



SCOPE OF ACCREDITATION TO ISO 17025:2005 & ANSI/NCSL Z540-1-1994 & ANSI/NCSL
Z540.3-2006

ACR TECHNICAL SERVICES, INC
710 Industrial Park Drive
Newport News, VA 23608
Richard Hogan Phone: 757 890 0460

CALIBRATION

Valid To: October 31, 2018

Certificate Number: 2171.01

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

I. Acoustics & Vibration

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
Vibration – Measuring Equipment (0.02 to 5000) pC/g (1 to 10 000) mV/g	(5 to 19) Hz	2.9 %	B&K 9610 w/ 4808
	(20 to 99) Hz	1.5 %	
	(0.1 to 1) kHz	1.5 %	
	(1 to 5) kHz	1.6 %	
	(5 to 10) kHz	2.6 %	
	100 Hz, 160 Hz	1.3 %	B&K 9610 w/ 4809

II. Chemical

Parameter/Equipment	Range	CMC ² (±)	Comments
pH Measuring Equipment	4.005 pH 6.989 pH 10.006 pH	0.02 pH 0.02 pH 0.02 pH	pH buffer solutions

Parameter/Equipment	Range	CMC ² (±)	Comments
Conductivity – Liquid	1.01 μS 9.55 μS 99.8 μS 999 μS 9 988 μS 99 799 μS	0.43 μS 0.56 μS 4.3 μS 29 μS 1.1 % of value 1.3 % of value	Conductivity solutions
Gas Detection Equipment – CO ₂	5 % 10 % 20 % 30 %	1.1 % of value 1.3 % of value 1.2 % of value 1.2 % of value	Standard gas
O ₂	5 % 15 % 19 % 21 %	1.1 % of value 1.2 % of value 1.2 % of value 1.2 % of value	
CO	0.01 %	1.1 % of value	
Propane (LEL)	25 %	2.5 % of value	

III. Dimensional

Parameter/Equipment	Range	CMC ^{2, 5} (±)	Comments
Dial Indicators ^{3, 7}	Up to 1 in	93 μin	Universal calibrator
Micrometers and Calipers ^{3, 7}	(0.05 to 4) in (4 to 20) in	(13 + 8.3L) μin (32 + 3.6L) μin	Gage blocks
Anvil and Spindle Flatness on Micrometers and Calipers ³	2 in diameter Convex Concave	5.4 μin 5.6 μin	Optical flat and monochromatic light
Crimpers	(0.011 to 0.06) in (0.06 to 0.25) in	(270 – 630D) μin (210 + 380D) μin	Pin gages

IV. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 4, 6} (±)	Comments
DC Voltage ³ – Generate	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1100) V	9.0 μV/V + 0.4 μV 5.2 μV/V + 0.7 μV 4.3 μV/V + 2.5 μV 4.3 μV/V + 4 μV 5.2 μV/V + 40 μV 7.3 μV/V + 400 μV	Fluke 5700A/EP with opt 3
	(1 to 10) kV	1.0 %	Fluke 80K40 and Agilent 3458A, opt 002
DC Voltage – Fixed Points	0.1 V 1 V 10 V 100 V 1000 V	7.5 μV/V 1.5 μV/V 0.91 μV/V 2.7 μV/V 4.2 μV/V	Fluke 732A & Fluke 752A
	10 V Fixed	0.52 μV/V	Fluke 732A
DC Voltage ³ – Measure	(0 to 100) mV (0.1 to 1) V (1 to 10) V (10 to 100) V (0.1 to 1) kV*	12 μV/V + 0.3 μV 4.5 μV/V + 0.3 μV 4.3 μV/V + 0.5 μV 4.7 μV/V + 30 μV 7.3 μV/V + 100 μV	Agilent 3458A, opt 002 ACAL (24hrs & ± 1°C); TCAL ± 5°C, & MATH NULL, *add 12 (V _{in} /1000) ² ppm
	(1 to 10) kV	1.0 %	Fluke 80K40 and Agilent 3458A, opt 002
DC Current ³ – Measure	100 nA to 1 μA (1 to 10) μA (10 to 100) μA 100 μA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	37 μA/A + 40 pA 23 μA/A + 40 pA 23 μA/A + 100 pA 23 μA/A + 800 pA 23 μA/A + 5 nA 23 μA/A + 50 nA 40 μA/A + 500 nA	Agilent 3458A, opt 002
	Ohm's Law Method	(10 to 100) nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA 100 μA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A (1 to 10) A (10 to 100) A	9.7 μA/A 8.9 μA/A 8.6 μA/A 7.9 μA/A 7.2 μA/A 7.0 μA/A 7.8 μA/A 8.4 μA/A 8.8 μA/A 18 μA/A

Parameter/Equipment	Range	CMC ^{2,4,6} (±)	Comments
DC Current ³ – 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	44 μ A/A + 6 nA 39 μ A/A + 7 nA 37 μ A/A + 40 nA 50 μ A/A + 0.7 μ A 93 μ A/A + 12 μ A	Fluke 5700A/EP
	(2.2 to 3) A	0.041 % + 6 μ A	Fluke 5520A SC600
	(2.2 to 11) A (11 to 20) A	0.03 % + 1 mA 0.034 % + 1 mA	Fluke 5700A/EP w/ Fluke 5220A SC600
	(0 to 100) A	0.046 % + 20 mA	Fluke 5700A/EP w/ Ballantine 1620A
Clamp-On Meters	(10 to 16.5) A (16.5 to 150) A (150 to 1025) A	0.3 % + 2 mA 0.27 % + 15 mA 0.29 % + 50 mA	Fluke 5700A/EP Fluke 5220A SC600 Fluke 5500A coil
Ohm's Law Method	(10 to 100) nA	9.7 μ A/A	Fluke 5700A/EP Agilent 3458A, opt 002 ESI SR1060 Guildline 9211A
	100 nA to 1 μ A	8.9 μ A/A	
	(1 to 10) μ A	8.6 μ A/A	
	(10 to 100) μ A	7.9 μ A/A	
	100 μ A to 1 mA	7.2 μ A/A	
	(1 to 10) mA	7.0 μ A/A	
	(10 to 100) mA	7.8 μ A/A	
	100 mA to 1 A	8.4 μ A/A	
	(1 to 10) A	8.8 μ A/A	
	(10 to 100) A	18 μ A/A	
Resistance ³ – Generate			
Fixed Values			
1 Ω steps	(0 to 10) Ω	5.7 $\mu\Omega/\Omega$	ESI 242D ESI SR-104U ESI SR-1060
10 Ω steps	(0 to 100) Ω	5.1 $\mu\Omega/\Omega$	
100 Ω steps	(0 to 1000) Ω	4.0 $\mu\Omega/\Omega$	
1 k Ω steps	(0 to 10) k Ω	2.0 $\mu\Omega/\Omega$	
10 k Ω steps	(0 to 100) k Ω	2.5 $\mu\Omega/\Omega$	
100 k Ω steps	(0 to 1) M Ω	4.3 $\mu\Omega/\Omega$	
1 M Ω steps	(0 to 10) M Ω	5.5 $\mu\Omega/\Omega$	ESI SR-1050
10 M Ω steps	(0 to 100) M Ω	6.0 $\mu\Omega/\Omega$	
100 M Ω steps	(0 to 1) G Ω	0.33 % - 0.21 M Ω	IET HRRS-B-4-1 M
1 G Ω steps	(0 to 10) G Ω	0.62 %	
Fixed Values			
10 k Ω Fixed	10 k Ω	1.2 $\mu\Omega/\Omega$	ESI SR-104U
1 Ω Fixed	1 Ω	1.6 $\mu\Omega/\Omega$	Leeds & Northrop 4020B

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Resistance ³ – Measure	(0 to 10) Ω (0 to 100) Ω (0 to 1000) Ω (0 to 10) kΩ (0 to 100) kΩ (0 to 1) MΩ (0 to 10) MΩ (0 to 100) MΩ (0 to 1) GΩ	19 μΩ/Ω + 50 μΩ 15 μΩ/Ω + 500 μΩ 13 μΩ/Ω + 500 μΩ 12 μΩ/Ω + 5 mΩ 12 μΩ/Ω + 50 mΩ 18 μΩ/Ω + 2 Ω 58 μΩ/Ω + 100 Ω 0.057 % + 1 kΩ 0.57 % + 10 kΩ	Agilent 3458A, opt 002

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage, Fixed Points –			
2 mV	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	0.04 % 0.033 % 0.032 % 0.031 % 0.031 % 0.031 % 0.032 % 0.043 % 0.054 % 0.063 % 0.13 %	Fluke 792A
6 mV	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	0.023 % 0.022 % 0.016 % 0.016 % 0.016 % 0.016 % 0.021 % 0.028 % 0.04 % 0.046 % 0.065 %	
20 mV	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	0.011 % 69 μV/V 66 μV/V 65 μV/V 65 μV/V 65 μV/V 93 μV/V 0.016 % 0.026 % 0.036 % 0.042 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage, Fixed Points – (cont)			
60 mV	10 Hz	0.011 %	Fluke 792A
	20 Hz	70 µV/V	
	100 Hz	50 µV/V	
	1 kHz	50 µV/V	
	10 kHz	50 µV/V	
	20 kHz	57 µV/V	
	50 kHz	77 µV/V	
	100 kHz	0.016 %	
	300 kHz	0.028 %	
	500 kHz	0.037 %	
	1 MHz	0.044 %	
200 mV	10 Hz	39 µV/V	
	20 Hz	27 µV/V	
	100 Hz	21 µV/V	
	1 kHz	21 µV/V	
	10 kHz	21 µV/V	
	20 kHz	22 µV/V	
	50 kHz	26 µV/V	
	100 kHz	44 µV/V	
	300 kHz	82 µV/V	
	500 kHz	0.012 %	
	1 MHz	0.019 %	
600 mV	10 Hz	30 µV/V	
	20 Hz	24 µV/V	
	100 Hz	14 µV/V	
	1 kHz	13 µV/V	
	10 kHz	13 µV/V	
	20 kHz	14 µV/V	
	50 kHz	14 µV/V	
	100 kHz	18 µV/V	
	300 kHz	36 µV/V	
	500 kHz	39 µV/V	
	1 MHz	71 µV/V	
2 V	10 Hz	30 µV/V	
	20 Hz	24 µV/V	
	100 Hz	12 µV/V	
	1 kHz	11 µV/V	
	10 kHz	11 µV/V	
	20 kHz	11 µV/V	
	50 kHz	11 µV/V	
	100 kHz	17 µV/V	
	300 kHz	28 µV/V	
	500 kHz	33 µV/V	
	1 MHz	50 µV/V	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage, Fixed Points – (cont)			
6 V	10 Hz	30 μV/V	Fluke 792A
	20 Hz	23 μV/V	
	100 Hz	12 μV/V	
	1 kHz	11 μV/V	
	10 kHz	11 μV/V	
	20 kHz	11 μV/V	
	50 kHz	12 μV/V	
	100 kHz	16 μV/V	
	300 kHz	28 μV/V	
	500 kHz	33 μV/V	
	1 MHz	50 μV/V	
	20 V	10 Hz	
20 Hz		23 μV/V	
100 Hz		13 μV/V	
1 kHz		13 μV/V	
10 kHz		13 μV/V	
20 kHz		13 μV/V	
50 kHz		13 μV/V	
100 kHz		19 μV/V	
300 kHz		29 μV/V	
500 kHz		35 μV/V	
1 MHz		50 μV/V	
60 V		10 Hz	28 μV/V
	20 Hz	23 μV/V	
	100 Hz	14 μV/V	
	1 kHz	13 μV/V	
	10 kHz	13 μV/V	
	20 kHz	13 μV/V	
	50 kHz	15 μV/V	
	100 kHz	20 μV/V	
	300 kHz	36 μV/V	
200 V	10 Hz	41 μV/V	Fluke 792A
	20 Hz	25 μV/V	
	100 Hz	15 μV/V	
	1 kHz	15 μV/V	
	10 kHz	15 μV/V	
	20 kHz	15 μV/V	
	50 kHz	21 μV/V	
	100 kHz	26 μV/V	
600 V	100 Hz	22 μV/V	Fluke 792A
	1 kHz	17 μV/V	
	10 kHz	19 μV/V	
	20 kHz	23 μV/V	
	50 kHz	45 μV/V	
	100 kHz	73 μV/V	
1000 V	100 Hz	23 μV/V	Fluke 792A
	1 kHz	22 μV/V	
	10 kHz	23 μV/V	
	20 kHz	24 μV/V	
	50 kHz	51 μV/V	
	100 kHz	76 μV/V	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage Flatness – Generate			
1 mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.062 % 0.038 % 0.038 % 0.038 % 0.046 % 0.05 % 0.05 % 0.071 % 0.23 % 0.74 %	Fluke 5700A/EP/03
3 mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.038 % 0.024 % 0.024 % 0.024 % 0.033 % 0.033 % 0.036 % 0.061 % 0.11 % 0.19 %	
10 mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.033 % 0.021 % 0.021 % 0.021 % 0.028 % 0.029 % 0.033 % 0.058 % 0.1 % 0.18 %	
30 mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.035 % 0.02 % 0.02 % 0.02 % 0.025 % 0.029 % 0.032 % 0.057 % 0.1 % 0.18 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage Flatness – Generate (cont)			
100 mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.035 % 0.02 % 0.02 % 0.02 % 0.025 % 0.029 % 0.032 % 0.057 % 0.1 % 0.18 %	Fluke 5700A/EP/03
300 mV	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.026 % 0.018 % 0.018 % 0.018 % 0.027 % 0.028 % 0.033 % 0.053 % 0.1 % 0.17 %	
1 V	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.031 % 0.017 % 0.016 % 0.015 % 0.022 % 0.026 % 0.03 % 0.055 % 0.1 % 0.17 %	
3 V	(10 to 30) Hz (30 to 120) Hz (0.12 to 1.2) kHz (1.2 to 120) kHz (120 to 500) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.036 % 0.015 % 0.015 % 0.015 % 0.021 % 0.028 % 0.031 % 0.055 % 0.1 % 0.17 %	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Voltage ³ – Generate			
(0.22 to 2.2) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 4 μV 90 μV/V + 4 μV 80 μV/V + 4 μV 0.02 % + 4 μV 0.05 % + 4 μV 0.11 % + 10 μV 0.14 % + 10 μV 0.27 % + 20 μV	Fluke 5700A/EP
(2.2 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 4 μV 90 μV/V + 4 μV 80 μV/V + 4 μV 0.02 % + 4 μV 0.05 % + 4 μV 0.11 % + 10 μV 0.14 % + 10 μV 0.27 % + 20 μV	
(22 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 4 μV 90 μV/V + 4 μV 80 μV/V + 4 μV 0.02 % + 4 μV 0.05 % + 4 μV 0.11 % + 10 μV 0.14 % + 10 μV 0.27 % + 20 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 500 kHz to 1 MHz	0.024 % + 40 μV 90 μV/V + 15 μV 50 μV/V + 8 μV 80 μV/V + 10 μV 0.011 % + 30 μV 0.042 % + 80 μV 0.1 % + 200 μV 0.17 % + 300 μV	

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
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AC Voltage ³ – Generate (cont)			
(2.2 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 0.4 mV 90 μ V/V + 0.15 mV 50 μ V/V + 0.05 mV 80 μ V/V + 0.1 mV 0.01 % + 0.2 mV 0.028 % + 0.6 mV 0.1 % + 2 mV 0.15 % + 3.2 mV	Fluke 5700A/EP
(22 to 220) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 0.4 mV 90 μ V/V + 0.15 mV 50 μ V/V + 0.05 mV 80 μ V/V + 0.1 mV 0.015 % + 0.2 mV 0.09 % + 0.6 mV 0.44 % + 2 mV 0.8 % + 3.2 mV	
(220 to 1100) V	(15 to 50) Hz 50 Hz to 1 kHz	0.03 % + 16 mV 0.007 % + 3.5 mV	
AC Voltage ³ – Measure			
Up to 2.2 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.17 % + 1.3 μ V 0.074 % + 1.3 μ V 0.042 % + 1.3 μ V 0.081 % + 2 μ V 0.12 % + 2.5 μ V 0.23 % + 4 μ V 0.24 % + 8 μ V 0.35 % + 8 μ V	Fluke 5790A opt.003 uncertainty of wideband is for flatness relative to 1 kHz
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.07 % + 1 μ V 0.17 % + 1 μ V 0.3 % + 1 μ V 0.7 % + 2 μ V	
(2.2 to 7) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.085 % + 1.3 μ V 0.037 % + 1.3 μ V 0.021 % + 1.3 μ V 0.04 % + 2 μ V 0.06 % + 2.5 μ V 0.12 % + 4 μ V 0.13 % + 8 μ V 0.23 % + 8 μ V	

Parameter/Range	Frequency	CMC ^{2,4,6} (\pm)	Comments
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AC Voltage ³ – Measure (cont)			
(2.2 to 7) mV			
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.07 % + 1 μ V 0.1 % + 1 μ V 0.17 % + 1 μ V 0.37 % + 1 μ V	Fluke 5790A opt.003 uncertainty of wideband is for flatness relative to 1 kHz
(7 to 22) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.029 % + 1.3 μ V 0.019 % + 1.3 μ V 0.011 % + 1.3 μ V 0.021 % + 2 μ V 0.031 % + 2.5 μ V 0.081 % + 4 μ V 0.089 % + 8 μ V 0.17 % + 8 μ V	
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.07 % 0.1 % 0.17 % 0.37 %	
(22 to 70) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.024 % + 1.5 μ V 0.012 % + 1.5 μ V 0.007 % + 1.5 μ V 0.013 % + 2 μ V 0.026 % + 2.5 μ V 0.051 % + 4 μ V 0.067 % + 8 μ V 0.11 % + 8 μ V	
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.05 % 0.1 % 0.15 % 0.35 %	
(70 to 220) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.021 % + 1.5 μ V 0.009 % + 1.5 μ V 0.004 % + 1.5 μ V 0.007 % + 2 μ V 0.016 % + 2.5 μ V 0.025 % + 4 μ V 0.038 % + 8 μ V 0.1 % + 8 μ V	
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.05 % 0.1 % 0.15 % 0.35 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (\pm)	Comments
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AC Voltage ³ – Measure (cont)			
(220 to 700) mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.02 % + 1.5 μ V 70 μ V/V + 1.5 μ V 20 μ V/V + 1.5 μ V 50 μ V/V + 2 μ V 70 μ V/V + 2.5 μ V 0.016 % + 4 μ V 0.026 % + 8 μ V 0.09 % + 8 μ V	Fluke 5790A opt.003 uncertainty of wideband is for flatness relative to 1 kHz
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.05 % 0.1 % 0.15 % 0.35 %	
700 mV to 2.2 V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.021 % 80 μ V/V 30 μ V/V 50 μ V/V 80 μ V/V 0.018 % 0.03 % 0.1 %	
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.05 % 0.1 % 0.15 % 0.35 %	
(2.2 to 7) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.02 % 70 μ V/V 20 μ V/V 50 μ V/V 70 μ V/V 0.016 % 0.026 % 0.09 %	
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.05 % 0.1 % 0.15 % 0.35 %	
(7 to 22) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.02 % 70 μ V/V 20 μ V/V 50 μ V/V 80 μ V/V 0.019 % 0.04 % 0.12 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage ³ – Measure (cont)			
(22 to 70) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	0.02 % 70 μV/V 30 μV/V 50 μV/V 90 μV/V 0.02 % 0.041 % 0.12 %	Fluke 5790A opt.003 uncertainty of wideband is for flatness relative to 1 kHz
(70 to 220) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz	0.02 % 70 μV/V 30 μV/V 70 μV/V 0.01 % 0.021 % 0.05 %	
(220 to 700) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.02 % 0.01 % 40 μV/V 0.013 % 0.05 %	
(700 to 1000) V	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.02 % 0.01 % 0.004 % 0.013 % 0.05 %	
(0 to 10) mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.03 % + 3 μV 0.02 % + 1.1 μV 0.03 % + 1.1 μV 0.1 % + 1.1 μV 0.5 % + 1.1 μV 4 % + 2 μV 1.2 % + 5 μV	
(10 to 100) mV	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	70 μV/V + 4 μV 70 μV/V + 2 μV 0.014 % + 2 μV 0.03 % + 2 μV 0.08 % + 2 μV 0.3 % + 10 μV 1 % + 10 μV	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage ³ – Measure (cont)			
(0.1 to 10) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	70 μV/V + 0.4 mV 70 μV/V + 0.2 mV 0.014 % + 0.2 mV 0.03 % + 0.2 mV 0.08 % + 0.2 mV 0.3 % + 1 mV 1 % + 1 mV	Agilent 3458A, opt 002 *synchronous sub-sampled mode
(10 to 100) V	(1 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (0.3 to 1) MHz	0.02 % + 4 mV 0.02 % + 2 mV 0.035 % + 2 mV 0.12 % + 2 mV 0.4 % + 10 mV 1.5 % + 10 mV	
(100 to 1000) V	(1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.04 % + 40 mV 0.04 % + 20 mV 0.06 % + 20 mV 0.12 % + 20 mV 0.3 % + 20 mV	
(0 to 40) kV _{p-p} (0 to 28) kV _{rms}	60 Hz 60 Hz	5 % 5 %	Fluke 80K-40
AC Voltage Ratio ³ – Measure			
(0.0 to 0.1) V	(50 to 400) Hz (0.4 to 1) kHz (1 to 3) kHz (3 to 5) kHz (5 to 10) kHz	7.4 μV/V 7.8 μV/V 13 μV/V 13 μV/V 29 μV/V	DT72A w/ Fluke 5520A

Parameter/Range	Frequency	CMC ^{2,4} (±)	Comments
AC Current ³ – Generate			
(0 to 220) µA	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.025 % + 16 nA 0.016 % + 10 nA 0.012 % + 8 nA 0.028 % + 12 nA 0.11 % + 65 nA	Fluke 5700A/EP
(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	0.025 % + 40 nA 0.016 % + 35 nA 0.012 % + 35 nA 0.02 % + 110 nA 0.11 % + 650 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	0.025 % + 400 nA 0.016 % + 350 nA 0.012 % + 350 nA 0.02 % + 550 nA 0.11 % + 5 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	0.025 % + 4 µA 0.016 % + 3.5 µA 0.012 % + 2.5 µA 0.02 % + 3.5 µA 0.11 % + 10 µA	
(0.22 to 2.2) A	10 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.026 % + 35 µA 0.045 % + 80 µA 0.7 % + 160 µA	
(29 to 330) µA (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA (1.1 to 3) A	(10 to 30) kHz (10 to 30) kHz (10 to 30) kHz (10 to 30) kHz (5 to 10) kHz	1.6 % + 0.4 µA 1 % + 0.6 µA 0.4 % + 4 µA 0.4 % + 200 µA 2.5 % + 5 mA	Fluke 5520A SC600
(2.2 to 22) A	(10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz*	0.055 % + 1 mA 0.051 % + 1 mA 0.05 % + 1 mA 0.05 % + 1 mA	Fluke 5700A/EP Fluke 5520A SC600 *multiply by f in kHz

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Current ³ – Generate (cont)			
Clamp-On Meters			
(10 to 16.5) A	(45 to 65) Hz (65 to 440) Hz	0.33 % + 0.025 A 0.82 % + 0.027 A	Fluke 5700A/EP Fluke 5220A SC600 Fluke 5500A coil
(16.5 to 150) A	(45 to 65) Hz (65 to 440) Hz	0.3 % + 0.025 A 0.78 % + 0.027 A	
(150 to 1025) A	(45 to 65) Hz (65 to 440) Hz	0.4 % + 0.025 A 0.87 % + 0.027 A	
AC Current ³ – Measure			
(0 to 100) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 5 kHz	0.4 % + 30 nA 0.15 % + 30 nA 0.06 % + 30 nA	Agilent 3458A opt. 002
(0.1 to 1) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz (0.1 to 5) kHz	0.4 % + 0.2 µA 0.15 % + 0.2 µA 0.06 % + 0.2 µA 0.03 % + 0.2 µA	
(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	0.4 % + 20 µA 0.15 % + 20 µA 0.06 % + 20 µA 0.03 % + 20 µA 0.06 % + 20 µA 0.4 % + 40 µA 0.6 % + 150 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	0.4 % + 0.2 mA 0.16 % + 0.2 mA 0.08 % + 0.2 mA 0.1 % + 0.2 mA 0.3 % + 0.2 mA 1 % + 0.4 mA	
(0 to 550) µA	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.02 % 0.008 % 0.005 %	Fluke 5790A w/ A40
550 µA to 5.5 mA	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.02 % 0.008 % 0.005 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Current ³ – Measure (cont)			
(5.5 to 22) mA	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.02 % 0.008 % 0.005 %	Fluke 5790A w/ A40
(22 to 550) mA	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.02 % 0.008 % 0.005 %	
550 mA to 2.2 A	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.02 % 0.009 % 0.008 %	
(2.2 to 11) A	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.022 % 0.013 % 0.021 %	
(11 to 20) A	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.038 % 0.034 % 0.034 %	
Inductance ³ – Measure			
0.01 µH to 4.1 H	(12 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.049 % 0.029 % 0.059 % 0.23 %	GenRad 1693 Digibridge *Slow measure rate, averaging, open/short
(4.1 to 99 999) H	(12 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz	0.049 % 0.029 % 0.21 %	
Inductance ³ – Generate			
100 mH fixed	100 Hz 1 kHz	0.023 % 0.023 %	General ratio 1482-L
Capacitance ³ – Measure			
0.00001 pF to 6.4 nF	(12 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz	0.049 % 0.029 % 0.21 %	GenRad 1693 Digibridge *slow measure rate, averaging, open/short

Parameter/Range	Frequency	CMC ^{2, 4, 6} (±)	Comments
Phase ³ – Measure (cont) (0 to 360)°			
1:1 Resistive	1 Hz to 1 kHz (1 to 50) kHz	0.002° 0.003°	Clarke-Hess 5002 Agilent 3458A opt. 002
1:1 Capacitive	(1 to 50) kHz (50 to 200) kHz	0.003° 0.009°	
10:1 Capacitive	(1 to 50) kHz (50 to 200) kHz	0.003° 0.009°	
100:1 Capacitive	(1 to 50) kHz (50 to 200) kHz	0.003° 0.009°	
Distortion ³ – Measure			
0.3 to 100 % < 30 V	10 Hz to 1 MHz (1 to 3) MHz	3 % of full scale 7.1 % of full scale	HP 334A
(30 to 300) V	10 Hz to 300 kHz (300 to 500) kHz (0.5 to 3) MHz	3 % of full scale 7.1 % of full scale 13 % of full scale	
0.1 % < 30 V	(10 to 20) Hz (20 to 30) Hz 30 Hz to 300 kHz (300 to 500) kHz (0.5 to 1.2) MHz	13 % of full scale 7.1 % of full scale 3 % of full scale 7.1 % of full scale 13 % of full scale	
0.001 % to 100 % 50 mV to 300 V	20 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.3 dB	Agilent 8903B
Sine Wave Flatness ³ – Measure	1 MHz 10 MHz 20 MHz 50 MHz 100 MHz	0.087 % 0.14 % 0.19 % 0.58 % 1.3 %	Precision Measurements EL 1200

Parameter/Range	Frequency	CMC ^{2, 4, 6} (±)	Comments
Oscilloscopes ³ –			
Square Wave Signal			
10 Hz to 10 kHz			
50 Ω Impedance	1 mV to 6.6 V _{pk-pk}	0.25 % + 40 μV	Fluke 5520A SC600
1 MΩ Impedance	1 mV to 130 V _{pk-pk}	0.1 % + 40 μV	
Level Sine Wave	5 mV to 5.5 V	2 % + 300 μV	
Square Wave Signal	50 kHz to 100 MHz	3.5 % + 300 μV	
	(100 to 300) MHz	4 % + 300 μV	
	(300 to 600) MHz	6 % + 300 μV	
Amplitude (Reference, 50 kHz)	50 kHz to 100 MHz	1.5 % + 100 μV	
	(100 to 300) MHz	2 % + 100 μV	
	(300 to 600) MHz	4 % + 100 μV	
Flatness (Reference, 50 kHz)	5 s to 50 ms	25 μs/s	
	20 ms to 100 ns	2.5 μs/s	
Time Markers (5-2-1 Sequence) into a 50 W Load	(5 to 2) ns	2.5 μs/s	
	10 ns	2.5 μs/s	
	(50 to 20) ns	2.5 μs/s	
Rise Time 2.5 mV to 2.5 V	(24 to 300) ps	27 %	Fluke 5520A SC600

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple & Thermocouple Indicating Systems ³ –			
Type B	(0 to 800) °C (800 to 1820) °C	0.16 °C 0.17 °C	Fluke 5700A/EP and Omega TRC III ice point reference
Type C	(0 to 2320) °C	0.2 °C	
Type N	(-270 to 0) °C (0 to 1300) °C	0.18 °C 0.28 °C	
Type E	(-270 to 0) °C (0 to 1300) °C	0.17 °C 0.2 °C	
Type R	(-50 to 0) °C (0 to 1767) °C	0.17 °C 0.16 °C	
Type S	(-50 to 0) °C (0 to 1767) °C	0.17 °C 0.16 °C	
Type J	(-210 to 0) °C (0 to 1200) °C	0.28 °C 0.18 °C	
Type K	(-210 to 0) °C (0 to 1200) °C	0.28 °C 0.18 °C	
Type T	(-270 to 0) °C (0 to 400) °C	0.23 °C 0.18 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.28 °C 0.2 °C	
Electrical Calibration of RTD Indicating Systems ³ –			
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	0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.08 °C 0.24 °C	Fluke 5520A SC600
PtNi 385, 120 Ω	(-80 to 100) °C (100 to 260) °C	0.08 °C 0.15 °C	
Cu 427, 10 Ω	(-100 to 260) °C	0.34 °C	

V. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
RF Power – Generate			
Sine Wave (50 Ω) 1 mV to 3 V _{p-p} (-56.02 to 13.52) dB	0.001 Hz to 100 kHz 100 kHz to 20 MHz	0.15 dB 0.23 dB	HP 3325A opt 001, 002
(3 to 10) V _{p-p} (13.52 to 23.98) dB	0.001 Hz to 100 kHz 100 kHz to 20 MHz	0.19 dB 0.25 dB	
(25 to 10) dB (10 to -10) dB (-10 to -60) dB (-60 to -110) dB	10 MHz to 2 GHz	1.0 dB 0.75 dB 1.0 dB 1.5 dB	HP 83630A opt 001, 008, H53
(25 to 10) dB (10 to -10) dB (-10 to -60) dB (-60 to -110) dB	(2 to 18) GHz	1.1 dB 0.75 dB 1.3 dB 2.0 dB	
1 mW	50 MHz	0.010 mW	HP 436A
(0 to 50) W	(1 to 400) MHz	2.5 %	HP 83630A & amplifier
RF Power – Measure			
1 μW to 100 mW (-30 to +20) dB	(100 to 300) kHz 300 kHz to 1 MHz 1 MHz to 2 GHz (2 to 4.2) GHz	0.071 dB 0.070 dB 0.081 dB 0.086 dB	HP 436A w/ 8482A
1 μW to 100 mW (-30 to +20) dB	10 MHz to 3 GHz (3 to 10) GHz (10 to 15) GHz (15 to 18) GHz	0.055 dB 0.062 dB 0.083 dB 0.099 dB	HP 436A w/ 8481A
1 mW	50 MHz	0.010 mW	HP 432A, 478AH73, and 34401A
(0 to 50) W	(1 to 400) MHz	2.5 %	HP 436A w/ 8482A, directional coupler, & attenuators

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
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<p>Tuned RF Power – Measure</p> <p>(0 to -20) 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</p>	100 kHz to 18 GHz	0.10 dB 0.11 dB 0.13 dB 0.14 dB 0.20 dB 0.22 dB 0.24 dB 0.26 dB 0.33 dB 0.36 dB 0.38 dB 0.43 dB	HP 8902A, HP 11722A, HP 11792A
<p>Attenuation – Generate</p> <p>SMA, 1 dB step (1 to 11) dB</p> <p>SMA, 10 dB step (10 to 110) dB</p>	(DC to 12.4 GHz) (12.4 to 18) GHz (DC to 12.4 GHz) (12.4 to 18) GHz	2.1 % + 0.24 dB 2.1 % + 0.29 dB 2.3 % + 0.23 dB 2.7 % + 0.15 dB	Agilent 8494H Agilent 8496H
<p>Frequency Modulation – Generate</p> <p>Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak</p> <p>Rate: 100 kHz to 8 MHz Dev: < 500 kHz peak</p>	(11 to 13.5) MHz (88 to 108) MHz (352 to 432) MHz (2 to 18) GHz	0.56 % 0.49 % 0.43 % 5.3 %	Agilent 11715A Agilent 83630A
<p>Frequency Modulation – Measure</p> <p>Rate: 20 Hz to 10 kHz Dev: ≤ 40 kHz</p> <p>Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz</p> <p>Rate: 20 Hz to 200 kHz Dev: ≤ 400 kHz</p>	(0.25 to 10) MHz 10 MHz to 18 GHz 10 MHz to 18 GHz	0.73 % + 1 digit 2.2 % + 1 digit 4.3 % + 1 digit	HP 8902A w/ 11793A

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
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<p>Amplitude Modulation – Measure</p> <p>Rate: 150 kHz to 10 MHz Depths: (5 to 99) %</p> <p>Rate: 150 kHz to 10 MHz Depths: To 99 %</p> <p>Rate: (10 to 1300) MHz Depths: (5 to 99) %</p> <p>Rate: (10 to 1300) MHz Depths: To 99 %</p> <p>Rate: (1.3 to 18) GHz Depths: (5 to 99) %</p> <p>Rate: (1.3 to 18) GHz Depths: To 99 %</p>	<p>50 Hz to 10 kHz</p> <p>20 Hz to 10 kHz</p> <p>50 Hz to 50 kHz</p> <p>20 Hz to 100 kHz</p> <p>50 Hz to 50 kHz</p> <p>20 Hz to 100 kHz</p>	<p>1.9 % + 1 digit</p> <p>3.0 % + 1 digit</p> <p>1.3 % + 1 digit</p> <p>3.3 % + 1 digit</p> <p>1.3 % + 1 digit</p> <p>3.3 % + 1 digit</p>	<p>HP 8902A w/ 11793A</p>
<p>Amplitude Modulation – Generate</p> <p>Rate: 50 Hz to 100 kHz Depths: 5 % to 99 %</p> <p>Rate: DC to 100 kHz Depths: 5 % to 99 %</p>	<p>(11 to 13.5) MHz</p> <p>10 MHz to 18 GHz</p>	<p>1.4 %</p> <p>5.6 %</p>	<p>Agilent 11715A</p> <p>Agilent 83630A</p>
<p>Phase Modulation – Measure</p> <p>150 kHz to <10 MHz Carrier</p> <p>10 MHz to 18.0 GHz Carrier</p>	<p>200 Hz to 10 kHz</p> <p>200 Hz to 20 kHz</p>	<p>5.1 % + 1 digit</p> <p>6.7 % + 1 digit</p>	<p>HP 8902A w/ 11793A</p>

Parameter/Equipment	Range	CMC ^{2,7} (\pm)	Comments
Reflection S ₁₁ /S ₂₂ – Measure			
50 MHz to 500 MHz	(0.00001 to 1.0) lin	(0.0082 to 0.029) lin (1.7 to 180) ^o	HP 8720C w/ 85052D
500 MHz to 2 GHz	(0.00001 to 1.0) lin	(0.0083 to 0.029) lin (1.7 to 180) ^o	
(2 to 8) GHz	(0.00001 to 1.0) lin	(0.014 to 0.049) lin (2.8 to 180) ^o	
(8 to 20) GHz	(0.00001 to 1.0) lin	(0.026 to 0.066) lin (3.6 to 180) ^{=o}	
Transmission S ₁₂ /S ₂₁ – Measure			
(50 to 500) MHz	(10 to 0) dB (0 to -20) dB (-20 to -40) dB (-40 to -60) dB	(0.11 to 0.085) dB (0.085 to 0.091) dB (0.091 to 0.092) dB (0.092 to 0.11) dB	HP 8720C w/ 85052D
500 MHz to 2 GHz	(10 to 0) dB (0 to -20) dB (-20 to -40) dB (-40 to -60) dB	(0.11 to 0.083) dB (0.083 to 0.089) dB (0.089 to 0.090) dB (0.090 to 0.11) dB	
(2 to 8) GHz	(10 to 0) dB (0 to -20) dB (-20 to -40) dB (-40 to -60) dB	(0.23 to 0.15) dB (0.15 to 0.16) dB (0.16 to 0.16) dB (0.16 to 0.17) dB	
(8 to 18) GHz	(10 to 0) dB (0 to -20) dB (-20 to -40) dB (-40 to -60) dB	(0.74 to 0.22) dB (0.22 to 0.27) dB (0.27 to 0.27) dB (0.27 to 0.28) dB	

VI. Mechanical



Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Pressure and Vacuum Gauges ^{3,7} – Pneumatic	(0.001 to 24) in·H ₂ O	0.014 % + 0.0018 in·H ₂ O	Dwyer 1425-24
Vacuum ⁷	(30 to 100) microns (100 to 1000) microns	4.3 % + 1.0 microns 6.4 % – 1.1 microns	Leybold CTR 90
Pressure and Vacuum Gauges ^{3,7} – Pneumatic	(0.2 to 25) psia (0.2 to 25) psig (25 to 1000) psig (1000 to 12 140) psig	16 parts in 10 ⁶ psia 16 parts in 10 ⁶ psig 14 parts in 10 ⁶ psig 45 parts in 10 ⁶ psig	Ruska 2465-725 Ruska 2465-729 Ruska 2400-735-00, Ruska 2402
Hydraulic	(6 to 2428) psig (30 to 12 140) psig	28 parts in 10 ⁶ psig 39 parts in 10 ⁶ psig	Ruska 2400-736-00, Ruska 2400-735-00
Air/Nitrogen Flow ^{3,7} – (0.01 to 1000) SLPM (0.0004 to 35) SCFM	(3 to 10) sccm (10 to 30) sccm (30 to 100) sccm (100 to 300) sccm (0.3 to 1.0) slpm (1.0 to 3.0) slpm (3.0 to 10) slpm (10 to 30) slpm (30 to 100) slpm (100 to 300) slpm (300 to 1000) slpm	0.49 % + 0.0083 sccm 0.44 % + 0.014 sccm 0.43 % + 0.025 sccm 0.43 % + 0.16 sccm 0.44 % + 0.00052 slpm 0.44 % + 0.0016 slpm 0.45 % + 0.0042 slpm 0.50 % + 0.0067 slpm 0.51 % + 0.031 slpm 0.57 % + 0.038 slpm 0.57 % + 0.30 slpm	CME FCS-8A and laminar flow elements
Torque ^{3,7} – Measure	(5 to 15) in·ozf (15 to 200) in·ozf (10 to 20) in·lbf (20 to 100) in·lbf (10 to 125) ft·lbf (50 to 600) ft·lbf (100 to 1000) ft·lbf	0.16 % 0.16 % 0.2 % + 0.1 in·lbf 0.11 % + 0.12 in·lbf 0.16 % 0.16 % 0.16 %	CDI 2000-4-02 CDI 2000-5-02 Mountz TL-100i CDI 2000-10-02 CDI 2000-12-02 CDI 2000-13-02

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Torque Transducers ^{3, 7}	(8 to 336) in·ozf (5 to 200) in·lbf (15 to 260) ft·lbf (50 to 1050) ft·lbf	0.034 % 0.034 % 0.034 % 0.033 %	Torque wheel/arms, Class F weights and pan
Scales and Balances ^{3, 7} – Fixed Values			
(0 to 10) kg*	(1 to 500) mg 1 g 2 g 5 g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg	0.01 mg 0.048 mg 0.049 mg 0.084 mg 0.11 mg 0.12 mg 0.22 mg 0.28 mg 0.26 mg 0.47 mg 0.88 mg	Class 1, 2 or 3 weights *Fixed values. Uncertainties are per weight.
(0 to 1000) lb*	0.5 lb 1 lb 2 lb 5 lb 10 lb 20 lb 25 lb 50 lb 0.75 lb 5 lb 8 lb 13 lb	0.000046 lb 0.000095 lb 0.000095 lb 0.00029 lb 0.0008 lb 0.0009 lb 0.0013 lb 0.0018 lb 0.015 lb 0.017 lb 0.017 lb 0.019 lb	Class F weights *Fixed values. Uncertainties are per weight. Weight pans
Mass – Measure ⁷			
(0 to 210) g	(0.1 to 10) g (10 to 210) g	0.001 % + 1.5 mg 5.3 µg/g + 1.5 mg	Ohaus AR2140
(0.2 to 50) kg	(0.2 to 1) kg (1 to 10) kg (10 to 50) kg	0.34 % 0.035 % 0.007 %	TIF 9010A

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Piston Operated Volumetric Apparatus (POVA) ³ –	10 µL to 200 mL	100 µL 1.7 µL 120 µL 1.7 µL 150 µL 1.7 µL 200 µL 1.7 µL 250 µL 1.7 µL 300 µL 1.7 µL 500 µL 1.7 µL 600 µL 1.6 µL 1000 µL 1.6 µL 1.2 mL 0.0019 mL 1.25 mL 0.002 mL 2 mL 0.0031 mL 2.5 mL 0.0039 mL 5 mL 0.0076 mL 10 mL 0.015 mL 12.5 mL 0.016 mL 25 mL 0.033 mL 50 mL 0.065 mL 100 mL 0.13 mL 200 mL 0.26 mL	Ohaus AR2140 & DI H2O Notes: pipettes & syringes
	(1 to 10) L	1 L 0.0072 L 3 L 0.027 L 7 L 0.067 L 10 L 0.097 L	TIF 9010A & DI H2O Notes: pipettes & syringes
Force – Cable Tension			
1/16"	(5 to 100) lbf	0.5 %	King Nutronics 3615 Notes: cable tensionmeters, force gages
3/32"	(5 to 185) lbf	0.5 %	
1/8"	(5 to 352) lbf	0.5 %	
3/16"	(10 to 740) lbf	0.5 %	
7/32"	(10 to 1000) lbf	0.5 %	
1/4"	(20 to 1280) lbf	0.5 %	
9/32"	(20 to 1560) lbf	0.5 %	
5/16"	(20 to 1800) lbf	0.5 %	
3/8"	(20 to 2400) lbf	0.5 %	

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Velocity ^{3,7} – Measure	(0 to 300) fpm (0 to 1250) fpm (0 to 2500) fpm (0 to 5000) fpm (0 to 10 000) fpm	2.0 % + 5.1 fpm 2.1 % + 4.7 fpm 2.0 % + 6.0 fpm 2.2 % + 2.0 fpm 2.5 % fpm	Alnor 6006AP
Rotational Speed, RPM ^{3,7} – Measure			
Optical	(10 to 100 000) rpm	0.001 % + 0.13 rpm	HP 3325A
Mechanical	(0 to 5000) rpm	0.025 %	Quantum dynamics N-11-ECS/3A

VII. Thermodynamics

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Relative Humidity ³ – Measuring Equipment	11.31 % RH 33.07 % RH 75.47 % RH 97.6 % RH	0.42 % RH 0.39 % RH 0.44 % RH 0.56 % RH	LiCl MgCl ₂ NaCl K ₂ SO ₄
Relative Humidity ³ – Measure	(10 to 40) % RH (40 to 97) % RH	0.75 % RH 0.99 % RH	Vaisala MI70 w/ HMP-77B
Temperature ³ – Measure			
PRT Probe	(0 to 1000) °C (-196 to 0) °C 0 °C (0 to 232) °C (232 to 420) °C (420 to 660) °C 0 °C (0 to 260) °C	0.089 °C 0.031 °C 0.01 °C 0.037 °C 0.048 °C 0.34 °C 0.025 °C 0.15 °C	Fluke 1521, Fluke 5624 PRT, Fluke 5626 PRT Fluke 5627 PRT
Infrared Measure	(0 to 50) °C (50 to 200) °C (200 to 400) °C	1.1 °C 0.6 % + 0.8 °C 0.45 % + 1.1 °C	AR350

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Temperature ³ – Generate			
Ice point	0 °C	20 mK	DI H ₂ O & shaved ice
Low Temp Bath	-78.5 °C -196 °C	0.5 °C 20 mK	Frozen CO ₂ & ethanol LN2
Drywell	(-25 to 70) °C (70 to 140) °C (50 to 250) °C (250 to 450) °C (450 to 650) °C	0.26 °C - 0.063 % 0.11 % + 0.14 °C 0.38 °C 0.73 °C 0.92 °C	Fluke 9103 Fluke 9141 NOTE: add 1 °C for wells larger than 6.5 mm
Infrared Source	(25 to 500) °C	0.45 % + 0.57 °C	Reed BX-500

VIII. Time & Frequency

Parameter/Equipment	Range	CMC ² (±)	Comments
Frequency – Measuring Equipment	10 MHz reference (1 to 10) Hz (10 to 100) Hz (0.1 to 1) kHz (1 to 10) kHz (10 to 100) kHz (0.1 to 1) MHz (1 to 10) MHz (10 to 21) MHz (10 to 100) MHz (0.1 to 1) GHz (1 to 10) GHz (10 to 18) GHz	2.5 × 10 ⁻¹⁰ Hz/Hz 1.3 × 10 ⁻² Hz/Hz 1.3 × 10 ⁻³ Hz/Hz 1.3 × 10 ⁻⁴ Hz/Hz 1.3 × 10 ⁻⁵ Hz/Hz 1.7 × 10 ⁻⁶ Hz/Hz 4.9 × 10 ⁻⁷ Hz/Hz 2.9 × 10 ⁻⁷ Hz/Hz 1.7 × 10 ⁻⁷ Hz/Hz 2.4 × 10 ⁻⁸ Hz/Hz 4.5 × 10 ⁻⁹ Hz/Hz 5.0 × 10 ⁻¹⁰ Hz/Hz 3.1 × 10 ⁻¹⁰ Hz/Hz	Agilent Z3816A Agilent 3325B/GPS Agilent 83630A/GPS
Frequency – Measure	1 Hz to 225 MHz (10 to 100) MHz (0.1 to 1) GHz (1 to 10) GHz (10 to 20) GHz	2.9 × 10 ⁻¹⁰ Hz/Hz 2.4 × 10 ⁻⁸ Hz/Hz 2.4 × 10 ⁻⁹ Hz/Hz 3.5 × 10 ⁻¹⁰ Hz/Hz 2.8 × 10 ⁻¹⁰ Hz/Hz	Agilent 53132A/GPS HP 5350B/GPS

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

- 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 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 stated measured values are determined using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure or generate the measured value in the ranges indicated. CMCs are expressed as either a specific value that covers the full range or as a fraction/percentage of the reading plus a fixed floor specification.
- ⁵ In the statement of CMC, L is the numerical value of the nominal length of the device measured in inches, and D is the diameter of the device in inches.
- ⁶ In the statement of CMC, percentages are percentages of reading, unless otherwise indicated.
- ⁷ The contributions from the “best existing device” are not included in the CMC claim.