



SCOPE OF ACCREDITATION TO ISO 17025:2017
& ANSI/NCSL Z540-1-1994 & ANSI/NCSL Z540.3-2006

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CALIBRATION

Valid To: March 31, 2023

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 calibrations^{1,9}:

I. Acoustics & Vibration

Parameter/Range	Frequency	CMC ^{2,6,8} (±)	Comments
Sound Level – Measuring Equipment 94 dB	1 kHz	0.31 dB	Bruel & Kjaer 4230
Sound Level – Measure (40 to 130) dB	125 Hz to 8 kHz	1.1 dB	Sound level meter

II. Chemical

Parameter/Equipment	Range	CMC ^{2,8} (±)	Comments
pH – Measuring Equipment	4 pH 7 pH 10 pH	0.02 pH 0.02 pH 0.02 pH	pH buffer solutions

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Conductivity – Measuring Equipment			
Liquid	~1 µS ~10 µS ~100 µS ~1000 µS ~1413 µS ~10 000 µS ~100 000 µS	0.43 µS 0.69 µS 4.2 µS 29 µS 31 µS 230 µS 2100 µS	Conductivity solutions
Gas Detection Equipment			Calibration gases:
C ₃ H ₈	0.7%	2.1 %	Propane
CH ₄	2.5%	2.1 %	Methane
CO	0.005 % 0.01 %	2.6 % 1.6 %	Carbon monoxide
O ₂	20.9 %	1.1 %	Oxygen
H ₂ S	0.0016 % 0.0025 %	7.6 % 5.1 %	Hydrogen sulfide

III. Dimensional

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Dial Indicators ^{3, 7}	Up to 1 in	170 µin	Universal calibrator
Dial Indicator Calibrator	Up to 2 in	25 µin	Gage blocks & electronic height gage
Rulers & Tape Measures	Up to 1200 in	0.014 % + 0.017 in	Steel rule
Coating Thickness Gauges	Up to 10 mils Up to 100 mils	0.074 mils + 0.66 % 0.13 mils + 0.13 %	Coating thickness shims

Parameter/Equipment	Range	CMC ^{2,5,6} (\pm)	Comments
Coating Thickness Shims	Up to 1000 mils Up to 25 mm	0.057 mils + 0.0093 % 1.4 μ m + 0.0093 %	Micrometer
Feeler Gauges	Up to 0.125 in	94 μ in	Micrometer
Micrometers and Calipers ^{3,7}	Up to 4 in (4 to 20) in	(13 + 8.3L) μ in (32 + 3.6L) μ in	Gage blocks
Micrometer Rods & Length End Standards	Up to 10 in	(96 + 2.4L) μ in	Gage block & super micrometer
Anvil & Spindle Flatness on Micrometers & Calipers ³	2 in diameter Convex Concave	 5.4 μ in 5.6 μ in	 Optical flat & monochromatic light
Height Gauges	Up to 4 in (4 to 20) in	(47 + 3.0L) μ in (44 + 2.7L) μ in	Gage blocks
Crimpers	(0.011 to 0.06) in (0.06 to 0.25) in	(270 – 630D) μ in (210 + 380D) μ in	Pin gages

IV. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2,4,6} (\pm)	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 (1 to 10) kV	9.0 μ V/V + 0.4 μ V 5.2 μ V/V + 0.7 μ V 4.3 μ V/V + 2.5 μ V 4.3 μ V/V + 4 μ V 5.2 μ V/V + 40 μ V 7.3 μ V/V + 400 μ V 1.0 %	Fluke 5700A/EP w/ opt 3 Fluke 80K40 & Agilent 3458A, opt 002

Parameter/Equipment	Range	CMC ^{2, 4, 6} (\pm)	Comments
DC Voltage – Fixed Points	0.1 V 1 V 10 V 100 V 1000 V	7.5 μ V/V 1.5 μ V/V 0.91 μ V/V 2.7 μ V/V 4.2 μ V/V	Fluke 732A & Fluke 752A
	10 V Fixed	0.52 μ V/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 μ V/V + 0.3 μ V 4.5 μ V/V + 0.3 μ V 4.3 μ V/V + 0.5 μ V 4.7 μ V/V + 30 μ V 7.3 μ V/V + 100 μ V	Agilent 3458A, opt 002 ACAL (24hrs and $\pm 1^\circ$ C); TCAL $\pm 5^\circ$ C, & MATH NULL, *add 12 (V _{in} /1000) ² ppm
	(1 to 10) kV	1.0 %	Fluke 80K40 & Agilent 3458A, opt 002
DC Current ³ – Measure	100 nA to 1 μ A (1 to 10) μ A (10 to 100) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	37 μ A/A + 40 pA 23 μ A/A + 40 pA 23 μ A/A + 100 pA 23 μ A/A + 800 pA 23 μ A/A + 5 nA 23 μ A/A + 50 nA 40 μ A/A + 500 nA	Agilent 3458A, opt 002
	Ohm's Law Method (10 to 100) nA 100 nA to 1 μ A (1 to 10) μ A (10 to 100) μ A 100 μ A 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 μ A/A 8.9 μ A/A 8.6 μ A/A 7.9 μ A/A 7.2 μ A/A 7.0 μ A/A 7.8 μ A/A 8.4 μ A/A 8.8 μ A/A 18 μ A/A	Fluke 5700A/EP Agilent 3458A, opt 002 ESI SR1060 Guildline 9211A
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

Parameter/Equipment	Range	CMC ^{2,4,6} (±)	Comments	
DC Current ³ – Generate (cont)	(2.2 to 3) A	0.041 % + 6 µA	Fluke 5520A SC600	
	(2.2 to 11) A	0.03 % + 1 mA	Fluke 5700A/EP with Fluke 5520A SC600	
	(11 to 20) A	0.034 % + 1 mA		
	(0 to 100) A	0.046 % + 20 mA	Fluke 5700A/EP with Ballantine 1620A	
	Clamp-On Meters	(10 to 16.5) A	0.40 % + 0.055A	Fluke 5700A/EP Fluke 5520A SC600 Fluke 5500A coil
		(16.5 to 150) A	0.52 % + 0.15 A	
		(150 to 1025) A	0.49 % + 0.54 A	
	Ohm's Law Method	(10 to 100) nA	9.7 µA/A	Fluke 5700A/EP Agilent 3458A, opt 002 ESI SR1060 Guildline 9211A
		100 nA to 1 µA	8.9 µA/A	
		(1 to 10) µA	8.6 µA/A	
(10 to 100) µA		7.9 µA/A		
100 µA to 1 mA		7.2 µA/A		
(1 to 10) mA		7.0 µA/A		
(10 to 100) mA		7.8 µA/A		
100 mA to 1 A		8.4 µA/A		
(1 to 10) A		8.8 µA/A		
(10 to 100) A		18 µA/A		
Resistance ³ – Generate	Fixed Values		Guildline 9211A ESI 242D ESI SR-104U ESI SR-1060 ESI SR-1050 IET HRRS-B-4-1 M ESI SR-104U Leeds & Northrop 4020B	
	1 mΩ Fixed	1 mΩ		430 µΩ/Ω
	10 mΩ Fixed	10 mΩ		270 µΩ/Ω
	100 mΩ Fixed	100 mΩ		230 µΩ/Ω
	1 Ω Steps	Up to 10 Ω		5.7 µΩ/Ω
	10 Ω Steps	Up to 100 Ω		5.1 µΩ/Ω
	100 Ω Steps	Up to 1000 Ω		4.0 µΩ/Ω
	1 kΩ Steps	Up to 10 kΩ		2.0 µΩ/Ω
	10 kΩ Steps	Up to 100 kΩ		2.5 µΩ/Ω
	100 kΩ Steps	Up to 1 MΩ		4.3 µΩ/Ω
	1 MΩ Steps	Up to 10 MΩ		5.5 µΩ/Ω
	10 MΩ Steps	Up to 100 MΩ		6.0 µΩ/Ω
	100 MΩ Steps	Up to 1 GΩ		0.33 % + 0.21 MΩ
	1 GΩ Steps	Up to 10 GΩ		0.62 %
10 kΩ Fixed	10 kΩ	1.2 µΩ/Ω		
1 Ω Fixed	1 Ω	1.6 µΩ/Ω		

Parameter/Equipment	Range	CMC ^{2,4,6} (\pm)	Comments
Resistance ³ – Generate (cont)			
Fixed Values			
1 Ω to 100 M Ω	1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 k Ω 1.9 k Ω 10 k Ω 19 k Ω 100 k Ω 190 k Ω 1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω	80 $\mu\Omega/\Omega$ 84 $\mu\Omega/\Omega$ 29 $\mu\Omega/\Omega$ 29 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$ 10 $\mu\Omega/\Omega$ 8.9 $\mu\Omega/\Omega$ 8.4 $\mu\Omega/\Omega$ 6.9 $\mu\Omega/\Omega$ 8.9 $\mu\Omega/\Omega$ 12 $\mu\Omega/\Omega$ 12 $\mu\Omega/\Omega$ 19 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$ 40 $\mu\Omega/\Omega$ 40 $\mu\Omega/\Omega$ 140 $\mu\Omega/\Omega$	Fluke 5700A/EP
Up to 1.1 G Ω	Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω (0.33 to 1.1) k Ω (1.1 to 3.3) k Ω (3.3 to 11) k Ω (11 to 33) k Ω (33 to 110) k Ω (110 to 330) k Ω (0.33 to 1.1) M Ω (1.1 to 3.3) M Ω (3.3 to 11) M Ω (11 to 33) M Ω (33 to 110) M Ω (110 to 330) M Ω (0.33 to 1.1) G Ω	40 $\mu\Omega/\Omega + 0.0010 \Omega$ 30 $\mu\Omega/\Omega + 0.0015 \Omega$ 28 $\mu\Omega/\Omega + 0.0014 \Omega$ 28 $\mu\Omega/\Omega + 0.0020 \Omega$ 28 $\mu\Omega/\Omega + 0.000\ 002\ 0\ k\Omega$ 28 $\mu\Omega/\Omega + 0.000\ 020\ k\Omega$ 28 $\mu\Omega/\Omega + 0.000\ 020\ k\Omega$ 28 $\mu\Omega/\Omega + 0.000\ 20\ k\Omega$ 28 $\mu\Omega/\Omega + 0.000\ 20\ k\Omega$ 32 $\mu\Omega/\Omega + 0.0020\ k\Omega$ 32 $\mu\Omega/\Omega + 0.000\ 002\ 0\ M\Omega$ 60 $\mu\Omega/\Omega + 0.000\ 030\ M\Omega$ 130 $\mu\Omega/\Omega + 0.000\ 050\ M\Omega$ 250 $\mu\Omega/\Omega + 0.0025\ M\Omega$ 500 $\mu\Omega/\Omega + 0.0030\ M\Omega$ 0.30 % + 0.10 M Ω 1.5 % + 0.50 M Ω	Fluke 5520ASC600
Resistance ³ – Measure	Up to 10 Ω Up to 100 Ω Up to 1000 Ω	19 $\mu\Omega/\Omega + 50 \mu\Omega$ 15 $\mu\Omega/\Omega + 500 \mu\Omega$ 13 $\mu\Omega/\Omega + 500 \mu\Omega$	Agilent 3458A, opt 002

Parameter/Equipment	Range	CMC ^{2,4,6} (±)	Comments
Resistance ³ – Measure (cont)	Up to 10 kΩ Up to 100 kΩ Up to 1 MΩ Up to 10 MΩ Up to 100 MΩ Up to 1 GΩ	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 – Measure & Measuring Equipment			
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	0.011 % 69 μV/V 66 μV/V 65 μV/V 65 μV/V 65 μV/V	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage, Fixed Points – Measure & Measuring Equipment (cont)			
20 mV	50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	93 μV/V 0.016 % 0.026 % 0.036 % 0.042 %	Fluke 792A
60 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 % 70 μV/V 50 μV/V 50 μV/V 50 μV/V 57 μV/V 77 μV/V 0.016 % 0.028 % 0.037 % 0.044 %	
200 mV	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	39 μV/V 27 μV/V 21 μV/V 21 μV/V 21 μV/V 22 μV/V 26 μV/V 44 μV/V 82 μV/V 0.012 % 0.019 %	
600 mV	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	30 μV/V 24 μV/V 14 μV/V 13 μV/V 13 μV/V 14 μV/V 14 μV/V 18 μV/V 36 μV/V 39 μV/V 71 μV/V	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage, Fixed Points – Measure & Measuring Equipment (cont)			
2 V	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	30 µV/V 24 µV/V 12 µV/V 11 µV/V 11 µV/V 11 µV/V 11 µV/V 17 µV/V 28 µV/V 33 µV/V 50 µV/V	Fluke 792A
6 V	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	30 µV/V 23 µV/V 12 µV/V 11 µV/V 11 µV/V 11 µV/V 12 µV/V 16 µV/V 28 µV/V 33 µV/V 50 µV/V	
20 V	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz	30 µV/V 23 µV/V 13 µV/V 13 µV/V 13 µV/V 13 µV/V 13 µV/V 19 µV/V 29 µV/V 35 µV/V 50 µV/V	
60 V	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz	28 µV/V 23 µV/V 14 µV/V 13 µV/V 13 µV/V 13 µV/V 15 µV/V 20 µV/V 36 µV/V	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage, Fixed Points – Measure & Measuring Equipment (cont)			
200 V	10 Hz 20 Hz 100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	41 μV/V 25 μV/V 15 μV/V 15 μV/V 15 μV/V 15 μV/V 21 μV/V 26 μV/V	Fluke 792A
600 V	100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	22 μV/V 17 μV/V 19 μV/V 23 μV/V 45 μV/V 73 μV/V	
1000 V	100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz	23 μV/V 22 μV/V 23 μV/V 24 μV/V 51 μV/V 76 μV/V	
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	0.038 % 0.024 % 0.024 % 0.024 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage Flatness – Generate (cont)			
3 mV	(120 to 500) kHz	0.033 %	Fluke 5700A/EP/03
	(0.12 to 1.2) MHz	0.033 %	
	(1.2 to 2) MHz	0.036 %	
	(2 to 10) MHz	0.061 %	
	(10 to 20) MHz	0.11 %	
	(20 to 30) MHz	0.19 %	
10 mV	(10 to 30) Hz	0.033 %	
	(30 to 120) Hz	0.021 %	
	(0.12 to 1.2) kHz	0.021 %	
	(1.2 to 120) kHz	0.021 %	
	(120 to 500) kHz	0.028 %	
	(0.12 to 1.2) MHz	0.029 %	
	(1.2 to 2) MHz	0.033 %	
	(2 to 10) MHz	0.058 %	
	(10 to 20) MHz	0.1 %	
30 Mv	(20 to 30) MHz	0.18 %	
	(10 to 30) Hz	0.035 %	
	(30 to 120) Hz	0.02 %	
	(0.12 to 1.2) kHz	0.02 %	
	(1.2 to 120) kHz	0.02 %	
	(120 to 500) kHz	0.025 %	
	(0.12 to 1.2) MHz	0.029 %	
	(1.2 to 2) MHz	0.032 %	
	(2 to 10) MHz	0.057 %	
100 mV	(10 to 20) MHz	0.1 %	
	(20 to 30) MHz	0.18 %	
	(10 to 30) Hz	0.035 %	
	(30 to 120) Hz	0.02 %	
	(0.12 to 1.2) kHz	0.02 %	
	(1.2 to 120) kHz	0.02 %	
	(120 to 500) kHz	0.025 %	
	(0.12 to 1.2) MHz	0.029 %	
	(1.2 to 2) MHz	0.032 %	
(2 to 10) MHz	0.057 %		
300 mV	(10 to 20) MHz	0.1 %	
	(20 to 30) MHz	0.18 %	
	(10 to 30) Hz	0.026 %	
	(30 to 120) Hz	0.018 %	
	(0.12 to 1.2) kHz	0.018 %	
	(1.2 to 120) kHz	0.018 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments	
AC Voltage Flatness – Generate (cont)				
300 mV	(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	0.027 % 0.028 % 0.033 % 0.053 % 0.1 % 0.17 %	Fluke 5700A/EP/03	
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 %		
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	0.024 % + 4 μV 90 μV/V + 4 μV 80 μV/V + 4 μV		

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage ³ – Generate (cont)			
(2.2 to 22) mV	(20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.02 % + 4 μV 0.05 % + 4 μV 0.11 % + 10 μV 0.14 % + 10 μV 0.27 % + 20 μV	Fluke 5700A/EP
(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	
(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 μV/V + 0.15 mV 50 μV/V + 0.05 mV 80 μV/V + 0.1 mV 0.01 % + 0.2 mV 0.028 % + 0.6 mV 0.1 % + 2 mV 0.15 % + 3.2 mV	
(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 μV/V + 0.15 mV 50 μV/V + 0.05 mV 80 μV/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	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage ³ – Measure			
0 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 μV 0.074 % + 1.3 μV 0.042 % + 1.3 μV 0.081 % + 2 μV 0.12 % + 2.5 μV 0.23 % + 4 μV 0.24 % + 8 μV 0.35 % + 8 μV	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 μV 0.17 % + 1 μV 0.3 % + 1 μV 0.7 % + 2 μV	
(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 μV 0.037 % + 1.3 μV 0.021 % + 1.3 μV 0.04 % + 2 μV 0.06 % + 2.5 μV 0.12 % + 4 μV 0.13 % + 8 μV 0.23 % + 8 μV	
Wideband	(1 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz	0.07 % + 1 μV 0.1 % + 1 μV 0.17 % + 1 μV 0.37 % + 1 μV	
(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 μV 0.019 % + 1.3 μV 0.011 % + 1.3 μV 0.021 % + 2 μV 0.031 % + 2.5 μV 0.081 % + 4 μV 0.089 % + 8 μV 0.17 % + 8 μV	
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 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage ³ – Measure (cont)			
(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 μV 0.012 % + 1.5 μV 0.007 % + 1.5 μV 0.013 % + 2 μV 0.026 % + 2.5 μV 0.051 % + 4 μV 0.067 % + 8 μV 0.11 % + 8 μV	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 %	
(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 μV 0.009 % + 1.5 μV 0.004 % + 1.5 μV 0.007 % + 2 μV 0.016 % + 2.5 μV 0.025 % + 4 μV 0.038 % + 8 μV 0.1 % + 8 μV	
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 %	
(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 μV 70 μV/V + 1.5 μV 20 μV/V + 1.5 μV 50 μV/V + 2 μV 70 μV/V + 2.5 μV 0.016 % + 4 μV 0.026 % + 8 μV 0.09 % + 8 μV	
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} (±)	Comments
AC Voltage ³ – Measure (cont)			
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 μV/V 30 μV/V 50 μV/V 80 μV/V 0.018 % 0.03 % 0.1 %	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 %	
(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 μV/V 20 μV/V 50 μV/V 70 μV/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 μV/V 20 μV/V 50 μV/V 80 μV/V 0.019 % 0.04 % 0.12 %	
(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 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage ³ – Measure (cont)			
(70 to 220) V	(10 to 20) Hz	0.02 %	Fluke 5790A opt.003 uncertainty of wideband is for flatness relative to 1 kHz
	(20 to 40) Hz	70 μV/V	
	40 Hz to 20 kHz	30 μV/V	
	(20 to 50) kHz	70 μV/V	
	(50 to 100) kHz	0.01 %	
	(100 to 300) kHz	0.021 %	
(220 to 700) V	(300 to 500) kHz	0.05 %	
	(10 to 20) Hz	0.02 %	
	(20 to 40) Hz	0.01 %	
	40 Hz to 20 kHz	40 μV/V	
	(20 to 50) kHz	0.013 %	
(700 to 1000) V	(50 to 100) kHz	0.05 %	
	(10 to 20) Hz	0.02 %	
	(20 to 40) Hz	0.01 %	
	40 Hz to 20 kHz	0.004 %	
	(20 to 50) kHz	0.013 %	
(0 to 10) mV	(50 to 100) kHz	0.05 %	
	(1 to 40) Hz	0.03 % + 3 μV	
	40 Hz to 1 kHz	0.02 % + 1.1 μV	
	(1 to 20) kHz	0.03 % + 1.1 μV	
	(20 to 50) kHz	0.1 % + 1.1 μV	
	(50 to 100) kHz	0.5 % + 1.1 μV	
	(100 to 300) kHz	4 % + 2 μV	
	(0.3 to 1) MHz	1.2 % + 5 μV	
(10 to 100) mV	(1 to 40) Hz	70 μV/V + 4 μV	
	40 Hz to 1 kHz	70 μV/V + 2 μV	
	(1 to 20) kHz	0.014 % + 2 μV	
	(20 to 50) kHz	0.03 % + 2 μV	
	(50 to 100) kHz	0.08 % + 2 μV	
	(100 to 300) kHz	0.3 % + 10 μV	
	(0.3 to 1) MHz	1 % + 10 μV	
	(0.1 to 10) V	(1 to 40) Hz	70 μV/V + 0.4 mV
40 Hz to 1 kHz		70 μV/V + 0.2 mV	
(1 to 20) kHz		0.014 % + 0.2 mV	
(20 to 50) kHz		0.03 % + 0.2 mV	
(50 to 100) kHz		0.08 % + 0.2 mV	
(100 to 300) kHz		0.3 % + 1 mV	
(0.3 to 1) MHz		1 % + 1 mV	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Voltage ³ – Measure (cont)			
(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	Fluke 5790A opt.003 uncertainty of wideband is for flatness relative to 1 kHz
(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	Agilent 3458A, opt 002 NOTE: synchronous sub- sampled mode
(Up to 40) kV _{p-p} (Up 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 with Fluke 5520A
AC Power ³ – Generate			
Up to 300 W (330 to 2200) W (2200 to 20 500) W	(45 to 65) Hz	0.12 % 0.11 % 0.12 %	Fluke 5520A plus resistance standard
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	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Current ³ – Generate			
(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	Fluke 5700A/EP
(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
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			
Up 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

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
AC Current ³ – Measure			
(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	Agilent 3458A opt. 002
(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	
Up to 550 μA	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.02 % 0.008 % 0.005 %	Fluke 5790A with 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 %	
(5.5 to 22) mA	(5 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz	0.02 % 0.008 % 0.005 %	
(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 %	

Parameter/Range	Frequency	CMC ^{2,4,6} (±)	Comments
Inductance ³ – Measure 0.01 μH to 4.1 H (4.1 to 99 999) H	(12 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz (12 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz	0.049 % 0.029 % 0.059 % 0.23 % 0.049 % 0.029 % 0.21 %	GenRad 1693 Digibridge NOTE: slow measure rate, averaging, open/short
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 6.4 nF to 99 999 μF	(12 to 100) Hz 100 Hz to 1 kHz (1 to 20) kHz (12 to 100) Hz 100 Hz to 1 kHz (1 to 10) kHz (10 to 100) kHz	0.049 % 0.029 % 0.21 % 0.049 % 0.029 % 0.059 % 0.23 %	GenRad 1693 Digibridge NOTE: slow measure rate, averaging, open/short
Capacitance ³ – Generate (0.19 to 3.3) nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF (0.33 to 1.1) μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF (0.33 to 1.1) mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	10 Hz to 10 kHz	0.58 % + 0.01 nF 0.29 % + 0.01 nF 0.29 % + 0.1 nF 0.29 % + 0.3 nF 0.29 % + 1 nF 0.29 % + 3 nF 0.29 % + 10 nF 0.46 % + 30 nF 0.52 % + 100 nF 0.52 % + 300 nF 0.52 % + 1 μF 0.52 % + 3 μF 0.52 % + 10 μF 0.87 % + 30 μF 1.3 % + 100 μF	Fluke 5520A SC600

Parameter/Range	Frequency	CMC ^{2, 4, 6} (\pm)	Comments
Distortion ³ – Measure (0.3 to 100) % < 30 V (30 to 300) V 0.1 % < 30 V (0.001 to 100) % 50 mV to 300 V	 10 Hz to 1 MHz (1 to 3) MHz 10 Hz to 300 kHz (300 to 500) kHz (0.5 to 3) MHz (10 to 20) Hz (20 to 30) Hz 30 Hz to 300 kHz (300 to 500) kHz (0.5 to 1.2) MHz 20 Hz to 20 kHz (20 to 100) kHz	 3 % of full scale 7.1 % of full scale 3 % of full scale 7.1 % of full scale 13 % of full scale 13 % of full scale 7.1 % of full scale 3 % of full scale 7.1 % of full scale 13 % of full scale 1.2 dB 2.3 dB	 HP 334A 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
Oscilloscopes ³ – Square Wave Signal 10 Hz to 10 kHz 50 Ω Impedance 1 M Ω Impedance Level Sine Wave Square Wave Signal	 1 mV to 6.6 V _{pk-pk} 1 mV to 130 V _{pk-pk} 5 mV to 5.5 V 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz	 0.25 % + 40 μ V 0.1 % + 40 μ V 2 % + 300 μ V 3.5 % + 300 μ V 4 % + 300 μ V 6 % + 300 μ V	 Fluke 5520A SC600

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
Oscilloscopes ³ – (cont)			
Amplitude (Reference, 50 kHz)	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz	1.5 % + 100 μV 2 % + 100 μV 4 % + 100 μV	Fluke 5520A SC600
Flatness (Reference, 50 kHz)	5 s to 50 ms 20 ms to 100 ns	25 μs/s 2.5 μs/s	
Time Markers (5-2-1 Sequence) into a 50 W Load	(5 to 2) ns 10 ns (50 to 20) ns	2.5 μs/s 2.5 μs/s 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 ^{2,4} (±)	Comments
Electrical Calibration of Thermocouple & Thermocouple Indicating Systems ³ –			
Type B	Up to 800 °C (800 to 1820) °C	0.16 °C 0.17 °C	Fluke 5700A/EP & Omega TRC III ice point reference
Type C	Up to 2320 °C	0.2 °C	
Type E	(-270 to 0) °C Up to 1300 °C	0.17 °C 0.2 °C	
Type J	(-210 to 0) °C Up to 1200 °C	0.28 °C 0.18 °C	
Type K	(-210 to 0) °C Up to 1200 °C	0.28 °C 0.18 °C	
Type N	(-270 to 0) °C Up to 1300 °C	0.18 °C 0.28 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple & Thermocouple Indicating Systems ³ – (cont)			
Type R	(-50 to 0) °C Up to 1767 °C	0.17 °C 0.16 °C	Fluke 5700A/EP & Omega TRC III ice point reference
Type S	-50 to 0 °C Up to 1767 °C	0.17 °C 0.16 °C	
Type T	(-270 to 0) °C Up to 400 °C	0.23 °C 0.18 °C	
Type U	(-200 to 0) °C Up 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, 4, 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

Parameter/Range	Frequency	CMC ^{2, 4, 6} (\pm)	Comments
RF Power – Generate (cont)			
Sine Wave (50 Ω)			
(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	HP 3325A opt 001, 002
(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
(Up to 50) W	(1 to 400) MHz	2.5 %	HP 83630A & amplifier
RF Power – Measure			
1 μ W to 100 mW	(100 to 300) kHz	0.071 dB	HP 436A with 8482A
(-30 to +20) dB	300 kHz to 1 MHz 1 MHz to 2 GHz (2 to 4.2) GHz	0.070 dB 0.081 dB 0.086 dB	
1 μ W 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 with 8481A
1 mW	50 MHz	0.010 mW	HP 432A, 478AH73, & 34401A
(Up to 50) W	(1 to 400) MHz	2.5 %	HP 436A with 8482A, directional coupler, & attenuators

Parameter/Range	Frequency	CMC ^{2, 4, 6} (\pm)	Comments
Tuned RF Power – Measure (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	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
Attenuation – Generate SMA, 1 dB step (1 to 11) dB SMA, 10 dB step (10 to 110) dB	(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
Frequency Modulation – Generate Rate: 20 Hz to 200 kHz Dev.: \leq 400 kHz peak Rate: 100 kHz to 8 MHz Dev: $<$ 500 kHz peak	(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
Frequency Modulation – Measure Rate: 20 Hz to 10 kHz Dev: \leq 40 kHz Rate: 50 Hz to 100 kHz Dev: \leq 400 kHz	(0.25 to 10) MHz 10 MHz to 18 GHz	0.73 % + 1 digit 3.0 % + 1 digit	HP 8902A with 11793A

Parameter/Range	Frequency	CMC ^{2, 4, 6} (\pm)	Comments
Frequency Modulation – Measure (cont) Rate: 20 Hz to 200 kHz Dev: \leq 400 kHz	10 MHz to 18 GHz	4.3 % + 1 digit	HP 8902A with 11793A
Amplitude Modulation – Measure Rate: 150 kHz to 10 MHz Depths: (5 to 99) % Rate: 150 kHz to 10 MHz Depths: To 99 % Rate: (10 to 1300) MHz Depths: (5 to 99) % Rate: (10 to 1300) MHz Depths: To 99 % Rate: (1.3 to 18) GHz Depths: (5 to 99) % Rate: (1.3 to 18) GHz Depths: 0 to 99 %	50 Hz to 10 kHz 20 Hz to 10 kHz 50 Hz to 50 kHz 20 Hz to 100 kHz 50 Hz to 50 kHz 20 Hz to 100 kHz	1.9 % + 1 digit 3.0 % + 1 digit 1.3 % + 1 digit 3.3 % + 1 digit 1.3 % + 1 digit 3.3 % + 1 digit	HP 8902A with 11793A
Amplitude Modulation – Generate Rate: 50 Hz to 100 kHz Depths: (5 to 99) % Rate: DC to 100 kHz Depths: (5 to 99) %	(11 to 13.5) MHz 10 MHz to 18 GHz	1.4 % 5.6 %	Agilent 11715A Agilent 83630A

Parameter/Range	Frequency	CMC ^{2, 4, 6} (\pm)	Comments
Phase Modulation – Measure			
150 kHz to <10 MHz Carrier	200 Hz to 10 kHz	5.1 % + 1 digit	HP 8902A with 11793A
10 MHz to 18.0 GHz Carrier	200 Hz to 20 kHz	6.7 % + 1 digit	

Parameter/Equipment	Range	CMC ^{2, 4, 7} (\pm)	Comments
Reflection S ₁₁ /S ₂₂ – Measure			HP 8720C with 85052D
(50 to 500) MHz	(0.000 01 to 1.0) lin	(0.0082 to 0.029) lin (1.7 to 180) ^o	
500 MHz to 2 GHz	(0.000 01 to 1.0) lin	(0.0083 to 0.029) lin (1.7 to 180) ^o	
(2 to 8) GHz	(0.000 01 to 1.0) lin	(0.014 to 0.049) lin (2.8 to 180) ^o	
(8 to 18) GHz	(0.000 01 to 1.0) lin	(0.026 to 0.066) lin (3.6 to 180) ^o	
Transmission S ₁₂ /S ₂₁ – Measure			HP 8720C with 85052D
(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	
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	

Parameter/Equipment	Range	CMC ^{2,4,7} (±)	Comments
Transmission S ₁₂ /S ₂₁ – Measure (cont)			
(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	HP 8720C with 85052D

VI. Mechanical

Parameter/Equipment	Range	CMC ^{2,6,8} (±)	Comments
Accelerometers			
(0.02 to 5000) pC/g (1 to 10 000) mV/g	(5 to 19) Hz (20 to 99) Hz (0.1 to 1) kHz (1 to 5) kHz (5 to 10) kHz	2.9 % 1.5 % 1.5 % 1.6 % 2.6 %	B&K 9610 with 4808
	100 Hz, 160 Hz	1.3 %	B&K 9610 with 4809
Pressure & Vacuum Measure & Measuring Equipment ^{3,7} –			
Pneumatic	(30 to 100) microns (100 to 1000) microns (1 to 10) Torr	4.3 % + 1.0 microns 6.4 % – 1.1 microns 0.63 %	Leybold CTR 90
	(0.001 to 24) in·H ₂ O	0.014 % + 0.0018 in·H ₂ O	Dwyer 1425-24
	(0.2 to 25) psia (0.2 to 25) psig	15 parts in 10 ⁶ psia 15 parts in 10 ⁶ psig	Ruska 2465-725
	(25 to 1000) psig	16 parts in 10 ⁶ psig	Ruska 2465-729
	(1000 to 12 140) psig	0.0041 % + 0.012 psig	Ruska 2400-735-00, Ruska 2402

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Pressure & Vacuum Measure & Measuring Equipment ^{3, 7} – (cont)			
Pneumatic	Up to 100 psi Up to 1000 psi Up to 10 000 psi	0.021 % - 0.000 90 psi 0.018 % + 0.021 psi 0.0050 % + 0.80 psi	Fluke 2700G
	Up to 100 psi Up to 300 psi	0.031 % + 0.021 psi 0.024 % + 0.028 psi	Crystal XP2i
	(-14.7 to 0) psi Up to 5 psi Up to 15 psia Up to 300 psi Up to 1000 psi Up to 3000 psi Up to 5000 psi Up to 10 000 psi	0.042 psi 0.0012 psi 0.0024 psi 0.067 psi 0.28 psi 0.67 psi 1.2 psi 2.3 psi	Druck DPI-610 & transducers
Hydraulic	(30 to 12 140) psig	0.0039 % + 0.012 psig	Ruska 2400-735-00
	Up to 1000 psi Up to 10 000 psi	0.018 % + 0.021 psi 0.0050 % + 0.80 psi	Fluke 2700G
	Up to 1000 psi Up to 3000 psi Up to 5000 psi Up to 10 000 psi	0.28 psi 0.67 psi 1.2 psi 2.3 psi	Druck DPI-610 & transducers
Air/Nitrogen Flow ^{3, 7} – Measure			
(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 (1000 to 3000) slpm	0.68 % + 0.0090 sccm 0.67 % – 0.0031 sccm 0.65 % + 0.033 sccm 0.66 % + 0.012 sccm 0.59 % + 0.000 37 slpm 0.63 % + 0.000 47 slpm 0.56 % + 0.0054 slpm 0.63 % + 0.000 91 slpm 0.65 % + 0.017 slpm 0.72 % + 0.030 slpm 0.76 % + 0.062 slpm 0.99 % – 1.7 slpm	CME FCS-8A & laminar flow elements

Parameter/Equipment	Range	CMC ^{2,6,8} (±)	Comments
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
Torque Measuring Equipment ^{3,7}	(8 to 336) in·ozf (5 to 200) in·lbf (15 to 260) ft·lbf (50 to 1050) ft·lbf	0.025 % + 0.0022 in·ozf 0.032 % + 0.0012 in·lb 0.030 % + 0.0014 ft·lbf 0.038 % + 0.015 ft·lbf	Torque wheel/arms, Class F weights & pan
Scales & Balances ^{3,7} – Fixed Values (Up 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.
Fixed Values (Up to 1000) lb*	Up to 1 lb (1 to 10) lb (10 to 100) lb (100 to 1000) lb 0.75 lb 5 lb 8 lb 13 lb	0.0092 % 0.0094 % 0.0094 % 0.0093 % 0.015 lb 0.017 lb 0.017 lb 0.019 lb	Class F weights Weight pans

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Force – Measuring Equipment	Up to 10 lb Up to 100 lb Up to 1000 lb	0.0056 % + 0.0037 lbf 0.0063 % + 0.0037 lbf 0.011 % - 0.0010 lbf	Class F weights
Mass ⁷ – Measure			
(0 to 205) g	(0.1 to 62) g (62 to 205) g	0.000 67 % + 0.000 081 g 0.000 45 % + 0.000 30 g	Mettler AT261
(0 to 600)g	(0 to 600)g	0.000 14 % + 0.0037 g	Mettler XS603S
(0 to 6000)g	(0 to 6000)g	0.000 16 % + 0.025 g	Mettler XS6002S
(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
Piston Operated Volumetric Apparatus (POVA) –			
10 µL to 200 mL	(10 to 100) µL (100 to 1000) µL (1 to 10) mL (10 to 100) mL (100 to 200) mL	0.16 % + 0.078 µL 0.21 % + 0.030 µL 0.22 % + 0.000 10 mL 0.21 % + 0.0010 mL 0.21 %	Mettler AT261 & DI H2O Notes: pipettes & syringes
Piston Operated Volumetric Apparatus (POVA) ³ –	(1 to 10) L	0.30 % + 0.0020 L	TIF 9010A & DI H2O Notes: pipettes & syringes
Velocity ^{3, 7} – Measure	Up to 6000 fpm	1.1 % + 5.7 fpm	Alnor RVA501
Rotational Speed, RPM ^{3, 7} – Measuring Equipment			
Optical	(10 to 100 000) rpm	0.001 % + 0.13 rpm	HP 3325A
Mechanical	(Up to 5000) rpm	0.025 %	Quantum dynamics N-11-ECS/3A

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Rotational Speed, RPM ^{3, 7} – Measure			
Optical	(10 to 600) rpm	0.041 % + 0.42 RPM	Tachometer
	(600 to 100 000) rpm	0.010 % + 0.60 RPM	
Mechanical	(Up to 5000) rpm	0.15 % + 2.0 RPM	

VII. Fluid Quantities

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Viscosity ^{3, 7} – Dip Cups			
S90 Zahn Cup #2	(39 to 238) mm ² /s	1.7 %	Standard oils, thermometer, & stopwatch
EZ Zahn Cup #2	(19 to 156) mm ² /s	1.7 %	

VIII. Thermodynamics

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Relative Humidity ³ – Measuring Equipment	11.31 % RH 33.07 % RH 75.47 % RH 97.6 % RH	0.61 % RH 0.62 % RH 0.97 % RH 1.5 % RH	LiCl MgCl ₂ NaCl K ₂ SO ₄
	(10 to 40) % RH (40 to 97) % RH	0.97 % RH 1.3 % RH	Vaisala MI70 with HMP-77B
Relative Humidity ³ – Measure	(10 to 40) % RH (40 to 97) % RH	0.83 % RH 1.1 % RH	Vaisala MI70 with HMP-77B

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Temperature ³ – Measure			
PRT Probe	(0 to 1000) °C	0.089 °C	Fluke 1521, Fluke 5624 PRT, Fluke 5626 PRT
	(-196 to 0) °C	0.031 °C	
	0 °C	0.01 °C	
	(0 to 232) °C	0.037 °C	
	(232 to 420) °C (420 to 660) °C	0.048 °C 0.34 °C	
	0 °C (0 to 260) °C	0.025 °C 0.15 °C	Fluke 5627 PRT
Infrared Measure	(0 to 100) °C (100 to 500) °C	0.51 % + 0.89 °C 1.4 %	Fluke 561
	(0 to 100) °C (100 to 500) °C	1.2 % + 0.88 °C 1.2 % + 1.0 °C	Fluke 62
Temperature ³ – Measuring Equipment			
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 LN ₂
Drywell	(-25 to 70) °C (70 to 140) °C	0.26 °C - 0.063 % 0.11 % + 0.14 °C	Fluke 9103
	(-25 to 70) °C (70 to 140) °C	0.11 °C 0.11 °C	Comparison to PRT
	(50 to 250) °C (250 to 450) °C (450 to 650) °C	0.38 °C 0.73 °C 0.92 °C	Fluke 9141 Notes: add 1 °C for wells larger than 6.5 mm
	(50 to 250) °C (250 to 450) °C (450 to 650) °C	0.11 °C 0.52 °C 0.52 °C	Comparison to PRT
Infrared Source	(25 to 500) °C	0.45 % + 0.57 °C	Reed BX-500

Parameter/Equipment	Range	CMC ^{2, 6, 8} (±)	Comments
Temperature – System Accuracy Test (SAT). Controllers, Ovens, Furnaces, Freezers	(200 to 400) °F (400 to 1204) °F	1.8 °F 0.45 % - 0.20 °F	AMS 2750F Fluke 1586A DAQ w/ TC, Fluke 744
Temperature – Thermal Uniformity Survey (TUS). Ovens, Furnaces	(200 to 400) °F (400 to 1200) °F	2.1 °F 0.75 % - 0.90 °F	AMS 2750E Fluke 1586A DAQ w/ TC

IX. Time & Frequency

Parameter/Equipment	Range	CMC ^{2, 8} (±)	Comments
Frequency – Measuring Equipment	10 MHz reference	2.5×10^{-10} Hz/Hz	Agilent Z3816A
	(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	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 3325B/GPS Agilent 83630A/GPS
Frequency – Measure	1 Hz to 225 MHz 225 MHz to 3 GHz	2.9×10^{-10} Hz/Hz 2.9×10^{-9} Hz/Hz	Agilent 53132A/GPS
	(10 to 100) MHz (0.1 to 1) GHz (1 to 10) GHz (10 to 20) GHz	2.4×10^{-8} Hz/Hz 2.4×10^{-9} Hz/Hz 3.5×10^{-10} Hz/Hz 2.8×10^{-10} Hz/Hz	HP 5350B/GPS
Timers/Stopwatches	(1 to 86 400) sec	0.039 sec	Agilent 53132A/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. 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.
- ⁸ The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter.
- ⁹ This scope meets A2LA's *P112 Flexible Scope Policy*.
- ¹⁰ When "ppm" is used on the scope, it refers to parts in 10^6



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Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994, the requirements of ANSI/NCSL Z540.3-2006, and R205 – Specific Requirements: Calibration Laboratory Accreditation Program. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).



Presented this 30th day of April 2021.

A blue ink signature of the Vice President of Accreditation Services.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2171.01
Valid to March 31, 2023
Revised February 28, 2023

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