



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

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CALIBRATION

Valid To: March 31, 2021

Certificate Number: 2820.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations^{1,8}:

I. Dimensional

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|--|--------------|------------------------|----------------------------------|
| Bore Gages & ID Measuring Tools ³ – | | | |
| 3 Point | Up to 4 in | (36 + 2.3D) μin | Ring gages |
| 2 Point | Up to 12 in | (35 + 2.3D) μin | Gage blocks |
| Countersink & Chamfer Gages ³ | Up to 3.5 in | 450 μin | Modified ring gages |
| Coordinate Measuring Machines (CMM) ³ – | | | ASME B89.4.10360.2 Section 6.3.3 |
| Length Measurement Error (E _L) | Up to 27 in | (14 + 4.9L) μin | Step gage |
| | Up to 127 in | (7.9 + 3.8L) μin | Gage blocks |
| | Up to 240 in | (6.2 + 1.2L) μin | Laser system |

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|---|-------------------|-------------------------------|--|
| Coordinate Measuring Machines (CMM) ³ – (cont) | | | ASME B89.4.10360.2 Section 6.1.1 |
| Repeatability (R ₀) | (10 to 50) mm | 27 μin | Sphere |
| Spherical CMM (Laser Tracker) ³ | Up to 600 in | 590 μin | Reference length bar |
| Laser Interferometer Length Dependent Error | Up to 40 in | 0.47 parts in 10 ⁶ | ASME B89.1.8 Sec 4 XD1 reference laser |
| Articulated Arm CMM ³ – | | | |
| Effective Dia Perf Test | N/A | 55 μin | Sphere |
| Single Point Articulation Test | N/A | 90 μin | Trihedral socket |
| Volumetric Perf Test | Up to 108” radius | (170 + 0.18L) μin | Gage block ref. length |
| CNC, Machine Tools ³ – | | | |
| Repeatability @ 2 Sigma | --- | 18 μin | Laser per ASME B5.54 Sec. 7.3 |
| Linear Displacement Accuracy | Up to 60 ft | (83 + 1.6L) μin | Laser per ASME B5.54 Sec. 7.3 |
| Volumetric Performance (By Body Diagonals) | | | |
| Bi-Directional System Deviation | Up to 60 ft | 85 μin | Laser per ASME B5.54 Sec. 7.7 |
| Reversal Deviation | Up to 60 ft | 90 μin | Laser per ASME B5.54 Sec. 7.7 |
| Bi-Directional Repeatability | Up to 60 ft | 80 μin | Laser per ASME B5.54 Sec. 7.3 |

| Parameter/Equipment | Range | CMC ^{2,5} (\pm) | Comments |
|--|---|--|--------------------------------|
| Gage Blocks | Up to 0.1 in (0.1 to 4) in (4 to 20) in | 4 μ in (1.9 + 1.4L) μ in (6.3 + 1.2L) μ in | Master gage blocks & amplifier |
| Micrometers ³ – | | | |
| Linearity | Up to 42 in | (39 + 2.7L) μ in | Gage blocks |
| Parallelism | Up to 42 in | (31 + 0.25L) μ in | |
| Micrometer Standards & Length Artifacts | Up to 41 in | (12 + 2.4L) μ in | Universal LMS |
| Depth Micrometers & Gages ³ | Up to 9 in | (31 + 1.8L) μ in | Gage blocks |
| Thread Micrometers | Up to 4.125 | (66 + 6L) μ in | Thread plugs |
| Calipers ³ – | | | |
| Digital | Up to 72 in | (300 + 1.7L) μ in | Gage blocks and ring gages |
| Dial and Vernier | Up to 72 in | (600 + 1.9L) μ in | |
| Indicators, Dial and Digital ³ (For Dial, Res. = 0.2 Least Grad.) | Up to 1 in (1 to 4) in | 6.3 μ in + 0.6R (3.3 + 3L) μ in + 0.6R | Gage blocks |
| Height Gages ³ | Up to 40 in | (12 + 1.3L) μ in | Gage blocks |

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|--|--------------------------------|--|--|
| Plug / Pin Gages & outside Cylindrical Diameter | Up to 1 in (1 to 10) in | (6.8 + 2.1L) μin (5.4 + 1.7L) μin | Laser scan micrometer P&W Supermicrometer™, gage blocks |
| Plain Rings & Inside Cylindrical Diameter | (0.04 to 11) in | (4.4 + 0.96D) μin | Internal Supermicrometer™, master gage blocks |
| Straight Threaded Plug Gages – Pitch Diameter (TPI 4.5 to 96) Major Diameter | Up to 6 in Up to 5 in | (74 + 6.2D) μin (12 + 1.7D) μin | 3 wire method P&W Supermicrometer™, gage blocks |
| Tapered Threaded Plug Gages – Pitch Diameter (TPI 4.5 to 96) Major Diameter | Up to 4 in Up to 4.5 in | 90 μin 35 μin | 3-wire method, tapered sine block P&W Supermicrometer™, gage blocks |
| Adjustable Threaded Ring Gages | (0.05 to 2) in diameter | (53 + 8.7D) μin | Setting plugs |

| Parameter/Equipment | Range | CMC ^{2,5} (\pm) | Comments |
|--|---|---|---|
| Steel Rules ³ – Length Graduations | Up to 72 in ---- | (600 + 1.5L) μ in (670 + 16L) μ in | Gage blocks Glass scale |
| Surface Plates ³ – Flatness Repeat Reading | Up to 300 in diagonal ---- | (8.7 + 1.2L) μ in (6.8 + 0.017L) μ in | LDDM Repeat reading gage |
| Optical Comparators ³ – Linearity Angle Magnification Accuracy | 12 in travel $\pm 180^\circ$ 5X to 100X | (12 + 6.4L) μ in 38 arc seconds 0.014 % of magnification | Glass scale |
| Measuring Tapes – Length Graduations | Up to 330 ft ---- | (0.00072 + 0.0000058L) in 0.0013 in | Test frame Glass scale |
| Wire Crimpers Cylindrical Crimping Chamber Shaped Crimping Chamber Crimp Height | (0.011 to 0.250) in Up to 1 in Up to 1 in | 590 μ in 280 μ in 190 μ in | Pin gages Optical comparator Crimp height micrometer |

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|-----------------------------|-------------------|------------------------|---|
| Profilometers, Ra | 20 μin 120 μin | 1.5 μin 3.1 μin | Surface roughness masters |
| Surface Roughness Standards | (16 to 132) μin | (1.2 + 0.014Ra) μin | Comparison with surface roughness masters |
| Radius Standard | (0.01 to 3) in | (190 + 62L) μin | Optical comparator |

II. Dimensional Testing¹

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|-------------------------|-----------------------|------------------------|--------------------|
| Length, 1D ⁶ | Up to 10 in | (27 + 1.2L) μin | Supermicrometer™ |
| | Up to 56 in | (590 + 2.1L) μin | CMM |
| | Up to 8.5 in | (410 + 96L) μin | Optical comparator |
| | Up to 60 ft | (83 + 1.6L) μin | Laser |
| Length, 2D ⁶ | Up to 8" X 3" | (370 + 120L) μin | Optical comparator |
| Length, 3D ⁶ | Up to 47" X 32" X 24" | 700 μin | CMM |

III. Electrical – DC/Low Frequency

| Parameter/Equipment | Range | CMC ^{2,7} (±) | Comments |
|------------------------------------|--|--|---|
| DC Voltage – Measure ³ | Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V | 4.5 μV/V + 0.62 μV 4.7 μV/V + 0.5 μV 4.6 μV/V + 1.1 μV 7 μV/V + 36 μV 7.1 μV/V + 160 μV | HP 3458A |
| DC Voltage – Generate ³ | Up to 100 mV (0.1 to 1) V (1 to 10) V (10 to 100) V (100 to 1000) V | 4.5 μV/V + 0.62 μV 4.7 μV/V + 0.5 μV 4.6 μV/V + 1.1 μV 7 μV/V + 36 μV 7.1 μV/V + 160 μV | HP 3458A, Fluke 5502A |
| DC Current – Measure ³ | Up to 100 nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A (1 to 20) A | 34 μA/A + 0.048 nA 23 μA/A + 0.049 nA 24 μA/A + 0.12 nA 23 μA/A + 0.12 nA 23 μA/A + 6.0 nA 23 μA/A + 59 nA 40 μA/A + 0.63 μA 130 μA/A + 12 μA 60 μA/A + 8.6 μA | HP 3458A EL 7520 current shunt |
| DC Current – Generate ³ | Up to 100 nA 100 nA to 1 μA (1 to 10) μA (10 to 100) μA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A (1 to 20) A (11 to 30) A (30 to 110) A (110 to 205) A (55 to 150) A (150 to 550) A (525 to 1025) A | 34 μA/A + 0.048 nA 23 μA/A + 0.048 nA 24 μA/A + 0.12 nA 23 μA/A + 0.12 nA 23 μA/A + 6.0 nA 23 μA/A + 59 nA 40 μA/A + 0.63 μA 130 μA/A + 12 μA 60 μA/A + 8.6 μA 0.2 % rdg + 1.6 mA 0.21 % rdg + 3.9 mA 0.23 % rdg + 6.4 mA 0.2 % rdg + 7.7 mA 0.22 % rdg + 19 mA 0.23 % rdg + 32 mA | HP 3458A with Fluke 5502A With EL 7520 current shunt Fluke 5502A, 10 turn coil Fluke 5502A, 50 turn coil |

| Parameter/Equipment | Range | CMC ^{2,7} (\pm) | Comments |
|---|---|---|---|
| Resistance – Generate and Measure ³ | (0 to 1) Ω (1 to 10) Ω (10 to 100) Ω 100 Ω to 1 k Ω (1 to 10) k Ω (10 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 | 0.22 $\mu\Omega/\Omega$ + 2.4 $\mu\Omega$ 0.23 $\mu\Omega/\Omega$ + 23 $\mu\Omega$ 0.85 $\mu\Omega/\Omega$ + 19 $\mu\Omega$ 12 $\mu\Omega/\Omega$ + 0.59 m Ω 12 $\mu\Omega/\Omega$ + 5.9 m Ω 12 $\mu\Omega/\Omega$ + 58 m Ω 18 $\mu\Omega/\Omega$ + 2.3 Ω 59 $\mu\Omega/\Omega$ + 120 Ω 0.058 % rdg + 1.2 k Ω 0.58 % rdg + 12 k Ω | HP34420A, HP3458A |
| Capacitance – Measuring Equipment | (0.22 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF (0.33 to 1.1) μ F (1.1 to 3.3) μ F (3.3 to 11) μ F (11 to 33) μ F (33 to 110) μ F (110 to 330) μ F (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 | 0.58 % rdg + 12 pF 0.29 % rdg + 12 pF 0.29 % rdg + 120 pF 0.29 % rdg + 120 pF 0.29 % rdg + 350 pF 0.29 % rdg + 1.2 nF 0.29 % rdg + 3.5 nF 0.29 % rdg + 12 nF 0.46 % rdg + 36 nF 0.52 % rdg + 120 nF 0.52 % rdg + 350 nF 0.52 % rdg + 1.2 μ F 0.52 % rdg + 3.5 μ F 0.52 % rdg + 13 μ F 0.87 % rdg + 35 μ F 1.3 % rdg + 120 μ F | Fluke 5502A |
| Electrical Calibration of Thermocouple Indicators & Simulators ³ – | | | |
| Type E | -454 $^{\circ}$ F to 300 $^{\circ}$ F 300 $^{\circ}$ F to 1100 $^{\circ}$ F 1100 $^{\circ}$ F to 1832 $^{\circ}$ F | 0.12 $^{\circ}$ F 0.09 $^{\circ}$ F 0.091 $^{\circ}$ F | HP 3458A, HP 34420A, Fluke 8842A, with HP 3245A |
| Type J | -346 $^{\circ}$ F to 500 $^{\circ}$ F 500 $^{\circ}$ F to 1350 $^{\circ}$ F 1350 $^{\circ}$ F to 2192 $^{\circ}$ F | 0.14 $^{\circ}$ F 0.11 $^{\circ}$ F 0.11 $^{\circ}$ F | |
| Type K | -454 $^{\circ}$ F to -400 $^{\circ}$ F -400 $^{\circ}$ F to 500 $^{\circ}$ F 500 $^{\circ}$ F to 1500 $^{\circ}$ F 1500 $^{\circ}$ F to 2500 $^{\circ}$ F | 0.76 $^{\circ}$ F 0.19 $^{\circ}$ F 0.12 $^{\circ}$ F 0.13 $^{\circ}$ F | |

| Parameter/Equipment | Range | CMC ^{2,7} (±) | Comments |
|--|---|--|---|
| Electrical Calibration of Thermocouple Indicators & Simulators ³ – (cont) | | | |
| Type N | (-454 to -400) °F (-400 to -150) °F (-150 to 700) °F (700 to 1500) °F (1500 to 2372) °F | 1.5 °F 0.24 °F 0.14 °F 0.12 °F 0.13 °F | HP 3458A, HP 34420A, Fluke 8842A, with HP 3245A |
| Type R | (-58 to 32) °F (32 to 1100) °F (1100 to 2200) °F (2200 to 3214) °F | 0.26 °F 0.19 °F 0.16 °F 0.17 °F | |
| Type S | (-58 to 32) °F (32 to 1100) °F (1100 to 2200) °F (2200 to 3214) °F | 0.22 °F 0.18 °F 0.17 °F 0.17 °F | |
| Type T | (-454 to -400) °F (-400 to 200) °F (200 to 752) °F | 0.41 °F 0.18 °F 0.11 °F | |
| Electrical Calibration of RTD Indicators & Simulators ³ – | | | |
| Pt 385, 100 Ω | (-320 to 32) °F (32 to 400) °F (400 to 800) °F (800 to 1200) °F (1200 to 1562) °F | 0.013 °F 0.016 °F 0.021 °F 0.027 °F 0.034 °F | HP 3458A |
| Pt 385, 1000 Ω | (-320 to 32) °F (32 to 400) °F (400 to 800) °F (800 to 1200) °F (1200 to 1562) °F | 0.009 °F 0.016 °F 0.020 °F 0.027 °F 0.033 °F | |

| Parameter/Range | Frequency | CMC ^{2,7} (±) | Comments |
|-----------------------------------|---|--|----------|
| AC Voltage – Measure ³ | | | |
| (1 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 (1 to 4) MHz (4 to 8) MHz | 0.035 % + 3.6 μV 0.023 % + 1.4 μV 0.033 % + 1.6 μV 0.11 % + 1.9 μV 0.57 % + 2.1 μV 4.6 % + 4.2 μV 4.6 % + 7.8 μV 8.1 % + 9.7 μV 23 % + 20 μV | HP 3458A |
| (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 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 83 μV/V + 4.7 μV 84 μV/V + 2.4 μV 0.016 % + 2.8 μV 0.035 % + 2.5 μV 0.093 % + 2.5 μV 0.35 % + 12 μV 1.2 % + 12 μV 1.7 % + 48 μV 4.6 % + 110 μV 4.6 % + 120 μV 17 % + 450 μV | |
| 100 mV to 1 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 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 82 μV/V + 47 μV 82 μV/V + 24 μV 0.016 % + 26 μV 0.035 % + 24 μV 0.092 % + 28 μV 0.35 % + 120 μV 1.2 % + 120 μV 1.7 % + 470 μV 4.6 % + 1.1 mV 4.6 % + 1.2 mV 17 % + 4.5 mV | |
| (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 300 kHz to 1 MHz (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 83 μV/V + 0.47 mV 82 μV/V + 0.24 mV 0.016 % + 0.26 mV 0.035 % + 0.24 mV 0.092 % + 0.28 mV 0.35 % + 1.2 mV 1.2 % + 1.2 mV 1.7 % + 4.6 mV 4.6 % + 11 mV 4.6 % + 12 mV 17 % + 44 mV | |

| Parameter/Range | Frequency | CMC ^{2,7} (\pm) | Comments |
|---|--|--|--------------------------|
| AC Voltage – Measure ³ (cont) | | | |
| (10 to 100) 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 300 kHz to 1 MHz | 0.023 % + 4.8 mV 0.023 % + 2.5 mV 0.023 % + 2.5 mV 0.04 % + 2.8 mV 0.14 % + 2.4 mV 0.46 % + 14 mV 1.7 % + 44 mV | HP 3458A |
| (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 | 0.046 % + 49 mV 0.046 % + 26 mV 0.069 % + 27 mV 0.14 % + 24 mV 0.35 % + 24 mV | |
| AC Voltage – Generate | | | |
| (1 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 300 kHz to 1 MHz | 0.034 % + 3.6 μ V 0.022 % + 1.5 μ V 0.033 % + 1.7 μ V 0.11 % + 1.9 μ V 0.57 % + 2.1 μ V 4.6 % + 4.2 μ V 4.6 % + 7.8 μ V | HP 3458A, Fluke 5502A |
| (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 300 kHz to 1 MHz | 83 μ V/V + 4.7 μ V 83 μ V/V + 2.5 μ V 0.016 % + 2.8 μ V 0.035 % + 2.5 μ V 0.092 % + 3.0 μ V 0.35 % + 12 μ V 1.2 % + 12 μ V | |
| 100 mV to 1 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 300 kHz to 1 MHz | 82 μ V/V + 47 μ V 82 μ V/V + 24 μ V 0.016 % + 26 μ V 0.035 % + 24 μ V 0.092 % + 28 μ V 0.35 % + 120 μ V 1.2 % + 120 μ V | |

| Parameter/Range | Frequency | CMC ^{2,7} (±) | Comments |
|---------------------------------|--|--|--------------------------|
| AC Voltage – Generate (cont) | | | |
| (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 300 kHz to 1 MHz | 83 μV/V + 0.47 mV 82 μV/V + 0.24 mV 0.016 % + 0.26 mV 0.035 % + 0.24 mV 0.092 % + 0.28 mV 0.35 % + 1.2 mV 1.2 % + 1.2 mV | HP 3458A, Fluke 5502A |
| (10 to 20) 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 300 kHz to 1 MHz | 0.023 % + 4.7 mV 0.023 % + 2.4 mV 0.023 % + 2.4 mV 0.041 % + 2.4 mV 0.14 % + 2.4 mV 0.46 % + 12 mV 1.7 % + 18 mV | |
| (20 to 100) V | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz | 0.023 % + 4.8 mV 0.023 % + 2.5 mV 0.023 % + 2.5 mV 0.04 % + 2.8 mV 0.14 % + 2.4 mV | |
| (100 to 330) V | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz | 0.046 % + 47 mV 0.046 % + 24 mV 0.069 % + 25 mV 0.14 % + 24 mV 0.35 % + 24 mV | |
| (330 to 1000) V | (1 to 40) Hz 40 Hz to 1 kHz (1 to 10) kHz | 0.046 % + 49 mV 0.046 % + 26 mV 0.069 % + 27 mV | |

| Parameter/Range | Frequency | CMC ^{2,7} (±) | Comments |
|--|--|---|---|
| AC Current – Generate and Measure ³ | | | |
| Up to 100 µA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 5 kHz | 0.46 % + 0.037 µA 0.17 % + 0.038 µA 0.069 % + 0.036 µA | HP 3458A with HP 3245A or Fluke 5502A |
| 100 µA to 1 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 | 0.46 % + 0.25 µA 0.17 % + 0.27 µA 0.069 % + 0.24 µA 0.035 % + 0.24 µA 0.07 % + 0.24 µA 0.47 % + 0.47 µA 0.64 % + 1.8 µA | |
| (1 to 10) mA | (10 Hz to 20) Hz (20 Hz to 45) Hz (45 Hz to 100) Hz 100 Hz to 5 kHz (5 kHz to 20) kHz (20 to 50) kHz (50 to 100) kHz | 0.46 % + 2.5 µA 0.17 % + 2.7 µA 0.069 % + 2.4 µA 0.035 % + 2.4 µA 0.07 % + 2.4 µA 0.47 % + 4.7 µA 0.64 % + 18 µA | |
| (10 to 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 | 0.46 % + 25 µA 0.17 % + 27 µA 0.069 % + 24 µA 0.035 % + 24 µA 0.07 % + 24 µA 0.47 % + 47 µA 0.64 % + 0.18 mA | |
| 100 mA to 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 | 0.46 % + 0.25 mA 0.18 % + 0.28 mA 0.082 % + 0.34 mA 0.12 % + 0.24 mA 0.35 % + 0.23 mA 1.2 % + 0.46 mA | |
| (1 to 10) A | (1 to 50) Hz 50 Hz to 1 kHz (1 to 5) kHz | 0.019 % + 0.50 mA 0.018 % + 0.46 mA 0.017 % + 0.71 mA | HP 3458A with Fluke 5502A and current shunt |
| (10 to 20) A | (1 to 50) Hz 50 Hz to 1 kHz (1 to 5) kHz | 0.035% + 2 mA 0.050 % + 2 mA 0.085 % + 2 mA | |

| Parameter/Range | Frequency | CMC ^{2,7} (±) | Comments |
|------------------------------------|---|---|-------------|
| AC Current – Generate ³ | | | |
| (29 to 330) µA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz | 0.23 % + 0.12 µA 0.17 % + 0.13 µA 0.14 % + 0.13 µA 0.35 % + 0.18 µA 0.92 % + 0.25 µA 1.8 % + 0.62 µA | Fluke 5502A |
| 330 µA to 3.3 mA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz | 0.23 % + 0.21 µA 0.14 % + 0.32 µA 0.12 % + 0.18 µA 0.23 % + 0.27 µA 0.58 % + 0.35 µA 1.2 % + 0.7 µA | |
| (3.3 to 33) mA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz | 0.21 % + 2.4 µA 0.1 % + 3.7 µA 0.046 % + 2.4 µA 0.092 % + 2.5 µA 0.23 % + 3.8 µA 0.46 % + 5.3 µA | |
| (33 to 330) mA | (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz | 0.21 % + 24 µA 0.1 % + 37 µA 0.046 % + 24 µA 0.12 % + 58 µA 0.23 % + 0.12 mA 0.46 % + 0.24 mA | |
| 330 mA to 1.1 A | (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.21 % + 0.12 mA 0.058 % + 0.12 mA 0.69 % + 1.2 mA 2.9 % + 5.8 mA | |
| (1.1 to 3) A | (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.21 % + 0.12 mA 0.069 % + 0.13 mA 0.69 % + 1.3 mA 2.9 % + 5.8 mA | |
| (3 to 11) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.069 % + 2.4 mA 0.12 % + 2.4 mA 3.5 % + 2.4 mA | |

| Parameter/Range | Frequency | CMC ^{2,7} (±) | Comments |
|--|--|--|----------------------------------|
| AC Current – Generate ³ (cont) | | | |
| (11 to 20.5) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.14 % + 5.8 mA 0.17 % + 6.5 mA 3.5 % + 5.8 mA | Fluke 5502A |
| (11 to 30) A | (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.29 % + 0.87 mA 0.21 % + 0.9 mA 0.72 % + 12 mA 2.9 % + 58 mA | Fluke 5502A with 10 turn coil |
| (30 to 110) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.21 % + 12 mA 0.23 % + 15 mA 3.5 % + 24 mA | |
| (110 to 205) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.24 % + 42 mA 0.26 % + 49 mA 3.5 % + 58 mA | |
| (60 to 220) A | 45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.21 % + 24 mA 0.23 % + 30 mA 3.5 % + 47 mA | Fluke 5502A with 20 turn coil |
| (220 to 410) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.24 % + 84 mA 0.26 % + 98 mA 3.5 % + 0.12 A | |
| (150 to 550) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.21 % + 59 mA 0.23 % + 74 mA 3.5 % + 0.12 A | Fluke 5502A with 50 turn coil |
| (550 to 1025) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.24 % + 0.21 A 0.26 % + 0.25 A 3.5 % + 0.29 A | |

| Parameter/Equipment | Range | CMC ^{2,9} (±) | Comments |
|---|---|---|-------------|
| DC Power – Generate ³ | Up to 109 μW (0.109 to 1.09) mW (1.09 to 10.9) mW (10.9 to 109) mW (0.109 to 1.09) W (1.09 to 10.9) W (10.9 to 109) W (109 to 330) W (0.33 to 3) kW (3 to 11) kW (11 to 20.5) kW | 0.36 % rdg 0.035 % rdg 0.023 % rdg 0.019 % rdg 0.023 % rdg 0.023 % rdg 0.023 % rdg 0.023 % rdg 0.015 % rdg 0.06 % rdg 0.089 % rdg 0.13 % rdg | Fluke 5502A |
| AC Power – Generate (45 to 65 Hz, PF=1) ³ | Up to 10.9 μW (10.9 to 109) μW (0.109 to 1.09) mW (1.09 to 10.9) mW (10.9 to 109) mW (0.109 to 1.09) W (1.09 to 10.9) W (10.9 to 109) W (109 to 363) W (363 to 990) W (0.99 to 3.63) kW (3.63 to 11.2) kW (11.2 to 20.9) kW | 2.5 % rdg 0.26 % rdg 0.16 % rdg 0.13 % rdg 0.078 % rdg 0.078 % rdg 0.13 % rdg 0.087 % rdg 0.12 % rdg 0.10 % rdg 0.21 % rdg 0.16 % rdg 0.21% rdg | Fluke 5502A |
| Electrical Calibration of Phase Indicators – Source Only ³ | (10 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz | 0.19° phase 1.1° phase 2.4° phase 7.0° phase 12° phase 18° phase | Fluke 5502A |

| Parameter/Equipment | Range | CMC ^{2,9} (±) | Comments |
|---|--|--|--|
| Electrical Conductivity – Measuring Equipment | Up to 16 % IACS (16 to 62) % IACS >62 % IACS | 0.1 % IACS 0.25 % rdg + 0.1 % IACS 0.3 % rdg + 0.07 % IACS | ASTM E1004 electrical conductivity by eddy current |
| Electrical Conductivity Standards | Up to 13 % IACS (13 to 62) % IACS >62 % IACS | 0.1 % IACS 0.25 % rdg + 0.1 % IACS 0.3 % rdg + 0.07% IACS | ASTM E1004 electrical conductivity by eddy current |

IV. Mechanical

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|----------------------------------|---|---|---|
| Torque Wrenches ³ | (0.5 to 15) in·ozf | 0.09 % setting + 0.017 in·ozf | Torque arm and deadweights |
| | 15 in·ozf to 2000 ft·lbf | 0.41 % setting | Torque transducers |
| Torque Transducers | (1.25 to 40) in·ozf (2.5 to 200) in·lbf (8.3 to 150) ft·lbf (150 to 1200) ft·lbf | 0.09 % rdg + 0.0006 in·ozf 0.062 % 0.042 % 0.029 % | Torque wheel/arms and weights |
| Air Gages ³ | ----- | 18 µin | Magnification test kit |
| Scales and Balances ³ | (0.5 to 1800) g | (0.092 + 0.00015W) mg | Ultra Class weights, Class 1 weights |
| | (0 to 200) g (200 to 1000) g (1 to 8.2) kg | (0.79 + 0.0055W) mg (2.1 + 0.011W) mg (13 + 0.0022W) mg | Class F and 6 weights |
| | (0.1 to 700) lb, ((0.045 to 318) kg) | (45 + 8.3W) mg (This instance, “W” = weight in lbs) | |

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|---|-------------|----------------------|------------------------------------|
| Indirect Verification of Rockwell Hardness Testers ³ | HRA | | Indirect verification per ASTM E18 |
| | Low | 0.31 HRA | |
| | Medium | 0.32 HRA | |
| | High | 0.20 HRA | |
| | HRBW | | |
| | Low | 0.36 HRBW | |
| | Medium | 0.26 HRBW | |
| | High | 0.39 HRBW | |
| | HRC | | |
| | Low | 0.39 HRC | |
| | Medium | 0.34 HRC | |
| | High | 0.32 HRC | |
| | HREW | | |
| | Low | 0.39 HREW | |
| | Medium | 0.49 HREW | |
| | High | 0.49 HREW | |
| | HRFW | | |
| | Low | 0.28 HRFW | |
| | Medium | 0.47 HRFW | |
| | High | 0.45 HRFW | |
| | HRHW | | |
| | Low | 0.42 HRHW | |
| | High | 0.36 HRHW | |
| | HR15N | | |
| Low | 0.42 HR15N | | |
| Medium | 0.42 HR15N | | |
| High | 0.51 HR15N | | |
| HR30N | | | |
| Low | 0.30 HR30N | | |
| Medium | 0.47 HR30N | | |
| High | 0.54 HR30N | | |
| HR45N | | | |
| Low | 0.50 HR45N | | |
| Medium | 0.25 HR45N | | |
| High | 0.20 HR45N | | |
| HR15TW | | | |
| Low | 0.45 HR15TW | | |
| Medium | 0.39 HR15TW | | |
| High | 0.31 HR15TW | | |

| Parameter/Equipment | Range | CMC ^{2,5} (±) | Comments |
|---|--|--|---|
| Indirect Verification of Rockwell Hardness Testers ³ (cont) | HR30TW Low Medium High HR45TW Low Medium High | 0.58 HR30TW 0.64 HR30TW 0.22 HR30TW 0.70 HR45TW 0.41 HR45TW 0.39 HR45TW | Indirect verification per ASTM E18 |
| Direct Verification of Rockwell Hardness Testers ³ – | | | ASTM E18 |
| Verification of Test Force | (3 to 15) kgf (30 to 150) kgf | 0.005 kgf + 0.03 % rdg 0.042 kgf + 0.02 % rdg | Verification of test force by load cell |
| Verification of Depth-Measuring Device | (0 to 260) µm | 0.32 µm | Per Direct Verification method of ASTM E18 |
| Verification of Hysteresis | N/A | 0.25 Rockwell Points | Per Direct Verification method of ASTM E18 |
| Indirect Verification of Brinell Hardness Testers at Test Condition(s) ³ – | | | ATSM E10 |
| 10/3000/15 | Repeatability: ≤ 225 HBW (> 225 to 650) HBW Error: | 0.024D 0.013D 1.5 % | <i>D</i> is the mean of the <i>n</i> mean test diameters in millimeters Error uncertainty is stated as a percentage of the standardized test block value |
| 10/500/15 | Repeatability: (40 to 109) HBW Error | 0.024D 1.9 % | |

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|---|---|--|---|
| Indirect Verification of Microindentation Hardness Testers ³ (Knoop and Vickers) | Vickers <240 HV (240 to 600) HV >600 HV Knoop <250 HK (250 to 650) HK >650 HK | 4.3 HV 10 HV 13 HV 5.2 HK 12 HK 15 HK | ASTM E384 and E92 |
| Pressure ³ – Absolute & Barometric Pressure Differential & Gage Pressure | (0 to 900) mm Hg (-150 to +150) in H ₂ O (0 to 30) psi (10 to 500) psi (200 to 10 000) psi | 39 ppm + 0.25 mm Hg 0.039 in H ₂ O 0.0092 psi + 0.1 % rdg 0.0067 psi + 0.0093 % rdg 0.05 psi + 0.01 % rdg | Meriam M202-AI0017 Additel 681 30PSIXP2i Deadweight tester |
| Vacuum ³ | (0 to 28.5) in Hg | 0.011 in Hg | Meriam M202-AI0017 |

V. Thermodynamics

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|-------------------------------|--|--|---|
| Thermometers ³ | (-112 °F to 32) °F (32 °F to 212) °F (212 °F to 392) °F (392 to 752) °F | 0.048 °F 0.041 °F 0.047 °F 0.098 °F | PRT, Fluke 1502A |
| Thermocouples – Type E | (-112 to -22) °F (-22 to 752) °F (752 to 1200) °F (1200 to 1832) °F | 0.15 °F 0.17 °F 1.3 °F 1.6 °F | Type "S" platinum standard T/C above 752 °F, PRT below 752 °F, Fluke 1502A, Fluke 8846A |

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|------------------------|---|--|--|
| Thermocouples – (cont) | | | |
| Type J | (-112 to -22) °F (-22 to 752) °F (752 to 1200) °F (1200 to 2000) °F (2000 to 2192) °F | 0.16 °F 0.20 °F 1.3 °F 1.6 °F 2.5 °F | Type "S" platinum standard T/C above 752 °F, PRT below 752 °F, Fluke 1502A, Fluke 8846A |
| Type K | (-112 to -22) °F (-22 to 752) °F (752 to 1200) °F (1200 to 2000) °F (2000 to 2500) °F | 0.19 °F 0.24 °F 1.3 °F 1.5 °F 3.2 °F | |
| Type N | (-112 to -22) °F (-22 to 752) °F (752 to 1200) °F (1200 to 2000) °F (2000 to 2372) °F | 0.25 °F 0.26 °F 1.3 °F 1.6 °F 2.9 °F | |
| Type R | (32 to 752) °F (752 to 1200) °F (1200 to 2000) °F (2000 to 2500) °F | 0.81 °F 1.3 °F# 1.6 °F 3.2 °F | |
| Type S | (32 to 752) °F (752 to 1200) °F (1200 to 2000) °F (2000 to 2500) °F | 0.81 °F 1.4 °F 2.1 °F 3.2 °F | |
| Type T | (-112 to -22) °F (-22 to 752) °F | 0.20 °F 0.19 °F | |
| Type R | (32 to 752) °F (752 to 1200) °F (1200 to 2000) °F (2000 to 2500) °F | 0.81 °F 0.98 °F 1.1 °F 3.2 °F | Above 752 °F, Comparison with NIST ref. standard Below 752 °F, PRT, Fluke 1502A, Fluke 8846A |
| Type S | (32 to 752) °F (752 to 1200) °F (1200 to 2000) °F (2000 to 2500) °F | 0.51 °F 0.54 °F 1.1 °F 3.2 °F | |

| Parameter/Equipment | Range | CMC ^{2,9} (±) | Comments |
|---|--|---------------------------------------|--|
| Temperature Uniformity Survey ^{3, 4} (per AMS 2750) | (-112 to 392) °F (392 to 1200) °F (1200 to 1800) °F (1800 to 2372) °F | 1.3 °F 1.9 °F 2.8 °F 4.5 °F | IoTech DaqBook, with expendable and non-expendable thermocouples |
| Temperature Probe ^{3, 4} ("SAT" per AMS 2750) | (-112 to 392) °F (392 to 1200) °F (1200 to 2000) °F (1800 to 2372) °F | 0.73 °F 1.6 °F 2.0 °F 3.5 °F | Fluke 726 or equivalent, expendable and non-expendable thermocouples |
| Infrared Thermometers ³ | (95 to 212) °F (212 to 392) °F (392 to 662) °F (662 to 932) °F | 1.2 °F 1.6 °F 2.7 °F 3.7 °F | Hart 4181 black body Emissivity- 0.95 |
| Relative Humidity ³ – Measuring Equipment | (10 to 70) % RH (70 to 95) % RH | 0.45 % RH 0.6 % RH | EdgeTech chilled mirror hygrometer |
| Dewpoint ³ – Measuring Equipment | (-20 to 65) °C | 0.28 °C | EdgeTech chilled mirror hygrometer |

VI. Time & Frequency

| Parameter/Equipment | Range | CMC ^{2,9} (±) | Comments |
|---------------------|---------------------------------|---------------------------|----------|
| Frequency – Measure | (1 to 40) Hz 40 Hz to 10 MHz | 0.06 % rdg 0.012 % rdg | HP3458A |

| Parameter/Equipment | Range | CMC ^{2,9} (\pm) | Comments |
|--|--|--|---|
| Frequency – Measuring Equipment ³ | Up to 120 Hz (0.12 to 1.2) kHz (1.2 to 12) kHz (12 to 120) kHz (0.12 to 1.2) MHz (1.2 to 2) MHz | 13 μ Hz/Hz + 0.006 Hz 9.5 μ Hz/Hz + 0.058 Hz 9.1 μ Hz/Hz + 0.58 Hz 28 μ Hz/Hz + 19 Hz 16 μ Hz/Hz + 61 Hz 0.013 % rdg + 440 Hz | Fluke 5502A |
| Timers, Stopwatches ³ | 15 s to 10 min 10 min to 24 hrs (2 to 24) hrs | 0.013 s + 0.0025 % of timed interval 0.016 s + 0.0041 % of timed interval 0.012 s | Reference stopwatch WWV signal |

¹ This laboratory offers commercial dimensional testing, calibration, and field calibration 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 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 CMC is stated for calibrations performed in the field only.

⁵ In the statement of the CMC, L is the numerical value of the nominal length of the device measured in inches. In the statement of best uncertainty, D is the numerical value of the nominal diameter of the device measured in inches; W is numerical value of the nominal applied mass in grams; and, R is the resolution of the device under test.

⁶ 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.

⁷ 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 are expressed as either a specific value that covers the full range or as a fraction or percentage of the reading plus a fixed floor specification.

⁸ This scope meets A2LA's *P112 Flexible Scope Policy*.

⁹ 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

JOHNSON GAGE AND INSPECTION

Wichita, KS

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/NCSLI 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 28th day of February 2019.

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

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2820.01
Valid to March 31, 2021

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