



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

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CALIBRATION

Valid To: April 30, 2024

Certificate Number: 2147.01

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

I. Acoustical Quantities

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
Sound Level – Measuring Equipment, Fixed Points ³	94 dB 114 dB	0.28 dB 0.28 dB	Brüel & Kjær 4231

II. Chemical

Parameter/Equipment	Range	CMC ² (±)	Comments
pH Meters, Fixed Points ³	4 pH 7 pH 10 pH	0.017 pH 0.012 pH 0.019 pH	Standard pH solutions
Conductivity Meters ³	≈10 µS/cm ≈1413 µS/cm ≈10 mS/cm ≈100.9 mS/cm	4.4 µS/cm 9.8 µS/cm 0.15 mS/cm 2.2 mS/cm	Standard conductivity solutions

III. Dimensional

Parameter/Equipment	Range	CMC ^{2, 6} ($\pm$)	Comments
Calipers ³ – Dial, Digital, Vernier – Length Parallelism	Up to 18 in (18 to 48) in Up to 2 in	$(290 + 7.3L) \mu\text{in}$ $(240 + 4.9L) \mu\text{in}$ $30 \mu\text{in}$	Gage blocks
Depth Gauge ³ – Dial, Digital, Vernier	(0.001 to 48) in	$(59 + 7.2L) \mu\text{in}$	Gage blocks, surface plate
Gage Blocks – Flatness	Up to 10 in Up to 2 in	$(3.2 + 0.9L) \mu\text{in}$ $2.5 \mu\text{in}$	Pratt & Whitney Labmaster TM LMU-175, gauge blocks, optical flat
Height Gauges ³	Up to 18 in (18 to 36) in	$(30 + 6.5L) \mu\text{in}$ $(16 + 7.3L) \mu\text{in}$	Gage blocks
Indicators – Dial & Digital ³	(0.000 01 to 2) in	$(11 + 8.9L) \mu\text{in}$	Gage blocks, surface plate, Pratt & Whitney Supermic TM
Length Standards ³ (Length only)	Up to 10 in (10 to 20) in (20 to 96) in	$(3.2 + 1.0L) \mu\text{in}$ $(7.8 + 15L) \mu\text{in}$ $(45 + 17L) \mu\text{in}$	Pratt & Whitney Labmaster TM LMU-175, micrometer head, gage blocks, P&W PC25
Measuring Rule ³	Up to 48 in	$(300 + 4.0L) \mu\text{in}$	Hexagon Optiv Classic 321
Measuring Tapes ^{3,6}	Up to 300 in	$0.015 + (0.004S) \text{ in}$	Master ruler, measuring tape fixture
Micrometers ³ – OD ID Flatness Parallelism	Up to 48 in Up to 24 in Up to 2 in Up to 2 in	$(30 + 13L) \mu\text{in}$ $(30 + 13L) \mu\text{in}$ $4.3 \mu\text{in}$ $4.3 \mu\text{in}$	Gage blocks Optical flat

Parameter/Equipment	Range	CMC ^{2,6} ($\pm$)	Comments
Optical Comparators ³ –			
Angularity	(0 to 180)°	0.79 arc min	Sine bar, gage blocks
Linearity X-Y	Up to 12 in	160 μ in	Glass scale
Magnification	Up to 50X	0.13 % of Magnification	Magnification master, pin gauge
Plain Gage ³ –			
Pins & Plugs	Up to 1 in (1 to 10) in (10 to 20) in	(7.8 + 9.1L) μ in (2.9 + 14L) μ in (11 + 13L) μ in	Pratt & Whitney Labmaster™ LMU-175, gage blocks, P&W PC25
Rings	Up to 1 in (1 to 10) in	(6.3 + 12L) μ in (2.4 + 16L) μ in	
Protractors ³	Up to 90°	0.060°	Surface plate, sine bar, gage blocks
Sine Bars –			
Length	(5 to 10) in	(76 + 4.6L) μ in	Hexagon Optiv Classic 321, Hexagon Global S Chrome
Parallelism	(5 to 10) in	29 μ in	Electronic gauge head
Surface Plates ³ –			
Flatness	Up to 170 in diagonal	(7.1 $\sqrt{D}$) μ in	Mahr Federal EMD-832-W3 electronic level
Repeatability	(-0.002 to 0.002) in	28 μ in	Rahn Repeat-O-Meter
Thickness Gauge ³ (Feeler Type)	(0.001 to 1) in	(8.6 + 30L) μ in	Pratt & Whitney Labmaster™ LMU-175
Thickness Gauge ³ (Ultrasonic)	(0.001 to 8) in	590 μ in	Gage blocks

Parameter/Equipment	Range	CMC ^{2, 9} (±)	Comments
Thread Gauges – Thread Ring, Adjustable ³ Thread Plugs Major Diameter Pitch Diameter	Up to 4 in Up to 3 in Up to 3 in (80 to 6) TPI	Thread Plug tolerance (W) 79 µin 120 µin	Set using master plug gages. ASME/ANSI B1.2- 1983 & ASME/ANSI B1.3- 2007 Pratt & Whitney Labmaster™ LMU-175, gauge blocks, thread wires
Thread Wires	(80 to 6) TPI	9.0 µin	Labmaster™ LMU-175, gauge blocks

IV. Dimensional Testing/Calibration¹⁰

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Dimensional Inspection – Linear (1D) Volumetric 3D Fixtures & Artifacts	Up to 10) mm (10 to 100) mm (100 to 300) mm (300 x 200 x 150) mm (24 x 32 x 22) in	0.0017 mm 0.0021 mm 0.0030 mm 0.0042 mm (65 + 2.8L) µin	Hexagon Optiv Classic 321 Hexagon Global S Chrome

V. Electrical DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
DC Voltage ³ – Generate Fixed point	10 V	0.5 μ V/V	Fluke 732B
DC Voltage ³ – Measure	0 V Short (0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V (1 to 10) kV (10 to 100) kV (100 to 125) kV (125 to 140) kV	0.62 μ V/V 2.7 μ V/V + 0.84 μ V 2.0 μ V/V + 5.7 μ V 4.4 μ V/V + 88 μ V 1.5 μ V/V + 2.0 mV 5.3 μ V/V + 2.0 mV 0.35 mV/V + 35 mV 0.58 mV/V + 0.50 V 0.17 kV 0.29 kV	Copper short HP 3458A Opt. 002 digital multimeter Vitrek 4700 high voltage multimeter, Vitrek HVL-100 high voltage probe
DC Voltage ³ – Generate	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V (0.1 to 1.0) kV (1.0 to 4.0) kV (4.0 to 9.0) kV (9.0 to 25) kV (25 to 50) kV (50 to 60) kV	9.6 μ V/V + 0.63 μ V 4.3 μ V/V + 4.4 μ V 4.0 μ V/V + 4.5 μ V 4.1 μ V/V + 4.9 μ V 5.7 μ V/V + 98 μ V 7.8 μ V/V + 660 μ V 0.61 V 2.5 V 4.7 V 38 V 58 V 81 V	Fluke 5700A HV Source monitored by Vitric 4700 HV Source monitored by Vitrek 4700/HVL150 probe

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
DC Current ³ –			
Measure	(0 to 100) μ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 2000) A (2000 to 2800) A 10 μ A 100 μ A 1 mA 10 mA 20 mA 100 mA 200 mA 1 A 1.9 A	20 μ A/A + 1.4 nA 21 μ A/A + 7.9 nA 21 μ A/A + 81 nA 39 μ A/A + 0.78 μ A 1.1 mA/A + 36 μ A 1.1 mA/A + 4.8 mA 6.1 mA/A + 19 μ A 18 mA/A + 12 mA 7.9 nA 3.3 nA 0.012 μ A 0.18 μ A 0.15 μ A 1.8 μ A 1.8 μ A 24 μ A 26 μ A	HP 3458A opt. 002 digital multimeter Agilent 34461A current shunt, HP 3458A opt. 002 digital multimeter LEM PR2000 current clamp, HP 3458A opt. 002 digital multimeter HP 3458A opt. 002, Fluke A40B series current shunts Fluke 5700A Fluke 5520A Fluke 5520A w/ coil
Generate	(0 to 220) μ A (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A (1.1 to 3) A (1.2 (3 to 11) A (11 to 20.5) A	10 nA/A + 7.1 nA 8.7 nA/A + 13 nA 8.7 nA/A + 49 nA 1.1 nA/A + 0.84 μ A 2.0 nA/A + 31 μ A 400 μ A/A + 1.5 mA 1 mA/A + 2.4 mA 1.1 mA/A + 2.4 mA	
Clamp Meters	(20.5 to 1000) A	6.0 mA/A + 0.60 A	

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
Resistance ³ – Generate			
Fixed	0.000 333 3 Ω	0.3 $\mu\Omega$	9211A Guildline
	0.001 Ω	0.5 $\mu\Omega$	
	0.01 Ω	1.0 $\mu\Omega$	
	0.1 Ω	10 $\mu\Omega$	
	100 m Ω	0.89 m Ω	Guidline 9330 series resistors
	1 Ω	0.89 m Ω	
	10 k Ω	7.4 m Ω	
	10 M Ω	0.32 k Ω	Metrohm P4085 series resistors
	1 G Ω	0.56 M Ω	
	10 G Ω	0.61 M Ω	
	100 G Ω	0.12 G Ω	
	1 T Ω	2.6 G Ω	
	0 Ω	47 $\mu\Omega$	Fluke 5720A
	1 Ω	110 $\mu\Omega$	
	1.9 Ω	110 $\mu\Omega$	
	10 Ω	35 $\mu\Omega$	
	19 Ω	43 $\mu\Omega$	
	100 Ω	0.15 m Ω	
	190 Ω	0.28 m Ω	
	1 k Ω	1.6 m Ω	
	1.9 k Ω	2.9 m Ω	
	10 k Ω	15 m Ω	
	19 k Ω	29 m Ω	
	100 k Ω	0.18 Ω	
	190 k Ω	0.30 Ω	
	1 M Ω	17 Ω	
	1.9 M Ω	19 Ω	
	10 M Ω	71 Ω	
	19 M Ω	250 Ω	
	100 M Ω	4.2 k Ω	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Voltage ³ – Measure			
(0 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.43 mV/V + 1.5 μ V 0.25 mV/V + 1.5 μ V 0.25 mV/V + 1.5 μ V 0.46 mV/V + 2.3 μ V 0.69 mV/V + 2.9 μ V 1.4 mV/V + 4.6 μ V 1.5 mV/V + 9.2 μ V 2.7 mV/V + 9.2 μ V	Fluke 5790A
(2.2 to 7) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.22 mV/V + 1.5 μ V 0.13 mV/V + 1.5 μ V 0.13 mV/V + 1.5 μ V 0.24 mV/V + 2.3 μ V 0.36 mV/V + 2.9 μ V 0.95 mV/V + 4.6 μ V 1.0 μ V/V + 9.2 μ V 2.0 mV/V + 9.2 μ V	
(7 to 22) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.15 mV/V + 1.8 μ V 78 μ V/V + 1.8 μ V 78 μ V/V + 1.8 μ V 0.14 mV/V + 3.1 μ V 0.24 mV/V + 5.9 μ V 0.63 mV/V + 4.7 μ V 0.82 mV/V + 9.3 μ V 1.3 mV/V + 9.3 μ V	
(22 to 70) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	99 μ V/V + 1.9 μ V 45 μ V/V + 1.9 μ V 45 μ V/V + 1.9 μ V 70 μ V/V + 4.1 μ V 0.14 mV/V + 9.8 μ V 0.31 mV/V + 5.0 μ V 0.45 mV/V + 9.5 μ V 1.2 mV/V + 9.6 μ V	
(70 to 220) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	15 μ V/V + 77 μ V 3.6 μ V/V + 65 μ V 3.6 μ V/V + 65 μ V 6.6 μ V/V + 85 μ V 7.8 μ V/V + 0.15 mV 24 μ V/V + 0.28 mV 59 μ V/V + 0.28 mV 0.44 mV/V + 0.28 mV	

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Voltage ³ – Measure (cont)			
(220 to 700) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	12 μ V/V + 0.17 mV 3.4 μ V/V + 83 μ V 3.4 μ V/V + 84 μ V 24 μ V/V + 36 μ V 39 μ V/V + 49 μ V 44 μ V/V + 0.34 mV 92 μ V/V + 0.35 mV 0.68 μ V/V + 0.36 mV	Fluke 5790A
(0.7 to 2.2) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	28 μ V/V + 0.22 mV 15 μ V/V + 45 μ V 15 μ V/V + 45 μ V 52 μ V/V + 16 μ V 83 μ V/V + 26 μ V 0.22 mV/V + 50 μ V 0.13 mV/V + 1.7 mV 0.89 mV/V + 1.5 mV	
(2.2 to 7) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	70 μ V/V + 80 μ V 25 μ V/V + 59 μ V 25 μ V/V + 59 μ V 49 μ V/V + 59 μ V 87 μ V/V + 52 μ V 0.23 mV/V + 40 μ V 0.45 mV/V + 0.19 mV 1.3 mV/V + 0.43 mV	
(7 to 22) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	76 μ V/V + 0.12 mV 34 μ V/V + 0.10 mV 34 μ V/V + 0.10 mV 62 μ V/V + 0.10 mV 100 μ V/V + 0.30 mV 0.20 mV/V + 0.86 mV 0.45 mV/V + 0.75 mV 1.4 mV/V + 0.58 mV	
(22 to 70) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	75 μ V/V + 0.51 mV 30 μ V/V + 0.64 mV 30 μ V/V + 0.64 mV 74 μ V/V + 0.51 mV 100 μ V/V + 1.1 mV 0.21 mV/V + 2.8 mV 0.57 mV/V + 1.0 mV	

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
AC Voltage ³ – Measure (cont)			
(70 to 220) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	80 $\mu\text{V/V} + 0.51 \text{ mV}$ 35 $\mu\text{V/V} + 0.64 \text{ mV}$ 35 $\mu\text{V/V} + 0.64 \text{ mV}$ 78 $\mu\text{V/V} + 0.51 \text{ mV}$ 0.11 $\text{mV/V} + 1.1 \text{ mV}$ 0.23 $\text{mV/V} + 2.8 \text{ mV}$ 0.58 $\text{mV/V} + 1.0 \text{ mV}$	Fluke 5790A
(220 to 700) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.11 $\text{mV/V} + 4.2 \text{ mV}$ 43 $\mu\text{V/V} + 3.4 \text{ mV}$ 43 $\mu\text{V/V} + 3.4 \text{ mV}$ 90 $\mu\text{V/V} + 64 \text{ mV}$ 0.31 $\text{mV/V} + 0.27 \text{ V}$	
(700 to 1000) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.11 $\text{mV/V} + 4.2 \text{ mV}$ 44 $\mu\text{V/V} + 3.4 \text{ mV}$ 44 $\mu\text{V/V} + 3.4 \text{ mV}$ 0.11 $\text{mV/V} + 64 \text{ mV}$ 0.37 $\text{mV/V} + 0.27 \text{ V}$	
AC Voltage – Wideband Measure			
(0 to 2.2) mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	7.9 $\text{mV/V} + 1.9 \mu\text{V}$ 7.5 $\text{mV/V} + 1.9 \mu\text{V}$ 7.5 $\text{mV/V} + 1.9 \mu\text{V}$ 7.5 $\text{mV/V} + 1.9 \mu\text{V}$ 7.7 $\text{mV/V} + 3.0 \mu\text{V}$	Fluke 5790A w/ wideband opt.
(2.2 to 7) mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	7.7 $\text{mV/V} + 2.6 \mu\text{V}$ 7.2 $\text{mV/V} + 2.6 \mu\text{V}$ 7.2 $\text{mV/V} + 2.6 \mu\text{V}$ 7.2 $\text{mV/V} + 2.6 \mu\text{V}$ 7.4 $\text{mV/V} + 3.7 \mu\text{V}$	
(7 to 22) mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	7.4 $\text{mV/V} + 4.9 \mu\text{V}$ 6.9 $\text{mV/V} + 4.9 \mu\text{V}$ 6.9 $\text{mV/V} + 4.9 \mu\text{V}$ 6.9 $\text{mV/V} + 4.9 \mu\text{V}$ 7.0 $\text{mV/V} + 6.6 \mu\text{V}$	
(22 to 70) mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	7.4 $\text{mV/V} + 6.1 \mu\text{V}$ 6.8 $\text{mV/V} + 6.1 \mu\text{V}$ 6.8 $\text{mV/V} + 6.1 \mu\text{V}$ 6.8 $\text{mV/V} + 6.1 \mu\text{V}$ 6.7 $\text{mV/V} + 6.1 \mu\text{V}$	

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
AC Voltage – Wideband Measure (cont.)			
(70 to 220) mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	7.0 mV/V + 35 µV 6.4 mV/V + 35 µV 6.4 mV/V + 35 µV 6.4 mV/V + 35 µV 6.4 mV/V + 35 µV	Fluke 5790A w/ wideband opt.
(220 to 700) mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	5.8 mV/V + 93 µV 5.1 mV/V + 93 µV 5.1 mV/V + 93 µV 5.1 mV/V + 93 µV 5.1 mV/V + 93 µV	
(0.7 to 2.2) V	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	5.7 mV/V + 0.35 mV 5.0 mV/V + 0.35 mV 5.0 mV/V + 0.35 mV 5.0 mV/V + 0.35 mV 5.0 mV/V + 0.35 mV	
(2.2 to 7) V	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz	5.2 mV/V + 0.49 mV 4.4 mV/V + 0.49 mV 4.4 mV/V + 0.49 mV 4.4 mV/V + 0.49 mV 4.4 mV/V + 0.49 mV	
AC Voltage ³ – Generate			
(0.005 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.022 % + 5.2 µV 0.011 % + 5.2 µV 0.011 % + 5.2 µV 0.038 % + 5.2 µV 0.087 % + 8.1 µV 0.12 % + 15 µV 0.17 % + 29 µV 0.36 % + 29 µV	Fluke 5700A
(2.2 to 220) mV	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.022 % + 9.5 µV 0.011 % + 9.6 µV 0.011 % + 9.4 µV 0.018 % + 62 µV 0.058 % + 130 µV 0.11 % + 37 µV 0.18 % + 41 µV 0.37 % + 93 µV	

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
AC Voltage ³ – Generate (cont)			
(0.22 to 2.2) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.016 % + 48 µV 0.074 % + 14 µV 0.075 % + 11 µV 29 µV/V + 0.70 mV 0.016 % + 0.38 mV 0.046 % + 0.15 mV 0.11 % + 0.42 mV 0.22 % + 1.0 mV	Fluke 5700A
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.016 % + 0.38 mV 73 µV/V + 0.15 mV 75 µV/V + 0.12 mV 0.011 % + 0.82 mV 0.024 % + 0.47 mV 0.053 % + 1.7 mV 0.14 % + 5.0 mV 0.29 % + 1.0 mV	
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.16 % + 3.9 mV 80 µV/V + 1.5 mV 82 µV/V + 1.2 mV 0.022 % + 4.2 mV 0.53 % + 9.5 mV 0.16 % + 0.1 V 0.53 % + 0.1 V 1.3 % + 0.2 V	Wavetek 4808
(220 to 750) V	(15 to 50) Hz (0.05 to 1) kHz	0.042 % + 19 mV 78 µV/V + 9.2 mV	
(750 to 1000) V	(10 to 31) Hz (32 to 330) Hz (0.3 to 10) kHz (10 to 33) kHz (30 to 100) kHz (100 to 330) kHz (0.3 to 1000) MHz	110 µV/V + 340 µV 66 µV/V + 210 µV 56 µV/V + 110 µV 65 µV/V + 210 µV 110 µV/V + 340 µV 620 µV/V + 3.5 mV 8.9 mV/V + 14 mV	Fluke 5520A
(1000 to 1100) V	(10 to 330) Hz (0.3 to 10) kHz (10 to 33) kHz	160 µV/V + 2.3 mV 120 µV/V + 2.2 mV 160 µV/V + 2.3 mV	
(1 to 33) mV	(10 to 45) Hz (0.045 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	99 µV/V + 19 µV 99 µV/V + 19 µV 9.3 µV/V + 250 µV 48 µV/V + 140 µV 0.045 % + 100 µV 0.22 % + 87 µV	

Parameter/Range	Frequency	CMC ^{2,7} (±)	Comments
AC Voltage ³ – Generate (cont)			
(33 to 330) mV	(10 to 45) Hz (0.045 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.012 % + 0.12 mV 0.012 % + 0.12 mV 13 µV/V + 1.8 mV 35 µV/V + 1.1 mV 0.045 % + 0.43 mV 0.26 % + 0.80 mV	Fluke 5520A
(0.33 to 3.3) V	(10 to 45) Hz (0.045 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.017 % + 0.71 mV 0.017 % + 0.71 mV 0.027 % + 0.72 mV 0.040 % + 0.74 mV 0.10 % + 1.9 mV 0.28 % + 0.80 mV	
(3.3 to 33) V	(10 to 45) Hz (0.045 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.021 % + 3.0 mV 0.022 % + 7.8 mV 0.024 % + 10 mV 0.019 % + 20 mV 0.22 % + 62 mV	
(330 to 1020) V	(0.045 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.034 % + 19 mV 0.028 % + 20 mV 0.033 % + 32 mV	
(0.1 to 1.0) kV (1.0 to 4.0) kV (4.0 to 9.0) kV	(50 to 60) Hz (50 to 60) Hz (50 to 60) Hz	2.1 V 6.4 V 18 V	HV source monitored by Vitrek 4700
(9.0 to 10) kV	(50 to 60) Hz	0.12 kV	HV source monitored by Vitrek 4700 w/ HVL-150 probe
AC Voltage ³ – Measure 10 mV	(10 to 40) Hz (40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz	340 µV/V + 3.7 µV 230 µV/V + 1.4 µV 340 µV/V + 1.4 µV 1.2 mV/V + 1.6 µV 5.8 mV/V + 1.5 µV 47 mV/V + 2.7 µV	HP 3458A

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
AC Voltage ³ – Measure (cont.)			
100 mV	(10 to 40) Hz (40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	56 μ V/V + 110 μ V 73 μ V/V + 38 μ V 160 μ V/V + 35 μ V 110 μ V/V + 690 μ V 0.68 mV/V + 0.33 mV 3.3 mV/V + 0.27 mV 12 mV/V + 97 μ V 17 mV/V + 420 μ V	
1 V	(10 to 40) Hz (40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz (1 to 2) MHz	56 μ V/V + 1.1 mV 65 μ V/V + 0.46 mV 0.16 mV/V + 0.35 mV 0.32 mV/V + 0.69 mV 0.92 mV/V + 0.38 mV 3.5 mV/V + 1.6 mV 12 mV/V + 0.97 mV 17 mV/V + 4.3 mV	
10 V	(10 to 40) Hz (40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 1) MHz (1 to 2) MHz	0.21 mV/V + 7.3 mV 0.23 mV/V + 3.4 mV 0.23 mV/V + 3.3 mV 0.41 mV/V + 3.0 mV 1.4 mV/V + 3.4 mV 4.6 mV/V + 13 mV 17 mV/V + 22 mV 17 mV/V + 22 mV	
100 V	(10 to 40) Hz (40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.44 mV/V + 54 mV 0.45 mV/V + 30 mV 0.64 mV/V + 34 mV 1.3 mV/V + 40 mV 3.6 mV/V + 20 mV 4.1 mV/V + 0.7 V 18 mV/V + 0.8 V	
1000 V	(10 to 40) Hz (40 to 1000) Hz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.44 mV/V + 54 mV 0.46 mV/V + 30 mV 0.64 mV/V + 34 mV 1.3 mV/V + 40 mV 3.5 mV/V + 20 mV	
(1 to 10) kV	(0.01 to 600) Hz	1.4 mV/V + 0.12 V	Vitretek 4700 high voltage multimeter
(10 to 75) kV (60.0 to 80) kV (80.0 to 100.0) kV	(0.01 to 600) Hz (50 to 60) Hz (50 to 60) Hz	1.2 mV/V + 0.77 V 0.49 kV 0.59 kV	Vitretek 4700 with HVL-150 high voltage probe

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
AC Current ³ – Measure			
Up to 100 µA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 1) kHz	1.9 mA/A + 0.56 µA 0.37 mA/A + 0.58 µA 91 µA/A + 0.58 µA 84 µA/A + 0.57 µA	HP 3458 opt. 002 digital multimeter
(1 to 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	4.7 mA/A + 24 µA 1.8 mA/A + 24 µA 0.70 mA/A + 24 µA 0.35 mA/A + 24 µA 0.70 mA/A + 24 µA 4.7 mA/A + 47 µA 6.4 mA/A + 170 µA	
(0.1 to 1) A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz (5 to 20) kHz (20 to 50) kHz	4.7 mA/A + 0.24 mA 1.9 mA/A + 0.24 mA 0.92 mA/A + 0.25 mA 1.3 mA/A + 0.25 mA 3.5 mA/A + 0.24 mA 12 mA/A + 0.47 mA	
(1 to 20) A	(2 to 10) kHz 3 Hz to 10 kHz	0.10 % 0.30 %	Fluke 8508A
(20 to 2800) A	1 Hz to 10 kHz	0.22 mA	LEM PR2000 current clamp, HP 3458A opt. 002 digital multimeter
10 µA 100 µA 1 mA 10 mA 20 mA 100 mA 200 mA 1 A 1.9 A	1 kHz	0.78 nA 4.4 nA 0.053 µA 0.49 µA 0.43 µA 2.1 µA 2.4 µA 0.032 mA 0.047 mA	Fluke A40B series shunts, HP 3458A opt. 002 digital multimeter
AC Current ³ – Generate			
(0.02 to 220) µA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	35 µA/A + 0.50 µA 170 µA/A + 0.048 µA 170 µA/A + 0.048 µA 220 µA/A + 0.22 µA 0.14 % + 1.0 µA	Fluke 5700A

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
AC Current ³ – Generate (cont)			
(0.22 to 2.2) mA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	210 µA/A + 0.63 µA 170 µA/A + 0.48 µA 170 µA/A + 0.48 µA 130 µA/A + 2.4 µA 0.15 % + 7.2 µA	Fluke 5520A
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	94 µA/A + 17 µA 170 µA/A + 3.6 µA 170 µA/A + 3.6 µA 130 µA/A + 16 µA 0.057 % + 77 µA	
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz (0.04 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.016 % + 0.20 mA 0.037 % + 0.12 mA 0.037 % + 0.12 mA 0.044 % + 0.32 mA 0.77 % + 0.73 mA	
(0.22 to 2.2) A	(0.02 to 1) kHz (1 to 5) kHz (5 to 10) kHz	110 µA/A + 3.9 mA 0.034 % + 5.1 mA 0.17 % + 12 mA	
(1.1 to 3) A	(10 to 45) Hz (0.045 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.045 % + 4.5 mA 0.038 % + 5.6 mA 0.69 % + 1.2 mA 2.9 % + 5.8 mA	
(3 to 11) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.16 % + 7.7 mA 0.16 % + 7.7 mA 3.4 % + 14 mA	Fluke 5520A, 5500A/coil
(11 to 20.5) A	(45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.17 % + 7.7 mA 0.17 % + 7.7 mA 3.4 % + 14 mA	
(20.5 to 150) A			
Toroidal	(45 to 65) Hz (65 to 440) Hz	5.8 mA/A + 0.53 A 11 mA/A + 0.47 A	
Non-Toroidal	(45 to 65) Hz (65 to 440) Hz	7.8 mA/A + 0.56 A 12 mA/A + 0.51 A	

Parameter/Range	Frequency	CMC ^{2,7} (±)	Comments
AC Current ³ – Generate (cont) (150 to 1000) A			Fluke 5520A, 5500A/coil
Toroidal	(45 to 65) Hz (65 to 440) Hz	7.0 mA/A + 0.59 A 12 mA/A + 0.59 A	
Non-Toroidal	(45 to 65) Hz (65 to 440) Hz	8.6 mA/A + 0.59 A 13 mA/A + 0.59 A	

Parameter/Equipment	Range	CMC ^{2,7} (±)	Comments
DC Watts – Generate ³	(0.010 89 to 10.89) mW (10.890 to 99) mW (99 to 336.6) W (336.6 to 3060) W (3060 to 20 910) W	0.033 % 0.14 % 0.14 % 0.12 % 0.07 %	Fluke 5520A
AC Watts – Generate ³ , (45 to 65) Hz/PF=1	(0.1089 to 0.297) mW (0.297 to 2.97) mW (2.97 to 10.89) mW (10.89 to 72.60) mW (72.60 to 1485) mW (1.485 to 6.765) W (6.765 to 33.66) W (33.66 to 336.6) W (336.6 to 917.9) W (917.9 to 2244) W (2244 to 20 910) W	0.17 % 0.13 % 0.12 % 0.24 % 0.23 % 0.21 % 0.19 % 0.22 % 0.21 % 0.23 % 0.13 %	Fluke 5520A

Parameter/Equipment	Range	CMC ^{2, 7} ($\pm$)	Comments
Phase Angle ³ – Measure (0 to 359.9999) ° Generate (0 to 999.999) °	10 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 200) kHz 1 Hz to 1 kHz (1 to 50) kHz (50 to 200) kHz	0.012° 0.017° 0.051° 0.11° 0.028° 0.056° 0.068°	North Atlantic PAV 2250A Clarke Hess 5000
Inductance ³ – Measure Generate Fixed points Variable	(0.1 to 10) μH (0.01 to 10) mH 0.01 to 100) mH (0.1 to 10) kH (10 to 100) kH 20 mH 100 mH 200 mH 2 H (1 to 10) mH (10 to 100) mH (0.1 to 1) H (1 to 10) H	0.022 μH 0.21 μH 0.02 H 6.4 H 0.61 kH 0.012 mH 0.054 mH 0.12 mH 1.3 mH 9.5 μH 0.81 mH 0.011 H 0.2 H	HP 4284A General radio 1482 series inductors General radio 1490D
Capacitance ³ – Fixed	1 nF 2 nF 10 nF 100 nF 200 nF 1 μF	0.50 pF 1.1 pF 5.4 pF 7.4 pF 0.10 nF 0.19 nF	General radio 1409 series standard capacitors

Parameter/Equipment	Range	CMC ^{2, 7} (±)	Comments
Capacitance ³ –			
Measure	(0 to 1) nF (0.001 to 10) µF (0.001 to 10) mF (0.01 to 110) mF	1.1 pF 5.4 nF 0.011 mF 0.28 mF	HP 4284A
Generate	(0.19 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF (0.33 to 1.1) µF (1.1 to 3.3) µF (3.3 to 11) µF (11 to 33) µF (33 to 110) µF (110 to 330) µF (0.33 to 1.1) mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 100) mF	0.26 % + 13 pF 0.56 % + 12 pF 0.27 % + 13 pF 0.29 % + 120 pF 0.27 % + 140 pF 0.27 % + 390 pF 0.27 % + 1.3 nF 0.27 % + 3.9 nF 0.25 % + 15 nF 0.26 % + 42 nF 0.38 % + 170 nF 0.45 % + 480 nF 0.50 % + 1.4 µF 0.44 % + 4.9 µF 0.26 % + 36 µF 0.78 % + 49 µF 0.83 % + 360 µF 1.1 % + 360 µF	Fluke 5520A
Thermocouple Simulation ³ –			
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.58 °C 0.20 °C 0.18 °C 0.20 °C 0.26 °C	Fluke 5520A
Type J	(-210 to -30) °C (-30 to 50) °C (50 to 500) °C (500 to 1200) °C	0.30 °C 0.29 °C 0.16 °C 0.23 °C	
Type K	(-200 to -100) °C (-100 to -30) °C (-30 to 120) °C (120 to 1050) °C (1050 to 1371.1) °C	0.35 °C 0.19 °C 0.17 °C 0.15 °C 0.23 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Thermocouple Simulation ³ (cont.) –			Fluke 5520A
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.42 °C 0.24 °C 0.21 °C 0.20 °C 0.28 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.62 °C 0.41 °C 0.37 °C 0.43 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.53 °C 0.41 °C 0.41 °C 0.49 °C	
Type T	(-250 to -150) °C (-250 to -100) °C (-100 to 0) °C (0 to 400) °C	0.64 °C 0.26 °C 0.18 °C 0.15 °C	
RTD Simulation ³ –			Fluke 5520A
Cu427	100 to 260°C	0.34°C	
Ni120	(-80 to 0) °C (0 to 100) °C (100 to 260) °C	0.085 °C 0.084 °C 0.15 °C	
Pt 385, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.090 °C 0.093 °C 0.11 °C 0.13 °C 0.14 °C 0.15 °C 0.25 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
RTD Simulation ³ –			
Pt 385, 200 Ω	(-200 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.046 °C 0.055 °C 0.13 °C 0.14 °C 0.15 °C 0.17 °C	Fluke 5520A
Pt 385, 500 Ω	(-200 to -80) °C (-80 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.042 °C 0.051 °C 0.061 °C 0.081 °C 0.092 °C 0.12 °C	
Pt 385, 1000 Ω	(-200 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C	0.031 °C 0.041 °C 0.052 °C 0.062 °C 0.072 °C 0.23 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.28 °C 0.058 °C 0.067 °C 0.075 °C 0.093 °C 0.11 °C 0.11 °C 0.12 °C 0.24 °C	
Pt 3926, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.066 °C 0.083 °C 0.11 °C 0.12 °C 0.14 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Oscilloscopes – Amplitude – DC Signal ³ 50 Ω Load 1 MΩ Load Amplitude – Square Wave 50 Ω Load 1 MΩ Load	(0 to 6) V (0 to 130) V 1 mV _{p-p} to 6.6 V _{p-p} ; 10 Hz to 10 kHz 1 mV _{p-p} to 130 V _{p-p} ; 10 Hz to 10 kHz	29 mV/V + 0.58 mV 590 μV/V + 75 μV 29 mV _{p-p} /V _{p-p} + 75 μV _{p-p} 280 μV _{p-p} /V _{p-p} + 75 μV _{p-p}	5520A-SC1100 multifunction calibrator w/ oscilloscope opt
Oscilloscopes – Edge Functions ³	(200 to 300) ps	120 ps	5520A-SC1100 multifunction calibrator w/ oscilloscope opt
Oscilloscopes – Bandwidth ³ 5 mV to 5.5 V _{p-p} 4 mV to 3.5 V _{p-p} Leveled Sine Wave – Frequency ³ Time Marker	50 kHz 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz 50 kHz to 1.1 GHz 2 ns to 20 ms 50 ms to 5 s	58 mV _{p-p} /V _{p-p} + 470 μV _{p-p} 58 mV _{p-p} /V _{p-p} + 470 μV _{p-p} 70 mV _{p-p} /V _{p-p} + 470 μV _{p-p} 120 mV _{p-p} /V _{p-p} + 470 μV _{p-p} 140 mV _{p-p} /V _{p-p} + 470 μV _{p-p} 0.58 kHz 2.9 μs/s + 0.15 ps 1.2 ms/s + 58 μs	5520A-SC1100 multifunction calibrator w/ oscilloscope opt

Parameter/Equipment	Range	CMC ² ($\pm$)	Comments
Oscilloscopes – Wave Functions - Square, Sine, & Triangle ³ 50 Ω Load 1 M Ω Load Pulse Characteristics ³ – Pulse Width Pulse Period Rise Time – Generate	 1.8 mV _{p-p} to 2.5 V _{p-p} ; 10 Hz to 10 kHz 1.8 mV _{p-p} to 55 V _{p-p} ; 10 Hz to 10 kHz (4 to 500) ns 200 ns to 20 ms 1 kHz to 2 MHz (200 to 300) ps 2 to 10 MHz (200 to 350) ps	 35 mV _{p-p} /V _{p-p} + 120 μ V _{p-p} 35 mV _{p-p} /V _{p-p} + 120 μ V _{p-p} 2.6 ns 150 ps 120 ps 120 ps	 5520A-SC1100 multifunction calibrator w/ oscilloscope opt
Dissipation Factor – Measure (Df) ³ 1 pF to 100 μ F	 (0.0001 to 10) Df	 3.5 % + 1 cts	 Multi-frequency LCR Meter cts: Counts of LSD

IV. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
RF Power ³ – Measure (-67 to +20) dB	 10 MHz to 40 GHz	 0.82 dB	 Anritsu MA2444D

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
RF Power ³ – Measure (cont.)			
(-35 to +20) dB	DC to 100 MHz 100 MHz to 4 GHz (4 to 8) GHz (8 to 12.4) GHz (12.4 to 18) GHz (18 to 26.5) GHz (26.5 to 30) GHz (30 to 35) GHz (35 to 40) GHz	0.061 dB 0.077 dB 0.091 dB 0.11 dB 0.13 dB 0.11 dB 0.13 dB 0.14 dB 0.14 dB	Rohde & Schwarz NRP-Z55
(-30 to +20) dB	50 MHz to 50 GHz	0.11 dB	HP 8487A, Agilent E4418B
RF Power – Generate			
(-100 to +24) dB (-100 to +20) dB (-100 to +18) dB	1 mHz to 4.024 GHz (1.4 to 20) GHz (20 to 26.5) GHz	0.60 dB 1.2 dB 1.2 dB	Fluke 96270A leveled microwave output
Leveled Sine Wave – Generate			
(-130 to -94) dBm	(10 to 128) MHz 128 MHz to 3 GHz	0.74 dB 1.6 dB	Fluke 96270A
(-94 to -84) dBm	100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 3 GHz	0.52 dB 0.35 dB 0.51 dB 1.1 dB	
(-84 to -74) dBm	100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 4) GHz	0.51 dB 0.13 dB 0.33 dB 0.54 dB 1.1 dB	
(-74 to -48) dBm	100 kHz to 10 MHz (10 to 128) MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 4) GHz	0.21 dB 0.11 dB 0.11 dB 0.43 dB 0.58 dB	

Parameter/Range	Frequency	CMC ^{2, 7} (±)	Comments
RF Power – Generate (cont.) Leveled Sine Wave – Generate (-48 to -17) dBm (-17 to +14) dBm	(10 to 100) kHz 100 kHz to 128 MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.4 to 3) GHz (3 to 4) GHz (10 to 100) kHz 100 kHz to 128 MHz (128 to 300) MHz 300 MHz to 1.4 GHz (1.3 to 4) GHz	0.032 dB 0.062 dB 0.079 dB 0.22 dB 0.38 dB 0.53 dB 0.031 dB 0.059 dB 0.079 dB 0.22 dB 0.33 dB	Fluke 96270A
RF Power ³ – Leveled Sine Wave – Generate (cont) (+14 to +20) dBm (+20 to +24) dBm	(10 to 100) kHz 100 kHz to 128 MHz (128 to 300) MHz 300 MHz to 1.4 GHz (10 to 100) kHz 100 kHz to 128 MHz	0.051 dB 0.058 dB 0.11 dB 0.26 dB 0.031 dB 0.059 dB	Fluke 96270A
Attenuation ^{3, 5} – Measure 10 Hz to 128 MHz	(0 to 55) dB (55 to 64) dB (64 to 100) dB (100 to 116) dB	0.044 dB 0.057 dB 0.17 dB 0.23 dB	Fluke 96270A, Rohde & Schwarz FSP
Amplitude Modulation ³ – Measure Carrier: 150 kHz to 10 MHz Rate: 50 Hz to 10 kHz Rate: 20 Hz to 10 kHz Carrier: 10 MHz to 1.3 GHz Rate: 50 Hz to 50 kHz Rate: 20 Hz to 100 kHz	Depth: (5 to 99) % Depth: (5 to 99) % Depth: (5 to 99) % Depth: (5 to 99) %	2.7 % 3.8 % 1.9 % 3.8 %	HP 8901B

Parameter/Range	Frequency	CMC ^{2, 7} ($\pm$)	Comments
Amplitude Modulation ³ – Generate Carrier: 50 kHz to 4 GHz Rate: 1 Hz to 100 kHz	Depth: (5 to 10) % Depth: (10 to 99) %	1.6 % 3.9 %	Fluke 96270A
Frequency Modulation ³ – Measure Carrier: 150 kHz to 10 MHz Rate: 20 Hz to 10 kHz Carrier: 10 MHz to 1.3 GHz Rate: 50 Hz to 100 kHz Carrier: 10 MHz to 1.3 GHz Rate: 20 Hz to 200 kHz	Deviation: Up to 40 kHz Deviation: Up to 400 kHz Deviation: Up to 400 kHz	26 mHz/Hz + 310 mHz 15 mHz/Hz + 320 mHz 59 mHz/Hz + 290 mHz	HP 8901B
Frequency Modulation ³ – Generate Carrier: 9 MHz to 31.25 MHz Rate: 1 Hz to 50 kHz Rate: 50 Hz to 300 kHz Carrier: 31.25 MHz to 125 MHz Rate: 1 Hz to 50 kHz Rate: 50 Hz to 300 kHz Carrier: 125 MHz to 4 GHz Rate: 1 Hz to 50 kHz Rate: 50 Hz to 300 kHz	Deviation: 10 Hz to 300 kHz Deviation: 10 Hz to 750 kHz Deviation: 10 Hz to 4.8 MHz	11 mHz/Hz 60 mHz/Hz 11 mHz/Hz 36 mHz/Hz 11 mHz/Hz 36 mHz/Hz	Fluke 96270A
Phase Modulation ³ – Measure Carrier: 150 kHz to 10 MHz Rate: 200 Hz to 10 kHz Carrier: 10 MHz to 1.3 GHz Rate: 200 Hz to 20 kHz	Deviation: Up to 420 rad Deviation: Up to 420 rad	0.050 rad/rad + 0.067 rad 0.040 rad/rad + 0.067 rad	HP 8901B
Amplitude Modulation ³ – Sine Distortion (10.0 to 89.0) %	50 kHz to 125 MHz	-40 dBc	Fluke 9640A

Parameter/Range	Frequency	CMC ^{2, 6, 7} (±)	Comments
Phase Modulation ³ – Generate Carrier: 9 MHz to 4 GHz Rate: 1 Hz to 50 kHz Rate: 50 kHz to 300 kHz	Deviation: Up to 1000 rad	0.011 rad/rad 0.036 rad/rad	Fluke 96270A
Total Harmonic Distortion ³	47 Hz to 100 kHz	1.7 %	North Atlantic PAV 2250A

VI. Mechanical

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Accelerometers ³	50 Hz to 2 kHz (2 to 10) kHz	3.4 % 5.0 %	Modal shop 9100D shaker, HP 3458A opt. 002 digital multimeter, Endevco BF11 signal conditioner
Scales & Balances ³ – Linearity Only	(1 to 50) mg (50 to 500) mg (0.5 to 1) g (1 to 5) g (5 to 50) g (50 to 100) g (100 to 200) g (200 to 2000) g (2000 to 6000) g	0.017 mg 0.027 mg 0.055 mg 0.055 mg 0.16 mg 0.64 mg 0.77 mg 6.9 mg 0.14 g	Class 1 weights

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Scales & Balances ³ (cont.) – Linearity Only	(1.0 to 2.0) lbf (2.0 to 5.0) lbf (5.0 to 10.0) lbf (10.0 to 20.0) lbf (20.0 to 100.0) lbf (100.0 to 200.0) lbf	1.1 x 10 ⁻³ lbf 2.0 x 10 ⁻³ lbf 3.5 x 10 ⁻³ lbf 2.6 x 10 ⁻³ lbf 9.2 x 10 ⁻³ lbf 1.6 x 10 ⁻² lbf	Reference Weights
Force – Measuring Equipment ³	(1 to 100) lb (50 to 500) lb (0.5 to 5) klb (10 to 100) klb	0.052 % 0.090 % 0.16 % 0.049 %	Transducer Techniques MDB-10, Rice Lake RL20000I-100 Rice Lake RL2000I-T10-500 Interface RL9000TWM-5K Omega LCW-100K
Pneumatic Pressure – Measuring Equipment ³	(-15 to 0) psig Up to 25 psig (25 to 100) psig Up to 625 psig (625 to 2500) psig Up to 3000 psig (3000 to 10 000) psig	0.0019 psi 0.004 % + 0.0017 psi 0.0057 % + 0.0041 psi 0.057 psi 0.70 psi 0.33 psi 1.1 psi	Fluke 700PD7, Fluke 744 Fluke 7252i dual channel pressure controller Wika CPG 2500
Tachometers ³ – Optical	(30 to 250 000) rpm	12 µRPM/RPM + 0.6R	Fluke 5520A with LED
Torque – Measure ³	(1 to 9) lbf·in (5 to 50) lbf·in (50 to 300) lbf·in (10 to 150) lbf·ft (150 to 600) lbf·ft (600 to 1000) lbf·ft	2.1 % 0.64 % 0.38 % 0.35 % 0.31 % 7.1 lbf·ft	Delta Regis DRBT-10 Sturtevant Richmond system 8 w/ transducers Torque transducers w/ torque analyzer

Parameter/Equipment	Range	CMC ^{2, 6, 8} ($\pm$)	Comments
Mass Flow (Gas) - Measure	(0 to 0.5) slpm	0.03 % + 0.0011 slpm	Fluke Molbox1+ A700K, Molbloc-L 3E4-VCR-V-Q, Molbloc-L 5E3-VCR-V-Q
	(0.5 to 5) slpm	0.26 % + 0.03 slpm	
	(5 to 50) slpm	0.26 % + 0.0002 slpm	
	(50 to 100) slpm	0.13 % + 0.0002 slpm	

V. Thermodynamics

Parameter/Equipment	Range	CMC ^{2, 8} ($\pm$)	Comments
Humidity ³ – Measuring Equipment	(5 to 95) % RH	0.84 % RH	Rotronic HF53W-ID, Rotronic HC2A probe
Temperature ³ – Measuring Equipment			
Thermometers	(-20 to 375) °C (375 to 600) °C	0.088 °C 0.32 °C	WIKA CTP5000-450 probe
Infrared	(-15 to 0) °C (0 to 50) °C (50 to 100) °C (100 to 120) °C	0.96 °C 0.99 °C 1.0 °C 1.2 °C	Fluke 4180 wavelength (8 to 14) μ m emissivity 0.95
	(35 to 100) °C (100 to 200) °C (200 to 350) °C (350 to 500) °C	0.82 °C 1.4 °C 2.0 °C 3.0 °C	Fluke 4181 wavelength (8 to 14) μ m emissivity 0.95
	(500 to 1000) °C (1000 to 1100) °C (1100 to 1400) °C (1400 to 1500) °C	7 °C 9 °C 10 °C 11 °C	Mikron 335 wavelength (0.65 to 1.8) μ m emissivity 1.0

Parameter/Equipment	Range	CMC ^{2,8} (±)	Comments
Infrared – Measure ³	(30 to 100) °C (100 to 150) °C (150 to 200) °C (200 to 250) °C	2.4 °C 3.5 °C 4.7 °C 6 °C	Infrared camera Fluke VT04 wavelength (6.5 to 14) μm emissivity 0.01 to 1.0
	(160 to 500) °C (500 to 900) °C (900 to 1300) °C (1300 to 1650) °C	3 °C 4 °C 5 °C 5 °C	Infrared camera Williamson SW-22- 45C-FOV wavelength (2.2) μm emissivity 0.01 to 1.5
Temperature – Measure	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 420) °C	0.084 °C 0.034 °C 0.037 °C 0.085 °C	Fluke 5616-12 probe, Fluke 1524 reference thermometer
	(420 to 550) °C (550 to 660) °C (660 to 700) °C (700 to 800) °C (800 to 900) °C (900 to 1000) °C	0.12 °C 0.13 °C 3.8 °C 4.0 °C 4.0 °C 4.0 °C	Fluke 9144 w/ Fluke 5609 SPRT Pyromation S-type probe

VI. Time & Frequency

Parameter/Equipment	Range	CMC ^{2,8} (±)	Comments
Frequency ³ – Measuring Equipment	0.001 Hz to 10 kHz 10 kHz to 4 GHz (4 to 26) GHz	0.091 μHz/Hz 0.060 μHz/Hz 0.058 μHz/Hz	Fluke 96270A
Reference Oscillator	10 MHz	0.12 mHz	Trimble Thunderbolt E
Frequency ³ – Measure	1 mHz to 20 GHz	0.085 μHz/Hz + 0.9 nHz	Agilent 53132A
Timers/Stopwatches ³	Up to 24 hr	0.065 s/day	Timometer 4500

¹ This laboratory offers commercial calibration service and field calibration service.

- ² Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.
- ³ Field calibration service is available for this calibration Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.
- ⁴ Specifications are typical below 10 MHz.
- ⁵ Relative to +16 dBm output.
- ⁶ In the statement of CMC, L is the numerical value of the nominal length of the device measured in inches; R is instrument resolution; D is diagonal length; S is each segment greater than the first 36 inch segment; percentages are percentage of reading, unless otherwise indicated.
- ⁷ The measurands stated are generated using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure the 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.
- ⁸ The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter.
- ⁹ Adjustable thread rings are set to applicable specifications using calibrated master set plug gages.
- ¹⁰ This laboratory meets R205 – Specific Requirements: Calibration Laboratory Accreditation Program for the types of dimensional tests listed above and is considered equivalent to that of a calibration.
- ¹¹ This scope meets A2LA's *P112 Flexible Scope Policy*.



Accredited Laboratory

A2LA has accredited

ENI LABS

Fort Wayne, IN

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and R205 – Specific Requirements: Calibration Laboratory Accreditation Program. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).



Presented this 22nd of August, 2022.

A blue ink signature of Mr. Trace McInturff.

Mr. Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2147.01
Valid to April 30, 2024
Revised March 27, 2024

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