



# CERTIFICATE OF ACCREDITATION

## The ANSI National Accreditation Board

Hereby attests that

**Advantage Center Co., Ltd.**  
59/494 Moo 6, Frakham Road, T. Kukhot, Lumlookkar,  
Pathumthani 12130 Thailand

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: 21 March 2023

Certificate Number: AC-2662



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

### Advantage Center Co., Ltd.

59/494 Moo 6, Frakham Road, T. Kukhot, Lumlookkar,  
Pathumthani 12130 Thailand

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### CALIBRATION

Valid to: **March 21, 2023**

Certificate Number: **AC-2662**

#### Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Sound Level Meter	1 kHz		
	94 dB 114 dB	0.88 dB 0.88 dB	Sound Calibrator

#### Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> pH Meter	4.00 pH	0.01 pH	Standard pH Solution
	7.00 pH	0.01 pH	
	10.00 pH	0.017 pH	
<sup>1</sup> Conductivity Meter	84 µS/cm	1.2 µS /cm	Standard Conductivity Solution
	1 413 µS/cm	20 µS /cm	
	12.88 mS/cm	0.18 mS/cm	
	111.3 mS/cm	1.6 mS/cm	
<sup>1</sup> Turbidity Meter	15 NTU	0.12 NTU	Standard Turbidity Solution
	50 NTU	0.21 NTU	
	500 NTU	3.1 NTU	
	1 000 NTU	5.1 NTU	
<sup>1</sup> Refractometer	10 % Brix	0.07 % Brix	Standard Sucrose Solution
	20 % Brix	0.08 % Brix	
	30 % Brix	0.096 % Brix	
	50 % Brix	0.12 % Brix	



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**Chemical Quantities**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Refractometer Refractive Index	1.347 83 nD	0.000 21 nD	Standard Sucrose Solution
	1.363 84 nD	0.000 21 nD	
	1.381 13 nD	0.000 21 nD	
	1.420 09 nD	0.000 21 nD	
<sup>1</sup> Total Dissolved Solids (TDS) Meter	1 000 mg/L	31 mg/L	TDS Solution

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> DC Voltage – Source	Up to < 330 mV	48 $\mu$ V/V + 9 $\mu$ V	Fluke 5500A Multiproduct Calibrator
	330 mV to < 3.3 V	40 $\mu$ V/V + 60 $\mu$ V	
	(3.3 to < 33) V	40 $\mu$ V/V + 0.6 mV	
	(33 to < 330) V	45 $\mu$ V/V + 6 mV	
	(330 to 1 000) V	45 $\mu$ V/V + 60 mV	
<sup>1</sup> DC Current – Source	Up to < 3.3 mA	0.11 mA/A + 85 nA	Fluke 5500A Multiproduct Calibrator
	(3.3 to < 33) mA	80 $\mu$ A/A + 0.65 $\mu$ A	
	(33 to < 330) mA	80 $\mu$ A/A + 8 $\mu$ A	
	(0.33 to < 2.2) A	0.25 mA/A + 85 $\mu$ A	
	(2.2 to 11) A	0.47 mA/A + 0.75 mA	
<sup>1</sup> DC Current Clamp-on Meters – Source	(10 to < 16.5) A	5.8 mA/A + 70 mA	Fluke 5500A Multiproduct Calibrator, 50-turn Coil
	(16.5 to < 150) A	5.9 mA/A + 0.2 A	
	(150 to 550) A	5.9 mA/A + 0.6 A	
<sup>1</sup> AC Voltage – Source	(1 to < 33) mV		Fluke 5500A Multiproduct Calibrator
	(10 to 45) Hz	2.8 mV/V + 16 $\mu$ V	
	> 45 Hz to 10 kHz	1.2 mV/V + 16 $\mu$ V	
	(> 10 to 20) kHz	1.6 mV/V + 16 $\mu$ V	
	(> 20 to 50) kHz	2 mV/V + 16 $\mu$ V	
	(> 50 to 100) kHz	2.8 mV/V + 26 $\mu$ V	
	(> 100 to 450) kHz	8 mV/V + 50 $\mu$ V	
	(33 to < 330) mV		
	(10 to 45) Hz	2 mV/V + 20 $\mu$ V	
	> 45 Hz to 10 kHz	0.4 mV/V + 20 $\mu$ V	
	(> 10 to 20) kHz	0.8 mV/V + 20 $\mu$ V	
	(> 20 to 50) kHz	1.3 mV/V + 32 $\mu$ V	
	(> 50 to 100) kHz	1.9 mV/V + 0.15 mV	
(> 100 to 450) kHz	5.5 mV/V + 0.3 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> AC Voltage – Source	(0.33 to < 3.3) V		Fluke 5500A Multiproduct Calibrator
	(10 to 45) Hz	1.2 mV/V + 0.21 mV	
	> 45 Hz to 10 kHz	0.3 mV/V + 0.1 mV	
	(> 10 to 20) kHz	0.7 mV/V + 80 μV	
	(> 20 to 50) kHz	1.1 mV/V + 0.25 mV	
	(> 50 to 100) kHz	1.9 mV/V + 1.4 mV	
	(> 100 to 450) kHz	4 mV/V + 2.6 mV	
	(3.3 to < 33) V		
	(10 to 45) Hz	1.2 mV/V + 2.2 mV	
	> 45 Hz to 10 kHz	0.32 mV/V + 0.75 mV	
	(> 10 to 20) kHz	0.63 mV/V + 2.2 mV	
	(> 20 to 50) kHz	1.5 mV/V + 4 mV	
	(> 50 to 90) kHz	1.9 mV/V + 14 mV	
	(33 to < 330) V		
	45 Hz to 1 kHz	0.4 mV/V + 7.8 mV	
(> 1 to 10) kHz	0.7 mV/V + 13 mV		
(> 10 to 18) kHz	0.7 mV/V + 27 mV		
(330 to 1 000) V			
45 Hz to 1 kHz	0.4 mV/V + 85 mV		
(> 1 to 5) kHz	1.6 mV/V + 0.11 V		
(> 5 to 10) kHz	1.6 mV/V + 0.4 V		
<sup>1</sup> AC Current – Source	(29 to < 330) μA		Fluke 5500A Multiproduct Calibrator
	(20 to 45) Hz	2 mA/A + 0.12 μA	
	> 45 Hz to 1 kHz	1 mA/A + 0.2 μA	
	(> 1 to 5) kHz	3.2 mA/A + 0.12 μA	
	(> 5 to 10) kHz	9.8 mA/A + 0.12 μA	
	(0.33 to < 3.3) mA		
	(20 to 45) Hz	1.6 mA/A + 0.25 μA	
	> 45 Hz to 1 kHz	0.8 mA/A + 0.25 μA	
	(> 1 to 5) kHz	1.6 mA/A + 0.25 μA	
	(> 5 to 10) kHz	4.4 mA/A + 0.25 μA	
	(3.3 to < 33) mA		
	(20 to 45) Hz	1.6 mA/A + 2.5 μA	
	> 45 Hz to 1 kHz	0.7 mA/A + 2.5 μA	
	(> 1 to 5) kHz	1.6 mA/A + 2.5 μA	
	(> 5 to 10) kHz	4.7 mA/A + 2.5 μA	
(33 to < 330) mA			
(20 to 45) Hz	1.6 mA/A + 25 μA		
> 45 Hz to 1 kHz	0.7 mA/A + 25 μA		
(> 1 to 5) kHz	1.6 mA/A + 25 μA		
(> 5 to 10) kHz	4.7 mA/A + 25 μA		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> AC Current – Source	(0.33 to < 2.2) A (10 to 45) Hz > 45 Hz to 1 kHz (> 1 to 5) kHz (2.2 to 11) A (45 to 65) Hz (> 65 to 500) Hz > 500 Hz to 1 kHz	1.6 mA/A + 0.25 mA 0.78 mA/A + 0.25 mA 6 mA/A + 0.25 mA  0.5 mA/A + 2 mA 0.8 mA/A + 2 mA 2.6 mA/A + 2 mA	Fluke 5500A Multiproduct Calibrator
<sup>1</sup> AC Current Clamp-on Meters – Source	(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 550) A (45 to 65) Hz (> 65 to 100) Hz	6.6 mA/A + 90 mA 12 mA/A + 70 mA  6.5 mA/A + 0.3 A 12 mA/A + 0.3 A  6.5 mA/A + 1.1 A 12 mA/A + 1.1 A	Fluke 5500A Multiproduct Calibrator, 50-turn Coil
<sup>1</sup> Resistance – Source (Simulation)	(0 to < 11) Ω (11 to < 33) Ω (33 to < 110) Ω (110 to < 330) Ω 330 Ω to < 1.1 kΩ (1.1 to < 3.3) kΩ (3.3 to < 11) kΩ (11 to < 33) kΩ (33 to < 110) kΩ (110 to < 330) kΩ 330 kΩ to < 1.1 MΩ (1.1 to < 3.3) MΩ (3.3 to < 11) MΩ (11 to < 33) MΩ (33 to 100) MΩ	0.1 mΩ/Ω + 8.5 mΩ 0.1 mΩ/Ω + 15 mΩ 70 μΩ/Ω + 15 mΩ 70 μΩ/Ω + 15 mΩ 70 μΩ/Ω + 0.1 Ω 70 μΩ/Ω + 0.1 Ω 70 μΩ/Ω + 0.9 Ω 70 μΩ/Ω + 0.9 Ω 90 μΩ/Ω + 7.5 Ω 0.1 mΩ/Ω + 9 Ω 0.13 mΩ/Ω + 80 Ω 0.13 mΩ/Ω + 0.1 kΩ 0.48 mΩ/Ω + 1 kΩ 0.8 mΩ/Ω + 1.3 kΩ 0.4 mΩ/Ω + 4.3 kΩ	Fluke 5500A Multiproduct Calibrator
<sup>1</sup> Resistance – Source (Variable Artifact)	(0.1 to 1) Ω (1 to 500) Ω (0.5 to 5) kΩ (5 to 10) kΩ (10 to 100) kΩ	5.8 mΩ 58 mΩ 1.2 Ω 60 Ω 58 Ω	Resistance Decade Box

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> High Resistance, Insulation Testers, Resistivity Meters @ (50 to 1 000) V	(0.1 to 10) MΩ (10 to 20) MΩ (20 to 30) MΩ (30 to 50) MΩ (50 to 100) MΩ (100 to 200) MΩ (200 to 500) MΩ (0.5 to 1) GΩ 10 GΩ	5.8 kΩ 32 kΩ 69 kΩ 75 kΩ 94 kΩ 2.8 MΩ 4.5 MΩ 7.1 MΩ 72 MΩ	Resistance Decade Box
<sup>1</sup> Electrical Simulation of RTD Indicating Devices – Source/Measure	Pt 385, 100 Ω (-200 to 0) °C (0 to 400) °C (400 to 650) °C	0.15 °C 0.25 °C 0.48 °C	Fluke 744 Process Calibrator
<sup>1</sup> Electrical Simulation of RTD Indicating Devices – Source	Pt 385, 100 Ω (-200 to 0) °C (0 to 300) °C (300 to 400) °C (400 to 630) °C (630 to 800) °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 Pt 385, 500 Ω (-200 to -80) °C (-80 to 100) °C (100 to 260) °C (260 to 400) °C (400 to 600) °C (600 to 630) °C Pt 385, 1 000 Ω (-200 to -80) °C (-80 to 100) °C (100 to 260) °C (260 to 400) °C (400 to 600) °C (600 to 630) °C	0.09 °C 0.14 °C 0.15 °C 0.18 °C 0.33 °C 0.08 °C 0.09 °C 0.18 °C 0.19 °C 0.2 °C 0.23 °C 0.08 °C 0.09 °C 0.1 °C 0.13 °C 0.14 °C 0.16 °C 0.08 °C 0.09 °C 0.1 °C 0.13 °C 0.14 °C 0.16 °C	Fluke 5500A Multiproduct Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Electrical Simulation of RTD Indicating Devices – Source	Pt 3916, 100 Ω		Fluke 5500A Multiproduct Calibrator
	(-200 to -190) °C	0.36 °C	
	(-190 to -80) °C	0.08 °C	
	(-80 to 0) °C	0.09 °C	
	(0 to 260) °C	0.11 °C	
	(260 to 300) °C	0.13 °C	
	(300 to 400) °C	0.14 °C	
	(400 to 600) °C	0.15 °C	
	(600 to 630) °C	0.33 °C	
	Pt 3926, 100 Ω		
	(-200 to 0) °C	0.09 °C	
	(0 to 100) °C	0.12 °C	
	(100 to 300) °C	0.14 °C	
	(300 to 400) °C	0.16 °C	
(400 to 630) °C	0.18 °C		
<sup>1</sup> Electrical Simulation of RTD Indicating Devices – Measure	Cu 427, 10 Ω		Agilent 34401A 6.5 Digit Multimeter
	(-100 to 260) °C	0.42 °C	
	Pt 385, 100 Ω		
	(-200 to 0) °C	0.02 °C	
	(0 to 300) °C	0.022 °C	
<sup>1</sup> Electrical Simulation of Thermocouple Indicating Devices – Source/Measure	(300 to 400) °C	0.024 °C	Fluke 744 Process Calibrator
	(400 to 650) °C	0.03 °C	
	Type E		
	(-200 to -100) °C	0.47 °C	
	(-100 to 0) °C	0.3 °C	
	(0 to 1 000) °C	0.29 °C	
	Type J		
	(-200 to 0) °C	0.44 °C	
	(0 to 600) °C	0.3 °C	
	(600 to 900) °C	0.29 °C	
	(900 to 1 200) °C	0.3 °C	
	Type K		
	(-200 to 0) °C	0.54 °C	
	(0 to 150) °C	0.4 °C	
(150 to 1 100) °C	0.4 °C		
(1 100 to 1 372) °C	0.4 °C		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment		
<sup>1</sup> Electrical Simulation of Thermocouple Indicating Devices – Source/Measure	Type N (-200 to 0) °C (0 to 150) °C (150 to 900) °C (900 to 1 300) °C	0.83 °C 0.62 °C 0.62 °C 0.4 °C	Fluke 744 Process Calibrator		
	Type R (0 to 200) °C (200 to 400) °C (400 to 1 760) °C	1.6 °C 1.2 °C 1.2 °C			
	Type S (0 to 200) °C (200 to 1 760) °C	1.6 °C 1.3 °C			
	Type T (-200 to -100) °C (-100 to 0) °C (0 to 400) °C	0.56 °C 0.52 °C 0.4 °C			
	<sup>1</sup> Electrical Simulation of Thermocouple Indicating Devices – Source/Measure	Type E (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1 000) °C		0.7 °C 0.23 °C 0.2 °C 0.23 °C 0.3 °C	Fluke 5500A Multiproduct Calibrator
		Type J (-210 to -100) °C (-100 to -25) °C (-25 to 150) °C (150 to 760) °C (760 to 1 200) °C		0.38 °C 0.23 °C 0.2 °C 0.24 °C 0.33 °C	
		Type K (200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1 000) °C (1 000 to 1 372) °C		0.46 °C 0.26 °C 0.23 °C 0.37 °C 0.56 °C	
		Type N (-250 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1 300) °C		0.56 °C 0.32 °C 0.28 °C 0.26 °C 0.38 °C	



**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Electrical Simulation of Thermocouple Indicating Devices – Source/Measure	Type R (0 to 250) °C (250 to 400) °C (400 to 1 000) °C (1 000 to 1 767) °C Type S (0 to 250) °C (250 to 400) °C (400 to 1 000) °C (1 000 to 1 767) °C Type T (-250 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.8 °C 0.5 °C 0.47 °C 0.56 °C 0.66 °C 0.51 °C 0.52 °C 0.65 °C 0.88 °C 0.34 °C 0.23 °C 0.21 °C	Fluke 5500A Multiproduct Calibrator
<sup>1</sup> Capacitance – Source	50 Hz to 1 kHz (330 to 500) pF (0.5 to 1.09) nF (1.1 to 3.29) nF (3.3 to 10.9) nF (11 to 32.9) nF (33 to 109.9) nF (110 to 329.9) nF (0.33 to 1.09) μF (1.1 to 3.29) μF (50 to 400) Hz (3.3 to 10.9) μF (11 to 32.9) μF (50 to 200) Hz (33 to 109.9) μF (50 to 100) Hz (110 to 329.9) μF (0.33 to 1) mF	0.4 % of reading + 8 pF 0.4 % of reading + 10 pF 0.4 % of reading + 10 pF 0.4 % of reading + 12 pF 0.2 % of reading + 0.1 nF 0.2 % of reading + 0.1 nF 0.2 % of reading + 0.65 nF 0.2 % of reading + 1.3 nF 0.2 % of reading + 6.5 nF 0.2 % of reading + 10 nF 0.32 % of reading + 80 nF 0.37 % of reading + 0.1 μF 0.54 % of reading + 0.65 μF 0.78 % of reading + 0.65 μF	Fluke 5500A Multiproduct Calibrator
<sup>1</sup> DC Power – Source (0.33 to 1 000) V	< 330 mA (0.1 089 to < 330) W (0.33 to < 2.2) A (0.33 to < 2.2) kW (2.2 to 10) A (2.2 to 10) kW	0.42 mW/W + 6 mW 0.84 mW/W + 60 mW 1.3 mW/W + 0.6 W	Fluke 5500A Multiproduct Calibrator



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**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> AC Power – Source (45 to 65) Hz PF = 1 (0.33 to 1 000) V	Up to 329 mA (0.1089 to < 10.9) W (10.9 to < 330) W (0.33 to < 2.2) A (0.33 to < 2.2) kW (2.2 to 10) A (2.2 to < 3.3) kW (3.3 to 10) kW	1.2 mW/W + 1.3 mW 1.2 mW/W + 6 mW 1.6 mW/W + 60 mW 1.6 mW/W + 60 mW 1.6 mW/W + 0.6 W	Fluke 5500A Multiproduct Calibrator
<sup>1</sup> Power Factor – Source Phase Angle ( $\phi$ ) (0 to 10) ° (10 to 20) ° (20 to 30) ° (30 to 40) ° (40 to 50) ° (50 to 60) ° (60 to 70) ° (70 to 80) ° (80 to 90) °  Phase Angle ( $\phi$ ) (0 to 10) ° (10 to 20) ° (20 to 30) ° (30 to 40) ° (40 to 50) ° (50 to 60) ° (60 to 70) ° (70 to 80) ° (80 to 90) °	(10 to 65) Hz Power Factor (Cos $\phi$ ) (0.985 to 1) (0.940 to 0.984) (0.866 to 0.939) (0.766 to 0.865) (0.643 to 0.765) (0.500 to 0.642) (0.342 to 0.499) (0.174 to 0.341) (0 to 0.173)  (65 to 500) Hz Power Factor (Cos $\phi$ ) (0.985 to 1) (0.940 to 0.984) (0.866 to 0.939) (0.766 to 0.865) (0.643 to 0.765) (0.500 to 0.642) (0.342 to 0.499) (0.174 to 0.341) (0 to 0.173)	0.001 1 PF 0.001 5 PF 0.002 PF 0.001 3 PF 0.002 6 PF 0.002 9 PF 0.003 PF 0.003 2 PF 0.003 3 PF  0.003 PF 0.005 PF 0.007 PF 0.009 PF 0.011 PF 0.012 PF 0.013 PF 0.013 PF 0.014 PF	Fluke 5500A Multiproduct Calibrator
<sup>1</sup> Power Factor – Source Phase Angle ( $\phi$ ) (0 to 10) ° (10 to 20) ° (20 to 30) ° (30 to 40) ° (40 to 50) ° (50 to 60) ° (60 to 70) ° (70 to 80) ° (80 to 90) °	500 Hz to 1 kHz Power Factor (Cos $\phi$ ) (0.985 to 1) (0.940 to 0.984) (0.866 to 0.939) (0.766 to 0.865) (0.643 to 0.765) (0.500 to 0.642) (0.342 to 0.499) (0.174 to 0.341) (0 to 0.173)	0.006 PF 0.011 PF 0.015 PF 0.02 PF 0.022 PF 0.025 PF 0.027 PF 0.028 PF 0.03 PF	Fluke 5500A Multiproduct Calibrator

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> DC Voltage – Measure	Up to 10 mV (> 10 to 100) mV (> 0.1 to 1) V (> 1 to 10) V (> 10 to 100) V (>100 to 1 000) V	60 $\mu$ V/V + 2 $\mu$ V 60 $\mu$ V/V + 5 $\mu$ V 46 $\mu$ V/V + 10 $\mu$ V 40 $\mu$ V/V + 60 $\mu$ V 52 $\mu$ V/V + 0.7 mV 52 $\mu$ V/V + 12 mV	Agilent 34401A 6.5 Digit Multimeter
<sup>1</sup> DC High Voltage – Measure	Up to 1 kV (> 1 to 2) kV (> 2 to 3) kV (> 3 to 4) kV (> 4 to 5) kV (>5 to 6) kV (> 6 to 7) kV (> 7 to 8) kV (> 8 to 9) kV (> 9 to 10) kV	24 V 47 V 70 V 93 V 0.12 kV 0.14 kV 0.17 kV 0.19 kV 0.21 kV 0.24 kV	Digital Multimeter, Fluke 80K-40 High Voltage Probe
<sup>1</sup> AC Voltage – Measure	10 Hz to 20 kHz Up to 10 mV (> 10 to 100) mV (> 0.1 to 1) V (> 1 to 10) V (> 10 to 100) V (> 100 to 750) V (20 to 50) kHz Up to 100 mV (> 0.1 to 1) V (> 1 to 10) V (> 10 to 100) V (> 100 to 750) V	0.7 mV/V + 50 $\mu$ V 0.7 mV/V + 50 $\mu$ V 0.7 mV/V + 0.4 mV 0.7 mV/V + 3.6 mV 0.7 mV/V + 36 mV 0.7 mV/V + 0.3 V 1.5 mV/V + 60 $\mu$ V 1.5 mV/V + 0.5 mV 15 mV/V + 5 mV 1.5 mV/V + 50 mV 1.5 mV/V + 0.36 V	Agilent 34401A 6.5 Digit Multimeter
<sup>1</sup> AC High Voltage – Measure	50 Hz Up to 1 kV (> 1 to 2) kV (> 2 to 3) kV (> 3 to 4) kV (> 4 to 5) kV (> 5 to 6) kV (> 6 to 7) kV (> 7 to 8) kV (> 8 to 9) kV (> 9 to 10) kV	58 V 0.12 kV 0.18 kV 0.24 kV 0.29 kV 0.35 kV 0.41 kV 0.47 kV 0.53 kV 0.58 kV	Digital Multimeter, Fluke 80K-40 High Voltage Probe

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> DC Current – Measure	Up to 1 mA (> 1 to 10) mA (> 10 to 100) mA (> 0.1 to 1) A (> 1 to 3) A	0.6 mA/A + 0.25 μA 0.6 mA/A + 2.5 μA 0.6 mA/A + 6 μA 1.2 mA/A + 0.12 mA 1.4 mA/A + 0.7 mA	Agilent 34401A 6.5 Digit Multimeter
	Up to 30 A (> 30 to 50) A	3.5 mA/A + 5 μA 2.5 mA/A + 5 μA	Agilent 34330A Current Shunt, Yokogawa Standard Current Shunt, Agilent 34401A 6.5 Digit Multimeter
<sup>1</sup> AC Current – Measure	10 Hz to 5 kHz Up to 0.1 mA (> 0.1 to 1) mA (> 1 to 10) mA (> 10 to 100) mA (> 0.1 to 1) A (> 1 to 3) A	1.2 mA/A + 0.6 μA 1.2 mA/A + 1.2 μA 1.2 mA/A + 7 μA 1.2 mA/A + 70 μA 1.2 mA/A + 0.7 mA 2.7 mA/A + 2.0 mA	Agilent 34401A 6.5 Digit Multimeter
	50 Hz to 1 kHz Up to 30 A (1 to 5) kHz Up to 10 A	3.6 mA/A + 50 μA 58 mA/A + 50 μA	Agilent 34330A Current Shunt, Agilent 34401A 6.5 Digit Multimeter
<sup>1</sup> DC/AC Cutoff Current – Measure	DC (Up to 100) mA	0.025 mA/A + 10 μA	Agilent 34401A 6.5 Digit Multimeter
	AC @ (50, 60) Hz (Up to 50) mA (> 50 to 100) mA	0.18 mA/A + 75 μA 0.18 mA/A + 85 μA	
<sup>1</sup> Resistance – Measure	Up to 100 Ω (> 100 to 1 000) Ω (> 1 to 10) kΩ (> 10 to 100) kΩ (> 0.1 to 1) MΩ (> 1 to 2) MΩ (> 2 to 10) MΩ (> 10 to 100) MΩ	0.12 mΩ/Ω + 5 mΩ 0.12 mΩ/Ω + 12 mΩ 0.12 mΩ/Ω + 0.12 Ω 0.12 mΩ/Ω + 1.2 Ω 0.12 mΩ/Ω + 13 Ω 0.12 mΩ/Ω + 0.12 kΩ 0.47 mΩ/Ω + 0.16 kΩ 0.93 mΩ/Ω + 12 kΩ	Agilent 34401A 6.5 Digit Multimeter

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Caliper (External/Internal/Depth)	Up to 300 mm (> 300 to 500) mm (> 500 to 600) mm (> 600 to 1 000) mm	18 µm 25 µm 36 µm 42 µm	Gauge Block Set (Steel)
<sup>1</sup> Height Gauge Dial and Digital	Up to 200 mm (> 200 to 300) mm (> 300 to 600) mm (> 600 to 1 000) mm	16 µm 18 µm 36 µm 42 µm	Gauge Block Set (Steel)
<sup>1</sup> Outside /Inside Micrometer	(0 to 25) mm (> 25 to 50) mm (> 50 to 75) mm (> 75 to 100) mm (> 100 to 125) mm (> 125 to 150) mm (> 150 to 175) mm (> 175 to 200) mm (> 200 to 225) mm (> 225 to 250) mm (> 250 to 275) mm (> 275 to 325) mm (> 325 to 375) mm (> 375 to 425) mm (> 425 to 450) mm (> 450 to 475) mm (> 475 to 500) mm	1 µm 1.6 µm 2.3 µm 3 µm 6.8 µm 7.2 µm 7.6 µm 8 µm 8.5 µm 9 µm 9.6 µm 11 µm 12 µm 13 µm 14 µm 15 µm 16 µm	Gauge Block Set (Steel)
<sup>1</sup> Dial and Digital Thickness Gauge	Up to 25 mm (> 25 to 50) mm (> 50 to 75) mm (> 75 to 100) mm	1.5 µm 1.9 µm 2.5 µm 3 µm	Gauge Block Set
<sup>1</sup> Dial and Digital Depth Gauge	Up to 300 mm (> 300 to 450) mm (> 450 to 600) mm	16 µm 18 µm 21 µm	Gauge Block Set per JIS B 7518.
<sup>1</sup> Holtest/Borematic/ Three-point Internal Micrometer	(10 to 25) mm (> 25 to 50) mm (> 50 to 75) mm (> 75 to 100) mm	2 µm 2.3 µm 3.1 µm 4.2 µm	Master Ring Gauge

### Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Coating Thickness Gauge	50 µm 100 µm 250 µm 500 µm 1 000 µm 1 977 µm 3 044 µm 3 817 µm 4 832 µm 5 631 µm	0.5 µm 0.5 µm 0.8 µm 0.8 µm 0.8 µm 0.8 µm 1 µm 1 µm 1.3 µm 1.4 µm	Master Calibration Foil
<sup>1</sup> Caliper Gauge (External/Internal)	Up to 10 mm (> 10 to 20) mm (> 20 to 50) mm (> 50 to 100) mm	3 µm 3.2 µm 6.1 µm 12 µm	Gauge Block Set
<sup>1</sup> Surface Roughness Testers	Ra = 2.94 µm Rz = 9.3 µm	0.091 µm 0.29 µm	Roughness Specimen per JIS B 0651.
<sup>1</sup> Ultrasonic Thickness Gauge	Up to 50 mm (50 to 100) mm (100 to 200) mm (200 to 300) mm	0.006 mm 0.007 mm 0.008 mm 0.01 mm	Gauge Block Set
<sup>1</sup> Cylinder Gauge/ Bore Gauge	Up to 1.5 mm	5 µm	Calibration Tester per JIS-B 7515.
<sup>1</sup> Dial Test Indicator	Up to 1.5 mm	5 µm	Calibration Tester per JIS-B 7533.
<sup>1</sup> Dial Gauge & Digital Indicator	Up to 50 mm	7.7 µm	Calibration Tester per JIS-B 7503.

### Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Scales and Balances (0.000 01 g Resolution)	1 mg to 10 g (> 10 to 20) g (> 20 to 100) g	0.18 mg 0.19 mg 0.2 mg	Master OIML Class E2, F1, M1 weights and internal calibration procedure utilized in the calibration of the weighing system.
<sup>1</sup> Scales and Balances (0.000 1 g Resolution)	(> 100 to 200) g (> 200 to 300) g	0.31 mg 1 mg	
<sup>1</sup> Scales and Balances (0.001 g Resolution)	(> 300 to 500) g (> 500 to 1 000) g (> 1 000 to 2 000) g	1.1 mg 1.8 mg 12 mg	

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Scales and Balances (0.01 g Resolution)	(>2 000 to 5 000) g	18 mg	OIML Class E2, F1, M1 weights and internal calibration procedure utilized in the calibration of the weighing system.
<sup>1</sup> Scales and Balances (0.001 kg Resolution)	(> 5 to 10) kg (> 10 to 20) kg	87 mg 0.12 g	
<sup>1</sup> Scales and Balances (0.01 kg Resolution)	(> 20 to 30) kg (> 30 to 60) kg (> 60 to 100) kg (> 100 to 150) kg (> 150 to 200) kg	8.2 g 8.3 g 8.5 g 8.9 g 17 g	
<sup>1</sup> Scales and Balances (0.02 kg Resolution)	(> 200 to 300) kg	18 g	
<sup>1</sup> Scales and Balances (0.05 kg Resolution)	(>300 to 400) kg (> 400 to 500) kg (> 500 to 600) kg	43 g 44 g 45 g	
<sup>1</sup> Scales and Balances (0.1 kg Resolution)	(> 600 to 1 000) kg	85 g	
<sup>1</sup> Mass Determination	50 mg 100 mg 200 mg 500 mg 1 g 2 g 5 g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 2 kg 5 kg 10 kg 20 kg	83 µg 83 µg 83 µg 83 µg 84 µg 85 µg 88 µg 94 µg 0.12 mg 0.2 mg 0.37 mg 0.72 mg 2.8 mg 4.3 mg 12 mg 23 mg 89 mg 0.11 g	
<sup>1</sup> Push-Pull Gauge, Force Gauge, Tension Gauge, Tensile Gauge	(0 to 29.4) N (> 29.4 to 98) N (> 98 to 980) N	0.058 N 0.3 N 0.6 N	OIML Class E2, F1, and M1 weights



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**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Pressure Gauge (Pneumatic) Digital Pressure Gauge, Pressure Transducer, Differential Pressure Gauge, Manometer, Pressure Switch	(0 to 200) kPa (> 200 to 2 000) kPa	0.12 kPa 1.2 kPa	Pressure Calibrator
<sup>1</sup> Pressure Gauge (Hydraulic) Digital Pressure Gauge, Pressure Transducer, Differential Pressure Gauge, Manometer, Pressure Switch	(0 to 10) MPa (>10 to 20) MPa (> 20 to 70) MPa	8.5 kPa 15 kPa 53 kPa	Pressure Calibrator
<sup>1</sup> Differential Pressure Gauge	(-250 to 0) Pa (0 to 250) Pa	0.88 Pa 0.88 Pa	Pressure Calibrator
<sup>1</sup> Vacuum Gauge	(- 90 to 0) kPa	53 Pa	Pressure Calibrator
<sup>1</sup> Pressure Transmitter	(- 90 to 0) kPa (> 0 to 200) kPa (> 200 to 2 000) kPa	0.09 kPa 0.2 kPa 2 kPa	Pressure Calibrator/ Process Calibrator
<sup>1</sup> Flow Meter (Liquid flow)	(0 to 8.334) l/s (> 8.334 to 16.668) l/s (> 16.668 to 30.56) l/s	0.21 % of reading 0.12 % of reading 0.31 % of reading	Ultrasonic Flow Meter
<sup>1</sup> Volumetric Glass Ware and Operated Volumetric Apparatus - Volumetric flask, Cylinder, Beaker	5 mL 10 mL 25 mL 50 mL 100 mL 200 mL 250 mL 500 mL 1 000 mL 2 000 mL	3.4 µL 3.4 µL 10 µL 17 µL 27 µL 34 µL 40 µL 67 µL 0.1 mL 0.2 mL	Electronic Balance, OIML Class E2 and F1 weights
<sup>1</sup> Measuring Pipettes, Graduated pipette, Volumetric pipette	(0.5 to 5) mL 10 mL 15 mL 25 mL 50 mL 100 mL	3.4 µL 3.4 µL 10 µL 10 µL 17 µL 34 µL	Electronic Balance, OIML Class E2 and F1 weights



### Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Micro Pipette, Auto Pipette, Dispenser	(10 to 100) $\mu\text{L}$ (> 100 to 200) $\mu\text{L}$ (> 200 to 500) $\mu\text{L}$ (> 500 to 1 000) $\mu\text{L}$ (> 1 to 2) mL (> 2 to 5) mL (> 5 to 10) mL	0.1 $\mu\text{L}$ 0.17 $\mu\text{L}$ 0.22 $\mu\text{L}$ 0.26 $\mu\text{L}$ 0.32 $\mu\text{L}$ 0.47 $\mu\text{L}$ 0.62 $\mu\text{L}$	Electronic Balance, OIML Class E2 and F1 weights
<sup>1</sup> Burettes	5 mL 10 mL 25 mL 50 mL 100 mL	3.4 $\mu\text{L}$ 3.4 $\mu\text{L}$ 10 $\mu\text{L}$ 17 $\mu\text{L}$ 34 $\mu\text{L}$	Electronic Balance, OIML Class E2 and F1 weights
<sup>1</sup> Viscosity Meter (25 to 50) $^{\circ}\text{C}$	Dynamic Viscosity 29.07 cP 45.3 cP 50.41 cP 99.85 cP 204.7 cP 366.6 cP 421.6 cP 1 021 cP 2 095 cP 4 486 cP 5 318 cP 15 228 cP	0.068 cP 0.086 cP 0.11 cP 0.17 cP 0.36 cP 0.63 cP 0.73 cP 2.2 cP 4.3 cP 9.9 cP 12 cP 36 cP	Viscosity Solution Standard

### Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Temperature Controlled Chamber, Hot Air Oven, Incubator, Refrigerator, Freezer	(-40 to -10) $^{\circ}\text{C}$ (> -10 to 0) $^{\circ}\text{C}$ (> 0 to 10) $^{\circ}\text{C}$ (> 10 to 70) $^{\circ}\text{C}$ (> 70 to 150) $^{\circ}\text{C}$ (> 150 to 250) $^{\circ}\text{C}$	0.26 $^{\circ}\text{C}$ 0.26 $^{\circ}\text{C}$ 0.25 $^{\circ}\text{C}$ 0.25 $^{\circ}\text{C}$ 1.1 $^{\circ}\text{C}$ 1.5 $^{\circ}\text{C}$	Agilent 34970A Data Logger
<sup>1</sup> Autoclave	(105 to 135) $^{\circ}\text{C}$	0.68 $^{\circ}\text{C}$	Agilent 34970A Data Logger

**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Liquid Bath, Micro Bath	(-20 to -10) °C (> -10 to 0) °C (> 0 to 100) °C (> 100 to 200) °C	0.25 °C 0.26 °C 0.3 °C 0.3 °C	Agilent 34970A Data Logger
<sup>1</sup> Temperature Gauges & Dial Thermometers	(-20 to -10) °C (-10 to 0) °C (> 0 to 200) °C (> 200 to 400) °C	0.34 °C 0.34 °C 0.36 °C 0.62 °C	PRT Standard, Digital Readout
<sup>1</sup> Thermocouple Sensors	Types K, J, E, T, N, R, S (-20 to -10) °C (> -10 to 0) °C (> 0 to 200) °C (> 200 to 400) °C	0.36 °C 0.4 °C 0.4 °C 0.43 °C	PRT Standard, Digital Readout
<sup>1</sup> Thermocouple Sensors	Types K, J, E, T, N, R, S (> 400 to 550) °C (> 550 to 700) °C (> 700 to 1 200) °C	1.8 °C 2.8 °C 3.1 °C	Thermocouple Standard, Digital Readout
<sup>1</sup> Temperature Indicator with Thermocouple Sensor	Types K, J, E, T, N (-20 to -10) °C (> -10 to 200) °C (> 200 to 400) °C	0.25 °C 0.25 °C 0.61 °C	PRT Standard, Digital Readout
<sup>1</sup> Temperature Indicator with Thermocouple Sensor	Types K, J, E, T, N (> 400 to 550) °C (> 550 to 700) °C (> 700 to 1 200) °C	1.7 °C 2.8 °C 3.1 °C	Thermocouple Standard, Digital Readout
<sup>1</sup> Temperature Indicator with Thermocouple Sensor	Types R, S (0 to 200) °C (> 200 to 400) °C	0.2 °C 0.6 °C	PRT Standard, Digital Readout
<sup>1</sup> Temperature Indicator with Thermocouple Sensor	Types R, S (> 400 to 550) °C (> 550 to 700) °C (> 700 to 1 200) °C	1.7 °C 2.8 °C 3.1 °C	Thermocouple Standard, Digital Readout
<sup>1</sup> Temperature Indicator with RTD Sensor or Thermistor Sensor	(-20 to -10) °C (> -10 to 200) °C (>100 to 300) °C (>300 to 400) °C	0.17 °C 0.18 °C 0.2 °C 0.2 °C	PRT Standard, Digital Readout
<sup>1</sup> Temperature Indicator with RTD Sensor or Thermistor Sensor	(> 400 to 550) °C (> 550 to 650) °C	1.7 °C 2.8 °C	Thermocouple Standard, Digital Readout
<sup>1</sup> RTD Sensor	(-20 to -10) °C (-10 to 400) °C	0.21 °C 0.21 °C	PRT Standard, Digital Readout

### Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> RTD Sensor	(> 400 to 550) °C (> 550 to 650) °C	1.7 °C 2.8 °C	Thermocouple Standard, Digital Readout
<sup>1</sup> Liquid in Glass Thermometer	(-20 to 200) °C	0.17 °C	PRT Standard, Digital Readout
<sup>1</sup> Dry Block, Dry Well	(-20 to 400) °C	0.36 °C	PRT Standard, Digital Readout
<sup>1</sup> Dry Block, Dry Well	(>400 to 550) °C (>550 to 700) °C (>700 to 1 200) °C	0.8 °C 2.4 °C 2.7 °C	Thermocouple Standard, Digital Readout
<sup>1</sup> Thermo-Hygrometer Temperature Humidity	(20 to 40) °C (30 to 80) %RH	0.5 °C 1.8 %RH	Comparison to Data Logger
<sup>1</sup> Infrared Thermometer	(30 to 50) °C (>50 to 100) °C (>100 to 200) °C (>200 to 300) °C (>300 to 400) °C (>400 to 500) °C	0.78 °C 1.3 °C 2.5 °C 3.6 °C 4.8 °C 5.9 °C	Blackbody Source, Digital Thermometer (Flat Plate) $\epsilon = 0.95, \lambda = (8 \text{ to } 14) \mu\text{m}$

### Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Frequency – Source	10 mHz to 500 Hz > 500 Hz to 5 kHz (> 5 to 50) kHz (> 50 to 100) kHz	20 $\mu\text{Hz/Hz} + 5.9 \text{ mHz}$ 20 $\mu\text{Hz/Hz} + 58 \text{ mHz}$ 20 $\mu\text{Hz/Hz} + 0.58 \text{ Hz}$ 20 $\mu\text{Hz/Hz} + 5.8 \text{ Hz}$	Fluke 5500A Multiproduct Calibrator
<sup>1</sup> Digital Tachometer (Photo-type)	(2.5 to 999.99) rpm (> 999.99 to 9 999.9) rpm (> 9 999.9 to 99 999) rpm	0.005 8 rpm 0.058 rpm 0.58 rpm	Fluke 5500A Multiproduct Calibrator, Light Emitting Diode (LED)
<sup>1</sup> Centrifuge Timer	Up to 30 min	31 ms	Digital Stopwatch

**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
<sup>1</sup> Centrifuge Speed	(10 to 100) rpm	0.21 rpm	Digital Tachometer
	(> 100 to 500) rpm	0.45 rpm	
	(> 500 to 900) rpm	0.66 rpm	
	(> 900 to 1 000) rpm	0.72 rpm	
	(> 1 000 to 2 000) rpm	1.3 rpm	
	(> 2 000 to 3 000) rpm	2 rpm	
	(> 3 000 to 5 000) rpm	3.1 rpm	
	(> 5 000 to 9 000) rpm	5.4 rpm	
	(> 9 000 to 10 000) rpm	7.1 rpm	
	(> 10 000 to 12 000) rpm	8.3 rpm	
(> 12 000 to 15 000) rpm	10 rpm		

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-2662.



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