



# CERTIFICATE OF ACCREDITATION

## The ANSI National Accreditation Board

Hereby attests that

**McHale & Associates, Inc.**  
**4700 Coster Road**  
**Knoxville, TN 37912**

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).

A handwritten signature in black ink, appearing to read 'R. Douglas Leonard Jr.', is positioned above a horizontal line.

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 17 September 2024

Certificate Number: AC-2909



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**

**McHale & Associates, Inc.**

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**CALIBRATION**

Valid to: **September 17, 2024**

Certificate Number: **AC-2909**

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source <sup>1</sup>	Up to 330 mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1 000) V	0.016 $\mu$ V/mV + 1.2 $\mu$ V 0.021 mV/V + 4.4 $\mu$ V 0.009 4 mV/V + 0.06 mV 0.014 mV/V + 0.7 mV 0.014 mV/V + 2.6 mV	Multi-Product Calibrator
DC Voltage - Measure <sup>1</sup>	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1 000) V	0.006 $\mu$ V/mV + 0.2 $\mu$ V 0.0029 mV/V + 0.3 $\mu$ V 0.0029 mV/V + 0.5 $\mu$ V 0.0043 mV/V + 0.03 mV 0.0046 mV/V + 0.5 mV	Reference Multimeter
DC High Voltage - Measure <sup>1</sup>	Up to 10 kV	30 mV/V + 0.07 V	Precision HV Meter
DC Current – Source <sup>1</sup>	Up to 330 $\mu$ A (0.33 to 3.3) mA (3.3 to 33) mA (33 to 330) mA (0.33 to 1.1) A (1.1 to 3) A (3 to 11) A (11 to 20.5) A	0.12 nA/ $\mu$ A + 0.02 $\mu$ A 0.078 $\mu$ A/mA + 0.05 $\mu$ A 0.078 $\mu$ A/mA + 0.4 $\mu$ A 0.078 $\mu$ A/mA + 4.1 $\mu$ A 0.16 mA/A + 0.05 mA 0.29 mA/A + 0.1 mA 0.39 mA/A + 0.7 mA 0.78 mA/A + 2.4 mA	Multi-Product Calibrator
DC Current – Source <sup>1</sup>	(10 to 16.5) A (16.5 to 150) A (150 to 1 025) A	11 mA/A + 2.5 mA 2.5 mA/A + 0.02 A 2.6 mA/A + 0.2 A	Multi-Product Calibrator with 50-turn Coil

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current - Measure <sup>1</sup>	Up to 10 $\mu$ A (10 to 100) $\mu$ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A (1 to 10) A (10 to 30) A	0.027 nA/ $\mu$ A + 0.4 nA 0.0094 nA/ $\mu$ A + 0.4 nA 0.0085 $\mu$ A/mA + 4.0 nA 0.04 $\mu$ A/mA + 0.04 $\mu$ A 0.067 $\mu$ A/mA + 1.0 $\mu$ A 0.26 mA/A + 0.1 mA 0.18 mA/A + 0.4 mA 0.51 mA/A + 4.4 mA	Reference Multimeter
Resistance – Source <sup>1</sup>	Up to 11 $\Omega$ (11 to 33) $\Omega$ (33 to 110) $\Omega$ (110 to 330) $\Omega$ (0.33 to 1.1) k $\Omega$ (1.1 to 3.3) k $\Omega$ (3.3 to 11) k $\Omega$ (11 to 33) k $\Omega$ (33 to 110) k $\Omega$ (110 to 330) k $\Omega$ (0.33 to 1.1) M $\Omega$ (1.1 to 3.3) M $\Omega$ (3.3 to 11) M $\Omega$ (11 to 33) M $\Omega$ (33 to 110) M $\Omega$ (110 to 330) M $\Omega$ (330 to 1 100) M $\Omega$	0.032 m $\Omega$ / $\Omega$ + 0.8 m $\Omega$ 0.024 m $\Omega$ / $\Omega$ + 1.2 m $\Omega$ 0.022 m $\Omega$ / $\Omega$ + 1.2 m $\Omega$ 0.022 m $\Omega$ / $\Omega$ + 1.9 m $\Omega$ 0.022 $\Omega$ /k $\Omega$ + 4.6 m $\Omega$ 0.023 $\Omega$ /k $\Omega$ + 0.02 $\Omega$ 0.022 $\Omega$ /k $\Omega$ + 0.04 $\Omega$ 0.022 $\Omega$ /k $\Omega$ + 0.2 $\Omega$ 0.022 $\Omega$ /k $\Omega$ + 0.4 $\Omega$ 0.025 $\Omega$ /k $\Omega$ + 2.4 $\Omega$ 0.025 k $\Omega$ /M $\Omega$ + 4.9 $\Omega$ 0.05 k $\Omega$ /M $\Omega$ + 0.03 k $\Omega$ 0.1 k $\Omega$ /M $\Omega$ + 0.1 k $\Omega$ 0.19 k $\Omega$ /M $\Omega$ + 3.0 k $\Omega$ 0.39 k $\Omega$ /M $\Omega$ + 0.1 M $\Omega$ 2.3 k $\Omega$ /M $\Omega$ + 0.1 M $\Omega$ 12 k $\Omega$ /M $\Omega$ + 0.8 M $\Omega$	Multi-Product Calibrator
AC Voltage – Source <sup>1</sup>	(1 to 33) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (33 to 330) mV (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.62 $\mu$ V/mV + 5.4 $\mu$ V 0.12 $\mu$ V/mV + 5.5 $\mu$ V 0.16 $\mu$ V/mV + 5 $\mu$ V 0.78 $\mu$ V/mV + 5.5 $\mu$ V 2.7 $\mu$ V/mV + 0.01 mV 6.2 $\mu$ V/mV + 0.04 mV 0.23 $\mu$ V/mV + 6.2 $\mu$ V 0.11 $\mu$ V/mV + 6.2 $\mu$ V 0.12 $\mu$ V/mV + 0.01 mV 0.27 $\mu$ V/mV + 0.01 mV 0.62 $\mu$ V/mV + 0.03 mV 1.6 $\mu$ V/mV + 0.09 mV	Multi-Product Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1</sup>	(0.33 to 3.3) V (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz (3.3 to 33) V (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (33 to 330) V (10 to 45) Hz 45 Hz to 10 kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (330 to 1 020) V 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.23 mV/V + 0.2 mV 0.12 mV/V + 0.2 mV 0.15 mV/V + 0.07 mV 0.23 mV/V + 0.1 mV 0.54 mV/V + 0.2 mV 1.9 mV/V + 1 mV 0.23 mV/V + 1.8 mV 0.12 mV/V + 2.2 mV 0.19 mV/V + 0.9 mV 0.27 mV/V + 1.2 mV 0.7 mV/V + 1.9 mV 0.15 mV/V + 7.4 mV 0.16 mV/V + 0.02 V 0.19 mV/V + 0.01 V 0.23 mV/V + 0.02 V 1.6 mV/V + 0.08 V 0.23 mV/V + 0.03 V 0.19 mV/V + 0.03 V 0.23 mV/V + 0.04 V	Multi-Product Calibrator
AC Voltage - Measure <sup>1</sup>	Up to 10 mV 1 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 (10 to 100) mV 1 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 (1 to 2) MHz (2 to 4) MHz (4 to 8) MHz (8 to 10) MHz	0.28 μV/mV + 1.1 μV 0.36 μV/mV + 1.1 μV 0.39 μV/mV + 1.1 μV 3 μV/mV + 1.1 μV 10 μV/mV + 4 μV 20 μV/mV + 4 μV 0.075 μV/mV + 0.5 μV 0.12 μV/mV + 0.5 μV 0.21 μV/mV + 1 μV 0.51 μV/mV + 5 μV 2 μV/mV + 0.03 mV 10 μV/mV + 0.1 mV 15 μV/mV + 0.5 mV 40 μV/mV + 1 mV 80 μV/mV + 1 mV 151 μV/mV + 1 mV	Reference Multimeter

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure <sup>1</sup>	(0.1 to 1) V		Reference Multimeter
	1 Hz to 2 kHz	0.67 mV/V + 5 μV	
	(2 to 10) kHz	0.11 mV/V + 5 μV	
	(10 to 30) kHz	0.21 mV/V + 0.01 mV	
	(30 to 100) kHz	0.51 mV/V + 0.05 mV	
	(100 to 300) kHz	2 mV/V + 0.3 mV	
	300 kHz to 1 MHz	10 mV/V + 1 mV	
	(1 to 2) MHz	16 mV/V + 5 mV	
	(2 to 4) MHz	40 mV/V + 0.01 V	
	(4 to 8) MHz	81 mV/V + 0.01 V	
	(8 to 10) MHz	151 mV/V + 0.01 V	
	(1 to 10) V		
	1 Hz to 2 kHz	0.066 mV/V + 0.05 mV	
	(2 to 10) kHz	0.11 mV/V + 0.05 mV	
	(10 to 30) kHz	0.21 mV/V + 0.1 mV	
	(30 to 100) kHz	0.54 mV/V + 0.5 mV	
	(100 to 300) kHz	2 mV/V + 3.0 mV	
	300 kHz to 1 MHz	10 mV/V + 0.01 V	
	(1 to 2) MHz	15 mV/V + 0.05 V	
	(2 to 4) MHz	40 mV/V + 0.1 V	
(4 to 8) MHz	80 mV/V + 0.1 V		
(8 to 10) MHz	150 mV/V + 0.1 V		
(10 to 100) V	1 Hz to 2 kHz	0.073 mV/V + 0.5 mV	
	(2 to 10) kHz	0.093 mV/V + 0.5 mV	
	(10 to 30) kHz	0.21 mV/V + 1 mV	
	(30 to 100) kHz	0.51 mV/V + 5 mV	
	(100 to 300) kHz	3.5 mV/V + 0.05 V	
	300 kHz to 1 MHz	10 mV/V + 0.5 V	
AC Voltage - Measure <sup>1</sup>	(100 to 1 000)V		Reference Multimeter
	1 Hz to 2 kHz	0.092 mV/V + 0.03 V	
	(2 to 10) kHz	0.10 mV/V + 0.03 V	
	(10 to 30) kHz	0.22 mV/V + 0.03 V	
	(30 to 100) kHz	0.52 mV/V + 0.1 V	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC High Voltage - Measure <sup>1</sup>	Up to 10 kV		Precision HV Meter
	(30 to 600) Hz		
	30 Hz to 200 Hz	120 mV/V + 0.2 V	
	200 Hz to 450 Hz	400 mV/V + 0.2 V	
	450 Hz to 600 Hz	750 mV/V + 0.2 V	
	(10 to 150) Hz		
	10 Hz to 65 Hz	120 mV/V + 0.2 V	
	65 Hz to 150 Hz	400 mV/V + 0.2 V	
	(1 to 75) Hz		
	1 Hz to 35 Hz	120 mV/V + 0.2 V	
	35 Hz to 75 Hz	400 mV/V + 0.2 V	
	(0.1 to 35) Hz		
	0.1 Hz to 15 Hz	120 mV/V + 0.2 V	
	15 Hz to 35 Hz	400 mV/V + 0.2 V	
(0.01 to 2) Hz			
0.01 Hz to 1 Hz	120 mV/V + 0.2 V		
(1 to 2) Hz	400 mV/V + 0.2 V		
AC Current – Source <sup>1</sup>	Up to 330 $\mu$ A		Multi-Product Calibrator
	(10 to 20) Hz	1.6 nA/ $\mu$ A + 0.08 $\mu$ A	
	(20 to 45) Hz	1.2 nA/ $\mu$ A + 0.08 $\mu$ A	
	45 Hz to 1 kHz	0.97 nA/ $\mu$ A + 0.1 $\mu$ A	
	(1 to 5) kHz	2.3 nA/ $\mu$ A + 0.2 $\mu$ A	
	(5 to 10) kHz	6.2 nA/ $\mu$ A + 0.2 $\mu$ A	
	(10 to 30) kHz	12 nA/ $\mu$ A + 0.3 $\mu$ A	
	(0.33 to 3.3) mA		
	(10 to 20) Hz	1.6 $\mu$ A/mA + 0.2 $\mu$ A	
	(20 to 45) Hz	0.97 $\mu$ A/mA + 0.2 $\mu$ A	
	45 Hz to 1 kHz	0.78 $\mu$ A/mA + 0.2 $\mu$ A	
	(1 to 5) kHz	1.6 $\mu$ A/mA + 0.7 $\mu$ A	
	(5 to 10) kHz	3.9 $\mu$ A/mA + 0.3 $\mu$ A	
	(10 to 30) kHz	7.8 $\mu$ A/mA + 1.1 $\mu$ A	
	(3.3 to 33) mA		
	(10 to 20) Hz	1.4 $\mu$ A/mA + 4.5 $\mu$ A	
	(20 to 45) Hz	0.7 $\mu$ A/mA + 2.7 $\mu$ A	
	45 Hz to 1 kHz	0.31 $\mu$ A/mA + 7 $\mu$ A	
	(1 to 5) kHz	0.62 $\mu$ A/mA + 7 $\mu$ A	
	(5 to 10) kHz	1.6 $\mu$ A/mA + 3.9 $\mu$ A	
(10 to 30) kHz	3.1 $\mu$ A/mA + 9.1 $\mu$ A		

**Electrical – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Current – Source <sup>1</sup>	(33 to 330) mA (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10 kHz (10 to 30) kHz	1.4 $\mu$ A/mA + 0.05 mA 0.7 $\mu$ A/mA + 0.03 mA 0.31 $\mu$ A/mA + 0.06 mA 0.78 $\mu$ A/mA + 0.07 mA 1.6 $\mu$ A/mA + 0.2 mA 3.1 $\mu$ A/mA + 0.2 mA	Multi-Product Calibrator
AC Current – Source <sup>1</sup>	(0.33 to 1.1) A (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (1.1 to 3) A (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (3 to 11) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz (11 to 20.5) A (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	1.4 mA/A + 0.1 mA 0.39 mA/A + 0.1 mA 4.7 mA/A + 0.9 mA 19 mA/A + 4 mA 1.4 mA/A + 0.2 mA 0.47 mA/A + 0.2 mA 4.7 mA/A + 1.1 mA 19 mA/A + 4.3 mA 0.47 mA/A + 1.9 mA 0.78 mA/A + 2.1 mA 23 mA/A + 7.3 mA 0.93 mA/A + 4.7 mA 1.2 mA/A + 5.2 mA 23 mA/A + 0.02 A	Multi-Product Calibrator
AC Current – Source <sup>1</sup>	(10 to 16.5) A (45 to 65) Hz (65 to 440) Hz (16.5 to 150) A (45 to 65) Hz (65 to 440) Hz (150 to 1 025) A (45 to 65) Hz (65 to 440) Hz	2.8 mA/A + 3.3 mA 2.8 mA/A + 25 mA 2.8 mA/A + 0.09 A 7.9 mA/A + 6.4 mA 8 mA/A + 0.2 A 8 mA/A + 0.3 A	Multi-Product Calibrator with 50-turn Coil

**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 10 $\mu$ A 1 Hz to 30 kHz (10 to 100) $\mu$ A 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (0.1 to 1) mA 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (1 to 10) mA 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (10 to 100) mA 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (0.1 to 1) A 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (1 to 10) A 10 Hz to 10 kHz (10 to 30) A 10 Hz to 2 kHz (2 to 10) kHz	2 nA/ $\mu$ A + 2.5 nA  0.27 nA/ $\mu$ A + 5 nA 0.51 nA/ $\mu$ A + 5 nA 0.73 nA/ $\mu$ A + 5 nA 4 nA/ $\mu$ A + 0.01 $\mu$ A  0.27 $\mu$ A/mA + 0.05 $\mu$ A 0.51 $\mu$ A/mA + 0.05 $\mu$ A 0.72 $\mu$ A/mA + 0.05 $\mu$ A 4 $\mu$ A/mA + 0.1 $\mu$ A  0.27 $\mu$ A/mA + 0.5 $\mu$ A 0.51 $\mu$ A/mA + 0.5 $\mu$ A 0.72 $\mu$ A/mA + 0.5 $\mu$ A 4 $\mu$ A/mA + 1 $\mu$ A  0.27 $\mu$ A/mA + 5 $\mu$ A 0.5 $\mu$ A/mA + 5 $\mu$ A 0.7 $\mu$ A/mA + 5 $\mu$ A  0.27 mA/A + 0.1 mA 0.51 mA/A + 0.1 mA 0.73 mA/A + 0.1 mA  0.8 mA/A + 0.5 mA  0.8 mA/A + 0.012 A 1.2 mA/A + 0.012 A	Reference Multimeter
Resistance - Measure <sup>1</sup>	Up to 1 $\Omega$ (1 to 10) $\Omega$ (10 to 100) $\Omega$ (0.1 to 1) k $\Omega$ (1 to 10) k $\Omega$ (10 to 100) k $\Omega$ (0.1 to 1) M $\Omega$ (1 to 10) M $\Omega$ (10 to 100) M $\Omega$ (0.1 to 1) G $\Omega$	0.011 m $\Omega$ / $\Omega$ + 4 $\mu\Omega$ 0.0082 m $\Omega$ / $\Omega$ + 0.01 m $\Omega$ 0.0074 m $\Omega$ / $\Omega$ + 0.05 m $\Omega$ 0.0072 $\Omega$ /k $\Omega$ + 0.5 m $\Omega$ 0.0077 $\Omega$ /k $\Omega$ + 5.0 m $\Omega$ 0.0075 $\Omega$ /k $\Omega$ + 0.05 $\Omega$ 0.0093 k $\Omega$ /M $\Omega$ + 1.0 $\Omega$ 0.012 k $\Omega$ /M $\Omega$ + 0.1 k $\Omega$ 0.044 k $\Omega$ /M $\Omega$ + 0.01 M $\Omega$ 0.51 M $\Omega$ /G $\Omega$ + 1.0 M $\Omega$	Reference Multimeter



**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source <sup>1</sup>	(0.19 to 0.4) nF (0.4 to 1.1) nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF 330 μF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	4.6 pF/nF + 8.4 pF 4 pF/nF + 8.4 pF 3.9 pF/nF + 8.1 pF 1.9 pF/nF + 0.01 nF 1.9 pF/nF + 7.9 pF 1.9 pF/nF + 0.07 nF 1.9 pF/nF + 0.2 nF 1.9 nF/μF + 0.01 μF 1.9 nF/μF + 0.03 μF 1.9 nF/μF + 0.01 μF 3.1 nF/μF + 0.03 μF 3.5 nF/μF + 0.2 μF 3.5 nF/μF + 0.3 μF 3.5 μF/mF + 0.9 μF 3.5 μF/mF + 2.5 μF 3.5 μF/mF + 8.4 μF 5.8 μF/mF + 0.03 mF 8.5 μF/mF + 0.09 mF	Multi-Product Calibrator
Capacitance - Measure <sup>1</sup>	Up to 1 nF (1 to 10) nF (10 to 100) nF (0.1 to 1) μF (1 to 10) μF (10 to 100) μF (0.1 to 1) mF (1 to 10) mF (10 to 100) mF	1.1 pF/nF + 1.0 pF 0.64 pF/nF + 2 pF 0.42 pF/nF + 0.01 nF 0.41 nF/μF + 0.1 nF 0.42 nF/μF + 1 nF 0.61 nF/μF + 0.01 μF 0.61 μF/mF + 0.1 μF 0.71 μF/mF + 1 μF 0.71 μF/mF + 0.01 mF	Reference Multimeter
Electrical Simulation of Thermocouple Indicating Instruments – Source <sup>1</sup>	Type B (600 to 800) °C (800 to 1 000) °C (1 000 to 1 550) °C (1 550 to 1 820) °C Type C (0 to 150) °C (150 to 650) °C (650 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 316) °C	0.35 °C 0.27 °C 0.24 °C 0.26 °C 0.24 °C 0.21 °C 0.25 °C 0.39 °C 0.65 °C	Multi-Product Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Instruments – Source <sup>1</sup>	Type E		Multi-Product Calibrator
	(-250 to -100) °C	0.39 °C	
	(-100 to -25) °C	0.14 °C	
	(-25 to 350) °C	0.13 °C	
	(350 to 650) °C	0.14 °C	
	(650 to 1 000) °C	0.18 °C	
	Type J		
	(-210 to -100) °C	0.22 °C	
	(-100 to -30) °C	0.14 °C	
	(-30 to 150) °C	0.12 °C	
	(150 to 760) °C	0.15 °C	
	(760 to 1 200) °C	0.19 °C	
	Type K		
	(-200 to -100) °C	0.26 °C	
	(-100 to -25) °C	0.15 °C	
	(-25 to 120) °C	0.14 °C	
	(120 to 1 000) °C	0.21 °C	
	(1 000 to 1 372) °C	0.32 °C	
	Type L		
	(-200 to -100) °C	0.29 °C	
	(-100 to 800) °C	0.21 °C	
	(800 to 900) °C	0.15 °C	
	Type N		
	(-200 to -100) °C	0.32 °C	
(-100 to -25) °C	0.18 °C		
(-25 to 120) °C	0.16 °C		
(120 to 410) °C	0.15 °C		
(410 to 1 300) °C	0.22 °C		
Type R			
(0 to 250) °C	0.45 °C		
(250 to 400) °C	0.28 °C		
(400 to 1 000) °C	0.26 °C		
(1 000 to 1 767) °C	0.32 °C		
Type S			
(0 to 200) °C	0.37 °C		
(250 to 1 400) °C	0.29 °C		
(1 400 to 1 767) °C	0.36 °C		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Instruments – Source <sup>1</sup>	Type T (-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C Type U (-200 to 0) °C (0 to 600) °C	0.49 °C 0.20 °C 0.14 °C 0.13 °C 0.44 °C 0.22 °C	Multi-Product Calibrator
Electrical Simulation of RTD Indicating Instruments – Source <sup>1</sup>	Pt 385 100 Ω (-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °C Pt 3926 100 Ω (-200 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (400 to 630) °C Pt 3916 100 Ω (-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C Pt 3916 300 Ω (0 to 400) °C Pt 3916 400 Ω (0 to 600) °C Pt 3916 600 Ω (600 to 630) °C Pt 385 200 Ω (-200 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.039 °C 0.054 °C 0.07 °C 0.078 °C 0.093 °C 0.18 °C 0.039 °C 0.054 °C 0.07 °C 0.078 °C 0.093 °C 0.19 °C 0.031 °C 0.039 °C 0.047 °C 0.054 °C 0.062 °C 0.07 °C 0.078 °C 0.18 °C 0.031 °C 0.39 °C 0.93 °C 0.10 °C 0.11 °C 0.12 °C	Multi-Product Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Instruments – Source <sup>1</sup>	Pt 385 500 Ω		Multi-Product Calibrator
	(-200 to -80) °C	0.032 °C	
	(-80 to 100) °C	0.039 °C	
	(100 to 260) °C	0.047 °C	
	(260 to 400) °C	0.062 °C	
	(400 to 600) °C	0.07 °C	
	(600 to 630) °C	0.086 °C	
	Pt 385 1 000 Ω		
	(-200 to 0) °C	0.026 °C	
	(0 to 100) °C	0.033 °C	
	(100 to 260) °C	0.04 °C	
	(260 to 300) °C	0.048 °C	
	(300 to 600) °C	0.056 °C	
(600 to 630) °C	0.18 °C		
PtNi 385 120 Ω			
(-80 to 100) °C	0.062 °C		
(100 to 260) °C	0.11 °C		
Cu 427 10 Ω			
(-100 to 260) °C	0.23 °C		
AC Voltage Harmonics – Source <sup>1</sup>	(0.01 to 5) V		Multi-Product Calibrator
	(10 to 45) Hz	0.78 mV/V + 1 mV	
	(45 to 65) kHz	0.7 mV/V + 0.9 mV	
	(0.1 to 5) V		
	(65 to 500) kHz	0.7 mV/V + 0.9 mV	
	500 Hz to 5 kHz	1.6 mV/V + 2.5 mV	
(5 to 10) kHz	3.1 mV/V + 3.2 mV		
(0.1 to 3.3) V			
(10 to 30) kHz	39 mV/V + 4.3 mV		
AC Current Harmonics – Source <sup>1</sup>	(33 to 330) mA		Multi-product Calibrator
	(5 to 10) kHz	1.6 μA/mA + 0.2 mA	
	(10 to 30) kHz	3.1 μA/mA + 0.3 mA	
	3.3 mA to 3 A		
	(10 to 45) Hz	1.4 mA/A + 0.3 mA	
	3.3 mA to 20.5 A		
(45 to 65) Hz	0.93 mA/A + 8.2 mA		
33 mA to 20.5 A			
(65 to 500) Hz	1.2 mA/A + 8.2 mA		
500 Hz to 5 kHz	23 mA/A + 0.02 A		
DC Power Source <sup>1</sup>	33mV to 1 020 V		Multi-Product Calibrator
	(0.33 to 330) mA	0.014 mW/W + 0.06 W	
	330 mA to 3 A	0.29 mW/W + 0.6 W	
	(3 to 20.5) A	0.78 mW/W + 5.8 W	

**Electrical – DC/Low Frequency**

<b>Parameter/Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
AC Power- Source <sup>1</sup>	(33 to 330) mV (3.3 to 33) mA (33 to 330) mA (330 to 900) mA 900 mA to 2.2 A (2.2 to 4.5) A (4.5 to 20.5) A 330 mV to 1 020 V (3.3 to 9) mA (9 to 90) mA (90 to 330) mA (330 to 900) mA 900 mA to 4.5 A (4.5 to 20.5) A	0.000 33 mW/W + 6.5 μW 0.000 33 mW/W + 0.02 mW 0.39 mW/W + 0.1 mW 0.47 mW/W + 0.1 mW 0.47 mW/W + 2 mW 0.93 mW/W + 5 mW 0.23 mW/W + 7.8 mW 0.23 mW/W + 9.7 mW 0.23 mW/W + 0.06 W 0.45 mW/W + 0.06 W 0.52 mW/W + 0.6 W 0.96 W/W + 5.8 W	Multi-Product Calibrator
Phase - Source <sup>1</sup>	0 to 360° (10 to 65) Hz (65 to 500) Hz (0.5 to 1) kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.083° 0.19° 0.39° 1.9° 3.9° 7.8°	Multi-Product Calibrator
Oscilloscopes <sup>1</sup>			
DC Voltage (50 Ω)	(1 to 109.99) mV (0.11 to 2.199 9) V (2.2 to 6.6) V	1.9 μV/mV + 0.03 mV 2.0 mV/V + 0.1 mV 2.0 mV/V + 2.1 mV	Multi-Product Calibrator
DC Voltage (1M Ω)	(1 to 24.999) mV (25 to 109.99) mV (0.11 to 2.199 9) V (2.2 to 10.999) V (11 to 130) V	0.46 μV/mV + 0.03 mV 0.39 μV/V + 0.03 mV 0.39 mV/V + 0.1 mV 0.39 mV/V + 0.9 mV 0.39 mV/V + 7.6 mV	
AC Voltage (50 Ω)	(1 to 109.99) mV (0.11 to 2.1999) V (2.2 to 6.6) V	1.9 μV/mV + 0.05 mV 2.2 mV/mV + 0.8 mV 2.0 mV/V + 1.4 mV	
AC Voltage (1MΩ)	(1 to 24.999) mV (25 to 109.99) mV (0.11 to 2.199 9) V (2.2 to 10.999) V (11 to 130) V	0.81 μV/mV + 0.05 mV 0.78 μV/V + 0.4 mV 0.82 mV/V + 1.4 mV 0.78 mV/V + 0.01 V 0.79 mV/V + 0.2 V	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes 1 Leveled Sine Wave – Voltage	(0.005 to 5.5) Vp-p Up to 50 kHz (0.05 to 100) MHz (100 to 300) MHz (300 to 600) MHz (0.005 to 3.5) Vp-p (0.6 to 1.1) GHz	19 mV/V + 0.02 V 28 mV/V + 0.02 V 31 mV/V + 0.01 V 47 mV/V + 0.04 V 54 mV/V + 0.04 V	Multi-Product Calibrator
Time Markers	(1 to 5) ns 10 ns (20 to 50) ns (0.1 to 20) ms (0.05 to 5) s	0.001 9 ps/ns + 0.6 ps 0.001 9 ps/ns + 0.6 ps 0.001 9 ps/ns + 5.8 ps 0.025 μs/ms + 5.8 μs 11 ms/s + 0.02 s	
Wave Generator (50 Ω)	1.8 mVp-p to 2.5 Vp-p	24 mV/V + 1 mV	
Wave Generator (1M Ω)	1.8 mVp-p to 55 Vp-p	23 mV/V + 0.08 mV	
Pulse Generator – Width	(4 to 45) ns (45 to 500) ns	39 ps/ns + 1.6 ns 39 ps/ns + 2.2 ns	
Pulse Generator – Period	200 ns to 20 ms	0.025 μs/ms + 0.6 μs	
Input Impedance Measure	(40 to 60) Ω (0.5 to 1.5) MΩ	0.78 mΩ/Ω + 300 Ω 0.78 kΩ/MΩ + 0.8 kΩ	
Input Capacitance Measurement	(5 to 50) pF	39 fF/pF + 0.6 pF	

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Calipers <sup>1</sup>	Up to 8 in (8 to 24) in (24 to 40) in	74 μin 450 μin 510 μin	Gage Blocks

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Depth Micrometer <sup>1</sup>	Up to 8 in (8 to 12) in (12 to 24) in (24 to 40) in	77 μin 100 μin 450 μin 870 μin	Gage Blocks Surface Plate
Height Gage <sup>1</sup>	Up to 24 in (24 to 40) in	190 μin 310 μin	Gage Blocks Surface Plate
Indicators <sup>1</sup>	Up to 6 in	63 μin	Gage Blocks Surface Plate
Micrometer, OD <sup>1</sup>	Up to 1 in (1 to 6) in (6 to 12) in (12 to 24) in (24 to 40) in	42 μin 62 μin 98 μin 200 μin 310 μin	Gage Blocks
Optical Comparators <sup>1</sup> Linearity Magnification	Up to 12 in 10x to 200x	140 μin 590 μin	Glass Scale, Reticle

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure Measuring Instruments <sup>1</sup>	(0.025 to 64) inH <sub>2</sub> O	0.02 % of reading	Pressurements V1600 Deadweight Tester
	(0.1 to 30) psia (15 to 1 000) psi	0.008 7 % of reading 0.008 3 % of reading	DHI A200Kp, A700Kp, A7Mp Pressure Controller
	9.5 to 500 psi (150 to 5000) psi	0.016 % of reading 0.015 % of reading	Pressurements M2000/3 Deadweight Tester
	(-30 to 30) inH <sub>2</sub> O (-13.5 to 35) psi	0.044 inH <sub>2</sub> O 0.013 psi	Additel ADT760 Pressure Calibrator
	(-13.5 to 300) psi (-12.5 to 1 000) psi	0.057 psi 0.23 psi	Additel ADT761 Pressure Calibrator

### Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure <sup>1</sup>	(-40 to 0) °C	0.0097 °C	Hart 5628 SPRT Hart 1502A Indicator
	(0 to 420) °C	0.026 °C	
	(420 to 660) °C	0.033 °C	
Temperature – Source	(-34.4 to 93) °C	0.017 °C	Hart 5699 SPRT Fluke 8505A Multimeter Hart 1529 Indicator Liquid Bath
Temperature – Source	(50 to 660) °C	0.066 °C	Hart 5699 SPRT Fluke 8505A Multimeter Hart 1529 Indicator Dry Well Calibrator
Thermocouple Probes	(-34.4 to 93) °C	0.47 °C	Hart 5699 SPRT Fluke 8505A Multimeter Hart 1529 Indicator Liquid Bath
	(50 to 660) °C	0.47 °C	Hart 5699 SPRT Fluke 8505A Multimeter Hart 1529 Indicator Dry Well Calibrator
Temperature Uniformity Surveys <sup>1</sup>	(-34.4 to 93) °C	0.24 °C	RTD, IDEAS Data Logging System
	(50 to 660) °C	0.81 °C	Thermocouples, IDEAS Data Logging System

### Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency - Source <sup>1</sup>	120 Hz	0.000 089 mHz/Hz + 3.9 μHz	Multi-Product Calibrator SyncServer 650 Time & Frequency Standard Reference Multimeter
	1.2 kHz	0.000 087 Hz/kHz + 3.9 μHz	
	12 kHz	0.000 087 Hz/kHz + 3.9 μHz	
	120 kHz	0.000 56 Hz/kHz + 3.9 μHz	
	1200 kHz	0.000 52 Hz/kHz + 3.9 μHz	
	2 MHz	0.003 kHz/MHz + 3.9 μHz	
	100 MHz (Scope Out)	0.001 9 kHz/MHz + 0.100 kHz	
Frequency - Source <sup>1</sup>	600 MHz (Scope Out)	0.001 9 kHz/MHz + 5.8 kHz	Multi-Product Calibrator, SyncServer 650 Time & Frequency Standard
	1.1 GHz (Scope Out)	0.001 9 kHz/MHz + 0.06 MHz	



**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency - Measure <sup>1</sup>	10 Hz to 100 MHz	0.000 087 mHz/Hz + 0.03 μHz	Reference Multimeter Time & Frequency Standard

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. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-2909.



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