



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

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CALIBRATION

Valid To: June 30, 2013

Certificate Number: 1623.07

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations¹:

I. Chemical Quantities

Parameter/Equipment	Range	CMC ^{2,8} (±)	Comments
pH ³	4.01 pH 7 pH 10 pH	0.02 pH 0.02 pH 0.02 pH	Inorganic Ventures
Conductivity ³	(100 to 15 000) µS	1.2 %	Cole Parmer

II. Dimensional

Parameter/Equipment	Range	CMC ^{2,7} (±)	Comments
Micrometers, Height Gages, and Depth Gages End Measuring Rods, Torque Wheels ³	Up to 60 in	(77 + 1.6L) µin	Grade 1 gage blocks

Parameter/Equipment	Range	CMC ^{2, 7, 8} (±)	Comments
Rulers, Straightedges and Tape Measures ³	Up to 50 ft	0.009 in	Gage blocks
Surface Flatness ³	Up to 24 in	62 μin	Surface plate w/ Federal 432
Surface Plates ³	Up to 500 μin flatness > 500 μin	7.8 μin 0.63 %	Mahr-Federal digital level
Optical Flats ³	Up to 5 in	0.77 μin	Comparison to optical flat
Stage Micrometer and Glass Scales ³	Up to 10 in	420 μin	Optical comparator w/software
Steel Balls ³	Up to 8 in diameter	(14 + 1.6L) μin	SIP machine w/ grade 1 gage blocks
Optical Comparators ³ – Up to 36 in			
Angle	Up to 360°	37 ”	15°, 30°, 45° Angle blocks
Length	Up to 36 in	52 μin	Grade 1 gage blocks
Magnification	10X, 20X, 31.25X, 50X	110 μin	Ball set and glass scale
Angle Irons ³	Up to 24 in	10 μin	Federal 432 w/ head and gage blocks
Thickness (Feeler) Gage ³	Up to 2 in	(14 + 1.6L) μin	SIP machine
Cylindrical Pins, Plugs & Rings ³	Up to 8 in	(14 + 1.6L) μin	SIP and gage blocks
Threaded Plugs ³ – Pitch Diameter	Up to 8 in	(14 + 1.6L) μin	SIP and gage blocks

Parameter/Equipment	Range	CMC ^{2,7} (\pm)	Comments
Gage Blocks	Up to 4 in	$(3.7 + 1.6L) \mu\text{in}$	Federal comparator
Thread Wires ³	(4 to 96) TPI	$(14 + 1.6L) \mu\text{in}$	SIP and gage blocks
Indicators ³	Up to 2 in	$(77 + 1.6L) \mu\text{in}$	Grade 1 gage blocks
Calipers ³	Up to 60 in	$(70 + 1.6L) \mu\text{in}$	Grade 1 gage blocks
Protractors & Levels ³	0.25° to 160°	184 ''	Sine plate and gage blocks
Inclinometer	0° to 45°	184 ''	Sine plate and gage blocks
Pitch Gages ³	Up to 120 TPI	$(230 + 10D) \mu\text{in}$	Optical comparator
Radius Gages ³	Up to 3 in	420 μin	Optical comparator
Angle ³	0° to 360°	3.6 ''	Optical comparator
	15°, 30°, 45°	2.1 ''	15°, 30°, 45° angle blocks
Squareness ³ (squares)	18 in	71 μin	Master squares
Surface Parallelism ³	Up to 24 in	10 μin	Federal 432 w/ head and gage blocks
V-block ³	Up to 24 in	10 μin	Federal 432 w/ head and gage blocks

III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 4, 5, 8} (±)	Comments
DC Voltage – Generate ³	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	8.1 μV/V + 0.6 μV 7.1 μV/V + 1 μV 7.1 μV/V + 3.5 μV 7.1 μV/V + 6.5 μV 8.1 μV/V + 80 μV 9.1 μV/V + 500 μV	Fluke 5700A w/ 5725A
	(1.1 to 75) kV	0.24 %	Hallmark divider w/ Glassman kV supply
	(1.1 to 200) kV	0.12 %	Ross divider
DC Current – Generate ³	(0 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A (2.2 to 11) A	50 μA/A + 8 nA 50 μA/A + 80 nA 60 μA/A + 0.8 μA 80 μA/A + 25 μA 0.036 % + 480 μA	Fluke 5700A/5725A
	(11 to 20.5) A	0.1 % + 0.75 mA	Fluke 5520A
	(20.5 to 100) A	0.04 % + 0.03 A	Valhalla 2555A
	(0 to 240) A (0 to 875) A	0.16 % 0.16 %	HP 6682A HP 6680A
	Clamp-On Only (0 to 550) A	0.3 % + 0.5 A	Fluke 5500A w/ coil
DC Power – Generate ³	(0.01 to 330) W (0.33 to 11) kW (11 to 20.5) kW	0.2 % 0.21 % 0.23 %	Fluke 5520A

Parameter/Equipment	Range	CMC ^{2,4,8} (\pm)	Comments
DC Resistance – Generate ³	(0 to 11) Ω	40 $\mu\Omega/\Omega$ + 1 m Ω	Fluke 5520A
	(11 to 33) Ω	30 $\mu\Omega/\Omega$ + 1.5 m Ω	
	(33 to 110) Ω	28 $\mu\Omega/\Omega$ + 1.4 m Ω	
	(0.11 to 1.1) k Ω	28 $\mu\Omega/\Omega$ + 2 m Ω	
	(1.1 to 11) k Ω	28 $\mu\Omega/\Omega$ + 20 m Ω	
	(11 to 110) k Ω	28 $\mu\Omega/\Omega$ + 0.2 Ω	
	(0.11 to 1.1) M Ω	32 $\mu\Omega/\Omega$ + 2 Ω	
	(1.1 to 3.3) M Ω	60 $\mu\Omega/\Omega$ + 30 Ω	
	(3.3 to 11) M Ω	0.013 % + 50 Ω	
	(11 to 33) M Ω	0.025 % + 2.5 k Ω	
	(33 to 110) M Ω	0.05 % + 3 k Ω	
	(110 to 330) M Ω	0.3 % + 100 k Ω	
	(330 to 1100) M Ω	1.5 % + 500 k Ω	
Fixed Points	100 M Ω	0.023 %	Fluke 5450
	0.05 Ω	0.29 %	Empro shunt
	0.01 Ω	0.05 %	L&N 4361
	0.1 Ω	8 parts in 10 ⁶	L&N 4015-B
	1 Ω	95 parts in 10 ⁶	Fluke 5700A
	1.9 Ω	95 parts in 10 ⁶	
	10 Ω	28 parts in 10 ⁶	
	19 Ω	27 parts in 10 ⁶	
	100 Ω	17 parts in 10 ⁶	
	190 Ω	17 parts in 10 ⁶	
	1 k Ω	13 parts in 10 ⁶	
	1.9 k Ω	13 parts in 10 ⁶	
	10 k Ω	12 parts in 10 ⁶	
	19 k Ω	12 parts in 10 ⁶	
	100 k Ω	14 parts in 10 ⁶	
	190 k Ω	14 parts in 10 ⁶	
	1 M Ω	20 parts in 10 ⁶	
	1.9 M Ω	21 parts in 10 ⁶	
	10 M Ω	40 parts in 10 ⁶	
	19 M Ω	47 parts in 10 ⁶	
	100 M Ω	110 parts in 10 ⁶	
	1 Ω	9.7 parts in 10 ⁶	Fluke 742-X
	10 Ω	9.7 parts in 10 ⁶	
	100 Ω	7.5 parts in 10 ⁶	
	1 k Ω	7.3 parts in 10 ⁶	
	10 k Ω	5 parts in 10 ⁶	
	100 k Ω	7.4 parts in 10 ⁶	
	1 M Ω	9.7 parts in 10 ⁶	
	10 M Ω	14 parts in 10 ⁶	

Parameter/Equipment	Range	CMC ^{2,4,8} (\pm)	Comments		
DC Current – Measure ³	(0 to 200) μ A	16 μ A/A + 0.4 pA	Fluke 8508A		
	(0.2 to 20) mA	16 μ A/A + 4 nA			
	(2 to 20) mA	17 μ A/A + 40 nA			
	(20 to 200) mA	49 μ A/A + 0.8 μ A			
	(0.2 to 2) A	0.019 % + 16 μ A	w/L&N 4361		
	(2 to 20) A	0.04 % + 400 μ A			
	(10 to 100) A	0.05 %			
	(100 to 1500) A	0.29 %	w/Ram meter 2500A shunt		
	(1500 to 3000) A	0.29 %	w/Empro 3000-300 shunt		
DC Voltage – Measure ³	(0 to 200) mV	5.2 μ V/V + 0.1 μ V	Fluke 8508A		
	(0.2 to 2) V	3.7 μ V/V + 0.4 μ V			
	(2 to 20) V	3.7 μ V/V + 4 μ V	Hallmark kV divider		
	(20 to 200) V	5.7 μ V/V + 40 μ V			
	(200 to 1050) V	5.7 μ V/V + 500 μ V			
	(1.1 to 75) kV	0.14 %			
DC Resistance – Measure ³	(0 to 2) Ω	17 $\mu\Omega/\Omega$ + 4 $\mu\Omega$	Fluke 8508A		
	(2 to 20) Ω	10 $\mu\Omega/\Omega$ + 14 $\mu\Omega$			
	(20 to 200) Ω	8 $\mu\Omega/\Omega$ + 50 $\mu\Omega$			
	(0.2 to 2) k Ω	8 $\mu\Omega/\Omega$ + 0.5 m Ω			
	(2 to 20) k Ω	8 $\mu\Omega/\Omega$ + 5 m Ω			
	(20 to 200) k Ω	9 $\mu\Omega/\Omega$ + 50 m Ω			
	(0.2 to 2) M Ω	11 $\mu\Omega/\Omega$ + 1 Ω			
	(2 to 20) M Ω	26 $\mu\Omega/\Omega$ + 100 Ω			
	(20 to 200) M Ω	0.012 % + 10 k Ω			
	(0.2 to 2) G Ω	0.15 % + 1 M Ω			
	Fixed Points	10 M Ω		0.35 parts in 10 ⁶	Guildline 9520
		100 M Ω		0.03 parts in 10 ⁶	
		1 G Ω		0.05 parts in 10 ⁶	
10 G Ω		0.09 parts in 10 ⁶			
100 G Ω		0.11 parts in 10 ⁶			
1 T Ω		0.17 parts in 10 ⁶			
10 T Ω		0.33 parts in 10 ⁶			
100T Ω	0.58 parts in 10 ⁶				

Parameter/Range	Frequency	CMC ^{2, 4} (±)	Comments
AC Voltage – Generate ³			
(0.2 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 (0.5 to 1) MHz	0.055 % + 4.5 μV 0.021 % + 4.5 μV 0.011 % + 4.5 μV 0.037 % + 4.5 μV 0.086 % + 7 μV 0.11 % + 13 μV 0.17 % + 25 μV 0.34 % + 25 μV	Fluke 5700A w/ 5725A
(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 (0.5 to 1) MHz	0.055 % + 5 μV 0.021 % + 5 μV 0.011 % + 5 μV 0.037 % + 5 μV 0.085 % + 7 μV 0.11 % + 12 μV 0.17 % + 25 μV 0.34 % + 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 (0.5 to 1) MHz	0.055 % + 13 μV 0.021 % + 8 μV 0.011 % + 8 μV 0.032 % + 8 μV 0.085 % + 25 μV 0.11 % + 25 μV 0.17 % + 35 μV 0.34 % + 80 μV	
(0.22 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 (0.5 to 1) MHz	0.05 % + 80 μV 0.016 % + 25 μV 75 μV/V + 6 μV 0.012 % + 16 μV 0.025 % + 70 μV 0.043 % + 130 μV 0.11 % + 350 μV 0.22 % + 850 μV	
(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 (0.5 to 1) MHz	0.05 % + 0.8 mV 0.016 % + 0.25 mV 75 μV/V + 0.06 mV 0.012 % + 0.16 mV 0.025 % + 0.35 mV 0.05 % + 1.5 mV 0.13 % + 4.3 mV 0.27 % + 8.5 mV	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage – Generate ³ (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 (0.5 to 1) MHz	0.05 % + 8 mV 0.016 % + 2.5 mV 81 μV/V + 0.8 mV 0.022 % + 3.5 mV 0.05 % + 8 mV 0.15 % + 90 mV 0.47 % + 90 mV 1.2 % + 190 mV	Fluke 5700A w/ 5725A
(220 to 1100) V	(15 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz	0.04 % + 16 mV 80 μV/V + 3.5 mV 0.06 % + 6 mV 0.23 % + 11 mV	
(220 to 750) V	30 Hz to 50 kHz (50 to 100) kHz	0.09 % + 11 mV 0.17 % + 45 mV	
AC Current – Generate ³			
(9 to 220) μA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.07 % + 25 nA 0.035 % + 20 nA 0.014 % + 16 nA 0.06 % + 40 nA 0.16 % + 80 nA	Fluke 5700A
(0.22 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	0.07 % + 40 nA 0.035 % + 35 nA 0.014 % + 35 nA 0.06 % + 400 nA 0.16 % + 800 nA	
(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	0.07 % + 0.4 μA 0.035 % + 0.35 μA 0.014 % + 0.35 μA 0.06 % + 4 μA 0.16 % + 8 μA	
(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	0.07 % + 4 μA 0.035 % + 3.5 μA 0.014 % + 3.5 μA 0.06 % + 40 μA 0.16 % + 80 μA	

Parameter/Range	Frequency	CMC ^{2, 4, 6, 8} (±)	Comments
AC Current – Generate ³ (cont)			
(0.22 to 2.2) A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.065 % + 35 µA 0.075 % + 80 µA 0.85 % + 160 µA	Fluke 5700A
(2.2 to 11) A	20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.046 % + 170 µA 0.095 % + 380 µA 0.36 % + 750 µA	
(11 to 20.5) A	(10 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	0.15 % + 5 mA 0.18 % + 5 mA 3.5 % + 5 mA	Fluke 5520A
(10 to 100)	(0.4 to 1) kHz	0.07 % of output	Weston 327 Type 2
Clamp-On Only			
(0 to 550) A (0 to 110) A	(45 to 65) Hz (65 to 440) Hz	0.38 % + 0.5 A 0.32 % + 0.5 A	Fluke 5500A w/ coil
(1.0 to 2.2) mA	(20 to 40) Hz (40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.024 % 0.022 % 0.018 % 0.03 % 0.15 %	Fluke A40 shunts w/ Fluke 5720/5725 and Fluke 3458A
(2.2 to 22) mA	(20 to 40) Hz (40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.034 % 0.032 % 0.029 % 0.044 % 0.31 %	
(22 to 220) mA	(20 to 40) Hz 40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.034 % 0.028 % 0.025 % 0.036 % 0.13 %	
(.22 to 2.2) A	(20 to 40) Hz (40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.046 % 0.046 % 0.044 % 0.075 % 0.58 %	
(2.2 to 11) A	(40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.075 % 0.073 % 0.12 % 0.34 %	
(11 to 20) A	(10 to 440) Hz	0.073 %	Fluke A40 shunts w/ Voltech 25555A, Fluke 5790A and HP 3458A

Parameter/Range	Frequency	CMC ^{2, 4, 6, 8} (±)	Comments
AC Current – Measure ³			
(1 to 2.2) mA	(20 to 40) Hz (40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.016 % 0.016 % 0.011 % 0.011 % 0.011 %	Fluke A40 shunts w/ 5720A/5725A, and HP 3458A
(2.2 to 22) mA	(20 to 40) Hz (40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.017 % 0.017 % 0.012 % 0.012 % 0.012 %	
(22 to 220) mA	(20 to 40) Hz (40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.018 % 0.018 % 0.013 % 0.013 % 0.013 %	
(0.22 to 2.2) A	(20 to 40) Hz (40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.024 % 0.024 % 0.02 % 0.02 % 0.02 %	
(2.2 to 11) A	(40 to 400) Hz (0.4 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.059 % 0.058 % 0.058 % 0.058 %	
(11 to 20) A	(10 to 440) Hz	0.072 %	
(1 to 20) A	DC to 5 kHz	(0.025 + 0.012f) %	

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
AC Resistance – Generate ³ , Fixed Values			
10 Ω	DC to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.13 % 0.14 % 0.17 % 0.19 % 0.26 % 0.66 % 1 %	HP 42030 resistor set
100 Ω	DC to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.13 % 0.14 % 0.17 % 0.14 % 0.17 % 0.34 % 0.46 %	
1 kΩ	DC to 3 MHz (3 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.08 % 0.11 % 0.28 % 0.41 %	
10 kΩ	DC to 1 MHz	0.07 %	
100 kΩ	DC to 1 MHz	0.09 %	
Distortion – Measure (0 to 99.9) dB			
20 Hz to 20 kHz (20 to 100) kHz	(50 to 500) kHz (50 to 500) kHz	1.2 dB 2.3 dB	HP 8903B
Inductance – Generate			
100 μH (1, 10, 100) mH (1, 2, 5) H	(0.1 to 1) kHz (0.1 to 1) kHz (0.1 to 1) kHz	0.1 % 0.03 % 0.05 %	GenRad 1482X
Inductance – Measure			
100 μH to 10 H	10 Hz to 1 MHz	0.05 %	Quadtech 7400
Capacitance – Measure			
1 pF to 1 F	10 Hz to 500 kHz	0.05 %	Quadtech 7400

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
Capacitance – Generate ³			
Fixed Values			
1 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.062 % 0.072 % 0.083 % 0.099 % 0.16 % 0.22 % 0.68 % 1 %	HP 1638XX standard capacitor
10 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.062 % 0.066 % 0.075 % 0.076 % 0.083 % 0.095 % 0.15 % 0.18 %	
100 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.073 % 0.066 % 0.075 % 0.076 % 0.083 % 0.095 % 0.15 % 0.18 %	
1000 pF	100 Hz to 1 kHz 1 kHz to 1 MHz (1 to 2) MHz (2 to 3) MHz (3 to 4) MHz (4 to 5) MHz (5 to 10) MHz (10 to 13) MHz	0.062 % 0.072 % 0.083 % 0.099 % 0.13 % 0.16 % 0.35 % 0.48 %	
(10, 100) nF	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.063 % 0.062 % 0.064 % 0.071 %	

Parameter/Range	Frequency	CMC ^{2, 4, 8} (±)	Comments
Capacitance – Generate ³ (cont.)			
Fixed Values			
1 μF	(100 to 120) Hz 120 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.067 % 0.062 % 0.067 % 0.091 %	HP 1638XX standard capacitor
0.005 μF	1 kHz	0.03 %	GenRad 1409K
0.02 μF	1 kHz	0.03 %	GenRad 1409M
0.05 μF	1 kHz	0.03 %	GenRad 1409R
0.2 μF	1 kHz	0.03 %	GenRad 1409U
0.5 μF	1 kHz	0.03 %	GenRad 1409X
(0.19 to 1.09) nF	10 Hz to 10 kHz	0.54 % + 0.01 nF	Fluke 5520A
(1.1 to 3.29) nF	10 Hz to 3 kHz	0.54 % + 0.01 nF	
(3.3 to 10.9) nF	10 Hz to 1 kHz	0.32 % + 0.01 nF	
(11 to 109.9) nF	10 Hz to 1 kHz	0.27 % + 0.1 nF	
(110 to 329.9) nF	10 Hz to 1 kHz	0.27 % + 0.3 nF	
(0.33 to 1.09) μF	(10 to 600) Hz	0.27 % + 1 nF	
(1.1 to 3.29) μF	(10 to 300) Hz	0.27 % + 3 nF	
(3.29 to 10.9) μF	(10 to 150) Hz	0.29 % + 10 nF	
(11 to 32.9) μF	(10 to 120) Hz	0.46 % + 30 nF	
(33 to 109.9) μF	(10 to 80) Hz	0.51 % + 100 nF	
(110 to 329.9) μF	(10 to 50) Hz	0.54 % + 300 nF	
(0.33 to 1.09) mF	(10 to 20) Hz	0.62 % + 1000 nF	
AC Voltage ³ – Measure			
(0 to 200) mV	(10 to 40) Hz (40 to 100) Hz (0.1 to 2) kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.015 % + 4 μV 0.012 % + 4 μV 0.012 % + 2 μV 0.015 % + 4 μV 0.035 % + 8 μV 0.077 % + 20 μV	Fluke 8508A
(0.2 to 2) V	(10 to 40) Hz (40 to 100) Hz (0.1 to 2) kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.012 % + 0.02 mV 94 μV/V + 0.02 mV 84 μV/V + 0.02 mV 0.013 % + 0.02 mV 0.026 % + 0.04 mV 0.059 % + 0.2 mV 0.3 % + 2 mV 1 % + 20 mV	

Parameter/Range	Frequency	CMC ^{2, 4, 8} (±)	Comments
AC Voltage ³ – Measure (cont.)			
(2 to 20) V	(10 to 40) Hz (40 to 100) Hz (0.1 to 2) kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.013 % + 0.2 mV 94 μV/V + 0.2 mV 80 μV/V + 0.2 mV 0.011 % + 0.2 mV 0.023 % + 0.4 mV 0.057 % + 2 mV 0.3 % + 20 mV 1 % + 200 mV	Fluke 8508A
(20 to 200) V	(10 to 40) Hz (40 to 100) Hz (0.1 to 2) kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.013 % + 2 mV 95 μV/V + 2 mV 81 μV/V + 2 mV 0.011 % + 2 mV 0.023 % + 4 mV 0.058 % + 20 mV 0.3 % + 200 mV 1 % + 2 V	
(200 to 300) V	(10 to 40) Hz (0.04 to 10) kHz (10 to 30) kHz (30 to 100) kHz	0.014 % + 20 mV 0.013 % + 20 mV 0.023 % + 40 mV 0.061 % + 200 mV	
(300 to 1050) V	(10 to 40) Hz (0.04 to 10) kHz	0.014 % + 20 mV + (0.0004)(reading-300) ² μV/V 0.013 % + 20 mV + (0.0004)(reading-300) ² μV/V	
(300 to 1050) V	(10 to 30) kHz (30 to 100) kHz	0.023 % + 40 mV + [(0.0004 + (Frequency- 10000)(10 ⁻⁷))] (reading-300) ² μV/V 0.061 % + 200 mV + (0.0024)(reading-300) ² μV/V	
(0 to 2.2) mV	500 kHz to 1.2MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.23 % + 1 μV 0.25 % + 1 μV 0.34 % + 1 μV 0.42 % + 1 μV 0.81 % + 2 μV	5790A Opt. 3 wideband
(2.2 to 7) mV	500 kHz to 1.2MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.11 % + 1 μV 0.11 % + 1 μV 0.14 % + 1 μV 0.21 % + 1 μV 0.41 % + 1 μV	

Parameter/Range	Frequency	CMC ^{2,4,8} (±)	Comments
AC Voltage ³ – Measure (cont.)			
(7 to 22) mV	500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.095 % 0.094 % 0.13 % 0.2 % 0.4 %	5790A Opt 3 wideband
(22 to 70) mV	500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.06 % 0.06 % 0.11 % 0.16 % 0.36 %	
(70 to 220) mV	500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.06 % 0.062 % 0.11 % 0.16 % 0.36 %	
(220 to 700) mV	500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.073 % 0.056 % 0.11 % 0.16 % 0.36 %	
(0.7 to 2.2) V	500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.053 % 0.053 % 0.11 % 0.16 % 0.36 %	
(2.2 to 7) V	500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.053 % 0.053 % 0.11 % 0.16 % 0.36 %	
AC Power ³ – Generate PF = 1			
(0.01 to 0.1) W (0.1 to 890) W (0.89 to 3) kW (3 to 11) kW (11 to 20.5) kW	(45 to 65) Hz	0.23 % 0.14 % 0.13 % 0.15 % 0.13 %	Fluke 5520A

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Current – Measure ³			
(0 to 200) μA	10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.032 % + 0.02 μA 0.072 % + 0.02 μA 0.4 % + 0.02 μA	Fluke 8508A
(0.2 to 2) mA	10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.032 % + 0.2 μA 0.072 % + 0.2 μA 0.4 % + 0.2 μA	
(2 to 20) mA	10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	0.032 % + 2 μA 0.072 % + 2 μA 0.4 % + 2 μA	
(20 to 200) mA	10 Hz to 10 kHz (10 to 30) kHz	0.031 % + 20 μA 0.063 % + 20 μA	
(0.2 to 2) A	10 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz	0.063 % + 0.2 mA 0.073 % + 0.2 mA 0.3 % + 0.2 mA	
(2 to 20) A	10 Hz to 2 kHz (2 to 10) kHz	0.083 % + 2 mA 0.25 % + 2 mA	
(10 to 100) A	(0.4 to 1) kHz	0.07 % of output	
Phase AC Voltage – Generate and Measure ³			
0° to 360°			Clark-Hess 5500 bridge
5 V	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 100) kHz	21 m° 21 m° 24 m° 31 m°	
50 mV to 5 V, (5 to 100) V	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 100) kHz	21 m° 24 m° 27 m° 51 m°	
(100 to 120) V	1 Hz to 1 kHz (1 to 6.25) kHz (6.25 to 50) kHz (50 to 100) kHz	23 m° 31 m° 40 m° 95 m°	

Parameter/Range	Frequency	CMC ^{2, 4, 6, 8} (±)	Comments
AC Level Flatness – Measure ³			
0.5 V	10 Hz 100 Hz (10, 30) kHz 100 kHz 300 kHz 1 MHz (3, 8, 10) MHz 20 MHz 30 MHz 50 MHz 70 MHz 80 MHz 100 MHz	0.045 % 0.018 % 0.018 % 0.029 % 0.076 % 0.041 % 0.11 % 0.16 % 0.22 % 0.43 % 1.6 % 1.7 % 1.8 %	Ballantine 1395A-1 and 1395A-3 w/ HP 3458A and Fluke 5700A
(1, 3) V	10 Hz 100 Hz (10, 30) kHz 100 kHz 300 kHz 1 MHz (3, 8, 10) MHz (20, 30) MHz 50 MHz 70 MHz 80 MHz 100 MHz	0.015 % 0.009 % 0.009 % 0.009 % 0.01 % 0.01 % 0.06 % 0.12 % 0.34 % 0.46 % 0.69 % 0.81 %	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple Indicators ³ –			
Type B	(600 to 800) °C (800 to 1000) °C (1000 to 1550) °C (1550 to 1820) °C	0.46 °C 0.36 °C 0.36 °C 0.39 °C	Fluke 5520A
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.36 °C 0.32 °C 0.37 °C 0.56 °C 0.9 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple Indicators ³ (cont) –			
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.56 °C 0.22 °C 0.21 °C 0.22 °C 0.27 °C	Fluke 5520A
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.33 °C 0.22 °C 0.21 °C 0.23 °C 0.29 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.39 °C 0.24 °C 0.22 °C 0.32 °C 0.46 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.46 °C 0.28 °C 0.25 °C 0.24 °C 0.33 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.63 °C 0.41 °C 0.39 °C 0.46 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.53 °C 0.42 °C 0.43 °C 0.52 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.69 °C 0.3 °C 0.22 °C 0.2 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.62 °C 0.3 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of RTD Indicators ³			
Pt 385, 100 Ω	(-200 to -80) °C	0.06 °C	Fluke 5520A
	(-80 to 0) °C	0.06 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 630) °C	0.12 °C	
	(630 to 800) °C	0.23 °C	
Pt 3926, 100 Ω	(-200 to -80) °C	0.06 °C	
	(-80 to 0) °C	0.06 °C	
	(0 to 100) °C	0.08 °C	
	(100 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 630) °C	0.13 °C	
Pt 3916, 100 Ω	(-200 to -190) °C	0.26 °C	
	(-190 to -80) °C	0.05 °C	
	(-80 to 0) °C	0.06 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 260) °C	0.08 °C	
	(260 to 300) °C	0.09 °C	
	(300 to 400) °C	0.10 °C	
	(400 to 600) °C	0.11 °C	
Pt 385, 200 Ω	(-200 to 100) °C	0.05 °C	
	(100 to 260) °C	0.06 °C	
	(260 to 300) °C	0.13 °C	
	(300 to 400) °C	0.14 °C	
	(400 to 600) °C	0.15 °C	
	(600 to 630) °C	0.17 °C	
Pt 385, 500 Ω	(-200 to -80) °C	0.05 °C	
	(-80 to 100) °C	0.06 °C	
	(100 to 260) °C	0.07 °C	
	(260 to 400) °C	0.09 °C	
	(400 to 600) °C	0.1 °C	
	(600 to 630) °C	0.12 °C	
Pt 385, 1000 Ω	(-200 to 0) °C	0.04 °C	
	(0 to 100) °C	0.05 °C	
	(100 to 260) °C	0.06 °C	
	(260 to 300) °C	0.07 °C	
	(300 to 600) °C	0.08 °C	
	(600 to 630) °C	0.24 °C	

Parameter/Equipment	Range	CMC ^{2, 4, 8} (±)	Comments
Electrical Calibration of RTD Indicators ³ (cont.) – PtNi 385, 120 Ω Cu 427, 10 Ω	(-80 to 100) °C (100 to 260) °C (-100 to 260) °C	0.09 °C 0.15 °C 0.3 °C	Fluke 5520A
Bandwidth ³	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	2.1 % 2.6 % 4.8 % 5.9 %	Fluke 5520A/SC1.1
Rise Time – Generate ³	< 1 ns	3.5 %	Tektronix PG506
Rise Time – Measure ³	< 600 ps	3.5 %	HP 54120B w/54121A

IV. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ² (±)	Comments
RF Attenuation Tuned RF Power – Measure ³ (-0.0 to -1) dB (-1 to -10) dB (-10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -70) dB (-70 to -80) dB (-80 to -90) dB (-90 to -100) dB (-100 to -110) dB (-110 to -120) dB	100 kHz to 26.5 GHz	0.008 dB 0.023 dB 0.052 dB 0.073 dB 0.11 dB 0.13 dB 0.15 dB 0.19 dB 0.22 dB 0.24 dB 0.26 dB 0.31 dB 0.37 dB	HP 8902A HP 11722A HP 11792A HP 11793A

Parameter/Range	Frequency	CMC ^{2,7,8} (±)	Comments
RF Power – Measure ³ (+30 to -20) dBm (-70 to +20) dBm	100 kHz to 2.6 GHz (2.6 to 26.5) GHz	2.9 % 2.9 %	HP 8902A w/ 11722A HP 438A w/ 8485A
RF Power – Generate ³ (+23.98 to -56.02) dBm (+10 to -127) dBm (+13 to -110) dBm	0.01 Hz to 20 MHz 20 MHz to 3 GHz 10 MHz to 26.5 GHz	0.5 dB 1.3 dB 0.2 dB	HP 3325A HP 8648C Agilent 83630A
Phase Noise – Measure ³ Up to 18 GHz @ Offset of: ≤ -54 dBc ≤ -84 dBc ≤ -104 dBc ≤ -121 dBc ≤ -121 dBc ≤ -129 dBc ≤ -145 dBc ≤ -157 dBc	≤ 1 Hz ≤ 10 Hz ≤ 100 Hz ≤ 1 kHz ≤ 3 kHz ≤ 5 kHz ≤ 10 kHz ≤ 100 kHz	2.4 dBc 2.4 dBc 2.4 dBc 2.4 dBc 2.4 dBc 2.4 dBc 2.4 dBc 2.4 dBc	Agilent 8563E and 8663A
Phase Modulation – Measure ³ Rate: (0.2 to 10) kHz Rate: (0.2 to 20) kHz	(0.15 to 10) MHz 10 MHz to 1.3 GHz (1.3 to 26.5) GHz	4.6 % + 1 digit 3.4 % + 1 digit 4.6 % + 1 digit	HP 8902A w/11793A
VSWR – Measure ³ Into 50 Ohms 1 <VSWR> 1.22 1.22 <VSWR> 1.67 1.167 <VSWR> 3.00 3 <VSWR> 7.00	(0.1 to 2) GHz	0.013 Γ 0.018 Γ 0.038 Γ 0.069 Γ	Wiltron 60N50 w/ Agilent 8902A w/ 11722A

Parameter/Range	Frequency	CMC ^{2, 8} (\pm)	Comments
Digital Modulation – Measure ³			
Carrier: 2 MHz to 26.5 GHz			
Error vector magnitude for Modulation types: MSK, GMSK, BPSK, DQPSK, $\pi/4$ DQPSK, 8PSK, 16QAM, and 32QAM	Mod Freq Span (0.001 to 100) kHz (0.1 to 1) MHz (1 to 2650) MHz	0.22° 0.45° 0.73°	Agilent 89441A
Error vector magnitude for FSK modulation	Mod Freq 3.2 kHz 1.152 kHz	0.68 % 2.1 %	
Phase error for FSK Modulation	Mod Freq 3.2 kHz 1.152 MHz	17 Hz 3.4 kHz	
Error vector magnitude for Modulation types: QPSK and OQPSK	Mod Freq 2.6 MHz	1.2 %	
Phase error for modulation Types: QPSK and OQPSK	Mod Freq 2.6 MHz	0.69°	
Carrier: 2 MHz to 26.5 GHz			
Error vector magnitude for Modulation types: MSK, GMSK, BPSK, DQPSK, $\pi/4$ DQPSK, 8PSK, 16QAM, and 32QAM	Mod Freq Span (0.001 to 100) kHz (0.1 to 1) MHz (1 to 2650) MHz	0.36 % 0.59 % 1.2 %	

Parameter/Range	Frequency	CMC ^{2,8} (±)	Comments
Amplitude Modulation – Measure ³			
Rate: 50 Hz to 10 kHz Depths: 5 % to 99 %	(0.15 to 10) MHz	2 % + 1 digit	HP 8902A
Rate: 20 Hz to 10 kHz Depths: to 99 %	(0.15 to 10) MHz	3 % + 1 digit	
Rate: 50 Hz to 50 kHz Depths: 5 % to 99 %	10 MHz to 1.3 GHz	1 % + 1 digit	w/11793A
Rate: 20 Hz to 100 kHz Depths: to 99 %	10 MHz to 1.3 GHz	3 % + 1 digit	
Rate: 20 Hz to 100 kHz Depths: to 99 %	(1.3 to 26.5) GHz	1.8 % + 1 digit	
Rate: 20 Hz to 100 kHz Depths: to 99 %	(1.3 to 26.5) GHz	3 % + 1 digit	
Amplitude Modulation – Generate ³			
Rate: 50 Hz to 100 kHz Depths: 5 % to 99 %	(11 to 13.5) MHz	0.12 %	HP 11715A
Power Sensor Calibration – Calibration Factor ³			
HP 8481 A, B, H	10 MHz 30 MHz 50 MHz 100 MHz 300 MHz 500 MHz 1 GHz 1.5 GHz	0.89 % 1.2 % 0.69 % 0.6 % 0.65 % 0.64 % 0.59 % 0.49 %	HP 8481A with Gold Cal and HP8340A, HP438A, HP3325B

Parameter/Range	Frequency	CMC ^{2,8} (±)	Comments
Power Sensor Calibration – Calibration Factor ³ (cont)			
HP 8481A, B, H	2 GHz	0.52 %	HP 8481A with Gold Cal and HP8340A, HP438A, HP3325B
	3 GHz	0.66 %	
	4 GHz	0.54 %	
	5 GHz	0.76 %	
	6 GHz	0.69 %	
	7 GHz	0.59 %	
	8 GHz	0.64 %	
	9 GHz	0.67 %	
	10 GHz	0.74 %	
	11 GHz	0.85 %	
	12 GHz	0.6 %	
	12.4 GHz	0.86 %	
	13 GHz	0.73 %	
	14 GHz	0.64 %	
	15 GHz	0.8 %	
	16 GHz	0.85 %	
	(17, 18) GHz	0.97 %	
HP 8482A, B, H	0.1 MHz	0.45 %	
	0.3, 0.5, 1 MHz	0.48 %	
	3, 5, 10 MHz	0.6 %	
	30 MHz	0.69 %	
	50 MHz	0.67 %	
	100 MHz	0.7 %	
	300 MHz	0.51 %	
	500 MHz	0.52 %	
	1 GHz	0.6 %	
	1.5 GHz	0.56 %	
	2 GHz	0.55 %	
	2.5 GHz	0.52 %	
	3 GHz	0.53 %	
	3.5 GHz	0.61 %	
	4 GHz	0.59 %	
4.2 GHz	0.66 %		
HP 8484A/8481D	10 MHz	2.1 %	
	30 MHz	1.6 %	
	50 MHz	1.6 %	
	100 MHz	1.4 %	
	300 MHz	1.5 %	
	500 MHz	1.4 %	

Parameter/Range	Frequency	CMC ^{2, 8} (±)	Comments
Power Sensor Calibration – Calibration Factor ³ (cont.) HP 8484A/8481D	1 GHz 1.5, 2 GHz 3 GHz 4 GHz 5 GHz 6 GHz 7 GHz 8 GHz 9 GHz 10 GHz 11 GHz 12 GHz 12.4 GHz 13 GHz 14 GHz 15 GHz 16 GHz 17 GHz 18 GHz	1.5 % 1.4 % 1.4 % 1.4 % 1.4 % 1.5 % 1.4 % 1.5 % 1.5 % 1.5 % 1.5 % 1.5 % 1.5 % 1.5 % 1.5 % 1.5 % 1.5 % 1.6 % 1.7 %	HP 8484A Gold Cal sensor with HP8340A, HP438A, HP3325B
Phase Modulation – Generate ³ Rate: 20 Hz to 10 kHz Carrier: 20 Hz to 249 MHz Phase: (0 to 10) rad Carrier: (249 to 501) MHz Phase: (0 to 5) rad Carrier: (501 to 1001) MHz Phase: (0 to 10) rad Carrier: (1.001 to 2.001) GHz Phase: (0 to 20) rad Carrier: (2.001 to 3.2) GHz Phase: (0 to 40) rad	9 kHz to 1001 MHz (1.001 to 2.001) GHz (2.001 to 3.2) GHz 9 kHz to 1001 MHz (1.001 to 2.001) GHz (2.001 to 3.2) GHz 9 kHz to 1001 MHz (1.001 to 2.001) GHz (2.001 to 3.2) GHz 9 kHz to 1001 MHz (1.001 to 2.001) GHz (2.001 to 3.2) GHz	3.5 % + 0.05 rad 3.5 % + 0.1 rad 3.5 % + 0.2 rad 3.5 % + 0.05 rad 3.5 % + 0.1 rad 3.5 % + 0.2 rad 3.5 % + 0.05 rad 3.5 % + 0.1 rad 3.5 % + 0.2 rad 3.5 % + 0.05 rad 3.5 % + 0.1 rad 3.5 % + 0.2 rad	HP 8648C

Parameter/Range	Frequency	CMC ^{2, 7, 8} (\pm)	Comments
Frequency Modulation – Measure ³			
Rate: 20 Hz to 10 kHz Dev.: ≤ 40 kHz peak	(0.25 to 10) MHz	2 % + 1 digit	HP 8902A
Rate: 50 Hz to 100 kHz Dev.: ≤ 400 kHz peak	10 MHz to 1.3 GHz	1 % + 1 digit	
Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	10 MHz to 1.3 GHz	6 % + 1 digit	
Rate: 50 Hz to 100 kHz Dev.: ≤ 400 kHz peak	(1.3 to 26.5) GHz	1 % + 1 digit	w/11793A
Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	(1.3 to 26.5) GHz	6 % + 1 digit	
Reflection Magnitude ³ (Into 50 Ω)			
$0 < \Gamma \leq 0.2$	300 kHz to 3 GHz (3 to 6) GHz	0.006 Γ 0.009 Γ	HP 8753E w/ 7 mm connector
$0.2 < \Gamma \leq 0.4$	300 kHz to 3 GHz (3 to 6) GHz	0.008 Γ 0.014 Γ	
$0.4 < \Gamma \leq 0.6$	300 kHz to 3 GHz (3 to 6) GHz	0.011 Γ 0.018 Γ	
$0.6 < \Gamma \leq 0.8$	300 kHz to 3 GHz (3 to 6) GHz	0.013 Γ 0.023 Γ	
$0.8 < \Gamma \leq 1$	300 kHz to 3 GHz (3 to 6) GHz	0.017 Γ 0.026 Γ	
Frequency Modulation – Generate ³			
Rate: 20 Hz to 200 kHz Dev.: ≤ 12.5 kHz peak	(11 to 13.5) MHz	0.23 %	HP 11715A
Rate: 20 Hz to 200 kHz Dev.: ≤ 100 kHz peak	(88 to 108) MHz	0.27 %	
Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	(352 to 432) MHz	0.35 %	

Parameter/Range	Frequency	CMC ^{2,8} (±)	Comments
Transmission Phase ³ – (Into 50 Ω, 0° to 360°) (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB	300 kHz to 6 GHz	4.6° 1.1° 1.1° 1.1° 1.1° 1.3° 2.2°	HP 8753E w/ 7 mm connector
Transmission Magnitude ³ – (Into 50 Ω) (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -70) dB (10 to 0) dB (0 to -10) dB (-10 to -20) dB (-20 to -30) dB (-30 to -40) dB (-40 to -50) dB (-50 to -60) dB (-60 to -70) dB	300 kHz to 3 GHz (3 to 6) GHz	0.3 dB 0.9 dB 0.1 dB 0.1 dB 0.1 dB 0.1 dB 0.11 dB 0.18 dB 0.35 dB 0.52 dB 0.13 dB 0.13 dB 0.13 dB 0.13 dB 0.17 dB 0.25 dB 0.68 dB	HP 8753E w/ 7 mm connector
Reflection Phase ^{3,7} – (Into 50 Ω, 0° to 360°) 0.2 < Γ ≤ 0.4 0.4 < Γ ≤ 0.6 0.6 < Γ ≤ 0.8 Γ > 0.8	300 kHz to 3 GHz (3 to 6) GHz 300 kHz to 3 GHz (3 to 6) GHz 300 kHz to 3 GHz (3 to 6) GHz 300 kHz to 3 GHz (3 to 6) GHz	2.0° 3.1° 1.4° 2.2° 1.2° 1.9° 1.1° 1.8°	HP 8753E w/ 7 mm connector

V. Mechanical

Parameter/Equipment	Range	CMC ^{2,8} (±)	Comments
Force Gauges – Compression and Tension Test, Dynamometer ³	(0.25 to 250) lbf	0.1 %	Class F weights
Torque – Measuring Equipment ³	(2 to 40) in·oz 40 in·oz to 50 in·lb 50 in·lb to 250 ft·lb (250 to 600) ft·lb	0.12 % 0.12 % 0.12 % 0.12 %	Class F weights w/ 2.5 in wheel 5 in wheel 10 in wheel 40 in torque arm
Torque – Measure ³	(5 to 50) in·lb (50 to 250) in·lb (250 to 1000) in·lb (25 to 250) ft·lb (250 to 1000) ft·lb (1000 to 2000) ft·lb	0.32 % 0.32 % 0.32 % 0.32 % 0.33 % 0.39 %	CDI 950-DT w/ TTPM-41 CDI 2000 system
Pressure ³	Up to 3000 psig (3000 to 10 000) psig Up to 50 psi Up to 5 psi Up to 60 psi Up to 10 psi Up to 200 psi	1.8 psig 0.12 % 0.041 % of span 0.041 % of span 0.041 % of span 0.041 % of span 0.041 % of span	Eaton UPC 5000 Omega DWT 1305D Heise PTE-1 w/HSQ-1 Heise PTE-1 w/HSQ-2
Durometers ³	(0 to 100) units	0.45 units	REX RDC-1
Vacuum ³	(-14.5 to 0) psi	0.041 % of span	Heise PTE-1 w/HSQ-2

Parameter/Equipment	Range	CMC ² (±)	Comments
Scales & Balances ³	(1 to 10) mg (10 to 500) mg (1 to 50) g (50 to 300) g (300 to 500) g (0.5 to 1) kg (1 to 3) kg (3 to 5) kg (5 to 10) kg (10 to 20) kg (20 to 26.5) kg (26.5 to 40) kg	0.011 mg 0.026 mg 0.08 mg 0.4 mg 0.6 mg 1.3 mg 4.6 mg 6.5 mg 19 mg 29 mg 34 mg 52 mg	Class 3 weights
	(0.25 to 0.5) lb (0.5 to 10) lb (10 to 25) lb (25 to 50) lb (50 to 100) lb (100 to 500) lb	0.0001 lb 0.001 lb 0.004 lb 0.006 lb 0.014 lb 0.052 lb	Class F weights
Mass ³	(1 to 10) mg (10 to 20) mg (20 to 200) mg 200 mg to 1 g (1 to 3) g (3 to 5) g (5 to 20) g (20 to 30) g (30 to 50) g (50 to 100) g	0.05 mg 0.06 mg 0.24 mg 0.26 mg 0.27 mg 0.3 mg 0.4 mg 0.5 mg 0.6 mg 1 mg	Mettler AE240
	(100 to 200) g (200 to 500) g (500 to 1000) g 2 kg 3 kg 5 kg 10 kg 20 kg 26 kg 40 kg (0.25 to 0.5) lb (0.5 to 10) lb (10 to 25) lb (25 to 50) lb	13 mg 14 mg 16 mg 25 mg 34 mg 53 mg 110 mg 210 mg 270 mg 410 mg 0.1 mlb 0.001 lb 0.004 lb 0.006 lb	Mettler XP26003L w/class 3 weights w/class F weights

VI. Time & Frequency

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
Time Interval ³	1 s to 3 hr	0.059 s/day	Vibrograph TM 4500
Frequency – Measure ³	10 MHz	5 x 10 ⁻¹² Hz	Datum GPS
	10 Hz to 26.5 GHz	5 x 10 ⁻¹⁰ Hz	HP 5351B
Frequency – Measuring Equipment ³	10 MHz	5 x 10 ⁻¹² Hz	Austron GPS
	0.01 Hz to 20 MHz	5 x 10 ⁻¹⁰ Hz	HP 3325B
	20 MHz to 2 GHz	5 x 10 ⁻¹⁰ Hz	HP 8648C
	(2 to 26.5) GHz	5 x 10 ⁻¹⁰ Hz	HP 8340A
RPM – Measure ³	(100 to 25 000) RPM	0.1 %	HP 3325A w/Datum GPS

VI. Thermodynamics

Parameter/Equipment	Range	CMC ² (±)	Comments
Temperature – Measuring Equipment	(200 to 300) °C	0.27 °C	Hart 9100 drywell w/ 1502 and 5626 PRT
	(-26 to 200) °C	0.08 °C	VWR Scientific 1197 Bath w/ Hart 1502 and 5626 probe
Temperature – Measure	(-196 to 420) °C	0.05 °C	Hart 1502 w/ 5626 PRT
Relative Humidity – Measure	(5 to 95) % RH	0.61 % RH 1.2 % RH	General eastern optica Vaisala HMI41 w/HP46 probe

¹ This laboratory offers commercial and field calibration service.

² 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.

³ 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.

⁴ The measurands stated are generated with the Fluke 5000 and 8000 series instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMCs are expressed as either a specific value that covers the full range or as a combination of the percent or portion of the reading plus a fixed floor specification.

⁵ The measurands stated are generated with the Valhalla 2555A series instruments. This capability is suitable for the calibration of the devices intended to measure the stated measurand in the ranges indicated. CMCs are expressed as either a specific value that covers the full range or as a combination of the percent or portion of the reading plus a fixed floor specification

⁶ The measurands stated are measured with the HP 3458A. This capability is suitable for the calibration of the devices intended to generate the measurand in the ranges indicated. CMC is based upon one-year floor specifications and is read as output plus range. CMCs are expressed as either a specific value that covers the full range or as a combination of the percent or portion of the reading plus a fixed floor specification.

⁷ In the statement of CMC, L is the numerical value of the nominal length of the device measured in inches. In the statement of CMC, D is nominal diameter in inches. Γ refers to the magnitude of the reflection value being read.

⁸ In the statement of CMC, percentages are to be read as percent of reading, unless noted otherwise.



World Class Accreditation

The American Association for Laboratory Accreditation

Accredited Laboratory

A2LA has accredited

TEKTRONIX SERVICE SOLUTIONS

Addison, IL

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 28th day of September 2011.



A handwritten signature in black ink, reading "Peter Meyer".

President & CEO
For the Accreditation Council
Certificate Number 1623.07
Valid to June 30, 2013

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