



# CERTIFICATE OF ACCREDITATION

**The ANSI National Accreditation Board**

Hereby attests that

**Transcat – Philadelphia**  
**100 Dobbs Lane, Suite 108-110**  
**Cherry Hill, NJ 08034**

Fulfills the requirements of

**ISO/IEC 17025:2017**

and the national standards

**ANSI/NCSL Z540-1-1994 (R2002) AND**  
**ANSI/NCSL Z540.3-2006 (R2013)**

In the fields of

**CALIBRATION AND DIMENSIONAL MEASUREMENT**

This certificate is valid only when accompanied by a current scope of accreditation document.  
The current scope of accreditation can be verified at [www.anab.org](http://www.anab.org).

Jason Stine, Vice President

Expiry Date: 07 September 2025  
Certificate Number: AC-2489.03



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017.  
This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory  
quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

**SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017**

**AND**

**ANSI/NCSL Z540-1-1994 (R2002)**

**ANSI/NCSL Z540.3-2006 (R2013)**

**Transcat – Philadelphia**

100 Dobbs Lane, Suite 108-110

Cherry Hill, NJ 08034

Joffrey McClure joffrey.mcclure@transcat.com

**CALIBRATION AND DIMENSIONAL MEASUREMENT**

Valid to: **September 7, 2025**

Certificate Number: **AC-2489.03**

**CALIBRATION**

**Chemical Quantities**

| Parameter/Equipment                       | Range  | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment |
|---|--|---|--|
| pH – Measuring Equipment <sup>1</sup>     | 4 pH<br>7 pH<br>10 pH  | 0.011 pH<br>0.011 pH<br>0.012 pH  | Certified Reference Material                 |
| Conductivity Meters – Measuring Equipment | 5 µS/cm<br>10 µS/cm<br>100 µS/cm<br>1000 µS/cm<br>10 000 µS/cm<br>100 000 µS/cm<br>150 000 µS/cm | 0.35 µS/cm<br>0.35 µS/cm<br>0.84 µS/cm<br>3.5 µS/cm<br>38 µS/cm<br>310 µS/cm<br>610 µS/cm | Certified Reference Material                 |

**Electrical – DC/Low Frequency**

| Parameter/Equipment              | Range  | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment |
|----------------------------------|--|---|--|
| DC Voltage – Source <sup>1</sup> | (0 to 220) mV<br>(0.22 to 2.2) V<br>(2.2 to 11) V<br>(11 to 22) V<br>(22 to 220) V<br>(220 to 1 100) V | 7.5 µV/V + 0.4 µV<br>5 µV/V + 0.7 µV<br>3.5 µV/V + 2.5 µV<br>3.5 µV/V + 4 µV<br>5 µV/V + 40 µV<br>6.5 µV/V + 0.4 mV | Fluke 5730A<br>Multiproduct Calibrator       |



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Electrical – DC/Low Frequency

| Parameter/Equipment                      | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment  |
|--|--|--|---|
| DC Voltage – Measure <sup>1</sup>        | Up to 100 mV<br>100 mV to 1 V<br>(1 to 10) V<br>(10 to 100) V<br>(100 to 500) V<br>(500 to 800) V<br>(800 to 1 000) V  | 8.3 $\mu$ V/V + 0.58 $\mu$ V<br>5.3 $\mu$ V/V + 0.58 $\mu$ V<br>5.3 $\mu$ V/V + 0.58 $\mu$ V<br>7.7 $\mu$ V/V + 35 $\mu$ V<br>15 $\mu$ V/V + 0.12 mV<br>18 $\mu$ V/V + 0.12 mV<br>21 $\mu$ V/V + 0.12 mV   | Agilent 3458A Opt.002<br>8.5 Digit Multimeter   |
| DC High Voltage – Measure <sup>1</sup>   | (1 to 10) kV<br>(10 to 35) kV<br>(35 to 70) kV<br>(70 to 100) kV   | 0.04 % of reading + 40 mV<br>0.064 % of reading + 66 mV<br>0.088 % of reading + 80 mV<br>0.17 % of reading + 0.92 V  | Vitrek 4700A<br>High Voltage Meter;<br>Vitrek HVL-35, HVL-70,<br>HVL-100 High<br>Voltage Probes   |
| DC Voltage – Source/Measure <sup>1</sup> | Up to 100 mV<br>100 mV to 1 V<br>(1 to 10) V<br>(10 to 100) V<br>(100 to 500) V<br>(500 to 800) V<br>(800 to 1 000) V  | 8.3 $\mu$ V/V + 0.58 $\mu$ V<br>5.3 $\mu$ V/V + 0.58 $\mu$ V<br>5.3 $\mu$ V/V + 0.58 $\mu$ V<br>7.7 $\mu$ V/V + 35 $\mu$ V<br>15 $\mu$ V/V + 0.12 mV<br>18 $\mu$ V/V + 0.12 nV<br>21 $\mu$ V/V + 0.12 mV   | Fluke 5700A/EP<br>Multiproduct Calibrator,<br>Fluke 5725A Amplifier,<br>Characterized with<br>Agilent 3458A Opt.002<br>8.5 Digit Multimeter |
| AC Voltage – Source <sup>1</sup>         | Up to 2.2 mV<br>(10 to 20) Hz<br>(20 to 40) Hz<br>40 Hz to 20 kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(100 to 300) kHz<br>(300 to 500) kHz<br>500 kHz to 1 MHz<br>(2.2 to 22) mV<br>(10 to 20) Hz<br>(20 to 40) Hz<br>40 Hz to 20 kHz<br>(20 to 50) kHz<br>(50 to 100) kHz<br>(100 to 300) kHz<br>(300 to 500) kHz<br>500 kHz to 1 MHz | 0.024 % of reading + 4 $\mu$ V<br>0.009 % of reading + 4 $\mu$ V<br>0.008 % of reading + 4 $\mu$ V<br>0.02 % of reading + 4 $\mu$ V<br>0.05 % of reading + 5 $\mu$ V<br>0.11 % of reading + 10 $\mu$ V<br>0.14 % of reading + 20 $\mu$ V<br>0.27 % of reading + 20 $\mu$ V<br>0.024 % of reading + 4 $\mu$ V<br>0.009 % of reading + 4 $\mu$ V<br>0.008 % of reading + 4 $\mu$ V<br>0.02 % of reading + 4 $\mu$ V<br>0.05 % of reading + 5 $\mu$ V<br>0.11 % of reading + 10 $\mu$ V<br>0.14 % of reading + 20 $\mu$ V<br>0.27 % of reading + 20 $\mu$ V | Fluke 5730A<br>Multiproduct 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 <sup>1</sup> | (22 to 220) mV                |   | Fluke 5730A<br>Multiproduct Calibrator       |
|                                  | (10 to 20) Hz                 | 0.024 % of reading + 12 μV                |  |
|                                  | (20 to 40) Hz                 | 0.009 % of reading + 7 μV                 |  |
|                                  | 40 Hz to 20 kHz               | 0.005 7 % of reading + 7 μV               |  |
|                                  | (20 to 50) kHz                | 0.012 % of reading + 7 μV                 |  |
|                                  | (50 to 100) kHz               | 0.031 % of reading + 17 μV                |  |
|                                  | (100 to 300) kHz              | 0.066 % of reading + 20 μV                |  |
|                                  | (300 to 500) kHz              | 0.14 % of reading + 25 μV                 |  |
|                                  | 500 kHz to 1 MHz              | 0.27 % of reading + 45 μV                 |  |
|                                  | (0.22 to 2.2) V               |   |  |
|                                  | (10 to 20) Hz                 | 0.024 % of reading + 40 μV                |  |
|                                  | (20 to 40) Hz                 | 0.009 % of reading + 15 μV                |  |
|                                  | 40 Hz to 20 kHz               | 0.004 2 % of reading + 8 μV               |  |
|                                  | (20 to 50) kHz                | 0.006 7 % of reading + 10 μV              |  |
|                                  | (50 to 100) kHz               | 0.008 5 % of reading + 30 μV              |  |
|                                  | (100 to 300) kHz              | 0.034 % of reading + 80 μV                |  |
|                                  | (300 to 500) kHz              | 0.1 % of reading + 0.2 mV                 |  |
|                                  | 500 kHz to 1 MHz              | 0.17 % of reading + 0.3 mV                |  |
|                                  | (2.2 to 22) V                 |   |  |
|                                  | (10 to 20) Hz                 | 0.024 % of reading + 0.4 mV               |  |
|                                  | (20 to 40) Hz                 | 0.009 % of reading + 0.15 mV              |  |
|                                  | 40 Hz to 20 kHz               | 0.004 2 % of reading + 50 μV              |  |
|                                  | (20 to 50) kHz                | 0.006 7 % of reading + 0.1 mV             |  |
|                                  | (50 to 100) kHz               | 0.008 3 % of reading + 0.2 mV             |  |
|                                  | (100 to 300) kHz              | 0.034 % of reading + 0.6 mV               |  |
|                                  | (300 to 500) kHz              | 0.1 % of reading + 2 mV                   |  |
|                                  | 500 kHz to 1 MHz              | 0.17 % of reading + 3.2 mV                |  |
|                                  | (22 to 220) V                 |   |  |
| (10 to 20) Hz                    | 0.024 % of reading + 4 mV     |   |  |
| (20 to 40) Hz                    | 0.009 % of reading + 1.5 mV   |   |  |
| 40 Hz to 20 kHz                  | 0.005 2 % of reading + 0.6 mV |   |  |
| (20 to 50) kHz                   | 0.008 % of reading + 1 mV     |   |  |
| (50 to 100) kHz                  | 0.015 % of reading + 2.5 mV   |   |  |
| (100 to 300) kHz                 | 0.09 % of reading + 16 mV     |   |  |
| (300 to 500) kHz                 | 0.44 % of reading + 40 mV     |   |  |
| 500 kHz to 1 MHz                 | 0.8 % of reading + 80 mV      |   |  |
| (220 to 250) V                   |                               |   |  |
| (15 to 50) Hz                    | 0.03 % of reading + 16 mV     |   |  |
| (250 to 1 100) V                 |                               |   |  |
| 50 Hz to 1 kHz                   | 0.007 % of reading + 3.5 mV   |   |  |

**Electrical – DC/Low Frequency**

| Parameter/Equipment               | Range   | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment                     |
|-----------------------------------|---|---|--|
| AC Voltage – Source <sup>1</sup>  | (220 to 750) V<br>(30 to 50) kHz<br>(50 to 100) kHz<br>(220 to 1 100) V<br>40 Hz to 1 kHz<br>(1 to 20) kHz<br>(20 to 30) kHz  | 0.06 % of reading + 11 mV<br>0.06 % of reading + 11 mV<br>0.009 % of reading + 4 mV<br>0.017 % of reading + 6 mV<br>0.23 % of reading + 45 mV   | Fluke 5730A<br>Multiproduct Calibrator,<br>Fluke 5725A Amplifier |
| AC Voltage – Measure <sup>1</sup> | 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>300 kHz to 1 MHz<br>1 MHz to 4 MHz<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<br>(2 to 4) MHz<br>(4 to 8) MHz<br>(8 to 10) MHz<br>(0.1 to 1) V<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<br>(2 to 4) MHz<br>(4 to 8) MHz<br>(8 to 10) MHz | 0.04 % of reading + 3.5 μV<br>0.03 % of reading + 1.2 μV<br>0.04 % of reading + 1.2 μV<br>0.15 % of reading + 1.2 μV<br>0.59 % of reading + 1.2 μV<br>4.6 % of reading + 2.3 μV<br>1.5 % of reading + 5.8 μV<br>8.1 % of reading + 8.1 μV<br>0.013 % of reading + 4.6 μV<br>0.009 7 % of reading + 2.3 μV<br>0.017 % of reading + 2.3 μV<br>0.038 % of reading + 2.3 μV<br>0.093 % of reading + 2.3 μV<br>0.36 % of reading + 12 μV<br>1.2 % of reading + 12 μV<br>1.8 % of reading + 12 μV<br>4.7 % of reading + 81 μV<br>4.7 % of reading + 92 μV<br>17 % of reading + 0.12 mV<br>0.008 8 % of reading + 46 μV<br>0.008 3 % of reading + 23 μV<br>0.017 % of reading + 23 μV<br>0.036 % of reading + 23 μV<br>0.093 % of reading + 23 μV<br>0.35 % of reading + 0.12 mV<br>1.2 % of reading + 0.12 mV<br>1.8 % of reading + 0.12 mV<br>4.6 % of reading + 0.81 mV<br>4.6 % of reading + 0.92 mV<br>17 % of reading + 1.2 mV | Agilent 3458A Opt. 002<br>8.5 Digit Multimeter                   |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                    | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment  |
|--|--|--|---|
| AC Voltage – Measure <sup>1</sup>      | (1 to 10) V<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<br>(2 to 4) MHz<br>(4 to 8) MHz<br>(8 to 10) MHz<br>(10 to 100) V<br>(1 to 40) Hz<br>40Hz 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>(100 to 700) V<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 | 0.009 5 % of reading + 0.46 mV<br>0.023 % of reading + 0.23 mV<br>0.017 % of reading + 0.23 mV<br>0.036 % of reading + 0.23 mV<br>0.093 % of reading + 0.23 mV<br>0.35 % of reading + 1.2 mV<br>1.2 % of reading + 1.2 mV<br>1.8 % of reading + 1.2 mV<br>4.6 % of reading + 8.1 mV<br>4.6 % of reading + 9.2 mV<br>17 % of reading + 12 mV<br>0.024 % of reading + 4.6 mV<br>0.024 % of reading + 2.3 mV<br>0.024 % of reading + 2.3 mV<br>0.041 % of reading + 2.3 mV<br>0.14 % of reading + 2.3 mV<br>0.46 % of reading + 12 mV<br>1.7 % of reading + 12 mV<br>0.048 % of reading + 46 mV<br>0.048 % of reading + 23 mV<br>0.071 % of reading + 23 mV<br>0.19 % of reading + 23 mV<br>0.35 % of reading + 23 mV | Agilent 3458A Opt. 002<br>8.5 Digit Multimeter  |
| AC High Voltage – Measure <sup>1</sup> | (1 to 10) kV<br>(10 to 200) Hz<br>(200 to 450) Hz<br>(450 to 600) Hz<br>(10 to 35) kV<br>(30 to 200) Hz<br>(200 to 450) Hz<br>(450 to 600) Hz<br>(35 to 70) kV<br>(30 to 100) Hz<br>(100 to 450) Hz<br>(450 to 600) Hz<br>(70 to 100) kV<br>(30 to 100) Hz<br>(100 to 450) Hz<br>(450 to 600) Hz   | 0.14 % of reading + 0.17 V<br>0.46 % of reading + 0.17 V<br>0.86 % of reading + 0.17 V<br>0.11 % of reading + 0.81 V<br>0.7 % of reading + 0.81 V<br>1.5 % of reading + 0.81 V<br>0.14 % of reading + 1 V<br>0.7 % of reading + 1 V<br>2.9 % of reading + 1 V<br>0.21 % of reading + 1.3 V<br>1.2 % of reading + 1.3 V<br>17 % of reading + 1.3 V  | Vitrek 4700A<br>High Voltage Meter;<br>Vitrek HVL-35, HVL-70,<br>HVL-100 High<br>Voltage Probes |



**Electrical – DC/Low Frequency**

| Parameter/Equipment                | Range  | Expanded Uncertainty of Measurement (+/-)               | Reference Standard, Method, and/or Equipment |                            |  |
|------------------------------------|--|---|--|----------------------------|--|
| Capacitance – Source <sup>1</sup>  | 10 Hz to 10 kHz<br>190 pF to 1.1 nF                | 0.39 % of reading + 7.8 pF                              | Fluke 5522A<br>Multiproduct Calibrator       |                            |  |
|                                    | 10 Hz to 3 kHz<br>(1.1 to 3.3) nF                  | 0.39 % of reading + 7.8 pF                              |  |                            |  |
|                                    | 10 Hz to 1 kHz<br>(3.3 to 11) nF<br>(11 to 110) nF | 0.21 % of reading + 7.8 pF<br>0.21 % of reading + 78 pF |  |                            |  |
|                                    | 10 Hz to 1 kHz<br>(110 to 330) nF                  | 0.21 % of reading + 0.23 nF                             |  |                            |  |
|                                    | (10 to 600) Hz<br>330 nF to 1.1 μF                 | 0.21 % of reading + 0.78 nF                             |  |                            |  |
|                                    | (10 to 300) Hz<br>(1.1 to 3.3) μF                  | 0.21 % of reading + 2.3 nF                              |  |                            |  |
|                                    | (10 to 150) Hz<br>(3.3 to 11) μF                   | 0.21 % of reading + 7.8 nF                              |  |                            |  |
|                                    | (10 to 120) Hz<br>(11 to 33) μF                    | 0.32 % of reading + 23 nF                               |  |                            |  |
|                                    | (10 to 80) Hz<br>(33 to 110) μF                    | 0.35 % of reading + 78 nF                               |  |                            |  |
|                                    | DC to 50 Hz<br>(110 to 330) μF                     | 0.35 % of reading + 0.23 μF                             |  |                            |  |
|                                    | DC to 20 Hz<br>330 μF to 1.1 mF                    | 0.35 % of reading + 0.78 μF                             |  |                            |  |
|                                    | Capacitance – Source <sup>1</sup>                  | DC to 6 Hz<br>(1.1 to 3.3) mF                           |  | 0.35 % of reading + 2.3 μF | Fluke 5522A<br>Multiproduct Calibrator |
|                                    |  | DC to 2 Hz<br>(3.3 to 11) mF                            |  | 0.35 % of reading + 7.8 μF |  |
| DC to 0.6 Hz<br>(11 to 33) mF      |  | 0.58 % of reading + 23 μF                               |  |                            |  |
| DC to 0.2 Hz<br>(33 to 110) mF     |  | 0.85 % of reading + 78 μF                               |  |                            |  |
| Capacitance – Measure <sup>1</sup> | 100 Hz to 1 kHz<br>Up to 10 pF                     | 0.5 % of reading + 0.05 pF                              | GR 1689-M<br>Precision<br>Impedance Meter    |                            |  |
|                                    | (10 to 100) pF                                     | 0.59 % of reading + 0.05 pF                             |  |                            |  |
|                                    | 100 pF to 1 μF<br>(1 to 100) μF                    | 0.024 % of reading + 0.05 pF<br>0.12 % of reading       |  |                            |  |
|                                    | 100 μF to 1 mF                                     | 0.24 % of reading                                       |  |                            |  |
|                                    |  |   |  |                            |  |
| DC Current – Source <sup>1</sup>   | (0.2 to 220) μA                                    | 40 μA/A + 6 nA  | Fluke 5730A<br>Multiproduct Calibrator       |                            |  |
|                                    | (0.22 to 2.2) mA                                   | 35 μA/A + 7 nA  |  |                            |  |
|                                    | (2.2 to 22) mA                                     | 35 μA/A + 40 nA   |  |                            |  |
|                                    | (22 to 220) mA                                     | 45 μA/A + 0.7 μA  |  |                            |  |
|                                    | (0.22 to 2.2) A                                    | 80 μA/A + 12 μA   |  |                            |  |



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Electrical – DC/Low Frequency

| Parameter/Equipment   | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment   |
|---|--|--|--|
| DC Current – Source <sup>1</sup>  | Up to 2 A<br>(2.2 to 11) A<br>(2 to 20) A  | 0.036 % of reading + 0.48 mA<br>0.012 % of reading + 0.16 mA<br>0.012 % of reading + 1.6 mA  | Fluke 5730A<br>Multiproduct Calibrator,<br>Fluke 5725A Amplifier                           |
| DC Current – Source <sup>1</sup>  | (20 to 120) A  | 0.012 % of reading + 9.6 mA  | Fluke 5730A<br>Multiproduct Calibrator,<br>Fluke 52120A<br>Current Amplifier               |
| DC Clamp-on Ammeters<br>(Non-Toroidal Type)<br>Transformer Type Sensor <sup>1</sup> | (20 to 150) A<br>(150 to 1 000) A  | 0.51 % of reading + 0.14 A<br>0.51 % of reading + 0.5 A  | Fluke 5520A Multiproduct<br>Calibrator,<br>5500A/COIL<br>50-turn Coil                      |
| DC Current –<br>Source/Measure <sup>1</sup>   | Up to 100 $\mu$ A<br>100 $\mu$ A to 1 mA<br>(1 to 10) mA<br>(10 to 100) mA<br>100 mA to 1 A            | 33 $\mu$ A/A + 0.92 nA<br>29 $\mu$ A/A + 5.8 nA<br>29 $\mu$ A/A + 58 nA<br>46 $\mu$ A/A + 0.58 $\mu$ A<br>0.013 % of reading + 12 $\mu$ A        | Current Source,<br>Characterized with<br>Agilent 3458A Opt.002<br>8.5 Digit Multimeter     |
| DC Current –<br>Source/Measure <sup>1</sup>   | (1 to 100) A   | 0.15 mA/A + 3 mA   | Ohms Labs CS-100<br>Current Shunt,<br>Agilent 3458A Opt. 002<br>8.5 Digit Multimeter       |
| DC Current –<br>Source/Measure <sup>1</sup>   | (100 to 1 500) A   | 0.58 % of reading + 0.52A  | Empo WT-1500-50<br>Current Shunt,<br>Agilent 3458A Opt. 002<br>8.5 Digit Multimeter        |
| DC Clamp-on Ammeter<br>(Non-Toroidal Type)<br>Hall Effect Sensor <sup>1</sup>       | (20 to 1 000) A  | 0.58 % of reading + 0.52 A   | Fluke 5522A<br>Multiproduct Calibrator,<br>Fluke 5500A/Coil<br>50-turn Coil                |
| DC Clamp-on Ammeter<br>(Non-Toroidal Type)<br>Hall Effect Sensor <sup>1</sup>       | (1 to 5) kA  | 0.58 % of reading  | Fluke 5522A<br>Multiproduct Calibrator,<br>Fluke 52120A Amplifier,<br>3 kA Coil, 6 kA Coil |
| AC Current – Source <sup>1</sup>  | Up to 220 $\mu$ A<br>(10 to 20) Hz<br>(20 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz | 0.025 % of reading + 16 nA<br>0.016 % of reading + 10 nA<br>0.011 % of reading + 8 nA<br>0.028 % of reading + 12 nA<br>0.11 % of reading + 65 nA | Fluke 5730A<br>Multiproduct Calibrator   |



**Electrical – DC/Low Frequency**

| Parameter/Equipment              | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment                                 |
|----------------------------------|--|--|--|
| AC Current – Source <sup>1</sup> | (0.22 to 2.2) mA<br>(10 to 20) Hz<br>(20 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(2.2 to 22) mA<br>(10 to 20) Hz<br>(20 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz | 0.25 % of reading + 40 nA<br>0.016 % of reading + 35 nA<br>0.011 % of reading + 35 nA<br>0.02 % of reading + 0.11 μA<br>0.11 % of reading + 0.65 μA<br>0.025 % of reading + 0.4 μA<br>0.016 % of reading + 0.35 μA<br>0.011 % of reading + 0.35 μA<br>0.020 % of reading + 0.55 μA<br>0.11 % of reading + 5 μA | Fluke 5730A<br>Multiproduct Calibrator                                       |
| AC Current – Source <sup>1</sup> | (2.2 to 22) mA<br>(10 to 20) Hz<br>(20 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(22 to 220) mA<br>(10 to 20) Hz<br>(20 to 40) Hz<br>40 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz   | 0.025 % of reading + 0.4 μA<br>0.016 % of reading + 0.35 μA<br>0.011 % of reading + 0.35 μA<br>0.02 % of reading + 0.55 μA<br>0.11 % of reading + 5 μA<br>0.025 % of reading + 4 μA<br>0.016 % of reading + 3.5 μA<br>0.011 % of reading + 2.5 μA<br>0.02 % of reading + 3.5 μA<br>0.11 % of reading + 10 μA   | Fluke 5730A<br>Multiproduct Calibrator,<br>Fluke 5725A<br>Amplifier          |
| AC Current – Source <sup>1</sup> | (0.22 to 2.2) A<br>20 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz<br>(2.2 to 11) A<br>(40 to 100) Hz<br>(1 to 5) kHz<br>(5 to 10) kHz   | 0.025 % of reading + 35 μA<br>0.045 % of reading + 80 μA<br>0.7 % of reading + 0.16 μA<br>0.046 % of reading + 0.17 mA<br>0.095 % of reading + 0.38 mA<br>0.36 % of reading + 0.75 mA  | Fluke 5730A<br>Multiproduct Calibrator,<br>Fluke 5725A<br>Amplifier          |
| AC Current – Source <sup>1</sup> | Up to 2 A<br>(10 to 850) Hz<br>850 Hz to 6 kHz<br>(6 to 10) kHz<br>(2 to 20) A<br>(10 to 850) Hz<br>850 Hz to 6 kHz<br>(6 to 10) kHz   | 0.009 % of reading + 40 μA<br>0.04 % of reading + 80 μA<br>1.6 % of reading + 62 mA<br>0.009 % of reading + 0.4 mA<br>0.04 % of reading + 0.8 mA<br>2.3 % of reading + 94 mA   | Fluke 5730A<br>Multiproduct Calibrator,<br>Fluke 52120A<br>Current Amplifier |

**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>  |
|---|--|--|--|
| AC Current – Source <sup>1</sup>  | (20 to 120) A<br>(10 to 850) Hz<br>850 Hz to 6 kHz<br>(6 to 10) kHz  | 0.009 % of reading + 2.4 mA<br>0.04 % of reading + 4.8 mA<br>3.1 % of reading + 0.7 A  | Fluke 5730A<br>Multiproduct Calibrator,<br>Fluke 52120A<br>Current Amplifier               |
| AC Current – Source <sup>1</sup><br>Extended Frequency Ranges                   | (29 to 330) $\mu$ A<br>(10 to 30) kHz<br>(0.33 to 3.3) mA<br>(10 to 30) kHz<br>(3.3 to 33) mA<br>(10 to 30) kHz<br>(33 to 330) mA<br>(10 to 30) kHz                              | 1.2 % of reading + 0.31 $\mu$ A<br>0.78 % of reading + 0.47 $\mu$ A<br>0.031 % of reading + 3.1 $\mu$ A<br>0.31 % of reading + 0.16 mA   | Fluke 5522A<br>Multiproduct Calibrator   |
| AC Clamp-on Ammeters<br>(Toroidal Type)<br>Transformer Type Sensor <sup>1</sup> | (20 to 150) A<br>(45 to 65) Hz<br>(65 to 440) Hz<br>(150 to 1 000) A<br>(45 to 65) Hz<br>(65 to 440) Hz  | 0.34 % of reading + 35 mA<br>0.95 % of reading + 66 mA<br>0.38 % of reading + 0.17 A<br>1.2 % of reading + 0.29A   | Fluke 5520A Multiproduct<br>Calibrator,<br>5500A/COIL<br>50-turn Coil                      |
| AC Clamp-on Ammeters<br>(Non-Toroidal Type)<br>Hall Effect Sensor <sup>1</sup>  | (20 to 150) A<br>(45 to 65) Hz<br>(65 to 440) Hz<br>(150 to 1 000) A<br>(45 to 65) Hz<br>(65 to 440) Hz  | 0.66 % of reading + 0.26 A<br>1.2 % of reading + 0.29 A<br>0.68 % of reading + 1 A<br>1.4 % of reading + 1.1 A   | Fluke 5520A Multiproduct<br>Calibrator,<br>5500A/COIL<br>50-turn Coil                      |
| AC Clamp-on Ammeters<br>(Non-Toroidal Type)<br>Hall Effect Sensor <sup>1</sup>  | (10 to 300) Hz<br>(1 to 6) kA<br>(30 to 440) Hz<br>(1 to 2) kA<br>(2 to 6) kA  | 0.6 % of reading<br>0.8 % of reading<br>0.66 % of reading  | Fluke 5522A<br>Multiproduct Calibrator,<br>Fluke 52120A Amplifier,<br>3 kA Coil, 6 kA Coil |
| AC Current – Measure <sup>1</sup>   | Up to 100 $\mu$ A<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(0.1 to 1) mA<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 5 kHz | 0.46 % of reading + 35 nA<br>0.17 % of reading + 35 nA<br>0.072 % of reading + 35 nA<br>0.072 % of reading + 35 nA<br>0.46 % of reading + 0.23 $\mu$ A<br>0.17 % of reading + 0.23 $\mu$ A<br>0.071 % of reading + 0.23 $\mu$ A<br>0.038 % of reading + 0.23 $\mu$ A | Agilent 3458A Opt. 002<br>8.5 Digit Multimeter   |



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Electrical – DC/Low Frequency

| Parameter/Equipment  | Range                           | Expanded Uncertainty of Measurement (+/-)    | Reference Standard, Method, and/or Equipment   |
|--|---------------------------------|--|--|
| AC Current – Measure <sup>1</sup>                          | (1 to 10) mA                    |  | Agilent 3458A Opt. 002<br>8.5 Digit Multimeter                                       |
|  | (10 to 20) Hz                   | 0.46 % of reading + 2.3 $\mu$ A              |  |
|  | (20 to 45) Hz                   | 0.17 % of reading + 2.3 $\mu$ A              |  |
|  | (45 to 100) Hz                  | 0.071 % of reading + 2.3 $\mu$ A             |  |
|  | 100 Hz to 5 kHz                 | 0.038 % of reading + 2.3 $\mu$ A             |  |
|  | (10 to 100) mA                  |  |  |
|  | (10 to 20) Hz                   | 0.48 % of reading + 23 $\mu$ A               |  |
|  | (20 to 45) Hz                   | 0.17 % of reading + 23 $\mu$ A               |  |
|  | (45 to 100) Hz                  | 0.071 % of reading + 23 $\mu$ A              |  |
|  | 100 Hz to 5 kHz                 | 0.037 % of reading + 23 $\mu$ A              |  |
|  | (0.1 to 1) A                    |  |  |
|  | (10 to 20) Hz                   | 0.46 % of reading + 0.23 mA                  |  |
| (20 to 45) Hz  | 0.19 % of reading + 0.23 mA     |  |  |
| (45 to 100) Hz   | 0.097 % of reading + 0.23 mA    |  |  |
| 100 Hz to 5 kHz  | 0.12 % of reading + 0.23 mA     |  |  |
| AC Current – Measure <sup>1</sup>                          | (10 to 100) A                   |  | Ohms Labs CS-100<br>Current Shunt,<br>Agilent 3458A Opt. 002<br>8.5 Digit Multimeter |
|  | 50/60 Hz                        | 0.023 % of reading + 5 mA                    |  |
|  | 400 Hz                          | 0.11 % of reading + 5 mA                     |  |
|  | 1 kHz                           | 0.2 % of reading + 5 mA                      |  |
| DC Resistance – Source <sup>1</sup><br>(Fixed Artifacts)   | 1 m $\Omega$                    | 59 $\mu\Omega/\Omega$                        | Standard Resistors   |
|  | 10 m $\Omega$                   | 58 $\mu\Omega/\Omega$                        |  |
|  | 100 m $\Omega$                  | 58 $\mu\Omega/\Omega$                        |  |
|  | 1 $\Omega$                      | 58 $\mu\Omega/\Omega$                        |  |
|  | 100 $\Omega$                    | 1.3 $\mu\Omega/\Omega$                       |  |
| DC Resistance – Source <sup>1</sup><br>(Variable Artifact) | (1 to 10) G $\Omega$            | 0.58 % of reading + 1.2 $\mu\Omega/\Omega/V$ | IET HRRS-B-7-100k-5kV<br>Decade Resistor<br>(V is the DUT Voltage)                   |
|  | (10 to 100) G $\Omega$          | 1.2 % of reading + 2.3 $\mu\Omega/\Omega/V$  |  |
|  | 100 G $\Omega$ to 1 T $\Omega$  | 1.2 % of reading + 5.8 $\mu\Omega/\Omega/V$  |  |
| DC Resistance – Source <sup>1</sup><br>(Simulation)        | (1.1 to 3.3) M $\Omega$         | 0.0059 % of reading + 23 $\Omega$            | Fluke 5522A<br>Multiproduct Calibrator   |
|  | (3.3 to 11) M $\Omega$          | 0.011 % of reading + 39 $\Omega$             |  |
|  | (11 to 33) M $\Omega$           | 0.021 % of reading + 1.9 k $\Omega$          |  |
|  | (33 to 110) M $\Omega$          | 0.041 % of reading + 2.3 k $\Omega$          |  |
|  | (110 to 330) M $\Omega$         | 0.26 % of reading + 78 k $\Omega$            |  |
| DC Resistance –<br>Source/Measure <sup>1</sup>             | 250 $\mu\Omega$ to 4 m $\Omega$ | 85 $\mu\Omega/\Omega$                        | Fluke 1594A Bridge in<br>Ratio Mode,<br>Characterized Resistors                      |
|  | (4 to 40) m $\Omega$            | 25 $\mu\Omega/\Omega$                        |  |
|  | (40 to 400) m $\Omega$          | 20 $\mu\Omega/\Omega$                        |  |
|  | 400 m $\Omega$ to 4 $\Omega$    | 16 $\mu\Omega/\Omega$                        |  |
|  | 4 $\Omega$ to 400 k $\Omega$    | 5 $\mu\Omega/\Omega$                         |  |



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Electrical – DC/Low Frequency

| Parameter/Equipment  | Range   | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment                       |
|--|---|---|--|
| DC Resistance – Source/Measure <sup>1</sup>  | Up to 10 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 + 58 μΩ<br>15 μΩ/Ω + 0.58 mΩ<br>μΩ/Ω + 0.58 mΩ<br>12 μΩ/Ω + 5.8 mΩ<br>13 μΩ/Ω + 58 mΩ<br>21 μΩ/Ω + 2.3 Ω<br>62 μΩ/Ω + 0.12 kΩ<br>0.059 % of reading + 1.2 kΩ<br>0.82 % of reading + 12 kΩ | Agilent 3458A Opt. 002<br>8.5 Digit Multimeter<br>Decade Resistors |
| AC Resistance – Measure <sup>1</sup>   | 10 Ω to 100 kΩ<br>12 Hz to 99.9 kHz   | 0.039 % of reading + 10 mΩ  | GenRad 1689M<br>Precision Impedance Meter                          |
| Inductance – Source <sup>1</sup><br>(Fixed Artifacts)                                  | 1 kHz<br>1 mH<br>10 mH<br>100 mH<br>1 H   | 0.13 % of reading<br>0.13 % of reading<br>0.13 % of reading<br>0.13 % of reading  | Standard Inductors   |
| Inductance – Measure <sup>1</sup>  | 100 Hz to 1 kHz<br>(1 to 10) mH<br>10 mH to 10 H  | 0.041 % of reading + 0.1 μH<br>0.035 % of reading + 1.4 μH  | GenRad 1689M<br>Precision Impedance Meter                          |
| Electrical Simulation of Thermocouple Indicating Devices – Measure/Source <sup>1</sup> | Type B<br>(250 to 350) °C<br>(350 to 445) °C<br>(445 to 580) °C<br>(580 to 750) °C<br>(750 to 1 000) °C<br>(1 000 to 1 820) °C<br>Type C<br>(0 to 250) °C<br>(250 to 1 000) °C<br>(1 000 to 1 500) °C<br>(1 500 to 1 800) °C<br>(1 800 to 2 000) °C<br>(2 000 to 2 250) °C<br>(2 250 to 2 315) °C | 1.2 °C<br>0.9 °C<br>0.71 °C<br>0.55 °C<br>0.45 °C<br>0.35 °C<br>0.24 °C<br>0.19 °C<br>0.21 °C<br>0.24 °C<br>0.27 °C<br>0.33 °C<br>0.37 °C   | Ectron 1140A<br>Thermocouple<br>Calibrator/Simulator               |

**Electrical – DC/Low Frequency**

| Parameter/Equipment  | Range               | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment   |
|--|---------------------|---|--|
| Electrical Simulation of Thermocouple Indicating Devices – Measure/Source <sup>1</sup> | Type E              |   | Ectron 1140A Thermocouple Calibrator/Simulator |
|  | (-270 to -245) °C   | 1.6 °C                                    |  |
|  | (-245 to -195) °C   | 0.24 °C                                   |  |
|  | (-195 to -155) °C   | 0.12 °C                                   |  |
|  | (-155 to -90) °C    | 0.09 °C                                   |  |
|  | (-90 to 0) °C       | 0.08 °C                                   |  |
|  | (0 to 15) °C        | 0.08 °C                                   |  |
|  | (15 to 890) °C      | 0.06 °C                                   |  |
|  | (890 to 1 000) °C   | 0.07 °C                                   |  |
|  | Type J              |   |  |
|  | (-210 to -180) °C   | 0.13 °C                                   |  |
|  | (-180 to -120) °C   | 0.11 °C                                   |  |
|  | (-120 to -50) °C    | 0.09 °C                                   |  |
|  | (-50 to 990) °C     | 0.08 °C                                   |  |
|  | (990 to 1 200) °C   | 0.08 °C                                   |  |
|  | Type K              |   |  |
|  | (-270 to -255) °C   | 2.5 °C                                    |  |
|  | (-255 to -195) °C   | 0.85 °C                                   |  |
|  | (-195 to -115) °C   | 0.16 °C                                   |  |
|  | (-115 to -55) °C    | 0.12 °C                                   |  |
|  | (-55 to 1 000) °C   | 0.09 °C                                   |  |
|  | (1 000 to 1 372) °C | 0.1 °C                                    |  |
|  | Type N              |   |  |
|  | (-270 to -260) °C   | 5.4 °C                                    |  |
| (-260 to -200) °C  | 1.5 °C              |   |  |
| (-200 to -140) °C  | 0.29 °C             |   |  |
| (-140 to -70) °C   | 0.18 °C             |   |  |
| (-70 to 25) °C   | 0.14 °C             |   |  |
| (-25 to 160) °C  | 0.12 °C             |   |  |
| (160 to 1 300) °C  | 0.11 °C             |   |  |
| Type R   |                     |   |  |
| (-50 to -30) °C  | 0.8 °C              |   |  |
| (-30 to 45) °C   | 0.69 °C             |   |  |
| (45 to 160) °C   | 0.49 °C             |   |  |
| (160 to 380) °C  | 0.35 °C             |   |  |
| (380 to 775) °C  | 0.3 °C              |   |  |
| (775 to 1 768) °C  | 0.26 °C             |   |  |

**Electrical – DC/Low Frequency**

| Parameter/Equipment  | Range                           | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment   |
|--|---------------------------------|---|--|
| Electrical Simulation of Thermocouple Indicating Devices – Measure/Source <sup>1</sup> | Type S                          |   | Ectron 1140A Thermocouple Calibrator/Simulator |
|  | (-50 to -30) °C                 | 0.76 °C                                   |  |
|  | (-30 to 45) °C                  | 0.68 °C                                   |  |
|  | (45 to 105) °C                  | 0.49 °C                                   |  |
|  | (105 to 310) °C                 | 0.31 °C                                   |  |
|  | (310 to 615) °C                 | 0.35 °C                                   |  |
|  | (615 to 1 768) °C               | 0.31 °C                                   |  |
|  | Type T                          |   |  |
|  | (-270 to -255) °C               | 1.9 °C                                    |  |
|  | (-255 to -240) °C               | 0.6 °C                                    |  |
|  | (-240 to -210) °C               | 0.36 °C                                   |  |
|  | (-210 to -150) °C               | 0.22 °C                                   |  |
| (-150 to -40) °C   | 0.15 °C                         |   |  |
| (-40 to 100) °C  | 0.09 °C                         |   |  |
| (100 to 400) °C  | 0.08 °C                         |   |  |
| DC Power – Source <sup>1</sup><br>(0.33 to 330) mA<br>(0.33 to 3) A<br>(3 to 20.5) A   | (11 to 330) μW                  | 0.018 % of reading                        | Fluke 5520A Multiproduct Calibrator            |
|  | 11 W to 3 kW                    | 0.017 % of reading                        |  |
|  | 99 mW to 20.9 kW                | 0.054 % of reading                        |  |
| AC Power – Source <sup>1,2</sup><br>PF = 1   | 3.3 mA to 3 A (10 to 45) Hz     | 0.11 mW to 99 W                           | Fluke 5520A Multiproduct Calibrator            |
|  | 3.3 mA to 20.5 A (45 to 65) Hz  | 0.11 mW to 20.9 kW                        |  |
|  | 33 mA to 3 A (65 to 500) Hz     | 11 mW to 3.06 kW                          |  |
|  | 33 mA to 20.5 A 500 Hz to 1 kHz | 11 mW to 20.9 kW                          |  |
|  | (3 to 20.5) A (65 to 500) Hz    | 9.9 W to 20.9 kW                          |  |
|  |                                 |   |  |
| Phase – Source <sup>1</sup>  | Up to 180°                      |   | Fluke 5520A Multiproduct Calibrator            |
|  | (10 to 65) Hz                   | 0.092°                                    |  |
|  | (65 to 500) Hz                  | 0.2°                                      |  |
|  | 500 Hz to 1 kHz                 | 0.39°                                     |  |
|  | (1 to 5) kHz                    | 1.9°                                      |  |
|  | (5 to 10) kHz                   | 3.9°                                      |  |
|  | (10 to 20) kHz                  | 7.8°                                      |  |



**Electrical – DC/Low Frequency**

| Parameter/Equipment          | Range                  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                            |
|------------------------------|------------------------|---|---|
| Oscilloscopes <sup>1,3</sup> |                        |   | Fluke 9500B/3200<br>3.2 GHz High-Performance<br>Oscilloscope Calibrator |
| Amplitude – DC               |                        |   |   |
| into 50 Ω load               | (-5 to 5) V            | 0.023 % of reading + 19 μV                |   |
| into 1 MΩ load               | (-200 to 200) V        | 0.023 % of reading + 19 μV                |   |
| Amplitude – Square Wave      |                        |   |   |
| Rate: 10 Hz to 10 kHz        |                        |   |   |
| into 50 Ω load               | 40 μVp-p to 1 mVp-p    | 0.78 % of reading + 7.8 μV                |   |
|                              | 1 mVp-p to 5 Vp-p      | 0.078 % of reading + 7.8 μV               |   |
| into 1 MΩ load               | 40 μVp-p to 1 mVp-p    | 0.78 % of reading + 7.8 μV                |   |
| Rate: 10 Hz to 100 kHz       |                        |   |   |
| into 50 Ω load               | 1 mVp-p to 5 Vp-p      | 0.16 % of reading + 7.8 μV                |   |
| into 1 MΩ load               | 1 mVp-p to 200 Vp-p    | 0.78 % of reading + 7.8 μV                |   |
| Time Markers                 |                        |   |   |
| 100 mVp-p to 1 Vp-p          |                        |   |   |
| into 50 Ω load               |                        |   |   |
| Square Wave                  | 9.009 1 ns to 83 μs    | 0.19 μs/s                                 |   |
|                              | 83 μs to 55s           | 2.3 μs/s                                  |   |
| Sine Wave                    | 450.5 ps to 9.009 ns   | 0.19 μs/s                                 |   |
| Pulse                        | 900.91 ns to 83 μs     | 0.19 μs/s                                 |   |
|                              | 83 μs to 55s           | 2.3 μs/s                                  |   |
| Triangle Wave                | 900.91 ns to 83 μs     | 0.19 μs/s                                 |   |
|                              | 83 μs to 55s           | 2.3 μs/s                                  |   |
| Rise Time                    |                        |   |   |
| into 50 Ω load               |                        |   |   |
| Rate: 10 Hz to 2 MHz         | 5 mVp-p to 3 Vp-p      |   |   |
|                              | 500 ps (nominal)       | 290 ps                                    |   |
|                              | 150 ps (nominal)       | 35 ps                                     |   |
| Rate: 10 Hz to 1 MHz         | 25 mVp-p to 2 Vp-p     |   |   |
|                              | 70 ps (nominal)        | 24 ps                                     |   |
|                              | 425 mVp-p to 575 mVp-p |   |   |
|                              | 25 ps (nominal)        | 6.7 ps                                    |   |



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Electrical – DC/Low Frequency

| Parameter/Equipment   | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment  |
|---|---|--|---|
| Oscilloscopes <sup>1,3</sup><br>Leveled Sine Wave<br>50 kHz Reference<br>into 50 Ω load   | 5 mVp-p to 5 Vp-p<br>50 kHz to 10 MHz   | 1.2 % of reading   | Fluke 9500B/3200<br>3.2 GHz High-Performance<br>Oscilloscope Calibrator,<br>Fluke 9530                        |
| Input Impedance Measure   | (10 to 40) Ω<br>(40 to 90) Ω<br>(90 to 150) Ω<br>(50 to 800) kΩ<br>(0.8 to 1.2) MΩ<br>(1.2 to 12) MΩ  | 0.39 % of reading<br>0.083 % of reading<br>0.39 % of reading<br>0.39 % of reading<br>0.083 % of reading<br>0.39 % of reading | 3.2 GHz Active Head,<br>Fluke 9550<br>Active Head w/ 25 ps<br>Capability,<br>Fluke 9560                       |
| Input Capacitance Measure   | (1 to 35) pF<br>(35 to 95) pF   | 1.6 % of reading + 0.19 pF<br>2.3 % of reading + 0.19 pF   | 6 GHz Active Head,<br>Tektronix 067-1330-000<br>Calibration Fixture   |
| Bandwidth Flatness Measure <sup>1</sup><br>into VSWR (1.2:1)<br>(wrt Reference Frequency) | 5 mVp-p to 5 Vp-p<br>100 MHz to 300 MHz<br>(300 to 550) MHz<br>5 mVp-p to 3 Vp-p<br>550 MHz to 1.1 GHz<br>(1.1 to 2.5) GHz<br>5 mVp-p to 2 Vp-p<br>(2.5 to 3.2) GHz | 1.6 % of reading<br>1.9 % of reading<br>2.7 % of reading<br>3.1 % of reading<br>3.1 % of reading                             | Fluke 9500B/3200<br>3.2 GHz High-Performance<br>Oscilloscope Calibrator,<br>Fluke 9530<br>3.2 GHz Active Head |
| Total Harmonic Distortion –<br>Measure  | (-80 to 0) dB<br>20 Hz to 20 kHz<br>(20 to 100) kHz   | 1.1 dB<br>2 dB   | Agilent 8903A<br>Audio Analyzer   |
| Total Harmonic Distortion –<br>Measure<br>(0.3 to 100) %                                  | < 30 V<br>10 Hz to 1 MHz<br>(1 to 3) MHz<br>> 30 V<br>10 Hz to 300 kHz<br>(300 to 500) kHz<br>500 kHz to 3 MHz  | 3 % Distortion<br>6 % Distortion<br>3 % Distortion<br>6 % Distortion<br>12 % Distortion                                      | HP 334A<br>Distortion Analyzer  |
| 0.1 %   | < 30 V<br>(10 to 20) Hz<br>(20 to 30) Hz<br>30 Hz to 300 kHz<br>(300 to 500) kHz<br>500 kHz to 1.2 MHz  | 12 % Distortion<br>6 % Distortion<br>3 % Distortion<br>6 % Distortion<br>12 % Distortion                                     |   |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                          | Range   | Expanded Uncertainty of Measurement (+/-)                              | Reference Standard, Method, and/or Equipment  |
|--|---|--|---|
| Total Harmonic Distortion – Measure<br>0.1 % | > 30 V<br>(20 to 30) Hz<br>30 Hz to 300 kHz<br>(300 to 500) kHz<br>500 kHz to 1.2 MHz | 12 % Distortion<br>3 % Distortion<br>6 % Distortion<br>12 % Distortion | HP 334A<br>Distortion Analyzer  |
| Rise Time – Measure                          | ≥ 17.5 ps   | 12 ps  | Agilent 83484A<br>Dual Channel 50 GHz<br>Electrical Module,<br>Agilent 86100C<br>Wideband Oscilloscope<br>Mainframe |

**Electrical – RF/Microwave**

| Parameter/Equipment  | Range  | Expanded Uncertainty of Measurement (+/-)                                    | Reference Standard, Method, and/or Equipment                   |
|--|--|--|--|
| RF Power – Power Meter<br>Reference  | 50 MHz<br>1 mW Reference   | 0.43 % of reading  | HP 478A<br>Coaxial Thermistor Mount,<br>HP 432A<br>Power Meter |
| S11/S22 Reflection<br>Coefficients<br>Magnitude – Measure <sup>1,7</sup><br>(Linear) | (10 to 700) MHz<br>≤ 0.25 lin<br>(> 0.25 to 0.5) lin<br>(> 0.5 to ≤ 0.7) lin<br>(> 0.7 to ≤ 1) lin<br>700 MHz to 24 GHz<br>≤ 0.25 lin<br>(> 0.25 to 0.5) lin<br>(> 0.5 to ≤ 0.7) lin<br>(> 0.7 to ≤ 1) lin | 0.012<br>0.013<br>0.014<br>0.016<br><br>0.006 2<br>0.006 6<br>0.076<br>0.097 | R&S® ZVA50<br>Vector Network Analyzer,<br>Calibration Kits     |



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Electrical – RF/Microwave

| Parameter/Equipment   | Range   | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment               |
|---|---|---|--|
| S11/S22 Reflection Coefficients Magnitude – Measure <sup>1,7</sup> (Linear) | (24 to 33) GHz<br>$\leq 0.25$ lin<br>$(> 0.25$ to $0.5)$ lin<br>$(> 0.5$ to $\leq 0.7)$ lin<br>$(> 0.7$ to $\leq 1)$ lin<br>(33 to 50) GHz<br>$\leq 0.25$ lin<br>$(> 0.25$ to $0.5)$ lin<br>$(> 0.5$ to $\leq 0.7)$ lin<br>$(> 0.7$ to $\leq 1)$ lin    | 0.019<br>0.019<br>0.022<br>0.023<br>0.019<br>0.019<br>0.022<br>0.023                            | R&S® ZVA50<br>Vector Network Analyzer,<br>Calibration Kits |
| S11/S22 Reflection Coefficients Phase – Measure <sup>1</sup>                | (10 to 700) MHz<br>$\leq 0.25$ lin<br>$(> 0.25$ to $0.5)$ lin<br>$(> 0.5$ to $\leq 0.7)$ lin<br>$(> 0.7$ to $\leq 1)$ lin   | 4°<br>2°<br>2°<br>1°  | R&S® ZVA50<br>Vector Network Analyzer,<br>Calibration Kits |
| S11/S22 Reflection Coefficients Phase – Measure <sup>1</sup> (Linear)       | 700 MHz to 24 GHz<br>$\leq 0.25$ lin<br>$(> 0.25$ to $0.5)$ lin<br>$(> 0.5$ to $\leq 0.7)$ lin<br>$(> 0.7$ to $\leq 1)$ lin<br>(24 to 50) GHz<br>$\leq 0.25$ lin<br>$(> 0.25$ to $0.5)$ lin<br>$(> 0.5$ to $\leq 0.7)$ lin<br>$(> 0.7$ to $\leq 1)$ lin | 4°<br>1°<br>1°<br>1°<br>11°<br>3°<br>2°<br>2°   | R&S® ZVA50<br>Vector Network Analyzer,<br>Calibration Kits |
| S21/S12 Transmission Coefficients Magnitude – Measure <sup>1</sup> (dB)     | (10 to 700) MHz<br>(-90 to $\leq -80)$ dB<br>(-80 to $\leq -70)$ dB<br>(-70 to $\leq -60)$ dB<br>(-60 to $\leq -50)$ dB<br>(-50 to $\leq -40)$ dB<br>(-40 to $\leq -30)$ dB<br>(-30 to $\leq -20)$ dB<br>(-20 to $\leq -10)$ dB<br>(-10 to $\leq 0)$ dB | 0.56 dB<br>0.21 dB<br>0.13 dB<br>0.12 dB<br>0.12 dB<br>0.12 dB<br>0.12 dB<br>0.12 dB<br>0.12 dB | R&S® ZVA50<br>Vector Network Analyzer,<br>Calibration Kits |

**Electrical – RF/Microwave**

| Parameter/Equipment  | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment                            |  |   |
|--|--|--|---|--|---|
| <p>S21/S12 Transmission Coefficients<br/>Magnitude – Measure <sup>1</sup><br/>(dB)</p> | <p>700 MHz to 24 GHz<br/>(-80 to ≤ -70) dB<br/>(-70 to ≤ -60) dB<br/>(-60 to ≤ -50) dB<br/>(-50 to ≤ -40) dB<br/>(-40 to ≤ -30) dB<br/>(-30 to ≤ -20) dB<br/>(-20 to ≤ -10) dB<br/>(-10 to ≤ 0) dB</p> | <p>0.55 dB<br/>0.19 dB<br/>0.08 dB<br/>0.06 dB<br/>0.05 dB<br/>0.05 dB<br/>0.05 dB<br/>0.06 dB</p>                                   | <p>R&amp;S® ZVA50<br/>Vector Network Analyzer,<br/>Calibration Kits</p> |  |   |
|  | <p>(24 to 33) GHz<br/>(-80 to ≤ -70) dB<br/>(-70 to ≤ -60) dB<br/>(-60 to ≤ -50) dB<br/>(-50 to ≤ -40) dB<br/>(-40 to ≤ -30) dB<br/>(-30 to ≤ -20) dB<br/>(-20 to ≤ -10) dB<br/>(-10 to ≤ 0) dB</p>    | <p>0.56 dB<br/>0.21 dB<br/>0.11 dB<br/>0.1 dB<br/>0.1 dB<br/>0.1 dB<br/>0.1 dB<br/>0.1 dB</p>  |   |  |   |
|  | <p>(33 to 50) GHz<br/>(-80 to ≤ -70) dB<br/>(-70 to ≤ -60) dB<br/>(-60 to ≤ -50) dB<br/>(-50 to ≤ -40) dB<br/>(-40 to ≤ -30) dB<br/>(-30 to ≤ -20) dB<br/>(-20 to ≤ -10) dB<br/>(-10 to ≤ 0) dB</p>    | <p>0.56 dB<br/>0.21 dB<br/>0.11 dB<br/>0.1 dB<br/>0.1 dB<br/>0.1 dB<br/>0.1 dB<br/>0.1 dB</p>  |   |  |   |
|  | <p>S21/S12 Transmission Coefficients<br/>Phase – Measure <sup>1</sup><br/>(dB)</p>   | <p>(10 to 700) MHz<br/>(-90 to ≤ -40) dB<br/>(-40 to ≤ -30) dB<br/>(-30 to ≤ -20) dB<br/>(-20 to ≤ -10) dB<br/>(-10 to ≤ 0) dB</p>   |   | <p>180°<br/>52°<br/>14°<br/>4.5°<br/>1°</p>    | <p>R&amp;S® ZVA50<br/>Vector Network Analyzer,<br/>Calibration Kits</p> |
|  |  | <p>700 MHz to 24 GHz<br/>(-80 to ≤ -40) dB<br/>(-40 to ≤ -30) dB<br/>(-30 to ≤ -20) dB<br/>(-20 to ≤ -10) dB<br/>(-10 to ≤ 0) dB</p> |   | <p>180°<br/>23°<br/>7.2°<br/>2.6°<br/>0.6°</p> |   |



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Electrical – RF/Microwave

| Parameter/Equipment   | Range  | Expanded Uncertainty of Measurement (+/-)                                | Reference Standard, Method, and/or Equipment                    |
|---|--|--|---|
| S21/S12 Transmission Coefficients<br>Phase – Measure <sup>1</sup><br>(dB)                             | (24 to 33) GHz<br>(-80 to ≤ -40) dB<br>(-40 to ≤ -30) dB<br>(-30 to ≤ -20) dB<br>(-20 to ≤ -10) dB<br>(-10 to ≤ 0) dB<br>(33 to 50) GHz<br>(-80 to ≤ -40) dB<br>(-40 to ≤ -30) dB<br>(-30 to ≤ -20) dB<br>(-20 to ≤ -10) dB<br>(-10 to ≤ 0) dB | 180°<br>52°<br>14°<br>4.5°<br>1°<br>180°<br>52°<br>14°<br>4.5°<br>1°     | R&S® ZVA50<br>Vector Network Analyzer,<br>Calibration Kits      |
| Absolute RF Power – Measure <sup>8</sup>  | 8 kHz to 18 GHz<br>(-70 to 23) dBm   | 0.18 dB  | R&S® NRP18A<br>Power Sensor,<br>NRX Power Meter                 |
| Absolute RF Power – Measure <sup>8</sup>  | (-35 to 20) dBm<br>DC to 100 MHz<br>> 100 MHz to 2.4 GHz<br>(> 2.4 to 12.4) GHz<br>(> 12.4 to 18) GHz<br>(>18 to 26.5) GHz<br>(>26.5 to 40) GHz<br>(>40 to 50) GHz   | 0.08 dB<br>0.08 dB<br>0.09 dB<br>0.1 dB<br>0.11 dB<br>0.13 dB<br>0.17 dB | R&S® NRP18A<br>R&S® NRP50T<br>Power Sensors;<br>NRX Power Meter |
| Relative RF Power – Measure <sup>8</sup>  | (-30 to 20) dBm<br>DC to 50 GHz  | 0.04 dB  | R&S® NRP18T<br>R&S® NRP50T<br>Power Sensors;<br>NRX Power Meter |
| Amplitude Modulation – AM<br>Depth Measure<br>(Absolute)<br>Rate: 10 Hz to 150 kHz                    | 100 kHz to 50 GHz<br>Up to 100 % Depth   | 0.5 % of reading   | R&S® FSMR<br>Measuring Receiver<br>(B2, B4, B24)                |
| Amplitude Modulation – AM<br>Depth Measure<br>(Flatness reference to 1 kHz)<br>Rate: 10 Hz to 150 kHz | 100 kHz to 50 GHz<br>Up to 100 % Depth   | 0.3 % of reading   | R&S® FSMR<br>Measuring Receiver<br>(B2, B4, B24)                |
| Frequency Modulation – FM<br>Deviation Measure<br>Rate: 10 Hz to 5 MHz                                | 100 kHz to 50 GHz<br>Dev ≤ 5 MHz   | 1.2 % of reading   | R&S® FSMR<br>Measuring Receiver<br>(B2, B4, B24)                |





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Electrical – RF/Microwave

| Parameter/Equipment  | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment          |
|--|--|--|---|
| Phase Modulation – Deviation Measure<br>Rate: 10 Hz to 5 MHz               | 100 kHz to 50 GHz<br>Dev ≤ 10 000 rad  | 1.2 % of reading   | R&S® FSMR Measuring Receiver (B2, B4, B24)            |
| Single-sideband Phase Noise – Source/Measure <sup>8</sup>                  | 1 MHz to 50 GHz<br>10 mHz ≤ Offset < 1 MHz<br>1 MHz ≤ Offset ≤ 30 MHz<br>Offset > 30 MHz   | 1.8 dB<br>2.3 dB<br>3.5 dB   | R&S® FSWP50 Phase Noise Analyzer (B1, B24, B320, K70) |
| Adjacent Channel Leakage Ratio (ACLR) <sup>8</sup><br>Signal Noise > 16 dB | DC to 50 GHz<br>(-90 to -70) dB<br>(-70 to 0) dB   | 0.18 dB<br>0.14 dB   | R&S® FSWP50 Phase Noise Analyzer                      |
| Error Vector Magnitude (EVM) <sup>8</sup><br>Rate: Up to 320 MHz           | 100 kHz to 6 GHz<br>FSK/ASK/PSK/APSK/<br>MSK/16QAM/64QAM/<br>128QAM/256QAM/<br>1024QAM   | 2.3 % of reading   | R&S® FSWP50 Phase Noise Analyzer                      |
| Relative Tuned RF Power – Measure <sup>1</sup>                             | 100 kHz to 22 GHz<br>(-120 to -110) dBm<br>(-110 to -100) dBm<br>(-100 to -90) dBm<br>(-90 to -80) dBm<br>(-80 to -70) dBm<br>(-70 to -60) dBm<br>(-60 to -50) dBm<br>(-50 to -40) dBm<br>(-40 to -30) dBm<br>(-30 to -20) dBm<br>(-20 to -10) dBm<br>(-10 to 0) dBm | 0.67 dB<br>0.22 dB<br>0.13 dB<br>0.12 dB<br>0.11 dB<br>0.11 dB<br>0.11 dB<br>0.11 dB<br>0.088 dB<br>0.086 dB<br>0.084 dB<br>0.083 dB | R&S® FSMR Measuring Receiver                          |



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Electrical – RF/Microwave

| Parameter/Equipment                            | Range              | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment   |
|--|--------------------|---|--|
| Relative Tuned RF Power – Measure <sup>1</sup> | (22 to 40) GHz     |   | R&S <sup>®</sup> FSMR Measuring Receiver   |
|  | (-120 to -110) dBm | 0.68 dB                                   |  |
|  | (-110 to -100) dBm | 0.23 dB                                   |  |
|  | (-100 to -90) dBm  | 0.14 dB                                   |  |
|  | (-90 to -80) dBm   | 0.13 dB                                   |  |
|  | (-80 to -70) dBm   | 0.13 dB                                   |  |
|  | (-70 to -60) dBm   | 0.12 dB                                   |  |
|  | (-60 to -50) dBm   | 0.12 dB                                   |  |
|  | (-50 to -40) dBm   | 0.12 dB                                   |  |
|  | (-40 to -30) dBm   | 0.092 dB                                  |  |
|  | (-30 to -20) dBm   | 0.09 dB                                   |  |
|  | (-20 to -10) dBm   | 0.088 dB                                  |  |
|  | (-10 to 0) dBm     | 0.086 dB                                  |  |
|  | (40 to 50) GHz     |   |  |
|  | (-120 to -110) dBm | 0.69 dB                                   |  |
|  | (-110 to -100) dBm | 0.26 dB                                   |  |
|  | (-100 to -90) dBm  | 0.19 dB                                   |  |
|  | (-90 to -80) dBm   | 0.18 dB                                   |  |
|  | (-80 to -70) dBm   | 0.17 dB                                   |  |
|  | (-70 to -60) dBm   | 0.17 dB                                   |  |
|  | (-60 to -50) dBm   | 0.16 dB                                   |  |
|  | (-50 to -40) dBm   | 0.16 dB                                   |  |
|  | (-40 to -30) dBm   | 0.11 dB                                   |  |
| (-30 to -20) dBm                               | 0.11 dB            |   |  |
| (-20 to -10) dBm                               | 0.1 dB             |   |  |
| (-10 to 0) dBm                                 | 0.1 dB             |   |  |
| Absolute Tuned RF Power – Measure <sup>1</sup> | 100 kHz to 22 GHz  |   | R&S <sup>®</sup> FSMR Measuring Receiver;<br>R&S <sup>®</sup> NRP18T<br>R&S <sup>®</sup> NRP50T<br>Power Sensors;<br>NRX Power Meter |
|  | (-120 to -110) dBm | 0.68 dB                                   |  |
|  | (-110 to -100) dBm | 0.25 dB                                   |  |
|  | (-100 to -90) dBm  | 0.17 dB                                   |  |
|  | (-90 to -80) dBm   | 0.16 dB                                   |  |
|  | (-80 to -70) dBm   | 0.16 dB                                   |  |
|  | (-70 to -60) dBm   | 0.16 dB                                   |  |
|  | (-60 to -50) dBm   | 0.16 dB                                   |  |
|  | (-50 to -40) dBm   | 0.16 dB                                   |  |
|  | (-40 to -30) dBm   | 0.14 dB                                   |  |
|  | (-30 to -20) dBm   | 0.14 dB                                   |  |
|  | (-20 to -10) dBm   | 0.14 dB                                   |  |
|  | (-10 to 0) dBm     | 0.14 dB                                   |  |

**Electrical – RF/Microwave**

| Parameter/Equipment                            | Range               | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment  |
|--|---------------------|---|---|
| Absolute Tuned RF Power – Measure <sup>1</sup> | (22 to 40) GHz      |   | R&S® FSMR<br>Measuring Receiver;<br>R&S® NRP18T<br>R&S® NRP50T<br>Power Sensors;<br>NRX Power Meter |
|  | (-120 to -110) dBm  | 0.69 dB                                   |   |
|  | (-110 to -100) dBm  | 0.26 dB                                   |   |
|  | (-100 to -90) dBm   | 0.19 dB                                   |   |
|  | (-90 to -80) dBm    | 0.18 dB                                   |   |
|  | (-80 to -70) dBm    | 0.18 dB                                   |   |
|  | (-70 to -60) dBm    | 0.18 dB                                   |   |
|  | (-60 to -50) dBm    | 0.18 dB                                   |   |
|  | (-50 to -40) dBm    | 0.18 dB                                   |   |
|  | (-40 to -30) dBm    | 0.16 dB                                   |   |
|  | (-30 to -20) dBm    | 0.16 dB                                   |   |
|  | (-20 to -10) dBm    | 0.16 dB                                   |   |
|  | (-10 to 0) dBm      | 0.16 dB                                   |   |
|  | (40 to 50) GHz      |   |   |
|  | (-120 to -110) dBm  | 0.71 dB                                   |   |
|  | (-110 to -100) dBm  | 0.31 dB                                   |   |
|  | (-100 to -90) dBm   | 0.25 dB                                   |   |
|  | (-90 to -80) dBm    | 0.25 dB                                   |   |
|  | (-80 to -70) dBm    | 0.24 dB                                   |   |
|  | (-70 to -60) dBm    | 0.24 dB                                   |   |
| (-60 to -50) dBm                               | 0.23 dB             |   |   |
| (-50 to -40) dBm                               | 0.23 dB             |   |   |
| (-40 to -30) dBm                               | 0.2 dB              |   |   |
| (-30 to -20) dBm                               | 0.2 dB              |   |   |
| (-20 to -10) dBm                               | 0.2 dB              |   |   |
| (-10 to 0) dBm                                 | 0.2 dB              |   |   |
| Absolute Tuned RF Power – Measure              | 2.5 MHz to 26.5 GHz |   | HP 8902A Opt. 050<br>Measuring Receiver;<br>HP 11722A, HP 11792A,<br>HP 11793A Power Sensors        |
|  | (-127 to -120) dB   | 0.26 dB                                   |   |
|  | (-120 to -110) dB   | 0.26 dB                                   |   |
|  | (-110 to -100) dB   | 0.26 dB                                   |   |
|  | (-100 to -90) dB    | 0.26 dB                                   |   |
|  | (-90 to -80) dB     | 0.26 dB                                   |   |
|  | (-80 to -70) dB     | 0.25 dB                                   |   |
|  | (-70 to -60) dB     | 0.25 dB                                   |   |
|  | (-60 to -50) dB     | 0.25 dB                                   |   |
|  | (-50 to -40) dB     | 0.25 dB                                   |   |
|  | (-40 to -30) dB     | 0.14 dB                                   |   |
|  | (-30 to -20) dB     | 0.14 dB                                   |   |
|  | (-20 to -10) dB     | 0.14 dB                                   |   |
|  | (-10 to -0) dB      | 0.14 dB                                   |   |

**Electrical – RF/Microwave**

| Parameter/Equipment               | Range               | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment   |
|-----------------------------------|---------------------|---|--|
| Relative Tuned RF Power – Measure | 2.5 MHz to 26.5 GHz |   | HP 8902A Opt. 050 Measuring Receiver;<br>HP 11722A, HP 11792A, HP 11793A Power Sensors |
|                                   | (-127 to -120) dB   | 0.23 dB                                   |  |
|                                   | (-120 to -110) dB   | 0.23 dB                                   |  |
|                                   | (-110 to -100) dB   | 0.23 dB                                   |  |
|                                   | (-100 to -90) dB    | 0.23 dB                                   |  |
|                                   | (-90 to -80) dB     | 0.22 dB                                   |  |
|                                   | (-80 to -70) dB     | 0.084 dB                                  |  |
|                                   | (-70 to -60) dB     | 0.081 dB                                  |  |
|                                   | (-60 to -50) dB     | 0.074 dB                                  |  |
|                                   | (-50 to -40) dB     | 0.071 dB                                  |  |
|                                   | (-40 to -30) dB     | 0.068 dB                                  |  |
|                                   | (-30 to -20) dB     | 0.064 dB                                  |  |
| (-20 to -10) dB                   | 0.06 dB             |   |  |
| (-10 to -0) dB                    | 0.056 dB            |   |  |

**Length – Dimensional Metrology**

| Parameter/Equipment  | Range                         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--|-------------------------------|---|--|
| Angle Measuring Devices, Protractors, Inclinometers, Squares, Angle Gages <sup>4</sup> | (0.005 6 to 5)°               | 3.2"                                      | 5 in Sine Bar, Gage Blocks, Surface Plate    |
|  | (5 to 20)°                    | 6.1"                                      |  |
|  | (20 to 35)°                   | 11"                                       |  |
|  | (35 to 45)°                   | 15"                                       |  |
|  | (45 to 60)°                   | 25"                                       |  |
|  | (60 to 75)°                   | 54"                                       |  |
|  | (75 to 85)°                   | 166"                                      |  |
|  |                               | 90°                                       | 1.1"   |
| Calipers, Micrometers <sup>1,4</sup><br>Travel<br>(Outside, Inside, Depth, Step)       | Up to 1 in<br>(1 to 9) in     | (16 + 1L) μin<br>(11 + 4L) μin            | B89.1 Grade 00 Gage Blocks                   |
|  | (4 to 15) in<br>(15 to 40) in | (13 + 4.5L) μin<br>(15 + 4.6L) μin        | B89.1 Grade 0 Gage Blocks                    |
| Anvil Flatness   | Up to 1 in diameter           | 4.4 μin                                   | Optical Flats                                |
| Anvil Parallelism  | Up to 1 in diameter           | 8.2 μin                                   | Optical Parallels                            |
| Dial/Digital Indicators, LVDT's, Gage Amplifiers                                       | Up to 2 in<br>(2 to 6) in     | (17 + 1L) μin<br>(18 + 2.2L) μin          | Universal Length Measuring Machine           |

**Length – Dimensional Metrology**

| Parameter/Equipment                                    | Range  | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment                    |
|--|--|---|---|
| Length – Single Axis <sup>4</sup><br>Outside Dimension | Up to 1 in<br>(1 to 7) in<br>(7 to 12) in<br>(12 to 24) in     | $(6 + 1.3L) \mu\text{in}$<br>$(4.5 + 4L) \mu\text{in}$<br>$(2 + 4L) \mu\text{in}$<br>$(24 + 5L) \mu\text{in}$ | Universal Length Measuring Machine<br><br>Gage Amp, Gage Blocks |
| Length – Single Axis <sup>4</sup><br>Inside Dimension  | (0.04 to 1) in<br>(1 to 2.5) in<br>(2.5 to 10) in              | 11 $\mu\text{in}$<br>11 $\mu\text{in}$<br>$(18 + 3L) \mu\text{in}$  | Universal Length Measuring Machine                              |
| Outside Dimension                                      | Up to 1 in<br>(1 to 7) in<br>(7 to 12) in                      | $(6 + 1L) \mu\text{in}$<br>$(4 + 3.5L) \mu\text{in}$<br>4L $\mu\text{in}$                                     |   |
| Height Gages <sup>1,4</sup>                            | Up to 4 in<br>(4 to 44) in                                     | 110 $\mu\text{in}$<br>$(94 + 3L) \mu\text{in}$  | Gage Blocks,<br>Surface Plate                                   |
| Parallelism, Flatness,<br>Straightness                 | Up to 12 in<br>(12 to 24) in<br>(24 to 36) in<br>(36 to 48) in | 45 $\mu\text{in}$<br>55 $\mu\text{in}$<br>67 $\mu\text{in}$<br>160 $\mu\text{in}$                             | Gage Amplifier,<br>Surface Plate                                |
| Squareness   | Up to 18 in  | 9.4 $\mu\text{in/in}$   | Gage Amplifier,<br>Granite Master Square                        |
| Cylindrical Plug Gages<br>Outside Diameter             | Up to 1 in<br>(1 to 7) in                                      | 12 $\mu\text{in}$<br>$(9 + 3L) \mu\text{in}$  | Universal Length Measuring Machine                              |
| Cylindrical Ring Gages<br>Inside Diameter              | Up to 2.5 in<br>(2.5 to 10) in<br>(10 to 14) in                | 11 $\mu\text{in}$<br>$(18 + 3L) \mu\text{in}$<br>$(38 + 3L) \mu\text{in}$                                     | Universal Length Measuring Machine                              |
| Thread Plug Gages <sup>4</sup><br>Pitch Diameter       | Up to 1 in<br>(1 to 7) in<br>(7 to 12) in                      | 79 $\mu\text{in}$<br>80 $\mu\text{in}$<br>83 $\mu\text{in}$   | Universal Length Measuring Machine,<br>Thread Wires             |
| Major Diameter   | Up to 1 in<br>(1 to 7) in                                      | 13 $\mu\text{in}$<br>$(10 + 3L) \mu\text{in}$   | Universal Length Measuring Machine                              |
| Thread Ring Gages <sup>4</sup><br>Inner Pitch Diameter | Up to 1 in<br>(1 to 4) in<br>(4 to 7) in                       | 79 $\mu\text{in}$<br>80 $\mu\text{in}$<br>83 $\mu\text{in}$   | Master Thread Setting<br>Plug Uncertainty                       |
| Thread Wires<br>(2 to 120) TPI                         | (0.008 to 0.5) in  | 12 $\mu\text{in}$   | Universal Length Measuring Machine                              |

**Length – Dimensional Metrology**

| Parameter/Equipment                               | Range  | Expanded Uncertainty of Measurement (+/-)                | Reference Standard, Method, and/or Equipment |
|---|--|--|--|
| Measuring Tapes, Rulers <sup>1,4</sup>            | Up to 3 ft<br>(3 to 12) ft<br>(12 to 100) ft | 0.003 5 in<br>(0.003 4 + 25L) μin<br>(0.007 2 + 12L) μin | Glass Rule                                   |
| Measuring Tapes, Rulers <sup>4</sup>              | Up to 1 ft<br>(1 to 3) ft<br>(3 to 1 000) ft | (463 + 2L) μin<br>(410 + 6L) μin<br>(18L) μin            | Single Axis Vision System                    |
| Optical Comparators <sup>1,4</sup><br>X, Y Length | Up to 12 in                                  | (100 + 20L) μin  | Calibration Grids                            |
| Magnification                                     | 10X to 50X                                   | (240 + 21L) μin  | Magnification Checker                        |

**Mass and Mass Related**

| Parameter/Equipment                      | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment                            |
|--|---|--|---|
| Gas Flow Devices                         | (2 to 200) sccm<br>(0.2 to 40) slpm<br>(40 to 80) slpm<br>(80 to 100) slpm          | 0.33 % of reading<br>0.23 % of reading<br>0.32 % of reading<br>0.57 % of reading | Fluke molbloc<br>Laminar Flow Element<br>Gas Flow Calibration<br>System |
| Gas Flow Devices                         | (100 to 300) slpm<br>(300 to 1 200) slpm  | 0.6 % of reading<br>0.81 % of reading  | Fluke molbloc<br>Sonic Nozzle<br>Gas Flow Calibration<br>System         |
| Force Gages<br>(Tension and Compression) | Up to 5 lbf<br>(5 to 10) lbf<br>(10 to 20) lbf<br>(20 to 30) lbf<br>(30 to 100) lbf | 0.001 1 lbf<br>0.002 lbf<br>0.005 8 lbf<br>0.009 3 lbf<br>0.061 lbf              | Characterized NIST<br>Class F Weights                                   |
| Force Gages<br>(Tension and Compression) | Up to 5 lbf<br>(5 to 10) lbf<br>(10 to 20) lbf<br>(20 to 30) lbf<br>(30 to 100) lbf | 0.001 2 lbf<br>0.002 3 lbf<br>0.006 2 lbf<br>0.009 9 lbf<br>0.063 lbf            | NIST Class F Weights  |
| Force Gages<br>(Tension and Compression) | (10 to 300) lbf<br>(300 to 2 000) lbf   | 0.024 % of reading + 0.041 lbf<br>0.024 % of reading + 0.33 lbf                  | Morehouse Force<br>Calibration System                                   |





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Mass and Mass Related

| Parameter/Equipment            | Range   | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--------------------------------|---------|---|--|
| Mass Determination Metric (SI) | 1 mg    | 1.9 µg                                    | Echelon II                                   |
|                                | 2 mg    | 1.9 µg                                    |  |
|                                | 3 mg    | 1.9 µg                                    |  |
|                                | 5 mg    | 1.9 µg                                    |  |
|                                | 10 mg   | 1.9 µg                                    |  |
|                                | 20 mg   | 1.9 µg                                    |  |
|                                | 30 mg   | 1.9 µg                                    |  |
|                                | 50 mg   | 1.9 µg                                    |  |
|                                | 100 mg  | 1.9 µg                                    |  |
|                                | 200 mg  | 1.9 µg                                    |  |
|                                | 300 mg  | 1.9 µg                                    |  |
|                                | 500 mg  | 1.9 µg                                    |  |
|                                | 1 g     | 4.2 µg                                    |  |
|                                | 2 g     | 4.4 µg                                    |  |
|                                | 3 g     | 6 µg                                      |  |
|                                | 5 g     | 5.2 µg                                    |  |
|                                | 10 g    | 7.6 µg                                    |  |
|                                | 20 g    | 11.1 µg                                   |  |
|                                | 30 g    | 13.6 µg                                   |  |
|                                | 50 g    | 16.5 µg                                   |  |
|                                | 100 g   | 33.3 µg                                   |  |
|                                | 200 g   | 70 µg                                     |  |
|                                | 300 g   | 74 µg                                     |  |
|                                | 500 g   | 0.16 mg                                   |  |
|                                | 1 kg    | 0.33 mg                                   |  |
| 2 kg                           | 0.73 mg |   |  |
| 3 kg                           | 1 mg    |   |  |
| 5 kg                           | 1.6 mg  |   |  |
| 10 kg                          | 3.6 mg  |   |  |
| 20 kg                          | 7.2 mg  |   |  |
| 25 kg                          | 9.9 mg  |   |  |



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Mass and Mass Related

| Parameter/Equipment            | Range  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|--------------------------------|--------|---|--|
| Mass Determination Metric (SI) | 1 mg   | 4.5 µg                                    | Echelon III                                  |
|                                | 2 mg   | 4.5 µg                                    |  |
|                                | 3 mg   | 4.5 µg                                    |  |
|                                | 5 mg   | 4.5 µg                                    |  |
|                                | 10 mg  | 4.5 µg                                    |  |
|                                | 20 mg  | 4.5 µg                                    |  |
|                                | 30 mg  | 4.5 µg                                    |  |
|                                | 50 mg  | 4.5 µg                                    |  |
|                                | 100 mg | 4.5 µg                                    |  |
|                                | 200 mg | 4.5 µg                                    |  |
|                                | 300 mg | 4.5 µg                                    |  |
|                                | 500 mg | 4.5 µg                                    |  |
|                                | 1 g    | 11.8 µg                                   |  |
|                                | 2 g    | 12 µg                                     |  |
|                                | 3 g    | 13.4 µg                                   |  |
|                                | 5 g    | 12.4 µg                                   |  |
|                                | 10 g   | 18.5 µg                                   |  |
|                                | 20 g   | 27 µg                                     |  |
|                                | 30 g   | 29 µg                                     |  |
|                                | 50 g   | 43 µg                                     |  |
|                                | 100 g  | 62 µg                                     |  |
|                                | 200 g  | 0.18 mg                                   |  |
|                                | 300 g  | 0.25 mg                                   |  |
|                                | 500 g  | 0.42 mg                                   |  |
|                                | 1 kg   | 0.9 mg                                    |  |
| 2 kg                           | 1.9 mg |   |  |
| 3 kg                           | 2.9 mg |   |  |
| 5 kg                           | 4.4 mg |   |  |
| 10 kg                          | 6.9 mg |   |  |
| 20 kg                          | 19 mg  |   |  |
| 25 kg                          | 25 mg  |   |  |

**Mass and Mass Related**

| Parameter/Equipment   | Range   | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment                   |
|---|---|--|--|
| Mass Determination<br>Avoirdupois                                     | 0.0312 5 oz<br>0.062 5 oz<br>0.125 oz<br>0.25 oz<br>0.5 oz<br>1 oz<br>2 oz<br>4 oz<br>8 oz<br>1 lb<br>2 lb<br>5 lb<br>7.5 lb<br>10 lb<br>15 lb<br>20 lb<br>25 lb<br>50 lb | 7.4 µg<br>12 µg<br>13 µg<br>17 µg<br>24 µg<br>31 µg<br>43 µg<br>93 µg<br>0.17 mg<br>0.25 mg<br>0.5 mg<br>1.8 mg<br>2.8 mg<br>2.9 mg<br>4.6 mg<br>5.3 mg<br>6.7 mg<br>17 mg | Echelon III  |
| Rockwell Hardness Testers <sup>1</sup>                                | HRC Scale<br>Low<br>Middle<br>High<br>HRBw Scale<br>Low<br>Middle<br>High   | 0.78 HRC<br>0.59 HRC<br>0.43 HRC<br>1.1 HRBw<br>1 HRBw<br>1 HRBw   | Indirect verification per ASTM E18 using Hardness Test Blocks. |
| Durometers<br>Spring Force Only<br>Type A, B, E, O<br>Type D, C, DO   | Up to 100 Duro<br>Up to 100 Duro  | 0.31 Duro<br>0.16 Duro   | Durometer Calibrator   |
| Torque Wrenches,<br>Torque Drivers,<br>Torque Indicators <sup>1</sup> | (3 to 80) ozf·in<br>15 ozf·in to 600 lbf·ft<br>5 lbf·in to 800 lbf·ft   | 1.7 % of reading<br>0.5 % of reading<br>1 % of reading   | Torque Calibrators   |
| Hydraulic Torque Devices <sup>1</sup><br>(1 000 to 10 000) psig       | (270 to 2 700) N·m<br>(2 700 to 4 000) N·m<br><br>(200 to 2 000) lbf·ft<br>(2 000 to 20 000) lbf·ft   | 1.3 % of reading<br>1.3 % of reading<br><br>1.3 % of reading<br>1.3 % of reading   | Torque Calibration System                                      |

**Mass and Mass Related**

| Parameter/Equipment                               | Range  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment   |
|---|--|---|--|
| Torque Multipliers <sup>1</sup>                   | (270 to 2 700) N·m                           | 1.5 % of reading                          | Torque Calibration System  |
|   | (2 700 to 4 000) N·m                         | 1.5 % of reading                          |  |
|   | (200 to 2 000) lbf·ft                        | 1.5 % of reading                          |  |
|   | (2 000 to 20 000) lbf·ft                     | 1.5 % of reading                          |  |
| Torque Angle <sup>1</sup>                         | 45°  | 0.35°                                     | Torque Angle Fixture   |
|   | 90°  | 0.35°                                     |  |
|   | 135°   | 0.35°                                     |  |
|   | 180°   | 0.35°                                     |  |
|   | 360°   | 0.35°                                     |  |
| Torque Calibration Equipment                      | 5 ozf·in to 2.5 lbf·in<br>(2.5 to 50) lbf·in | 0.09 % of reading<br>0.05 % of reading    | Torque Wheel,<br>Master Weights  |
| Torque Calibration Equipment                      | 50 lbf·in to 250 lbf·ft                      | 0.06 % of reading                         | Torque Butterfly,<br>Master Weights  |
| Balances and Scales <sup>1,5</sup><br>Metric (SI) | Up to 500 mg                                 | 2.5 µg                                    | Characterized<br>ASTM E617 Class 1<br>weights and internal<br>calibration procedure<br>utilized for the calibration<br>of the weighing system. |
|   | 500 mg to 2 g                                | 6.2 µg                                    |  |
|   | (2 to 5) g                                   | 6.7 µg                                    |  |
|   | (5 to 10) g                                  | 11 µg                                     |  |
|   | (10 to 20) g                                 | 16 µg                                     |  |
|   | (20 to 50) g                                 | 27 µg                                     |  |
|   | (50 to 100) g                                | 58 µg                                     |  |
|   | (100 to 200) g                               | 0.11 mg                                   |  |
|   | (200 to 500) g                               | 0.27 mg                                   |  |
|   | 500 g to 1 kg                                | 0.54 mg                                   |  |
|   | (1 to 2) kg                                  | 1.8 mg                                    |  |
|   | (2 to 5) kg                                  | 3 mg                                      |  |
|   | (5 to 10) kg                                 | 6.6 mg                                    |  |
|   | (10 to 20) kg                                | 14 mg                                     |  |
|   | (20 to 30) kg                                | 20 mg                                     |  |
|   | (30 to 40) kg                                | 27 mg                                     |  |
| (40 to 50) kg                                     | 25 mg  |   |  |
| (50 to 60) kg                                     | 26 mg  |   |  |
| (60 to 70) kg                                     | 28 mg  |   |  |
| (70 to 80) kg                                     | 29 mg  |   |  |
| (80 to 100) kg                                    | 30 mg  |   |  |
| Balances and Scales <sup>1,5</sup><br>Metric (SI) | Up to 5 g                                    | 32 µg                                     | Characterized<br>ASTM E617 Class 2<br>weights and internal<br>calibration procedure<br>utilized for the calibration<br>of the weighing system. |
|   | (5 to 10) g                                  | 44 µg                                     |  |
|   | (10 to 20) g                                 | 59 µg                                     |  |
|   | (20 to 30) g                                 | 88 µg                                     |  |
|   | (30 to 50) g                                 | 0.15 mg                                   |  |
|   | (50 to 100) g                                | 0.29 mg                                   |  |

**Mass and Mass Related**

| Parameter/Equipment                               | Range                           | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment   |
|---|---------------------------------|---|--|
| Balances and Scales <sup>1,5</sup><br>Metric (SI) | (100 to 200) g                  | 0.58 mg                                     | Characterized<br>ASTM E617 Class 2<br>weights and internal<br>calibration procedure<br>utilized for the calibration<br>of the weighing system. |
|   | (200 to 300) g                  | 0.89 mg                                     |  |
|   | (300 to 500) g                  | 1.5 mg                                      |  |
|   | (500 to 1 000) g                | 3 mg  |  |
|   | (1 to 2) kg                     | 6.2 mg                                      |  |
|   | (2 to 3) kg                     | 9 mg  |  |
|   | (3 to 5) kg                     | 15 mg                                       |  |
|   | (5 to 6) kg                     | 18 mg                                       |  |
|   | (6 to 7) kg                     | 21 mg                                       |  |
|   | (7 to 8) kg                     | 24 mg                                       |  |
| Balances and Scales <sup>1,5</sup><br>Metric (SI) | Up to 250 g                     | 0.023 % of reading                          | NIST Class F weights<br>and internal calibration<br>procedure utilized for the<br>calibration of the weighing<br>system.                       |
|   | (250 to 500) g                  | 0.017 % of reading                          |  |
|   | 500 g to 750 kg                 | 0.012 % of reading                          |  |
| Balances and Scales <sup>1,5</sup><br>Avoirdupois | Up to 0.5 lb                    | 0.023 % of reading                          |  |
|   | (0.5 to 1) lb                   | 0.017 % of reading                          |  |
|   | (1 to 1 700) lb                 | 0.012 % of reading                          |  |
| Volumetric Devices                                | 1 mL to 5 L                     | 0.2 % of reading + 20 µL                    | Gravimetric method<br>utilizing Balances.  |
| Pneumatic Absolute Pressure                       | Up to 30 psia                   | 0.002 6 psi                                 | Fluke RPM4<br>Reference Pressure<br>Monitor with Pressure<br>Source.   |
|   | (30 to 300) psia                | 0.008 8 % of reading                        |  |
|   | (300 to 1 000) psia             | 0.01 % of reading                           |  |
| Pneumatic Gauge Pressure <sup>1</sup>             | (-15 to 3) psig                 | 0.015 % of reading                          | Cosa Instruments T3500/3<br>Pressure Calibrator  |
|   | (3 to 500) psig                 | 0.006 5 % of reading                        |  |
| Pneumatic Gauge Pressure                          | (-60 to -22) inH <sub>2</sub> O | 0.009% of reading + 150 µinH <sub>2</sub> O | Fluke PPC4 Pressure<br>Controller/Calibrator   |
|   | (-22 to 22) inH <sub>2</sub> O  | 0.002 2 inH <sub>2</sub> O                  |  |
|   | (22 to 60) inH <sub>2</sub> O   | 0.009% of reading + 150 µinH <sub>2</sub> O |  |
|   | (60 to 72) inH <sub>2</sub> O   | 0.006 7 inH <sub>2</sub> O                  |  |
| Pneumatic Gauge Pressure                          | (72 to 804) inH <sub>2</sub> O  | 0.009% of reading + 150 µinH <sub>2</sub> O |  |
|   | (-15 to 30) psig                | 0.002 1 psi                                 |  |
| Pneumatic Gauge Pressure                          | (30 to 1 000) psig              | 0.007 % of reading                          | Fluke RPM4<br>Reference Pressure<br>Monitor with Pressure<br>Source.   |
|   |                                 |   |  |
| Hydraulic Pressure <sup>1</sup>                   | (50 to 15 000) psia             | 0.011 % of reading + 0.002 6 psi            | Ametek T-150<br>Deadweight Tester,<br>Fluke RPM4<br>Reference Pressure<br>Monitor  |
| Hydraulic Pressure <sup>1</sup>                   | (50 to 15 000) psig             | 0.011 % of reading                          | Ametek T-150<br>Deadweight Tester  |

**Photometry and Radiometry**

| Parameter/Equipment | Range   | Expanded Uncertainty of Measurement (+/-)                | Reference Standard, Method, and/or Equipment |
|---------------------|---|--|--|
| Illuminance         | (30 to 10 764) lx<br>(10 764 to 21 258) lx<br>(21 258 to 32 300) lx | 1.1 % of reading<br>1.7 % of reading<br>2.1 % of reading | Standard Lamp                                |

**Thermodynamic**

| Parameter/Equipment                                 | Range  | Expanded Uncertainty of Measurement (+/-)   | Reference Standard, Method, and/or Equipment                |
|---|--|---|---|
| Humidity – Source                                   | (-10 to 15) °C<br>(10 to 75) %RH<br>(75 to 95) %RH<br>(15 to 35) °C<br>(10 to 95) %RH<br>(35 to 70) °C<br>(10 to 50) %RH<br>(50 to 70) %RH<br>(70 to 95) %RH | 0.5 %RH<br>0.65 %RH<br>0.5 %RH<br>0.5 %RH<br>0.7 %RH<br>0.85 %RH  | Humidity Generator  |
| Humidity – Measure <sup>1</sup>                     | (10 to 30) °C<br>(10 to 90) %RH  | 1.3 %RH   | Vaisala HMI41/HMP46 Temp/Humidity Indicator/Probe           |
| Temperature – Source                                | (-100 to 0) °C<br>(0 to 150) °C<br>(150 to 420) °C<br>(420 to 650) °C  | 0.014 °C<br>0.001 % of reading + 0.024 °C<br>0.001 % of reading + 0.036 °C<br>0.001 % of reading + 0.078 °C | Metrology Wells, SPRT, Hart Black Stack                     |
| Thermocouple Measuring System                       | (600 to 1 000) °C<br>(1 000 to 1450) °C  | 0.94 °C<br>2.9 °C   | Metrology Furnace, Hart 5650 Type S Thermocouple Probe, DMM |
| Temperature – Measure <sup>1</sup>                  | (-195 to 0) °C<br>(0 to 420) °C<br>(420 to 650) °C   | 0.012 °C<br>0.001 % of reading + 0.02 °C<br>0.001 % of reading + 0.028 °C                                   | SPRT, Hart Black Stack                                      |
| Temperature – Measure <sup>1</sup>                  | (600 to 1 000) °C<br>(1 000 to 1450) °C  | 0.94 °C<br>2.9 °C   | Hart 5650 Type S Thermocouple Probe, DMM                    |
| SPRT/PRT/RTD Calibration by Comparison <sup>6</sup> | -195 °C  | 3.4 mK  | NBPLN <sub>2</sub> , SPRT, Superthermometer                 |
| SPRT/PRT/RTD Calibration by Comparison              | -78 °C<br>-38 °C<br>0 °C   | 3.2 mK<br>2.9 mK<br>2.9 mK  | Precision Bath, SPRT, Superthermometer                      |





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**Thermodynamic**

| Parameter/Equipment                      | Range   | Expanded Uncertainty of Measurement (+/-)                             | Reference Standard, Method, and/or Equipment   |
|--|---|---|--|
| SPRT/PRT/RTD Calibration by Comparison   | 0.01 °C   | 1.5 mK  | Triple Point of Water Cell   |
| SPRT/PRT/RTD Calibration by Comparison   | 100 °C<br>156 °C<br>231 °C<br>300 °C<br>420 °C  | 3.6 mK<br>4.6 mK<br>6 mK<br>5.8 mK<br>8.4 mK                          | Precision Bath, SPRT, Superthermometer   |
| SPRT/PRT/RTD Calibration by Comparison   | (-100 to 420) °C  | 0.003 % of reading + 5.9 mK   | Precision Bath, SPRT, Superthermometer   |
| Infrared Temperature Measuring Equipment | (-15 to 0) °C<br>(0 to 50) °C<br>(50 to 100) °C<br>(100 to 120) °C<br>(120 to 200) °C<br>(200 to 350) °C<br>(350 to 500) °C | 0.8 °C<br>0.65 °C<br>0.7 °C<br>0.76 °C<br>0.95 °C<br>1.6 °C<br>2.1 °C | Blackbody Sources (flat plate)<br>$\epsilon = (0.1 \text{ to } 1)$ ,<br>$\lambda = (8 \text{ to } 14) \mu\text{m}$ |

**Time and Frequency**

| Parameter/Equipment              | Range  | Expanded Uncertainty of Measurement (+/-)                   | Reference Standard, Method, and/or Equipment  |
|----------------------------------|--|---|---|
| Frequency – Source/Measure       | 10 MHz   | 5.9 mHz   | Rubidium Frequency Oscillator   |
| Frequency – Measure <sup>1</sup> | (1 to 10) kHz<br>10 kHz to 10 MHz<br>(10 to 225) MHz | 0.64 nHz/Hz + 4.5 μHz<br>0.64 nHz/Hz + 5 μHz<br>0.64 nHz/Hz | Agilent 53132A Universal Counter, Stanford Research FS725 Rubidium Frequency Standard                     |
| Frequency – Source <sup>1</sup>  | 1 Hz to 50 MHz                                       | 58 nHz/Hz   | Agilent 33250A Function/Arbitrary Function Generator, Stanford Research FS725 Rubidium Frequency Standard |
| Period – Measure <sup>1</sup>    | (1 to 100) s   | 45 μs   | Agilent 53132A Universal Counter, Stanford Research FS725 Rubidium Frequency Standard                     |

**Time and Frequency**

| Parameter/Equipment  | Range  | Expanded Uncertainty of Measurement (+/-)  | Reference Standard, Method, and/or Equipment  |
|--|--|--|---|
| Period – Source <sup>1</sup>   | (1 to 100) s   | 58 ns/s  | Agilent 33250A Function/Arbitrary Function Generator, Stanford Research FS725 Rubidium Frequency Standard |
| Stopwatches, Timers <sup>1</sup>   | Up to 599 s/mon  | 58 ms/day  | Vibrograf 4500 Timometer  |
| AC Duty Cycle – Source <sup>1</sup><br>Square-wave < 3.3 Vp-p<br>Freq: 0.1 Hz to 100 kHz | (1 to 10) % Duty Cycle<br>10 μs to 100 s<br>(10 to 49) % Duty Cycle<br>10 μs to 100 s<br>50 % Duty Cycle<br>10 μs to 100 s<br>(51 to 90) % Duty Cycle<br>10 μs to 100 s<br>(91 to 99) % Duty Cycle<br>10 μs to 100 s | 0.62 % of reading + 78 ns<br>0.039 % of reading + 78 ns<br>0.001 6 % of reading + 78 ns<br>0.039 % of reading + 78 ns<br>0.62 % of reading + 78 ns | Fluke 5522A Multiproduct Calibrator   |

**DIMENSIONAL MEASUREMENT**

**1 Dimensional**

| Parameter/Equipment          | Range  | Expanded Uncertainty of Measurement (+/-)                      | Reference Standard, Method, and/or Equipment                                |
|------------------------------|--|--|---|
| Dimensional Measurement – 1D | X-Axis<br>Up to 1 in<br>(1 to 3) in<br>(3 to 6) in<br>Y-Axis<br>Up to 2 in<br>(2 to 3) in<br>(3 to 5) in | 210 μin<br>370 μin<br>480 μin<br>360 μin<br>410 μin<br>560 μin | Optical Comparator utilized as Reference for Length Measurement Inspection. |

**2 Dimensional**

| Parameter/Equipment          | Range                                    | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                |
|------------------------------|--|---|---|
| Dimensional Measurement – 2D | Up to 180°                               | 0.008°                                    | Optical Comparator utilized as Reference for Angle Measurement Inspection.  |
| Dimensional Measurement – 2D | Up to 1 in<br>(1 to 3) in<br>(3 to 6) in | 260 μin<br>450 μin<br>590 μin             | Optical Comparator utilized as Reference for Radius Measurement Inspection. |

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 this parameter, 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. The uncertainties shown are for the most favorable conditions. There is an increase in uncertainty that corresponds to the laboratory’s AC voltage and current uncertainties at different frequencies other than the ones shown. Power factors (PF) other than the one shown contribute to the power uncertainty. PF is related to the cosine of phase. Therefore, uncertainties track the laboratory’s phase uncertainty closely at PF near one but are magnified heavily as PF approaches zero. The lab may also report reactive power, apparent power, and power factor under this accreditation. If needed, contact laboratory for more information regarding uncertainties at frequency and power factor combinations other than the ones shown.
3. The stated uncertainty is the laboratory’s ability to source a fast rise pulse that is approximately 500 ps, 125 ps, and 25 ps. In the typical application of measuring rise time of an oscilloscope, this value is one of the contributing factors, but other factors are derived from the DUT. The known source rise time is mathematically removed from the total measured rise time measured on the DUT.
4.  $L$  = length in inches;  $DL$  = diagonal length in inches; " = arc-second.
5. The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The CMC presented here does not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.
6. NBPLN<sub>2</sub> = Boiling Point of Liquid Nitrogen.
7. The Uncertainty for this measurand is a Unitless measure.
8. Mismatch due to the effect of device-under-test (DUT) and instruments is not included in the Scope CMC, but will be included in the Measurement Uncertainty (MU) on the calibration certificate.
9. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.03.



Jason Stine, Vice President