



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

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CALIBRATION

Valid To: June 30, 2018

Certificate Number: 1855.01

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

I. Chemical Quantities

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|----------------------------------|---------------------------------------|--|------------------------|
| pH Meters ³ | 4 pH unit 7 pH unit 10 pH unit | 0.014 pH 0.015 pH 0.025 pH | Certified pH standards |
| Conductivity Meters ³ | 10 µS 100 µS 1000 µS 1430 µS | 0.12 µS 0.86 µS 5.9 µS 8.5 µS | Certified uS standards |

II. Dimensional

| Parameter/Equipment | Range | CMC ^{2,6} (±) | Comments |
|---------------------|---------------------------------|----------------------------------|--|
| Gage Blocks | (0.010 to 4) in (5 to 12) in | 2.1 + 1.4L µin 6.5 + 1.1L µin | P&W Labmaster TM (UMM) & gage blocks |
| Sphere Diameter | Up to 1 in | 3.6 µin | |

| Parameter/Equipment | Range | CMC ^{2, 6} (\pm) | Comments |
|-----------------------------------|---|--|--|
| Length Standards – 1D | Up to 10 in (11 to 48) in | (23 + 2.6L) μ in (37 + 4.1L) μ in | Supermicrometer TM Linear amplifier w/ probe, gage blocks, & surface plate |
| Cylindrical Plug Gage | Up to 6 in: (0 to 1) in (1 to 2) in (2 to 3) in (3 to 4) in (4 to 5) in (5 to 6) in | 5.1 μ in 9.1 μ in 13 μ in 17 μ in 21 μ in 25 μ in | P&W Labmaster TM (UMM), gage blocks |
| Pin Gage | (0.011 to 1) in (0.22 to 25.4) mm | 18 μ in 0.83 μ m | Supermicrometer TM |
| Angle – Precision Angle Blocks | 1", 3", 5", 20", 30" 1', 3', 5', 20', 30' 1°, 3°, 5°, 15°, 30°, 45° | 5 seconds | Reference angle blocks, P&W Labmaster TM (UMM) |
| Flatness | Up to 1 μ in Deflection ⁷ | 4.8 μ in | Optical flat & monochromatic light |
| Dial Indicator ³ | Up to 1 in (1 to 12) in | (19 + 0.6R) μ in (76 + 0.6R) μ in | Indicator calibrator Indicator calibrator & gage blocks |
| Test Indicator ³ | Up to 0.2 in | (38 + 0.6R) μ in | Indicator calibrator |
| Bore Gages ³ | Up to 12 in | (70 + 4.0L) μ in | Gage blocks & cylindrical rings |
| Height Gages ⁷ | Up to 24 in | (30 + 3.2L + 0.6R) μ in | Gage blocks & surface plates |

| Parameter/Equipment | Range | CMC ^{2,6} (±) | Comments |
|--|---|---|--|
| Height Masters | Up to 24 in | $(35 + 2.7L) \mu\text{in}$ | Linear amplifier w/ probe and gage blocks |
| Calipers ³ – | | | |
| Dial/Digital/Vernier | Up to 6 in (6 to 12) in (12 to 72) in | $(110 + 0.6R) \mu\text{in}$ $(120 + 0.6R) \mu\text{in}$ $(370 + 0.6R) \mu\text{in}$ | Gage blocks and cylindrical rings |
| Inside/Outside Calipers | Up to 2 in | 200 μin | Gage blocks |
| Snap Gages | Up to 12 in | $(190 + 4.0L) + 0.6R \mu\text{in}$ | Gage blocks |
| Micrometers ³ – | | | |
| Depth | Up to 12 in | $(80 + 0.6R) \mu\text{in}$ | Gage blocks |
| Groove | Up to 1 in (1 to 4) in (4 to 36) in | $(20 + 0.6R) \mu\text{in}$ $(40 + 0.6R) \mu\text{in}$ $(37 + 4.0L) + 0.6R$ | |
| O.D. | Up to 1 in (1 to 4) in (4 to 36) in | $(20 + 0.6R) \mu\text{in}$ $(40 + 0.6R) \mu\text{in}$ $(37 + 4.0L) + 0.6R$ | |
| I.D. | Up to 36 in | $(490 + 0.6R) \mu\text{in}$ | |
| Thread Micrometers (Screw Thread, Pitch, Point) ³ | Up to 2 in | $(40 + 0.6R) \mu\text{in}$ | Optical comparator and gage blocks |
| Angle | Up to 60° | 340 seconds | |
| Hole Micrometers ³ | Up to 6 in | $(80 + 0.6R) \mu\text{in}$ | Cylindrical rings |



| Parameter/Equipment | Range | CMC ^{2, 6, 8} (±) | Comments |
|--|----------------|----------------------------------|--|
| Sine Plates/Bars – Flatness | (5, 10, 15) in | 9.6 μin | Optical flat & monochromatic light |
| Parallelism | (5, 10, 15) in | 51 μin | Linear amplifier w/ probe & surface plate |
| Angle | Up to 45° | 7.8 seconds | Linear amplifier w/ probe, gage blocks, angle blocks & surface plate |
| Thickness Gages ³ – Dial & Digital | Up to 1 in | (40 + 0.6R) μin | Gage blocks |
| Thickness Tester – Coating ³ | Up to 0.060 in | 1.1 % + 2.2 μin (0.0022 mils) | Master films |
| Chamfer Gages/Counter Sink Gages ³ | Up to 2 in | (52 + 0.6R) μin | Cylindrical rings |
| Linear Gage Amplifier w/ Probe | Up to 1 in | (0.6R + 8) μin | Gage blocks |
| Riser Blocks & Stands | Up to 24 in | (35 + 2.7H) μin | Gage blocks & gage amplifier w/ probe |
| Clinometers & Inclinometers ³ | 360° | 2.6' | Sine bar & gage blocks / master angle blocks |
| Straightness & Straight Edges | Up to 72 in | 76 μin | Linear amplifier w/ probe, gage blocks, & surface plate |



| Parameter/Equipment | Range | CMC ^{2,6} (±) | Comments |
|--|---|--|--|
| V-Blocks – Parallelism Squareness & Parallelism of the V center Squareness of block | Up to 8 in × 8 in × 8 in | 51 μin 39 μin 56 μin | Linear amplifier w/ probe, surface plate & master setting disk |
| Indicator Calibrator | Up to 1 in: 0.0001 in resolution 0.00001 in resolution | 120 μin 12 μin | Gage blocks |
| Box Parallels – Parallelism Squareness | 5 in × 10 in × 10 in | 43 μin 26 μin | Gage blocks & Linear amplifier w/ probe & surface plate |
| Microscopes ³ – Reticule | Up to 50 mm | 4.2 μm | Glass scale |
| Rules & Scales – Tape Measures PI Tapes | Up to 100 in Up to 300 ft Up to 48 in (48 to 780) in | 0.0031 in 0.008 in/25 ft 0.0011 in 0.018 in | Horizontal Trimos w/ microscope attachment |
| Squareness – Perpendicularity | Up to 24 in | 26 μin | Linear amplifier w/ probe, surface plate & gage block |
| Parallels – Steel Granite | 1.5 in × 6 in 8 in × 48 in | 43 μin 43 μin | Linear amplifier w/ probe & surface plate |
| Snap Gages ³ | Up to 3 in | 0.0002 in | Gage amplifier w/ gage block |
| Plain Ring Gages – I.D. Measurements | (0.125 to 4) in (5 to 12) in | (3.9 + 3.8D) μin (9.5 + 5.5D) μin | P&W Labmaster™ (UMM), gage blocks |

| Parameter/Equipment | Range | CMC ^{2,6} (±) | Comments |
|---|--|--|---|
| <p>Thread Plugs/Thread Lead – Pitch Diameter</p> <p>Screw:</p> <p>Standard 60°</p> <p>Acme</p> <p>Stub Acme</p> <p>Buttress Inch</p> <p>Metric</p> <p>Pipe:</p> <p>Inch (NPT, NPSM, NPSL)</p> <p>Inch (ANPT)</p> <p>Dryseal</p> <p>British Taper</p> <p>British Parallel</p> <p>Plain Taper</p> | <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(1.58 to 254) mm</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>Up to 1 in</p> | <p>(120 + 4.0L) μin</p> <p>(120 + 4.0L) μin</p> <p>(120 + 4.0L) μin</p> <p>(120 + 4.0L) μin</p> <p>(3.0 + 0.1L) μm</p> <p>(120 + 4.0L) μin</p> <p>(120 + 4.0L) μin</p> <p>(120 + 4.0L) μin</p> <p>(120 + 4.0L) μin</p> <p>(120 + 4.0L) μin</p> <p>40 μin</p> | <p>Supermicrometer™ w/ thread measuring wires &:</p> <p>ASME B1.2</p> <p>ASME B1.5</p> <p>ASME B1.8</p> <p>ASME B1.9</p> <p>ASME B1.16M</p> <p>ASME B1.20.1</p> <p>MIL P-7105B</p> <p>ASME B1.20.5</p> <p>BS21</p> <p>BS2779</p> <p>MIL P-7105B</p> |
| <p>Thread Rings –</p> <p>Adjustable</p> <p>Pipe Rings:</p> <p>Inch (NPT, NPSM, NPSL)</p> <p>Inch (ANPT)</p> <p>Dryseal</p> <p>British Taper</p> <p>British Parallel</p> | <p>Up to 12 in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> <p>(0.0625 to 10) in</p> | <p>XX (Set Plug Tolerance)</p> <p>(190 + 4.0L) μin</p> <p>(190 + 4.0L) μin</p> <p>(190 + 4.0L) μin</p> <p>(190 + 4.0L) μin</p> <p>(190 + 4.0L) μin</p> | <p>Set using master plug gages.</p> <p>ASME/ANSI B1.2 & ASME/ANSI B1.3</p> <p>ASME B1.20.1</p> <p>MIL P-7105B</p> <p>ASME B1.20.5</p> <p>BS21</p> <p>BS2779</p> |
| <p>Bench Micrometers³ – Supermicrometers</p> | <p>Up to 10 in</p> | <p>(9 + 4.0L) μin</p> | <p>Gage blocks</p> |
| <p>Depth Gage³</p> | <p>Up to 12 in</p> | <p>(190 + 0.6R) μin</p> | <p>Gage blocks</p> |
| <p>Coating Thickness Standards</p> | <p>(1 to 10) mils</p> <p>(10 to 65) mils</p> | <p>4.7 μin</p> <p>28 μin</p> | <p>Gage blocks & Supermicrometer™</p> |



| Parameter/Equipment | Range | CMC ^{2, 6, 8} (±) | Comments |
|--|---------------------------------------|----------------------------|---|
| Surface Plates ³ – Flatness | 12 in to 20 ft | $2.0\sqrt{D}$ | <i>D</i> is the diagonal in inches Renishaw laser interferometer |
| Repeatability | 12 in to 20 ft | 46 μin | Repeat-O-Meter |
| Optical Comparators ³ – Angle | (15° / 30° / 45°) | 3.3 seconds | Angle blocks |
| XY Linearity | (0.010 to 6) in | 76 μin | Glass master scale |
| Magnification | 10x, 20x, 31.25x, 50x, 62.5x, 100x | 0.0023 in | Glass scale & magnification spheres |
| Angle Plates Squareness | Up to 36 in | 26 μin | Surface plate, gage blocks & linear amplifier w/ probe |
| Angle Blocks – Non-Precision | (0 to 45)° | 1.3" | Linear amplifier w/ probe & master angle blocks, surface plate |
| Protractor ³ – Digital & Mechanical | (0 to 180)° | $0.6R + 0.06 \%$ | Angle blocks |
| Levels (Machinist) ³ | Up to 96 in | $(49 + 0.6R) \mu\text{in}$ | Gage blocks, surface plate |
| Radius Gage | Up to 1 in | 0.00026 in | Optical comparator |
| Feeler/Thickness Gage | (0.0015 to 0.25) in | 24 μin | Supermicrometer TM & gage blocks |
| Thread Wires (Working) | Up to 0.2 in | 20 μin | P&W Labmaster TM (UMM) & gage blocks |

J. C. Bennett

| Parameter/Equipment | Range | CMC ^{2,6} (±) | Comments |
|--|---------------|------------------------|--|
| CMM ³ – Non-articulating | | | |
| Linear Displacement Accuracy: X, Y, Z | Up to 200 in | (7 + 1.3L) μin | Gage blocks, Renishaw laser Interferometer |
| Squareness | Up to 18 in | 45 μin | Granite square |
| Volumetric Repeatability | Up to 72 in | 160 μin | Ball bar |
| CMM ³ – Articulating Arm | | | |
| Effective Diameter | (10 to 50) mm | 8.2 μin | CMM sphere |
| Single Point Articulation | | 1 μin | Conical socket |
| Volumetric Performance | Up to 65 in | 32 μinL + 0.0009" | Ball bar kit |

III. Dimensional Testing/Calibration¹

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|--|-------------|----------------------|-----------------------------|
| Dimensional Measurement ^{3,9} – Fixtures, Parts | Up to 72 in | 0.0016 in | Faro articulated arm CMM |



IV. Electrical – DC/Low Frequency

| Parameter/Equipment | Range | CMC ^{2,4,8} (±) | Comments |
|---|---|---|---|
| DC Voltage ³ – Measure | (0 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V | 10 µV/V + 0.3 µV 10 µV/V + 0.3 µV 10 µV/V + 0.5 µV 10 µV/V + 30 µV 11 µV/V + 100 µV | HP 3458A opt 002 |
| | (1 to 10) kV | 0.3 % + 0.1 V | Vitrek 4700 |
| DC Voltage ³ – Generate | (0 to 330) mV 330 mV to 3.3 V (3.3 to 33) V (33 to 330) V (330 to 1000) V | 16 µV/V + 1.0 µV 10 µV/V + 2.0 µV 10 µV/V + 20 µV 14 µV/V + 150 µV 14 µV/V + 1.5 mV | Fluke 5520A |
| DC Current ³ – Measure | Up to 100 µA 100 µA to 10 mA (10 to 100) mA 100 mA to 1 A | 24 µA/A + 0.8 nA 24 µA/A + 0.05 µA 35 µA/A + 0.5 µA 0.013 % + 10 µA | HP 3458A |
| | (1 to 3) A (3 to 10) A (10 to 1000) A | 0.13 % 0.17 % 0.3 % | Fluke 8845A Fluke 8845A Empro shunt |
| DC Current ³ – Generate | (0 to 330) µA 330 µA to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3) A (3 to 11) A (11 to 20.5) A | 0.013 % + 0.02 µA 0.008 % + 0.05 µA 0.008 % + 0.25 µA 0.009 % + 2.5 µA 0.017 % + 40 µA 0.03 % + 40 µA 0.04 % + 0.5 mA 0.08 % + 0.75 mA | Fluke 5520A |
| | Clamp Meter (20 to 1000) A | 0.25 % + 0.5 A | w/ 5500A coil |
| DC Power ³ – (0.33 to 330) mA (0.33 to 3) A (3 to 20) A | 33 mV to 1020 V 33 mV to 1020 V 33 mV to 1020 V | 0.010 % 0.031 % 0.081 % | Fluke 5520A |



| Parameter/Equipment | Range | CMC ^{2,4,8} (±) | Comments |
|------------------------------------|--|--|--|
| Resistance ³ – Measure | (1 to 10) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ | 15 μΩ/Ω + 50 μΩ 10 μΩ/Ω + 0.5 mΩ 15 μΩ/Ω + 0.5 mΩ 10 μΩ/Ω + 5 mΩ 10 μΩ/Ω + 50 mΩ 15 μΩ/Ω + 2 Ω 51 μΩ/Ω + 100 Ω 0.05 % + 1 kΩ 0.5 % + 10 kΩ | HP 3458A |
| Resistance ³ – Generate | Up to 11 Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω 330 Ω to 1.1 kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 33) kΩ (33 to 110) kΩ (110 to 330) kΩ 330 kΩ to 1.1 MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ (330 to 1100) MΩ | 39 μΩ/Ω + 0.001 Ω 22 μΩ/Ω + 0.0015 Ω 21 μΩ/Ω + 0.0015 Ω 23 μΩ/Ω + 0.002 Ω 22 μΩ/Ω + 0.002 Ω 23 μΩ/Ω + 0.015 Ω 21 μΩ/Ω + 0.07 Ω 23 μΩ/Ω + 0.2 Ω 23 μΩ/Ω + 0.15 Ω 32 μΩ/Ω + 10 Ω 33 μΩ/Ω + 10 Ω 0.006 % + 150 Ω 0.013 % + 250 Ω 0.026 % + 2500 Ω 0.51 % + 3000 Ω 0.3 % + 0.1 MΩ 1.5 % + 0.5 MΩ | Fluke 5520A |
| Stated Value | (0.001, 0.01, 0.1) Ω 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ | 0.07 % 0.012 % 0.023 % 0.009 % 0.007 % 0.006 % 0.003 % 0.005 % | Biddle 601240; L&N 4222-B, 4221, 4020-B, 4030-B, 4035-B, 4025-B, 4045-B, 4050-B |



| Parameter/Equipment | Range | CMC ^{2, 4, 8} (±) | Comments |
|--|---|--|-------------------------|
| Oscilloscope ³ – Squarewave Signal 50 Ω at 1 kHz Source | (1 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 1100) V | 0.28 % + 48 μV 0.28 % + 120 μV 0.28 % + 1.2 mV 0.28 % + 12 mV | Fluke 5520A w/ SC600 |
| Squarewave Signal 1 MΩ at 1 kHz Source | (1 to 110) mV 110 mV to 2.2 V (2.2 to 11) V (11 to 1100) V | 0.12 % + 48 μV 0.12 % + 120 μV 0.12 % + 1.2 mV 0.12 % + 12 mV | Fluke 5520A w/ SC600 |
| Leveled Sine Wave Amplitude at 50 kHz Ref | 50 kHz reference 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz | 2.0 % + 300 μV 3.5 % + 300 μV 4.0 % + 300 μV 6.0 % + 300 μV | |
| Leveled Sine Wave Flatness (Relative to 50 kHz) | 50 kHz to 100 MHz (100 to 300) MHz (300 to 600) MHz | 1.5 % + 100 μV 2.0 % + 100 μV 4.0 % + 100 μV | |
| Time Marker 50 Ω Generate & Period | 5 s to 50 ms 20 ms to 2 ns | 0.0026 % + 0.07 ms 0.00026 % | |
| Rise Time | ≤ 300 ps | +0 / -100 ps | |
| AC Power ³ , PF=1 45 Hz to 1 kHz | 33 mA to 1 A (1 to 3) A (3 to 11) A (11 to 20.5) A | 0.053 % 0.055 % 0.065 % 0.12 % | Fluke 5520A |
| (1 to 5) kHz | 33 mA to 3 A (3 to 20.5) A | 0.50 % 2.4 % | |



| Parameter/Equipment | Range | CMC ² (±) | Comments |
|--|---|---|-------------|
| Electrical Simulation of Thermocouple Indicators & Indicating Systems ³ Source and Measure – | | | |
| Type E | (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1000) °C | 0.39 °C 0.14 °C 0.12 °C 0.14 °C 0.17 °C | Fluke 5520A |
| Type J | (-210 to -100) °C (-100 to -30) °C (-30 to 150) °C (150 to 760) °C (760 to 1200) °C | 0.22 °C 0.14 °C 0.12 °C 0.14 °C 0.19 °C | |
| Type K | (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1000) °C (1000 to 1372) °C | 0.26 °C 0.15 °C 0.14 °C 0.21 °C 0.32 °C | |
| Type R | (0 to 250) °C (250 to 1000) °C (1000 to 1767) °C | 0.45 °C 0.28 °C 0.32 °C | |
| Type S | (0 to 250) °C (250 to 1400) °C (1400 to 1767) °C | 0.37 °C 0.29 °C 0.36 °C | |
| Type T | (-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C | 0.49 °C 0.20 °C 0.14 °C 0.12 °C | |
| Electrical Simulation of RTD Indicators & Indicating Systems ³ – | | | |
| Pt 385, 100 Ω | (-200 to 0) °C (0 to 400) °C (400 to 630) °C (630 to 800) °C | 0.05 °C 0.08 °C 0.10 °C 0.18 °C | Fluke 5520A |
| Pt 3926, 100 Ω | (-200 to 630) °C (0 to 400) °C (400 to 630) °C | 0.05 °C 0.08 °C 0.10 °C | |
| PtNi 385, 120 Ω | (-80 to 100) °C (100 to 260) °C | 0.07 °C 0.12 °C | |



| Parameter/Range | Frequency | CMC ^{2,4} (±) | Comments |
|------------------------------------|---|--|-------------|
| AC Current ³ – Generate | | | |
| (29 to 330) μA | 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.10 % + 0.1 μA 0.24 % + 0.15 μA 0.64 % + 0.2 μA | Fluke 5520A |
| 330 μA to 3.3 mA | 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.08 % + 0.15 μA 0.16 % + 0.2 μA 0.40 % + 0.3 μA | |
| (3.3 to 33) mA | 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.05 % + 2 μA 0.064 % + 2 μA 0.16 % + 3 μA | |
| (33 to 330) mA | 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.033 % + 20 μA 0.08 % + 50 μA 0.16 % + 100 μA | |
| 330 mA to 1.1 A | 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.04 % + 100 μA 0.47 % + 1000 μA 1.9 % + 5000 μA | |
| (1.1 to 3) A | 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.033 % + 20 μA 0.08 % + 50 μA 0.16 % + 100 μA | |
| (3 to 11) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.052 % + 2 mA 0.082 % + 2 mA 2.4 % + 2 mA | |
| (11 to 20.5) A | (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz | 0.1 % + 5 mA 0.12 % + 5 mA 2.4 % + 5 mA | |
| (20 to 1000) A | (45 to 65) Hz (65 to 440) Hz | 0.25 % + 0.5 A 0.5 % + 0.5 A | |



| Parameter/Range | Frequency | CMC ^{2,4} (±) | Comments |
|------------------------------------|---|---|-------------|
| AC Voltage ³ – Generate | | | |
| (1 to 33) mV | (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz | 0.063 % + 6.0 μV 0.016 % + 6.0 μV 0.019 % + 6.0 μV 0.08 % + 6.0 μV 0.27 % + 12 μV 0.63 % + 50 μV | Fluke 5520A |
| (33 to 330) mV | (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz | 0.023 % + 8.0 μV 0.012 % + 8.0 μV 0.013 % + 8.0 μV 0.028 % + 8.0 μV 0.063 % + 32 μV 0.16 % + 70 μV | |
| (0.33 to 3.3) V | (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz | 0.024 % + 50 μV 0.012 % + 60 μV 0.015 % + 60 μV 0.024 % + 50 μV 0.055 % + 130 μV 0.19 % + 600 μV | |
| (3.3 to 33) V | (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz | 0.023 % + 650 μV 0.012 % + 600 μV 0.019 % + 600 μV 0.028 % + 600 μV 0.073 % + 1.6 mV | |
| (33 to 330) V | 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz | 0.015 % + 2.0 mV 0.016 % + 6.0 mV 0.02 % + 6.0 mV 0.025 % + 6.0 mV 0.16 % + 50 mV | |
| (330 to 1020) V | 45 Hz to 10 kHz | 0.024 % + 10 mV | |



| Parameter/Range | Frequency | CMC ^{2,4} (±) | Comments |
|-----------------------------------|--|---|-------------|
| AC Voltage ³ – Measure | | | |
| (0 to 10) mV | (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz | 0.031 % + 3 μV 0.022 % + 1 μV 0.033 % + 1.1 μV 0.11 % + 1.1 μV 0.5 % + 1.1 μV 4 % + 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 | 0.01 % + 4 μV 0.01 % + 2 μV 0.016 % + 2 μV 0.032 % + 2 μV 0.081 % + 2 μV 0.3 % + 10 μV 1 % + 10 μV 1.5 % + 10 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 2 MHz | 0.0072 % + 40 μV 0.0072 % + 20 μV 0.015 % + 20 μV 0.03 % + 20 μV 0.08 % + 20 μV 0.3 % + 100 μV 1.2 % + 100 μV | |
| (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 2 MHz | 0.0074 % + 400 μV 0.0072 % + 200 μV 0.015 % + 200 μV 0.03 % + 200 μV 0.08 % + 200 μV 0.3 % + 1 mV 1.5 % + 1 mV | |
| (10 to 100) V | (1 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz | 0.02 % + 4 mV 0.02 % + 2 mV 0.035 % + 2 mV 0.12 % + 2 mV | |
| (100 to 700) 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 | |
| (1 to 10) kV | (30 to 200) Hz | 0.25 % + 0.1 V | Vitrek 4700 |



V. Electrical – RF/Microwave

| Parameter/Equipment | Frequency | CMC ^{2, 8} (±) | Comments |
|---|------------------------------------|---|----------------------|
| Distortion – Measure | 20 Hz to 20 kHz (20 to 100) kHz | 1.3 dB 2.4 dB | HP 8903B |
| Amplitude Modulation – Measure | | | |
| 150 kHz to 10 MHz | 20 Hz to 10 kHz | 3.5 % | HP 8902A |
| (10 to 1300) MHz | 20 Hz to 100 kHz | 3.5 % | |
| Frequency Modulation – Measure | | | |
| Rate: 250 kHz to 10 MHz Dev: ≤ 40 kHz | 20 Hz to 10 kHz | 3.5 % | HP 8902A |
| Rate: (10 to 1300) MHz Dev: < 400 kHz | 20 Hz to 100 kHz | 3.5 % | |
| Tuned RF Power, Relative ³ – Measure | | | |
| 0 dB, Reference (-0.0 to -3) dB (-3 to -10) dB (-10 to -40) dB (-40 to -50) dB (-50 to -80) dB (-80 to -90) dB (-90 to -110) dB (-110 to -127) dB | 2.5 MHz to 1.3 GHz | 0.03 dB 0.05 dB 0.05 dB 0.13 dB 0.13 dB 0.09 dB 0.12 dB 0.14 dB 0.35 dB | HP 8902A HP11722A |



VI. Mechanical

| Parameter/Equipment | Range | CMC ^{2, 6, 8} (±) | Comments |
|---|---|--|--|
| Mass ³ | (10 to 500) mg (1 to 10) g (20 to 40) g 50 g (100 to 200) g (300 to 500) g (1 to 3) kg 5 kg (10 to 35) kg | 0.029 mg 0.036 mg 0.050 mg 0.27 mg 0.30 mg 5.9 mg 6.1 mg 6.6 mg 800 mg | Analytical balance & weighing scale, by direct reading |
| Pressure ³ – Gauges | Up to 10 psi (11 to 1000) psi (1001 to 10000) psi (0 to 28) inH ₂ O | 0.020 psi 0.011 % + 0.0001 psi 0.031 % 0.009 inH ₂ O | Deadweight tester & pressure transducer |
| Vacuum ³ – Gauges | (0 to -15) psi | 0.020 psi | Pressure transducer |
| Torque ³ – Wrenches, Screwdrivers & Analyzers | (1 to 20) in·lbf (10 to 100) in·lbf (10 to 100) ft·lbf (51 to 800) ft·lbf (801 to 2000) ft·lbf | 0.07 % + 0.001 in·lbf 0.13 % + 0.01 in·lbf 0.13 % + 0.01 ft·lbf 0.11 % + 0.05 ft·lbf 0.13 % + 1 ft·lbf | Torque calibration system |
| Tachometers ³ – Photo | Up to 999.99 rpm (1000 to 5000) rpm (5000 to 60000) rpm | (0.004 + 0.6R) rpm (0.009 + 0.6R) rpm (0.13 + 0.6R) rpm | Fluke 5520A & LED |
| RPM ³ - Measure | Up to 99.999 rpm: (100 to 999.99) rpm (1000 to 9999.9) rpm (10000 to 60000) rpm | 0.02 % + 0.005 rpm 0.012 % + 0.01 rpm 0.012 % 0.01 % | Laser tachometer |



| Parameter/Equipment | Range | CMC ^{2, 6, 8} (\pm) | Comments |
|---|--|--|--|
| Balances ³ | Up to 500 mg (1 to 3) g 5 g 10 g (20 to 30) g 50 g 100 g 200 g 300 g 500 g 1 kg 2 kg 3 kg 4 kg 5 kg 10 kg 20 kg 30 kg 50 kg | 0.003 mg + 0.6R 0.006 mg + 0.6R 0.007 mg + 0.6R 0.011 mg + 0.6R 0.016 mg + 0.6R 0.025 mg + 0.6R 0.050 mg + 0.6R 0.10 mg + 0.6R 0.15 mg + 0.6R 0.25 mg + 0.6R 0.50 mg + 0.6R 1 mg + 0.6R 1.5 mg + 0.6R 2 mg + 0.6R 2.5 mg + 0.6R 5 mg + 0.6R 10 mg + 0.6R 15 mg + 0.6R 25 mg + 0.6R | ASTM Class 1 weights |
| Scales ³ | Up to 1 lbs (1 to 2) lbs (2 to 5) lbs (5 to 10) lbs (10 to 20) lbs (20 to 50) lbs | 0.000008 oz + 0.6R 0.000017 oz + 0.6R 0.000035 oz + 0.6R 0.00007 oz + 0.6R 0.00014 oz + 0.6R 0.00039 oz + 0.6R | ASTM Class 1 weights |
| Scales ³ | (50 to 100) lbs (100 to 500) lbs (500 to 2000) lbs | 0.0053 lbs + 0.6R 0.03 lbs + 0.6R 0.11 lbs + 0.6R | NIST Class F weights |
| Air Velocity – Anemometers, Velometers ³ | 492 fpm 984 fpm 1969 fpm 2953 fpm | 8.5 fpm 15 fpm 28 fpm 40 fpm | Standard anemometer |
| Force ³ – Tension & Compression, Dynamometers, Spring Testers | Up to 10 lbf (10 to 50) lbf 50 to 100) lbf 100 to 500) lbf (500 to 2000) lbf (2000 to 5000) lbf (5000 to 10 000) lbf (10000 to 30 000) lbf (50 000 to 100 000) lbf | 0.001 lbs + 0.6R 0.0017 lbs + 0.6R 0.008 lbs + 0.6R 0.07 lbs + 0.6R 2.5 lbs + 0.6R 6.2 lbs + 0.6R 13 lbs + 0.6R 22 lbs + 0.6R 71 lbs + 0.6R | NIST Class F weights Load cells |



| Parameter/Equipment | Range | CMC ^{2,6} (±) | Comments |
|--|--|---|---|
| Direct Verification of Durometer Spring Force ³ – Shore Types A, D | (0 to 100) duro units | 0.36 duros + 0.6R | The durometer spring is verified with a duro-calibrator that is calibrated with dead weights. |
| Indirect Verification of Brinnell & Portable Brinnell Hardness Testers (HBW10/3000) | HBW: (100 to 350) HBW (351 to 650) HBW | 0.037 mm 0.029 mm | ASTM E10 ASTM E110 |
| Indirect Verification of Knoop Hardness Tester | HK: (250 to 650) HK (> 650) HK | 0.49 µm 0.52 µm | ASTM E384 |
| Indirect Verification of Vickers | HV: 300 HV 500 HV | 0.63 µm 0.77 µm | ASTM E384 |
| Indirect Verification of Rockwell & Rockwell Superficial Hardness Testers ³ – Portable Hardness Testers | HRC: Low Medium High HRBW: Low Medium High HRA: Low Medium High HRHW: Low High HREW: Low Medium High HR15TW: Low Medium High | 0.46 HRC 0.55 HRC 0.21 HRC 0.61 HRBW 0.47 HRBW 0.59 HRBW 0.31 HRA 0.21 HRA 0.24 HRA 0.31 HRHW 0.25 HRHW 0.31 HREW 0.50 HREW 0.35 HREW 0.79 HR15TW 0.46 HR15TW 0.29 HR15TW | ASTM E18 ASTM E110 |



| Parameter/Equipment | Range | CMC ² (±) | Comments |
|---|---|--|-------------------------------------|
| Indirect Verification of Rockwell & Rockwell Superficial Hardness Testers ³ – Portable Hardness Testers (cont) | HR30TW: Low Medium High HR45TW: Low Medium High HR15N: Low Medium High HR30N: Low Medium High HR45N: Low Medium High | 0.67 HR30TW 0.48 HR30TW 0.30 HR30TW 0.58 HR45TW 0.23 HR45TW 0.37 HR45TW 0.39 HR15N 0.45 HR15N 0.29 HR15N 0.32 HR30N 0.67 HR30N 0.25 HR30N 0.65 HR45N 0.47 HR45N 0.42 HR45N | ASTM E18 ASTM E110 |
| Electrical Conductivity Meters (% IACS) – Generate Stated Value | 24.87 % 44.93 % 58.60 % | 0.28 % IACS 0.49 % IACS 0.69 % IACS | Eddy current conductivity standards |
| Gas Flow ³ – Flow Meters & Rotameters | (1 to 100) SCCM (0.1 to 1000) SLPM | 1.1 % | CME FCS-8A & Laminar flow elements |



VII. Thermodynamic

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|---|--|------------------------------|---------------------|
| Temperature ³ – Measuring Equipment | (-50 to 200) °C (200 to 400) °C | 0.019 °C 0.11 °C | PRT w/1502A |
| Temperature ³ – Measure – Ovens, Baths, Dry Blocks | (-50 to 200) °C (200 to 400) °C | 0.019 °C 0.11 °C | PRT w/1502A |
| Infrared Thermometers ³ | (50 to 100) °C (100 to 300) °C (300 to 500) °C | 0.65 °C 0.81 °C 1.0 °C | Fluke 9132 |
| Relative Humidity ³ | (10 to 95) % RH | 1.2 % RH | Rotronic hygrometer |

VIII. Time & Frequency

| Parameter/Equipment | Range | CMC ² (±) | Comments |
|--|-----------------------------------|--|---|
| Frequency – Measuring Equipment | 1 Hz to 10 Mhz 10 MHz to 1 GHz | 1.2 parts in 10 ⁸ Hz/Hz 1.2 parts in 10 ⁸ Hz/Hz | Monitored with GPS conditioned counter HP 3325a Giga-Tronics 6061A |
| Frequency – Measure | 10 Hz to 1 GHz | 1.7 parts in 10 ⁹ Hz/Hz | GPS conditioned Agilent 5386A |

¹ This laboratory offers commercial dimensional testing/calibration and field 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 measurands stated are generated and measured using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure the measurand in the ranges indicated. CMC are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification.
- ⁵ Based on using the standard at the temperature the Fluke 5520A was calibrated ($t_{cal} \pm 5 \text{ }^{\circ}\text{C}$) and assuming the instrument was zeroed at least every seven days or when the ambient temperature changes more than $5 \text{ }^{\circ}\text{C}$, the CMC is read as percent output plus 1-year floor specifications. For resistance, a zero calibration is performed at least every 12 hours within $\pm 1 \text{ }^{\circ}\text{C}$ of use. For AC Current, CMC's are determined with LCOMP off.
- ⁶ Unless otherwise noted, in the statement of CMC L is the nominal length of the device in inches; R is the resolution of the unit; D is the nominal diameter in inches; H is the nominal height of the unit under test.
- ⁷ Deflection is the maximum deviation from the reference plane.
- ⁸ In the statement of CMC, the value is defined as the percentage of reading, unless otherwise noted.
- ⁹ This laboratory meets R205 – *Specific Requirements: Calibration Laboratory Accreditation Program* for the dimensional test listed above and is considered equivalent to that of a calibration.



Accredited Laboratory

A2LA has accredited

TIC-MS, INC.

St. Louis, MO

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSLI Z540-1-1994 and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).



Presented this 22nd day of August 2016.

A handwritten signature in blue ink, appearing to read "J. C. Bunt".

Senior Director of Quality and Communications
For the Accreditation Council
Certificate Number 1855.01
Valid to June 30, 2018
Revised August 26, 2016

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