.1) V <sub>rms</sub>  (0.1 to 120) V <sub>rms</sub>	10 Hz to 10 kHz (10 to 50) kHz (50 to 100) kHz  10 Hz to 50 kHz (50 to 100) kHz	0.24° 0.42° 0.82°  0.06° 0.42°	KH 6620 phase meter
Phase – Generate  (0.1 to 100) V <sub>rms</sub>	1 Hz to 1 kHz (1.001 to 6.25) kHz (6.25 to 50) kHz (50.01 to 100) kHz	15 m° 16 m° 31 m° 56 m°	Clark-Hess 5000
Leveled Sine Wave <sup>3</sup> – Frequency	50 kHz to 500 MHz	1.6 parts in 10 <sup>6</sup>	Agilent 53131
Harmonics	0.1 MHz to 8 GHz (8 to 13) GHz (13 to 18) GHz	0.75 dBc + 3 % rdg 0.75 dBc + 4 % rdg 0.75 dBc + 5 % rdg	L1500A
Flatness – High Frequency	0.1 MHz to 18 GHz	0.04 dB + 3 % rdg	E4418 power meter and 8481D and 8482A power sensors

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouple Indicating Devices <sup>3</sup> –			
Type E	-250 °C to -100 °C -100 °C to 650 °C 650 °C to 1000 °C	0.5 °C 0.15 °C 0.21 °C	Fluke 5520A
Type J	-210 °C to -100 °C -100 °C to 760 °C 760 °C to 1200 °C	0.28 °C 0.16 °C 0.23 °C	
Type K	-200 °C to -100 °C -100 °C to 120 °C 120 °C to 1000 °C 1000 °C to 1372 °C	0.34 °C 0.17 °C 0.26 °C 0.4 °C	
Type S	0 °C to 250 °C 250 °C to 1400 °C 1400 °C to 1767 °C	0.47 °C 0.37 °C 0.46 °C	
Type T	-250 °C to -150 °C -150 °C to 0 °C 0 °C to 400 °C	0.63 °C 0.24 °C 0.15 °C	
Electrical Calibration of RTD Indicating Devices <sup>3</sup> –			
Pt 395, 100 Ω	-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 Ω	-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 Ω	-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 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 0.10 °C 0.12 °C	

Parameter/Range	Frequency	CMC <sup>2,6</sup> (±)	Comments
AC Power <sup>3</sup> –			
PF = 1			Fluke 5520A
(3.3 to 9) mA	(10 to 65) Hz	0.15 %	
(9 to 33) mA	33 mV to 1020 V	0.1 %	
(33 to 90) mA		0.13 %	
(90 to 330) mA		0.1 %	
330 mA to 0.9 A		0.08 %	
(0.9 to 2.2) A		0.08 %	
(2.2 to 4.5) A		0.28 %	
(4.5 to 20.5) A		0.15 %	

Parameter/Range	Frequency	CMC <sup>2,6</sup> (±)	Comments
AC Power <sup>3</sup> (cont)– PF = 1			
(3.3 to 9 ) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA 330 mA to 0.9 A (0.9 to 2.2) A (2.2 to 4.5) A (4.5 to 20.5) A	(65 to 500) Hz 33 mV to 1020 V	0.09 % 0.07 % 0.1 % 0.11 % 0.08 % 0.08 % 0.18 % 0.18 %	Fluke 5520A
(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA 330 mA to 0.9 A (0.9 to 2.2) A (2.2 to 4.5) A (4.5 to 20.5) A	500 Hz to 1 kHz 33 mV to 1020 V	0.1 % 0.07 % 0.1 % 0.11 % 0.06 % 0.08 % 0.18 % 0.18 %	
(3.3 to 9 ) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA 330 mA to 0.9 A (0.9 to 2.2) A (2.2 to 4.5) A (4.5 to 20.5) A	(1 to 5) kHz 33 mV to 1020 V	0.14 % 0.12 % 0.21 % 0.15 % 0.69 % 0.56 % 2.5 % 2.5 %	
(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA 330 mA to 0.9 A (0.9 to 2.2) A	(5 to 10) kHz 33 mV to 1020 V	0.38 % 0.35 % 0.52 % 0.38 % 3.1 % 2.4 %	
(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA	(10 to 30) kHz 33 mV to 1020 V	1.3 % 1.2 % 1.4 % 1.3 %	

Parameter/Range	Frequency	CMC <sup>2, 7</sup> (±)	Comments
AC Voltage – Generate <sup>3</sup>			
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	0.1 % + 5 μV 0.14 % + 5 μV 0.11 % + 5 μV 0.11 % + 5 μV 0.25 % + 6 μV 0.44 % + 12 μV 0.66 % + 25 μV 0.79 % + 19 μV	Fluke 5700A/EP
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.039 % + 5 μV 0.015 % + 5 μV 0.017 % + 5 μV 0.036 % + 5 μV 0.058 % + 6 μV 0.13 % + 12 μV 0.17 % + 25 μV 0.31 % + 25 μV	
(22 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.029 % + 15 μV 0.12 % + 8 μV 81 μV/V + 8 μV 0.02 % + 8 μV 0.045 % + 20 μV 0.074 % + 25 μV 0.13 % + 30 μV 0.25 % + 60 μV	
220 mV to 2.2 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.028 % + 50 μV 85 μV/V + 20 μV 50 μV/V + 10 μV 83 μV/V + 12 μV 0.12 % + 40 μV 0.036 % + 0.1 mV 0.089 % + 0.25 mV 0.16 % + 0.6 mV	
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.028 % + 0.5 mV 82 μV/V + 0.2 mV 44 μV/V + 70 μV 80 μV/V + 0.12 mV 0.012 % + 2 mV 0.3 % + 0.8 mV 0.93 % + 2.5 mV 0.17 % + 4 mV	

Parameter/Range	Frequency	CMC <sup>2, 6, 7</sup> ( $\pm$ )	Comments
AC Voltage – Generate <sup>3</sup> (cont)			
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1MHz	0.028 % + 5 mV 83 $\mu$ V/V + 2 mV 55 $\mu$ V/V + 0.7 mV 98 $\mu$ V/V + 1.2 mV 0.016 % + 3 mV 0.08 % + 20 mV 0.41 % + 50 mV 0.7 % + 100 mV	Fluke 5720A
(Limited to 2.2 x 10 <sup>7</sup> V-Hz)			
(220 to 1100)V	(15 to 50) Hz 50 Hz to 1 kHz	0.025 % + 20 mV 0.013 % + 4 mV	
(220 to 750) V	(30 to 50) Hz (50 to 100) kHz	0.03 % + 11 mV 0.11 % + 45 mV	
(750 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	71 $\mu$ V/V + 4 mV 0.01 % + 6 mV 0.03 % + 8.5 mV	with 5725A
AC High Voltage – Measure <sup>3</sup>			
(1 to 2) kV <sub>peak</sub>	(20 to 100) Hz (100 to 400) Hz	0.1 % rdg + 0.12 % rng 0.46 % rdg + 0.12 % rng	Vitrek 4600A
(2 to 20) kV <sub>peak</sub>	(2 to 100) Hz	0.23 % rdg + 0.12 % rng	
(20 to 50) kV <sub>peak</sub>	(50 to 60) Hz	0.46 % rdg + 0.17 % rng	Vitrek 4670A
AC Voltage – Measure <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	0.17 % + 1.3 $\mu$ V 0.077 % + 1.3 $\mu$ V 0.047 % + 1.3 $\mu$ V 0.084 % + 2 $\mu$ V 0.12 % + 2.5 $\mu$ V 0.24 % + 4 $\mu$ V 0.25 % + 8 $\mu$ V 0.38 % + 8 $\mu$ V	Fluke 5790A

Parameter/Range	Frequency	CMC <sup>2, 7</sup> (±)	Comments
AC Voltage – Measure <sup>3</sup> (cont)			
(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	0.086 % + 1.3 μV 0.039 % + 1.3 μV 0.025 % + 1.3 μV 0.042 % + 2 μV 0.062 % + 2.5 μV 0.13 % + 4 μV 0.14 % + 8 μV 0.24 % + 8 μV	Fluke 5790A
(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	0.03 % + 1.3 μV 0.02 % + 1.3 μV 0.012 % + 1.3 μV 0.022 % + 2 μV 0.032 % + 2.5 μV 0.084 % + 4 μV 0.093 % + 8 μV 0.18 % + 8 μV	
(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	0.026 % + 1.5 μV 0.014 % + 1.5 μV 0.008 % + 2 μV 0.014 % + 1.5 μV 0.03 % + 2.5 μV 0.058 % + 4 μV 0.076 % + 8 μV 0.12 % + 8 μV	
(70 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.022 % + 1.5 μV 0.01 % + 1.5 μV 0.0044 % + 1.5 μV 0.0073 % + 2 μV 0.016 % + 2.5 μV 0.027 % + 4 μV 0.039 % + 8 μV 0.1 % + 8 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 1MHz	0.022 % + 1.5 μV 0.0077 % + 1.5 μV 0.0035 % + 1.5 μV 0.0056 % + 2 μV 0.008 % + 2.5 μV 0.02 % + 4 μV 0.031 % + 8 μV 0.1 % + 8 μV	

Parameter/Range	Frequency	CMC <sup>2,7</sup> (±)	Comments
AC Voltage – Measure <sup>3</sup> (cont)			
(0.7 to 2.2) V	(10 to 20) Hz	0.022 %	Fluke 5790A
	(20 to 40) Hz	0.0074 %	
	40 Hz to 20 kHz	0.0027 %	
	20 kHz to 50 kHz	0.005 %	
	(50 to 100) kHz	0.0073 %	
	(100 to 300) kHz	0.018 %	
	(300 to 500) kHz	0.028 %	
500 kHz to 1 MHz	0.093 %		
(2.2 to 7) V	(10 to 20) Hz	0.02 %	
	(20 to 40) Hz	0.0069 %	
	40 Hz to 20 kHz	0.0028 %	
	(20 to 50) kHz	0.0051 %	
	(50 to 100) kHz	0.0082 %	
	(100 to 300) kHz	0.022 %	
	(300 to 500) kHz	0.043 %	
500 kHz to 1 MHz	0.13 %		
(7 to 22) V	(10 to 20) Hz	0.022 %	
	(20 to 40) Hz	0.0072 %	
	40 Hz to 20 kHz	0.0039 %	
	(20 to 50) kHz	0.0061 %	
	(50 to 100) kHz	0.0095 %	
	(100 to 300) kHz	0.021 %	
	(300 to 500) kHz	0.041 %	
500 kHz to 1 MHz	0.12 %		
(22 to 220) V	(10 to 20) Hz	0.02 %	
	(20 to 40) Hz	0.0072 %	
	40 Hz to 20 kHz	0.0039 %	
	(20 to 50) kHz	0.0071 %	
	(50 to 100) kHz	0.01 %	
	(100 to 300) kHz	0.022 %	
	(300 to 500) kHz	0.05 %	
(220 to 700) V	(10 to 20) Hz	0.02 %	
	(20 to 40) Hz	0.01 %	
	40 Hz to 20 kHz	0.0046 %	
	(20 to 50) kHz	0.014 %	
	(50 to 100) kHz	0.05 %	
(700 to 1000) V	(10 to 20) Hz	0.02 %	
	(20 to 40) Hz	0.01 %	
	40 Hz to 20 kHz	0.0043 %	
	(20 to 50) kHz	0.014 %	
	(50 to 100) kHz	0.05 %	

Parameter/Range	Frequency	CMC <sup>2, 5</sup> (±)	Comments
AC Voltage – Measure <sup>3</sup> (cont) ≤ 2 MHz			
(0 to 10) mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.036 % + 3 μV 0.026 % + 1.1 μV 0.038 % + 1.1 μV 0.12 % + 1.1 μV 0.58 % + 1.1 μV 4.6 % + 2 μV	Agilent/HP 3458A
(10 to 100) mV	1 Hz to 40Hz 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	0.033 % + 4 μV 0.015 % + 2 μV 0.023 % + 2 μV 0.047 % + 2 μV 0.01 % + 2 μV 0.036 % + 10 μV 1.2 % + 10 μV 1.8 % + 10 μV	
(0.1 to 1) V	(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 MHz to 2 MHz	0.0081 % + 4 μV 0.0081 % + 2 μV 0.016 % + 2 μV 0.035 % + 2 μV 0.1 % + 2 μV 0.35 % + 10 μV 1.2 % + 10 μV 1.8 % + 10 μV	
(1 to 10) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.01 % + 0.4 mV 0.009 % + 0.2 mV 0.017 % + 0.2 mV 0.035 % + 0.2 mV 0.1 % + 0.2 mV 0.35 % + 1 mV 1.2 % + 1 mV 1.8 % + 1 mV	
(10 to 100) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.031 % + 4 mV 0.025 % + 2 mV 0.024 % + 2 mV 0.041 % + 2 mV 0.14 % + 2 mV 0.047 % + 10 mV 1.8 % + 10 mV	
(100 to 1000) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.05 % + 40 mV 0.047 % + 20 mV 0.07 % + 20 mV 0.14 % + 20 mV 0.035 % + 20 mV	

Parameter/Range	Frequency	CMC <sup>2, 5, 6, 7</sup> ( $\pm$ )	Comments
AC Current – Measure <sup>3</sup> (0 to 100) $\mu$ A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % + 30 nA 0.17 % + 30 nA 0.071 % + 30 nA 0.071 % + 30 nA	Agilent/HP 3458A
(0.1 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.46 % + 20 $\mu$ A 0.17 % + 20 $\mu$ A 0.071 % + 20 $\mu$ A 0.038 % + 20 $\mu$ A 0.071 % + 20 $\mu$ A 0.46 % + 40 $\mu$ A 0.64 % + 0.15 mA	
(0.1 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	0.46 % + 0.2 mA 0.18 % + 0.2 mA 0.09 % + 0.2 mA 0.012 % + 0.2 mA 0.35 % + 0.2 mA 0.12 % + 0.4 mA	
(1 to 2) A	10 Hz to 2 kHz (1 to 10) kHz (10 to 30) kHz	0.055 % + 0.24 mA 0.063 % + 0.24 mA 0.25 % + 0.24 mA	Fluke 8508
(1 to 20)A	10 Hz to 2 kHz (1 to 10) kHz	0.07 % + 2.4 mA 0.2 % + 2.4 mA	
(20 to 50) A	50 Hz to 1 kHz	0.007 %	Agilent 3458A with shunts
50A to 1kA	60 Hz	2 %	Fluke 337
AC Current – Generate			
33 $\mu$ A	(1 to 10) kHz (10 to 30) kHz	0.022 % 0.033 %	Fluke 5790A, 5700A/EP, 5520A, A40
190 $\mu$ A	(45 to 10) kHz (10 to 30) kHz	0.008 % 0.025 %	
330 $\mu$ A	10 Hz to 10) kHz (10 to 30) kHz	0.007 % 0.025 %	
0.33 mA	(1 to 5) kHz (5 to 30) kHz	0.007 % 0.025 %	
(0.33 to 200) mA	10Hz (10 to 20) Hz 20 Hz to 10 kHz	0.012 % 0.01 % 0.008 %	

Parameter/Range	Frequency	CMC <sup>2,6</sup> (±)	Comments
AC Current – Generate 200 mA to 2 A	10 Hz (10 to 20) Hz 20 Hz to 10 kHz	0.014 % 0.012 % 0.011 %	Fluke 5790A, 5700A/EP, 5520A, A40
AC Current – Generate (2 to 20) A  (20 to 150) A 150 A to 1 kA	10 Hz to 5 kHz  50 Hz to 1 kHz	0.05 %  0.26 % 0.51 %	Fluke 5520A  with 5500A coil
AC Current – Generate <sup>3</sup>  (0 to 220) µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.023 % + 20 nA 0.016 % + 12 nA 0.012 % + 10 nA 0.026 % + 15 nA 0.09 % + 80 nA	Fluke 5720A/EP
220 µA to 2.2 mA	(10 to 30) kHz	1.3 % + 0.4 µA	Fluke 5520A
220 µA to 2.2 mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.03 % + 50 nA 0.015 % + 40 nA 0.012 % + 40 nA 0.018 % + 0.13 µA 0.09 % + 0.8 µA	Fluke 5720A/EP
(2.2 to 22) mA	(10 to 30) kHz	0.078 % + 0.6 µA	Fluke 5520A
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.03 % + 0.5 µA 0.014 % + 0.4 µA 0.011 % + 0.4 µA 0.018 % + 0.7 µA 0.09 % + 6 µA	Fluke 5720A/EP
(22 to 220) mA	(10 to 30) kHz	0.32 % + 4 µA	Fluke 5520A
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.023 % + 5 µA 0.014 % + 4 µA 0.011 % + 3 µA 0.018 % + 4 µA 0.09 % + 12 µA	Fluke 5720A/EP
(22 to 220) mA	(10 to 30) kHz	0.32 % + 200 µA	Fluke 5520A

Parameter/Range	Frequency	CMC <sup>2, 5, 6</sup> ( $\pm$ )	Comments
AC Current – Generate <sup>3</sup>  220 mA to 2.2 A  (2.2 to 11) A	20 Hz to 1kHz (1 to 5) kHz (5 to 10) kHz  40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.024 % + 40 $\mu$ A 0.036 % + 100 $\mu$ A 0.55 % + 0.2 mA  0.031 % + 0.17 mA 0.066 % + 0.38 mA 0.26 % + 0.75 mA	Fluke 5720A/EP  Fluke 5720A/EP /5725
AC Current – Generate <sup>3</sup>  (11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.1 % + 5 mA 0.12 % + 5 mA 2.4 % + 5 mA	Fluke 5520A
High Frequency Capacitance, Fixed Points <sup>3</sup> –  1 pF  10 pF  100 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz  1 kHz (1, 2) MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz  1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	73 parts in 10 <sup>6</sup> 0.01 % rdg 0.023 % rdg 0.041 % rdg 0.063 % rdg 0.088 % rdg 0.26 % rdg 0.38 % rdg  62 parts in 10 <sup>6</sup> 62 parts in 10 <sup>6</sup> 64 parts in 10 <sup>6</sup> 67 parts in 10 <sup>6</sup> 72 parts in 10 <sup>6</sup> 0.013 % rdg 0.017 % rdg  61 parts in 10 <sup>6</sup> 62 parts in 10 <sup>6</sup> 68 parts in 10 <sup>6</sup> 82 parts in 10 <sup>6</sup> 0.01 % rdg 0.014 % rdg 0.034 % rdg 0.05 % rdg	Agilent/HP 16380A series capacitors

Parameter/Range	Frequency	CMC <sup>2, 5</sup> (±)	Comments
High Frequency Capacitance, Fixed Points <sup>3</sup> (cont) –			
1000 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	63 parts in 10 <sup>6</sup> 80 parts in 10 <sup>6</sup> 0.016 % rdg 0.028 % rdg 0.046 % rdg 0.064 % rdg 0.2 % rdg 0.29 % rdg	Agilent/HP 16380A series capacitors
0.01 μF	(0.12, 1, 10, 100) kHz	63 parts in 10 <sup>6</sup>	
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>	

#### IV. Electrical – RF/Microwave

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
RF Power <sup>3</sup> – Absolute (Uncertainties do not include UUT mismatch error)	0 dBm @ 50MHz	0.04 dB	8478B, 432A
	+45 to 20 dBm (0.1 MHz to 4.2 GHz)	0.06 dB	8482B, power meter
	+20 to -20 dBm (0.1 MHz to 26.5 GHz)	0.05 dB	8482A, 8481A, 8485A, power meter
	-20 to -127 dBm (0.9 MHz to 1.3 GHz)	0.15 dB	11722A, 8902A
	-20 to -100 dBm (1.3 GHz to 26.5 GHz)	0.15 dB	11792A, 8902A 11793A, E8244A

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
RF Power (Relative) –  + 10 to -100 dBm (0.9 MHz to 26.5 GHz)  -100 to -127dBm (0.9 MHz to 1.3 GHz)	0 dB -10 dB -20 dB -30 dB -40 dB -50 dB -60 dB -70 dB -80 dB -90 dB -100 dB  -110 dB -120 dB -127 dB	0.01 dB 0.04 dB 0.04 dB 0.04 dB 0.08 dB 0.08 dB 0.08 dB 0.08 dB 0.10 dB 0.10 dB 0.10 dB  0.10 dB 0.12 dB 0.19 dB	11722A, 8902A 11793A, E8244A (Uncertainties do not include UUT mismatch error)
Amplitude Modulation <sup>3</sup> –  Rate: 50 Hz to 10 kHz Rate: 20 Hz to 10 kHz  Rate 50 Hz to 10 kHz Rate: 20 Hz to 10 kHz  Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz  Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz  Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz  Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz	150 Hz to 10 MHz 5 % to 40 % AM Depth  40 % to 99 % AM Depth  (10 to 1300) MHz 5 % to 40 % AM Depth  40 % to 99 % AM Depth  (1.3 to 26.5) GHz 5 % to 40 % AM Depth  40 % to 99 % AM Depth	2 % rdg + 0.01 % AM 3.1 % rdg + 0.01 % AM  2 % rdg + 0.1 % AM 3.1 % rdg + 0.1 % AM  1 % rdg + 0.01 % AM 3.1 % rdg + 0.01 % AM  1 % rdg + 0.1% AM 3.1 % rdg + 0.1 % AM  1 % rdg + 0.01 % AM 3.1 % rdg + 0.01 % AM  1 % rdg + 0.1 % AM 3.1 % rdg + 0.1 % AM	Measuring receiver      Measuring receiver, down converter and local oscillator
Phase Modulation <sup>3</sup>  < 40 Radians (peak) < 400 Radians (peak)  < 4 Radians (peak) < 40 Radians (peak) < 400 Radians (peak)	150 kHz to 10 MHz Rate: 200 Hz to 10 kHz  (10 to 1300) MHz Rate: 200 Hz to 20 kHz	4 % rdg + 0.01 rad 4 % rdg + 0.1 rad  3.8 % rdg + 0.001 rad 3 % rdg + 0.01 rad 3 % rdg + 0.1 rad	Measuring receiver

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Phase Modulation <sup>3</sup> (cont) – < 4 Radians (peak) < 40 Radians (peak) < 400 Radians (peak)	(1.3 to 26.5) GHz Rate: 200 Hz to 20 kHz	3.3 % rdg + 0.001 rad 3 % rdg + 0.01 rad 3 % rdg + 0.1 rad	Measuring receiver, down converter and local oscillator
Frequency Modulation <sup>3</sup> – Carrier Frequency:  250 kHz to 10 MHz (10 to 1300) MHz (10 to 1300) MHz (1.3 to 26.5) GHz	20 Hz to 10 kHz (50 to 100) kHz (20 to 200) kHz (20 to 200) kHz	2.4 % rdg 1.2 % rdg 5.8 % rdg 6 % rdg + 20 Hz	Agilent 8902
Power Sensors, Fixed Points <sup>3</sup>	100 kHz 300 kHz 1 MHz (10, 30, 50) MHz 100MHz (0.3, 0.5, 1) MHz 2 GHz 3 GHz 4 GHz	2.8 % rdg 0.98 % rdg 0.93 % rdg 0.92 % rdg 0.77% rdg 0.83 % rdg 0.85 % rdg 0.88 % rdg 0.87 % rdg	Signal generator, power splitter, attenuator, standard sensors, and power meter referenced to 50MHz, 1µW
Spectrum Analyzers <sup>3</sup> –  Frequency Range  Residual FM  Amplitude  Resolution Bandwidth	9 kHz to 3.2 GHz  250 kHz to 26.5 GHz  9 kHz to 26.5 GHz  (-130 to +30) dbm  1 kHz to 5 MHz	3 <i>F</i> µHz + 1.2 <i>R</i>  0.15 <i>F</i> µHz + 1.2 <i>R</i>  7.6 Hz  0.15 dB  0.7 % rdg (@ mdpt)	Agilent 8648C; <i>F</i> is the frequency in hertz.  Agilent E8244A; <i>F</i> is the frequency in hertz.  Agilent/HP 8648C or Agilent E8244A  Agilent/HP 8902  Agilent/HP 8648C

Parameter/Equipment	Frequency	CMC <sup>2</sup> (±)	Comments
Power Sensors, Fixed Points <sup>3</sup> (cont)	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	1.1 % rdg 1.1 % rdg 1.1 % rdg 1.1 % rdg 1.3 % rdg 1.4 % rdg 1.7 % rdg 1.4 % rdg 1.3 % rdg 1.4 % rdg 1.7 % rdg 1.7 % rdg 1.4 % rdg 2.1 % rdg  3.2 % rdg 3.5 % rdg 3.5 % rdg 2.6 % rdg 2.4 % rdg 2.5 % rdg 2.6 % rdg 2.9 % rdg 2.9 % rdg	Signal generator, power splitter, attenuator, standard sensors, and power meter referenced to 50MHz, 1μW
Power Meters, Fixed Points <sup>3</sup> –  Zero Set  Instrument Accuracy	   3 μW 10 μW 30 μW (100, 300) μW (1, 2) mW (10, 30, 100) mW	   0.25 % rdg + 6.2 nW  1.6 % rdg 0.46 % rdg 0.28 % rdg 0.26 % rdg 0.28 % rdg 0.30 % rdg	Range calibrator, Agilent 11683A or Agilent 8477A
Power Reference, Fixed Point <sup>3</sup> – @ 1 mW	50 MHz	0.40 % rdg	Agilent 432A power meter with 8478 thermistor mount

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
Reflective Impedance – Measure	100 kHz to 0.3 GHz (0.3 to 2) GHz (2 to 8) GHz (8 to 21) GHz (21 to 26.5) GHz	8.5 mρ 9.4 mρ 17 mρ 30 mρ 45 mρ	Network analyzer 3577A with S parameter test set 35677 or network analyzer 8753ES with calibration kit or network analyzer 8510C with calibration kit
Transmission S <sub>12</sub> /S <sub>21</sub> Magnitude and Phase – Measure			
3.5 mm (0 to 20) dB	(1.5 to 26.5) GHz	(± 0.11 to ± 0.29) dB (± 1.2 to ± 12) deg	Agilent 85053B 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	Agilent 85029B verification kit
	(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	
	(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	
N-Type (10 to -90) dB	300 kHz to 1.3 GHz	(± 0.03 to ± 6.0) dB (± 0.2 to ± 80) deg	
	(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	

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
Reflection S <sub>11/22</sub> Magnitude and Phase – Measure			
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	Agilent 85053B verification kit
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	Agilent 85029B verification kit
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	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Reflection S <sub>11/22</sub> Magnitude and Phase – Measure (cont)			
N-Type 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 ± 0.018) lin (± 0.005 to ± 0.025) lin (± 0.01 to ± 0.05) lin	Agilent 85029B verification kit
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	

#### V. Fluid Quantities

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Flow <sup>3</sup>	(0.1 to 10) sccm (10 to 1000) sccm (50 to 5000) sccm (1 to 100) slm 0.1 sccm to 750 slm	1.5 % rdg + 0.7 % fs 1.5 % rdg + 0.7 % fs 1.5 % rdg + 0.7 % fs 1.5 % rdg + 0.7 % fs 0.4 % of rdg	Flow rate monitor
Viscometers <sup>3</sup>	(0 to 100 000) cps	1.6 % rdg + 1 cps	Standard viscosity fluids
Viscosity Cups <sup>3</sup>	Zahn cups (1 to 5) Shell cups (1 to 6)	0.84 s + 0.24 % rdg	Portable temperature bath, viscosity oils
Volumetric Calibration	(0 to 400) mL (400 to 1200) mL (1200 to 8200) mL  (1 to 10) gallon	0.01 mL 0.016 mL 0.084 mL  0.00062 gallon or 0.14 in <sup>3</sup>	Gravimetric method

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Hydrometers –	Specific Gravity:		
Baume Lighter than Water	1.00	0.0058 % rdg + 0.6R	Distilled water
80.5 to 57 API 81 to 57	0.66 to 0.75	0.0072 % rdg + 0.6R	Petroleum based solutions
57 to 10 API 57 to 10	0.75 to 1	0.006 % rdg + 0.6R	Alcohol solutions
Heavier than Water			
0.72 to 21 API 10 to -11	1 to 1.17	0.0058 % rdg + 0.6R	Sulfuric acid and/or glycerine solutions
0.72 to 67	1 to 1.85	0.0058 % rdg + 0.6R	Sulfuric acid solutions

#### VI. Foundry-Industry Specific Calibrations

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Sand (Green) Strength Machine <sup>3</sup>	(0 to 500) psi	2.3 % rdg + 3.4 psi	Master proving gage
Sand Rammer <sup>3</sup> (Compactability Tester)	---	0.6R + 0.0066 in	Impact rings
Sand Sieves –			ASTM E11, optical comparator
Brass Wire	Standard Sieve Designations	0.6 μm	
Steel Wire	125 mm to 20 μm	0.6 μm	
Permmeter <sup>3</sup>	(0 to 500) perms	6.2 perms	Perm standard

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Moisture Teller <sup>3</sup>	(0 to 300) °F	2 °F	Temperature calibrator
Mold Strength Tester <sup>3</sup>	(0 to 50) psi	0.6R + 0.2 % rdg	Balances and weights
AFS Clay Tester <sup>3</sup>	---	0.42 s	Stopwatch
Friability Tester <sup>3</sup>	60 s	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
Ultrasonic Cleaner/Scrubber <sup>3</sup> – Temperature Time	18 °F 30 min	0.64 °F 0.42 s	Thermometer Stopwatch
Wet Tensile Tester <sup>3</sup> – Load Temperature Load Rate Pressure	0.449 N/cm <sup>2</sup> (300 to 320) °F 0.05 N/cm <sup>2</sup> /s (4 to 5) bars	0.002 N/cm <sup>2</sup> 0.7 °F 0.0017 N/cm <sup>2</sup> /s 0.3 psi	Dead weight Thermometer Stopwatch Pressure calibrator
Melt Point Apparatus <sup>3</sup>	(200 to 220) °F	2.8 °F	Temperature measuring device
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

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Sand Squeezer <sup>3</sup>	(0 to 10 000) psi	1.2 % rdg + 1 psi	Pressure calibrator
Welders <sup>3</sup>	(0 to 50) V (0 to 50) A	1 % rdg 1 % rdg	Loadbank and DMM

## VII. Mechanical

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Extensometers <sup>3</sup>	Up to 4 in	120 $\mu$ m	Extensometer verification device (micrometer)
Scales <sup>3</sup>	(0.5 to 5) lb (5 to 100) lb (100 to 1000) lb	0.002 lb 0.02 lb 0.2 lb	Verification with Class F weights
Scales and Balances <sup>3</sup>	(1 to 500) mg 500 mg to 30 g 30 g to 8 kg (8 to 50) kg	0.003 mg 0.012 mg 1.1 mg 0.02 g	Verification with Class 1, 2, or 4 weights
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	0.2 lb + 0.6R 0.26 lb + 0.6R 0.32 lb + 0.6R 0.38 lb + 0.6R 0.44 lb + 0.6R	Class F weights
Mass	1 mg to 400 g 400 g to 1.2 kg (1.2 to 8.2) kg (8.2 to 30) kg	0.56 mg 3.2 mg 20 mg 0.2 g	By comparison
Mass <sup>3</sup>	(2 to 30) kg	0.2 g	By comparison

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Force Gages	(0 to 250) lbf (250 to 500) lbf (500 to 10 000) lbf	0.12 % rdg + 0.6R 1.2 % rdg + 0.6R 0.88 % rdg + 1.2 lbf	Deadweights Load cell
Force Gages <sup>3</sup>	(0 to 250) lbf	0.12 % rdg + 0.6R	Deadweights
Tensile Testers <sup>3</sup>	(0 to 30 000) lbf (30 000 to 50 000) lbf	0.4 % rdg + 0.08 % fs 0.8 % rdg + 0.08 % fs	Load cells
Torque Wrenches	Up to 1000 ft·lb (1000 to 2000) ft·lb	0.07 % rdg + 0.1 ft·lb 0.04 % rdg + 1.3 ft·lb	Torque calibrator
Torque – Calibration of Torque Meters and Sensors	(0.1 to 2000) ft·lb	0.14 % rdg	Weights
Torque Watches <sup>3</sup>	(0.5 to 215) in·oz	0.48 % rdg + 0.52 in·oz	Torque calibrator
Tachometers <sup>3</sup> –			
Photo	(0 to 100 000) rpm	0.014 % rdg + 1.2R	Function generator
Contact	(0 to 5000) rpm (5000 to 15 000) rpm	1.4 rpm 0.032 % rdg + 0.84 rpm	Tachometer calibrator
Pressure/Vacuum Gauges <sup>3</sup>	(-15 to 1000) psi Pneumatic	0.0022 psi + 0.012 % fs	Pressure calibrator
	(1000 to 5000) psi	0.9 psi + 0.026 % fs	Pressure transducers
	(5000 to 10 000) psi	1.8 psi + 0.026 % fs	
Pipettes	10 µL 20 µL 50 µL 100 µL 200 µL 500 µL 1000 µL (2000 to 5000) µL	3.1 % of rdg 1.6 % of rdg 0.64 % of rdg 0.33 % of rdg 0.19 % of rdg 0.14 % of rdg 0.08 % of rdg 0.06 % of rdg	Gravimetric method

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Indirect Verification of Rockwell Hardness and Rockwell Superficial Hardness Testers <sup>3</sup>	HRA: Low, Middle, High HRB: Low, Middle, High HRC: Low, Middle, High HRE: Low, Middle, High HRF: Low, Middle, High HR15N: Low, Middle, High HR30N: Low, Middle, High HR45N: Low, Middle, High HR15T: Low, Middle, High HR30T: Low, Middle, High HR45T: Low, Middle, High	0.7 HRA 0.7 HRB 0.7 HRC 0.7 HRE 0.7 HRF 0.7 HR15N 0.7 HR30N 0.7 HR45N 0.7 HR15T 0.7 HR30T 0.7 HR45T	ASTM E18
Indirect Verification of Brinell Hardness Testers at Test Condition(s) <sup>3</sup> –  10/3000/15	(150 to 260) HBW	0.008 <i>d</i>	ASTM E10  <i>d</i> is the mean of the <i>n</i> mean test diameter in millimeters.
Durometer Calibrator	Scales A and D	0.36 units	Scale and linear measure, weights and moment arm

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Indirect Verification of Microindentation Hardness Testers (Knoop and Vickers) <sup>3</sup> –	Repeatability under forces $P$ (gf): $1 \leq P < 500$ $100 \leq HK \leq 940$ $100 \leq HV \leq 940$	20 HK + 1.2 % 13 HV + 3 %	ASTM E384  CMC is stated as the repeatability as defined in E384.
Indirect Verification of Leeb Hardness Testers	Up to 800 HLD	7.4 HLD	Standard test block
Direct Verification of Durometers <sup>3</sup> –  Verification of Indenter Shape and Extension:  Extension at Aero Reading	-----  Diameter of the base of the frustum  Diameter of the top of the frustum  Cone angle  Tip radius  Indenter thickness  Indenter radius	3 μm  3 μm  3 μm  1 min  4 μm  3 μm  3 μm	ASTM D2240    The dimensional characteristics of the indenters are verified by optical projection
Verification of the Durometer Spring	-----	6.2 mN	The durometer spring is verified with deadweights. This CMC applies to all durometer types.
Load Cells	(0 to 500) lbf  (500 to 10 000) lbf	0.034 % rdg + 0.00044 lbf  0.04 % rdg + 0.38 lbf	Dead weights, comparison to master load cell

Parameter/Equipment	Range	CMC <sup>2,4</sup> ( $\pm$ )	Comments
Load Cells <sup>3</sup>	(0 to 10 000) lbf	0.1 % rdg + 0.002 lbf	Dead weights, comparison to master load cell
Dynamometer and Force Rings <sup>3</sup>	(0 to 10 000) lbf	0.11 % rdg + 0.6R	Load cells
Spring Testers <sup>3</sup> – Force Scale	(0 to 1000) lbf	0.6R + 0.02 %	Weights, load cells; R is the resolution of the force scale of the spring tester.
Deflection Accuracy	Up to 20 in	0.6R + 26 $\mu$ in	Gage blocks; R is the resolution of the deflection scale.
Cable Tensiometers/ Wire Tension Meters	(0 to 1000) lb	0.6R + 1.1 lb	Deadweights
Accelerometers – Shear and Charge <sup>3</sup>	(0.25 to 10) g (5 to 10 000) Hz	2.7 % rdg	Accelerometer; g is the acceleration due to gravity.
Refractometers <sup>3</sup>	(0 to 100) %	0.28 % rdg + 0.6R	Standard solutions
Ultrasonic Thickness Testers <sup>3</sup>	(0 to 10) in	(800 + 13L) $\mu$ in	Standard thickness specimen
Manometers	(0 to 24) inH <sub>2</sub> O	0.00017 inH <sub>2</sub> O	Hook gage
Deadweight Testers – Piston and Cylinder Area Mass Performance Test (Cross-Float)	(0 to 10 000) psi	(10 + 2D) $\mu$ in 0.2 g 0.04 % rdg	UMM Class F weights and scales Pressure calibrator with transducer

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Air Velocity	(100 to 4000) ft/min	0.48 % of rdg + 5.5 ft/min	Flowkinetics manometer
	(4000 to 9000) ft/min	0.48 % of rdg + 40 ft/min	

### VIII. Optical Quantities

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
Gloss Meters <sup>3</sup>	20°, 60°, 85°	(0.54 + 0.6R) GU	Gloss standards; GU represents gloss units.

### IX. Thermodynamics

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
Temperature – Measuring Equipment <sup>3</sup>	50 °C to 650 °C	0.045 °C + 0.6R	Dry-wells
Infrared Thermometers – Measure <sup>3</sup>	-18 °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
SPRT Verification	25.5 Ω 100 Ω	9.2 mK 8.5 mK	Triple Point Water
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

Parameter/Equipment	Range	CMC <sup>2,4</sup> (±)	Comments
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
Dew Point	-20 °C to 60 °C	0.3 °C + 0.6R	Dewpoint hygrometer Ultra DP5 and humidity chamber
Thermocouples and Thermocouple Wire	-80 °C to 650 °C	0.42 °C	Comparison to SPRT with Agilent 3458

#### X. Time & Frequency

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Frequency	10 Hz to 10 GHz	3 parts in 10 <sup>11</sup>	GPS
Frequency – Measure <sup>3</sup>	0.1 Hz to 5 GHz (5 to 20) GHz	25 nHz/Hz 25 nHz/Hz	Agilent 53131, Agilent 5350B
Stopwatches	15 s to 24 hr	5.3 µsec/sec + 0.2 s	Function generator and counter

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

<sup>2</sup> Calibration and Measurement Capability (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. Calibration and Measurement Capabilities 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  $f_s$  represents full scale.  $R_a$  is the numerical value of the nominal roughness of the surface measured in micrometer roughness.
- <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. Best measurement uncertainties 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> This accreditation covers calibrations performed at the main laboratory listed above, and the following satellite laboratory listed below:

Satellite Location  
2951 S. Oakwood Rd  
Oshkosh, WI 54904  
Keith Schuette Phone: 414 351 7420

#### I. Dimensional

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Depth Gages	Up to 12 in	0.6R + 12 µin/in	Gage blocks

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Dial Indicator	Up to 0.5 in (0.5 to 8) in	0.6R + 12 μin/in 0.6R + 12 μin/in	Indicator calibrator Gage blocks
Test Indicator	Up to 0.5"	0.0001 in	Indicator calibrator
Height Gage	Up to 36"	0.6R + 15 μin/in	Reference stack
Intertest/Oditest Calipers	Up to 4"	0.6R + 54 μin	Gage blocks
Micrometer OD Micrometers	Up to 42"	0.6R + 12 μin/in	Gage blocks
Snap (Jaw) Caliper	Up to 12"	(0.6R + 0.0001)in	Gage blocks
Tri-Bore Micrometers	Up to 3 in	0.6R + 15μin/in	Cylindrical rings
Bore Gages <sup>3</sup>	Up to 12 in	(10L + 0.6R) μin	Gage blocks
Calipers <sup>3</sup>	Up to 80 in	(10L + 0.6R) μin	Gage blocks
Micrometers <sup>3</sup> – Depth Groove	Up to 12 in Up to 4 in	(20L + 0.6R) μin (18L + 0.6R) μin	Gage blocks; <i>L</i> is the measured displacement in inches
Surface Plates <sup>3</sup> – Flatness	Up to 72 in × 144 in	8√ <i>D</i> μin	Electronic levels <i>D</i> is the length of the plate diagonal in inches.
Repeatability	Up to 72 in × 144 in	34 μin	Repeat-o-meter

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Protractor – Digital and Mechanical <sup>3</sup>	0° to 180°	0.08R + 0.08°/ 180°	Angle blocks
Box Parallels – Parallelism Squareness	5 in × 10 in × 10 in	(12 + 20H) μin (18 + 20H) μin	Gage amp with probe, cylindrical square
Thickness Gages <sup>3</sup> – Dial and Digital	Up to 1 in	(19 + 0.6R) μin	Gage blocks
Chamfer Gages/Hole Gages <sup>3</sup>	Up to 12 in	(20 + 0.6R) μin	Cylindrical rings
Gage Amplifier and Probe <sup>3</sup>	---	(5 + 0.6R) μin	Gage blocks
Rules/Scales <sup>3</sup>	Up to 72 in	0.6R + 24μin/in	Master rule
Tape Measures <sup>3</sup>	Up to 25 ft	(0.026 + 0.6R) in	Master tape

## II. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
DC Voltage – Generate	(0 to 330) μV 330 μV to 3.3 V (3.3 to 33) V (33 to 330) V (330 to 1000) V	16 V + 1 μV 9.1 μV/V + 2 μV 11 μV/V + 20 μV 15 μV/V + 150 μV 15 μV/V + 1500 μV	Fluke 5520A
DC Voltage – Measure	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V	10 μV/V + 0.3 μV 6.9 μV/V + 0.3 μV 6.1 μV/V + 0.5 μV 8.1 μV/V + 30 μV 8.3 μV/V + 1 mV	HP 3458A

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
DC Current – Generate	(0 to 330) µA 330 µA to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3.0) A (3 to 11) A (11 to 20.5) A	0.012 % + 0.02 µA 79 µA/A + 0.05 µA 79 µA/A + 0.25 µA 79 µA/A + 2.5 µA 0.016 % + 40 µA 0.03 % + 40 µA 0.04 % + 500 µA 0.078 % + 750 µA	Fluke 5520A
DC Current – Measure	Up to 100 nA 100 nA to 1 µA (1 to 10) µA (10 to 100) µA 100 µA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A (1 to 2) A (2 to 20) A	52 µA/A + 0.04 nA 25 µA/A + 0.04 nA 25 µA/A + 0.1 nA 26 µA/A + 0.8 nA 27 µA/A + 5 nA 26 µA/A + 50 nA 42 µA/A + 0.5 µA 0.013 % + 10 µA 0.013 % + 16 µA 0.035 % + 0.4 mA	HP 3458A
DC Power <sup>3</sup> –  33 mV to 1020 V	330 µA to 330 mA 330 mA to 3 A (3 to 20.5) A	0.068 % 0.07 % 0.12 %	Fluke 5520A
Capacitance – Generate	(0.19 to 3.3) nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF 330 nF to 1.1 µF (1.1 to 3.3) µF (3.3 to 11) µF (11 to 33) µF (33 to 110) µF (110 to 330) µF 330 µF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF	0.5 % + 0.01 nF 0.25 % + 0.01 nF 0.25 % + 0.1 nF 0.25 % + 0.3 nF 0.25 % + 1 nF 0.25 % + 3 nF 0.25 % + 10 nF 0.4 % + 30 nF 0.45 % + 100 nF 0.45 % + 300 nF 0.45 % + 1 µF 0.45 % + 3 µF 0.45 % + 10 µF 0.75 % + 30 µF	Fluke 5520A

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Resistance – Measure	(0 to 10) Ω (10 to 100) Ω 100 Ω to 1 k Ω (1 to 10) k Ω (10 to 100) k Ω 100 k Ω to 1 M Ω (1 to 10) M Ω (10 to 100) M Ω 100 M Ω to 1 G Ω	19 μΩ / Ω + 50 μΩ 14 μΩ / Ω + 0.5 m Ω 12 μΩ / Ω + 0.5 m Ω 12 μΩ / Ω + 5 m Ω 12 μΩ / Ω + 50 m Ω 17 μΩ / Ω + 2 Ω 59 μΩ / Ω + 100 Ω 0.058 % + 1 k Ω 0.58 % + 10 k Ω	HP 3458A
Resistance – Generate	(0 to 11) Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (330 to 1100) Ω (1.1 to 3.3) kΩ (3.3 to 11) k Ω (11 to 33) k Ω (33 to 110) k Ω (110 to 330) k Ω (330 to 1100) k Ω (1.1 to 3.3) M Ω (3.3 to 11) M Ω (11 to 33) M Ω (33 to 110) M Ω (110 to 330) M Ω (330 to 1100) M Ω	34 μΩ / Ω + 0.001 Ω 30 μΩ / Ω + 0.015 Ω 25 μΩ / Ω + 0.015 Ω 27 μΩ / Ω + 0.02 Ω 24 μΩ / Ω + 0.02 Ω 25 μΩ / Ω + 0.2 Ω 24 μΩ / Ω + 0.1 Ω 24 μΩ / Ω + 1 Ω 24 μΩ / Ω + 1 Ω 31 μΩ / Ω + 10 Ω 28 μΩ / Ω + 10 Ω 47 μΩ / Ω + 0.15 k Ω 0.011 % + 0.25 k Ω 0.02 % + 2.5 k Ω 0.039 % + 3 k Ω 0.24 % + 0.1 M Ω 1.2 % + 0.5 M Ω	Fluke 5520A
Electrical Calibration of Thermocouple Indicating Devices <sup>3</sup> –			
Type E	-250 °C to -100 °C -100 °C to 650 °C 650 °C to 1000 °C	0.5 °C 0.15 °C 0.21 °C	Fluke 5520A
Type J	-210 °C to -100 °C -100 °C to 760 °C 760 °C to 1200 °C	0.28 °C 0.16 °C 0.23 °C	
Type K	-200 °C to -100 °C -100 °C to 120 °C 120 °C to 1000 °C 1000 °C to 1372 °C	0.34 °C 0.17 °C 0.26 °C 0.4 °C	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of Thermocouple Indicating Devices <sup>3</sup> –			
Type S	0 °C to 250 °C 250 °C to 1400 °C 1400 °C to 1767 °C	0.47 °C 0.37 °C 0.46 °C	Fluke 5520A
Type T	-250 °C to -150 °C -150 °C to 0 °C 0 °C to 400 °C	0.63 °C 0.24 °C 0.15 °C	
Electrical Calibration of RTD Indicating Devices <sup>3</sup> –			
Pt 395, 100 Ω	-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 Ω	-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 Ω	-80 °C to 100 °C 100 °C to 260 °C	0.08 °C 0.16 °C	
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	
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	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Electrical Calibration of RTD Indicating Devices <sup>3</sup> (cont) –			
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	Fluke 5520A
Pt 3916, 100 Ω	-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 0.10 °C 0.12 °C	
Oscilloscope Calibration <sup>3</sup> –			
Squarewave Signal 50 Ω at 1 kHz Source	1 mV to 6.6 Vp-p	0.28 % + 40 μV	Fluke 5520A/SC1100
Squarewave Signal 1 M Ω at 1 kHz Source	1 mV to 130 Vp-p	0.12 % + 40 μV	
Leveled Sine Wave Amplitude – Range: 5 mV to 5.5 Vp-p	50 kHz reference 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz	2 % + 300 μV 3.5 % + 300 μV 4 % + 300 μV 6 % + 300 μV	
Leveled Sine Wave Amplitude – Range: 4 mV to 3.5 Vp-p	(600 to 1100) MHz	7 % + 300 μV	
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 % + 100 μV 2 % + 100 μV 4 % + 100 μV 5 % + 100 μV	

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Oscilloscope Calibration <sup>3</sup> (cont) –			Fluke 5520A/SC1100
Time Marker into 50 Ω Source and Measure	5 s to 50 ms	(26 + <i>t</i> *1000) parts in 10 <sup>6</sup>	<i>t</i> is in seconds
Rise Time	20 ms to 1 ns	2.6 parts in 10 <sup>6</sup>	
	≤ 300 ps	+0 / -100 ps	

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
AC Power <sup>3</sup> –			Fluke 5520A
PF = 1			
(3.3 to 9) mA	(10 to 65) Hz	0.15 %	
(9 to 33) mA	33 mV to 1020 V	0.1 %	
(33 to 90) mA		0.13 %	
(90 to 330) mA		0.1 %	
330 mA to 0.9 A		0.08 %	
(0.9 to 2.2) A		0.08 %	
(2.2 to 4.5) A		0.28 %	
(4.5 to 20.5) A		0.15 %	
(3.3 to 9) mA	(65 to 500) Hz	0.09 %	
(9 to 33) mA	33 mV to 1020 V	0.07 %	
(33 to 90) mA		0.1 %	
(90 to 330) mA		0.11 %	
330 mA to 0.9 A		0.08 %	
(0.9 to 2.2) A		0.08 %	
(2.2 to 4.5) A		0.18 %	
(4.5 to 20.5) A		0.18 %	
(3.3 to 9) mA	500 Hz to 1 kHz	0.14 %	
(9 to 33) mA	33 mV to 1020 V	0.12 %	
(33 to 90) mA		0.21 %	
(90 to 330) mA		0.15 %	
330 mA to 0.9 A		0.69 %	
(0.9 to 2.2) A		0.56 %	
(2.2 to 4.5) A		2.5 %	
(4.5 to 20.5) A		2.5 %	

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
AC Power <sup>3</sup> (cont)– PF = 1			
(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA 330 mA to 0.9 A (0.9 to 2.2) A (2.2 to 4.5) A (4.5 to 20.5) A	(1 to 5) kHz 33 mV to 1020 V	0.14 % 0.12 % 0.21 % 0.15 % 0.69 % 0.56 % 2.5 % 2.5 %	Fluke 5520A
(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA 330 mA to 0.9 A (0.9 to 2.2) A	(5 to 10) kHz 33 mV to 1020 V	0.38 % 0.35 % 0.52 % 0.38 % 3.1 % 2.4 %	
(3.3 to 9) mA (9 to 33) mA (33 to 90) mA (90 to 330) mA	(10 to 30) kHz 33 mV to 1020 V	1.3 % 1.2 % 1.4 % 1.3 %	
AC Current – Measure <sup>3</sup> (0 to 100) µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz	0.46 % + 30 nA 0.17 % + 30 nA 0.071 % + 30 nA 0.071 % + 30 nA	Agilent/HP 3458A
(0.1 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.46 % + 20 µA 0.17 % + 20 µA 0.071 % + 20 µA 0.038 % + 20 µA 0.071 % + 20 µA 0.46 % + 40 µA 0.64 % + 0.15 mA	
(0.2 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	0.46 % 0.2 mA 0.18 % + 0.2 mA 0.09 % + 0.2 mA 0.012 % + 0.2 mA 0.35 % + 0.2 mA 0.12 % + 0.4 mA	
(1 to 2) A	10 Hz to 2 kHz (1 to 10) kHz (10 to 30) kHz	0.055 % + 0.24 mA 0.063 % + 0.24 mA 0.25 % + 0.24 mA	Fluke 8508

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
AC Current (cont) – Measure <sup>3</sup>			
(1 to 20)A	10 Hz to 2 kHz (1 to 10) kHz	0.07 % + 2.4 mA 0.2 % + 2.4 mA	Fluke 8508
(20 to 50) A 50A to 1kA	50 Hz to 1 kHz 60 Hz	0.007 % 2 %	Fluke 5520A with 5500A coil
AC Current – Generate			
(29 to 330) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.16 % + 0.1 µA 0.12 % + 0.1 µA 0.1 % + 0.1 µA 0.24 % + 0.15 µA 0.62 % + 0.2 µA 1.3 % + 0.4 µA	Fluke 5520A
330 µA 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	0.16 % + 0.15µA 0.1 % + 0.15 µA 0.08 % + 0.15 µA 0.16 % + 0.2 µA 0.38 % + 0.3 µA 0.8 % + 0.6 µA	
(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	0.14 % + 2 µA 0.07 % + 2 µA 0.031 % + 2 µA 0.062 % + 2 µA 0.16 % + 3 µA 0.31 % + 4 µA	
(33 to 330) mA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.14 % + 20 µA 0.07 % + 20 µA 0.032 % + 20 µA 0.08 % + 50 µA 0.16 % + 0.12 mA 0.31 % + 0.2 mA	
330 mA to 1.1 A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.14 % + 0.1 mA 0.039 % + 0.1 mA 0.46 % + 1 mA 1.94 % + 5 mA	

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
AC Current (cont) – Generate			
(1.1 to 3) A	(10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.14 % + 0.1 mA 0.047 % + 0.1 mA 0.46 % + 1 mA 1.9 % + 5 mA	Fluke 5520
(3 to 11) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.048 % + 5 mA 0.081 % + 2 mA 2.4 % + 2 mA	
(11 to 20.5) A	(45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	0.095 % + 5 mA 0.12 % + 5 mA 2.4 % + 5 mA	
(20 to 150) A 150 A to 1 kA	50 Hz to 1 kHz 50 Hz to 1 kHz	0.26 % 0.51 %	w/5500A coil
AC Voltage – 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	0.063 % + 6 μV 0.017 % + 6 μV 0.02 % + 6 μV 0.08 % + 6 μV 0.27 % + 12 μV 0.62 % + 50 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	0.023 % + 8 μV 0.012 % + 8 μV 0.013 % + 8 μV 0.028 % + 8 μV 0.062 % + 32 μV 0.16 % + 70 μV	

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
AC Voltage (cont) – Generate			
330 mV 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	0.023 % + 50 µV 0.012 % + 60 µV 0.016 % + 60 µV 0.024 % + 50 µV 0.055 % + 0.13 mV 0.19 % + 0.6 mV	Fluke 5520A
(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	0.023 % + 0.65 mV 0.012 % + 0.6 mV 0.019 % + 0.6 mV 0.028 % + 0.6 mV 0.072 % + 1.6 mV	
(33 to 330) V	(10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.015 % + 2 mV 0.016 % + 6 mV 0.02 % + 6 mV 0.026 % + 6 mV 0.16 % + 50 mV	
(330 to 1020) V	45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.024 % + 10 mV 0.02 % + 10 mV 0.024 % + 10 mV	
AC Voltage – Measure			
10 mV	(1 to 40) Hz 40Hz to 1kHz 1k to 20kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	0.039 % + 3 µV 0.03 % + 1.1 µV 0.039 % + 1.1 µV 0.12 % + 1.1 µV 0.58 % + 1.1 µV 4.6 % + 2 µV	HP 3458A
100 mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100)kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.014 % + 4 µV 0.012 % + 2 µV 0.018 % + 2 µV 0.031 % + 2 µV 0.092 %+ 2 µV 0.34 % + 10 µV 1.2 % + 10 µV 1.8 % + 10 µV	

Parameter/Range	Frequency	CMC <sup>2</sup> (±)	Comments
AC Voltage (cont) – Measure			
1 V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100)kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.014 % + 40 μV 0.012 % + 20 μV 0.018 % + 20 μV 0.031 % + 20 μV 0.092 % + 20 μV 0.34 % + 0.1 mV 1.2 % + 0.1 mV 1.8 % + 0.1 mV	HP 3458A
10 V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100)kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz	0.014 % + 0.4 mV 0.012 % + 0.2 mV 0.018 % + 0.2 mV 0.031 % + 0.2 mV 0.092 % + 0.2 mV 0.34 % + 1 mV 1.2 % + 1 mV 1.8 % + 1 mV	
100 V	(1 to 40)Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.025 % + 4 mV 0.025 % + 2 mV 0.025 % + 2 mV 0.04 % + 2 mV 0.14 % + 2 mV 0.46 % + 10 mV 1.7 % + 10 mV	
1000 V	(1 to 40)Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.047 % + 40 mV 0.047 % + 20 mV 0.07 % + 20 mV 0.14 % + 20 mV 0.34 % + 20 mV	

### III. Mechanical

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Pressure/Vacuum Gauges <sup>3</sup>	(-15 to 1000) psi Pneumatic	0.0022 psi + 0.012 % fs	Pressure calibrator
	(1000 to 5000) psi	0.9 psi + 0.026 % fs	Pressure transducers
	(5000 to 10 000) psi	1.8 psi + 0.026 % fs	
Scales & Balances	(1 to 100) mg 100 mg to 1 g (1 to 10)g 10 mg to 50 g (50 to 300)g	0.12 mg 0.22 mg 0.52 mg 1.2 mg 4.2 mg	Verification with class 4 weights
Scales <sup>3</sup>	(0.5 to 5) lb (5 to 100) lb	0.002 lb 0.02 lb	Verification with class F weights
Force Gages <sup>3</sup>	(0 to 120) lbf	0.12 % rdg + 0.6R	Deadweights
Torque Wrenches	Up to 1000 in-lb Up to 250 ft-lb	0.6 % rdg + 0.6R 0.6 % rdg + 0.1 ft-lb	Torque calibrator

### IV. Time & Frequency

Parameter/Equipment	Range	CMC <sup>2</sup> (±)	Comments
Frequency – Measure <sup>3</sup>	0.1 Hz to 5 GHz (5 to 20) GHz	25 nHz/Hz 25 nHz/Hz	Agilent 53131, Agilent 5350B