



CERTIFICATE OF ACCREDITATION

ANSI National Accreditation Board
11617 Coldwater Road, Fort Wayne, IN 46845 USA

This is to certify that

Fox Valley Metrology, Ltd.
3114 Medalist Drive
Oshkosh, WI 54902

has been assessed by ANAB and meets the requirements of international standard

ISO/IEC 17025:2017

and national standards

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

while demonstrating technical competence in the field of

CALIBRATION and DIMENSIONAL MEASUREMENT

Refer to the accompanying Scope of Accreditation for information regarding the types of activities to which this accreditation applies

ACT-1272

Certificate Number


ANAB Approval

Certificate Valid Through: 06/15/2021
Version No. 011 Issued: 03/19/2019



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

Fox Valley Metrology, Ltd.

3114 Medalist Drive
Oshkosh, WI 54902
Mark Toll 920-426-5894

CALIBRATION

Valid to: **June 15, 2021**

Certificate Number: **ACT-1272**

Acoustics and Vibration

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|---------------------------------|---|---|
| Sound Level – Source ¹ 100 Hz, 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz | 114 dB | 0.6 dB | Gen Rad 1562-A Sound Level Calibrator |
| Accelerometers 1 g reference 1 g reference | 20 Hz to 2 kHz (2 to 15) kHz | 1.7 % of reading 2.6 % of reading | PCB 9150C Accelerometer Calibration Workstation |

Chemical Quantities

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|----------------------------------|---------------------------|---|---|
| pH Meters ¹ | (4.01, 7, 10) pH | 0.02 pH | pH Buffer Solutions |
| Conductivity Meters ¹ | 12.85 mS/cm 1408 µS/cm | 0.18 mS/cm 14 µS/cm | Conductivity Solutions |
| Refractometers ¹ | (0.0, 18.0, 29.7) Brix | 0.24 Brix | Refractive Index Solutions |

Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|-------|---|---|
| DC Voltage - Source ¹ Fixed Value | 10 V | 0.8 µV/V | Fluke 732B Voltage Standard |

Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|---|---|---|
| DC Voltage - Source ¹ | Up to 220 mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V 220 V to 1.1 kV | 12 μ V/V + 0.4 μ V 5.8 μ V/V + 0.7 μ V 4.2 μ V/V + 2.5 μ V 4.1 μ V/V + 4 μ V 5.8 μ V/V + 40 μ V 7.6 μ V/V + 0.4 mV | Fluke 5720A Multiproduct Calibrator |
| DC Voltage - Measure ¹ | Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV | 7.8 μ V/V + 0.8 μ V 5.7 μ V/V + 0.8 μ V 5.6 μ V/V + 1 μ V 7.9 μ V/V + 80 μ V 7.9 μ V/V + 0.15 mV | Agilent 3458A Opt 002 Multimeter |
| DC Voltage - Measure ¹ | Up to 200 mV 200 mV to 2 V (2 to 20) V (20 to 200) V 200 V to 1.05 kV | 5 μ V/V + 0.10 μ V 3.5 μ V/V + 0.4 μ V 3.5 μ V/V + 4 μ V 5.5 μ V/V + 40 μ V 5.5 μ V/V + 500 μ V | Fluke 8508A Multimeter |
| DC High Voltage - Measure ¹ | (1 to 10) kV (10 to 100) kV | 60 V 0.6 kV | Hipotronics KVM-100 High Voltage Meter |
| DC Current - Source ¹ | Up to 220 μ A 220 μ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A | 0.12 mA/A + 6 nA 42 μ A/A + 7 nA 41 μ A/A + 40 nA 52 μ A/A + 0.7 μ A 93 μ A/A + 12 μ A | Fluke 5720A Multiproduct Calibrator |
| DC Current - Source ¹ | (2.2 to 11) A (11 to 20.5) A | 0.58 mA/A + 0.5 mA 1.2 mA/A + 0.75 mA | Fluke 5520A Multiproduct Calibrator |
| DC Current - Source ¹ | (20.5 to 1 000) A | 86 mA/A + 0.5 A | Fluke 5520A Multiproduct Calibrator with 50-turn Coil |
| DC Current - Measure ¹ | Up to 100 nA 100 nA to 1 μ A (1 to 10) μ A (10 to 100) μ A 100 μ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A | 48 μ A/A + 65 pA 35 μ A/A + 65 pA 35 μ A/A + 0.15 nA 35 μ A/A + 1.3 nA 35 μ A/A + 10 nA 36 μ A/A + 0.1 μ A 15 μ A/A + 1 μ A 0.14 mA/A + 20 μ A | Agilent 3458A Opt 002 Multimeter |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|--|---|
| DC Current - Measure ¹ | Up to 200 μ A 200 μ A to 2 mA (2 to 20) mA (20 to 200) mA 200 mA to 2 A (2 to 20) A | 12 μ A/A + 0.4 nA 12 μ A/A + 4 nA 14 μ A/A + 40 nA 48 μ A/A + 0.8 μ A 0.19 mA/A + 16 μ A 4 mA/A + 0.4 mA | Fluke 8508A Multimeter |
| DC Current - Measure ¹ | (1 to 10) A | 2.4 mA/A + 0.7 mA | Fluke Multimeter |
| Resistance - Measure ¹ Normal Mode | Up to 2 Ω (2 to 20) Ω (20 to 200) Ω 200 Ω to 2 k Ω (2 to 20) k Ω (20 to 200) k Ω 200 k Ω to 2 M Ω (2 to 20) M Ω (20 to 200) M Ω | 17 $\mu\Omega/\Omega$ + 4 $\mu\Omega$ 9.5 $\mu\Omega/\Omega$ + 14 $\mu\Omega$ 8 $\mu\Omega/\Omega$ + 50 $\mu\Omega$ 8 $\mu\Omega/\Omega$ + 0.5 m Ω 8 $\mu\Omega/\Omega$ + 5 m Ω 8 $\mu\Omega/\Omega$ + 50 m Ω 9 $\mu\Omega/\Omega$ + 1 Ω 20 $\mu\Omega/\Omega$ + 0.1 k Ω 0.12 m Ω/Ω + 10 k Ω | Fluke 8508A Multimeter |
| Resistance - Measure ¹ High Voltage Mode | (2 to 20) M Ω (20 to 200) M Ω 200 m Ω to 2 G Ω (2 to 20) G Ω | 17 $\mu\Omega/\Omega$ + 10 Ω 65 $\mu\Omega/\Omega$ + 1 k Ω 0.18 m Ω/Ω + 0.1 M Ω 15 m Ω/Ω + 10 M Ω | Fluke 8508A Multimeter |
| Resistance - Source ¹ | 0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 k Ω 1.9 k Ω 10 k Ω 19 k Ω 100 k Ω 190 k Ω 1 M Ω 1.9 M Ω | 0.11 m Ω 0.11 m Ω 0.21 m Ω 0.27 m Ω 0.51 m Ω 1.4 m Ω 2.6 m Ω 11 m Ω 21 m Ω 0.11 Ω 0.21 Ω 1.3 Ω 2.7 Ω 24 Ω 48 Ω | Fluke 5720A Multiproduct Calibrator |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|-----------------------------------|--|---|---|
| Resistance - Source ¹ | 10 MΩ 19 MΩ 100 MΩ | 0.48 kΩ 1.1 kΩ 23 kΩ | Fluke 5720A Multiproduct Calibrator |
| Resistance - Source ¹ | 1 GΩ 10 GΩ 100 GΩ | 1.9 MΩ 47 MΩ 0.95 GΩ | IET Labs HRRS Decade Box |
| Resistance - Measure ¹ | Up to 10 Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ (10 to 100) MΩ 100 MΩ to 1 GΩ | 24 μΩ/Ω + 0.1 mΩ 20 μΩ/Ω + 1 mΩ 18 μΩ/Ω + 1 mΩ 18 μΩ/Ω + 10 mΩ 18 μΩ/Ω + 0.1 Ω 24 μΩ/Ω + 7 mΩ 87 μΩ/Ω + 0.2 Ω 0.73 mΩ/Ω + 2 Ω 7.2 mΩ/Ω + 20 kΩ | Agilent 3458A Opt 002 Multimeter |
| AC Voltage - Source ¹ | Up to 2.2 mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (2.2 to 22) mV (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz | 2.4 mV/V + 4 μV 2.4 mV/V + 4 μV 2.2 mV/V + 4 μV 2.2 mV/V + 4 μV 2.3 mV/V + 5 μV 2.5 mV/V + 10 μV 2.7 mV/V + 20 μV 3.8 mV/V + 20 μV 0.61 mV/V + 4 μV 0.56 mV/V + 4 μV 0.36 mV/V + 4 μV 0.42 mV/V + 4 μV 0.70 mV/V + 5 μV 1.3 mV/V + 10 μV 1.7 mV/V + 20 μV 3.4 mV/V + 20 μV | Fluke 5720A Multiproduct Calibrator |



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Electrical – DC/Low Frequency

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|----------------------------------|--------------------|---|---|
| AC Voltage - Source ¹ | (22 to 220) mV | | Fluke 5720A Multiproduct Calibrator |
| | (10 to 20) Hz | 0.29 mV/V + 12 μV | |
| | (20 to 40) Hz | 0.13 mV/V + 7 μV | |
| | 40 Hz to 20 kHz | 0.11 mV/V + 7 μV | |
| | (20 to 50) kHz | 0.24 mV/V + 7 μV | |
| | (50 to 100) kHz | 0.54 mV/V + 17 μV | |
| | (100 to 300) kHz | 1.1 mV/V + 20 μV | |
| | (300 to 500) kHz | 1.6 mV/V + 25 μV | |
| | 500 kHz to 1 MHz | 3.3 mV/V + 45 μV | |
| | (0.22 to 2.2) V | | |
| | (10 to 20) Hz | 0.28 mV/V + 40 μV | |
| | (20 to 40) Hz | 0.11 mV/V + 15 μV | |
| | 40 Hz to 20 kHz | 55 μV/V + 8 μV | |
| | (20 to 50) kHz | 0.12 mV/V + 10 μV | |
| | (50 to 100) kHz | 0.13 mV/V + 30 μV | |
| | (100 to 300) kHz | 0.49 mV/V + 80 μV | |
| | (300 to 500) kHz | 1.2 mV/V + 0.2 mV | |
| | 500 kHz to 1 MHz | 2.0 mV/V + 0.3 mV | |
| | (2.2 to 22) V | | |
| | (10 to 20) Hz | 0.28 mV/V + 0.2 mV | |
| | (20 to 40) Hz | 0.11 mV/V + 0.15 mV | |
| | 40 Hz to 20 kHz | 56 μV/V + 50 μV | |
| | (20 to 50) kHz | 0.12 mV/V + 0.1 mV | |
| | (50 to 100) kHz | 0.12 mV/V + 0.2 mV | |
| | (100 to 300) kHz | 0.32 mV/V + 0.6 mV | |
| | (300 to 500) kHz | 1.2 mV/V + 2 mV | |
| | 500 kHz to 1 MHz | 1.8 mV/V + 3.2 mV | |
| | (22 to 220) V | | |
| | (10 to 20) Hz | 0.28 mV/V + 4 mV | |
| | (20 to 40) Hz | 0.11 mV/V + 1.5 mV | |
| 40 Hz to 20 kHz | 65 μV/V + 0.6 mV | | |
| (20 to 50) kHz | 0.12 mV/V + 1 mV | | |
| (50 to 100) kHz | 0.18 mV/V + 2.5 mV | | |
| (100 to 300) kHz | 1.1 mV/V + 16 mV | | |
| (300 to 500) kHz | 5.1 mV/V + 40 mV | | |
| 500 kHz to 1 MHz | 9.3 mV/V + 80 mV | | |
| 220 V to 1.1 kV | | | |
| (15 to 50) Hz | 0.35 mV/V + 16 mV | | |
| 50 Hz to 1 kHz | 88 μV/V + 3.5 mV | | |



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Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|---|---|
| AC Voltage Harmonics – Source (2 nd to 50 th) ¹ (10 to 45) Hz (45 to 65) Hz (65 to 500) Hz 500 Hz to 5 kHz (5 to 10) kHz | 32 mV to 33 V 33 mV to 1 kV 33 mV to 1 kV 330 mV to 1 kV 3.3 V to 1 kV | 0.35 mV/V + 16 μV 0.21 mV/V + 16 μV 0.21 mV/V + 16 μV 0.21 mV/V + 0.21 mV 0.21 mV/V + 1.2 mV | Fluke 5520A Multiproduct Calibrator |
| AC Voltage - Measure ¹ Bandwidth < 2 MHz | Up to 10 mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (10 to 100) mV (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz 100 mV to 1 V (1 to 40) Hz 40 Hz to 1 kHz (1 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (1 to 2) MHz | 0.46 mV/V + 13 μV 0.35 mV/V + 11 μV 0.46 mV/V + 11 μV 1.3 mV/V + 11 μV 5.9 mV/V + 11 μV 46 μV/V + 12 μV 0.14 mV/V + 4.5 μV 0.14 mV/V + 2.5 μV 0.22 mV/V + 2.5 μV 0.41 mV/V + 2.5 μV 0.99 mV/V + 2.5 μV 3.5 mV/V + 11 μV 12 mV/V + 11 μV 18 mV/V + 11 μV 0.14 mV/V + 45 μV 0.14 mV/V + 25 μV 0.22 mV/V + 25 μV 0.41 mV/V + 25 μV 0.99 mV/V + 25 μV 3.5 mV/V + 0.11 mV 12 mV/V + 0.11 mV 18 mV/V + 0.11 mV | Agilent 3458A Opt 002 Multimeter |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|-------------------|---|---|
| AC Voltage - Measure ¹ Bandwidth < 2 MHz | (1 to 10) V | | Agilent 3458A Opt 002 Multimeter |
| | (1 to 40) Hz | 0.14 mV/V + 0.45 mV | |
| | 40 Hz to 1 kHz | 0.14 mV/V + 0.25 mV | |
| | (1 to 20) kHz | 0.22 mV/V + 0.25 mV | |
| | (20 to 50) kHz | 0.41 mV/V + 0.25 mV | |
| | (50 to 100) kHz | 0.98 mV/V + 0.25 mV | |
| | (100 to 300) kHz | 3.5 mV/V + 1.1 mV | |
| | 300 kHz to 1 MHz | 12 mV/V + 1.1 mV | |
| | (1 to 2) MHz | 18 mV/V + 1.1 mV | |
| | (10 to 100) V | | |
| | (1 to 40) Hz | 0.29 mV/V + 4.5 mV | |
| | 40 Hz to 1 kHz | 0.29 mV/V + 2.5 mV | |
| | (1 to 20) kHz | 0.29 mV/V + 2.5 mV | |
| | (20 to 50) kHz | 0.29 mV/V + 2.5 mV | |
| | (50 to 100) kHz | 1.5 mV/V + 2.5 mV | |
| | (100 to 300) kHz | 4.7 mV/V + 11 mV | |
| 300 kHz to 1 MHz | 18 mV/V + 11 mV | | |
| AC Voltage - Measure ¹ Bandwidth < 2 MHz | 100 V to 1 kV | | Hipotronics KVM-100 High Voltage Meter |
| | (1 to 40) Hz | 0.52 mV/V + 45 mV | |
| | 40 Hz to 1 kHz | 0.52 mV/V + 25 mV | |
| | (1 to 20) kHz | 0.75 mV/V + 25 mV | |
| | (20 to 50) kHz | 1.5 mV/V + 25 mV | |
| | (50 to 100) kHz | 3.5 mV/V + 25 mV | |
| AC Voltage - Measure ¹ Bandwidth > 2 MHz | (1 to 10) kV | | Agilent 3458A Opt 002 Multimeter |
| | (50 to 60) Hz | 0.12 kV | |
| | (10 to 100) kV | | |
| | (50 to 60) Hz | 1.2 kV | |
| | Up to 10 mV | | |
| | 45 Hz to 100 kHz | 1.2 mV/V + 6 μV | |
| | 100 kHz to 1 MHz | 14 mV/V + 5.1 μV | |
| | (1 to 4) MHz | 83 mV/V + 7.1 μV | |
| | (4 to 8) MHz | 0.24 V/V + 8.1 μV | |
| | (10 to 100) mV | | |
| | 45 Hz to 100 kHz | 1.1 mV/V + 61 μV | |
| | 100 kHz to 1 MHz | 24 mV/V + 51 μV | |
| (1 to 4) MHz | 47 mV/V + 71 μV | | |
| (4 to 8) MHz | 47 mV/V + 81 μV | | |
| (8 to 10) MHz | 0.18 V/V + 0.1 mV | | |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|---|---|---|
| AC Voltage - Measure ¹ Bandwidth > 2 MHz | 100 mV to 1 V 45 Hz to 100 kHz 100 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 1.1 mV/V + 0.61 mV 24 mV/V + 0.51 mV 47 mV/V + 0.71 mV 47 mV/V + 0.81 mV 0.18 V/V + 1 mV | Agilent 3458A Opt 002 Multimeter |
| | (1 to 10) V 45 Hz to 100 kHz 100 kHz to 1 MHz (1 to 4) MHz (4 to 8) MHz (8 to 10) MHz | 1.2 mV/V + 6.1 μV 24 mV/V + 5.1 μV 47 mV/V + 7.1 μV 47 mV/V + 8.1 μV 0.18 V/V + 10 μV | |
| AC Voltage - Measure ¹ Bandwidth > 2 MHz | (10 to 100) V 45 Hz to 100 kHz | 1.5 mV/V + 2.5 mV | Hipotronics KVM-100 High Voltage Meter |
| | 100 V to 1 kV 45 Hz to 100 kHz | 3.6 mV/V + 0.11 V | |
| AC Voltage - Measure ¹ Bandwidth < 1 MHz | Up to 200 mV (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz 200 mV to 2 V (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz | 0.17 mV/V + 14 μV 0.14 mV/V + 4 μV 0.12 mV/V + 4 μV 0.11 mV/V + 2 μV 0.14 mV/V + 4 μV 0.34 mV/V + 8 μV 0.77 mV/V + 20 μV 0.15 mV/V + 0.12 mV 0.12 mV/V + 20 μV 90 μV/V + 20 μV 75 μV/V + 20 μV 0.11 mV/V + 20 μV 0.22 mV/V + 0.84 mV 0.57 mV/V + 0.2 mV 3 mV/V + 2 mV 10 mV/V + 2 mV | Fluke 8508A Multimeter |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|---|---|
| AC Voltage - Measure ¹ Bandwidth < 1 MHz | (2 to 20) V (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz | 0.15 mV/V + 1.2 mV 0.12 mV/V + 0.2 mV 90 μV/V + 0.2 mV 75 μV/V + 0.2 mV 0.11 mV/V + 0.2 mV 0.22 mV/V + 8.4 mV 0.57 mV/V + 2 mV 3 mV/V + 20 mV 10 mV/V + 20 mV | Fluke 8508A Multimeter |
| | (20 to 200) V (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz | 0.15 mV/V + 12 mV 0.12 mV/V + 2 mV 90 μV/V + 2 mV 75 μV/V + 2 mV 0.11 mV/V + 2 mV 0.22 mV/V + 84 mV 0.57 mV/V + 20 mV 3 mV/V + 0.2 V 10 mV/V + 0.2 V | |
| AC Voltage - Measure ¹ Bandwidth < 1 MHz | 200 V to 1.05 kV (1 to 10) Hz (10 to 40) Hz 40 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz | 0.15 mV/V + 70 mV 0.12 mV/V + 20 mV 0.12 mV/V + 20 mV 0.23 mV/V + 40 mV 0.58 mV/V + 0.2 V | Fluke 8508A Multimeter |
| AC Current - Source ¹ | Up to 220 μA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz 220 μA to 2.2 mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.30 mA/A + 16 nA 0.20 mA/A + 10 nA 0.16 mA/A + 8 nA 0.22 mA/A + 12 nA 1.3 mA/A + 65 nA 0.31 mA/A + 40 nA 0.22 mA/A + 35 nA 0.15 mA/A + 35 nA 0.24 mA/A + 0.11 μA 1.3 mA/A + 0.65 μA | Fluke 5720A Multiproduct Calibrator |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|--|---|
| AC Current - Source ¹ | (2.2 to 22) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (22 to 220) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz 220 mA to 2.2 A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (2 to 3) A (10 to 45) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz | 0.32 mA/A + 0.4 μA 0.23 mA/A + 0.35 μA 0.15 mA/A + 0.35 μA 0.24 mA/A + 0.55 μA 1.3 mA/A + 5 μA 0.3 mA/A + 4 μA 0.2 mA/A + 3.5 μA 0.15 mA/A + 2.5 μA 0.24 mA/A + 3.5 μA 1.3 mA/A + 10 μA 0.31 mA/A + 35 μA 0.53 mA/A + 80 μA 8.1 mA/A + 0.16 mA 2.1 mA/A + 0.1 mA 0.75 mA/A + 0.1 mA 6.9 mA/A + 1 mA 29 mA/A + 5 mA | Fluke 5720A Multiproduct Calibrator |
| AC Current - Source ¹ | (3 to 11) A (45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz (11 to 20.5) A (45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz | 0.74 mA/A + 2 mA 1.2 mA/A + 2 mA 35 mA/A + 2 mA 1.4 mA/A + 5 mA 1.8 mA/A + 5 mA 35 mA/A + 5 mA | Fluke 5520A Multiproduct Calibrator |
| AC Current - Source ¹ | (20.5 to 1 000) A (45 to 65) Hz (20.5 to 150) A (65 to 440) Hz | 90 mA/A + 0.5 A 0.55 mA/A + 0.5 mA | Fluke 5520A Multiproduct Calibrator w/ 50-turn Coil |
| AC Current Harmonics - Source ¹ (2 nd to 50 th) | (10 to 45) Hz (45 to 65) Hz (65 to 500) Hz 500 Hz to 5 kHz (5 to 10) kHz 3.3 mA to 3 A 3.3 mA to 20.5 A 33 mA to 20.5 A 33 mA to 20.5 A (33 to 330) mA | 1.1 mA/A + 4 μA 0.5 mA/A + 4 μA 1.2 mA/A + 0.1 mA 2.3 mA/A + 0.2 mA 4.6 mA/A + 0.4 mA | Fluke 5520A Multiproduct Calibrator |

Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|-----------------------------------|-----------------------|---|---|
| AC Current - Measure ¹ | Up to 100 μ A | | Agilent 3458A Opt 002 Multimeter |
| | (10 to 20) Hz | 4.8 mA/A + 30 nA | |
| | (20 to 45) Hz | 1.9 mA/A + 30 nA | |
| | (45 to 100) Hz | 0.83 mA/A + 30 nA | |
| | 100 Hz to 5 kHz | 0.83 mA/A + 30 nA | |
| | 100 μ A to 1 mA | | |
| | (10 to 20) Hz | 4.9 mA/A + 0.2 μ A | |
| | (20 to 45) Hz | 1.9 mA/A + 0.2 μ A | |
| | (45 to 100) Hz | 0.83 mA/A + 0.2 μ A | |
| | 100 Hz to 5 kHz | 0.47 mA/A + 0.2 μ A | |
| | (5 to 20) kHz | 0.83 mA/A + 0.2 μ A | |
| | (20 to 50) kHz | 4.9 mA/A + 0.4 μ A | |
| | (50 to 100) kHz | 6.6 mA/A + 1.5 μ A | |
| | (1 to 10) mA | | |
| | (10 to 20) Hz | 4.9 mA/A + 2 μ A | |
| | (20 to 45) Hz | 1.9 mA/A + 2 μ A | |
| (45 to 100) Hz | 0.83 mA/A + 2 μ A | | |
| 100 Hz to 5 kHz | 0.47 mA/A + 2 μ A | | |
| (5 to 20) kHz | 0.83 mA/A + 2 μ A | | |
| (20 to 50) kHz | 4.9 mA/A + 4 μ A | | |
| (50 to 100) kHz | 6.6 mA/A + 15 μ A | | |
| AC Current - Measure ¹ | (10 to 100) mA | | Agilent 3458A Opt 002 Multimeter |
| | (10 to 20) Hz | 4.9 mA/A + 20 μ A | |
| | (20 to 45) Hz | 1.9 mA/A + 20 μ A | |
| | (45 to 100) Hz | 0.83 mA/A + 20 μ A | |
| | 100 Hz to 5 kHz | 0.47 mA/A + 20 μ A | |
| | (5 to 20) kHz | 0.47 mA/A + 20 μ A | |
| | (20 to 50) kHz | 4.9 mA/A + 40 μ A | |
| | (50 to 100) kHz | 6.6 mA/A + 0.15 mA | |
| | 100 mA to 1 A | | |
| | (10 to 20) Hz | 4.8 mA/A + 0.2 mA | |
| | (20 to 45) Hz | 2 mA/A + 0.2 mA | |
| | (45 to 100) Hz | 1.1 mA/A + 0.2 mA | |
| | 100 Hz to 5 kHz | 1.3 mA/A + 0.2 mA | |
| | (5 to 20) kHz | 3.7 mA/A + 0.2 mA | |
| (20 to 50) kHz | 12 mA/A + 0.4 mA | | |
| AC Current - Measure ¹ | (1 to 10) A | | Fluke Multimeter |
| | (20 to 50) Hz | 0.23 A/A + 10 mA | |
| | 50 Hz to 2 kHz | 36 mA/A + 10 mA | |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|---|---|
| AC Current - Measure ¹ | Up to 200 μ A (1 to 10) Hz | 0.31 mA/A + 20 nA | Fluke 8508A Multimeter |
| | 10 Hz to 10 kHz (10 to 30) kHz | 0.3 mA/A + 20 nA | |
| | (30 to 100) kHz | 0.71 mA/A + 20 nA | |
| | 200 μ A to 2 mA (1 to 10) Hz | 4 mA/A + 20 nA | |
| | 10 Hz to 10 kHz (10 to 30) kHz | 0.31 mA/A + 0.2 μ A | |
| | (30 to 100) kHz | 0.3 mA/A + 0.2 μ A | |
| | (2 to 20) mA (1 to 10) Hz | 0.71 mA/A + 0.2 μ A | |
| | 10 Hz to 10 kHz (10 to 30) kHz | 4 mA/A + 0.2 μ A | |
| | (20 to 200) mA (1 to 10) Hz | 0.31 mA/A + 2 μ A | |
| | 10 Hz to 10 kHz (10 to 30) kHz | 0.3 mA/A + 2 μ A | |
| | (30 to 100) kHz | 0.71 mA/A + 2 μ A | |
| | 200 mA to 2 A (2 to 20) mA | 4 mA/A + 2 μ A | |
| AC Current - Measure ¹ | (2 to 20) A 10 Hz to 2 kHz (2 to 10) kHz | 0.31 mA/A + 20 μ A 0.3 mA/A + 20 μ A 0.63 mA/A + 20 μ A | Fluke 8508A Multimeter |
| | 10 Hz to 2 kHz (2 to 10) kHz | 0.62 mA/A + 0.2 mA 0.73 mA/A + 0.2 mA 3 mA/A + 0.2 mA | |
| Capacitance - Measure ¹ 42 Hz to 5 MHz | 0.32 pF to 370 mF | 1.1 mF/F | Hioki 3532-50 LCR Meter |
| Capacitance - Source ¹ | 130 pF to 3.3 nF (3.3 to 11) nF | 5.8 mF/F + 10 pF | Fluke 5520A Multiproduct Calibrator |
| | (11 to 110) nF (110 to 330) nF | 2.9 mF/F + 10 pF | |
| | 330 nF to 1.1 μ F (1.1 to 3.3) μ F | 2.9 mF/F + 0.1 nF | |
| | (3.3 to 11) μ F (11 to 33) μ F | 2.9 mF/F + 0.3 nF | |
| | (33 to 110) μ F (110 to 330) μ F | 2.9 mF/F + 1 nF | |
| | 330 μ F to 1.1 mF (1.1 to 3.3) mF | 2.9 mF/F + 3 nF | |
| | | 2.9 mF/F + 10 nF | |
| | | 4.7 mF/F + 30 nF | |
| | | 5.3 mF/F + 0.1 μ F | |
| | | 1 mF/F + 0.3 μ F | |
| | | 6 mF/F + 1 μ F | |
| | | 5.3 mF/F + 3 μ F | |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|---|---|
| Capacitance - Source ¹ | (3.3 to 11) mF (11 to 33) mF (33 to 110) mF | 5.3 mF/F + 10 μF 8.9 mF/F + 30 μF 13 mF/F + 0.1 mF | Fluke 5520A Multiproduct Calibrator |
| Phase - Measure ¹ | (0 to 360) ° 10 Hz to 2 kHz (2 to 5) kHz (5 to 10) kHz (10 to 50) kHz (50 to 60) kHz (60 to 70) kHz (70 to 80) kHz (80 to 90) kHz (90 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz | 0.026 ° 0.036 ° 0.048 ° 0.059 ° 0.07 ° 0.082 ° 0.093 ° 0.1 ° 0.12 ° 0.58 ° 1.2 ° | Clark Hess 6000A Phase Meter |
| DC Power - Source ¹ | 10 mW to 330 W 330 W to 3 kW (3 to 20.5) kW | 0.27 mW/W 0.26 mW/W 0.82 mW/W | Fluke 5520A Multiproduct Calibrator |
| AC Power - Source ¹ | 100 μW to 9 W (9 to 33) W (33 to 90) W (90 to 330) W (330 to 900) W 900 W to 2.2 kW | 1.7 mW/W 1.2 mW/W 1.7 mW/W 1.2 mW/W 11 mW/W 4.6 mW/W | Fluke 5520A Multiproduct Calibrator |
| Oscilloscopes ¹ DC Voltage (50 Ω) DC Voltage (1 MΩ) AC Voltage (50 Ω) AC Voltage (1 MΩ) Leveled Sine Wave 50 kHz to 1.1 GHz Time Markers Wave Generator (50 Ω) Wave Generator (1 MΩ) | 1 mV to 6.6 V 1 mV to 130 V 1 mV to 6.6 V 1 mV to 130 V 5 mV to 5.5 V 1 ns to 5 s 1.8 mV to 2.5 V p-p 1.8 mV to 55 V p-p | 2.9 mV/V + 40 μV 0.55 mV/V + 40 μV 2.9 mV/V + 40 μV 1.1 mV/V + 40 μV 51 mV/V + 0.1 mV 6.4 μs/s 35 mV/V + 0.1 mV 35 mV/V + 0.1 mV | Fluke 5520A SC1100 Multiproduct Calibrator |



ANSI National Accreditation Board

Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--------------------------------|---|---|
| Oscilloscopes ¹ Pulse Generator - Width | (4 to 45) ns (45 to 500) ns | 58 ms/s + 0.5 ns 58 ms/s + 4 ns | Fluke 5520A SC1100 Multiproduct Calibrator |
| Pulse Generator - Period | 200 ns to 20 ms | 58 ms/s + 0.2 μs | |
| Input Impedance Measure | (50 to 60) Ω 500 kΩ to 1 MΩ | 1.2 mΩ/Ω 1.2 mΩ/Ω | |
| Electrical Simulation of RTD Instrumentation ¹ | Pt 385, 100 Ω | | Fluke 5520A Multiproduct Calibrator |
| | (-200 to -80) °C | 0.05 °C | |
| | (-80 to 0) °C | 0.05 °C | |
| | (0 to 100) °C | 0.07 °C | |
| | (100 to 300) °C | 0.09 °C | |
| | (300 to 400) °C | 0.1 °C | |
| | (500 to 630) °C | 0.12 °C | |
| | (630 to 800) °C | 0.23 °C | |
| | Pt 3926, 100 Ω | | |
| | (-200 to -80) °C | 0.05 °C | |
| | (-80 to 0) °C | 0.05 °C | |
| | (0 to 100) °C | 0.07 °C | |
| | (100 to 300) °C | 0.09 °C | |
| | (300 to 400) °C | 0.1 °C | |
| | (500 to 630) °C | 0.12 °C | |
| | Pt 3916 (JIS) 100 Ω | | |
| | (-200 to -190) °C | 0.25 °C | |
| | (-190 to -80) °C | 0.04 °C | |
| | (-80 to 0) °C | 0.05 °C | |
| | (100 to 260) °C | 0.06 °C | |
| | (260 to 300) °C | 0.07 °C | |
| | (300 to 400) °C | 0.09 °C | |
| | (400 to 600) °C | 0.1 °C | |
| (600 to 630) °C | 0.23 °C | | |
| Pt 385, 200 Ω | | | |
| (-200 to -80) °C | 0.04 °C | | |
| (-80 to 0) °C | 0.04 °C | | |
| (0 to 100) °C | 0.04 °C | | |
| (100 to 260) °C | 0.05 °C | | |
| (260 to 300) °C | 0.12 °C | | |
| (300 to 400) °C | 0.13 °C | | |
| (400 to 600) °C | 0.14 °C | | |
| (600 to 630) °C | 0.16 °C | | |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|---------------------|---|---|
| Electrical Simulation of RTD Instrumentation ¹ | Pt 385, 500 Ω | | Fluke 5520A Multiproduct Calibrator |
| | (-200 to -80) °C | 0.04 °C | |
| | (-80 to 0) °C | 0.05 °C | |
| | (0 to 100) °C | 0.05 °C | |
| | (100 to 260) °C | 0.06 °C | |
| | (260 to 300) °C | 0.08 °C | |
| | (300 to 400) °C | 0.08 °C | |
| | (400 to 600) °C | 0.09 °C | |
| | (600 to 630) °C | 0.11 °C | |
| | Pt 385, 1 000 Ω | | |
| | (-200 to -80) °C | 0.03 °C | |
| | (-80 to 0) °C | 0.03 °C | |
| | (0 to 100) °C | 0.04 °C | |
| | (100 to 260) °C | 0.05 °C | |
| | (260 to 300) °C | 0.06 °C | |
| | (300 to 400) °C | 0.07 °C | |
| | (400 to 600) °C | 0.07 °C | |
| (600 to 630) °C | 0.23 °C | | |
| PtNi 385, 120 Ω, Ni 120 | | | |
| (-80 to 0) °C | 0.08 °C | | |
| (0 to 100) °C | 0.08 °C | | |
| (100 to 260) °C | 0.14 °C | | |
| Cu 427, 10 Ω | | | |
| (-100 to 260) °C | 0.03 °C | | |
| Electrical Simulation of Thermocouple Instrumentation ¹ | Type K | | Fluke 5520A Multiproduct Calibrator |
| | (-200 to -100) °C | 0.33 °C | |
| | (-100 to -25) °C | 0.18 °C | |
| | (-25 to 120) °C | 0.16 °C | |
| | (120 to 1 000) °C | 0.26 °C | |
| | (1 000 to 1 372) °C | 0.4 °C | |
| | Type J | | |
| | (-210 to -100) °C | 0.27 °C | |
| | (-100 to -30) °C | 0.16 °C | |
| | (-30 to 150) °C | 0.14 °C | |
| | (150 to 760) °C | 0.17 °C | |
| (760 to 1 200) °C | 0.23 °C | | |

| | | | |
|--|---------------------|---------|-------------------------------------|
| Electrical Simulation of Thermocouple Instrumentation ¹ | Type E | | |
| | (-250 to -100) °C | | 0.5 °C |
| | (-100 to -35) °C | | 0.16 °C |
| | (-25 to 350) °C | | 0.14 °C |
| | (350 to 650) °C | | 0.16 °C |
| | (650 to 1 000) °C | | 0.21 °C |
| | Type T | | |
| | (-250 to -150) °C | | 0.63 °C |
| | (-150 to 0) °C | | 0.24 °C |
| | (0 to 120) °C | | 0.16 °C |
| | (120 to 400) °C | | 0.14 °C |
| | Type S | | |
| | (0 to 250) °C | | 0.47 °C |
| | (250 to 1 000) °C | | 0.36 °C |
| | (1 000 to 1 400) °C | | 0.37 °C |
| | (1 400 to 1 767) °C | | 0.46 °C |
| | Type B | | |
| | (600 to 800) °C | | 0.44 °C |
| | (-100 to -25) °C | | 0.34 °C |
| | (-25 to 120) °C | | 0.3 °C |
| | (120 to 1 000) °C | | 0.33 °C |
| | Type C | | |
| | (0 to 150) °C | | 0.3 °C |
| | (150 to 650) °C | | 0.26 °C |
| | (650 to 1 000) °C | | 0.31 °C |
| | (1 000 to 1 800) °C | | 0.5 °C |
| | (1 800 to 2 316) °C | | 0.84 °C |
| | Type L | | |
| (-200 to -100) °C | | 0.37 °C | |
| (-100 to 800) °C | | 0.26 °C | |
| (800 to 900) °C | | 0.17 °C | |
| Type N | | | |
| (-200 to -100) °C | | 0.4 °C | |
| (-100 to -25) °C | | 0.22 °C | |
| (-25 to 120) °C | | 0.19 °C | |
| (120 to 410) °C | | 0.18 °C | |
| (410 to 1 300) °C | | 0.27 °C | |
| Type R | | | |
| (0 to 250) °C | | 0.57 °C | |
| (250 to 400) °C | | 0.35 °C | |
| (400 to 1 000) °C | | 0.33 °C | |
| (1 000 to 1767) °C | | 0.4 °C | |
| Type U | | | |
| (-200 to 0) °C | | 0.56 °C | |
| (0 to 600) °C | | 0.27 °C | |
| | | | Fluke 5520A Multiproduct Calibrator |



Electrical – DC/Low Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|--|--|---|
| Inductance - Source ¹ | (1 to 10) mH (10 to 100) mH 100 mH to 1 H (1 to 10) H | 22 mH/H 11 mH/H 6 mH/H 3 mH/H | General Radio 1490-D Decade Inductor |
| Ionizers ¹ Decay Time Float Voltage | (0.1 to 999.9) s (-1 100 to 1 100) V | 0.2 s 3.1 V | Trek 156A Charged Plate Monitor |
| ESD Simulators Rise Time Peak Current 30 nS Current 60 nS Current RC Time Constant RC Time Constant | 700 ps to 1 ns (7.5 to 30) A (4 to 16) A (2 to 8) A 600 ns 300 ns | 0.14 ns 50 mA/A 0.10 A/A 0.12 A/A 20 ns 15 ns | Tektronix TDS684B Oscilloscope with EM Test CTR2 ESD Target IEC 61000-4-2, SAE J1113-13 |

Electrical - RF/Microwave

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|---------------------------------------|---|--|
| RF Power – Measure ^{1,4} Absolute Level 100 kHz to 3 GHz (3 to 18) GHz (18 to 26.5) GHz | (+20 to +30) dBm | 0.37 dB 0.39 dB 0.4 dB | Agilent N5531S Measuring Receiver with N5532A Sensor Modules |
| 100 kHz to 3 GHz (3 to 18) GHz (18 to 26.5) GHz | (-20 to +20) dBm | 0.15 dB 0.18 dB 0.21 dB | |
| Relative Level (3.05 to 6.6) GHz | (-90 to +30) dBm (-113 to -90) dBm | 0.026 dB + 0.005 dB/10 dB 0.067 dB + 0.12 dB/10 dB | Agilent N5531S Measuring Receiver with N5532A Sensor Modules |
| (6.6 to 13.2) GHz | (-81 to +30) dBm (-104 to -81) dBm | 0.026 dB + 0.005 dB/10 dB 0.062 dB + 0.12 dB/10 dB | |
| (13.2 to 19.2) GHz | (-70 to +30) dBm (-93 to -70) dBm | 0.026 dB + 0.005 dB/10 dB 0.056 dB + 0.12 dB/10 dB | |



Electrical - RF/Microwave

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|---|---|--|
| Relative Level (19.2 to 26.5) GHz | (-62 to +30) dBm (-85 to -62) dBm | 0.026 dB + 0.005 dB/10 dB 0.051 dB + 0.12 dB/10 dB | Agilent N5531S Measuring Receiver with N5532A Sensor Modules |
| Amplitude Modulation - Source ^{1,4} Rate: DC to 100 kHz Depths: 0 % to 100 % | 250 kHz to 40 GHz | 7.1 % of setting + 1 % | Agilent E8257D Signal Generator |
| Amplitude Modulation - Measure ^{1,4} | | | |
| 100 kHz to 10 MHz | Rate: 50 Hz to 10 kHz Depths: 5 % to 99 % | 2.2 % of reading | Agilent N5531S Measuring Receiver with N5532A Sensor Modules |
| 10 MHz to 3 GHz | Rate: 50 Hz to 100 kHz Depths: 20 % to 99 % | 1.2 % of reading | |
| 10 MHz to 3 GHz | Rate: 50 Hz to 100 kHz Depths: 5 % to 20 % | 4.2 % of reading | |
| (3 to 26.5) GHz | Rate: 50 Hz to 100 kHz Depths: 20 % to 99 % | 3.5 % of reading | |
| (3 to 26.5) GHz | Rate: 50 Hz to 100 kHz Depths: 5 % to 20 % | 6 % of reading | |
| Phase Modulation - Source ^{1,4} Rate: DC to 100 kHz | 250 kHz to 40 GHz | 5.9 % setting + 0.1 rad | Agilent E8257D Signal Generator |
| Tuned RF Level - Measure ^{1,4} Absolute Level 500 kHz to 3.05 GHz | (+16 to +30) dBm (-106 to +16) dBm (-129 to -106) dBm | 0.37 dB + 0.005 dB/10 dB 0.15 dB + 0.005 dB/10 dB 0.15 dB + 0.12 dB/10 dB | Agilent N5531S Measuring Receiver with N5532A Sensor Modules |
| (3.05 to 6.6) GHz | (+20 to +30) dBm (-90 to +20) dBm (-114 to -90) dBm | 0.39 dB + 0.005 dB/10 dB 0.18 dB + 0.005 dB/10 dB 0.23 dB + 0.12 dB/10 dB | |
| (6.6 to 13.2) GHz | (+20 to +30) dBm (-81 to +20) dBm (-104 to -81) dBm | 0.39 dB + 0.005 dB/10 dB 0.18 dB + 0.005 dB/10 dB 0.23 dB + 0.12 dB/10 dB | |



Electrical - RF/Microwave

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|---|---|---|
| Tuned RF Level - Measure ^{1,4} Absolute Level (13.2 to 19.2) GHz (19.2 to 26.5) GHz 500 kHz to 3.05 GHz | (+20 to +30) dBm (-70 to +20) dBm (-93 to -70) dBm (+20 to +30) dBm (-62 to +20) dBm (-85 to -62) dBm (-90 to +30) dBm (-106 to -90) dBm (-129 to -106) dBm | 0.4 dB + 0.005 dB/10 dB 0.21 dB + 0.005 dB/10 dB 0.25 dB + 0.12 dB/10 dB 0.4 dB + 0.005 dB/10 dB 0.21 dB + 0.005 dB/10 dB 0.24 dB + 0.12 dB/10 dB 0.026 dB + 0.005 dB/10 dB 0.067 dB + 0.12 dB/10 dB 0.076 dB + 0.12 dB/10 dB | Agilent N5531S Measuring Receiver with N5532A Sensor Modules |
| RF Power - Source ¹ 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz | > -10 dBm (-10 to -70) dBm (-70 to -90) dBm | 0.72 dB 0.96 dB 1.1 dB 0.89 dB 1.1 dB 1.2 dB 0.95 dB 1.2 dB 1.21 dB | Agilent E8257D Signal Generator |
| RF Power Sensors- Calibration Factor ^{1,4} 100 kHz to 10 MHz 10 MHz to 10 GHz (10 to 18) GHz | (-20 to +14) dBm | 1.5 % 1.5 % 1.7 % | Tegam 1827 Power Sensor Calibrator, Agilent 3458A Multimeter, Agilent E8257D Signal Generator, Agilent E4419B Power Meter, Agilent 3325B Function Generator |



Electrical - RF/Microwave

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|--|--|--|
| Frequency Modulation - Measure ^{1,4} 250 kHz to 10 MHz 10 MHz to 3 GHz (3 to 26.5) GHz | Rate: 20 Hz to 10 kHz Dev.: ≤ 40 kHz peak Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak | 3.1 % of reading 3.1 % of reading 7.7 % of reading | Agilent N5531S Measuring Receiver with N5532A Sensor Modules |
| Frequency Modulation - Source ^{1,4} 250 kHz to 40 GHz | 1 dB Rate: DC to 100 kHz 3 dB Rate: DC to 10 MHz Dev.: ≤ (N X 800 kHz) | 4.2 % setting + 20 Hz | Agilent E8257D Signal Generator |
| Pulse Generation - Measure ^{1,4} DC to 225 MHz Pulse Width Rise/Fall Time | 5 ns to 10 ⁵ S 5 ns to 10 ⁵ S | 1.1 nS 1.1 nS | Agilent 53132A Counter |
| Pulse Generation - Source ^{1,4} Repetition Frequency: 0.024 Hz to 14.28 MHz Period: 70 ns to 42 s | 10 ns to 42 s | 17 ns | Agilent E8257D Signal Generator |

Length – Dimensional Metrology

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|-------------------------------|---------------|---|--|
| Gage Blocks ² | Up to 10 in | (3.9 + 1.3L) μin | LabMaster Universal Measuring Machine Per ASME B89.1.9 |
| Gage Blocks ² | (10 to 20) in | (8.5 + 1L) μin | ULM 600 Measuring Machine Per ASME B89.1.9 |
| Gage Blocks ² | Up to 20 in | (3.9 + 1.3L) μin | Mahr 828 Measuring Machine Per ASME B89.1.9 |
| Length Standards ² | Up to 9 in | (39 + 0.4L) μin | P&W Supermicrometer |

Length – Dimensional Metrology

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|--|--|---|
| Length Standards ² | (9 to 24) in | (12 + 1L) μin | ULM 600 Measuring Machine |
| Length Standards ² | (24 to 70) in | (390 + 2.6L) μin | CMM |
| Cylindrical Rings ² | (0.25 to 8) in (0.025 to 12) in | (13 + 1.3D) μin (13 + 1.8D) μin | LabMaster Universal ULM 600 ASME B89.1.6 |
| Cylindrical Rings ² | (0.025 to 18) in | (8 + 1.8D) μin | Mahr 828 CIM Measuring Machine ASME B89.1.6 |
| Cylindrical Rings ^{1,2} | (0.25 to 5) in | (12 + 3D) μin | Fowler Lab Concept Measuring Machine ASME B89.1.6 |
| Cylindrical Plugs ² | (0.010 to 8) in | (2.7 + 6D) μin | LabMaster Universal |
| Cylindrical Plugs ^{1,2} | (0.010 to 4) in | (53 + 0.4D) μin | Plug gage Comparator |
| Thread Rings ² Pitch Diameter Pitch Diameter Minor Diameter | Up to 8 in Up to 8 in Up to 8 in | (240 + 0.3D) μin 38 μin 120 μin | Setting Plug Gages ULM 600 Measuring Machine ID Bore Gages ASME B1.2 |
| NPT Rings ² Standoff and Basic Length | (0.0625 to 6) in | 250 μin | NPT Plugs, P&W LabMaster ASME B1.20.5 |
| NPT Plugs ² Standoff and Basic Length | (0.0625 to 6) in | 490 μin | NPT Rings, P&W LabMaster ASME B1.20.5 |
| Threaded Plugs ² Pitch Diameter Major Diameter | (0.01 to 10) in (0.01 to 10) in | (73 + 0.9D) μin (40 + 1.2D) μin | P&W Supermicrometer, Thread Measuring Wires ASME B1.2 |
| Threaded Plugs ^{1,2} Pitch Diameter Major Diameter | (0.01 to 4) in (0.01 to 4) in | (73 + 3.2D) μin (53 + 4.1D) μin | Plug gage Comparator |
| Thread Wires ² | (0.005 to 0.5) in | (11 + 1.5D) μin | ULM 600 Measuring Machine ASME B89.1.17 |
| Calipers ^{1,2} | Up to 80 in | (380 + 15L) μin | Gage Blocks |
| Indicators ^{1,2} | Up to 4 in | (36 + 10L) μin | Indicator Checker |



Length – Dimensional Metrology

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|--|--|
| Test Indicators ^{1,2} | Up to 0.06 in | 39 μin | Indicator Checker |
| OD Micrometers ^{1,2} | Up to 60 in | (72 + 12L) μin | Gage Blocks |
| ID Micrometer ^{1,2} | (1.5 to 40) in | (370 + 7L) μin | Gage Blocks |
| Height Gages ^{1,2} | Up to 40 in | (96 + 14L) μin | Gage Blocks |
| Bore Gages ^{1,2} | (0.25 to 12) in | 350 μin | Cylindrical Rings |
| Crimpers ^{1,2} Die Check Crimp Height | (0.011 to 0.5) in (0.01 to 0.5) in | 230 μin 0.001 2 in | Pin Gages Micrometer |
| Profilometers ^{1,2} | (2 to 300) μin Ra | 2.2 μin | Roughness Specimen |
| Profilometer Reference Specimens | (0.01 to 300) μin Ra | 2.1 μin | Profilometer |
| Surface Plates ^{1,2} Repeat Reading Overall Flatness | (4 to 34) in <i>DL</i> (34 to 175) in <i>DL</i> | (30 + 0.2DL) μin (66 + 0.2DL) μin | Repeat – O – Meter Electronic Levels |
| CMM Calibration ^{1,2} Volumetric Linearity Linearity | (5 to 40) in (1 to 60) in Above 60 in | (12 + 14L) μin (7 + 14L) μin (20 + 0.4L) μin | Ball Bars Step Gage Renishaw Laser System B89.4.1 |
| Linear Measurements | Up to 1 560 in | (38 + 0.5L) μin | Laser |
| Optical Comparators ^{1,2} Linearity Magnification | Up to 12 in 10x, 20x, 31.25x, 50x, 62.5x, 100x, 200x | (97 + 12L) μin 0.00046 in | Glass Scale Precision Balls Calibration Sphere |
| Roundness Testers ^{1,2} Axial Error Radial Error | (-1 000 to 1 000) μml | 0.15 μm 0.15 μm | Test Sphere |
| ULMs ^{1,2} Length | (1 to 100) mm | 0.19 μm | Gage Blocks |
| Film Thickness Gages ^{1,2} | (0.01 to 0.06) in | 380 μin | Film Thickness Standards |
| Brinell Scopes ^{1,2} | (1 to 6) mm | 11 μm | Stage Micrometer |

Mass and Mass Related

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|-------------------------------------|--|---|---|
| Bench and Floor Scales ¹ | (0.001 to 5 000) lb | 0.000 7 lb/lb | NIST 105 Class F Weights NIST Handbook 44 |
| Analytical Balances ¹ | (0.001 mg to 13 kg) | 0.19 µg/g | ASTM E617 Class 1 Weights NIST Handbook 44 |
| Mass | 0.5 lb 1 lb 5 lb 10 lb 20 lb 25 lb 50 lb | 24 mg 73 mg 84 mg 0.14 g 0.37 g 0.46 mg 0.65 mg | Class 1 Weights and Analytical Balance Modified Substitution |
| Mass | 5 000 g 3 000 g 2 000 g 1 000 g 500 g 300 g 200 g 100 g 50 g 30 g 20 g 10 g 5 g 3 g 2 g 1 g | 46 mg 30 mg 23 mg 18 mg 16 mg 16 mg 1.8 mg 0.9 mg 0.47 mg 0.32 mg 0.25 mg 0.2 mg 0.18 mg 0.18 mg 0.18 mg 0.17 mg | Class 1 Weights and Analytical Balance Modified Substitution |
| Pressure ¹ | (-13 to 300) psi (300 to 1 000) psi | 0.1 psi 1.3 psi | Pressure Calibrator |
| Pressure ¹ | (1 000 to 10 000) psi (10 000 to 30 000) psi | 3.9 psi 35 psi | Pressure Transducers |
| Pressure | (0.2 to 500) psia | 1.3 x 10 ⁻⁵ psi/psi | Ruska 2465 Deadweight Tester |
| Pressure | (500 to 3 000) psi | 3 x 10 ⁻⁵ psi/psi | Ruska 2470 Piston Gage |
| Pressure | (3 000 to 16 000) psi | 2 x 10 ⁻⁴ psi/psi | Budenburg 380 Deadweight Tester |



Mass and Mass Related

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|--|---|---|
| Environmental Pressure Gage ¹ | (0 to 100) in H ₂ O | 0.017 in H ₂ O | Pressure Module |
| Durometers ¹ | Up to 100 duro | 0.35 duro | Direct Verification per ASTM D2240 Durometer Calibrator |
| Spring Force | (0.1 to 45) N | 0.05 N | Triple Beam Balance, Video Measuring Machine |
| Indenter Angle | (20 to 40) ° | 0.07 ° | |
| Indenter Radius | (0.05 to 0.1) in | 340 μin | |
| Indenter Length | (0.049 to 0.198) in | 330 μin | Gage Blocks |
| Brinell Hardness Testers ¹ Verification of Test Force | (500, 750, 1 500, 2 000, 3 000) kgf | 7.2 Kgf | Direct Verification per ASTM E10 using Morehouse Proving Ring |
| Verification of Indenter Mean Diameter | 10 mm 5 mm | 0.002 mm 0.002 mm | |
| Brinell Hardness Testers ¹ | (1 to 7) mm | 0.03 mm | Indirect Verification per ASTM E10 using Brinell Test Blocks & Brinell Scope |
| Knoop and Vickers Hardness Testers ¹ | (1 to 200) μm | 0.25 μm | Indirect Verification per ASTM E384 using Knoop & Vickers Test Blocks |
| | (1 to 200) μm | 0.17 μm | |
| Leeb Hardness Tester ¹ | 550 LD, 836 LD | 20 LD | Indirect Verification per ASTM A596 using Leeb Test Block |
| Rockwell Hardness Testers ¹ | HRBW Low | 1.2 HRA | Indirect Verification per ASTM E18 using Rockwell Test Blocks |
| | HRBW Med | 1.2 HRA | |
| | HRBW High | 0.75 HRA | |
| | HRC Low | 1.4 HRBW | |
| | HRC Med | 1.4 HRBW | |
| | HRC High | 1.3 HRBW | |
| | HRA Low | 1.2 HRC | |
| | HRA Med | 1.2 HRC | |
| | HRA High | 0.7 HRC | |



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|--|-----------------------|-------------------|---|
| Rockwell Hardness Testers ¹ | HRE Low | 1.3 HRE | Indirect Verification per ASTM E18 using Rockwell Test Blocks |
| | HRE Med | 1.4 HRE | |
| | HRE High | 1.4 HRE | |
| | HRF Low | 1.4 HRF | |
| | HRF Med | 1.4 HRF | |
| | HRF High | 1.4 HRF | |
| | HRH Low | 1.4 HRH | |
| | HRH Med | 1.4 HRH | |
| | HRH High | 1.4 HRH | |
| | HRKW Low | 1.4 HRKW | |
| | HRKW Med | 1.3 HRKW | |
| | HRKW High | 1.3 HRKW | |
| | HRMW Low | 1.4 HRMW | |
| | HRMW Med | 1.4 HRMW | |
| | HRMW High | 1.3 HRMW | |
| | HR15N Low | 1.5 HR15N | |
| | HR15N Med | 1.3 HR15N | |
| | HR15N High | 0.9 HR15N | |
| | HR30N Low | 1.3 HR30N | |
| | HR30N Med | 1.3 HR30N | |
| | HR30N High | 0.9 HR30N | |
| | HR45N Low | 1.4 HR45N | |
| | HR45N Med | 1.3 HR45N | |
| | HR45N High | 0.95 HR45N | |
| HR15TW Low | 2 HR15TW | | |
| HR15TW Med | 1.4 HR15TW | | |
| HR15TW High | 1.5 HR15TW | | |
| HR30TW Low | 2 HR30TW | | |
| HR30TW Med | 1.5 HR30TW | | |
| HR30T High | 1.3 HR30TW | | |
| HR45TW Low | 2.0 HR45TW | | |
| HR45TW Med | 1.3 HR45TW | | |
| HR45TW High | 1.4 HR45TW | | |
| Force ¹ | (0.001 to 200) lb | 0.05 % of reading | Dead Weight |
| | (200 to 10 000) lb | 0.07 % of reading | Load Cell |
| | (10 000 to 50 000) lb | 0.1 % of reading | Load Cell |



Mass and Mass Related

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|--|--|
| Force | 1 g to 500 lb (500 to 1 000) lb (1 000 to 10 000) lb (10 000 to 100 000) lb | 0.05 % reading 0.03 % reading 0.03 % reading 0.04 % reading | Dead Weight, Proving Ring |
| Wedge Tester ¹ | (0 to 40 000) N | 32 N | Load Cell |
| Torque Transducers ¹ | (0.001 to 250) lbf-ft (250 to 2 000) lbf-ft | 0.05 % of reading 0.06 % of reading | Torque Arms, Dead Weight |
| Torque Tools ¹ | (10 to 200) ozf-in 4 lbf-in to 2 000 lbf-ft | 0.5 % of reading 0.3 % of reading | CDI Torque System |
| Viscosity Rotational Viscometers | 500 cP 5 000 cP | 0.02 cP/cP | Viscosity Solutions, Temperature Bath |
| Viscosity Cups | 17.82 cP 65.28 cP 231 cP | 0.03 cP/cP | Viscosity Solutions, Temperature Bath, Stopwatch ASTM D4212 |
| Pipettes | (100 to 200) µL (200 to 1 000) µL (1 000 to 5 000) µL (5 000 to 10 000) µL | 0.6 µL 0.7 µL 1.9 µL 3.6 µL | Analytical Balance ISO 8655-6 |
| Graduated Cylinder | (1 to 200) mL (200 to 6 000) mL (6 000 to 34 000) mL | 0.003 mL 0.46 mL 2.8 mL | Balances |
| Foundry Sand Test Equipment / Measurement ¹ Ultrasonic Cleaner/Scrubber | 18 °F 30 min | 1.7 °F 1.2 sec | Temperature Calibrator Stopwatch |
| Wet Tensile Tester | 0.449 N/cm ² (300 to 320) °F | 0.003 1 N/cm ² 2 °F | Dead Weight Temperature Calibrator |
| Sand Squeezer | (0 to 200) psi | 3.8 psi | Proving Ring |
| Tensile Testers | (0 to 10 000) lb | 7.2 lb | Load Cell |



Mass and Mass Related

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|-----------------------------------|---|---|
| Foundry Sand Test Equipment / Measurement ¹ | | | |
| AFS Clay Tester | (0 to 10) min | 1.2 s | Stopwatch |
| Friability Tester | 60 s | 1.2 s | Stopwatch |
| Sand Rammer | (0 to 2) in | 0.01 in | Impact Rings |
| Moisture Teller | (0 to 300 °F) | 1.9 °F | Temperature Calibrator |
| Permmeter | (0 to 500) perm | 0.43 perm | Perm Standards |
| Sand Strength Tester | (0 to 500) psi (0 to 1 000) lb | 1.1 psi 4.2 lb | Proving Ring |
| Core Scratch Tester | (0 to 0.1) in | 0.006 in | Flatness Block |
| Green Sand Hardness Tester (B&C) | (0 to 0.1) in | 0.006 in | Flatness Block |

Photometry and Radiometry

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|-------------------|---|---|
| Optical Power - Measure ¹ (800 to 1 650) nm | (-70 to +20) dBm | 0.03 dB/dBm | Agilent 81533B Interface, 81525A Optical Head |
| Optical Power - Source ¹ (820, 1 310, 1 550) nm | (-60 to 0) dB | 0.05 dB/dB | Agilent 81554SM Laser Source Module, 81533B Interface, 81525A Optical Head, 81655A Laser Module, 81570A Optical Attenuator, and 81578A Optical Attenuator |
| Optical Attenuation - Source ¹ (700 to 1 650) nm | (-60 to 0) dB | 0.04 dB/dB | Agilent 81570A and 81578A Optical Attenuators |
| Optical Wavelength - Measure ¹ | (700 to 1 650) nm | 0.05 nm | Agilent 86120B Multi-Wavelength Meter |



Photometry and Radiometry

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|-------------------------------|---------------|---|---|
| Gloss Meters 20°, 60°, 85° | (0 to 100) GU | 0.73 GU | Standard Gloss Tiles |

Thermodynamic

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|--------------------------------|---|---|
| Temperature - Source | (-30 to 600) °C | 0.03 °C | Hart Scientific 9011 Drywell with PRT |
| Immersion Probes ¹ | (-95 to 140) °C | 0.03 °C | Fluke 9190A Drywell with PRT |
| Infrared ¹ | (122 to 932) °F | 0.9 °F | Hart Scientific 9132 Blackbody $\lambda = (8 \text{ to } 14) \mu\text{m}, \epsilon = 0.95$ |
| Surface Probes ¹ | (35 to 400) °C | 1.3 °C | Hart Scientific 2200 Temperature Controller |
| Temperature - Measure ¹ | (-30 to 600) °C | 0.03 °C | Hart Scientific 1502 Indicator with PRT |
| Thermo-Hygrometers Temperature Humidity | (0 to 70) °C (10 to 98) %RH | 0.2 °C 0.9 %RH | Thunder Scientific 2500 Humidity Chamber |
| System Accuracy Test ¹ (SAT) | (0 to 2 200) °F | 2.6 °F | Certified Thermocouple |
| Temperature Uniformity Survey ¹ (TUS) | (0 to 2 200) °F | 4.9 °F | MV 1000 Data Logger or Equivalent |
| Calibration of Thermocouples and Thermocouple Wire ¹ | | | |
| Type E | (100 to 1 600) °F | 2.9 °F | Martel M3001 Multifunction Calibrator, AMS2750D |
| Type J | (100 to 1 400) °F | 2.9 °F | |
| Type K | (100 to 2 200) °F | 2.9 °F | |
| Type N | (100 to 2 200) °F | 2.9 °F | |
| Type R | (100 to 2 200) °F | 3.4 °F | |
| Type S | (100 to 2 200) °F | 3.4 °F | |
| Type C | (100 to 2 200) °F | 3 °F | |
| Type B | (1 112 to 2 200) °F | 3.4 °F | |



Time and Frequency

| Parameter / Equipment | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|---|---|---|
| Time Interval ¹ | (1 to 86 400) s | 0.000 45 s | Agilent 53132A Counter & Spectracom 8197B GPS Oscillator |
| Frequency - Measure ¹ | 0.1 Hz to 225 MHz | 2.4 parts in 10 ⁻¹¹ Hz | Agilent 53132A Counter & Spectracom 8197B GPS Oscillator |
| Frequency - Measure ¹ | 0.1 Hz to 26.5 GHz | 2.4 parts in 10 ⁻¹¹ Hz | Agilent N5531S Measuring Receiver, SRS FS725 Frequency Standard |
| Frequency - Source ¹ | 10 MHz | 2.4 parts in 10 ⁻¹¹ Hz | Spectracom 8197B GPS Oscillator |
| Frequency - Source ¹ | 0.1 mHz to 40 GHz | 2.4 parts in 10 ⁻¹¹ Hz | Agilent 3325B Function Generator, Agilent E8257D Signal Generator, SRS FS725 Frequency Standard |
| Tachometers ¹ Contact Non-Contact | (1 to 6 500) rpm (500 to 40 000) rpm | 0.08 % of reading | King Nutronics 3711-B Tachometer Test Set |
| Tachometers ¹ Non-Contact | (0.01 to 100 000) rpm | 0.005 % of reading | Fluke 5520A Multiproduct Calibrator |

DIMENSIONAL MEASUREMENT

Dimensional 2D

| Specific Tests and / or Properties Measured | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|---|-----------------------------|---|---|
| Linear | (0 to 8) in (0 to 20) in | (210 + 1.5L) μin 0.000 9 in | Video Measuring Machine |
| Surface Finish (Ra) | (0.01 to 300) μin | 2.1 μin | Profilometer |

Dimensional 3D

| Specific Tests and / or Properties Measured | Range | Expanded Uncertainty of Measurement (+/-) | Reference Standard, Method and/or Equipment |
|--|--|---|---|
| Dimensional Inspection Volumetric Linear | Up to (28 x 40 x 24) in Up to (28 x 40 x 24) in | 320 μ in (38 + 5.2L) μ in | CMM CMM |

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, D = diameter in inches, DL = diagonal length in inches
3. Where ranges overlap, the uncertainty associated with the higher range begins above the overlapping value
4. RF/Microwave uncertainties do not include inaccuracies due to sensor mismatch
5. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1272.



Vice President

