The American Association for Laboratory Accreditation

World Class Accreditation

Accredited Laboratory

A2LA has accredited

SYPRIS TEST & MEASUREMENT - CALIBRATION DIVISION

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 11th day of August 2009.

President & CEO
For the Accreditation Council
Certificate Number 1623.07
Valid to June 30, 2011

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

SYPRIS TEST & MEASUREMENT – CALIBRATION DIVISION
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CALIBRATION

Valid To: June 30, 2011 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 calibrations[1]:

I. Chemical Quantities

Parameter/Equipment	Range	Best Uncertainty[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	Best Uncertainty[2, 7] (±)	Comments
Micrometers, Height Gages, and Depth Gages End Measuring Rods, Torque Wheels[3]	(0 to 60) in	(77 + 1.6*L*) µin	Grade 1 gage blocks
Rulers, Straightedges and Tape Measures[3]	(0 to 50) ft	0.009 in	Gage blocks

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Parameter/Equipment	Range	Best Uncertainty[2, 7, 8] (±)	Comments
Surface Flatness[3]	(0 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]	(0 to 10) in	420 μin	Optical comparator w/software
Steel Balls[3]	(0 to 8) in diameter	(14 + 1.6*L*) μin	SIP machine w/ grade 1 gage blocks
Optical Comparators[3] – Up to 36 in			
Angles	(0 to 360)º	37 ”	15, 30, 45 Degree angle blocks
Length	(0 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]	(0 to 24) in	10 μin	Federal 432 w/ head and gage blocks
V-block[3]	(0 to 24) in	10 μin	Federal 432 w/ head and gage blocks
Thickness (Feeler) Gage[3]	(0 to 2) in	(14 + 1.6*L*) μin	SIP machine
Cylindrical Pins, Plugs & Rings[3]	(0 to 8) in	(39 + 1.6*L*) μin	SIP and gage blocks
Threaded Plugs[3] –			
Pitch Diameter	(0 to 8) in	(39 + 1.6*L*) μin	SIP and gage blocks

Parameter/Equipment	Range	Best Uncertainty[2, 7] (±)	Comments
Thread Wires[3]	(4 to 96) TPI	(39 + 1.6*L*) µin	SIP and gage blocks
Indicators[3]	(0 to 2) in	(77 + 1.6*L*) µin	Grade 1 gage blocks
Calipers[3]	(0 to 60) in	(70 + 1.6*L*) µin	Grade 1 gage blocks
Protractors & Levels[3]	0.25° to 160°	1800 ”	Sine plate and gage blocks
Inclinometer	0° to 45°	0.42”	Sine plate and gage blocks
Pitch Gages[3]	(0 to 120) TPI	(230 + 10*D*) µin	Optical comparator
Radius Gages[3]	(0 to 3) in	420 µin	Optical comparator
Angle[3]	0° to 360° 15°, 30°, 45°	3.6 ” 2.1 ”	Optical comparator 15°, 30°, 45° angle blocks
Squareness[3] (squares)	18 in	71 µin	Master squares
Surface Parallelism[3]	(0 to 24) in	10 µin	Federal 432 w/ head and gage blocks

III. Electrical – DC/Low Frequency

Parameter/Equipment	Range	Best Uncertainty[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 (1.1 to 75) kV	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 0.24 %	Fluke 5700A w/ 5725A Hallmark divider w/ Glassman kV supply
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 (11 to 20.5) A (20.5 to 100) A (0 to 240) A (0 to 875) A (0 to 550) 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 0.1 % + 0.75 mA 0.04 % + 0.03 A 0.16 % 0.16 % 0.3 % + 0.5 A	Fluke 5700A/5725A Fluke 5520A Valhalla 2555A HP 6682A HP 6680A 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	Best Uncertainty[2, 4, 8] (±)	Comments
DC Resistance – Generate[3]	(0 to 11) Ω	70 μΩ/Ω + 1 mΩ	Fluke 5520A
	(11 to 33) Ω	30 μΩ/Ω + 1.5 mΩ	
	(33 to 110) Ω	28 μΩ/Ω + 1.4 mΩ	
	(0.11 to 1.1) kΩ	28 μΩ/Ω + 2 mΩ	
	(1.1 to 11) kΩ	28 μΩ/Ω + 20 mΩ	
	(11 to 110) kΩ	28 μΩ/Ω + 0.2 Ω	
	(0.11 to 1.1) MΩ	32 μΩ/Ω + 2 Ω	
	(1.1 to 3.3) MΩ	60 μΩ/Ω + 30 Ω	
	(3.3 to 11) MΩ	0.015 % + 50 Ω	
	(11 to 33) MΩ	0.025 % + 2.5 kΩ	
	(33 to 110) MΩ	0.05 % + 3 kΩ	
	(110 to 330) MΩ	0.3 % + 100 kΩ	
	(330 to 1100) MΩ	1.5 % + 500 kΩ	
	(100) MΩ	0.026 %	Fluke 5450
Fixed Points	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 kΩ	13 parts in 10^6	
	1.9 kΩ	13 parts in 10^6	
	10 kΩ	12 parts in 10^6	
	19 kΩ	12 parts in 10^6	
	100 kΩ	14 parts in 10^6	
	190 kΩ	14 parts in 10^6	
	1 MΩ	20 parts in 10^6	
	1.9 MΩ	21 parts in 10^6	
	10 MΩ	40 parts in 10^6	
	19 MΩ	47 parts in 10^6	
	100 MΩ	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 KΩ	7.3 parts in 10^6	
	10 KΩ	5 parts in 10^6	
	100 KΩ	7.4 parts in 10^6	
	1 MΩ	9.7 parts in 10^6	
	10 MΩ	14 parts in 10^6	

Parameter/Equipment	Range	Best Uncertainty[2, 4, 8] (±)	Comments
DC Current – Measure[3]	(0 to 200) μA (0.2 to 20) mA (2 to 20) mA (20 to 200) mA (0.2 to 2) A (2 to 20) A	16 μA/A + 0.4 pA 16 μA/A + 4 nA 17 μA/A + 40 nA 49 μA/A + 0.8 μA 0.019 % + 16 μA 0.04 % + 400 μA	Fluke 8508A
	(10 to 100) A	0.05 %	w/ L&N 4361
	(100 to 1500) A	0.29 %	w/ Ram meter 2500A shunt
	(1500 to 3K) A	0.29 %	w/ Empro 3000-300 shunt
DC Voltage – Measure[3]	(0 to 200) mV (0.2 to 2) V (2 to 20) V (20 to 200) V (200 to 1050) V	5.2 μV/V + 0.1 μV 3.7 μV/V + 0.4 μV 3.7 μV/V + 4 μV 5.7 μV/V + 40 μV 5.7 μV/V + 500 μV	Fluke 8508A
	(1.1 to 75) kV	0.14 % of rdg	Hallmark kV divider
DC Resistance – Measure[3]	(0 to 2) Ω (2 to 20) Ω (20 to 200) Ω (0.2 to 2) kΩ (2 to 20) kΩ (20 to 200) kΩ (0.2 to 2) MΩ (2 to 20) MΩ (20 to 200) MΩ (0.2 to 2) GΩ	17 μΩ/Ω + 4 μΩ 10 μΩ/Ω + 14 μΩ 8 μΩ/Ω + 50 μΩ 8 μΩ/Ω + 0.5 mΩ 8 μΩ/Ω + 5 mΩ 9 μΩ/Ω + 50 mΩ 11 μΩ/Ω + 1 Ω 26 μΩ/Ω + 100 Ω 0.012 % + 10 kΩ 0.15 % + 1 MΩ	Fluke 8508A
Fixed Points	10 MΩ 100 MΩ 1 GΩ 10 GΩ 100 GΩ 1 TΩ 10 TΩ 100TΩ	0.35 parts in 10^6 0.03 parts in 10^6 0.05 parts in 10^6 0.09 parts in 10^6 0.11 parts in 10^6 0.17 parts in 10^6 0.33 parts in 10^6 0.58 parts in 10^6	Guildline 9520

Parameter/Range	Frequency	Best Uncertainty[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 0.085 % + 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	Best Uncertainty[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 80 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 90 µV/V + 4 mV 0.017 % + 6 mV 0.06 % + 11 mV	
(220 to 750) V	30 Hz to 50 kHz (50 to 100) kHz	0.06 % + 11 mV 0.23 % + 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	Best Uncertainty[2, 4, 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	Best Uncertainty[2, 4, 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 + 0.012*f*) %	Fluke A40 shunts HP 3458A, Voltech 2555A, Fluke 5790A Fluke Y5020 (*f*=Frequency in kHz)

Parameter/Range	Frequency	Best Uncertainty[2, 4, 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 % 0.23 % 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	0.09 % 0.11 % 0.28 % 0.41 %	
10 kΩ	DC to 1 MHz	0.09 %	
100 kΩ	DC to 1 MHz	0.09 %	
Distortion – Measure			
(0 to 99.9) dB			HP 8903B
20 Hz to 20 kHz (20 to 100) kHz	(50 to 500) kHz (50 to 500) kHz	1.2 dB 2.3 dB	
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
Capacitance – Measure			
1 uF to 1 mF	10 Hz to 1 MHz	0.05 %	Quadtech 7400
Inductance – Measure			
100 uH to 10 H	10 Hz to 1 MHz	0.05 %	Quadtech 7400

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

Parameter/Range	Frequency	Best Uncertainty[2, 4, 8] (±)	Comments
Capacitance – Generate[3] (cont.)			HP 1638XX standard capacitor
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 %	
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	Best Uncertainty[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	0.014 % + 20 mV + (0.0004)(reading-300)^2 µV/V	
	(0.04 to 10) kHz	0.013 % + 20 mV + (0.0004)(reading-300)^2 µV/V	
(300 to 1050) V	(10 to 30) kHz	0.023 % + 40 mV + (0.0004 + (Frequency-10000)(10^{-7})) (reading-300)^2 µV/V	
	(30 to 100) kHz	0.061 % + 200 mV + (0.0024)(reading-300)^2 µV/V	
(0 to 2.2) mV	(500K to 1.2M) Hz (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	(500K to 1.2M) Hz (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	Best Uncertainty[2, 4, 8] (±)	Comments
AC Voltage[3] – Measure (cont.)			
(7 to 22) mV	500K 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	500K 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	500K 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	500K 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	500K 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	500K 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	Best Uncertainty[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	Weston 327 Type 2
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 V 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	Best Uncertainty[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	Best Uncertainty[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	0.44 °C 0.34 °C 0.3 °C 0.33 °C	Fluke 5520A
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000C to 1800) °C (1800 to 2316) °C	0.3 °C 0.26 °C 0.31 °C 0.5 °C 0.84 °C	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Electrical Calibration of Thermocouple Indicators (cont) –			
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.5 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °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	0.27 °C 0.16 °C 0.14 °C 0.17 °C 0.23 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.33 °C 0.18 °C 0.16 °C 0.26 °C 0.4 °C	
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.4 °C 0.22 °C 0.19 °C 0.18 °C 0.28 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.57 °C 0.35 °C 0.33 °C 0.4 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.47 °C 0.36 °C 0.37 °C 0.46 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.63 °C 0.24 °C 0.16 °C 0.14 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.56 °C 0.27 °C	

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Electrical Calibration of RTDs[3]			
Pt 385, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C	0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.1 °C 0.12 °C 0.23 °C	Fluke 5520A
Pt 3926, 100 Ω	(-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C	0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.1 °C 0.12 °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	0.25 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.08 °C 0.09 °C 0.1 °C 0.23 °C	
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	0.04 °C 0.05 °C 0.12 °C 0.13 °C 0.14 °C 0.16 °C	
Pt 385, 500 Ω	(-200 to -80) °C (-80 to 100) °C (100 to 260) °C (260 to 400) °C (400 to 600) °C (600 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 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C	0.03 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.23 °C	

Parameter/Equipment	Range	Best Uncertainty[2, 4, 8] (±)	Comments

Electrical Calibration of RTDs[3] (cont.) –			
PtNi 385, 120 Ω	(-80 to 100) °C (100 to 260) °C	0.08 °C 0.14 °C	Fluke 5520A
Cu 427, 10 Ω	(-100 to 260) °C	0.3 °C	
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	Best Uncertainty[2] (±)	Comments
RF Attenuation Tuned RF Power – Measure[3]			
(-0.0 to -1) dB	100 kHz to 26.5 GHz	0.008 dB	HP 8902A
(-1 to -10) dB		0.023 dB	HP 11722A
(-10 to -20) dB		0.052 dB	HP 11792A
(-20 to -30) dB		0.073 dB	HP 11793A
(-30 to -40) dB		0.11 dB	
(-40 to -50) dB		0.13 dB	
(-50 to -60) dB		0.15 dB	
(-60 to -70) dB		0.19 dB	
(-70 to -80) dB		0.22 dB	
(-80 to -90) dB		0.24 dB	
(-90 to -100) dB		0.26 dB	
(-100 to -110) dB		0.31 dB	
(-110 to -120) dB		0.37 dB	

Parameter/Range	Frequency	Best Uncertainty[2](±)	Comments
RF Power – Measure[3]			
(+30 to -20) dBm	100 kHz to 2.6 GHz	2.9 % of rdg	HP 8902A w/ 11722A
(-70 to +20) dBm	(2.6 to 26.5) GHz	2.9 % of rdg	HP 438A w/ 8485A
RF Power – Generate[3]			
(+23.98 to -56.02) dBm	0.01 Hz to 20 MHz	0.5 dB	HP 3325A
(+10 to -127) dBm	20 MHz to 2 GHz	1.3 dB	HP 8648C
(+10 to -30) dBm	(2 to 6.6) GHz	0.2 dB	
(-30 to -60) dBm		0.2 dB	
(-60 to -70) dBm		0.2 dB	
(-70 to -80) dBm		0.2 dB	
(-80 to -90) dBm		0.2 dB	
(-90 to -100) dBm			
(+10 to -30) dBm	(6.6 to 12.3) GHz	0.2 dB	
(-30 to -60) dBm		0.2 dB	
(-60 to -70) dBm		0.2 dB	
(-70 to -80) dBm		0.2 dB	
(-80 to -90) dBm		0.2 dB	
(-90 to -100) dBm			
(+10 to -30) dBm	(12.3 to 18.6) GHz	0.2 dB	
(-30 to -60) dBm		0.2 dB	
(-60 to -70) dBm		0.2 dB	
(-70 to -80) dBm		0.2 dB	
(-80 to -90) dBm		0.2 dB	
(-90 to -100) dBm		0.2 dB	
Phase Noise – Measure[3]	Up to 18 GHz @ Offset of:		Agilent 8563E and 8663A
	≤ 1 Hz ≤ -54 d	2.4 dBc	
	≤ 10 Hz ≤ -84 dBc	2.4 dBc	
	≤ 100 Hz ≤ -104 dBc	2.4 dBc	
	≤ 1 kHz ≤ -121 dBc	2.4 dBc	
	≤ 3 kHz ≤ -121 dB	2.4 dBc	
	≤ 5 kHz ≤ -129 dBc	2.4 dBc	
	≤ 10 kHz ≤ -145 dBc	2.4 dBc	
	≤ 100 kHz ≤ -157 dBc	2.4 dBc	

Parameter/Range	Frequency	Best Uncertainty[2, 7, 8] (±)	Comments
Amplitude Modulation – Generate[3]			
Rate: 50 Hz to 100 kHz Depths: 5 % to 99 %	(11 to 13.5) MHz	0.12 %	HP 11715A
Phase Modulation – Measure[3]			
Rate: (0.2 to 10) kHz	(0.15 to 10) MHz	4 % + 1 digit	HP 8902A
Rate: (0.2 to 20) kHz	10 MHz to 1.3 GHz (1.3 to 26.5) GHz	3 % + 1 digit 4 % + 1 digit	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	0.013Γ 0.018Γ 0.038Γ 0.069Γ	Wiltron 60N50 w/ Agilent 8902A w/ 11722A
0.0 < Γ> 0.2 0.5 < Γ> 0.8 0.5 <Γ > 0.8	(0.045 to 18) GHz (18 to 20) GHz (20 to 26.5) GHz	0.0058Γ 0.014Γ 0.025Γ	Agilent 8510C
Digital Modulation – Measure[3]			
Carrier: 2 MHz to 26.5 GHz			Agilent 89441A
Error vector magnitude for Modulation types: MSK, GMSK, BPSK, DQPSK, π/4DQPSK, 8PSK, 16QAM, and 32QAM	Mod Freq Span (.001 to 100) KHz (0.1 to 1) MHz (1 to 2650) MHz	0.22º 0.45º 0.73º	

Parameter/Range	Frequency	Best Uncertainty[2, 8] (±)	Comments
Digital Modulation – Measure[3] (cont)			
Error vector magnitude for FSK modulation	Mod Freq 3.2 KHz 1.152 KHz	 0.68 % 2.1 %	Agilent 89441A
Phase error for FSK Modulation	Mod Freq 3.2 KHz 1.152 KHz	 17 Hz 3.4 Hz	
Error vector magnitude for Modulation types: QPSK and OQPSK	Mod Freq 2.6MHz	 1.2 %	
Phase error for modulation Types: QPSK and OQPSK	Mod Freq 2.6MHz	 0.69º	
Carrier: 2 MHz to 26.5 GHz			Agilent 89441A
Error vector magnitude for Modulation types: MSK, GMSK, BPSK, DQPSK, π/4DQPSK, 8PSK, 16QAM, and 32QAM	Mod Freq Span (.001 to 100) KHz (0.1 to 1) MHz (1 to 2650) MHz	0.36 % 0.59 % 1.2 %	
Power Sensor Calibration – Calibration Factor[3]			
HP 8481A, 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	Best Uncertainty[2, 8] (±)	Comments
Power Sensor Calibration – Calibration Factor[3] (cont)			
HP 8481A, B, H	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, 18) GHz	0.52 % 0.66 % 0.54 % 0.76 % 0.69 % 0.59 % 0.64 % 0.67 % 0.74 % 0.85 % 0.6 % 0.86 % 0.73 % 0.64 % 0.8 % 0.85 % 0.97 %	HP 8481A with Gold Cal and HP8340A, HP438A, HP3325B
HP 8482A, B, H	0.1 MHz 0.3, 0.5, 1 MHz 3, 5, 10 MHz 30 MHz 50 MHz 100 MHz 300 MHz 500 MHz 1 GHz 1.5 GHz 2 GHz 2.5 GHz 3 GHz 3.5 GHz 4 GHz 4.2 GHz	0.45 % 0.48 % 0.6 % 0.69 % 0.67 % 0.7 % 0.51 % 0.52 % 0.6 % 0.56 % 0.55 % 0.52 % 0.53 % 0.61 % 0.59 % 0.66 %	
HP 8484A/8481D	10 MHz 30 MHz 50 MHz 100 MHz 300 MHz 500 MHz	2.1 % 1.6 % 1.6 % 1.4 % 1.5 % 1.4 %	

Parameter/Range	Frequency	Best Uncertainty[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
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	1.5 % + 1 digit	
Rate: 20 Hz to 100 kHz Depths: to 99 %	(1.3 to 26.5) GHz	3 % + 1 digit	

Parameter/Range	Frequency	Best Uncertainty[2, 8] (±)	Comments
Phase Modulation – Generate[3]			
Rate: 20 Hz to 10 kHz Carrier: 20 Hz to 249 MHz Phase: (0 to 10) rad	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	HP 8648C
Carrier: (249 to 501) MHz Phase: (0 to 5) rad	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	
Carrier: (501 to 1001) MHz Phase: (0 to 10) rad	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	
Carrier: (1.001 to 2.001) GHz Phase: (0 to 20) rad	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	
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	3.5 % + 0.05 rad 3.5 % + 0.1 rad 3.5 % + 0.2 rad	
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	5 % + 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	5 % + 1 digit	

Parameter/Range	Frequency	Best Uncertainty[2, 7, 8] (±)	Comments
Frequency Modulation – Generate[3]			
Rate: 20 Hz to 200 kHz Dev.: ≤ 12.5 kHz peak	(11 to 13.5) MHz	0.1 %	HP 11715A
Rate: 20 Hz to 200 kHz Dev.: ≤ 100 kHz peak	(88 to 108) MHz	0.1 %	
Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	(352 to 432) MHz	0.25 %	
Reflection Magnitude[3] (Into 50 Ω)			
$0 < \Gamma \leq 0.2$	300 kHz to 3 GHz (3 to 6) GHz	0.003 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	0.006 Γ 0.012 Γ	
$0.4 < \Gamma \leq 0.6$	300 kHz to 3 GHz (3 to 6) GHz	0.009 Γ 0.016 Γ	
$0.6 < \Gamma \leq 0.8$	300 kHz to 3 GHz (3 to 6) GHz	0.011 Γ 0.018 Γ	
$0.8 < \Gamma \leq 1$	300 kHz to 3 GHz (3 to 6) GHz	0.013 Γ 0.022 Γ	
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 (-60 to -70) dB	300 kHz to 6 GHz	1.2° 0.4° 0.5° 0.61° 0.72° 1° 2.5° 6°	HP 8753E w/ 7 mm connector

Parameter/Range	Frequency	Best Uncertainty[2, 7] (±)	Comments
Transmission Magnitude[3] (Into 50 Ω)			
(10 to 0) dB	300 kHz to 3 GHz	0.06 dB	HP 8753E w/ 7 mm connector
(0 to -10) dB		0.04 dB	
(-10 to -20) dB		0.05 dB	
(-20 to -30) dB		0.06 dB	
(-30 to -40) dB		0.1 dB	
(-40 to -50) dB		0.12 dB	
(-50 to -60) dB		0.29 dB	
(-60 to -70) dB		0.81 dB	
(10 to 0) dB	(3 to 6) GHz	0.12 dB	
(0 to -10) dB		0.06 dB	
(-10 to -20) dB		0.08 dB	
(-20 to -30) dB		0.09 dB	
(-30 to -40) dB		0.12 dB	
(-40 to -50) dB		0.23 dB	
(-50 to -60) dB		0.48 dB	
(-60 to -70) dB		1.8 dB	
Reflection Phase[3] (Into 50 Ω, 0° to 360°)			
$0.2 < \Gamma \leq 0.4$	300 kHz to 3 GHz	1.5°	HP 8753E w/ 7 mm connector
	(3 to 6) GHz	2.3°	
$0.2 < \Gamma \leq 0.4$	300 kHz to 3 GHz	0.95°	
	(3 to 6) GHz	1.8°	

V. Mechanical

Parameter/Equipment	Range	Best Uncertainty[2, 8] (±)	Comments
Force Gauges – Compression and Tension Test, Dynomometer[3]	(0.25 to 250) lbf	0.1 %	Class F weights

Parameter/Equipment	Range	Best Uncertainty[2, 8] (±)	Comments
Torque – Measuring Equipment[3]			Class F weights w/
	(2 to 40) in·oz	0.12 %	2.5 in wheel
	40 in·oz to 50 in·lb	0.12 %	5 in wheel
	50 in·lb to 250 ft·lb	0.12 %	10 in wheel
	(250 to 600) ft·lb	0.12%	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	0.32 % 0.32 % 0.32 % 0.32 %	CDI 950-DT w/ TTPM-41
	(250 to 600) ft·lb	0.33%	CDI 6004-F-TTP
Pressure[3]	(0 to 3000) psig	1.8 psig	Eaton UPC 5000
	(3000 to 10 000) psig	0.12 %	Omega DWT 1305D
	(0 to 50) psi (0 to 5) psi	0.041% of Span 0.041% of Span	Heise PTE-1 w/HSQ-1
	(0 to 60) psi (0 to 10) psi (0 to 200) psi	0.041% of Span 0.041% of Span 0.041% of Span	Heise PTE-1 w/HSQ-2
Scales & Balances[3]	(1 to10) 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

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Scales & Balances[3] (cont)	(0.25 to 0.5) lbs (0.5 to 10) lbs (10 to 25) lbs (25 to 50) lbs (50 to 100) lbs (100 to 500) lbs	0.0001 lb 0.001 lb 0.004 lb 0.006 lb 0.014 lb 0.052 lb	Class F weights
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
Mass[3]	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 (1 to 2) lb 5 lb 10 lb (20 to 25) lb 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 0.3 mlb 0.6 mlb 1 mlb 3.5 mlb 5.6 mlb	Mettler XP26003L w/ Class 3 weights w/ class F weights

VI. Time & Frequency

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Time Interval[3]	1 s to 3 hr	0.059 s/day	Vibrograph TM 4500
Frequency – Measure[3]	10 MHz 10 Hz to 26.5 GHz	5×10^{-12} Hz 5×10^{-10} Hz	Datum GPS HP 5351B

Parameter/Equipment	Range	Best Uncertainty[2, 8] (±)	Comments
Frequency – Measuring Equipment[3]	10 MHz 0.01 Hz to 20 MHz 20 MHz to 2 GHz (2 to 26.5) GHz	5×10^{-12} Hz 5×10^{-10} Hz 5×10^{-10} Hz 5×10^{-10} Hz	Austron GPS HP 3325B HP 8648C HP 8340A
RPM – Measure[3]	(100 to 25 000) RPM	0.1%	HP 3325A w/Datum GPS

VI. Thermodynamics

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Temperature –Measuring Equipment	(-5 to 200) °C (200 to 300) °C (-26.1 to -1.1) °C	0.08 °C 0.27 °C 0.08 °C	Hart 7102 Bath w/Hart 1502 and 5626 PRT Hart 9100 drywell w/ 1502 and 5626 PRT VWR Scientific 1197 Bath w/ Hart 1502 and 5626 probe
Temperature – Measure	(-200 to 400) °C	0.07 °C	Hart 1502 w/ 5626 PRT
Relative Humidity – Measuring Equipment	(12, 33, 75) % RH	1.3 % RH	Salt solutions w/ Vaisala HMI41 w/ HP46Probe
Relative Humidity – Measure	(5 to 95) % RH	1.2 % RH	Vaisala HMI41 w/HP46 probe

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

[2] "Best Uncertainty" 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 of nearly ideal measuring equipment. Best uncertainties represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The best uncertainty of a specific calibration performed by the laboratory may be greater than the best uncertainty due to the behavior of the customer's device, to the environment 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 uncertainties achievable on a customer's site can normally be expected to be larger than the Best Measurement Capabilities (BMC) that the accredited laboratory has been assigned as Best Uncertainty 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 uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the calibration uncertainty being larger than the BMC.

[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. Best measurement uncertainties 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. Best measurement uncertainties 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. Best measurement uncertainty is based upon one-year floor specifications and is read as output plus range. Best measurement uncertainties 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 best uncertainty, *L* is the numerical value of the nominal length of the device measured in inches. In the best measurement uncertainty, D is nominal diameter in inches.Γ refers to the magnitude of the reflection value being read.

[8] In the statement of best uncertainty, percentages are to be read as percent of reading, unless noted otherwise.