



# CERTIFICATE OF ACCREDITATION

## The ANSI National Accreditation Board

Hereby attests that

**Transcat–Montreal**  
9900 Côte-de-Liesse  
Montréal, QC H8T 1A1 Canada

Fulfills the requirements of

**ISO/IEC 17025:2017**

In the field of

**CALIBRATION**

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-2489.28



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

**Transcat–Montreal**  
 9900 Côte-de-Liesse  
 Montréal, QC H8T 1A1 Canada  
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### CALIBRATION

Valid to: **September 7, 2025**

Certificate Number: **AC-2489.28**

#### Acoustics and Vibration

| Parameter/Equipment                                         | Range                                                                                                                                    | Expanded Uncertainty of Measurement (+/-)                                                                                                | Reference Standard, Method, and/or Equipment |
|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| Acceleration – Dynamic<br>Amplitude<br>Sensitivity: 10 mV/g | (0.1 to 10) g<br>(5 to 9) Hz<br>(10 to 99) Hz<br>100 Hz<br>(101 to 920) Hz<br>(921 to 5 000) Hz<br>(5 001 to 9 999) Hz<br>(10 to 15) kHz | 2.2 % of reading<br>1.7 % of reading<br>1.3 % of reading<br>1.4 % of reading<br>1.7 % of reading<br>2.2 % of reading<br>3.7 % of reading | Air Bearing<br>Calibration Shaker            |

#### Electrical – DC/Low Frequency

| Parameter/Equipment               | Range                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                                                | Reference Standard, Method, and/or Equipment |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| 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 5 kHz<br>100 $\mu$ A to 1 mA<br>(10 to 20) Hz<br>(20 to 45) Hz<br>(45 to 100) Hz<br>100 Hz to 5 kHz | 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><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<br>8.5 Digit Multimeter        |

## 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<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           |                                              |
|                                   | 100 mA to 1 A     |                                           |                                              |
|                                   | (10 to 20) Hz     | 0.46 % of reading + 0.23 mA               |                                              |
| AC Current – Measure <sup>1</sup> | (20 to 45) Hz     | 0.19 % of reading + 0.23 mA               | Keysight 34465A<br>6.5 Digit Multimeter      |
|                                   | (45 to 100) Hz    | 0.097 % of reading + 0.23 mA              |                                              |
|                                   | 100 Hz to 5 kHz   | 0.12 % of reading + 0.23 mA               |                                              |
|                                   | 3 Hz to 5 kHz     |                                           |                                              |
| AC Current – Source <sup>1</sup>  | (1 to 3) A        | 0.23% of reading + 1.2 mA                 | Fluke 5700A-EP<br>Multiproduct Calibrator    |
|                                   | (3 to 5) A        | 0.15% of reading + 4 mA                   |                                              |
|                                   | (5 to 10) A       | 0.35% of reading + 4.1 mA                 |                                              |
|                                   | Up to 220 $\mu$ A |                                           |                                              |
|                                   | (10 to 20) Hz     | 0.03 % of reading + 16 nA                 |                                              |
|                                   | (20 to 40) Hz     | 0.019 % of reading + 10 nA                |                                              |
|                                   | 40 Hz to 1 kHz    | 0.015 % of reading + 8 nA                 |                                              |
|                                   | (1 to 5) kHz      | 0.03 % of reading + 12 nA                 |                                              |
|                                   | (5 to 10) kHz     | 0.11 % of reading + 65 nA                 |                                              |
|                                   | (0.22 to 2.2) mA  |                                           |                                              |
|                                   | (10 to 20) Hz     | 0.03 % of reading + 40 nA                 |                                              |
|                                   | (20 to 40) Hz     | 0.018 % of reading + 35 nA                |                                              |
|                                   | 40 Hz to 1 kHz    | 0.013 % of reading + 35 nA                |                                              |
|                                   | (1 to 5) kHz      | 0.021 % of reading + 0.11 $\mu$ A         |                                              |
|                                   | (5 to 10) kHz     | 0.11 % of reading + 0.65 $\mu$ A          |                                              |
|                                   | (2.2 to 22) mA    |                                           |                                              |
|                                   | (10 to 20) Hz     | 0.039 % of reading + 0.4 $\mu$ A          |                                              |
|                                   | (20 to 40) Hz     | 0.018 % of reading + 0.35 $\mu$ A         |                                              |
|                                   | 40 Hz to 1 kHz    | 0.014 % of reading + 0.35 $\mu$ A         |                                              |
|                                   | (1 to 5) kHz      | 0.021 % of reading + 0.55 $\mu$ A         |                                              |
|                                   | (5 to 10) kHz     | 0.11 % of reading + 5 $\mu$ A             |                                              |

## Electrical – DC/Low Frequency

| Parameter/Equipment                                                                 | Range                                                                                                                                                                     | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                                                        | Reference Standard, Method, and/or Equipment                                     |
|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| AC Current – Source <sup>1</sup>                                                    | (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<br>(0.22 to 2.2) A<br>20 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz | 0.033 % of reading + 4 $\mu$ A<br>0.018 % of reading + 3.5 $\mu$ A<br>0.014 % of reading + 2.5 $\mu$ A<br>0.021 % of reading + 3.5 $\mu$ A<br>0.11 % of reading + 10 $\mu$ A<br>0.027 % of reading + 35 $\mu$ A<br>0.046 % of reading + 80 $\mu$ A<br>0.7 % of reading + 0.16 mA | Fluke 5700A-EP<br>Multiproduct Calibrator                                        |
| AC Current – Source <sup>1</sup>                                                    | (2.2 to 11) A<br>40 Hz to 1 kHz<br>(1 to 5) kHz<br>(5 to 10) kHz                                                                                                          | 0.048 % of reading + 0.17 mA<br>0.096 % of reading + 0.38 mA<br>0.36 % of reading + 0.75 mA                                                                                                                                                                                      | Fluke 5700A-EP<br>Multiproduct Calibrator,<br>Fluke 5725A<br>Amplifier           |
| AC Current – Source <sup>1</sup>                                                    | (11 to 20.5) A<br>(45 to 100) Hz<br>100 Hz to 1 kHz<br>(1 to 5) kHz                                                                                                       | 0.095 % of reading + 3.9 mA<br>0.12 % of reading + 3.9 mA<br>2.3 % of reading + 3.9 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                                                                   | 0.3 % of reading + 26 mA<br>0.83 % of reading + 47 mA<br>0.35 % of reading + 0.12 A<br>1.1 % of reading + 0.22 A                                                                                                                                                                 | Fluke 5522A<br>Multiproduct Calibrator,<br>Fluke 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                                                                   | 0.57 % of reading + 0.25 A<br>1 % of reading + 0.25 A<br>0.6 % of reading + 0.9 A<br>1.3 % of reading + 0.92 A                                                                                                                                                                   | Fluke 5522A<br>Multiproduct Calibrator,<br>Fluke 5500A/COIL<br>50-turn Coil      |
| 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/1100<br>Multiproduct Calibrator,<br>Fluke 5500A/COIL<br>50-turn Coil |

**Electrical – DC/Low Frequency**

| Parameter/Equipment               | Range            | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|-----------------------------------|------------------|-------------------------------------------|----------------------------------------------|
| AC Voltage – Measure <sup>1</sup> | Up to 10 mV      |                                           | Agilent 3458A<br>8.5 Digit Multimeter        |
|                                   | (1 to 40) Hz     | 0.04 % of reading + 3.5 $\mu$ V           |                                              |
|                                   | 40 Hz to 1 kHz   | 0.03 % of reading + 1.2 $\mu$ V           |                                              |
|                                   | (1 to 20) kHz    | 0.04 % of reading + 1.2 $\mu$ V           |                                              |
|                                   | (20 to 50) kHz   | 0.15 % of reading + 1.2 $\mu$ V           |                                              |
|                                   | (50 to 100) kHz  | 0.59 % of reading + 1.2 $\mu$ V           |                                              |
|                                   | (100 to 300) kHz | 4.6 % of reading + 2.3 $\mu$ V            |                                              |
|                                   | 300 kHz to 1 MHz | 1.5 % of reading + 5.8 $\mu$ V            |                                              |
|                                   | (1 to 4) MHz     | 8.1 % of reading + 8.1 $\mu$ V            |                                              |
|                                   | (10 to 100) mV   |                                           |                                              |
|                                   | (1 to 40) Hz     | 0.013 % of reading + 4.8 $\mu$ V          |                                              |
|                                   | 40 Hz to 1 kHz   | 0.009 7 % of reading + 2.3 $\mu$ V        |                                              |
|                                   | (1 to 20) kHz    | 0.017 % of reading + 2.3 $\mu$ V          |                                              |
|                                   | (20 to 50) kHz   | 0.038 % of reading + 2.3 $\mu$ V          |                                              |
|                                   | (50 to 100) kHz  | 0.093 % of reading + 2.3 $\mu$ V          |                                              |
|                                   | (100 to 300) kHz | 0.36 % of reading + 12 $\mu$ V            |                                              |
|                                   | 300 kHz to 1 MHz | 1.2 % of reading + 12 $\mu$ V             |                                              |
|                                   | (1 to 2) MHz     | 1.8 % of reading + 12 $\mu$ V             |                                              |
|                                   | (2 to 4) MHz     | 4.7 % of reading + 81 $\mu$ V             |                                              |
|                                   | (4 to 8) MHz     | 4.7 % of reading + 92 $\mu$ V             |                                              |
|                                   | (8 to 10) MHz    | 17 % of reading + 0.12 mV                 |                                              |
|                                   | (0.1 to 1) V     |                                           |                                              |
|                                   | (1 to 40) Hz     | 0.008 8 % of reading + 46 $\mu$ V         |                                              |
|                                   | 40 Hz to 1 kHz   | 0.008 3 % of reading + 23 $\mu$ V         |                                              |
|                                   | (1 to 20) kHz    | 0.017 % of reading + 23 $\mu$ V           |                                              |
|                                   | (20 to 50) kHz   | 0.036 % of reading + 23 $\mu$ V           |                                              |
|                                   | (50 to 100) kHz  | 0.093 % of reading + 23 $\mu$ V           |                                              |
|                                   | (100 to 300) kHz | 0.36 % of reading + 0.12 mV               |                                              |
|                                   | 300 kHz to 1 MHz | 1.2 % of reading + 0.12 mV                |                                              |
|                                   | (1 to 2) MHz     | 1.8 % of reading + 0.12 mV                |                                              |
|                                   | (2 to 4) MHz     | 4.6 % of reading + 0.81 mV                |                                              |
|                                   | (4 to 8) MHz     | 4.6 % of reading + 0.92 mV                |                                              |
|                                   | (8 to 10) MHz    | 17 % of reading + 1.2 mV                  |                                              |

## 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      |                                           | Agilent 3458A<br>8.5 Digit Multimeter                       |
|                                        | (1 to 40) Hz     | 0.009 5 % of reading + 0.46 mV            |                                                             |
|                                        | 40 Hz to 1 kHz   | 0.002 3 % of reading + 0.23 mV            |                                                             |
|                                        | (1 to 20) kHz    | 0.017 % of reading + 0.23 mV              |                                                             |
|                                        | (20 to 50) kHz   | 0.036 % of reading + 0.23 mV              |                                                             |
|                                        | (50 to 100) kHz  | 0.093 % of reading + 0.23 mV              |                                                             |
|                                        | (100 to 300) kHz | 0.36 % of reading + 1.2 mV                |                                                             |
|                                        | 300 kHz to 1 MHz | 1.2 % of reading + 1.2 mV                 |                                                             |
|                                        | (1 to 2) MHz     | 1.8 % of reading + 2 mV                   |                                                             |
|                                        | (2 to 4) MHz     | 4.6 % of reading + 8.1 mV                 |                                                             |
|                                        | (4 to 8) MHz     | 4.6 % of reading + 9.2 mV                 |                                                             |
|                                        | (8 to 10) MHz    | 17 % of reading + 12 mV                   |                                                             |
|                                        | (10 to 100) V    |                                           |                                                             |
|                                        | (1 to 40) Hz     | 0.024 % of reading + 4.6 mV               |                                                             |
|                                        | 40 Hz to 1 kHz   | 0.024 % of reading + 2.3 mV               |                                                             |
|                                        | (1 to 20) kHz    | 0.024 % of reading + 2.3 mV               |                                                             |
|                                        | (20 to 50) kHz   | 0.041 % of reading + 2.3 mV               |                                                             |
|                                        | (50 to 100) kHz  | 0.14 % of reading + 2.3 mV                |                                                             |
|                                        | (100 to 300) kHz | 0.46 % of reading + 12 mV                 |                                                             |
|                                        | 300 kHz to 1 MHz | 1.7 % of reading + 12 mV                  |                                                             |
| AC High Voltage – Measure <sup>1</sup> | (100 to 700) V   |                                           | Vitrek 4700<br>High Voltage Meter<br>with Associated Probes |
|                                        | (1 to 40) Hz     | 0.048 % of reading + 46 mV                |                                                             |
|                                        | 40 Hz to 1 kHz   | 0.048 % of reading + 23 mV                |                                                             |
|                                        | (1 to 20) kHz    | 0.071 % of reading + 23 mV                |                                                             |
|                                        | (20 to 50) kHz   | 0.19 % of reading + 23 mV                 |                                                             |
|                                        | (50 to 100) kHz  | 0.35 % of reading + 23 mV                 |                                                             |
|                                        | (1 to 10) kV     |                                           |                                                             |
|                                        | (10 to 200) Hz   | 0.14 % of reading + 0.17 V                |                                                             |
|                                        | (200 to 450) Hz  | 0.46 % of reading + 0.17 V                |                                                             |
|                                        | (450 to 600) Hz  | 0.86 % of reading + 0.17 V                |                                                             |
|                                        | (10 to 35) kV    |                                           |                                                             |
|                                        | (30 to 200) Hz   | 0.11 % of reading + 0.81 V                |                                                             |
|                                        | (200 to 450) Hz  | 0.7 % of reading + 0.81 V                 |                                                             |
|                                        | (450 to 600) Hz  | 1.5 % of reading + 0.81 V                 |                                                             |
|                                        | (35 to 70) kV    |                                           |                                                             |
|                                        | (30 to 100) Hz   | 0.14 % of reading + 1 V                   |                                                             |
|                                        | (100 to 450) Hz  | 0.7 % of reading + 1 V                    |                                                             |
|                                        | (450 to 600) Hz  | 3 % of reading + 1 V                      |                                                             |
|                                        | (70 to 100) kV   |                                           |                                                             |
|                                        | (30 to 100) Hz   | 0.2 % of reading + 1.3 V                  |                                                             |
|                                        | (100 to 450) Hz  | 1.2 % of reading + 1.3 V                  |                                                             |
|                                        | (450 to 600) Hz  | 17 % of reading + 1.3V                    |                                                             |

## Electrical – DC/Low Frequency

| Parameter/Equipment                    | Range                                                                                                                 | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                | Reference Standard, Method, and/or Equipment                           |
|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| DC Current – Measure <sup>1</sup>      | (0 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 + 580 nA<br>0.013 % of reading + 12 $\mu$ A                                                                      | Agilent 3458A<br>8.5 Digit Multimeter                                  |
| DC Current – Measure <sup>1</sup>      | (1 to 3) A<br>(3 to 5) A<br>(5 to 10) A                                                                               | 0.2 % of reading + 0.6 mA<br>0.12 % of reading + 1 mA<br>0.32 % of reading + 1.1 mA                                                                                                                      | Keysight 34465A<br>6.5 Digit Multimeter                                |
| DC Current – Source <sup>1</sup>       | (0.22 to 220) $\mu$ A<br>(0.22 to 2.2) mA<br>(2.2 to 22) mA<br>(22 to 220) mA<br>(0.22 to 2.2) A                      | 41 $\mu$ A/A + 6 nA<br>36 $\mu$ A/A + 7 nA<br>36 $\mu$ A/A + 40 nA<br>48 $\mu$ A/A + 0.7 $\mu$ A<br>57 $\mu$ A/A + 12 $\mu$ A                                                                            | Fluke 5700A-EP<br>Multiproduct Calibrator                              |
| DC Current – Source <sup>1</sup>       | (2.2 to 11) A                                                                                                         | 0.4 mA/A + 0.48 mA                                                                                                                                                                                       | Fluke 5700A-EP<br>Multiproduct Calibrator,<br>Fluke 5725A<br>Amplifier |
| DC Current – Source <sup>1</sup>       | (11 to 20) A                                                                                                          | 0.93 mA/A + 0.58 mA                                                                                                                                                                                      | Fluke 5522A<br>Multiproduct Calibrator                                 |
| DC Voltage – Measure <sup>1</sup>      | (0 to 100) mV<br>(0.1 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 45) 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>0.09 % of reading + 80 mV<br>0.17 % of reading + 0.92 V                                                                                       | Vitrek 4700<br>High Voltage Meter<br>with Associated Probes            |
| 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                | 8.5 $\mu$ V/V + 0.4 $\mu$ V<br>5.1 $\mu$ V/V + 0.7 $\mu$ V<br>4 $\mu$ V/V + 2.5 $\mu$ V<br>3.9 $\mu$ V/V + 4 $\mu$ V<br>6.2 $\mu$ V/V + 40 $\mu$ V<br>7.6 $\mu$ V/V + 0.4 mV                             | Fluke 5700A-EP<br>Multiproduct Calibrator                              |

## Electrical – DC/Low Frequency

| Parameter/Equipment                                          | Range                                                                                                                                                                                                                                              | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                                                                                                                                                           | Reference Standard, Method, and/or Equipment |
|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| DC Resistance – Measure <sup>1</sup>                         | (0 to 10) $\Omega$<br>(10 to 100) $\Omega$<br>100 $\Omega$ to 1 k $\Omega$<br>(1 to 10) k $\Omega$<br>(10 to 100) k $\Omega$<br>100 k $\Omega$ to 1 M $\Omega$<br>(1 to 10) M $\Omega$<br>(10 to 100) M $\Omega$<br>100 M $\Omega$ to 1 G $\Omega$ | 18 $\mu\Omega/\Omega$ + 58 $\mu\Omega$<br>15 $\mu\Omega/\Omega$ + 0.58 m $\Omega$<br>13 $\mu\Omega/\Omega$ + 0.58 m $\Omega$<br>21 $\mu\Omega/\Omega$ + 5.8 m $\Omega$<br>13 $\mu\Omega/\Omega$ + 58 m $\Omega$<br>21 $\mu\Omega/\Omega$ + 2.3 $\Omega$<br>62 $\mu\Omega/\Omega$ + 120 $\Omega$<br>0.059 % of reading + 1.2 k $\Omega$<br>0.82 % of reading + 12 k $\Omega$         | Agilent 3458A<br>8.5 Digit Multimeter        |
| DC Resistance – Source <sup>1</sup><br>(Fixed Simulation)    | 0 $\Omega$<br>1 $\Omega$<br>1.9 $\Omega$<br>10 $\Omega$<br>19 $\Omega$<br>100 $\Omega$<br>190 $\Omega$<br>1 k $\Omega$<br>1.9 k $\Omega$<br>10 k $\Omega$                                                                                          | 40 $\mu\Omega/\Omega$<br>98 $\mu\Omega/\Omega$<br>96 $\mu\Omega/\Omega$<br>24 $\mu\Omega/\Omega$<br>25 $\mu\Omega/\Omega$<br>11 $\mu\Omega/\Omega$<br>11 $\mu\Omega/\Omega$<br>9.4 $\mu\Omega/\Omega$<br>9.4 $\mu\Omega/\Omega$<br>9.4 $\mu\Omega/\Omega$                                                                                                                           | Fluke 5700A-EP<br>Multiproduct Calibrator    |
| DC Resistance – Source <sup>1</sup><br>(Fixed Simulation)    | 19 k $\Omega$<br>100 k $\Omega$<br>190 k $\Omega$<br>1 M $\Omega$<br>1.9 M $\Omega$<br>10 M $\Omega$<br>19 M $\Omega$<br>100 M $\Omega$                                                                                                            | 9.4 $\mu\Omega/\Omega$<br>12 $\mu\Omega/\Omega$<br>12 $\mu\Omega/\Omega$<br>22 $\mu\Omega/\Omega$<br>23 $\mu\Omega/\Omega$<br>42 $\mu\Omega/\Omega$<br>49 $\mu\Omega/\Omega$<br>0.11 m $\Omega/\Omega$                                                                                                                                                                              | Fluke 5700A-EP<br>Multiproduct Calibrator    |
| DC Resistance – Source <sup>1</sup><br>(Variable Simulation) | Up to 11 $\Omega$<br>(11 to 33) $\Omega$<br>(33 to 111) $\Omega$<br>(110 to 330) $\Omega$<br>330 $\Omega$ to 1.1 k $\Omega$<br>(1.1 to 3.3) k $\Omega$<br>(3.3 to 11) k $\Omega$<br>(11 to 33) k $\Omega$<br>(33 to 110) k $\Omega$                | 32 $\mu\Omega/\Omega$ + 0.78 m $\Omega$<br>24 $\mu\Omega/\Omega$ + 1.2 m $\Omega$<br>22 $\mu\Omega/\Omega$ + 1.1 m $\Omega$<br>22 $\mu\Omega/\Omega$ + 1.6 m $\Omega$<br>22 $\mu\Omega/\Omega$ + 1.6 m $\Omega$<br>22 $\mu\Omega/\Omega$ + 16 m $\Omega$<br>22 $\mu\Omega/\Omega$ + 16 m $\Omega$<br>22 $\mu\Omega/\Omega$ + 0.16 $\Omega$<br>22 $\mu\Omega/\Omega$ + 0.16 $\Omega$ | Fluke 5522A<br>Multiproduct Calibrator       |

## Electrical – DC/Low Frequency

| Parameter/Equipment                                                           | Range                                                                                                                                                                                                                                                                                                                | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                                                                                    | Reference Standard, Method, and/or Equipment                  |
|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| DC Resistance – Source <sup>1</sup><br>(Variable Simulation)                  | (110 to 330) kΩ<br>330 kΩ to 1.19 MΩ<br>(1.1 to 3.3) MΩ<br>(3.3 to 11) MΩ<br>(11 to 33) MΩ<br>(33 to 110) MΩ<br>(110 to 330) MΩ<br>330 MΩ to 1.1 GΩ                                                                                                                                                                  | 27 μΩ/Ω + 1.6 Ω<br>26 μΩ/Ω + 1.6 Ω<br>66 μΩ/Ω + 23 Ω<br>0.1 mΩ/Ω + 39 Ω<br>0.19 mΩ/Ω + 1.9 kΩ<br>0.41 mΩ/Ω + 2.3 kΩ<br>0.23 % of reading + 78 kΩ<br>12 % of reading + 0.39 MΩ                                                                                                                                | Fluke 5522A<br>Multiproduct Calibrator                        |
| DC Resistance – Source <sup>1</sup><br>Up to 5 kV Voltage<br>(Fixed Artifact) | 1 kΩ<br>10 kΩ<br>100 kΩ<br>1 MΩ<br>10 MΩ<br>100 MΩ<br>1 GΩ<br>10 GΩ<br>100 GΩ<br>1 TΩ                                                                                                                                                                                                                                | 0.012 % of reading<br>0.012 % of reading<br>0.012 % of reading<br>0.012 % of reading + 1.2 μΩ/Ω/V<br>0.014 % of reading + 1.2 μΩ/Ω/V<br>0.021 % of reading + 1.2 μΩ/Ω/V<br>0.58 % of reading + 1.2 μΩ/Ω/V<br>0.62 % of reading + 2.3 μΩ/Ω/V<br>1.2 % of reading + 5.8 μΩ/Ω/V<br>2.3 % of reading + 12 μΩ/Ω/V | IET Labs<br>VRS-100-10-1k-BP<br>High Resistance<br>Decade Box |
| Electrical Simulation of<br>RTD Indicating Devices –<br>Source <sup>1</sup>   | Pt 385, 100 Ω<br>(-200 to -80) °C<br>(-80 to 0) °C<br>(0 to 100) °C<br>(100 to 300) °C<br>(300 to 400) °C<br>(400 to 630) °C<br>(630 to 800) °C<br>Pt 385, 200 Ω<br>-200 to -80) °C<br>(-80 to 0) °C<br>(0 to 100) °C<br>(100 to 260) °C<br>(260 to 300) °C<br>(300 to 400) °C<br>(400 to 600) °C<br>(600 to 630) °C | 0.039 °C<br>0.039 °C<br>0.054 °C<br>0.07 °C<br>0.078 °C<br>0.093 °C<br>0.18 °C<br>0.031 °C<br>0.031 °C<br>0.031 °C<br>0.039 °C<br>0.093 °C<br>0.1 °C<br>0.11 °C<br>0.12 °C                                                                                                                                   | Fluke 5522A<br>Multiproduct Calibrator                        |

**Electrical – DC/Low Frequency**

| Parameter/Equipment                                                   | Range                  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|-----------------------------------------------------------------------|------------------------|-------------------------------------------|----------------------------------------------|
| Electrical Simulation of RTD Indicating Devices – Source <sup>1</sup> | Pt 385, 500 $\Omega$   |                                           | Fluke 5522A<br>Multiproduct Calibrator       |
|                                                                       | (-200 to -80) °C       | 0.031 °C                                  |                                              |
|                                                                       | (-80 to 0) °C          | 0.039 °C                                  |                                              |
|                                                                       | (0 to 100) °C          | 0.039 °C                                  |                                              |
|                                                                       | (100 to 260) °C        | 0.047 °C                                  |                                              |
|                                                                       | (260 to 300) °C        | 0.062 °C                                  |                                              |
|                                                                       | (300 to 400) °C        | 0.062 °C                                  |                                              |
|                                                                       | (400 to 600) °C        | 0.07 °C                                   |                                              |
|                                                                       | (600 to 630) °C        | 0.085 °C                                  |                                              |
|                                                                       | Pt 385, 1 000 $\Omega$ |                                           |                                              |
|                                                                       | (-200 to -80) °C       | 0.023 °C                                  |                                              |
|                                                                       | (-80 to 0) °C          | 0.023 °C                                  |                                              |
|                                                                       | (0 to 100) °C          | 0.031 °C                                  |                                              |
|                                                                       | (100 to 260) °C        | 0.039 °C                                  |                                              |
|                                                                       | (260 to 300) °C        | 0.047 °C                                  |                                              |
|                                                                       | (300 to 400) °C        | 0.054 °C                                  |                                              |
|                                                                       | (400 to 600) °C        | 0.054 °C                                  |                                              |
|                                                                       | (600 to 630) °C        | 0.18 °C                                   |                                              |
|                                                                       | Pt 3916, 100 $\Omega$  |                                           |                                              |
|                                                                       | (-200 to -190) °C      | 0.19 °C                                   |                                              |
|                                                                       | (-190 to -80) °C       | 0.031 °C                                  |                                              |
|                                                                       | (-80 to 0) °C          | 0.039 °C                                  |                                              |
|                                                                       | (0 to 100) °C          | 0.047 °C                                  |                                              |
|                                                                       | (100 to 260) °C        | 0.054 °C                                  |                                              |
|                                                                       | (260 to 300) °C        | 0.062 °C                                  |                                              |
|                                                                       | (300 to 400) °C        | 0.07 °C                                   |                                              |
|                                                                       | (400 to 600) °C        | 0.078 °C                                  |                                              |
|                                                                       | (600 to 630) °C        | 0.018 °C                                  |                                              |
|                                                                       | Pt 3926, 100 $\Omega$  |                                           |                                              |
|                                                                       | (-200 to -80) °C       | 0.039 °C                                  |                                              |
|                                                                       | (-80 to 0) °C          | 0.039 °C                                  |                                              |
|                                                                       | (0 to 100) °C          | 0.054 °C                                  |                                              |
|                                                                       | (100 to 300) °C        | 0.07 °C                                   |                                              |
|                                                                       | (300 to 400) °C        | 0.078 °C                                  |                                              |
|                                                                       | (400 to 630) °C        | 0.093 °C                                  |                                              |
|                                                                       | PtNi 385, 120 $\Omega$ |                                           |                                              |
|                                                                       | (-80 to 0) °C          | 0.062 °C                                  |                                              |
|                                                                       | (0 to 100) °C          | 0.062 °C                                  |                                              |
|                                                                       | (100 to 260) °C        | 0.1 °C                                    |                                              |
|                                                                       | Cu 427, 10 $\Omega$    |                                           |                                              |
|                                                                       | (-100 to 260) °C       | 0.23 °C                                   |                                              |

# Electrical – DC/Low Frequency

| Parameter/Equipment                                                                    | Range                       | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment |
|----------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------|----------------------------------------------|
| Electrical Simulation of Thermocouple Indicating Devices – Source/Measure <sup>1</sup> | Type B<br>(600 to 800) °C   | 0.35 °C                                   | Fluke 5522A<br>Multiproduct Calibrator       |
|                                                                                        | (800 to 1 000) °C           | 0.28 °C                                   |                                              |
|                                                                                        | (1 000 to 1 550) °C         | 0.24 °C                                   |                                              |
|                                                                                        | (1 550 to 1 820) °C         | 0.26 °C                                   |                                              |
|                                                                                        | Type C<br>(0 to 150) °C     | 0.24 °C                                   |                                              |
|                                                                                        | (150 to 650) °C             | 0.21 °C                                   |                                              |
|                                                                                        | (650 to 1 000) °C           | 0.24 °C                                   |                                              |
|                                                                                        | (1 000 to 1 800) °C         | 0.39 °C                                   |                                              |
|                                                                                        | (1 800 to 2 316) °C         | 0.65 °C                                   |                                              |
|                                                                                        | Type E<br>(-250 to -100) °C | 0.39 °C                                   |                                              |
|                                                                                        | (-100 to -25) °C            | 0.13 °C                                   |                                              |
|                                                                                        | (-25 to 350) °C             | 0.12 °C                                   |                                              |
|                                                                                        | (350 to 650) °C             | 0.13 °C                                   |                                              |
|                                                                                        | (650 to 1 000) °C           | 0.17 °C                                   |                                              |
|                                                                                        | Type J<br>(-210 to -100) °C | 0.21 °C                                   |                                              |
|                                                                                        | (-100 to -30) °C            | 0.13 °C                                   |                                              |
|                                                                                        | (-30 to 150) °C             | 0.12 °C                                   |                                              |
|                                                                                        | (150 to 760) °C             | 0.14 °C                                   |                                              |
|                                                                                        | (760 to 1 200) °C           | 0.18 °C                                   |                                              |
|                                                                                        | Type K<br>(-200 to -100) °C | 0.26 °C                                   |                                              |
|                                                                                        | (-100 to -25) °C            | 0.15 °C                                   |                                              |
|                                                                                        | (-25 to 120) °C             | 0.13 °C                                   |                                              |
|                                                                                        | (120 to 1 000) °C           | 0.21 °C                                   |                                              |
|                                                                                        | (1 000 to 1 372) °C         | 0.31 °C                                   |                                              |
|                                                                                        | Type L<br>(-200 to -100) °C | 0.29 °C                                   |                                              |
|                                                                                        | (-100 to 800) °C            | 0.21 °C                                   |                                              |
|                                                                                        | (800 to 900) °C             | 0.14 °C                                   |                                              |
|                                                                                        | Type N<br>(-200 to -100) °C | 0.31 °C                                   |                                              |
|                                                                                        | (-100 to -25) °C            | 0.18 °C                                   |                                              |
|                                                                                        | (-25 to 120) °C             | 0.15 °C                                   |                                              |
|                                                                                        | (120 to 410) °C             | 0.15 °C                                   |                                              |
|                                                                                        | (410 to 1 300) °C           | 0.21 °C                                   |                                              |

## Electrical – DC/Low Frequency

| Parameter/Equipment                                                                    | Range                                                                                                                                                                                                                    | Expanded Uncertainty of Measurement (+/-)                                                                                                                                  | Reference Standard, Method, and/or Equipment  |
|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Electrical Simulation of Thermocouple Indicating Devices – Source/Measure <sup>1</sup> | Type R<br>(0 to 250) °C                                                                                                                                                                                                  | 0.46 °C                                                                                                                                                                    | Fluke 5522A<br>Multiproduct Calibrator        |
|                                                                                        | (250 to 400) °C                                                                                                                                                                                                          | 0.29 °C                                                                                                                                                                    |                                               |
|                                                                                        | (400 to 1 000) °C                                                                                                                                                                                                        | 0.26 °C                                                                                                                                                                    |                                               |
|                                                                                        | (1 000 to 1 767) °C                                                                                                                                                                                                      | 0.32 °C                                                                                                                                                                    |                                               |
|                                                                                        | Type S<br>(0 to 250) °C                                                                                                                                                                                                  | 0.45 °C                                                                                                                                                                    |                                               |
|                                                                                        | (250 to 1 000) °C                                                                                                                                                                                                        | 0.3 °C                                                                                                                                                                     |                                               |
|                                                                                        | (1 000 to 1 400) °C                                                                                                                                                                                                      | 0.29 °C                                                                                                                                                                    |                                               |
|                                                                                        | (1 400 to 1 767) °C                                                                                                                                                                                                      | 0.36 °C                                                                                                                                                                    |                                               |
|                                                                                        | Type T<br>(-250 to -150) °C                                                                                                                                                                                              | 0.49 °C                                                                                                                                                                    |                                               |
|                                                                                        | (-150 to 0) °C                                                                                                                                                                                                           | 0.19 °C                                                                                                                                                                    |                                               |
|                                                                                        | (0 to 120) °C                                                                                                                                                                                                            | 0.13 °C                                                                                                                                                                    |                                               |
|                                                                                        | (120 to 400) °C                                                                                                                                                                                                          | 0.12 °C                                                                                                                                                                    |                                               |
|                                                                                        | Type U<br>(-200 to 0) °C                                                                                                                                                                                                 | 0.44 °C                                                                                                                                                                    |                                               |
|                                                                                        | (0 to 600) °C                                                                                                                                                                                                            | 0.21 °C                                                                                                                                                                    |                                               |
| Capacitance – Source <sup>1</sup><br>(Fixed Artifact)                                  | 1 kHz<br>10 pF                                                                                                                                                                                                           | 0.14 pF                                                                                                                                                                    | General Radio 1403G<br>Standard Air Capacitor |
| Capacitance – Source <sup>1</sup><br>(Variable Artifact)                               | 1 kHz<br>100 pF to 1 nF<br>(1 to 2) nF<br>(2 to 10) nF<br>(10 to 100) nF<br>100 nF to 1.111 µF                                                                                                                           | 0.18 % of reading + 0.58 pF<br>0.15 % of reading + 0.17 pF<br>0.12 % of reading + 0.17 pF<br>0.09 % of reading + 58 fF<br>0.08 % of reading + 58 fF                        | General Radio 1423A<br>Decade Capacitance Box |
| Capacitance – Source <sup>1</sup><br>(Simulation)                                      | (220 to 400) pF<br>10 Hz to 10 kHz<br>(0.4 to 1.1) nF<br>10 Hz to 10 kHz<br>(1.1 to 3.3) nF<br>10 Hz to 3 kHz<br>(3.3 to 11) nF<br>10 Hz to 3 kHz<br>(11 to 33) nF<br>10 Hz to 1 kHz<br>(33 to 110) nF<br>10 Hz to 1 kHz | 0.4 % of reading + 7.8 pF<br>0.4 % of reading + 7.8 pF<br>0.4 % of reading + 7.8 pF<br>0.21 % of reading + 7.8 pF<br>0.2 % of reading + 78 pF<br>0.21 % of reading + 78 pF | Fluke 5522A<br>Multiproduct Calibrator        |

## Electrical – DC/Low Frequency

| Parameter/Equipment                                                                                                                                                                     | Range                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                                                                                                                                                                                                                                                                    | Reference Standard, Method, and/or Equipment  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Capacitance – Source <sup>1</sup><br>(Simulation)                                                                                                                                       | (110 to 330) nF<br>10 Hz to 1 kHz<br>(0.33 to 1.1) $\mu$ F<br>(10 to 600) Hz<br>(1.1 to 3.3) $\mu$ F<br>(10 to 300) Hz<br>(3.3 to 11) $\mu$ F<br>(10 to 150) Hz<br>(11 to 33) $\mu$ F<br>(10 to 120) Hz<br>(33 to 110) $\mu$ F<br>(10 to 80) Hz<br>(110 to 330) $\mu$ F<br>DC to 50 Hz<br>(0.33 to 1.1) mF<br>DC to 20 Hz<br>(1.1 to 3.3) mF<br>DC to 6 Hz<br>(3.3 to 11) mF<br>DC to 2 Hz<br>(11 to 33) mF<br>DC to 0.6 Hz<br>(33 to 110) mF<br>DC to 0.2 Hz | 0.2 % of reading + 0.23 nF<br><br>0.21 % of reading + 0.78 nF<br><br>0.21 % of reading + 2.3 nF<br><br>0.2 % of reading + 7.8 nF<br><br>0.32 % of reading + 23 nF<br><br>0.37 % of reading + 78 nF<br><br>0.38 % of reading + 0.23 $\mu$ F<br><br>0.35 % of reading + 0.78 $\mu$ F<br><br>0.35 % of reading + 2.3 $\mu$ F<br><br>0.35 % of reading + 7.8 $\mu$ F<br><br>0.58 % of reading + 23 $\mu$ F<br><br>0.85 % of reading + 78 $\mu$ F | Fluke 5522A<br>Multiproduct Calibrator        |
| Oscilloscopes <sup>1,3</sup><br>Amplitude – DC<br>into 50 $\Omega$ load<br>into 1 M $\Omega$ load<br><br>Amplitude – Square Wave<br>into 50 $\Omega$ load<br><br>into 1 M $\Omega$ load | (-6.6 to 6.6) V<br>(-130 to 130) V<br><br>10 Hz to 100 kHz<br>1 mVp-p to 6.6 Vp-p<br><br>10 Hz to 1 kHz<br>1 mVp-p to 130 Vp-p<br>(1 kHz to 10) kHz<br>1 mVp-p to 130 Vp-p                                                                                                                                                                                                                                                                                    | 0.22 % of reading + 31 $\mu$ V<br>0.12 % of reading + 31 $\mu$ V<br><br>0.22 % of reading + 31 $\mu$ V<br><br>0.14 % of reading + 31 $\mu$ V<br>0.22 % of reading + 31 $\mu$ V                                                                                                                                                                                                                                                               | Fluke 5522A/SC1100<br>Multiproduct Calibrator |

## Electrical – DC/Low Frequency

| Parameter/Equipment                                                                 | Range                                                                                                                                     | Expanded Uncertainty of Measurement (+/-)                                                                                                                                        | Reference Standard, Method, and/or Equipment  |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Oscilloscopes <sup>1,3</sup><br>Time Markers<br>into 50 $\Omega$ load               | 1 ns to 20 ms<br>50 ms<br>0.1 s<br>0.2 s<br>0.5 s<br>1 s<br>2 s<br>5 s                                                                    | 0.000 22 % of reading<br>0.005 9 % of reading<br>0.009 8 % of reading<br>0.018 % of reading<br>0.041 % of reading<br>0.08 % of reading<br>0.16 % of reading<br>0.39 % of reading | Fluke 5522A/SC1100<br>Multiproduct Calibrator |
| Rise Time<br>into 50 $\Omega$ load<br>Rate: 1 kHz to 2 MHz<br>Rate: 2 MHz to 10 MHz | 5 mVp-p to 2.5 Vp-p<br>(200 to 300) ps<br>(250 to 350) ps                                                                                 | 50 ps<br>50 ps                                                                                                                                                                   |                                               |
| Leveled Sine Wave<br>into 50 $\Omega$ load                                          | 5 mVp-p to 5.5 Vp-p<br>50 kHz<br>50 kHz to 100 MHz<br>(100 to 300) MHz<br>(300 to 600) MHz<br>5.0 mVp-p to 3.5 Vp-p<br>600 MHz to 1.1 GHz | 1.8 % of reading + 0.23 mV<br>2.8 % of reading + 0.23 mV<br>3.2 % of reading + 0.23 mV<br>4 % of reading + 0.23 mV<br>5.5 % of reading + 0.23 mV                                 |                                               |
| Bandwidth/Flatness<br>(50 kHz Reference)<br>into 50 $\Omega$ load                   | 5 mVp-p to 5.5 Vp-p<br>50 kHz to 100 MHz<br>(100 to 300) MHz<br>(300 to 600) MHz<br>5.0 mVp-p to 3.5 Vp-p<br>600 MHz to 1.1 GHz           | 1.4 % of reading + 78 $\mu$ V<br>1.8 % of reading + 78 $\mu$ V<br>3.2 % of reading + 78 $\mu$ V<br>4 % of reading + 78 $\mu$ V                                                   |                                               |
|                                                                                     |                                                                                                                                           |                                                                                                                                                                                  |                                               |

### Electrical – DC/Low Frequency

| Parameter/Equipment                                   | Range                                                   | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment  |
|-------------------------------------------------------|---------------------------------------------------------|-------------------------------------------|-----------------------------------------------|
| Oscilloscopes <sup>1,3</sup>                          |                                                         |                                           |                                               |
| Input Impedance – Measure                             | (40 to 60) $\Omega$<br>500 k $\Omega$ to 1.5 M $\Omega$ | 0.082 % of reading<br>0.081 % of reading  | Fluke 5522A/SC1100<br>Multiproduct Calibrator |
| Input Capacitance – Measure                           | (5 to 50) pF                                            | 3.9 % of reading + 0.39 pF                |                                               |
| Waveform Generator (Sine, Square, Triangle) Amplitude | 10 Hz to 10 kHz                                         |                                           |                                               |
| into 50 $\Omega$ load                                 | 1.8 mVp-p to 2.5 Vp-p                                   | 2.3 % of reading + 78 $\mu$ V             |                                               |
| into 1 M $\Omega$ load                                | 1.8 mVp-p to 55 Vp-p                                    | 2.3 % of reading + 78 $\mu$ V             |                                               |
| Frequency                                             | 10 Hz to 10 kHz                                         | 0.001 9 % of reading + 12 mHz             |                                               |

### Length – Dimensional Metrology

| Parameter/Equipment                | Range                                                                  | Expanded Uncertainty of Measurement (+/-)                                              | Reference Standard, Method, and/or Equipment                                |
|------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Gauge Blocks <sup>2</sup>          | (0.05 to 4) in<br>(5 to 20) in<br><br>(1 to 100) mm<br>(125 to 500) mm | (1.2 + 1.5L) $\mu$ in<br>(1.7 + 0.9L) $\mu$ in<br><br>(40 + 1.6L) nm<br>(64 + 1.1L) nm | Gauge Block Comparator,<br>Master Gauge Blocks,<br>Master Long Gauge Blocks |
| Outside Micrometers <sup>1,2</sup> | Up to 6 in<br>(6 to 60) in                                             | (30 + 2L) $\mu$ in<br>(60 + 5L) $\mu$ in                                               | Gauge Blocks,<br>Long Gauge Blocks                                          |
| Inside Micrometers <sup>1</sup>    | Up to 24 in<br>(24 to 60) in                                           | 300 $\mu$ in<br>400 $\mu$ in                                                           | Height Master,<br>Surface Plate                                             |
| Depth Micrometers <sup>1,2</sup>   | Up to 12 in                                                            | 350 $\mu$ in                                                                           | Height Master,<br>Surface Plate                                             |
| Anvil Flatness <sup>1,2</sup>      | Up to 1 inD                                                            | 9.3 $\mu$ in                                                                           | Optical Flat                                                                |
| Anvil Parallelism <sup>1,2</sup>   | Up to 1 inD                                                            | 12 $\mu$ in                                                                            | Optical Parallel                                                            |

## Length – Dimensional Metrology

| Parameter/Equipment                                                                                                                | Range                                         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                          |
|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------|
| Calipers <sup>1</sup><br>Outside Diameter                                                                                          | Up to 12 in<br>(12 to 24) in<br>(24 to 40) in | 300 µin<br>430 µin<br>460 µin             | Gauge Blocks                                                                          |
| Inside Diameter, Depth, Step                                                                                                       | Up to 12 in                                   | 300 µin                                   | Gauge Blocks,<br>Gauge Block Accessories,<br>Surface Plate                            |
| Jaw Parallelism                                                                                                                    | Up to 1 in                                    | 7.2 µin                                   | Cylindrical Pin Gauges                                                                |
| Bore Gauges <sup>1,2</sup>                                                                                                         | Up to 8 in                                    | (75 + 2L) µin                             | Characterized Cylindrical Rings                                                       |
| Digital/Dial Indicators,<br>Test Indicators <sup>1</sup><br>0.001 in resolution<br>0.000 1 in resolution<br>0.000 01 in resolution | Up to 4 in<br>Up to 1 in<br>Up to 0.025 in    | 160 µin<br>24 µin<br>10 µin               | SIP Measuring Machine                                                                 |
| Electronic Linear<br>Displacement Probes <sup>2</sup>                                                                              | Up to 100 mm                                  | (0.031 + 0.003 1L) µm                     | Gauge Blocks                                                                          |
| Height Gauges/Stands <sup>1,2</sup>                                                                                                | Up to 40 in                                   | (240 + 1.2L) µin                          | Height Master,<br>Surface Plate                                                       |
| Step Gauges <sup>1,2</sup>                                                                                                         | Up to 60 in                                   | (35 + 1.3L) µin                           | Comparison to<br>Master Step Gauge<br>using Linear Probe,<br>Amplifier, Surface Plate |
| Height Master,<br>Riser Blocks <sup>1,2</sup>                                                                                      | Up to 24 in                                   | (35 + 1.3L) µin                           | Comparison to<br>Gauge Blocks using<br>Linear Probe, Amplifier,<br>Surface Plate      |
| Thread Wires                                                                                                                       | Up to 1 in                                    | 13 µin                                    | SIP Measuring Machine                                                                 |
| Cylindrical Plug Gauges <sup>2</sup><br>Outside Diameter                                                                           | Up to 12 in                                   | (16 + 5L) µin                             | SIP Measuring Machine                                                                 |
| Cylindrical Pin Gauges<br>Outside Diameter                                                                                         | Up to 1 in                                    | 25 µin                                    | Non-contact Measurement<br>using Laser Micrometer                                     |
| Cylindrical Ring Gauges <sup>2</sup><br>Inside Diameter                                                                            | Up to 12 in                                   | (16 + 5L) µin                             | Sip Measuring Machine                                                                 |

## Length – Dimensional Metrology

| Parameter/Equipment                                                                        | Range                                         | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                          |
|--------------------------------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------|
| Thread Plug Gauges, Thread Setting Plug Gauges <sup>2</sup><br>Pitch Diameter – 60° Thread | Up to 1.5 in<br>(1.5 to 6) in<br>(6 to 12) in | 100 µin<br>200 µin<br>300 µin             | SIP Measuring Machine,<br>Thread Wires                                                |
| Major Diameter                                                                             | Up to 12 in                                   | (16 + 5L) µin                             | SIP Measuring Machine,<br>Master Plug Gauge                                           |
| Step Height                                                                                | Up to 1 in                                    | 40 µin                                    | Comparison to<br>Height Master using<br>Electronic Probe,<br>Amplifier, Surface Plate |
| Solid Thread Ring Gauges<br>Inner Pitch Diameter                                           | Up to 1 in<br>(1 to 4) in<br>(4 to 7) in      | 79 µin<br>80 µin<br>83 µin                | SIP Measuring Machine                                                                 |
| Adjustable Thread Ring Gauges <sup>3</sup><br>Pitch Diameter – 60° Thread                  | Up to 1.5 in<br>(1.5 to 6) in<br>(6 to 12) in | See Footnote 3                            | Tactile Fit using Thread<br>Setting Plug Gauge                                        |
| Pipe Thread Plug Gauges<br>Simple Pitch Diameter<br>(4 to 80) TPI                          | Up to 1.5 in<br>(1.5 to 6) in                 | 100 µin<br>200 µin                        | SIP Measuring Machine,<br>Master Plug Gauge,<br>Thread Wires                          |
| Step Height                                                                                | Up to 2 in                                    | 40 µin                                    | Comparison to<br>Height Master using<br>Electronic Probe,<br>Amplifier, Surface Plate |
| Pipe Thread Ring<br>Simple Pitch Diameter                                                  | Up to 3 in                                    | 90 µin                                    | SIP Measuring Machine                                                                 |

## Mass and Mass Related

| Parameter/Equipment                                  | Range                                                                                                                                                                                  | Expanded Uncertainty of Measurement (+/-)                                                                           | Reference Standard, Method, and/or Equipment                                                                              |
|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Pipettes                                             |                                                                                                                                                                                        |                                                                                                                     |                                                                                                                           |
| Single Channel                                       | (0.2 to 2) $\mu$ l<br>(2 to 10) $\mu$ l<br>(10 to 20) $\mu$ l<br>(20 to 100) $\mu$ l<br>(100 to 200) $\mu$ l<br>(200 to 1 000) $\mu$ l<br>(1 to 5) ml<br>(5 to 10) ml<br>(10 to 50) ml | 17 nl<br>21 nl<br>25 nl<br>0.1 $\mu$ l<br>0.14 $\mu$ l<br>0.76 $\mu$ l<br>4.4 $\mu$ l<br>5.9 $\mu$ l<br>7.6 $\mu$ l | Gravimetric Method using Electronic Balances.                                                                             |
| Multi-Channel                                        | (2 to 20) $\mu$ l<br>(2 to 200) $\mu$ l<br>(200 to 1 000) $\mu$ l                                                                                                                      | 0.31 $\mu$ l<br>0.36 $\mu$ l<br>0.76 $\mu$ l                                                                        |                                                                                                                           |
| Torque Wrenches,<br>Torque Screwdrivers <sup>1</sup> | 10 ozf·in to 1 000 lbf·ft                                                                                                                                                              | 1.2 % of reading                                                                                                    | Torque Calibration System                                                                                                 |
| Pneumatic Pressure Devices                           | (-1.32 to 1.32) psig<br>(-2.2 to 2.2) psig<br>Up to 9 psig<br>(9 to 30) psig<br>Up to 300 psig<br>(300 to 1 000) psig                                                                  | 0.000 15 psi<br>0.01 % of reading<br>0.000 73 psi<br>0.008 2 % of reading<br>0.031 psi<br>0.01 % of reading         | Fluke PPC4 Pressure Controller/Calibrator, Fluke Reference Pressure Transducers                                           |
| Absolute Pneumatic Pressure Devices                  | (-14.7 to 300) psia<br>(300 to 1 000) psia                                                                                                                                             | 0.031 psi<br>0.01 % of reading                                                                                      | Fluke PPC4 Pressure Controller/Calibrator with Absolute Pressure Transducer, Built-in Barometric Pressure Reference Gauge |
| Hydraulic Pressure Devices                           | Up to 600 psig<br>(600 to 3 000) psig<br>(3 000 to 30 000) psig                                                                                                                        | 0.12 psi<br>0.6 psi<br>0.02 % of reading                                                                            | Fluke RPM4-E-DWT Electronic Deadweight Tester                                                                             |
| Mass Determination (SI)                              | (1 to 200) mg<br>300 mg<br>500 mg<br>1 g<br>2 g<br>3 g<br>5 g<br>10 g                                                                                                                  | 2 $\mu$ g<br>3 $\mu$ g<br>4 $\mu$ g<br>7 $\mu$ g<br>7 $\mu$ g<br>8 $\mu$ g<br>10 $\mu$ g<br>17 $\mu$ g              | Modified Double Substitution using ASTM E617 Class 1 Weight Set and Electronic Balances.                                  |

## Mass and Mass Related

| Parameter/Equipment                                   | Range                                                                                                                                                                                                                                                                 | Expanded Uncertainty of Measurement (+/-)                                                                                                                                                              | Reference Standard, Method, and/or Equipment                                                                      |
|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Mass Determination (SI)                               | 20 g<br>30 g<br>50 g<br>100 g<br>200 g<br>300 g<br>500 g<br>1 kg<br>2 kg<br>3 kg<br>5 kg<br>10 kg<br>20 kg<br>25 kg                                                                                                                                                   | 33 µg<br>50 µg<br>40 µg<br>80 µg<br>0.1 mg<br>0.15 mg<br>0.15 mg<br>0.5 mg<br>2 mg<br>2.4 mg<br>2.5 mg<br>10 mg<br>20mg<br>30 mg                                                                       | Modified Double Substitution using ASTM E617 Class 1 Weight Set and Electronic Balances.                          |
| Mass Determination (SI)                               | 10 kg<br>20 kg<br>25 kg                                                                                                                                                                                                                                               | 40 mg<br>60 mg<br>70 mg                                                                                                                                                                                | Single Substitution using ASTM E617 Class 1 Weight Set and Electronic Balances.                                   |
| Scales and Balances <sup>1,4</sup><br>(Non-automatic) | 1 mg<br>2 mg<br>5 mg<br>10 mg<br>20 mg<br>50 mg<br>100 mg<br>200 mg<br>500 mg<br>1 g<br>2 g<br>5 g<br>10 g<br>(10 to 20) g<br>(20 to 50) g<br>(50 to 100) g<br>(100 to 200) g<br>(200 to 300) g<br>(300 to 500) g<br>(0,5 to 1.2) kg<br>(1.2 to 8) kg<br>(8 to 30) kg | 3 µg<br>3 µg<br>3 µg<br>3 µg<br>3 µg<br>3 µg<br>3 µg<br>3 µg<br>3 µg<br>5 µg<br>7 µg<br>7 µg<br>10 µg<br>19 µg<br>35 µg<br>0.1 mg<br>0.1 mg<br>0.15 mg<br>0.25 mg<br>0.35 mg<br>2 mg<br>40 mg<br>80 mg | ASTM E617 Class 1 weights and internal calibration procedure utilized for the calibration of the weighing system. |

## Mass and Mass Related

| Parameter/Equipment                                   | Range                                                                  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                                                                      |
|-------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Scales and Balances <sup>1,4</sup><br>(Non-automatic) | (30 to 60) kg<br>(60 to 150) kg<br>(150 to 500) kg<br>(500 to 1000) kg | 30 mg<br>3 g<br>30 g<br>60 g              | ASTM E617 Class 1 weights and internal calibration procedure utilized for the calibration of the weighing system. |

## Thermodynamic

| Parameter/Equipment                                                                            | Range                                                                                                                       | Expanded Uncertainty of Measurement (+/-)                             | Reference Standard, Method, and/or Equipment                                                                                                 |
|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Infrared Thermometers <sup>1</sup>                                                             | (-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>0.94 °C<br>1.6 °C<br>2.1 °C | Fluke 4180, 4181<br>Blackbody Sources<br>(Flat Plate)<br>$\lambda = (8 \text{ to } 14) \mu\text{m}$ ,<br>$\varepsilon = (0.9 \text{ to } 1)$ |
| Liquid Baths,<br>Dry-wells                                                                     | (-200 to 630) °C                                                                                                            | 0.1 °C                                                                | SPRT,<br>Black Stack Thermometer                                                                                                             |
| Digital Thermometers with<br>RTD, PRT, and<br>Thermistor Probes                                | (-30 to 50) °C<br>(50 to 150) °C<br>(150 to 450) °C<br>(450 to 650) °C                                                      | 0.15 °C<br>0.17 °C<br>0.5 °C<br>0.65 °C                               | Comparison to<br>SPRT with Black Stack<br>Thermometer,<br>Dry-well                                                                           |
| Digital Thermometers with<br>Thermocouple Probes                                               | (-30 to 50) °C<br>(50 to 155) °C<br>(155 to 660) °C                                                                         | 0.3 °C<br>0.4 °C<br>0.066 % of reading + 0.67 °C                      | Comparison to<br>SPRT with Black Stack<br>Thermometer,<br>Dry-well                                                                           |
| Humidity – Measure <sup>1</sup>                                                                | (-10 to 70) °C<br>(10 to 90) %RH<br>(90 to 95) %RH                                                                          | 3.1 %RH<br>4 %RH                                                      | Vaisala HMI41/HMP45<br>Temp/Humidity<br>Indicator/Probe                                                                                      |
| Temperature/Humidity<br>Measuring Devices<br>Temperature – Generate<br><br>Humidity – Generate | (-10 to 70) °C<br><br>(-10 to 15) °C<br>(10 to 75) %RH<br>(75 to 95) %RH                                                    | 0.1 °C<br><br>0.5 %RH<br>0.65 %RH                                     | Thunder Scientific 2500<br>Two-Pressure<br>Humidity Generator                                                                                |

### Thermodynamic

| Parameter/Equipment                                           | Range                                                                                                  | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method, and/or Equipment                  |
|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------|
| Temperature/Humidity Measuring Devices<br>Humidity – Generate | (15 to 35) °C<br>(10 to 95) %RH<br>(35 to 70) °C<br>(10 to 50) %RH<br>(50 to 75) %RH<br>(75 to 95) %RH | 0.5 %RH<br>0.5 %RH<br>0.7 %RH<br>0.85 %RH | Thunder Scientific 2500<br>Two-Pressure<br>Humidity Generator |

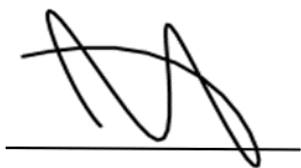
### Time and Frequency

| Parameter/Equipment                   | Range                                                                                                                                                              | Expanded Uncertainty of Measurement (+/-)                                      | Reference Standard, Method, and/or Equipment |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------|
| Contact Tachometers <sup>2</sup>      | (55 to 350) rpm<br>(351 to 1 499) rpm<br>(1 500 to 3 000) rpm<br>(3 001 to 5 000) rpm<br>(5 001 to 10 000) rpm<br>(10 001 to 15 000) rpm<br>(15 001 to 40 000) rpm | 0.12 rpm<br>0.11 rpm<br>0.29 rpm<br>0.37 rpm<br>0.78 rpm<br>1.8 rpm<br>3.3 rpm | Contact Tachometer<br>Calibration System     |
| Non-contact Tachometer <sup>1,2</sup> | (6 to 60) rpm<br>(60 to 600) rpm<br>(600 to 99 999) rpm                                                                                                            | 0.005 3 % of reading<br>0.000 75 % of reading<br>0.000 3 % of reading          | Signal Generator,<br>LED                     |
| Frequency – Measure <sup>1</sup>      | (1 to 10) Hz<br>10 Hz to 1 kHz<br>1 kHz to 1.3 GHz                                                                                                                 | 11 µHz<br>90 nHz/Hz + 10 µHz<br>0.1 µHz/Hz                                     | Fluke PM6681<br>Timer/Counter/Analyzer       |
| Period – Measure <sup>1</sup>         | (1 to 9) s                                                                                                                                                         | 9.8 µs/s + 1.2 µs                                                              | Fluke PM6681<br>Timer/Counter/Analyzer       |

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.  $L$  = length in inches or mm;  $D$  = diameter in inches; rpm = revolutions per minute.
3. The “tactile fit” setting of an adjustable thread ring with a thread setting plug is not a measurement of pitch diameter. The uncertainty for this pitch diameter setting is based on the contributors associated with the thread setting plug and environmental conditions only.
4. 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.
5. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2489.28.



Jason Stine, Vice President

