

**SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017  
AND  
ANSI/NCSL Z540-1-1994 (R2002)**

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**CALIBRATION AND DIMENSIONAL MEASUREMENT**

Valid to: **June 29, 2024**

Certificate Number: **AC-1647**

**CALIBRATION**

**Electrical – DC/Low Frequency**

| <b>Parameter/Equipment</b>              | <b>Range</b>   | <b>Expanded Uncertainty of Measurement (+/-)</b>  | <b>Reference Standard, Method, and/or Equipment</b>     |
|---|--|---|---|
| DC Current – Source                     | Up to 330 $\mu$ A<br>330 $\mu$ A to 3.3 mA<br>(3.3 to 33) mA<br>(33 to 330) mA<br>330 mA to 1.1 A<br>(1.1 to 3.0) A<br>(3.0 to 11) A<br>(11 A to 20.5) A | 150 $\mu$ A/A + 22 nA<br>100 $\mu$ A/A + 59 nA<br>100 $\mu$ A/A + 480 nA<br>100 $\mu$ A/A + 4.8 $\mu$ A<br>200 $\mu$ A/A + 51 $\mu$ A<br>380 $\mu$ A/A + 86 $\mu$ A<br>500 $\mu$ A/A + 980 $\mu$ A<br>1 mA/A + 1.8 mA | Fluke 5520A Multiproduct Calibrator                     |
|   | (20.5 to 30) A   | 470 $\mu$ A/A + 2.2 mA  | Transmille 4015 Multiproduct Calibrator                 |
| DC Current – Source (Clamp Meters Only) | (20 to 30) A<br>(30 to 110) A<br>(110 to 205) A  | 2.4 mA/A + 860 $\mu$ A<br>2.5 mA/A + 9.8 mA<br>3 mA/A + 18 mA   | Fluke 5520A Multiproduct Calibrator w/ 10 Turn Coil     |
|   | (205 to 300) A   | 2.8 mA/A + 22 mA  | Transmille 4015 Multiproduct Calibrator w/ 10 Turn Coil |
| DC Current – Source (Clamp Meters Only) | (205 to 550) A<br>(550 to 1 025) A   | 2.5 mA/A + 49 mA<br>3 mA/A + 89 mA  | Fluke 5520A Multiproduct Calibrator w/ 50 Turn Coil     |
|   | (1 025 to 1 500) A   | 2.8 mA/A + 110 mA   | Transmille 4015 Multiproduct Calibrator w/ 50 Turn Coil |



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Electrical – DC/Low Frequency

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|------------------------|---|--|--|
| DC Voltage - Source    | Up to 330 mV<br>330 mV to 3.3 V<br>(3.3 to 33) V<br>(33 to 330) V<br>(330 to 1.0) kV  | 20 $\mu$ V/V + 1.4 $\mu$ V<br>11 $\mu$ V/V + 8.7 $\mu$ V<br>12 $\mu$ V/V + 83 $\mu$ V<br>18 $\mu$ V/V + 830 $\mu$ V<br>18 $\mu$ V/V + 3.3 mV   | Fluke 5520A Multiproduct Calibrator          |
| DC Resistance - Source | Up to 11 $\Omega$<br>(11 to 33) $\Omega$<br>(33 to 110) $\Omega$<br>(110 to 330) $\Omega$<br>330 $\Omega$ to 1.1 k $\Omega$<br>(1.1 to 3.3) k $\Omega$<br>(3.3 to 11) k $\Omega$<br>(11 to 33) k $\Omega$<br>(33 to 110) k $\Omega$<br>(110 to 330) k $\Omega$<br>330 k $\Omega$ to 1.1 M $\Omega$<br>(1.1 to 3.3) M $\Omega$<br>(3.3 to 11) M $\Omega$<br>(11 to 33) M $\Omega$<br>(33 to 110) M $\Omega$<br>(110 to 330) M $\Omega$<br>330 M $\Omega$ to 1.1 G $\Omega$ | 40 $\mu\Omega/\Omega$ + 1.1 m $\Omega$<br>30 $\mu\Omega/\Omega$ + 1.6 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 1.7 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 2.8 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 4.3 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 26 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 33 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 340 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 710 m $\Omega$<br>32 $\mu\Omega/\Omega$ + 3.6 $\Omega$<br>32 $\mu\Omega/\Omega$ + 12 $\Omega$<br>60 $\mu\Omega/\Omega$ + 120 $\Omega$<br>130 $\mu\Omega/\Omega$ + 230 $\Omega$<br>250 $\mu\Omega/\Omega$ + 3.1 k $\Omega$<br>500 $\mu\Omega/\Omega$ + 12 k $\Omega$<br>3 m $\Omega/\Omega$ + 200 k $\Omega$<br>15 m $\Omega/\Omega$ + 4.2 M $\Omega$ | Fluke 5520A Multiproduct Calibrator          |
| Conductance - Source   | 910 pS to 3.0 nS<br>(3.0 to 9.1) nS<br>(9.1 to 30) nS<br>(30 to 91) nS<br>(91 to 300) nS<br>(300 to 910) nS<br>910 ns to 3.0 $\mu$ S<br>(3.0 to 9.1) $\mu$ S<br>(9.1 to 30) $\mu$ S<br>(30 to 91) $\mu$ S<br>(91 to 300) $\mu$ S<br>(300 to 910) $\mu$ S<br>910 $\mu$ $\mu$ S to 3.0 mS<br>(3.0 to 9.1) mS<br>(9.1 to 30) mS<br>(30 to 91) mS<br>(91 to 300) mS<br>(300 to 910) mS<br>910 mS to 3.0 S<br>(3.0 to 9.1) S   | 40 $\mu$ S/S + 12 pS<br>4.2 mS/S + 12 pS<br>620 $\mu$ S/S + 3.5 pS<br>620 $\mu$ S/S + 3.5 pS<br>150 $\mu$ S/S + 17 pS<br>95 $\mu$ S/S + 17 pS<br>39 $\mu$ S/S + 34 pS<br>55 $\mu$ S/S + 57 pS<br>35 $\mu$ S/S + 300 pS<br>51 $\mu$ S/S + 300 pS<br>35 $\mu$ S/S + 1.9 nS<br>51 $\mu$ S/S + 3.2 nS<br>35 $\mu$ S/S + 20 nS<br>51 $\mu$ S/S + 68 nS<br>80 $\mu$ S/S + 380 nS<br>210 $\mu$ S/S + 2.5 $\mu$ S<br>420 $\mu$ S/S + 26 $\mu$ S<br>1.2 mS/S + 210 $\mu$ S<br>3.8 mS/S + 2.3 mS<br>12 mS/S + 21 mS  | Fluke 5520A Multiproduct Calibrator          |



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|---------------------|--|--|--|
| AC Current – Source | (29 to 330) $\mu$ A<br>(10 Hz to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(10 to 30) kHz  | 2 mA/A + 150 nA<br>1.5 mA/A + 140 nA<br>1.3 mA/A + 140 nA<br>3 mA/A + 180 nA<br>8 mA/A + 220 nA<br>16 mA/A + 420 nA  | Fluke 5520A Multiproduct Calibrator          |
| AC Current – Source | 330 $\mu$ A to 3.3 mA<br>(10 Hz to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(10 to 30) kHz<br>(3.3 to 33) mA<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(10 to 30) kHz<br>(33 to 330) mA<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(10 to 30) kHz<br>330 mA to 1.1 A<br>(10 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(1.1 to 3.0) A<br>(10 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz | 2 mA/A + 730 nA<br>1.3 mA/A + 540 nA<br>1 mA/A + 560 nA<br>2 mA/A + 590 nA<br>5 mA/A + 700 nA<br>10 mA/A + 930 nA<br>1.8 mA/A + 6.7 $\mu$ A<br>900 $\mu$ A/A + 6.7 $\mu$ A<br>400 $\mu$ A/A + 6.7 $\mu$ A<br>800 $\mu$ A/A + 4 $\mu$ A<br>2 mA/A + 8.8 $\mu$ A<br>4 mA/A + 8.8 $\mu$ A<br>1.8 mA/A + 89 $\mu$ A<br>900 $\mu$ A/A + 89 $\mu$ A<br>400 $\mu$ A/A + 38 $\mu$ A<br>1 mA/A + 57 $\mu$ A<br>2 mA/A + 110 $\mu$ A<br>4 mA/A + 220 $\mu$ A<br>1.8 mA/A + 270 $\mu$ A<br>500 $\mu$ A/A + 160 $\mu$ A<br>6 mA/A + 1.1 mA<br>25 mA/A + 5.1 mA<br>1.8 mA/A + 730 $\mu$ A<br>600 $\mu$ A/A + 400 $\mu$ A<br>6 mA/A + 1.2 mA<br>25 mA/A + 5.1 mA | Fluke 5520A Multiproduct Calibrator          |



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|--|--|--|---|
| AC Current – Source                        | (3.0 to 11) A<br>(45 Hz to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                  | 600 $\mu$ A/A + 2.5 mA<br>1 mA/A + 2.7 mA<br>30 mA/A + 4.5 mA                    | Fluke 5520A Multiproduct Calibrator                     |
|  | (11 to 20.5) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                    | 1.2 mA/A + 6.4 mA<br>1.5 mA/A + 6.4 mA<br>30 mA/A + 12 mA                        |   |
| AC Current – Source                        | (20.5 to 30) A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz     | 2.3 mA/A + 16 mA<br>2.3 mA/A + 16 mA<br>1 mA/A + 5.4 mA<br>6.9 mA/A + 8 mA       | Transmille 4015 Multiproduct Calibrator                 |
|  | (20 to 30) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                      | 2.6 mA/A + 25 mA<br>3 mA/A + 27 mA<br>32 mA/A + 45 mA                            |   |
| AC Current – Source                        | (30 to 110) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                     | 3.2 mA/A + 64 mA<br>3.5 mA/A + 64 mA<br>32 mA/A + 120 mA                         | Fluke 5520A Multiproduct Calibrator w/ 10 Turn Coil     |
|  | (205 to 300) A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz     | 4.6 mA/A + 1.6 A<br>4.6 mA/A + 160 mA<br>3.3 mA/A + 54 mA<br>9.2 mA/A + 80 mA    |   |
| AC Current – Source<br>(Clamp Meters Only) | (205 to 550) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                    | 2.6 mA/A + 130 mA<br>3 mA/A + 140 mA<br>32 mA/A + 230 mA                         | Fluke 5520A Multiproduct Calibrator w/ 50 Turn Coil     |
|  | (550 to 1 025) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                  | 3.2 mA/A + 320 mA<br>3.5 mA/A + 320 mA<br>32 mA/A + 560 mA                       |   |
| AC Current – Source<br>(Clamp Meters Only) | (1 025 to 1 500) A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz | 4.6 mA/A + 800 mA<br>4.6 mA/A + 800 mA<br>3.3 mA/A + 270 mA<br>9.2 mA/A + 400 mA | Transmille 4015 Multiproduct Calibrator w/ 50 Turn Coil |
|  | (205 to 550) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                    | 2.6 mA/A + 130 mA<br>3 mA/A + 140 mA<br>32 mA/A + 230 mA                         |   |



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Electrical – DC/Low Frequency

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|---------------------|-------------------------------------|---|--|
| AC Voltage - Source | (1 to 33) mV                        |   | Fluke 5520A Multiproduct Calibrator          |
|                     | (10 to 45) Hz                       | 800 $\mu\text{V/V} + 6.7 \mu\text{V}$     |  |
|                     | 45 Hz to 10 kHz                     | 150 $\mu\text{V/V} + 6.7 \mu\text{V}$     |  |
|                     | (10 to 20) kHz                      | 200 $\mu\text{V/V} + 6.7 \mu\text{V}$     |  |
|                     | (20 to 50) kHz                      | 1 mV/V + 7.4 $\mu\text{V}$                |  |
|                     | (50 to 100) kHz                     | 3.5 mV/V + 15 $\mu\text{V}$               |  |
|                     | (100 to 500) kHz                    | 8 mV/V + 56 $\mu\text{V}$                 |  |
|                     | (33 to 330) mV                      |   |  |
|                     | (10 to 45) Hz                       | 300 $\mu\text{V/V} + 21 \mu\text{V}$      |  |
|                     | 45 Hz to 10 kHz                     | 150 $\mu\text{V/V} + 13 \mu\text{V}$      |  |
|                     | (10 to 20) kHz                      | 160 $\mu\text{V/V} + 14 \mu\text{V}$      |  |
|                     | (20 to 50) kHz                      | 350 $\mu\text{V/V} + 20 \mu\text{V}$      |  |
|                     | (50 to 100) kHz                     | 800 $\mu\text{V/V} + 42 \mu\text{V}$      |  |
|                     | (100 to 500) kHz                    | 2 mV/V + 120 $\mu\text{V}$                |  |
|                     | 330 mV to 3.3 V                     |   |  |
|                     | (10 to 45) Hz                       | 300 $\mu\text{V/V} + 110 \mu\text{V}$     |  |
|                     | 45 Hz to 10 kHz                     | 150 $\mu\text{V/V} + 95 \mu\text{V}$      |  |
|                     | (10 to 20) kHz                      | 190 $\mu\text{V/V} + 92 \mu\text{V}$      |  |
|                     | (20 to 50) kHz                      | 300 $\mu\text{V/V} + 140 \mu\text{V}$     |  |
|                     | (50 to 100) kHz                     | 700 $\mu\text{V/V} + 240 \mu\text{V}$     |  |
|                     | (100 to 500) kHz                    | 2.4 mV/V + 1.2 mV                         |  |
|                     | (3.3 to 33) V                       |   |  |
|                     | (10 to 45) Hz                       | 300 $\mu\text{V/V} + 2.1 \text{ mV}$      |  |
|                     | 45 Hz to 10 kHz                     | 150 $\mu\text{V/V} + 1.1 \text{ mV}$      |  |
|                     | (10 to 20) kHz                      | 240 $\mu\text{V/V} + 1.1 \text{ mV}$      |  |
|                     | (20 to 50) kHz                      | 350 $\mu\text{V/V} + 1.6 \text{ mV}$      |  |
|                     | (50 to 100) kHz                     | 900 $\mu\text{V/V} + 2.9 \text{ mV}$      |  |
| (33 to 330) V       |                                     |   |  |
| 45 Hz to 1 kHz      | 190 $\mu\text{V/V} + 12 \text{ mV}$ |   |  |
| (1 to 10) kHz       | 200 $\mu\text{V/V} + 13 \text{ mV}$ |   |  |
| (10 to 20) kHz      | 250 $\mu\text{V/V} + 13 \text{ mV}$ |   |  |
| (20 to 50) kHz      | 300 $\mu\text{V/V} + 20 \text{ mV}$ |   |  |
| (50 to 100) kHz     | 2 mV/V + 94 mV                      |   |  |
| (330 to 1 020) V    |                                     |   |  |
| 45 to 1 kHz         | 300 $\mu\text{V/V} + 41 \text{ mV}$ |   |  |
| (1 to 5) kHz        | 250 $\mu\text{V/V} + 44 \text{ mV}$ |   |  |
| (5 to 10) kHz       | 300 $\mu\text{V/V} + 40 \text{ mV}$ |   |  |



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|--|---|---|---|
| Capacitance - Simulation                           | (0.19 to 0.4) nF<br>(0.4 to 1.1) nF<br>(1.1 to 3.3) nF<br>(3.3 to 11) nF<br>(11 to 33) nF<br>(33 to 110) nF<br>(110 to 330) nF<br>330 nF to 1.1 μF<br>(1.1 to 3.3) μF<br>(3.3 to 11) μF<br>(11 to 33) μF<br>(33 to 110) μF<br>(110 to 330) μF<br>330 μF to 1.1 mF<br>(1.1 to 3.3) mF<br>(3.3 to 11) mF<br>(11 to 33) mF<br>(33 to 110) mF | 5 mF/F + 11 pF<br>5 mF/F + 11 pF<br>5 mF/F + 11 pF<br>2.5 mF/F + 13 pF<br>2.5 mF/F + 110 pF<br>2.5 mF/F + 130 pF<br>2.5 mF/F + 370 pF<br>2.5 mF/F + 1.3 nF<br>2.5 mF/F + 3.7 nF<br>2.5 mF/F + 13 nF<br>4 mF/F + 37 nF<br>4.5 mF/F + 130 nF<br>4.5 mF/F + 310 nF<br>4.5 mF/F + 1.1 μF<br>4.5 mF/F + 3.1 μF<br>4.5 mF/F + 11 μF<br>7.5 mF/F + 31 μF<br>11 mF/F + 110 μF | Fluke 5520A Multiproduct Calibrator           |
| Oscilloscopes<br>AC Voltage, Square Wave<br>(50 Ω) | (10 Hz to 10kHz)<br>(1 to 25) mV<br>(25 to 110) mV<br>(110 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 6.6) V  | 4.4 mV/V + 56 μV<br>4.4 mV/V + 160 μV<br>4.4 mV/V + 770 μV<br>4.4 mV/V + 3.9 mV<br>4.4 mV/V + 7.7 mV  | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| Oscilloscopes<br>AC Voltage, Square Wave<br>(1 MΩ) | (10 Hz to 1 kHz)<br>(1 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 11) V<br>(11 to 130) V<br>(1 to 10) kHz<br>(1 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 11) V<br>(11 to 130) V   | 3.7 mV/V + 770 μV<br>3.7 mV/V + 3.9 mV<br>3.7 mV/V + 16 mV<br>3.7 mV/V + 160 mV<br>4.4 mV/V + 770 μV<br>4.4 mV/V + 3.9 mV<br>4.4 mV/V + 16 mV<br>4.4 mV/V + 160 mV  | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| Oscilloscopes<br>DC Voltage<br>(50 Ω)              | (0 to 110) mV<br>(110 to 499) mV<br>499 mV to 2.2 V<br>(2.2 to 6.6) V   | 4.4 mV/V + 160 μV<br>4.4 mV/V + 770 μV<br>4.4 mV/V + 3.9 mV<br>4.4 mV/V + 7.7 mV  | Fluke 5520A-SC1100<br>Multiproduct Calibrator |



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**Electrical – DC/Low Frequency**

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|--|---|--|---|
| Oscilloscopes<br>DC Voltage<br>(1 MΩ)  | (0 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 11) V<br>(11 to 70.5) V<br>(70.5 to 130) V  | 3.6 mV/V + 770 μV<br>3.6 mV/V + 3.9 mV<br>3.6 mV/V + 16 mV<br>3.6 mV/V + 77 mV<br>3.6 mV/V + 160 mV                                      | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| Leveled Sine Wave<br>(Absolute)<br>(50 Ω, 50kHz)   | (5 to 10) mVpp<br>(10 to 40) mVpp<br>(40 to 100) mVpp<br>(100 to 800) mVpp<br>800 mVpp to 1.3 Vpp<br>(1.3 to 5.5) Vpp                         | 20 mV/V + 310 μV<br>20 mV/V + 310 μV<br>20 mV/V + 350 μV<br>20 mV/V + 1 mV<br>20 mV/V + 1.8 mV<br>20 mV/V + 8.2 mV                       |   |
| Leveled Sine Wave<br>(Absolute)<br>(50 Ω)<br>50 kHz to 10 MHz<br>(10 to 100) MHz<br>(100 to 300) MHz<br>(300 to 600) MHz<br>(600 to 1 100) MHz   | 5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 3.5 Vpp   | 36 mV/V + 7.7 mV<br>36 mV/V + 7.7 mV<br>41 mV/V + 7.7 mV<br>61 mV/V + 7.7 mV<br>71 mV/V + 7.7 mV   | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| Leveled Sine Wave<br>(Relative to 50 kHz)<br>(50 Ω)<br>50 kHz to 10 MHz<br>(10 to 100) MHz<br>(100 to 300) MHz<br>(300 to 600) MHz<br>(600 to 1 100) MHz<br>Oscilloscope Input Resistance<br>Measurement<br>(50 Ω Input)<br>(1 MΩ Input) | 5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 3.5 Vpp<br><br>(40 to 60) Ω<br>500 kΩ to 1.5 MΩ | 16 mV/V + 7.7 mV<br>17 mV/V + 7.7 mV<br>22 mV/V + 7.7 mV<br>41 mV/V + 7.7 mV<br>51 mV/V + 7.7 mV<br><br>1 mΩ/Ω + 15 mΩ<br>1 mΩ/Ω + 180 Ω | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| Oscilloscope Input<br>Capacitance Measurement<br>(1 MΩ Input)  | (5 to 50) pF  | 50 mF/F + 780 fF   | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| DC Current - Measure   | Up to 100 nA<br>100 nA to 1 μA<br>(1 to 10) μA<br>(10 to 100) μA<br>100 μA to 1 mA  | 35 μA/A + 47 pA<br>24 μA/A + 49 pA<br>24 μA/A + 190 pA<br>24 μA/A + 1.8 nA<br>24 μA/A + 12 nA  | Agilent / HP 3458A<br>Multimeter              |



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|----------------------|--|---|--|
| DC Current - Measure | (1 to 10) mA<br>(10 to 100) mA<br>100 mA to 1 A  | 24 $\mu$ A/A + 150 nA<br>41 $\mu$ A/A + 2.3 $\mu$ A<br>130 $\mu$ A/A + 46 $\mu$ A   | Agilent / HP 3458A<br>Multimeter             |
| DC Current - Measure | (1 to 3) A   | 1.4 mA/A + 1.6 mA   | Keysight 34401A<br>Multimeter                |
| DC Current - Measure | (3 to 10) A<br>(10 to 100) A<br>(100 to 200) A   | 1.3 mA/A + 48 $\mu$ A<br>1.3 mA/A + 480 $\mu$ A<br>1.3 mA/A + 1.9 mA  | Shunts, Keysight 3458A<br>Multimeter         |
| DC Current - Measure | Up to 1 000 A  | 24 mA/A + 3.4 A   | Fluke 381 Clamp Meter                        |
| AC Current - Measure | Up to 100 $\mu$ A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 5 kHz<br>100 $\mu$ A to 1 mA<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 5 kHz<br>(5 to 20) kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(1 to 10) mA<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 5 kHz<br>(5 to 20) kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(10 to 100) mA<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 5 kHz<br>(5 to 20) kHz<br>(20 to 50) kHz<br>(50 to 100) kHz | 4.6 mA/A + 39 nA<br>1.7 mA/A + 39 nA<br>700 $\mu$ A/A + 39 nA<br>700 $\mu$ A/A + 39 nA<br>4.6 mA/A + 260 nA<br>1.7 mA/A + 260 nA<br>700 $\mu$ A/A + 260 nA<br>350 $\mu$ A/A + 260 nA<br>700 $\mu$ A/A + 260 nA<br>4.6 mA/A + 480 nA<br>6.4 mA/A + 1.8 Ma<br>4.6 mA/A + 2.6 $\mu$ A<br>1.7 mA/A + 2.6 $\mu$ A<br>700 $\mu$ A/A + 2.6 $\mu$ A<br>350 $\mu$ A/A + 2.6 $\mu$ A<br>700 $\mu$ A/A + 2.6 $\mu$ A<br>4.6 mA/A + 4.8 $\mu$ A<br>6.4 mA/A + 18 $\mu$ A<br>4.6 mA/A + 26 $\mu$ A<br>1.7 mA/A + 26 $\mu$ A<br>700 $\mu$ A/A + 26 $\mu$ A<br>350 $\mu$ A/A + 26 $\mu$ A<br>700 $\mu$ A/A + 26 $\mu$ A<br>4.6 mA/A + 48 $\mu$ A<br>6.4 mA/A + 180 $\mu$ A | Agilent / HP 3458A<br>Multimeter             |



**Electrical – DC/Low Frequency**

| Parameter/Equipment  | Range   | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment             |
|----------------------|---|---|--|
| AC Current - Measure | 100 mA to 1 A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 5 kHz<br>(5 to 20) kHz<br>(20 to 50) kHz | 4.6 mA/A + 320 $\mu$ A<br>1.8 mA/A + 320 $\mu$ A<br>930 $\mu$ A/A + 320 $\mu$ A<br>1.2 mA/A + 320 $\mu$ A<br>3.5 mA/A + 320 $\mu$ A<br>12 mA/A + 510 $\mu$ A          | Agilent / HP 3458A<br>Multimeter                         |
| AC Current - Measure | (1 to 3) A<br>(3 to 5) Hz<br>(5 to 10) Hz<br>(10 to 5 000) Hz   | 13 mA/A + 3.4 mA<br>4 mA/A + 3.4 mA<br>1.7 mA/A + 3.4 mA  | Keysight 34401A<br>Multimeter                            |
| AC Current - Measure | (3 to 10) A<br>(40 to 1 000) Hz<br>(10 to 100) A<br>(40 to 1 000) Hz<br>(100 to 200) A<br>(40 to 1 000) Hz              | 1.8 mA/A + 520 $\mu$ A<br>1.7 mA/A + 5.2 mA<br>1.8 mA/A + 21 mA   | Shunts, Keysight 34401A<br>Multimeter                    |
| AC Current - Measure | (200 to 1 000) A<br>(10 to 100) Hz<br>(100 to 500) Hz   | 24 mA/A + 4.1 A<br>58 mA/A + 4.1 mA   | Fluke 381 Clamp Meter                                    |
|                      | (1 000 to 2 500) A<br>(45 to 500) Hz  | 35 mA/A + 7.2 A   | Fluke 381 Clamp Meter w/<br>iFlex Current Probe          |
| DC Voltage – Measure | Up to 1 mV<br>(1 to 10) mV  | 58 $\mu$ V/V + 27 nV<br>58 $\mu$ V/V + 100 nV   | Keysight 34420A<br>Multimeter                            |
| DC Voltage - Measure | Up to 100 mV<br>100 mV to 1 V<br>(1 to 10) V<br>(10 to 100) V<br>(100 to 1 000) V                                       | 11 $\mu$ V/V + 520 nV<br>9.2 $\mu$ V/V + 2.7 $\mu$ V<br>9.2 $\mu$ V/V + 25 $\mu$ V<br>12 $\mu$ V/V + 270 $\mu$ V<br>12 $\mu$ V/V + 5.9 mV                             | Agilent / HP 3458A<br>Multimeter                         |
| DC Voltage – Measure | (1 to 1.4) kV<br>(1.4 to 10) kV   | 350 $\mu$ V/V + 46 mV<br>350 $\mu$ V/V + 680 mV   | Vitrek 4700 Voltmeter                                    |
| DC Voltage – Measure | (10 to 35) kV   | 290 $\mu$ V/V + 2.7 V   | Vitrek 4700 Voltmeter w/<br>HVL-35 High Voltage<br>Probe |
| AC Voltage - Measure | Up to 10 mV<br>(1 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 20) kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(100 to 300) kHz | 350 $\mu$ V/V + 3.6 $\mu$ V<br>240 $\mu$ V/V + 1.6 $\mu$ V<br>350 $\mu$ V/V + 1.7 $\mu$ V<br>1.2 mV/V + 8.6 $\mu$ V<br>5.8 mV/V + 8.6 $\mu$ V<br>47 mV/V + 66 $\mu$ V | Agilent / HP 3458A<br>Multimeter                         |



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Electrical – DC/Low Frequency

| Parameter/Equipment  | Range                  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|----------------------|------------------------|---|--|
| AC Voltage - Measure | (10 to 100) mV         |   | Agilent / HP 3458A<br>Multimeter             |
|                      | (1 to 40) Hz           | 81 $\mu$ V/V + 6.5 $\mu$ V                |  |
|                      | 40 Hz to 1 kHz         | 81 $\mu$ V/V + 5.1 $\mu$ V                |  |
|                      | (1 to 20) kHz          | 170 $\mu$ V/V + 7.3 $\mu$ V               |  |
|                      | (20 to 50) kHz         | 350 $\mu$ V/V + 7.3 $\mu$ V               |  |
|                      | (50 to 100) kHz        | 930 $\mu$ V/V + 37 $\mu$ V                |  |
|                      | (100 to 300) kHz       | 350 $\mu$ V/V + 69 $\mu$ V                |  |
|                      | 300 kHz to 1 MHz       | 12 mV/V + 70 $\mu$ V                      |  |
|                      | (1 to 2) MHz           | 18 mV/V + 180 $\mu$ V                     |  |
|                      | 100 mV to 1 V          |   |  |
|                      | (1 to 40) Hz           | 81 $\mu$ V/V + 62 $\mu$ V                 |  |
|                      | 40 Hz to 1 kHz         | 81 $\mu$ V/V + 47 $\mu$ V                 |  |
|                      | (1 to 20) kHz          | 170 $\mu$ V/V + 68 $\mu$ V                |  |
|                      | (20 to 50) kHz         | 350 $\mu$ V/V + 140 $\mu$ V               |  |
|                      | (50 to 100) kHz        | 930 $\mu$ V/V + 210 $\mu$ V               |  |
|                      | (100 to 300) kHz       | 350 $\mu$ V/V + 620 $\mu$ V               |  |
|                      | 300 kHz to 1 MHz       | 12 mV/V + 1.7 mV                          |  |
|                      | (1 to 2) MHz           | 18 mV/V + 1.7 mV                          |  |
|                      | (1 to 10) V            |   |  |
|                      | (1 to 40) Hz           | 81 $\mu$ V/V + 720 $\mu$ V                |  |
|                      | 40 Hz to 1 kHz         | 81 $\mu$ V/V + 470 $\mu$ V                |  |
|                      | (1 to 20) kHz          | 170 $\mu$ V/V + 690 $\mu$ V               |  |
|                      | (20 to 50) kHz         | 350 $\mu$ V/V + 1.3 mV                    |  |
|                      | (50 to 100) kHz        | 930 $\mu$ V/V + 1.7 mV                    |  |
|                      | (100 to 300) kHz       | 350 $\mu$ V/V + 5.3 mV                    |  |
|                      | 300 kHz to 1 MHz       | 12 mV/V + 16 mV                           |  |
|                      | (1 to 2) MHz           | 18 mV/V + 21 mV                           |  |
| (10 to 100) V        |                        |   |  |
| (1 to 40) Hz         | 240 $\mu$ V/V + 6.2 mV |   |  |
| 40 Hz to 1 kHz       | 240 $\mu$ V/V + 4.8 mV |   |  |
| (1 to 20) kHz        | 240 $\mu$ V/V + 8.3 mV |   |  |
| (20 to 50) kHz       | 410 $\mu$ V/V + 7.9 mV |   |  |
| (50 to 100) kHz      | 1.4 mV/V + 24 mV       |   |  |
| (100 to 300) kHz     | 4.6 mV/V + 26 mV       |   |  |
| 300 kHz to 1 MHz     | 18 mV/V + 26 mV        |   |  |
| 750 V                |                        |   |  |
| (1 to 40) Hz         | 470 $\mu$ V/V + 70 mV  |   |  |
| 40 Hz to 1 kHz       | 470 $\mu$ V/V + 63 mV  |   |  |
| (1 to 20) kHz        | 700 $\mu$ V/V + 63 mV  |   |  |
| (20 to 50) kHz       | 1.4 mV/V + 63 mV       |   |  |
| (50 to 100) kHz      | 3.5 mV/V + 63 mV       |   |  |



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Electrical – DC/Low Frequency

| Parameter/Equipment                                | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment             |
|--|--|--|--|
| AC Voltage - Measure                               | (750 to 10 000) V<br>(0.01 to 1) Hz<br>(10 to 65) Hz<br>(30 to 200) Hz<br>(200 to 450) Hz  | 1.4 mV/V + 2.6 V<br>1.4 mV/V + 2.6 V<br>1.4 mV/V + 2.6 V<br>4.6 mV/V + 2.6 V   | Vitrek 4700 Voltmeter                                    |
|  | (10 to 30) kV<br>(0.01 to 1) Hz<br>(30 to 200) Hz<br>(200 to 450) Hz   | 1.7 mV/V + 5.9 V<br>580 $\mu$ V/V + 5.9 V<br>6.9 mV/V + 5.9 V  | Vitrek 4700 Voltmeter w/<br>HVL-35 High Voltage<br>Probe |
| DC Resistance – Measure<br>(Current Shunts)        | (0.25 to 10) m $\Omega$  | 550 $\mu\Omega/\Omega$   | Keysight 3458A,<br>Transmille 4015                       |
| AC Resistance – Measure<br>(Current Shunts)        | (0.25 to 10) m $\Omega$<br>(45 to 1 000) Hz  | 1.5 m $\Omega/\Omega$  |  |
| Resistance – Measure                               | Up to 1 $\Omega$<br>(1 to 10) $\Omega$   | 81 $\mu\Omega/\Omega$ + 8.1 $\mu\Omega$<br>70 $\mu\Omega/\Omega$ + 81 $\mu\Omega$  | Keysight 34420A  |
| Resistance Measure                                 | Up to 100 $\Omega$<br>(10 to 100) $\Omega$<br>100 $\Omega$ to 1 k $\Omega$<br>(1 to 10) k $\Omega$<br>(10 to 100) k $\Omega$<br>100 k $\Omega$ to 1 M $\Omega$<br>(1 to 10) M $\Omega$<br>(10 to 100) M $\Omega$<br>100 M $\Omega$ to 1 G $\Omega$ | 18 $\mu\Omega/\Omega$ + 110 $\mu\Omega$<br>14 $\mu\Omega/\Omega$ + 1.1 m $\Omega$<br>12 $\mu\Omega/\Omega$ + 7.4 m $\Omega$<br>12 $\mu\Omega/\Omega$ + 75 m $\Omega$<br>12 $\mu\Omega/\Omega$ + 750 m $\Omega$<br>18 $\mu\Omega/\Omega$ + 8.0 $\Omega$<br>58 $\mu\Omega/\Omega$ + 250 $\Omega$<br>580 $\mu\Omega/\Omega$ + 18 k $\Omega$<br>5.8 m $\Omega/\Omega$ + 180 k $\Omega$ | Agilent / HP 3458A<br>Multimeter                         |
| Resistance – Measure                               | (20 to 200) M $\Omega$<br>(200 to 2 000) M $\Omega$<br>(2 to 20) G $\Omega$<br>(20 to 200) G $\Omega$<br>(200 to 2 000) G $\Omega$<br>(2 to 20) T $\Omega$   | 1.7 m $\Omega/\Omega$ + 9.5 k $\Omega$<br>2.6 m $\Omega/\Omega$ + 150 k $\Omega$<br>2.6 m $\Omega/\Omega$ + 2.3 M $\Omega$<br>4 m $\Omega/\Omega$ + 72 M $\Omega$<br>4 m $\Omega/\Omega$ + 2.9 G $\Omega$<br>12 m $\Omega/\Omega$ + 57 G $\Omega$  | Keithley 6517A Multimeter                                |
| Electrical Simulation of RTD<br>Indicating Devices | Pt 385 100 $\Omega$<br>(-200 to -80) $^{\circ}$ C<br>(-80 to 0) $^{\circ}$ C<br>(0 to 100) $^{\circ}$ C<br>(100 to 300) $^{\circ}$ C<br>(300 to 400) $^{\circ}$ C<br>(400 to 630) $^{\circ}$ C<br>(630 to 800) $^{\circ}$ C                        | 0.053 $^{\circ}$ C<br>0.053 $^{\circ}$ C<br>0.072 $^{\circ}$ C<br>0.092 $^{\circ}$ C<br>0.11 $^{\circ}$ C<br>0.13 $^{\circ}$ C<br>0.24 $^{\circ}$ C  | Fluke 5520A Multiproduct<br>Calibrator                   |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                                      | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment |
|--|---|--|--|
| Electrical Simulation of RTD Indicating Devices          | Pt 385 200 Ω<br>(-200 to -80) °C<br>(-80 to 0) °C<br>(0 to 100) °C<br>(100 to 260) °C<br>(260 to 300) °C<br>(300 to 400) °C<br>(400 to 600) °C<br>(600 to 630) °C<br><br>Pt 385 500 Ω<br>(-200 to -80) °C<br>(-80 to 0) °C<br>(0 to 100) °C<br>(100 to 260) °C<br>(260 to 300) °C<br>(300 to 400) °C<br>(400 to 600) °C<br>(600 to 630) °C<br><br>Pt 385 1 000 Ω<br>(-200 to -80) °C<br>(-80 to 0) °C<br>(0 to 100) °C<br>(100 to 260) °C<br>(260 to 300) °C<br>(300 to 400) °C<br>(400 to 600) °C<br>(600 to 630) °C | 0.043 °C<br>0.043 °C<br>0.043 °C<br>0.053 °C<br>0.13 °C<br>0.14 °C<br>0.15 °C<br>0.17 °C<br><br>0.043 °C<br>0.053 °C<br>0.053 °C<br>0.062 °C<br>0.082 °C<br>0.082 °C<br>0.092 °C<br>0.12 °C<br><br>0.035 °C<br>0.035 °C<br>0.044 °C<br>0.053 °C<br>0.063 °C<br>0.072 °C<br>0.072 °C<br>0.24 °C | Fluke 5520A Multiproduct Calibrator          |
| Electrical Simulation of Thermocouple Indicating Devices | Type B<br>(600 to 800) °C<br>(800 to 1 000) °C<br>(1 000 to 1 550) °C<br>(1 550 to 1 820) °C<br><br>Type E<br>(-250 to -100) °C<br>(-100 to -25) °C<br>(-25 to 350) °C<br>(350 to 650) °C<br>(650 to 1 000) °C  | 0.49 °C<br>0.39 °C<br>0.35 °C<br>0.38 °C<br><br>0.53 °C<br>0.23 °C<br>0.21 °C<br>0.23 °C<br>0.26 °C  | Fluke 5520A Multiproduct Calibrator          |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                                      | Range               | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--|---------------------|---|--|
| Electrical Simulation of Thermocouple Indicating Devices | Type J              |   | Fluke 5520A Multiproduct Calibrator          |
|  | (-210 to -100) °C   | 0.32 °C                                   |  |
|  | (-100 to -30) °C    | 0.23 °C                                   |  |
|  | (-30 to 150) °C     | 0.21 °C                                   |  |
|  | (150 to 760) °C     | 0.23 °C                                   |  |
|  | (760 to 1 200) °C   | 0.28 °C                                   |  |
|  | Type K              |   |  |
|  | (-200 to -100) °C   | 0.37 °C                                   |  |
|  | (-100 to -25) °C    | 0.24 °C                                   |  |
|  | (-25 to 120) °C     | 0.23 °C                                   |  |
|  | (120 to 1 000) °C   | 0.31 °C                                   |  |
|  | (1 000 to 1 372) °C | 0.43 °C                                   |  |
|  | Type N              |   |  |
|  | (-200 to -100) °C   | 0.44 °C                                   |  |
|  | (-100 to -25) °C    | 0.28 °C                                   |  |
|  | (-25 to 120) °C     | 0.25 °C                                   |  |
|  | (120 to 410) °C     | 0.24 °C                                   |  |
|  | (410 to 1 300) °C   | 0.32 °C                                   |  |
|  | Type R              |   |  |
|  | (0 to 250) °C       | 0.61 °C                                   |  |
|  | (250 to 400) °C     | 0.4 °C                                    |  |
| (400 to 1 000) °C  | 0.38 °C             |   |  |
| (1 000 to 1 767) °C                                      | 0.44 °C             |   |  |
| Type S   |                     |   |  |
| (0 to 200) °C  | 0.52 °C             |   |  |
| (200 to 1 000) °C  | 0.41 °C             |   |  |
| (1 000 to 1 400) °C                                      | 0.41 °C             |   |  |
| (1 400 to 1 767) °C                                      | 0.5 °C              |   |  |
| Type T   |                     |   |  |
| (-250 to -150) °C  | 0.66 °C             |   |  |
| (-150 to 0) °C   | 0.29 °C             |   |  |
| (0 to 120) °C  | 0.23 °C             |   |  |
| (120 to 400) °C  | 0.21 °C             |   |  |

**Length – Dimensional Metrology**

| Parameter/Equipment             | Range                                       | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment              |
|---------------------------------|---|---|---|
| Length Standards <sup>2,3</sup> | Up to 1 in<br>(1 to 10) in<br>(10 to 20) in | 20 μin<br>(11 + 7.8L) μin<br>(20 + 10L) μin | Gauge Blocks,<br>Supermicrometer,<br>Electronic Indicator |

### Length – Dimensional Metrology

| Parameter/Equipment   | Range  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment          |
|---|--|---|---|
| Calipers <sup>3</sup>   | Up to 36 in<br>(36 to 84) in                     | (670 + 9.2L) μin<br>(41 + 1.2L) μin       | Gauge Blocks  |
| Micrometers – Outside <sup>3</sup>  | Up to 1 in<br>(1 to 36) in                       | 14 μin<br>(73 + 5.8L) μin                 | Gauge Blocks  |
| Plunger Indicators – Dial or Digital  | Up to 0.001 in<br>(0.001 to 1) in<br>(1 to 2) in | 24 μin<br>81 μin<br>84 μin                | Gauge Blocks, Micrometer Head                         |
| Lever Indicators – Dial, Digital, or Electronic <sup>3</sup>                    | Up to 0.001 in<br>(0.001 to 0.06) in             | (10 + 31 000L) μin<br>(46 + 1 300L) μin   | Gauge Blocks  |
| Micrometer Heads  | Up to 2 in                                       | 77 μin                                    | Gauge Blocks, Electronic Indicator                    |
| Height Gages  | Up to 6 in<br>(6 to 12) in<br>(12 to 20) in      | 82 μin<br>120 μin<br>160 μin              | Gauge Blocks, Surface Plate                           |
| Cylindrical Gauges - Thread Wires, Pin Gauges, Plain Plug Gauges <sup>2,3</sup> | Up to 1 in<br>(1 to 10) in                       | 18 μin<br>(11 + 5.7L) μin                 | Supermicrometer, Gauge Blocks                         |
| Thread Wires <sup>2,3</sup>   | Up to 1 in                                       | 18 μin                                    | Universal Supermicrometer, Gauge Blocks               |
| Thread Plug Gauges <sup>2</sup><br>Major Diameter<br>Pitch Diameter             | Up to 1 in<br>Up to 1 in                         | 18 μin<br>63 μin                          | Universal Supermicrometer, Gauge Blocks, Thread Wires |
| Feeler Gauges   | Up to 1 in                                       | 20 μin                                    | Universal Supermicrometer, Gauge Blocks               |
| Bore Gauges (2 Point) <sup>3</sup>  | Up to 6 in                                       | (140 + 4.3L) μin                          | Bore Gauge Setting Master Kit                         |
| Bore Gauges (3 Point) <sup>3</sup>  | (0.625 to 7.875) in                              | 160 μin                                   | Tru-Cal, Gauge Blocks Master Pins                     |
| Micrometer - Inside   | (1 to 6) in                                      | 97 μin                                    | Bore Gauge Setting Master Kit                         |
| Micrometer – Depth  | Up to 6 in                                       | 97 μin                                    | Square Gauge Blocks, Surface Plate                    |
| Parallels / Straight Edges  | Up to 36 in                                      | 130 μin                                   | Electronic Gauging Head / Surface Plate               |
| Ring Gauges <sup>2,3</sup>  | (0.04 to 11.5) in                                | (25 + 4.3L) μin                           | Universal Supermicrometer, Master Rings               |

**Length – Dimensional Metrology**

| Parameter/Equipment                        | Range                      | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                     |
|--|----------------------------|---|--|
| Sine Bars / Plates <sup>2</sup>            | Up to 5 in<br>(5 to 10) in | 61 μin<br>100 μin                         | Electronic Gauging Head,<br>Surface Plate, ???                   |
| Angle Blocks <sup>3</sup>                  | Up to 60°                  | (3.5 + 0.48A) arcsec                      | Sine Plate, Electronic<br>Gauging Head                           |
| Digital Inclinometers                      | Up to 90°                  | 0.067°                                    | Angle Blocks, Sine Plate   |
| Cylindrical Squares<br>Up to 24 in tall    | Up to 0.001 in             | 51 μin                                    | Electronic Gauging Head,<br>Surface Plate                        |
| Squares / Angle Plates<br>Up to 24 in tall | Up to 0.001 in             | 160 μin                                   | Cylindrical Square,<br>Electronic Gauging Head,<br>Surface Plate |

**Mass and Mass Related**

| Parameter/Equipment                                    | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment |
|--|--|--|--|
| Tensiometers <sup>3</sup>                              | Up to 200 lbf<br>(200 to 2 000) lbf  | (0.22 + 0.0023X) lbf<br>(0.91 + 2.1X) lbf  | Dead weights<br>Torque Sensor                |
| Torque Wrenches <sup>3</sup>                           | Up to 10 lbf·in<br>(10 to 100) lbf·in<br>(100 to 200) lbf·in<br>Up to 100 lbf·ft<br>(100 to 500) lbf·ft<br>(500 to 2 000) lbf·ft | 0.055 lbf·in<br>0.31 lbf·in<br>(0.14 + 0.000 83X) lbf·in<br>(0.027 + 0.001 1X) lbf·ft<br>(0.58 + 0.000 55X) lbf·ft<br>(0.45 + 0.001 1X) lbf·ft | Torque Sensor                                |
| Torque Multipliers                                     | (100 to 3 000) lbf·ft<br>(3 000 to 6 000) lbf·ft <sup>2</sup>  | 3.6 lbf·ft<br>0.02 % of reading  | Torque Sensor<br>Torque Arm, Dead Weight     |
| Torque Transducers <sup>2</sup>                        | (5 to 1 200) lbf·in<br>(100 to 1 000) lbf·ft<br>(1 000 to 2 500) lbf·ft<br>(2 500 to 6 000) lbf·ft <sup>2</sup>                  | 0.022 % of reading<br>0.021 % of reading<br>0.02 % of reading<br>0.02 % of reading   | Torque Arm, Dead Weight                      |
| Force Gages and Load Cells<br>Tension & Compression    | Up to 200 lbf<br>(200 to 2 000) lbf  | 0.002 6 % of reading + 0.000 22 lbf<br>0.002 1 % of reading + 0.009 3 lbf  | Dead Weights                                 |
|  | (1 000 to 10 000) lbf<br>(10 000 to 30 000) lbf  | 4.4 lbf<br>13 lbf  | Load Cell                                    |
| Force Gages and Load Cells<br>Compression <sup>2</sup> | (30 000 to 100 000) lbf  | 44 lbf   | Load Cell                                    |

### Mass and Mass Related

| Parameter/Equipment | Range  | Expanded Uncertainty of Measurement (+/-)                           | Reference Standard, Method, and/or Equipment            |
|---------------------|--|---|---|
| Scales              | Up to 5 000 gf   | 0.002 % of reading + 0.076 mgf                                      | Class 1 weights   |
| Scales              | (5 to 50) kgf<br>(100 to 2 000) lbf  | 0.000 16 % of reading + 0.11 gf<br>0.002 % of reading + 0.009 9 lbf | Class S-1 weights<br>Class F weights<br>Class F weights |
| Scales              | (2 000 to 10 000) lbf<br>(10 000 to 30 000) lbf  | 5.5 lbf<br>15 lbf   | Load Cell   |
| Scales <sup>2</sup> | (30 000 to 100 000) lbf  | 40 lbf  |   |
| Pressure Gauges     | Up to 95 psi   | 0.049 psi   | Setra 370 Pressure Indicator                            |
|                     | (35 to 500) psi<br>(500 to 5 000) psi<br>(5 000 to 10 000) psi<br>(10 000 to 15 000) psi | 0.74 psi<br>11 psi<br>7.7 psi<br>11 psi                             | Pressure Indicators                                     |
|                     | Up to 19 psia  | 0.003 psi   | Druck DPI 145 Pressure Tester                           |
|                     | (19 to 110) psia   | 0.032 psi   | Setra 370 Pressure Indicator                            |

### Thermodynamic

| Parameter/Equipment                 | Range                           | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|-------------------------------------|---------------------------------|---|--|
| Temperature Measure – Air           | (-80 to 420) °C                 | 0.044 °C                                  | PRT, Indicator                               |
| Temperature Measure – Dry Well      | (-25 to 420) °C                 | 0.12 °C                                   | PRT, Indicator                               |
| Temperature Measure – Liquid Bath   | (-20 to 150) °C                 | 0.043 °C                                  | PRT, Indicator                               |
| Humidity – Measure                  | (0 to 90) %RH<br>(90 to 95) %RH | 1.5 %RH<br>2.2 %RH                        | Humidity Air Probe                           |
| Thermometers – Dry Well             | (-20 to 420) °C                 | 0.12 °C                                   | PRT, Indicator                               |
| Thermometers – Chamber <sup>2</sup> | (-70 to 175) °C                 | 0.051 °C                                  | PRT, Indicator                               |



### Thermodynamic

| Parameter/Equipment                     | Range                           | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|---|---------------------------------|---|--|
| Thermometers – Liquid Bath <sup>2</sup> | (-20 to 150) °C                 | 0.038 °C                                  | PRT, Indicator                               |
| Hygrometer <sup>2</sup>                 | (0 to 90) %RH<br>(90 to 95) %RH | 1.6 %RH<br>2.3 %RH                        | Humidity Air Probe,<br>Humidity Chamber      |
| Temperature – Fixed Point               | 0 °C                            | 0.067 °C                                  | Kaye Ice Point Reference -<br>TPW            |

### Time and Frequency

| Parameter/Equipment  | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment  |
|--|---|--|---|
| Logic Pulses - Source<br>(0.01, 0.025, 0.1, 0.25, 1, 2.5) V<br>Pulse Width | (4 to 500) ns   | 50 ns/s + 3.2 ns   | Fluke 5520A-SC1100<br>Multiproduct Calibrator<br>with ERC 130<br>Frequency Standard |
| Logic Pulses - Source<br>(0.01, 0.025, 0.1, 0.25, 1, 2.5) V<br>Period      | 200 ns to 20 ms   | 100 ns/s + 500 ps  |   |
| Time Markers<br>(Spike or Square Wave)                                     | 5 ns to 20 ms   | 100 ns/s + 390 ps  | Fluke 5520A-SC1100<br>Multiproduct Calibrator<br>with ERC 130<br>Frequency Standard |
| Frequency - Source   | 0.01 Hz to 1 100 MHz<br>(1.1 to 26) GHz   | 5.8 μHz + 750 pHz/Hz<br>5.8 μHz + 750 pHz/Hz   | Fluke 5520A-SC1100<br>Multiproduct Calibrator<br>with ERC 130<br>Frequency Standard |
| Frequency - Source /<br>Fixed 10 MHz                                       | 10 MHz  | 14 mHz   | ERC 130 Frequency<br>Standard   |
| Photo Tachometers - Simulate   | (6 to 200 000) RPM  | 0.000 35 RPM + 1.1 E <sup>-9</sup><br>RPM/RPM  | Signal Generator with<br>ERC 130 Frequency<br>Standard                              |
| RPM – Measure  | (5 to 99) RPM<br>(100 to 999) RPM<br>(1 000 to 9 999) RPM<br>(10 000 to 99 999) RPM<br>(100 000 to 200 000) RPM | 0.013 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>0.13 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>0.61 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>6.1 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>22 RPM + 1.2 E <sup>-4</sup> RPM/RPM | Photo Tachometer  |
| Timers & Stopwatches   | (10 to 600 000) s   | 0.041 s + 750 ps/s   | Signal Generator,<br>Timer/Counter,<br>Frequency Standard                           |

### Time and Frequency

| Parameter/Equipment                                   | Range                                 | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment                   |
|---|---------------------------------------|--|--|
| Frequency – Measure                                   | 10 Hz to 225 MHz<br>225 MHz to 26 GHz | 12 mHz + 750 pHz/Hz<br>1.2 Hz + 750 pHz/Hz | Timer/Counter, Freq Std<br>Freq Counter,<br>Frequency Standard |
| Time Interval /<br>Period or Pulse Width –<br>Measure | 4.4 ns to 10 s<br>(10 to 100 000) s   | 390 ps + 1.4 ns/s<br>1.3 ns + 1.4 ns/s     | Universal Timer /<br>Counter, Frequency<br>Standard            |
| Duty Cycle – Measure<br>Up to 225 MHz <sup>3</sup>    | (0 to 100) %PW                        | 5.5 x E <sup>-8</sup> %PW/Hz               | Universal Timer /<br>Counter, Frequency<br>Standard            |

## DIMENSIONAL MEASUREMENT

### 1 Dimensional

| Parameter/Equipment                      | Range                    | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment             |
|--|--------------------------|---|--|
| Height / Linear Measurement <sup>3</sup> | Up to 6 in               | 200 μin                                   | Electronic Height Gauge                                  |
| Optical Linear Measurement <sup>2</sup>  | Up to 2 in<br>Up to 6 in | 170 μin<br>360 μin                        | Toolmakers Microscope<br>Optical Comparator /<br>Readout |

## Services performed at satellite location

975 Platte River Blvd., Unit M  
Brighton, CO 80601  
DuWain Ake 937-832-3322 x200

### CALIBRATION

#### Electrical – DC/Low Frequency

| Parameter/Equipment                        | Range  | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment            |
|--|--|---|---|
| DC Current – Source                        | Up to 330 $\mu$ A<br>330 $\mu$ A to 3.3 mA<br>(3.3 to 33) mA<br>(33 to 330) mA<br>330 mA to 1.1 A<br>(1.1 to 3.0) A<br>(3.0 to 11) A<br>(11 A to 20.5) A | 150 $\mu$ A/A + 22 nA<br>100 $\mu$ A/A + 59 nA<br>100 $\mu$ A/A + 480 nA<br>100 $\mu$ A/A + 4.8 $\mu$ A<br>200 $\mu$ A/A + 51 $\mu$ A<br>380 $\mu$ A/A + 86 $\mu$ A<br>500 $\mu$ A/A + 980 $\mu$ A<br>1.0 mA/A + 1.8 mA | Fluke 5520A Multiproduct Calibrator                     |
|  | (20.5 to 30) A   | 470 $\mu$ A/A + 2.2 mA  | Transmille 4015 Multiproduct Calibrator                 |
| DC Current – Source<br>(Clamp Meters Only) | (20 to 30) A<br>(30 to 110) A<br>(110 to 205) A  | 2.4 mA/A + 860 $\mu$ A<br>2.5 mA/A + 9.8 mA<br>3 mA/A + 18 mA   | Fluke 5520A Multiproduct Calibrator w/ 10 Turn Coil     |
|  | (205 to 300) A   | 2.8 mA/A + 22 mA  | Transmille 4015 Multiproduct Calibrator w/ 10 Turn Coil |
| DC Current – Source<br>(Clamp Meters Only) | (205 to 550) A<br>(550 to 1 025) A   | 2.5 mA/A + 49 mA<br>3.0 mA/A + 89 mA  | Fluke 5520A Multiproduct Calibrator w/ 50 Turn Coil     |
|  | (1 025 to 1 500) A   | 2.8 mA/A + 110 mA   | Transmille 4015 Multiproduct Calibrator w/ 50 Turn Coil |
| DC Voltage - Source                        | Up to 330 mV<br>330 mV to 3.3 V<br>(3.3 to 33) V<br>(33 to 330) V<br>(330 to 1.0) kV   | 20 $\mu$ V/V + 1.4 $\mu$ V<br>11 $\mu$ V/V + 8.7 $\mu$ V<br>12 $\mu$ V/V + 83 $\mu$ V<br>18 $\mu$ V/V + 830 $\mu$ V<br>18 $\mu$ V/V + 3.3 mV  | Fluke 5520A Multiproduct Calibrator                     |
| DC Resistance - Source                     | Up to 11 $\Omega$<br>(11 to 33) $\Omega$<br>(33 to 110) $\Omega$<br>(110 to 330) $\Omega$<br>330 $\Omega$ to 1.1 k $\Omega$                              | 40 $\mu\Omega/\Omega$ + 1.1 m $\Omega$<br>30 $\mu\Omega/\Omega$ + 1.6 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 1.7 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 2.8 m $\Omega$<br>28 $\mu\Omega/\Omega$ + 4.3 m $\Omega$          | Fluke 5520A Multiproduct Calibrator                     |



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Electrical – DC/Low Frequency

| Parameter/Equipment              | Range   | Expanded Uncertainty of Measurement (+/-)      | Reference Standard, Method, and/or Equipment |
|----------------------------------|---|--|--|
| DC Resistance - Source           | (1.1 to 3.3) k $\Omega$                       | 28 $\mu\Omega/\Omega$ + 26 m $\Omega$          | Fluke 5520A Multiproduct Calibrator          |
|                                  | (3.3 to 11) k $\Omega$                        | 28 $\mu\Omega/\Omega$ + 33 m $\Omega$          |  |
|                                  | (11 to 33) k $\Omega$                         | 28 $\mu\Omega/\Omega$ + 340 m $\Omega$         |  |
|                                  | (33 to 110) k $\Omega$                        | 28 $\mu\Omega/\Omega$ + 710 m $\Omega$         |  |
|                                  | (110 to 330) k $\Omega$                       | 32 $\mu\Omega/\Omega$ + 3.6 $\Omega$           |  |
|                                  | 330 k $\Omega$ to 1.1 M $\Omega$              | 32 $\mu\Omega/\Omega$ + 12 $\Omega$            |  |
|                                  | (1.1 to 3.3) M $\Omega$                       | 60 $\mu\Omega/\Omega$ + 120 $\Omega$           |  |
|                                  | (3.3 to 11) M $\Omega$                        | 130 $\mu\Omega/\Omega$ + 230 $\Omega$          |  |
|                                  | (11 to 33) M $\Omega$                         | 250 $\mu\Omega/\Omega$ + 3.1 k $\Omega$        |  |
|                                  | (33 to 110) M $\Omega$                        | 500 $\mu\Omega/\Omega$ + 12 k $\Omega$         |  |
| (110 to 330) M $\Omega$          | 3.0 m $\Omega/\Omega$ + 200 k $\Omega$        |  |  |
| 330 M $\Omega$ to 1.1 G $\Omega$ | 15 m $\Omega/\Omega$ + 4.2 M $\Omega$         |  |  |
| Conductance – Source             | 910 pS to 3.0 nS                              | 40 $\mu\text{S}/\text{S}$ + 12 pS              | Fluke 5520A Multiproduct Calibrator          |
|                                  | (3.0 to 9.1) nS                               | 4.2 mS/S + 12 pS                               |  |
|                                  | (9.1 to 30) nS                                | 620 $\mu\text{S}/\text{S}$ + 3.5 pS            |  |
|                                  | (30 to 91) nS                                 | 620 $\mu\text{S}/\text{S}$ + 3.5 pS            |  |
|                                  | (91 to 300) nS                                | 150 $\mu\text{S}/\text{S}$ + 17 pS             |  |
|                                  | (300 to 910) nS                               | 95 $\mu\text{S}/\text{S}$ + 17 pS              |  |
|                                  | 910 nS to 3.0 $\mu\text{S}$                   | 39 $\mu\text{S}/\text{S}$ + 34 pS              |  |
|                                  | (3.0 to 9.1) $\mu\text{S}$                    | 55 $\mu\text{S}/\text{S}$ + 57 pS              |  |
|                                  | (9.1 to 30) $\mu\text{S}$                     | 35 $\mu\text{S}/\text{S}$ + 300 pS             |  |
|                                  | (30 to 91) $\mu\text{S}$                      | 51 $\mu\text{S}/\text{S}$ + 300 pS             |  |
|                                  | (91 to 300) $\mu\text{S}$                     | 35 $\mu\text{S}/\text{S}$ + 1.9 nS             |  |
|                                  | (300 to 910) $\mu\text{S}$                    | 51 $\mu\text{S}/\text{S}$ + 3.2 nS             |  |
|                                  | 910 $\mu\text{S}$ to 3.0 mS                   | 35 $\mu\text{S}/\text{S}$ + 20 nS              |  |
|                                  | (3.0 to 9.1) mS                               | 51 $\mu\text{S}/\text{S}$ + 68 nS              |  |
|                                  | (9.1 to 30) mS                                | 80 $\mu\text{S}/\text{S}$ + 380 nS             |  |
|                                  | (30 to 91) mS                                 | 210 $\mu\text{S}/\text{S}$ + 2.5 $\mu\text{S}$ |  |
| (91 to 300) mS                   | 420 $\mu\text{S}/\text{S}$ + 26 $\mu\text{S}$ |  |  |
| (300 to 910) mS                  | 1.2 mS/S + 210 $\mu\text{S}$                  |  |  |
| 910 mS to 3.0 S                  | 3.8 mS/S + 2.3 mS                             |  |  |
| (3.0 to 9.1) S                   | 12 mS/S + 21 mS                               |  |  |
| AC Current – Source              | (29 to 330) $\mu\text{A}$                     | 2 mA/A + 150 nA                                | Fluke 5520A Multiproduct Calibrator          |
|                                  | (10 Hz to 20) Hz                              | 1.5 mA/A + 140 nA                              |  |
|                                  | (20 to 45) Hz                                 | 1.3 mA/A + 140 nA                              |  |
|                                  | 45 Hz to 1 kHz                                | 3 mA/A + 180 nA                                |  |
|                                  | (1 to 5) kHz                                  | 8 mA/A + 220 nA                                |  |
|                                  | (5 to 10) kHz                                 | 16 mA/A + 420 nA                               |  |
| (10 to 30) kHz                   |   |  |  |



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Electrical – DC/Low Frequency

| Parameter/Equipment                | Range                                     | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|------------------------------------|---|---|--|
| AC Current – Source                | 330 $\mu$ A to 3.3 mA<br>(10 Hz to 20) Hz | 2 mA/A + 730 nA                           | Fluke 5520A Multiproduct Calibrator          |
|                                    | (20 to 45) Hz                             | 1.3 mA/A + 540 nA                         |  |
|                                    | 45 Hz to 1 kHz<br>(1 to 5) kHz            | 1 mA/A + 560 nA                           |  |
|                                    | (5 to 10) kHz                             | 2 mA/A + 590 nA                           |  |
|                                    | (10 to 30) kHz                            | 5 mA/A + 700 nA                           |  |
|                                    | 10 mA/A + 930 nA                          |   |  |
|                                    | (3.3 to 33) mA<br>(10 to 20) Hz           | 1.8 mA/A + 6.7 $\mu$ A                    |  |
|                                    | (20 to 45) Hz                             | 900 $\mu$ A/A + 6.7 $\mu$ A               |  |
|                                    | 45 Hz to 1 kHz<br>(1 to 5) kHz            | 400 $\mu$ A/A + 6.7 $\mu$ A               |  |
|                                    | (5 to 10) kHz                             | 800 $\mu$ A/A + 4 $\mu$ A                 |  |
|                                    | (10 to 30) kHz                            | 2 mA/A + 8.8 $\mu$ A                      |  |
|                                    | 4 mA/A + 8.8 $\mu$ A                      |   |  |
|                                    | (33 to 330) mA<br>(10 to 20) Hz           | 1.8 mA/A + 89 $\mu$ A                     |  |
|                                    | (20 to 45) Hz                             | 900 $\mu$ A/A + 89 $\mu$ A                |  |
|                                    | 45 Hz to 1 kHz<br>(1 to 5) kHz            | 400 $\mu$ A/A + 38 $\mu$ A                |  |
|                                    | (5 to 10) kHz                             | 1 mA/A + 57 $\mu$ A                       |  |
|                                    | (10 to 30) kHz                            | 2 mA/A + 110 $\mu$ A                      |  |
|                                    | 4 mA/A + 220 $\mu$ A                      |   |  |
|                                    | 330 mA to 1.1 A<br>(10 to 45) Hz          | 1.8 mA/A + 270 $\mu$ A                    |  |
|                                    | 45 Hz to 1 kHz<br>(1 to 5) kHz            | 500 $\mu$ A/A + 160 $\mu$ A               |  |
|                                    | (5 to 10) kHz                             | 6 mA/A + 1.1 mA                           |  |
|                                    | 25 mA/A + 5.1 mA                          |   |  |
|                                    | (1.1 to 3.0) A<br>(10 to 45) Hz           | 1.8 mA/A + 730 $\mu$ A                    |  |
|                                    | 45 Hz to 1 kHz<br>(1 to 5) kHz            | 600 $\mu$ A/A + 400 $\mu$ A               |  |
| (5 to 10) kHz                      | 6 mA/A + 1.2 mA                           |   |  |
| 25 mA/A + 5.1 mA                   |   |   |  |
| (3.0 to 11) A<br>(45 Hz to 100) Hz | 600 $\mu$ A/A + 2.5 mA                    |   |  |
| 100 Hz to 1 kHz<br>(1 to 5) kHz    | 1 mA/A + 2.7 mA                           |   |  |
| 30 mA/A + 4.5 mA                   |   |   |  |
| (11 to 20.5) A<br>(45 to 100) Hz   | 1.2 mA/A + 6.4 mA                         |   |  |
| 100 Hz to 1 kHz<br>(1 to 5) kHz    | 1.5 mA/A + 6.4 mA                         |   |  |
| 30 mA/A + 12 mA                    |   |   |  |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                        | Range   | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment                  |
|--|---|---|---|
| AC Current – Source                        | (20.5 to 30) A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz  | 2.3 mA/A + 16 mA<br>2.3 mA/A + 16 mA<br>1 mA/A + 5.4 mA<br>6.9 mA/A + 8.0 mA  | Transmille 4015<br>Multiproduct Calibrator                    |
| AC Current – Source<br>(Clamp Meters Only) | (30 to 110) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz  | 2.6 mA/A + 25 mA<br>3 mA/A + 27 mA<br>32 mA/A + 45 mA   | Fluke 5520A Multiproduct<br>Calibrator w/ 10 Turn Coil        |
|  | (110 to 205) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz   | 3.2 mA/A + 64 mA<br>3.5 mA/A + 64 mA<br>32 mA/A + 120 mA  |   |
| AC Current – Source<br>(Clamp Meters Only) | (205 to 300) A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz  | 4.6 mA/A + 1606 mA<br>4.6 mA/A + 160 mA<br>3.3 mA/A + 54 mA<br>9.2 mA/A + 80 mA   | Transmille 4015<br>Multiproduct Calibrator w/<br>10 Turn Coil |
|  | (205 to 550) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz   | 2.6 mA/A + 130 mA<br>3 mA/A + 140 mA<br>32 mA/A + 230 mA  |   |
| AC Current – Source<br>(Clamp Meters Only) | (550 to 1 025) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz   | 3.2 mA/A + 320 mA<br>3.5 mA/A + 320 mA<br>32 mA/A + 560 mA  | Fluke 5520A Multiproduct<br>Calibrator w/ 50 Turn Coil        |
|  | (1 025 to 1 500) A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>45 Hz to 1 kHz<br>(1 to 5) kHz                                      | 4.6 mA/A + 800 mA<br>4.6 mA/A + 800 mA<br>3.3 mA/A + 270 mA<br>9.2 mA/A + 400 mA  |   |
| AC Voltage – Source                        | (1 to 33) mV<br>(10 to 45) Hz<br>45 Hz to 10 kHz<br>(10 to 20) kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(100 to 500) kHz | 800 $\mu$ V/V + 6.7 $\mu$ V<br>150 $\mu$ V/V + 6.7 $\mu$ V<br>200 $\mu$ V/V + 6.7 $\mu$ V<br>1 mV/V + 7.4 $\mu$ V<br>3.5 mV/V + 15 $\mu$ V<br>8 mV/V + 56 $\mu$ V | Fluke 5520A Multiproduct<br>Calibrator                        |



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Electrical – DC/Low Frequency

| Parameter/Equipment      | Range                  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--------------------------|------------------------|---|--|
| AC Voltage – Source      | (33 to 330) mV         |   | Fluke 5520A Multiproduct Calibrator          |
|                          | (10 to 45) Hz          | 300 $\mu$ V/V + 21 $\mu$ V                |  |
|                          | 45 Hz to 10 kHz        | 150 $\mu$ V/V + 13 $\mu$ V                |  |
|                          | (10 to 20) kHz         | 160 $\mu$ V/V + 14 $\mu$ V                |  |
|                          | (20 to 50) kHz         | 350 $\mu$ V/V + 20 $\mu$ V                |  |
|                          | (50 to 100) kHz        | 800 $\mu$ V/V + 42 $\mu$ V                |  |
|                          | (100 to 500) kHz       | 2 mV/V + 120 $\mu$ V                      |  |
|                          | 330 mV to 3.3 V        |   |  |
|                          | (10 to 45) Hz          | 300 $\mu$ V/V + 110 $\mu$ V               |  |
|                          | 45 Hz to 10 kHz        | 150 $\mu$ V/V + 95 $\mu$ V                |  |
|                          | (10 to 20) kHz         | 190 $\mu$ V/V + 92 $\mu$ V                |  |
|                          | (20 to 50) kHz         | 300 $\mu$ V/V + 140 $\mu$ V               |  |
|                          | (50 to 100) kHz        | 700 $\mu$ V/V + 240 $\mu$ V               |  |
|                          | (100 to 500) kHz       | 2.4 mV/V + 1.2 mV                         |  |
|                          | (3.3 to 33) V          |   |  |
|                          | (10 to 45) Hz          | 300 $\mu$ V/V + 2.1 mV                    |  |
|                          | 45 Hz to 10 kHz        | 150 $\mu$ V/V + 1.1 mV                    |  |
|                          | (10 to 20) kHz         | 240 $\mu$ V/V + 1.1 mV                    |  |
| (20 to 50) kHz           | 350 $\mu$ V/V + 1.6 mV |   |  |
| (50 to 100) kHz          | 900 $\mu$ V/V + 2.9 mV |   |  |
| Capacitance - Simulation | (33 to 330) V          |   | Fluke 5520A Multiproduct Calibrator          |
|                          | 45 Hz to 1 kHz         | 190 $\mu$ V/V + 12 mV                     |  |
|                          | (1 to 10) kHz          | 200 $\mu$ V/V + 13 mV                     |  |
|                          | (10 to 20) kHz         | 250 $\mu$ V/V + 13 mV                     |  |
|                          | (20 to 50) kHz         | 300 $\mu$ V/V + 20 mV                     |  |
|                          | (50 to 100) kHz        | 2 mV/V + 94 mV                            |  |
|                          | (330 to 1 020) V       |   |  |
|                          | 45 to 1 kHz            | 300 $\mu$ V/V + 41 mV                     |  |
|                          | (1 to 5) kHz           | 250 $\mu$ V/V + 44 mV                     |  |
|                          | (5 to 10) kHz          | 300 $\mu$ V/V + 40 mV                     |  |
|                          | (0.19 to 0.4) nF       | 5 mF/F + 11 pF                            |  |
|                          | (0.4 to 1.1) nF        | 5 mF/F + 11 pF                            |  |
| (1.1 to 3.3) nF          | 5 mF/F + 11 pF         |   |  |
| (3.3 to 11) nF           | 2.5 mF/F + 13 pF       |   |  |
| (11 to 33) nF            | 2.5 mF/F + 110 pF      |   |  |
| (33 to 110) nF           | 2.5 mF/F + 130 pF      |   |  |
| (110 to 330) nF          | 2.5 mF/F + 370 pF      |   |  |
| 330 nF to 1.1 $\mu$ F    | 2.5 mF/F + 1.3 nF      |   |  |
| (1.1 to 3.3) $\mu$ F     | 2.5 mF/F + 3.7 nF      |   |  |
| (3.3 to 11) $\mu$ F      | 2.5 mF/F + 13 nF       |   |  |



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**Electrical – DC/Low Frequency**

| Parameter/Equipment   | Range   | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment |
|---|---|---|--|
| Capacitance - Simulation                                    | (11 to 33) $\mu$ F<br>(33 to 110) $\mu$ F<br>(110 to 330) $\mu$ F<br>330 $\mu$ F to 1.1 mF<br>(1.1 to 3.3) mF<br>(3.3 to 11) mF<br>(11 to 33) mF<br>(33 to 110) mF            | 4 mF/F + 37 nF<br>4.5 mF/F + 130 nF<br>4.5 mF/F + 310 nF<br>4.5 mF/F + 1.1 $\mu$ F<br>4.5 mF/F + 3.1 $\mu$ F<br>4.5 mF/F + 11 $\mu$ F<br>7.5 mF/F + 31 $\mu$ F<br>11 mF/F + 110 $\mu$ F | Fluke 5520A Multiproduct Calibrator          |
| Oscilloscopes<br>AC Voltage, Square Wave<br>(50 $\Omega$ )  | (10 Hz to 10kHz)<br>(1 to 25) mV<br>(25 to 110) mV<br>(110 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 6.6) V  | 4.4 mV/V + 56 $\mu$ V<br>4.4 mV/V + 160 $\mu$ V<br>4.4 mV/V + 770 $\mu$ V<br>4.4 mV/V + 3.9 mV<br>4.4 mV/V + 7.7 mV   | Fluke 5520A-SC1100 Multiproduct Calibrator   |
| Oscilloscopes<br>AC Voltage, Square Wave<br>(1 M $\Omega$ ) | (10 Hz to 1 kHz)<br>(1 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 11) V<br>(11 to 130) V<br>(1 to 10) kHz<br>(1 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 11) V<br>(11 to 130) V | 3.7 mV/V + 770 $\mu$ V<br>3.7 mV/V + 3.9 mV<br>3.7 mV/V + 16 mV<br>3.7 mV/V + 160 mV<br>4.4 mV/V + 770 $\mu$ V<br>4.4 mV/V + 3.9 mV<br>4.4 mV/V + 16 mV<br>4.4 mV/V + 160 mV            | Fluke 5520A-SC1100 Multiproduct Calibrator   |
| Oscilloscopes<br>DC Voltage<br>(50 $\Omega$ )               | (0 to 110) mV<br>(110 to 499) mV<br>499 mV to 2.2 V<br>(2.2 to 6.6) V   | 4.4 mV/V + 160 $\mu$ V<br>4.4 mV/V + 770 $\mu$ V<br>4.4 mV/V + 3.9 mV<br>4.4 mV/V + 7.7 mV  | Fluke 5520A-SC1100 Multiproduct Calibrator   |
| Oscilloscopes<br>DC Voltage<br>(1 M $\Omega$ )              | (0 to 500) mV<br>500 mV to 2.2 V<br>(2.2 to 11) V<br>(11 to 70.5) V<br>(70.5 to 130) V  | 3.6 mV/V + 770 $\mu$ V<br>3.6 mV/V + 3.9 mV<br>3.6 mV/V + 16 mV<br>3.6 mV/V + 77 mV<br>3.6 mV/V + 160 mV  | Fluke 5520A-SC1100 Multiproduct Calibrator   |
| Leveled Sine Wave<br>(Absolute)<br>(50 $\Omega$ , 50kHz)    | (5 to 10) mVpp<br>(10 to 40) mVpp<br>(40 to 100) mVpp<br>(100 to 800) mVpp<br>800 mVpp to 1.3 Vpp<br>(1.3 to 5.5) Vpp   | 20 mV/V + 310 $\mu$ V<br>20 mV/V + 310 $\mu$ V<br>20 mV/V + 350 $\mu$ V<br>20 mV/V + 1.0 mV<br>20 mV/V + 1.8 mV<br>20 mV/V + 8.2 mV   |  |





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**Electrical – DC/Low Frequency**

| Parameter/Equipment  | Range   | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment  |
|--|---|---|---|
| Leveled Sine Wave<br>(Absolute)<br>(50 Ω)<br>50 kHz to 10 MHz<br>(10 to 100) MHz<br>(100 to 300) MHz<br>(300 to 600) MHz<br>(600 to 1 100) MHz           | 5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 3.5 Vpp                                   | 36 mV/V + 7.7 mV<br>36 mV/V + 7.7 mV<br>41 mV/V + 7.7 mV<br>61 mV/V + 7.7 mV<br>71 mV/V + 7.7 mV  | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| Leveled Sine Wave<br>(Relative to 50 kHz)<br>(50 Ω)<br>50 kHz to 10 MHz<br>(10 to 100) MHz<br>(100 to 300) MHz<br>(300 to 600) MHz<br>(600 to 1 100) MHz | 5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 5.5 Vpp<br>5 mVpp to 3.5 Vpp                                   | 16 mV/V + 7.7 mV<br>17 mV/V + 7.7 mV<br>22 mV/V + 7.7 mV<br>41 mV/V + 7.7 mV<br>51 mV/V + 7.7 mV  | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| Oscilloscope Input Resistance<br>Measurement<br>(50 Ω Input)<br>(1 MΩ Input)   | (40 to 60) Ω<br>500 kΩ to 1.5 MΩ  | 1 mΩ/Ω + 15 mΩ<br>1 mΩ/Ω + 180 Ω  |   |
| Oscilloscope Input<br>Capacitance Measurement<br>(1 MΩ Input)  | (5 to 50) pF  | 50 mF/F + 780 fF  | Fluke 5520A-SC1100<br>Multiproduct Calibrator |
| DC Current - Measure   | (20 to 100) nA<br>100 nA to 1 μA<br>(1 to 10) μA<br>(10 to 100) μA<br>100 μA to 1 mA<br>(1 to 10) mA<br>(10 to 100) mA<br>100 mA to 1 A | 35 μA/A + 47 pA<br>24 μA/A + 49 pA<br>24 μA/A + 190 pA<br>24 μA/A + 1.8 nA<br>24 μA/A + 12 nA<br>24 μA/A + 150 nA<br>41 μA/A + 2.3 μA<br>130 μA/A + 46 μA | Keysight 3458A<br>Multimeter                  |
| DC Current - Measure   | (1 to 3) A  | 1.4 mA/A + 1.6 mA   | Keysight 34401A<br>Multimeter                 |
| DC Current - Measure   | (3 to 10) A<br>(10 to 100) A<br>(100 to 200) A  | 1.3 mA/A + 48 μA<br>1.3 mA/A + 480 μA<br>1.3 mA/A + 1.9 mA  | Shunts, Keysight 3458A<br>Multimeter          |
| DC Current - Measure   | Up to 1 000 A   | 24 mA/A + 3.4 A   | Fluke 381 Clamp Meter                         |



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Electrical – DC/Low Frequency

| Parameter/Equipment  | Range                       | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|----------------------|-----------------------------|---|--|
| AC Current - Measure | Up to 100 $\mu$ A           |   | Keysight 3458A<br>Multimeter                 |
|                      | (10 to 20) Hz               | 4.6 mA/A + 39 nA                          |  |
|                      | (20 to 45) Hz               | 1.7 mA/A + 39 nA                          |  |
|                      | (45 to 100) Hz              | 700 $\mu$ A/A + 39 nA                     |  |
|                      | 100 Hz to 5 kHz             | 700 $\mu$ A/A + 39 nA                     |  |
|                      | 100 $\mu$ A to 1 mA         |   |  |
|                      | (10 to 20) Hz               | 4.6 mA/A + 260 nA                         |  |
|                      | (20 to 45) Hz               | 1.7 mA/A + 260 nA                         |  |
|                      | (45 to 100) Hz              | 700 $\mu$ A/A + 260 nA                    |  |
|                      | 100 Hz to 5 kHz             | 350 $\mu$ A/A + 260 nA                    |  |
|                      | (5 to 20) kHz               | 700 $\mu$ A/A + 260 nA                    |  |
|                      | (20 to 50) kHz              | 4.6 mA/A + 480 nA                         |  |
|                      | (50 to 100) kHz             | 6.4 mA/A + 1.8 $\mu$ A                    |  |
|                      | (1 to 10) mA                |   |  |
|                      | (10 to 20) Hz               | 4.6 mA/A + 2.6 $\mu$ A                    |  |
|                      | (20 to 45) Hz               | 1.7 mA/A + 2.6 $\mu$ A                    |  |
|                      | (45 to 100) Hz              | 700 $\mu$ A/A + 2.6 $\mu$ A               |  |
|                      | 100 Hz to 5 kHz             | 350 $\mu$ A/A + 2.6 $\mu$ A               |  |
|                      | (5 to 20) kHz               | 700 $\mu$ A/A + 2.6 $\mu$ A               |  |
|                      | (20 to 50) kHz              | 4.6 mA/A + 4.8 $\mu$ A                    |  |
|                      | (50 to 100) kHz             | 6.4 mA/A + 18 $\mu$ A                     |  |
|                      | (10 to 100) mA              |   |  |
|                      | (10 to 20) Hz               | 4.6 mA/A + 26 $\mu$ A                     |  |
|                      | (20 to 45) Hz               | 1.7 mA/A + 26 $\mu$ A                     |  |
| (45 to 100) Hz       | 700 $\mu$ A/A + 26 $\mu$ A  |   |  |
| 100 Hz to 5 kHz      | 350 $\mu$ A/A + 26 $\mu$ A  |   |  |
| (5 to 20) kHz        | 700 $\mu$ A/A + 26 $\mu$ A  |   |  |
| (20 to 50) kHz       | 4.6 mA/A + 48 $\mu$ A       |   |  |
| (50 to 100) kHz      | 6.4 mA/A + 180 $\mu$ A      |   |  |
| 100 mA to 1 A        |                             |   |  |
| (10 to 20) Hz        | 4.6 mA/A + 320 $\mu$ A      |   |  |
| (20 to 45) Hz        | 1.8 mA/A + 320 $\mu$ A      |   |  |
| (45 to 100) Hz       | 930 $\mu$ A/A + 320 $\mu$ A |   |  |
| 100 Hz to 5 kHz      | 1.2 mA/A + 320 $\mu$ A      |   |  |
| (5 to 20) kHz        | 3.5 mA/A + 320 $\mu$ A      |   |  |
| (20 to 50) kHz       | 12 mA/A + 510 $\mu$ A       |   |  |
| AC Current - Measure | (1 to 3) A                  |   | Keysight 34401A<br>Multimeter                |
|                      | (3 to 5) Hz                 | 13 mA/A + 3.4 mA                          |  |
|                      | (5 to 10) Hz                | 4.0 mA/A + 3.4 mA                         |  |
|                      | (10 to 5 000) Hz            | 1.7 mA/A + 3.4 mA                         |  |

**Electrical – DC/Low Frequency**

| Parameter/Equipment  | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment          |
|----------------------|---|--|---|
| AC Current - Measure | (3 to 10) A<br>(40 to 1 000) Hz   | 1.8 mA/A + 520 $\mu$ A   | Shunts, Keysight 34401A Multimeter                    |
|                      | (10 to 100) A<br>(40 to 1 000) Hz   | 1.7 mA/A + 5.2 mA  |   |
|                      | (100 to 200) A<br>(40 to 1 000) Hz  | 1.8 mA/A + 21 mA   |   |
| AC Current - Measure | (200 to 1 000) A<br>(10 to 100) Hz<br>(100 to 500) Hz   | 24 mA/A + 4.1 A<br>58 mA/A + 4.1 mA  | Fluke 381 Clamp Meter                                 |
|                      | (1 000 to 2 500) A<br>(45 to 500) Hz  | 35 mA/A + 7.2 A  | Fluke 381 Clamp Meter w/<br>iFlex Current Probe       |
| DC Voltage – Measure | Up to 1 mV<br>(1 to 10) mV  | 58 $\mu$ V/V + 27 nV<br>58 $\mu$ V/V + 100 nV  | Keysight 34420A Multimeter                            |
| DC Voltage - Measure | (10 to 100) mV<br>100 mV to 1 V<br>(1 to 10) V<br>(10 to 100) V<br>(100 to 1 000) V   | 11 $\mu$ V/V + 520 nV<br>9.2 $\mu$ V/V + 2.7 $\mu$ V<br>9.2 $\mu$ V/V + 25 $\mu$ V<br>12 $\mu$ V/V + 270 $\mu$ V<br>12 $\mu$ V/V + 5.9 mV  | Keysight 3458A Multimeter                             |
| DC Voltage – Measure | (1 to 1.4) kV<br>(1.4 to 10) kV   | 350 $\mu$ V/V + 46 mV<br>350 $\mu$ V/V + 680 mV  | Vitrek 4700 Voltmeter                                 |
| DC Voltage – Measure | (10 to 35) kV   | 290 $\mu$ V/V + 2.7 V  | Vitrek 4700 Voltmeter w/<br>HVL-35 High Voltage Probe |
| AC Voltage - Measure | Up to 10 mV<br>(1 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 20) kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(100 to 300) kHz<br>(10 to 100) mV<br>(1 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 20) kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(100 to 300) kHz<br>300 kHz to 1 MHz<br>(1 to 2) MHz | 350 $\mu$ V/V + 3.6 $\mu$ V<br>240 $\mu$ V/V + 1.6 $\mu$ V<br>350 $\mu$ V/V + 1.7 $\mu$ V<br>1.2 mV/V + 8.6 $\mu$ V<br>5.8 mV/V + 8.6 $\mu$ V<br>47 mV/V + 66 $\mu$ V<br>81 $\mu$ V/V + 6.5 $\mu$ V<br>81 $\mu$ V/V + 5.1 $\mu$ V<br>170 $\mu$ V/V + 7.3 $\mu$ V<br>350 $\mu$ V/V + 7.3 $\mu$ V<br>930 $\mu$ V/V + 37 $\mu$ V<br>350 $\mu$ V/V + 69 $\mu$ V<br>12 mV/V + 70 $\mu$ V<br>18 mV/V + 180 $\mu$ V | Keysight 3458A Multimeter                             |



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Electrical – DC/Low Frequency

| Parameter/Equipment                         | Range                   | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment             |
|---|-------------------------|---|--|
| AC Voltage - Measure                        | 100 mV to 1 V           |   | Keysight 3458A<br>Multimeter                             |
|   | (1 to 40) Hz            | 81 $\mu$ V/V + 62 $\mu$ V                 |  |
|   | 40 Hz to 1 kHz          | 81 $\mu$ V/V + 47 $\mu$ V                 |  |
|   | (1 to 20) kHz           | 170 $\mu$ V/V + 68 $\mu$ V                |  |
|   | (20 to 50) kHz          | 350 $\mu$ V/V + 140 $\mu$ V               |  |
|   | (50 to 100) kHz         | 930 $\mu$ V/V + 210 $\mu$ V               |  |
|   | (100 to 300) kHz        | 350 $\mu$ V/V + 620 $\mu$ V               |  |
|   | 300 kHz to 1 MHz        | 12 mV/V + 1.7 mV                          |  |
|   | (1 to 2) MHz            | 18 mV/V + 1.7 mV                          |  |
|   | (1 to 10) V             |   |  |
|   | (1 to 40) Hz            | 81 $\mu$ V/V + 720 $\mu$ V                |  |
|   | 40 Hz to 1 kHz          | 81 $\mu$ V/V + 470 $\mu$ V                |  |
|   | (1 to 20) kHz           | 170 $\mu$ V/V + 690 $\mu$ V               |  |
|   | (20 to 50) kHz          | 350 $\mu$ V/V + 1.3 mV                    |  |
|   | (50 to 100) kHz         | 930 $\mu$ V/V + 1.7 mV                    |  |
|   | (100 to 300) kHz        | 350 $\mu$ V/V + 5.3 mV                    |  |
|   | 300 kHz to 1 MHz        | 12 mV/V + 16 mV                           |  |
|   | (1 to 2) MHz            | 18 mV/V + 21 mV                           |  |
|   | (10 to 100) V           |   |  |
|   | (1 to 40) Hz            | 240 $\mu$ V/V + 6.2 mV                    |  |
| 40 Hz to 1 kHz                              | 240 $\mu$ V/V + 4.8 mV  |   |  |
| (1 to 20) kHz                               | 240 $\mu$ V/V + 8.3 mV  |   |  |
| (20 to 50) kHz                              | 410 $\mu$ V/V + 7.9 mV  |   |  |
| (50 to 100) kHz                             | 1.4 mV/V + 24 mV        |   |  |
| (100 to 300) kHz                            | 4.6 mV/V + 26 mV        |   |  |
| 300 kHz to 1 MHz                            | 18 mV/V + 26 mV         |   |  |
| (100 to 750) V                              |                         |   |  |
| (1 to 40) Hz                                | 470 $\mu$ V/V + 70 mV   |   |  |
| 40 Hz to 1 kHz                              | 470 $\mu$ V/V + 63 mV   |   |  |
| (1 to 20) kHz                               | 700 $\mu$ V/V + 63 mV   |   |  |
| (20 to 50) kHz                              | 1.4 mV/V + 63 mV        |   |  |
| (50 to 100) kHz                             | 3.5 mV/V + 63 mV        |   |  |
| AC Voltage - Measure                        | (750 to 10 000) V       |   | Vitrek 4700 Voltmeter                                    |
|   | (0.01 to 1) Hz          | 1.4 mV/V + 2.6 V                          |  |
|   | (10 to 65) Hz           | 1.4 mV/V + 2.6 V                          |  |
|   | (30 to 200) Hz          | 1.4 mV/V + 2.6 V                          |  |
|   | (200 to 450) Hz         | 4.6 mV/V + 2.6 V                          |  |
|   | (10 to 30) kV           |   | Vitrek 4700 Voltmeter w/<br>HVL-35 High Voltage<br>Probe |
|   | (0.01 to 1) Hz          | 1.7 mV/V + 5.9 V                          |  |
|   | (30 to 200) Hz          | 580 $\mu$ V/V + 5.9 V                     |  |
| (200 to 450) Hz                             | 6.9 mV/V + 5.9 V        |   |  |
| DC Resistance – Measure<br>(Current Shunts) | (0.25 to 10) m $\Omega$ | 550 $\mu\Omega/\Omega$                    | Keysight 3458A<br>Multimeter, Transmille                 |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                                | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment |
|--|---|--|--|
| AC Resistance – Measure<br>(Current Shunts)        | (0.25 to 10) mΩ<br>(45 to 1 000) Hz   | 1.5 mΩ/Ω   | 4015 Multiproduct Calibrator                 |
| Resistance – Measure                               | Up to 1 Ω<br>(1 to 10) Ω  | 81 μΩ/Ω + 8.1 μΩ<br>70 μΩ/Ω + 81 μΩ  | Keysight 34420A Multimeter                   |
| Resistance - Measure                               | (10 to 100) Ω<br>(10 to 100) Ω<br>100 Ω to 1 kΩ<br>(1 to 10) kΩ<br>(10 to 100) kΩ<br>100 kΩ to 1 MΩ<br>(1 to 10) MΩ<br>(10 to 100) MΩ<br>100 MΩ to 1 GΩ   | 18 μΩ/Ω + 110 μΩ<br>14 μΩ/Ω + 1.1 mΩ<br>12 μΩ/Ω + 7.4 mΩ<br>12 μΩ/Ω + 75 mΩ<br>12 μΩ/Ω + 750 mΩ<br>18 μΩ/Ω + 8.0 Ω<br>58 μΩ/Ω + 250 Ω<br>580 μΩ/Ω + 18 kΩ<br>5.8 mΩ/Ω + 180 kΩ       | Keysight 3458A Multimeter                    |
| Resistance – Measure                               | (20 to 200) MΩ<br>(200 to 2 000) MΩ<br>(2 to 20) GΩ<br>(20 to 200) GΩ<br>(200 to 2 000) GΩ<br>(2 to 20) TΩ  | 1.7 mΩ/Ω + 9.5 kΩ<br>2.6 mΩ/Ω + 150 kΩ<br>2.6 mΩ/Ω + 2.3 MΩ<br>4 mΩ/Ω + 72 MΩ<br>4 mΩ/Ω + 2.9 GΩ<br>12 mΩ/Ω + 57 GΩ  | Keithley 6517A Multimeter                    |
| Electrical Simulation of RTD<br>Indicating Devices | Pt 385 100 Ω<br>(-200 to -80) °C<br>(-80 to 0) °C<br>(0 to 100) °C<br>(100 to 300) °C<br>(300 to 400) °C<br>(400 to 630) °C<br>(630 to 800) °C<br>Pt 385 200 Ω<br>(-200 to -80) °C<br>(-80 to 0) °C<br>(0 to 100) °C<br>(100 to 260) °C<br>(260 to 300) °C<br>(300 to 400) °C<br>(400 to 600) °C<br>(600 to 630) °C | 0.053 °C<br>0.053 °C<br>0.072 °C<br>0.092 °C<br>0.11 °C<br>0.13 °C<br>0.13 °C<br>0.24 °C<br>0.043 °C<br>0.043 °C<br>0.043 °C<br>0.053 °C<br>0.13 °C<br>0.14 °C<br>0.15 °C<br>0.17 °C | Fluke 5520A Multiproduct Calibrator          |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                                      | Range                 | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--|-----------------------|---|--|
| Electrical Simulation of RTD Indicating Devices          | Pt 385 500 $\Omega$   |   | Fluke 5520A Multiproduct Calibrator          |
|  | (-200 to -80) °C      | 0.043 °C                                  |  |
|  | (-80 to 0) °C         | 0.053 °C                                  |  |
|  | (0 to 100) °C         | 0.053 °C                                  |  |
|  | (100 to 260) °C       | 0.062 °C                                  |  |
|  | (260 to 300) °C       | 0.082 °C                                  |  |
|  | (300 to 400) °C       | 0.082 °C                                  |  |
|  | (400 to 600) °C       | 0.092 °C                                  |  |
|  | (600 to 630) °C       | 0.12 °C                                   |  |
|  | Pt 385 1 000 $\Omega$ |   |  |
|  | (-200 to -80) °C      | 0.035 °C                                  |  |
|  | (-80 to 0) °C         | 0.035 °C                                  |  |
|  | (0 to 100) °C         | 0.044 °C                                  |  |
|  | (100 to 260) °C       | 0.053 °C                                  |  |
|  | (260 to 300) °C       | 0.063 °C                                  |  |
|  | (300 to 400) °C       | 0.072 °C                                  |  |
| (400 to 600) °C  | 0.072 °C              |   |  |
| (600 to 630) °C  | 0.24 °C               |   |  |
| Electrical Simulation of Thermocouple Indicating Devices | Type B                |   | Fluke 5520A Multiproduct Calibrator          |
|  | (600 to 800) °C       | 0.49 °C                                   |  |
|  | (800 to 1 000) °C     | 0.39 °C                                   |  |
|  | (1 000 to 1 550) °C   | 0.35 °C                                   |  |
|  | (1 550 to 1 820) °C   | 0.38 °C                                   |  |
|  | Type E                |   |  |
|  | (-250 to -100) °C     | 0.53 °C                                   |  |
|  | (-100 to -25) °C      | 0.23 °C                                   |  |
|  | (-25 to 350) °C       | 0.21 °C                                   |  |
|  | (350 to 650) °C       | 0.23 °C                                   |  |
|  | (650 to 1 000) °C     | 0.26 °C                                   |  |
|  | Type J                |   |  |
|  | (-210 to -100) °C     | 0.32 °C                                   |  |
|  | (-100 to -30) °C      | 0.23 °C                                   |  |
|  | (-30 to 150) °C       | 0.21 °C                                   |  |
|  | (150 to 760) °C       | 0.23 °C                                   |  |
| (760 to 1 200) °C  | 0.28 °C               |   |  |
| Type K   |                       |   |  |
| (-200 to -100) °C  | 0.37 °C               |   |  |
| (-100 to -25) °C   | 0.24 °C               |   |  |
| (-25 to 120) °C  | 0.23 °C               |   |  |
| (120 to 1 000) °C  | 0.31 °C               |   |  |
| (1 000 to 1 372) °C                                      | 0.43 °C               |   |  |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                                      | Range               | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--|---------------------|---|--|
| Electrical Simulation of Thermocouple Indicating Devices | Type N              |   | Fluke 5520A Multiproduct Calibrator          |
|  | (-200 to -100) °C   | 0.44 °C                                   |  |
|  | (-100 to -25) °C    | 0.28 °C                                   |  |
|  | (-25 to 120) °C     | 0.25 °C                                   |  |
|  | (120 to 410) °C     | 0.24 °C                                   |  |
|  | (410 to 1 300) °C   | 0.32 °C                                   |  |
|  | Type R              |   |  |
|  | (0 to 250) °C       | 0.61 °C                                   |  |
|  | (250 to 400) °C     | 0.4 °C                                    |  |
|  | (400 to 1 000) °C   | 0.38 °C                                   |  |
|  | (1 000 to 1 767) °C | 0.44 °C                                   |  |
|  | Type S              |   |  |
|  | (0 to 200) °C       | 0.52 °C                                   |  |
|  | (200 to 1 000) °C   | 0.41 °C                                   |  |
| (1 000 to 1 400) °C                                      | 0.41 °C             |   |  |
| (1 400 to 1 767) °C                                      | 0.5 °C              |   |  |
| Type T   |                     |   |  |
| (-250 to -150) °C  | 0.66 °C             |   |  |
| (-150 to 0) °C   | 0.29 °C             |   |  |
| (0 to 120) °C  | 0.23 °C             |   |  |
| (120 to 400) °C  | 0.21 °C             |   |  |

**Length – Dimensional Metrology**

| Parameter/Equipment  | Range                              | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--|------------------------------------|---|--|
| Length Standards <sup>2,3</sup>                              | Up to 1 in<br>(1 to 20) in         | 23 μin<br>(15 + 8.3L) μin                 | Gauge Blocks, Electronic Indicator           |
| Calipers <sup>3</sup>  | Up to 36 in<br>(36 to 84) in       | (670 + 9.2L) μin<br>(41 + 1.2L) μin       | Gauge Blocks                                 |
| Micrometers – Outside <sup>3</sup>                           | Up to 1 in<br>(1 to 36) in         | 14 μin<br>(73 + 5.8L) μin                 | Gauge Blocks                                 |
| Plunger Indicators – Dial or Digital <sup>3</sup>            | Up to 0.001 in<br>(0.001 to 2) in  | 24 μin<br>(67 + 9.8L) μin                 | Gauge Blocks, Surface Plate                  |
| Lever Indicators – Dial, Digital, or Electronic <sup>3</sup> | Up to 0.01 in<br>(0.01 to 0.06) in | (10 + 31 000L) μin<br>(46 + 1 300L) μin   | Gauge Blocks                                 |
| Micrometer Heads   | Up to 2 in                         | 77 μin                                    | Gauge Blocks, Electronic Indicator           |

**Length – Dimensional Metrology**

| Parameter/Equipment   | Range                                       | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                     |
|---|---|---|--|
| Height Gages  | Up to 6 in<br>(6 to 12) in<br>(12 to 20) in | 82 μin<br>120 μin<br>160 μin              | Gauge Blocks, Surface Plate                                      |
| Cylindrical Gauges - Pin Gauges, Plain Plug Gauges <sup>2</sup>     | Up to 1 in                                  | 32 μin                                    | MDH Hand Micrometer  |
| Thread Wires <sup>3</sup>   | Up to 1 in                                  | 32 μin                                    | MDH Hand Micrometer  |
| Thread Plug Gauges <sup>2</sup><br>Major Diameter<br>Pitch Diameter | Up to 1 in<br>Up to 1 in                    | 32 μin<br>73 μin                          | MDH Hand Micrometer,<br>Thread Wires                             |
| Feeler Gauges   | Up to 1 in                                  | 30 μin                                    | MDH Hand Micrometer  |
| Bore Gauges (2 Point) <sup>3</sup>                                  | Up to 6 in                                  | (140 + 4.3L) μin                          | Bore Gauge Setting Master Kit                                    |
| Bore Gauges (3 Point) <sup>3</sup>                                  | (0.62 to 3.0) in                            | (110 + 33L) μin                           | Master Rings   |
| Micrometer - Inside   | (1 to 6) in                                 | 97 μin                                    | Bore Gauge Setting Master Kit                                    |
| Micrometer – Depth  | Up to 6 in                                  | 97 μin                                    | Square Gauge Blocks,<br>Surface Plate                            |
| Parallels / Straight Edges  | Up to 36"                                   | 47 μin                                    | Electronic Gauging Head /<br>Surface Plate                       |
| Sine Bars / Plates  | Up to 5 in<br>(5 to 10) in                  | 61 μin<br>100 μin                         | Electronic Gauging Head,<br>Surface Plate, Gauge<br>Blocks       |
| Angle Blocks <sup>3</sup>   | Up to 60°                                   | (3.5 + 0.48A) arcsec                      | Sine Plate, Electronic<br>Gauging Head                           |
| Digital Inclinometers   | Up to 90°                                   | 0.067 °                                   | Angle Blocks, Sine Plate,<br>Angle Plate                         |
| Cylindrical Squares<br>Up to 24 in tall                             | Up to 0.001 in                              | 51 μin                                    | Electronic Gauging Head,<br>Surface Plate                        |
| Squares / Angle Plates<br>Up to 24 in tall                          | Up to 0.001 in                              | 160 μin                                   | Cylindrical Square,<br>Electronic Gauging Head,<br>Surface Plate |





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**Mass and Mass Related**

| Parameter/Equipment                                 | Range  | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment |
|---|--|---|--|
| Tensiometers <sup>3</sup>                           | Up to 1 000 lbf<br>(1 000 to 2 000) lbf  | (0.22 + 0.002 3X) lbf<br>(0.91 + 2.1X) lbf  | Dead weights, Torque Sensor, Torque Arm      |
| Torque Wrenches <sup>3</sup>                        | Up to 10 lbf·in<br>(10 to 50) lbf·in<br>(50 to 240) lbf·in<br>(20 to 100) lbf·ft<br>(100 to 500) lbf·ft<br>(500 to 2 000) lbf·ft | 0.055 lbf·in<br>0.31 lbf·in<br>(0.14 + 0.000 83X) lbf·in<br>(0.027 + 0.001 1X) lbf·ft<br>(0.058 + 0.000 55X) lbf·ft<br>(0.45 + 0.001 1X) lbf·ft | Torque Sensor                                |
| Torque Multipliers                                  | (100 to 3 000) lbf·ft  | 3.6 lbf·ft  | Torque Sensor                                |
| Force Gages and Load Cells<br>Tension & Compression | Up to 50 lbf<br>(50 to 1 000) lbf  | 0.002 6 % of reading + 0.000 22 lbf<br>0.002 1 % of reading + 0.009 3 lbf   | Class F Weights                              |
|   | (1 000 to 10 000) lbf<br>(10 000 to 30 000) lbf  | 4.4 lbf<br>13 lbf   | Load Cell                                    |
| Scales  | Up to 5 000 gf   | 0.002 % of reading + 0.076 mgf  | Class 1 weights                              |
|   | (5 to 50) kgf<br>(100 to 1 000) lbf  | 0.000 16 % of reading + 0.11 kgf<br>0.002 % of reading + 0.009 9 lbf  | Class S-1 weights<br>Class F weights         |
|   | (1 000 to 10 000) lbf<br>(10 000 to 30 000) lbf  | 4.4lbf<br>15 lbf  | Load Cell                                    |
| Pressure Gauges                                     | Up to 95 psi   | 0.049 psi   | Setra 370 Pressure Indicator                 |
|   | (35 to 500) psi<br>(500 to 5 000) psi<br>(5 000 to 10 000) psi<br>(10 000 to 15 000) psi   | 0.74 psi<br>11 psi<br>7.7 psi<br>11 psi   | Pressure Indicators                          |
|   |  |   |  |
| Vacuum Gauges                                       | Up to 19 psia  | 0.003 3 psi   | Druck DPI 145 Pressure Tester                |
|   | (19 to 110) psia   | 0.032 psi   | Setra 370 Pressure Indicator                 |

### Time and Frequency

| Parameter/Equipment   | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment  |
|---|---|--|---|
| Logic Pulses - Source<br>(0.01, 0.025, 0.1, 0.25, 1, 2.5)<br>V<br>Pulse Width | (4 to 500) ns   | 50 ms/s + 3.2 ns   | Fluke 5520A-SC1100<br>Multiproduct Calibrator<br>with ERC 130 Frequency<br>Standard |
| Logic Pulses - Source<br>(0.01, 0.025, 0.1, 0.25, 1, 2.5)<br>V<br>Period      | 200 ns to 20 ms   | 100 ns/s + 500 ps  |   |
| Time Markers<br>(Spike or Square Wave)  | 5 ns to 20 ms   | 100 ns/s + 390 ps  | Fluke 5520A-SC1100<br>Multiproduct Calibrator<br>with ERC 130 Frequency<br>Standard |
| Frequency - Source  | 0.01 Hz to 1 100 MHz  | 5.8 $\mu$ Hz + 750 pHz/Hz  | Fluke 5520A-SC1100<br>Multiproduct Calibrator<br>with ERC 130 Frequency<br>Standard |
| Frequency - Source / Fixed 10<br>MHz - Source                                 | 10 MHz  | 14 mHz   | ERC 130 Frequency<br>Standard   |
| Photo Tachometers - Simulate  | (10 to 200 000) RPM   | 0.000 035 RPM + 1.4 E <sup>-9</sup><br>RPM/RPM   | Signal Generator with ERC<br>130 Frequency Standard                                 |
| RPM – Measure   | (5 to 99) RPM<br>(100 to 999) RPM<br>(1 000 to 9 999) RPM<br>(10 000 to 99 000) RPM<br>(100 000 to 200 000) RPM | 0.013 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>0.13 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>0.61 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>6.1 RPM + 1.2 E <sup>-4</sup> RPM/RPM<br>22 RPM + 1.2 E <sup>-4</sup> RPM/RPM | Photo Tachometer  |
| Timers & Stopwatches  | (10 to 600 000) s   | 0.041 s + 750 ps/s   | Signal Generator,<br>Timer/Counter, Frequency<br>Standard                           |
| Frequency – Measure   | 10 Hz to 3 GHz  | 12 mHz + 750 pHz/Hz  | Agilent 53131A Freq<br>Counter, Freq Std  |
| Time Period or Pulse Width –<br>Measure                                       | 4.4 ns to 10 s<br>(10 to 100 000) s   | 390 ps + 1.4 ns/s<br>1.3 ns + 1.4 ns/s   | Universal Timer / Counter,<br>Freq Std.   |
| Duty Cycle – Measure<br>(Up to 225 MHz) <sup>3</sup>                          | (0 to 100) %PW  | 5.5 E <sup>-8</sup> %PW/Hz   | Universal Timer / Counter,<br>Freq Std  |

**Thermodynamic**

| Parameter/Equipment               | Range                           | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|-----------------------------------|---------------------------------|---|--|
| Temperature Measure – Air         | (-80 to 420) °C                 | 0.044 °C                                  | PRT, Indicator                               |
| Temperature Measure – Dry Well    | (-25 to 420) °C                 | 0.12 °C                                   | PRT, Indicator                               |
| Temperature Measure – Liquid Bath | (-20 to 150) °C                 | 0.043 °C                                  | PRT, Indicator                               |
| Humidity – Measure                | (0 to 90) %RH<br>(90 to 95) %RH | 1.5 %RH<br>2.2 %RH                        | Humidity Air Probe                           |
| Thermometers – Dry Well           | (-20 to 420) °C                 | 0.12 °C                                   | PRT, Indicator                               |

**DIMENSIONAL MEASUREMENT**


**1 Dimensional**

| Parameter/Equipment                      | Range      | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment      |
|--|------------|---|---|
| Height / Linear Measurement <sup>3</sup> | Up to 6 in | 200 µin                                   | Electronic Indicator, Gauge Blocks, Surface Plate |

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 ( $k=2$ ), corresponding to a confidence level of approximately 95%.

Notes:

1. On-site calibration service is available for most parameters, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. This parameter is only available at the laboratory facility.
3.  $A$  = angle in degrees,  $L$  = length in inches,  $PW$  = pulse width in seconds,  $X$  = force/torque applied.
4. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1647.



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