



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

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CALIBRATION

Valid To: January 31, 2022

Certificate Number: 1888.03

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

I. Acoustical Quantities

Parameter/Equipment	Range	CMC ² (±)	Comments
Sound Measuring Equipment ³ –	74 dB	1.2 dB	General Radio 1986
	84 dB	1.0 dB	General Radio 1986
	94 dB	0.5 dB	Extech 407766
	104 dB	1.0 dB	General Radio 1986
	114 dB	0.51 dB	General Radio 1986
Sound Calibration of Acoustic Calibrators (74 to 130) dB	Frequency: (31.5 to 125) Hz 125 Hz to 10 kHz	0.18 dB 0.10 dB	Bruel & Kjaer system 4160 4192T 3160-A-4/S
Pistonphones – Sound Pressure Level	124 dB & 250 Hz	0.10 dB	Bruel & Kjaer system

II. Chemical

Parameter/Equipment	Range	CMC ² (±)	Comments
pH Measuring Equipment ³	(4, 7, 10) pH	0.02 pH	pH buffer solutions
Conductivity ³ –			
Liquid	10 µS 100 µS 1000 µS 10 000 µS 100 000 µS	0.19 µS 0.87 µS 5 µS 35 µS 350 µS	Reference conductivity solutions
Solid Measuring Equipment	Up to 30 % IACS (>30 to 48) % IACS (>48 to 100) % IACS	1.5 % of value 0.50 % IACS 0.85 % IACS	Reference standard blocks
Standards	(6 to 60) % IACS (60 to 102) % IACS	0.54 % IACS 1.1 % IACS	SigmaScope 350, reference blocks

III. Dimensional

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Gage Blocks	Up to 1 in 2 in 3 in 4 in 5 in 6 in 7 in 8 in 10 in 12 in 16 in 20 in	3.3 µin 4.2 µin 5.4 µin 6.7 µin 8.5 µin 10 µin 12 µin 13 µin 16 µin 19 µin 25 µin 32 µin	By mechanical comparison with master blocks
Calipers ³	Up to 80 in	(200 + 15L) µin	Gage blocks

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Micrometers ³ – Length Only	Up to 6 in (6 to 80) in	(20 + 10L) μin (55 + 13L) μin	Gage blocks
Height Gages ³	Up to 40 in	(55 + 9L) μin	Gage blocks
Bore Gages ³	Up to 6 in	(90 + 12L) μin + 0.58R	Ring gages
Length Indicators ³ (Dal, Test, LVDTs)	Up to 6 in (6 to 12) in	(26 + 3L) μin (26 + 4L) μin + 0.58R	Gage blocks, universal length machines (ULMs)
Rulers and Tapes ³	Up to 72 in (6 to 100) feet	0.004 in 0.000 66 in per ft	Digital length scale
Digital Length Scales ³	Up to 78 in	(120 + 3L) μin	Gage blocks and LVDT
Coating Thickness Gages ³	Up to 665 mils	(0.035 + 0.01M) mils + 0.58R	Master foils M=nominal thickness in mils
Ultrasonic Thickness Gages ³	Up to 10 in	200 μin + 0.58R	Gage blocks
Cylindrical Gages ^{3,10} – OD (Pins, Plugs, Master Disks)	Up to 12 in	(6 + 2L) μin	Universal length machines (ULMs)
Cylindrical Gages – ID Plain Ring Gages	Up to 10 in	(9 + 1.5L) μin	Universal length machines (ULMs)
Thread Wires	(2 to 100) TPI	8 μin	Universal length machines (ULMs)

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Thread Plug Gages ^{3,10} – Pitch Diameter Major Diameter	Up to 10 in Up to 12 in	100 μin (6 + 2L) μin	ULM, thread wires ULM
Thread Ring Gages – Adjustable Fixed Pitch Diameter Minor Diameter	Up to 6 in Up to 6 in Up to 10 in	Set Plug Tolerance 120 μin (9 + 1.5L) μin	Class W thread setting plugs ULM ULM
NPT Tread Plugs – Pitch Diameter Notch Height	Up to 7.5 in (4 to 80 TPI) Up to 2 in	100 μin 300 μin	ULM, thread wires Height gage
NPT Thread Rings – Stand Off	Up to 2 in	0.001 in	Height gage, master set plug
Feeler Gages ³	Up to 1 in	110 μin	OD micrometer
Radius Gages	Up to 5 in	250 μin	Vision machine
Screw Pitch Gages	(3½ to 84) TPI	350 μin	Vision machine

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Depth Micrometer Masters	Up to 24 in	$(45 + 2.5L) \mu\text{in}$	Linear height gage, gage blocks
Length Standards (End rods, Micrometer Setting Standards, Caliper Masters)	Up to 12 in	$(27 + 2L) \mu\text{in}$	ULM
Micrometer Standards	Up to 12 in (>12 to 60) in (>60 to 100) in	$(27 + 2L) \mu\text{in}$ $(100 + 4L) \mu\text{in}$ $(210 + 4L) \mu\text{in}$	ULM CMM CMM
Inspection Fixtures (V-blocks, 1-2-3 blocks, bar parallels, angle squares) – Angle Flatness Perpendicularity Parallelism	Up to 90° Up to 36 in Up to 36 in Up to 36 in	0.0008° 160 μin $(110 + 4L) \mu\text{in}$ $(110 + 4L) \mu\text{in}$	CMM
Straight Edges – Flatness	Up to 59 in (>59 to 100) in	$(90 + 4L) \mu\text{in}$ $(200 + 4L) \mu\text{in}$	CMM
Coating Thickness Foils	Up to 1.5 in	$(12 + 500L) \mu\text{in}$	ULM
Spheres & Balls	Up to 6 in	$(6 + 2L) \mu\text{in}$	ULM
Sine Bars & Plates – Flatness Distance between rolls	Up to 36 in Up to 36 in	100 μin $(90 + 5L) \mu\text{in}$	CMM
Glass Scales, Stage Micrometers & Reticules	Up to 12 in Up to 18 in	$(150 + 8L) \mu\text{in}$ $(190 + 8L) \mu\text{in}$	Vision machine 12x12x8 Vision machine 18x18x8

Parameter/Equipment	Range	CMC ^{2, 4} (\pm)	Comments
Angle Standards	Up to 360°	0.0008°	CMM
Surface Finish Standards (Specimens) ³	(5 to 250) μ in	5.2 μ in	Surface analyzer, master surface finish standard
Surface Finish Testers ³	(5 to 125) μ in	5.2 μ in + 0.58R	Master surface finish standard
Levels	Up to 48 in	300 μ in	Gage blocks
Testing Sieves	(5 to 225) #	150 μ in	Vision machine
Surface Plate ³ – Flatness	12 in \times 12 in to 12 ft \times 12 ft	(20 + 2DL) μ in	Electronic level system DL=diagonal distance Repeat-o-meter
Repeat Reading	12 in \times 12 in to 12 ft \times 12 ft	34 μ in	
Optical Comparator and Vision Machines ³ – X-Y Linearity	Up to 12 in	280 μ in + 0.58R	Glass master
Crimp Tools ³	Go/No Go	0.001 in	Pin gages
	Crimp Height	640 μ in	Crimp micrometer
	Pullout	3.5 lbf	Crimp pull tester
Protractors ³	Up to 90°	0.044°	Angle blocks
	Up to 65°	0.030°	Sine plate & gage blocks

IV. Dimensional Testing¹

Parameter	Range	CMC ^{2, 4, 12} (±)	Comments
Geometry Measurements ⁷	27 in × 39 in × 27 in: Volumetric	(80 + 3.4L) μin	Coordinate measuring machine (CMM), ASME Y 14.5
	59 in x 118 in x 39 in: Volumetric	(110 + 3.6L) μin	Coordinate measuring machine (CMM), ASME Y 14.5
	12 in x 12 in x 8 in: Linear Angular	230 μin 0.0014°	Vision system, ASME Y 14.5
	18 in x 18 in x 8 in: Linear Angular	230 μin 0.0017°	Vision system, ASME Y 14.5
	32 in x 54 in x 29 in: Volumetric	(95 + 3.5L) μin	Coordinate measuring machine (CMM), ASME Y 14.5
	Up to 24 in	(160 + 9L) μin	Linear height gage
	Up to 1 in 300 x 300 x 600 mm	110 μin (0.0045 + L/50) mm	O.D. micrometer Zeiss Metrotom 1500 ASME Y 14.5
Surface Finish ⁶	(5 to 125) μin	5.2 μin	Surface texture tester, surface finish standard

V. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC ^{2, 5, 9} (\pm)	Comments
DC Voltage – Generate ³	Up 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	8.9 μ V/V + 0.8 μ V 8 μ V/V + 1.2 μ V 8 μ V/V + 4 μ V 8 μ V/V + 8 μ V 9 μ V/V + 100 μ V 11 μ V/V + 600 μ V	Fluke 5700A
	(1 to 50) kV	0.15 %	Ross VD60-2
DC Voltage – Measure ³	(0 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V (1 to 60) kV (60 to 240) kV	10 μ V/V + 0.3 μ V 9 μ V/V + 0.3 μ V 9 μ V/V + 5 μ V 11 μ V/V + 30 μ V 11 μ V/V + 100 μ V 0.15 % 0.15 %	Agilent 3458A Ross VD60-2 Ross VPM 240
	DC Current – Generate ³	(0 to 220) μ A 220 μ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (2.2 to 11) A (11 to 20.5) A (2 to 20) A (20 to 120) A (120 to 3000) A	060 μ A/A + 10 nA 60 μ A/A + 10 nA 60 μ A/A + 100 nA 70 μ A/A + 1 μ A 95 μ A/A + 30 μ A 0.036 % + 480 μ A 0.1 % + 750 μ A 90 μ A/A + 0.1 mA 80 μ A/A + 8 mA 0.8 % + 0.08 A
DC Current – Measure ³	(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 3) A (3 to 300) A 300 A to 2 kA (2 to 10) kA	22 μ A/A + 1 nA 22 μ A/A + 5 nA 22 μ A/A + 50 nA 37 μ A/A + 0.5 nA 0.012 % + 10 μ A 0.13 % + 0.6 mA 0.013 % 0.25 % 1.0 %	Agilent 3458A Agilent 34401A Guildline 9211A Empro shunts

Parameter/Equipment	Range	CMC ^{2, 5, 9} (\pm)	Comments
DC Power – Generate ³	(0.01 to 2900) W (>2900 to 20 500) W	0.023 % + 0.083 W 0.07 % + 0.083 W	Fluke 5522A
Resistance – Generate ³	(0 to 11) Ω (11 to 33) Ω (33 to 110) Ω 110 Ω to 1.1 k Ω (1.1k to 11k) Ω (11 to 110) k Ω 110 k Ω 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 (330 to 1100) M Ω (1 to 10) G Ω (10 to 100) G Ω	40 $\mu\Omega/\Omega$ + 1 m Ω 30 $\mu\Omega/\Omega$ + 1.5 m Ω 28 $\mu\Omega/\Omega$ + 1.4 m Ω 28 $\mu\Omega/\Omega$ + 2 m Ω 28 $\mu\Omega/\Omega$ + 20 m Ω 28 $\mu\Omega/\Omega$ + 0.2 Ω 32 $\mu\Omega/\Omega$ + 2 Ω 60 $\mu\Omega/\Omega$ + 30 Ω 0.013 % + 50 Ω 0.025 % + 2.5 k Ω 0.05 % + 3 k Ω 0.3 % + 100 k Ω 1.5 % + 500 k Ω 0.51 % 1.1 %	Fluke 5522A Biddle 72-6345-4 Biddle 72-6345-4
Fixed Points ³	0.333 m Ω 1.0 m Ω 10.0 m Ω 100.0 m Ω 1 Ω 0 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	0.013 % 50 $\mu\Omega/\Omega$ 50 $\mu\Omega/\Omega$ 50 $\mu\Omega/\Omega$ 50 $\mu\Omega/\Omega$ 50 $\mu\Omega$ 0.011 % 0.011 % 33 $\mu\Omega/\Omega$ 31 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$ 20 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$ 14 $\mu\Omega/\Omega$ 14 $\mu\Omega/\Omega$ 16 $\mu\Omega/\Omega$ 16 $\mu\Omega/\Omega$ 23 $\mu\Omega/\Omega$ 24 $\mu\Omega/\Omega$ 46 $\mu\Omega/\Omega$ 55 $\mu\Omega/\Omega$ 0.013 %	Guildline 9211A L&N Resistor L&N Resistor L&N Resistor L&N Resistor Fluke 5700

Parameter/Equipment	Range	CMC ^{2, 5, 9} (\pm)	Comments
Resistance – Measure ³	(0 to 10) Ω (10 to 100) Ω (100 to 100) k Ω 100 k Ω to 1 M Ω (1 to 10) M Ω (10 to 100) M Ω 100 M Ω to 1 G Ω	20 $\mu\Omega/\Omega$ + 50 $\mu\Omega$ 15 $\mu\Omega/\Omega$ + 500 $\mu\Omega$ 13 $\mu\Omega/\Omega$ + 500 $\mu\Omega$ 18 $\mu\Omega/\Omega$ + 2 Ω 53 $\mu\Omega/\Omega$ + 100 Ω 0.06 % + 1 k Ω 0.5 % + 10 k Ω	Agilent 3458A
Capacitance – Generate ³	(0.19 to 3.3) nF (3.3 to 330) nF 330 nF to 3.3 μ F (3.3 to 33) μ F (33 to 330) μ F 330 μ F to 3.3 mF (3.3 to 33) mF (33 to 110) mF	0.5 % + 0.01 nF 0.25 % + 0.3 nF 0.20 % + 3 nF 0.40 % + 30 nF 0.45 % + 300 nF 0.45 % + 3 μ F 0.75 % + 30 μ F 0.66 % + 100 μ F	Fluke 5522A
Capacitance – Generate ³ Fixed Points ³	(10 to 1.1) μ F (50 to 1100) μ F (0.001, 0.01, 0.1) μ F 1 μ F	0.07 % 1.8 % 0.16 %	Quad Tech 1413 GR 1422-CB air cap GR 1409 series
Capacitance – Measure, at 1 kHz ³	(Up to 10) pF (>10 to 100) pF (>100 pF to 1) μ F (1 to 1120) μ F	6.9 μ F/F 6.0 μ F/F 7.1 μ F/F 0.03 %	Andeen Hagerling 2500A GR 1689

Parameter/Range	Frequency	CMC ^{2, 5, 9} (\pm)	Comments
Inductance – Generate ³ 1.0 mH 1 mH 10.0 mH 100 mH	400 Hz 1 kHz 1 kHz 1 kHz	0.12 % 0.12 % 0.10 % 0.10 %	GR 1482-E GR1482-H GR1482-L

Parameter/Equipment	Range	CMC ^{2,9} (±)	Comments
Inductance – Measure, at 1 kHz ³	1 μH to 100 H	0.34 mH/H	GR 1689
Electrical Calibration of Thermocouple Indicators ³ –			
Type B	(600 to 800) °C (800 to 1000) °C (1000 to 1550) °C (1550 to 1800) °C	0.49 °C 0.40 °C 0.36 °C 0.31 °C	Fluke 5522A
Type C	(0 to 150) °C (150 to 650) °C (650 to 1000) °C (1000 to 1800) °C (1800 to 2316) °C	0.28 °C 0.23 °C 0.28 °C 0.45 °C 0.73 °C	
Type E	(-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C	0.05 °C 0.15 °C 0.13 °C 0.16 °C 0.20 °C	
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C	0.32 °C 0.15 °C 0.13 °C 0.17 °C 0.22 °C	
Type K	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C	0.30 °C 0.17 °C 0.15 °C 0.23 °C 0.35 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple Indicators ³ – (cont)			
Type L	(-200 to -100) °C (-100 to 800) °C (800 to 900) °C	0.43 °C 0.31 °C 0.20 °C	Fluke 5522A
Type N	(-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1300) °C	0.36 °C 0.20 °C 0.18 °C 0.17 °C 0.25 °C	
Type R	(0 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1767) °C	0.56 °C 0.33 °C 0.31 °C 0.36 °C	
Type S	(0 to 250) °C (250 to 1000) °C (1000 to 1400) °C (1400 to 1767) °C	0.55 °C 0.35 °C 0.33 °C 0.40 °C	
Type T	(-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.56 °C 0.22 °C 0.15 °C 0.13 °C	
Type U	(-200 to 0) °C (0 to 600) °C	0.65 °C 0.32 °C	

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of RTDs ³ –			
Pt 385, 100 Ω	(-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 630) °C (630 to 800) °C	0.063 °C 0.083 °C 0.1 °C 0.12 °C 0.25 °C	Fluke 5522A
Pt 3926, 100 Ω	(-200 to 0) °C (0 to 300) °C (300 to 630) °C	0.06 °C 0.1 °C 0.12 °C	
Pt 3916, 100 Ω	(-200 to -190) °C (-190 to 0) °C (0 to 260) °C (260 to 600) °C (600 to 630) °C	0.29 °C 0.07 °C 0.08 °C 0.1 °C 0.27 °C	
Pt 385, 200 Ω	(-200 to 260) °C 260 °C to 630 °C	0.06 °C 0.17 °C	
Pt 385, 500 Ω	(-200 to 260) °C (260 to 400) °C (400 to 630) °C	0.06 °C 0.09 °C 0.11 °C	
Pt 385, 1000 Ω	(-200 to 260) °C (260 to 600) °C (600 to 630) °C	0.05 °C 0.08 °C 0.26 °C	
Ni 120, 120 Ω	(-80 to 100) °C (100 to 260) °C	0.09 °C 0.16 °C	
Cu 427 10 Ω	(-100 to 260) °C	0.35 °C	

Parameter/Range	Frequency	CMC ^{2, 5, 9} (±)	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	0.06 % + 5 μV 0.024 % + 5 μV 0.012 % + 5 μV 0.041 % + 5 μV 0.095 % + 8 μV 0.13 % + 15 μV 0.18 % + 30 μV 0.36 % + 30 μV	Fluke 5700A
(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	0.06 % + 6 μV 0.024 % + 6 μV 0.012 % + 6 μV 0.041 % + 6 μV 0.095 % + 8 μV 0.13 % + 15 μV 0.18 % + 30 μV 0.36 % + 30 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	0.06 % + 16 μV 0.024 % + 10 μV 0.011 % + 10 μV 0.036 % + 10 μV 0.090 % + 30 μV 0.11 % + 30 μV 0.18 % + 40 μV 0.36 % + 100 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	0.06 % + 100 μV 0.018 % + 30 μV 0.0085 % + 7 μV 0.014 % + 20 μV 0.028 % + 80 μV 0.048 % + 150 μV 0.12 % + 400 μV 0.24 % + 1 mV	
(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	0.06 % + 1.0 mV 0.018 % + 0.3 mV 0.0085 % + 0.07 mV 0.014 % + 0.2 mV 0.028 % + 0.4 mV 0.06 % + 1.7 mV 0.14 % + 5 mV 0.30 % + 9 mV	

Parameter/Range	Frequency	CMC ^{2, 5, 9} (\pm)	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 (500 to 1000) kHz	0.06 % + 10 mV 0.018 % + 3 mV 0.009 % + 1 mV 0.025 % + 4 mV 0.06 % + 10 mV 0.16 % + 110 mV 0.54 % + 110 mV 1.3 % + 220 mV	Fluke 5700A w/5725A
(220 to 1100) V	40 Hz to 1 kHz (1 to 20) kHz (20 to 30) kHz (20 to 50) kHz (50 to 100) kHz	0.009 % + 4 mV 0.017 % + 6 mV 0.060 % + 11 mV 0.060 % + 11 mV 0.23 % + 45 mV	Ross VD60-2
(1 to 50) kV	60 Hz	0.58 %	
AC Voltage – Measure ³			
(0 to 2.2) mV	(1 to 10) Hz (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	0.38 mV/V + 3.5 μ V 1.3 mV/V + 1.0 μ V 0.61 mV/V + 1.0 μ V 0.38 mV/V + 1.0 μ V 0.66 mV/V + 1.6 μ V 0.96 mV/V + 1.9 μ V 1.8 mV/V + 3.1 μ V 1.9 mV/V + 6.2 μ V 3 mV/V + 6.2 μ V	Agilent 3458A Or Fluke 5790B
(2.2 to 7) mV	(1 to 10) Hz (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	0.38 mV/V + 3.5 μ V 0.66 mV/V + 1.0 μ V 0.30 mV/V + 1.0 μ V 0.18 mV/V + 1.0 μ V 0.32 mV/V + 1.6 μ V 0.47 mV/V + 1.9 μ V 0.95 mV/V + 3.1 μ V 1 mV/V + 6.2 μ V 1.6 mV/V + 6.2 mV	

Parameter/Range	Frequency	CMC ^{2, 5, 9} (\pm)	Comments
AC Voltage – Measure ³ (cont)			
(7 to 22) mV	(1 to 10) Hz (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	0.16 mV/V + 4.6 μ V 0.24 mV/V + 1.0 μ V 0.16 mV/V + 1.0 μ V 94 μ V/V + 1.0 μ V 0.17 mV/V + 1.6 μ V 0.25 mV/V + 1.9 μ V 0.66 mV/V + 3.1 μ V 0.73 mV/V + 6.2 μ V 1.4 mV/V + 6.2 μ V	Agilent 3458A Or Fluke 5790B
(22 to 70) mV	(1 to 10) Hz (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	0.16 mV/V + 4.6 μ V 0.15 mV/V + 5.0 μ V 0.11 mV/V + 1.2 μ V 73 μ V/V + 1.2 μ V 0.12 mV/V + 1.6 μ V 0.25 mV/V + 1.9 μ V 0.48 mV/V + 3.1 μ V 0.63 mV/V + 6.2 μ V 0.95 mV/V + 6.2 μ V	
(70 to 200) mV	(1 to 10) Hz (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	0.10 mV/V + 46 μ V 0.15 mV/V + 5.0 μ V 70 μ V/V + 1.2 μ V 35 μ V/V + 1.2 μ V 67 μ V/V + 1.6 μ V 0.15 mV/V + 1.9 μ V 0.23 mV/V + 3.1 μ V 0.32 mV/V + 6.2 μ V 0.81 mV/V + 6.2 μ V	
(200 to 700) mV	(1 to 10) Hz (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	0.10 mV/V + 46 μ V 0.11 mV/V + 24 μ V 69 μ V/V + 1.2 μ V 28 μ V/V + 1.2 μ V 45 μ V/V + 1.6 μ V 65 μ V/V + 1.9 μ V 0.17 mV/V + 3.1 μ V 0.24 mV/V + 6.2 μ V 0.76 mV/V + 6.2 μ V	

Parameter/Range	Frequency	CMC ^{2, 5, 9} (\pm)	Comments
AC Voltage – Measure ³ (cont)			
(0.7 to 1) V	(1 to 10) Hz (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	0.10 mV/V + 46 μ V 0.11 mV/V + 24 μ V 62 μ V/V 22 μ V/V 42 μ V/V 60 μ V/V 0.16 mV/V 0.22 mV/V 0.71 mV/V	Agilent 3458A or Fluke 5790B
(1 to 2) V	(100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz (1 to 10) Hz (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	0.16 mV/V 0.22 mV/V 0.71 mV/V 99 μ V/V + 0.46 mV 0.11 mV/V + 24 μ V 62 μ V/V 22 μ V/V 42 μ V/V 60 μ V/V 0.16 mV/V 0.22 mV/V 0.71 mV/V	
(2 to 7) V	(1 to 10) Hz (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	99 μ V/V + 0.46 mV 0.13 mV/V + 0.20 mV 57 V/V 20 μ V V/V 43 μ V V/V 64 μ V V/V 0.17 mV/V 0.32 mV/V 0.96 mV/V	
(7 to 10) V	(1 to 10) Hz (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	99 μ V/V + 0.46 mV 0.13 mV/V + 0.20 mV 57 μ V V/V 24 μ V V/V 39 μ V/V 65 μ V/V 0.17 mV/V 0.32 mV/V 0.96 mV/V	

Parameter/Range	Frequency	CMC ^{2, 5, 9} (\pm)	Comments
AC Voltage – Measure ³ (cont)			
(10 to 20) V	(1 to 10) Hz (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	0.24 mV/V + 4.6 mV 0.13 mV/V + 0.20 mV 57 μ V V/V 24 μ V V/V 39 μ V/V 65 μ V/V 0.17 mV/V 0.32 mV/V 0.96 mV/V	Agilent 3458A or Fluke 5790B
(20 to 70) V	(1 to 10) Hz (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	0.24 mV/V + 4.6 mV 0.12 mV/V + 2.4 mV 57 μ V V/V 28 μ V/V 54 μ V/V 75 μ V/V 0.17 mV/V 0.33 mV/V 0.96 mV/V	
(70 to 100) V	(1 to 10) Hz (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	0.24 mV/V + 4.6 mV 0.12 mV/V + 2.4 mV 58 μ V/V 28 μ V/V 56 μ V/V 79 μ V/V 0.18 mV/V 0.40 mV/V 8.1 mV/V + 2.4 mV	
(100 to 200) V	(1 to 10) Hz (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	0.47 mV/V + 46 mV 0.12 mV/V + 2.4 mV 58 μ V/V 28 μ V/V 56 μ V/V 79 μ V/V 0.18 mV/V 0.40 mV/V 8.1 mV/V + 2.4 mV	

Parameter/Range	Frequency	CMC ^{2, 5, 9} (\pm)	Comments
AC Voltage – Measure ³ (cont)			
(10 to 20) V	(1 to 10) Hz (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	0.24 mV/V + 4.6 mV 0.12 mV/V + 2.4 mV 57 μ V/V 28 μ V/V 54 μ V/V 75 μ V/V 0.17 mV/V 0.33 mV/V 0.96 mV/V	Agilent 3458A or Fluke 5790B
(70 to 100) V	(1 to 10) Hz (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	0.24 mV/V + 4.6 mV 0.12 mV/V + 2.4 mV 58 μ V/V 28 μ V/V 56 μ V/V 79 μ V/V 0.18 mV/V 0.40 mV/V 8.1 mV/V + 2.4 mV	
(100 to 200) V	(1 to 10) Hz (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	0.47 mV/V + 46 mV 0.12 mV/V + 2.4 mV 58 μ V/V 28 μ V/V 56 μ V/V 79 μ V/V 0.18 mV/V 0.40 mV/V 8.1 mV/V + 2.4 mV	
(200 to 700) V	(1 to 10) Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.16 mV/V + 80 mV 0.12 mV/V + 25 mV 80 μ V/V 37 μ V/V 0.11 mV/V 0.39 mV/V	

Parameter/Range	Frequency	CMC ^{2, 5, 9} (\pm)	Comments
AC Voltage – Measure ³ (cont)			
(700 to 1000) V	(1 to 10) Hz (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	0.16 mV/V + 80 mV 0.12 mV/V + 25 mV 80 μ V/V 39 μ V/V 0.11 mV/V 0.39 mV/V	Agilent 3458A or Fluke 5790B
(1 to 42) kV	60 Hz	0.58 %	Ross VD60-2
(42 to 170) kV	60 Hz	0.58 %	Ross VPM 240
AC Current – Generate ³			
(0 to 220) μ A	(10 to 20) Hz (20 to 40) Hz (0.40 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.08 % rdg + 30 nA 0.042 % rdg + 25 nA 0.016 % rdg + 20 nA 0.07 % rdg + 50 nA 0.18 % rdg + 100 nA	Fluke 5700
220 μ A to 2.2 mA	(10 to 20) Hz (20 to 40) Hz (0.40 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.08 % rdg + 50 nA 0.042 % rdg + 40 nA 0.016 % rdg + 40 nA 0.07 % rdg + 0.5 μ A 0.18 % rdg + 1 μ A	
(2.2 to 22) mA	(10 to 20) Hz (20 to 40) Hz (0.40 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.08 % rdg + 0.5 μ A 0.042 % rdg + 0.4 μ A 0.016 % rdg + 0.4 μ A 0.07 % rdg + 5 μ A 0.18 % rdg + 10 μ A	
(22 to 220) mA	(10 to 20) Hz (20 to 40) Hz (0.40 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.08 % rdg + 5 μ A 0.042 % rdg + 4 μ A 0.018 % rdg + 4 μ A 0.07 % rdg + 4 μ A 0.18 % rdg + 100 μ A	
220 mA to 2.2 A	(40 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.075 % rdg + 40 μ A 0.085 % rdg + 100 μ A 1.00 % rdg + 200 μ A	

Parameter/Range	Frequency	CMC ^{2,5,9} (±)	Comments
AC Current – Generate ³ (cont)			
(2.2 to 11) A	(40 to 1) kHz (1 to 5) kHz (5 to 10) kHz	0.046 % rdg + 0.17 mA 0.095 % rdg + 0.38 mA 0.36 % rdg + 0.7 mA	Fluke 5700
(11 to 20.5) A	(45 to 100) Hz (0.1 to 5) kHz	1.0 % rdg + 500 mA 2.5 % rdg + 500 mA	Fluke 5522A
(20.5 to 120) A	(10 to 65) Hz (65 to 300) Hz (0.3 to 1.0) kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	0.014 % + 19 mA 0.024 % + 28 mA 0.078 % + 94 mA 0.23 % + 230 mA 0.76 % + 420 mA 3.1 % + 700 mA	Fluke 52120A
(20.5 to 3000) A	(16 to 850) Hz (0.85 to 6) kHz	0.7 % + 0.84 A 0.8 % + 0.84 A	Fluke 52120A/coil
Clamp-On Only (20.5 to 1025) A	(45 to 65) Hz (65 to 440) Hz	0.8 % 0.99 %	Fluke 5522A w/Fluke 50-turn coil

Parameter/Range	Frequency	CMC ^{2, 5, 9} (±)	Comments
AC Current – Measure ³			
(5 to 100) µA	(10 to 20) Hz (20 to 45) Hz 45 Hz to 5 kHz	0.45 % rdg + 0.03 % rng 0.18 % rdg + 0.03 % rng 0.08 % rdg + 0.04 % rng	Agilent 3458A
(1, 10, 100) mA	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.41 % rdg + 0.02 % rng 0.16 % rdg + 0.02 % rng 0.07 % rdg + 0.02 % rng 0.04 % rdg + 0.02 % rng 0.07 % rdg + 0.03 % rng 0.42 % rdg + 0.04 % rng 0.56 % rdg + 0.16 % rng	Agilent 3458A
1 A	(10 to 20) Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz	0.42 % rdg + 0.02 % rng 0.16 % rdg + 0.02 % rng 0.10 % rdg + 0.02 % rng 0.12 % rdg + 0.02 % rng 0.35 % rdg + 0.02 % rng 1.12 % rdg + 0.02 % rng	Agilent 3458A
3 A	(3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	1.2 % rdg + 0.06 % rng 0.37 % rdg + 0.06 % rng 0.17 % rdg + 0.06 % rng	HP 34401A
3 A to 1 kA	45 Hz to 5 kHz	0.8 %	AEMC clamp-on meter
(1 to 10) kA	10 Hz to 20 kHz	1.0 % + 3 A	AEMC Flex Clamp
AC Power – Generate ³			
(0.01 to 0.1) W (0.1 to 890) W (0.89 to 3) kW (3 to 20.5) kW (20.5 to 120) kW	(45 to 65) Hz; PF = 1	0.23 % 0.13 % 0.13 % 0.13 % 0.10 %	Fluke 5522A

Parameter/Range	Frequency	CMC ^{2,9} (±)	Comments
Oscilloscopes ³ –			
DC			
50 Ω	(0 to +/- 6.6) V	0.26 % + 40 μV	Fluke 5522A/SC1100
1 MΩ	(0 to +/- 130) V	0.06 % + 40 μV	
Square Wave			
50 Ω	(0 to +/- 6.6) V	0.26 % + 40 μV	
1 MΩ	10 Hz to 10 kHz (0 to +/- 130) V 10 Hz to 10 kHz	0.2 % + 40 μV	
Level Sine Wave			
Amplitude (50 kHz Reference)	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	2.0 % + 300 μV 2.5 % + 300 μV 5.0 % + 300 μV 6.0 % + 300 μV	
Flatness (50 kHz Reference)	50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz (600 to 1100) MHz	2.0 % + 100 μV 3.0 % + 100 μV 5.0 % + 100 μV 6.0 % + 100 μV	
Time Marker	1 ns to 20 ms 50 ms to 5 s	3 μs/s (30 + 1000t) μs/s	<i>t</i> = time in seconds
Phase Angle – Sine Wave			
(0 to 360)°	1 Hz to 1 kHz (1 to 6.5) kHz (6.5 to 50) kHz (50 to 100) kHz	7.0 m° 14 m° 30 m° 59 m°	Clark-Hess 5000

VI. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2, 5, 9} (±)	Comments
RF Power – Measure ³ (-70 to -20) dBm	(10 to 30) MHz (0.03 to 4) GHz (4 to 6) GHz (6 to 10) GHz (10 to 12) GHz (12 to 14) GHz (14 to 15) GHz (15 to 18) GHz	0.8 % 0.8 % 0.9 % 1.0 % 1.0 % 1.0 % 1.0 % 1.1 %	HP 8484A w/ power meter
RF Attenuation ³ – Measure (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 (70 to 80) dB (80 to 90) dB (90 to 100) dB (100 to 110) dB (110 to 120) dB	100 kHz to 1.3 GHz	0.064 dB 0.067 dB 0.069 dB 0.082 dB 0.10 dB 0.10 dB 0.11 dB 0.11 dB 0.14 dB 0.14 dB 0.15 dB 0.22 dB	HP 8902A w/ 11722A

Parameter/Range	Frequency	CMC ^{2, 5, 9} (±)	Comments
Amplitude Modulation – Measure ³			HP 8902A
Rate: 50 Hz to 10 kHz Depth: (5 to 99) %	(0.15 to 10) MHz	2.4 %	
Rate: 20 Hz to 10 kHz Depth: (5 to 99) %	(0.15 to 10) MHz	3.5 %	
Rate: 20 Hz to 100 kHz Depth: (5 to 99) %	(1.3 to 1.6) GHz	3.5 %	
Rate: 50 Hz to 50 kHz Depth: (5 to 99) %	(1.3 to 26.5) GHz	3.5 %	
Rate: 20 Hz to 100 kHz Depth: (5 to 99) %	(1.3 to 26.5) GHz	3.5 %	
Frequency Modulation – Measure ³			HP8902A
Rate: 20 Hz to 10 kHz Dev: ≤ 40 kHz peak	(0.15 to 10) MHz	2.6 %	
Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz peak	(0.01 to 1.3) GHz	1.3 %	
Rate: 20 Hz to 200 kHz Dev: ≤ 4.0 kHz peak	(0.01 to 1.3) GHz	5.9 %	
Rate: 50 Hz to 100 kHz Dev: ≤ 400 kHz peak	(1.3 to 26.5) GHz	3.7 %	
Rate: 20 Hz to 200 kHz Dev: ≤ 400 kHz peak	(1.3 to 26.5) GHz	3.7 %	
Phase Modulation – Measure ³			HP8902A
Rate: (0.1 to 20) kHz	150 kHz to 1.3 GHz	3.7 %	
Rate: (0.1 to 20) kHz	(1.3 to 26.5) GHz	3.7 %	

Parameter/Range	Frequency	CMC ^{2,9} (±)	Comments
RF Power – Generate ³			
(20 to 24) dBm (14 to 20) dBm (-17 to +14) dBm (-48 to -17) dBm (-74 to -48) dBm (-84 to -74) dBm (-94 to -84) dBm	(0.01 to 100) kHz	0.039 dBm 0.039 dBm 0.039 dBm 0.039 dBm 0.039 dBm 0.21 dBm 0.51 dBm	Fluke 96270A/LL/FF w/ leveling head
(20 to 24) dBm (14 to 20) dBm (-17 to +14) dBm (-48 to -17) dBm (-74 to -48) dBm (-84 to -74) dBm (-94 to -84) dBm	(0.01 to 10) MHz	0.065 dBm 0.065 dBm 0.065 dBm 0.065 dBm 0.21 dBm 0.51 dBm 0.51 dBm	
(20 to 24) dBm (0 to 20) dBm (-48 to 0) dBm (-54 to -48) dBm (-64 to -54) dBm (-74 to -64) dBm (-84 to -74) dBm (-94 to -84) dBm (-104 to -94) dBm (-114 to -104) dBm (-119 to -114) dBm (-129 to -119) dBm	(10 to 128) MHz	0.068 dBm 0.068 dBm 0.068 dBm 0.068 dBm 0.14 dBm 0.14 dBm 0.38 dBm 0.60 dBm 0.84 dBm 0.84 dBm 0.84 dBm 0.84 dBm	
(14 to 20) dBm (+ 4 to + 14) dBm (-48 to + 4) dBm (-54 to -48) dBm (-74 to -54) dBm (-84 to -74) dBm (-94 to -84) dBm (-119 to -94) dBm (-129 to -119) dBm	(128 to 300) MHz	0.089 dBm 0.089 dBm 0.089 dBm 0.14 dBm 0.14 dBm 0.38 dBm 0.60 dBm 1.5 dBm 1.5 dBm	

Parameter/Range	Frequency	CMC ^{2,9} (±)	Comments
RF Power – Generate ³ (cont)			
(-48 to 20) dBm (-74 to -48) dBm (-84 to -74) dBm (-94 to -84) dBm (-104 to -94) dBm (-114 to -104) dBm (-119 to -114) dBm (-129 to -119) dBm	(0.1 to 1.4) GHz	0.25 dB 0.50 dB 0.60 dB 1.2 dB 1.5 dBm 1.5 dBm 1.5 dBm 1.5 dBm	Fluke 96270A/LL/FF w/ leveling head
(-48 to +14) dBm (-64 to -48) dBm (-74 to -64) dBm (-94 to -74) dBm	(1.4 to 3) GHz	0.37 dBm 0.50 dBm 0.64 dBm 0.11 dBm	
(-17 to +14) dBm (-48 to -17) dBm (-64 to -48) dBm (-74 to -64) dBm (-84 to -74) dBm (-94 to -84) dBm	(3 to 4) GHz	0.37 dBm 0.37 dBm 0.50 dBm 0.64 dBm 0.11 dBm 0.11 dBm	
(-35 to +20) dBm (-35 to +20) dBm (-35 to +20) dBm (-35 to +20) dBm (-35 to +20) dBm (-35 to +20) dBm (-35 to +20) dBm	DC to 100 MHz > 100 MHz to 2.4 GHz (>2.4 to 8.0) GHz (>8.0 to 12.4) GHz (>12.4 to 18.0) GHz (>18.0 to 26.5) GHz (>26.5 to 40.0) GHz	0.041 dB 0.048 dB 0.053 dB 0.061 dB 0.085 dB 0.10 dB 0.13 dB	Fluke 96270A/LL/FF w/ NRP4OT
RF Level Linearity ³ (-3 to +21) dBm	50 MHz Ref Level 0 dBm	0.02 dBm	Fluke 96270A/LL/FF w/ NRP4OT

Parameter/Range	Frequency	CMC ^{2,9} (±)	Comments
RF Power – Measure ³ (-30 to +20) dBm	DC to 100 MHz > 100 MHz to 2.4 GHz (> 2.4 to 8) GHz (> 8 to 12.4) GHz (> 12.4 to 18) GHz (> 18 to 26.5) GHz	0.069 dBm 0.069 dBm 0.092 dBm 0.11 dBm 0.14 dBm 0.15 dBm	Fluke 96270A/LL/FF w/ NRP4OT

VII. Fluid Quantities

Parameter/Equipment	Range	CMC ² (±)	Comments
Gas Flow – Nitrogen Gas	(5 to 100) sccm (50 to 1000) sccm (3 to 50) slm (10 to 120) slm (45 to 600) slm	0.2% rdg + 0.005 sccm 0.2 % rdg + 0.05 sccm 0.2 % rdg + 0.002 slm 0.2 % rdg 0.2 % rdg	Molbox1, Druck DP1740
Air Velocity ³ – Anemometers, Vane, Thermal, Pitot, Style & Similar Equipment.	(0.5 to 5) m/sec (5 to 40) m/sec	(1 % + 0.008) m/sec (1 % + 0.008) m/sec	Wind tunnel
Liquid Flow Meters ³	(0.2 to 600) gpm	2 % gpm	Comparison to master flow meters

VIII. Magnetic Quantities

Parameter/Equipment	Range	CMC ^{2,9} (±)	Comments
Magnetic Flux Density – Fixed Points ³	-2.0 G 2.0 G -5.0 G 5.0 G -10 G 10 G 20 G -20 G 50 G 100 G 500 G 1000 G 5000 G	0.087 G 0.087 G 0.12 G 0.12 G 0.37 G 0.37 G 0.54 G 0.54 G 0.56 G 1.2 G 6.1 G 8 G 36 G	Reference magnets

IX. Mechanical

Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
Accelerometers	(5 to 9) Hz (10 to 99) Hz 100 Hz (101 to 920) Hz (921 to 5000) Hz (5000 to 10 000) Hz (10 000 to 15 000) Hz (15 000 to 20 000) Hz	1.9 % 1.5 % 0.93 % 1.1 % 1.5 % 2.0 % 2.3 % 2.9 %	Secondary std. reference and air bearing shaker table
Universal Testing Machines, Compression Testing Machines and Tension Testing Machines ³	(0.2 to 600) lbf Up to 600 000) lbf	0.04 % + 0.58R 0.4 % + 0.58R	Deadweights load cells; The range for testing machines in tension is only to 60 000 lbf. ASTM E4
Extensometers ³	Up to 2 in	0.00014 in	ASTM E83
COD Gages	Up to 2 in	0.00014 in	ASTM E399, E1820

Parameter/Equipment	Range	CMC ^{2, 4, 5, 12} (\pm)	Comments
Calibration of Force Gages, Load Cells, Dynamometers & Cable Tensiometers ³	Up to 600 lbf (0 to 500) lbf (0 to 1 000) lbf (0 to 10 000) lbf (0 to 30 000) lbf (0 to 100 000) lbf	0.02 % + 0.58R 0.3 lbf 4 lbf 13 lbf 5 lbf 40 lbf	Comparison to Class F weights Master load cells
Vacuum Gages and Transducers ³	Up to 28 inHg	0.02 % + 0.58R	DH Instruments PPC2+; gage pressure only, not absolute
Pressure Gages and Transducers ³ –			
Hydraulic ³	Up to 15 000 psi	0.15 % + 0.58R	Ametek DMT150 deadweight tester
Hydraulic	Up to 40 000 psi	0.05 % + 0.58R	Ruska 580EHX
Pneumatic ³	Up to 1000 psi	0.025 % + 0.58R	DH Instruments PPC2+
Pneumatic ³	Up to 30 psia	0.01 % + 0.58R	DH Instruments PPC3
Pneumatic ³	Up to 3000 psi	0.70 psi + 0.58R	Fluke PM200-G250M Transducer
Torque ³ –			
Wrenches	20 in·ozf to 2000 ft·lbf	0.8 %	CDI Datatest 950-DT
Analyzers	(0 to 24 000) in·lbf	0.10 % + 0.58R	Torque arm/wheel w/ deadweights
RPM ³ – Measure	(0 to 4999.9) RPM (5000 to 7999.9) RPM (8000 to 9999.9) RPM (10 000 to 35 000) RPM	0.02 % + 0.1 RPM 0.02 % + 0.2 RPM 0.02 % + 0.5 RPM 0.02 % + 1.0 RPM	Frequency counter, LED

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Torque ³ – Guns, Drivers, Screwdrivers	(0 to 250) Nm	0.40 % + 0.58R	Standard transducers
Calibration of Mass	(1, 2, 5, 10, 20) mg (50, 100, 200, 500) mg (1, 2, 5, 10, 20) g (50,100, 200) g 500 g 1 kg 2 kg (5, 10) kg 20 kg (1, 2) lb 5 lb (10, 20) lb 50 lb 100 lb	8 µg 8 µg 8 µg 0.18 mg 0.29 mg 0.52 mg 1.0 mg 8.0 mg 12 mg 0.35 mg 1.0 mg 8 mg 11 mg 19 mg	Comparison to Class 1 weights
Calibration of Scales and Balances ³	(1, 2, 5, 10, 20) mg (50, 100, 200, 500) mg (1, 2, 5) g (10, 20) g 50 g to 10 kg (1 to 20) lb (1 to 1200) lb	30 µg + 0.58R 30 µg + 0.58R 50 µg + 0.58R 0.001 % + 0.58R 0.0005 % + 0.58R 0.0002 % + 0.58R 0.012 % + 0.58R	Comparison to Class 1 weights Comparison to Class F weights

Parameter/Equipment	Range	CMC ² (±)	Comments
Durometer Calibration: (A, B, C, D, DO, E, M, O, OO, OOO)			ASTM D2240
Indenter Extension and Shape –			
Extension	Up to 0.2 in	340 μin	Optical inspection under magnification
Diameter	Diameter of the base of the frustrum: 0.5 in	340 μin	
	Diameter of the top of the frustrum: 0.5 in	340 μin	
	Diameter of the base of the cone: 0.5 in	340 μin	
Angle			
35° Right Circular Conical Frustrum	Cone angle	0.012°	
30° cone	Cone angle	0.012°	
Radius	Tip radius: 0.25 in	340 μin	
Indenter Display	Indenter thickness Indenter radius	240 μin 240 μin	
Spring Calibration – Force	(0 to 100) duro units (0 to 5000) gf	0.089 duro units 0.6 gf	Balance or electronic force cell

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Verification of Rockwell Hardness and Rockwell Superficial Hardness Tester ³	HRA:		Indirect Verification per ASTM E18
	Low	0.22 HRA	
	Medium	0.30 HRA	
	High	0.19 HRA	
	HRBW:		
	Low	0.47 HRBW	
	Medium	0.46 HRBW	
	High	0.34 HRBW	
	HRC:		
	Low	0.33 HRC	
	Medium	0.37 HRC	
	High	0.25 HRC	
	HRE:		
	Low	0.17 HRE	
Medium	0.13 HRE		
High	0.14 HRE		
HR15N:			
Low	0.32 HR15N		
Medium	0.12 HR15N		
High	0.17 HR15N		
HR15TW:			
Low	0.49 HR15TW		
Medium	0.25 HR15TW		
High	0.43 HR15TW		
HR15YW:			
Low	0.75 HR15YW		
High	0.70 HR15YW		
HR30N:			
Low	0.26 HR30N		
Medium	0.27 HR30N		
High	0.17 HR30N		
HR30TW:			
Low	0.49 HR30TW		
Medium	0.46 HR30TW		
High	0.46 HR30TW		
HR30YW:			
Low	0.94 HR30YW		
High	0.78 HR30YW		

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Verification of Rockwell Hardness and Rockwell Superficial Hardness Tester ³	HR45N: Low Medium High HR45TW: Low Medium High HR45YW: Low High	0.24 HR45N 0.31 HR45N 0.20 HR45N 0.35 HR45TW 0.49 HR45TW 0.35 HR45TW 0.77 HR45YW 0.68 HR45YW	Indirect Verification per ASTM E18
Indirect Verification of Microindentation Hardness Testers (Knoop and Vickers) ³	(100 to 250) HK (250 to 650) HK >650 HK (100 to 900) HV	9.2 HK 9.3 HK 24 HK 7.6 HV	Indirect verification method per ASTM E92
Indirect Verification of Brinell Hardness Testers at Test Conditions ³ – 10/3000/15 10/1500/15 10/500/15	(100 to 199) HBW (200 to 399) HBW (400 to 600) HBW	1.7 HBW 3.3 HBW 5.2 HBW	Indirect verification method per ASTM E10

X. Optical Quantities

Parameter/Equipment	Range	CMC ^{2,4,5} (±)	Comments
Gloss Meters ³	Up to 100 GU	0.74 GU + 0.58R	Gloss standards
Light – Measure White Black @ 365 nm	(0 to 3000) FC (0 to 42 000) lux (0 to 100 000) La (0 to 3000) μW/cm ²	2.9 % 2.9 % 2.9 % 4.5 %	Radiometer standards

XI. Thermodynamics

Parameter/Equipment	Range	CMC ^{2, 4, 12} (\pm)	Comments
Temperature Measuring Equipment ³ , Liquid in Glass Thermometers Dial, Surface, RTDs, PRT's, Thermocouples	-196 °C to 650 °C	0.025 °C + 0.58R	Master PRT display with probe, temperature bath
	650 °C to 1200 °C	0.5 °C + 0.58R	Block calibrations with master TC
	0.010 °C 29.7646 °C	0.000 33 °C 0.000 33 °C	Fixed Point Cell: TPW Fixed Point Cell: MPGa
Temperature – Measure ³	-196 °C to 650 °C	0.025 °C	Master PRT display with probe
	650 °C to 1200 °C	0.5 °C	Type R thermocouple probe with display
Relative Humidity – Measure ³	(10 to 95) % RH	1.4 % RH	Vaisala HMP Series
Relative Humidity – Measuring Equipment	(10 to 95) % RH	0.6 % RH	Thunder Scientific 2500
Ovens, Chambers, Freezers, Furnaces ^{3,8}	(-196 to 400) °C (>400 to 1200) °C	0.14 °C 1.1 °C	Fluke 1523 with RTD Fluke 753 with TC
IR – Measuring Equipment ³	(-30 to 35) °C	0.6 °C	Hart 9133
	(35 to 100) °C	0.6 °C	Fluke 4181
	(100 to 200) °C	0.73 °C	
	(200 to 300) °C	0.97 °C	
	(300 to 400) °C	1.6 °C	
(400 to 500) °C	2.1 °C		

XII. Time & Frequency

Parameter/Equipment	Range	CMC ^{2, 12} (±)	Comments
Frequency – Measure ³	10 MHz 10 Hz to 26.5 GHz	7.1 pHz/Hz 7.1 pHz/Hz	GPS receiver, HP 5334B w/GPS, HP 5351A w/GPS
Frequency – Measuring Equipment ³	10 Hz to 26.5 GHz	7.1 pHz/Hz	GPS receiver, HP 5334B, w/GPS, HP 5351B w/GPS
Tachometer – Optical ³	(0 to 60 000) RPM	0.001 RPM	Agilent 3325B
Stopwatches and Timers ³	(0.1 to 86 400) s	0.03 s/day	Helmut Timometer

¹ This laboratory offers commercial calibration service, field calibration service, and dimensional testing service.

² Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

³ Field calibration service is available for this calibration. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

⁴ In the statement of CMC, L is the length of the unit under test in inches; and R is the resolution of the device under test. In the statement of CMC for measurements using the ZEIS Metrotom 1500, L is in mm.

⁵ In the statement of CMC, the first percentage given is the percentage of the reading, unless otherwise noted; the second percentage or fraction given is a percentage or fraction of the range.

⁶ This test is not equivalent to that of a calibration.

⁷ This laboratory meets R205 – Specific Requirements: Calibration Laboratory Accreditation Program for the types of dimensional tests listed above and is considered equivalent to that of a calibration.

- ⁸ The CMC does not include the influence of the unit under test.
- ⁹ 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. CMC's are expressed as either a specific value that covers the full range or as a percent or fraction of the reading plus a fixed floor specification.
- ¹⁰ Calibrations in the field limited to a range of 10 inches.
- ¹¹ This scope meets A2LA's *P112 Flexible Scope Policy*.
- ¹² 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.



Accredited Laboratory

A2LA has accredited

APPLIED TECHNICAL SERVICES, LLC

Marietta, GA

for technical competence in the field of

Calibration

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



Presented this 14th day of February 2020.

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

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1888.03
Valid to January 31, 2022
Revised March 10, 2021

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