



ANSI National Accreditation Board

## Ming Deng Metrology Services (Thailand) Co., Ltd.

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### CALIBRATION

#### Acoustics and Vibration

Bangkok, Thailand

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sound Meter	@ 1 kHz (94, 114) dB	0.13 dB	Sound Calibrator

#### Chemical Quantities

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
pH Measuring Instruments <sup>1,5</sup>	4 pH 7 pH 10 pH	0.06 pH 0.06 pH 0.12 pH	Comparison to Certified Reference Material
Conductivity Measuring <sup>1,5</sup> Instruments	84 $\mu$ S/cm 1 413 $\mu$ S/cm 12.88 mS/cm	1 % of reading + 0.1 $\mu$ S/cm 1.5 % of reading + 0.6 $\mu$ S/cm 1.5 % of reading + 0.01 mS/cm	Comparison to Certified Reference Material
Refractometer <sup>1</sup>	5 % Brix 10 % Brix 30 % Brix 60 % Brix	0.07 % Brix	Comparison to Certified Reference Material

#### Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
DC Current Measure	(0 to 200) $\mu$ A 200 $\mu$ A to 2 mA (2 to 20) mA (20 to 200) mA 200 mA to 2 A (2 to 20) A	13 $\mu$ A/A + 0.62 nA 13 $\mu$ A/A + 6.1 nA 14 $\mu$ A/A + 61 nA 47 $\mu$ A/A + 0.96 $\mu$ A 0.18 mA/A + 16 $\mu$ A 0.39 mA/A + 0.36 mA	8508A Multimeter

**Electrical – DC/Low Frequency**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
DC Current Measure <sup>1</sup>	(0 to 300) $\mu$ A 300 $\mu$ A to 3 mA (3 to 30) mA (30 to 300) mA 300 mA to 1 A (1 to 10) A	0.47 mA/A + 0.052 $\mu$ A 0.47 mA/A + 0.3 $\mu$ A 0.47 mA/A + 2.9 $\mu$ A 0.93 mA/A + 52 $\mu$ A 0.93 mA/A + 0.73 mA 0.58 mA/A + 4.4 mA	3457A / 189 Multimeter
DC Current Source	(0 to 220) $\mu$ A 220 $\mu$ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A (2.2 to 3) A (3 to 11) A (11 to 20.5) A	47 $\mu$ A/A + 7.8 nA 47 $\mu$ A/A + 7.9 nA 47 $\mu$ A/A + 78 nA 55 $\mu$ A/A + 0.78 $\mu$ A 74 $\mu$ A/A + 24 $\mu$ A 0.3 mA/A + 31 $\mu$ A 0.39 mA/A + 0.39 mA 0.78 mA/A + 0.59 mA	5700A / 5522A Multi Product Calibrator
DC Current Clamp Meters	(20 to 55) A (55 to 150) A (150 to 550) A (550 to 1 025) A	0.29 % of reading + 19 mA 0.3 % of reading + 0.06 A 0.3 % of reading + 0.59 A 0.3 % of reading + 0.59 A	5522A Multi Product Calibrator with Current Coil
DC Current Source <sup>1</sup>	(0 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 mA/A + 0.016 $\mu$ A 78 $\mu$ A/A + 0.039 $\mu$ A 78 $\mu$ A/A + 0.2 $\mu$ A 78 $\mu$ A/A + 2 $\mu$ A 0.016 mA/A + 31 $\mu$ A 0.3 mA/A + 31 $\mu$ A 0.39 mA/A + 0.7 mA 0.78 mA/A + 0.59 mA	5522A Multi Product Calibrator
DC Current Clamp Meters <sup>1</sup>	(20 to 55) A (55 to 150) A (150 to 550) A (550 to 1 025) A	0.29 % of reading + 19 mA 0.3 % of reading + 0.06 A 0.3 % of reading + 0.59 A 0.3 % of reading + 0.59 A	5522A Multi Product Calibrator with Current Coil
AC Current Clamp Meters <sup>1</sup> 45 Hz to 65 Hz 65 Hz to 440 Hz 45 Hz to 65 Hz 65 Hz to 440 Hz 45 Hz to 65 Hz 65 Hz to 440 Hz 45 Hz to 65 Hz 65 Hz to 440 Hz	(20 to 55) A (20 to 55) A (55 to 150) A (55 to 150) A (150 to 550) A (150 to 550) A (550 to 1 025) A (550 to 1 025) A	0.34 % of reading + 0.03 A 0.95 % of reading + 0.032 A 0.34 % of reading + 0.065 A 0.95 % of reading + 0.066 A 0.35 % of reading + 0.59 A 1.2 % of reading + 0.59 A 0.36 % of reading + 0.59 A 1.2 % of reading + 0.59 A	5522A Multi Product Calibrator with Current Coil

**Electrical – DC/Low Frequency**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current Measure	<200 $\mu$ A 10 Hz to 10 kHz	0.049 % of reading + 0.021 $\mu$ A	Direct Measurement with a Fluke 8508A
	<2 mA 10 Hz 10 Hz to 10 kHz	0.031 % of reading + 0.2 $\mu$ A 0.029 % of reading + 0.2 $\mu$ A	
AC Current Measure	<20 mA 10 Hz 10 Hz to 10 kHz	0.031 % of reading + 2 $\mu$ A 0.029 % of reading + 2 $\mu$ A	Direct Measurement with a Fluke 8508A
	<200 mA 10 Hz 10 Hz to 10 kHz	0.031 % of reading + 20 $\mu$ A 0.028 % of reading + 20 $\mu$ A	
	<2A 10 Hz to 2 kHz (2 to 10) kHz	0.057 % of reading + 0.2 mA 0.067 % of reading + 0.2 mA	
	<20A 50 Hz to 2 kHz (2 to 10) kHz	0.072 % of reading + 2 mA 0.2 % of reading + 2 mA	
AC Current Measure <sup>1</sup>	(0 to 5) mA (20 to 45) Hz 45 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz	1.2 % of reading + 3.1 $\mu$ A 0.87 % of reading + 3.1 $\mu$ A 0.87 % of reading + 3.2 $\mu$ A 2.3 % of reading + 5.5 $\mu$ A	HP 3457A/Fluke 189
	5 mA to 30 mA (20 to 45) Hz (46 to 100) Hz (101 to 400) Hz 401 Hz to 20 kHz (21 to 100) kHz	1.1 % of reading + 34 $\mu$ A 0.44 % of reading + 34 $\mu$ A 0.39 % of reading + 34 $\mu$ A 0.39 % of reading + 34 $\mu$ A 1.3 % of reading + 47 $\mu$ A	
	(30 to 300) mA (20 to 45) Hz (46 to 100) Hz (101 to 400) Hz 401 Hz to 20 kHz (21 to 100) kHz	1.1 % of reading + 0.34 mA 0.44 % of reading + 0.34 mA 0.39 % of reading + 0.34 mA 0.39 % of reading + 0.34 mA 1.3 % of reading + 0.47 mA	
	300 mA to 1A (20 to 45) Hz (46 to 100) Hz (101 to 400) Hz 401 Hz to 20 kHz	1.2 % of reading + 3.3 mA 0.56 % of reading + 3.3 mA 0.5 % of reading + 3.3 mA 0.5 % of reading + 3.3 mA	

**Electrical – DC/Low Frequency**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current Measure <sup>1</sup>	(1 to 10) A 45 Hz to 1 kHz (1 to 20) kHz	1.8 % of reading + 11 mA 5.8 % of reading + 15 mA	HP 3457A/Fluke 189
AC Current Source	$\leq 220 \mu\text{A}$ (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz 220 $\mu\text{A}$ to 2.2 mA (10 to 20) Hz (20 to 30) Hz (30 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (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 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	0.063 % of reading + 30 nA 0.034 % of reading + 21nA 0.015 % of reading +19 nA 0.055 % of reading + 40nA 0.15 % of reading + 78 nA 0.063 % of reading + 40 nA 0.034 % of reading +32nA 0.034 % of reading +32nA 0.015 % of reading + 33 nA 0.055 % of reading + 0.39 $\mu\text{A}$ 0.15 % of reading +0.78 $\mu\text{A}$ 0.063 % of reading + 0.51 $\mu\text{A}$ 0.034 % of reading + 0.32 $\mu\text{A}$ 0.015 % of reading + 0.32 $\mu\text{A}$ 0.055 % of reading + 3.9 $\mu\text{A}$ 0.14 % of reading + 7.8 $\mu\text{A}$ 0.063 % of reading + 3.9 $\mu\text{A}$ 0.034 % of reading + 3.1 $\mu\text{A}$ 0.016 % of reading + 3.1 $\mu\text{A}$ 0.055 % of reading + 39 $\mu\text{A}$ 0.14 % of reading + 78 $\mu\text{A}$ 0.14 % of reading + 16 $\mu\text{A}$ 0.07 % of reading + 16 $\mu\text{A}$ 0.033 % of reading + 16 $\mu\text{A}$ 0.078 % of reading + 39 $\mu\text{A}$ 0.16 % of reading + 78 $\mu\text{A}$ 0.31 % of reading + 0.16 mA	5700A/5522A Multi Product Calibrator
AC Current Source	(0.33 to 3) A (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.14 % of reading + 0.13 mA 0.048 % of reading + 0.085 mA 0.47 % of reading + 0.78 mA 1.94 % of reading + 3.9 mA	5522A Multi Product Calibrator

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Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current Source	(3 to 11) A 45 Hz to 100 Hz (0.1 to 1) kHz (1 to 5) kHz (11 to 20.5) A 45 Hz to 100 Hz (0.1 to 1) kHz (1 to 5) kHz	0.048 % of reading + 1.6 mA 0.079 % of reading + 1.6 mA 2.4 % of reading + 1.6 mA 0.094 % of reading + 3.9 mA 0.12 % of reading + 3.9 mA 2.4 % of reading + 3.9 mA	5522A Multi Product Calibrator
AC Current Source <sup>1</sup>	(29 to 330) $\mu$ A (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 (0.33 to 3.3) 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 (3.3 to 33) 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 (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	0.16 % of reading + 0.08 $\mu$ A 0.12 % of reading + 0.079 $\mu$ A 0.098 % of reading + 0.079 $\mu$ A 0.24 % of reading + 0.12 $\mu$ A 0.62 % of reading + 0.16 $\mu$ A 1.3 % of reading + 0.31 $\mu$ A 0.16 % of reading + 0.12 $\mu$ A 0.098 % of reading + 0.12 $\mu$ A 0.078 % of reading + 0.12 $\mu$ A 0.16 % of reading + 0.16 $\mu$ A 0.39 % of reading + 0.24 $\mu$ A 0.78 % of reading + 0.47 $\mu$ A 0.14 % of reading + 1.6 $\mu$ A 0.07 % of reading + 1.6 $\mu$ A 0.032 % of reading + 1.6 $\mu$ A 0.063 % of reading + 1.6 $\mu$ A 0.16 % of reading + 2.4 $\mu$ A 0.31 % of reading + 3.1 $\mu$ A 0.14 % of reading + 16 $\mu$ A 0.071 % of reading + 16 $\mu$ A 0.032 % of reading + 16 $\mu$ A 0.078 % of reading + 39 $\mu$ A 0.16 % of reading + 78 $\mu$ A 0.31 % of reading + 0.16 mA	5522A Multi Product Calibrator



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Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current Source <sup>1</sup>	(0.33 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 Hz to 100 Hz (100 to 1) kHz (1 to 5) kHz (11 to 20.5) A 45 Hz to 100 Hz (100 to 1) kHz (1 to 5) kHz	0.14 % of reading + 0.23 mA 0.047 % of reading + 0.11 mA 0.47 % of reading + 0.78 mA 1.94 % of reading + 3.9 mA 0.048 % of reading + 1.7 mA 0.078 % of reading + 1.7 mA 2.4 % of reading + 1.7 mA 0.094 % of reading + 3.9 mA 0.12 % of reading + 3.9 mA 2.4 % of reading + 3.9 mA	5522A Multi Product Calibrator
Resistance Measure	(0 to 2) Ω (2 to 20) Ω (20 to 200) Ω 200 Ω to 2 kΩ (2 to 20) kΩ (20 to 200) kΩ 200 kΩ to 2 MΩ (2 to 20) MΩ (20 to 200) MΩ 200 MΩ to 2 GΩ (2 to 20) GΩ	17 μΩ/Ω + 7.4 μΩ 9.3 μΩ/Ω + 44 μΩ 7.8 μΩ/Ω + 0.24 mΩ 7.8 μΩ/Ω + 2.5 mΩ 7.8 μΩ/Ω + 26 mΩ 7.8 μΩ/Ω + 0.4 Ω 9.3 μΩ/Ω + 7.6 Ω 20 μΩ/Ω + 0.14 kΩ 62 μΩ/Ω + 3.34 kΩ 0.18 mΩ/Ω + 0.13 MΩ 1.4 mΩ/Ω + 9.3 MΩ	8508A Multimeter
Resistance Measure <sup>1</sup>	0 Ω (0 to 30) Ω (30 to 300) Ω 300 Ω to 3 kΩ (3 to 30) kΩ (30 to 300) kΩ 300 kΩ to 3 MΩ (3 to 30) MΩ (30 to 300) MΩ	4 mΩ 87 μΩ/Ω + 4.1 mΩ 64 μΩ/Ω + 9.2 mΩ 58 μΩ/Ω + 8.4 mΩ 58 μΩ/Ω + 0.84 Ω 58 μΩ/Ω + 9.4 Ω 76 μΩ/Ω + 0.17 kΩ 0.47 mΩ/Ω + 8.1 kΩ 1.9 % of reading + 0.81 MΩ	3457A Multimeter
Resistance Measure <sup>1</sup>	300 MΩ to 1 GΩ	19 % of reading + 1.4 MΩ	3457A Multimeter



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Resistance Measuring Instruments	0 Ω	40 μΩ	5700A Multi Product Calibrator
	1 Ω	86 μΩ/Ω + 8.6 μΩ	
	1.9 Ω	86 μΩ/Ω + 7.6 μΩ	
	10 Ω	26 μΩ/Ω + 8.6 μΩ	
	19 Ω	24 μΩ/Ω + 8.6 μΩ	
	100 Ω	16 μΩ/Ω + 58 μΩ	
	190 Ω	16 μΩ/Ω + 58 μΩ	
	1 kΩ	12 μΩ/Ω + 0.58 mΩ	
	1.9 kΩ	12 μΩ/Ω + 0.58 mΩ	
	10 kΩ	12 μΩ/Ω + 7.6 mΩ	
	19 kΩ	12 μΩ/Ω + 7 mΩ	
	100 kΩ	13 μΩ/Ω + 58 mΩ	
	190 kΩ	13 μΩ/Ω + 71 mΩ	
	1 MΩ	21 μΩ/Ω + 0.58 Ω	
	1.9 MΩ	20 μΩ/Ω + 0.58 Ω	
	10 MΩ	37 μΩ/Ω + 54 Ω	
19 MΩ	44 μΩ/Ω + 52 Ω		
100 MΩ	0.11 mΩ/Ω + 0.94 kΩ		
Resistance Measuring Instruments <sup>1</sup>	(0 to 11) Ω	35 μΩ/Ω + 0.8 mΩ	5522A Multi Product Calibrator
	(11 to 33) Ω	47 μΩ/Ω + 1.2 mΩ	
	(33 to 110) Ω	35 μΩ/Ω + 1.1 mΩ	
	110 Ω to 1.1 kΩ	26 μΩ/Ω + 1.7 mΩ	
	(1.1 to 11) kΩ	25 μΩ/Ω + 17 mΩ	
	(11 to 110) kΩ	25 μΩ/Ω + 0.17 Ω	
	110 kΩ to 1.1 MΩ	27 μΩ/Ω + 1.7 Ω	
	(1.1 to 3.3) MΩ	49 μΩ/Ω + 24 Ω	
	(3.3 to 11) MΩ	0.11 mΩ/Ω + 40 Ω	
	(11 to 33) MΩ	0.21 mΩ/Ω + 2 kΩ	
	(33 to 110) MΩ	0.4 mΩ/Ω + 2.6 kΩ	
(110 to 330) MΩ	2.4 mΩ/Ω + 78 kΩ		
(330 to 1 100) MΩ	12 mΩ/Ω + 0.39 MΩ		
Resistance Simulation of RTD Temperature Measuring Instrumentation	Pt 385, 100Ω		5522A Multi Product Calibrator
	(-200 to -80) °C	0.07 °C	
	(-80 to 0) °C	0.07 °C	
	(0 to 100) °C	0.08 °C	
	(100 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 630) °C	0.11 °C	
(630 to 800) °C	0.19 °C		

Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Resistance Simulation of RTD Temperature Measuring Instrumentation	Pt 3926, 100 Ω		5522A Multi Product Calibrator
	(-200 to -80) °C	0.07 °C	
	(-80 to 0) °C	0.07 °C	
	(0 to 100) °C	0.08 °C	
	(100 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(400 to 630) °C	0.11 °C	
	Pt 3916, 100 Ω		
	(-200 to -190) °C	0.2 °C	
	(-190 to -80) °C	0.07 °C	
	(-80 to 0) °C	0.07 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 260) °C	0.08 °C	
	(260 to 300) °C	0.08 °C	
	(300 to 400) °C	0.09 °C	
	(400 to 600) °C	0.1 °C	
	(600 to 630) °C	0.19 °C	
	Pt 385, 200 Ω		
	(-200 to -80) °C	0.07 °C	
	(-80 to 0) °C	0.07 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 300) °C	0.07 °C	
	(300 to 400) °C	0.11 °C	
	(400 to 600) °C	0.12 °C	
	(600 to 630) °C	0.14 °C	
	PT 385, 500Ω		
	(-200 to -80) °C	0.07 °C	
	(-80 to 0) °C	0.07 °C	
(0 to 100) °C	0.07 °C		
(100 to 260) °C	0.07 °C		
(260 to 300) °C	0.08 °C		
(300 to 400) °C	0.08 °C		
(400 to 630) °C	0.09 °C		
(630 to 800) °C	0.1 °C		



**Electrical – DC/Low Frequency**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Resistance Simulation of RTD Temperature Measuring Instrumentation	Pt 385, 1000 Ω		5522A Multi Product Calibrator
	(-200 to -80) °C	0.06°C	
	(-80 to 0) °C	0.06°C	
	(0 to 100) °C	0.07°C	
	(100 to 260) °C	0.07°C	
	(260 to 300) °C	0.07°C	
	(300 to 400) °C	0.08°C	
	(400 to 630) °C	0.08°C	
	(630 to 800) °C	0.19°C	
	Ni 120, 120 Ohm		
	(-80 to 0) °C	0.08°C	
	(0 to 100) °C	0.08°C	
	(100 to 260) °C	0.12°C	
Cu 10, 10 Ohm			
(-100 to 260) °C	0.24°C		
Source and Measure Resistance Simulation of RTD Temperature Measuring Instrumentation <sup>1</sup>	Pt 385, 100Ω		725 Process Calibrator
	(-200 to 800) °C	0.39 °C	
	Pt 3926, 100 Ω		
	(-200 to 630) °C	0.36 °C	
	Pt 3916, 100 Ω		
	(-200 to 630) °C	0.36 °C	
	Pt 385, 200 Ω		
(-200 to 250) °C	0.24 °C		
(250 to 630) °C	0.93 °C		
Pt385, 500Ω			
(-200 to 500) °C	0.36 °C		
(500 to 630) °C	0.47 °C		
Resistance Simulation of RTD Temperature Measuring Instrumentation <sup>1</sup>	Pt 385, 1000 Ω		725 Process Calibrator
	For Measurement		
	(-200 to 100) °C	0.24 °C	
	(100 to 630) °C	0.36 °C	
	For Source		
	(-200 to 100) °C	0.24 °C	
(100 to 630) °C	0.24 °C		
Ni120, 120 Ω			
(-80 to 260) °C	0.24 °C		



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High Resistance <sup>1</sup> Insulation Testers, Surface Resistivity Meters	(0 to 1) kΩ (1 to 10) kΩ (10 to 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ (10 to 100) MΩ (0.1 to 1) GΩ (1 to 10) GΩ (10 to 100) GΩ (0.1 to 1) TΩ	0.12 % of reading + 0.58 Ω 0.12 % of reading + 5.8 Ω 0.12 % of reading + 58 Ω 0.12 % of reading + 0.58 kΩ 1.2 % of reading + 5.8 kΩ 1.2 % of reading + 58 kΩ 1.2 % of reading + 0.58 MΩ 1.2 % of reading + 5.8 MΩ 2.3 % of reading + 58 MΩ 4 % of reading + 0.58 GΩ	High Voltage Decade Resistance Box
DC Voltage Measure	(0 to 200) mV 200 mV to 2 V (2 to 20) V (20 to 200) V (200 to 1 000) V	5.1 μV/V + 0.42 μV 3.5 μV/V + 1.4 μV 3.5 μV/V + 18 μV 5.5 μV/V + 0.12 mV 5.5 μV/V + 1.9 mV	8508A Multimeter
DC Voltage Measure <sup>1</sup>	(0 to 30) mV (30 to 300) mV 300 mV to 3.3 V (3.3 to 33) V (33 to 330) V (330 to 1 000) V	52 μV/V + 4.4 μV 41 μV/V + 7.1 μV 29 μV/V + 28 μV 47 μV/V + 38 mV 64 μV/V + 4.4 mV 1.2 mV/V + 0.26 V	3457A/189 Multimeter
DC High Voltage Measure <sup>1</sup>	(0 to 10) kV	5.8 mV/V + 4.0 V	149-10A High Voltage Meter
DC Voltage Source	(0 to 220) mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	7.8 μV/V + 0.63 μV 6.3 μV/V + 1.1 μV 6.3 μV/V + 6.6 μV 6.24 μV/V + 9.4 μV 7.1 μV/V + 97 μV 8.6 μV/V + 0.75 mV	5700A Multi Product Calibrator
DC Voltage Source <sup>1</sup>	(0 to 330) mV (0.33 to 3.3) V (3.3 to 33) V (33 to 330) V (330 to 1 000) V	16 μV/V + 1.4 μV 9.2 μV/V + 1.7 μV 11 μV/V + 17 μV 15 μV/V + 0.13 mV 15 μV/V + 1.4 mV	5522A Multi Product Calibrator



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AC Voltage Measure	<200 mV		8508A Multimeter
	(10 to 40) Hz	0.013 % of reading + 5.8 $\mu$ V	
	(40 to 100) Hz	0.011 % of reading + 5.3 $\mu$ V	
	100 Hz to 2 kHz	0.011 % of reading + 4 $\mu$ V	
	(2 to 10) kHz	0.013 % of reading + 5.2 $\mu$ V	
	(10 to 30) kHz	0.031 % of reading + 8.5 $\mu$ V	
	(30 to 100) kHz	0.067 % of reading + 21 $\mu$ V	
	200 mV to 2 V		
	(1 to 10) Hz	0.015 % of reading + 0.12 mV	
	(10 to 40) Hz	0.011 % of reading + 32 $\mu$ V	
	(40 to 100) Hz	0.008 5 % of reading + 39 $\mu$ V	
	100 Hz to 2 kHz	0.007% of reading + 31 $\mu$ V	
	(2 to 10) kHz	0.011 % of reading + 31 $\mu$ V	
	(10 to 30) kHz	0.021 % of reading + 46 $\mu$ V	
	(30 to 100) kHz	0.05 % of reading + 0.20mV	
	(100 to 300) kHz	0.24 % of reading + 1.9 mV	
	300 kHz to 1 MHz	0.78 % of reading + 19 mV	
	(2 to 20) V		
	(40 to 100) Hz	0.0086 % of reading + 0.57 mV	
	100 to 2 kHz	0.007 % of reading + 0.33 mV	
	(2 to 10) kHz	0.011 % of reading + 0.37 mV	
(10 to 30) kHz	0.021 % of reading + 0.47 mV		
(30 to 100) kHz	0.051 % of reading + 2.0 mV		
(100 to 300) kHz	0.24 % or reading + 19 mV		
300 kHz to 1 MHz	0.78% of reading + 0.19 V		
(20 to 200) V			
(40 to 100) Hz	0.0086 % of reading + 3.2 mV		
100 Hz to 2 kHz	0.007% of reading + 3.2 mV		
(2 to 10) kHz	0.011 % of reading + 3.2 mV		
(10 to 30) kHz	0.021 % of reading + 4.7 mV		
(30 to 100) kHz	0.051 % of reading + 20 mV		
(200 to 1 000) V			
(10 to 40) Hz	0.011 % of reading + 35 mV		
40 Hz to 10 kHz	0.011 % of reading + 34 mV		
(10 to 30) kHz	0.021 % of reading + 47 mV		



ANSI National Accreditation Board

Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage Measure <sup>1</sup>	<30 mV		3457A/189 Multimeter
	(20 Hz to 45) Hz	0.76 % of reading + 20 μV	
	(45 Hz to 100) Hz	0.36 % of reading + 20 μV	
	(100 Hz to 400) Hz	0.27 % of reading + 20 μV	
	400 Hz to 20 kHz	0.28 % of reading + 20 μV	
	(20 kHz to 100) kHz	0.89 % of reading + 32 μV	
	(100 kHz to 300) kHz	3.8 % of reading + 0.12 mV	
	300 kHz to 1 MHz	12 % of reading + 0.77 mV	
	(30 to 300) mV		
	(20 to 45) Hz	0.76 % of reading + 0.2 mV	
	(45 to 400) Hz	0.27 % of reading + 0.2 mV	
	400 Hz to 20 kHz	0.28 % of reading + 0.2 mV	
	(20 to 100) kHz	0.88 % of reading + 0.32 mV	
	(100 to 300) kHz	3.8 % of reading + 1.2 mV	
	300 kHz to 1 MHz	12 % of reading + 8.4 mV	
	300 mV to 3 V		
	(20 to 45) Hz	0.76 % of reading + 2 mV	
	(45 to 100) Hz	0.36 % of reading + 2 mV	
	(100 to 400) Hz	0.27 % of reading + 2 mV	
	400 Hz to 20 kHz	0.28 % of reading + 2.1 mV	
	(20 to 100) kHz	0.88 % of reading + 3.2 mV	
	(100 to 300) kHz	3.8 % of reading + 12 mV	
	300 kHz to 1 MHz	12 % of reading + 78 mV	
	(3 to 30) V		
	(20 to 45) Hz	0.76 % of reading + 20 mV	
	(45 to 100) Hz	0.36 % of reading + 20 mV	
	(100 Hz to 400) Hz	0.27 % of reading + 20 mV	
	400 Hz to 20 kHz	0.28 % of reading + 20 mV	
(20 to 100) kHz	0.88 % of reading + 32 mV		
(100 to 300) kHz	3.8 % of reading + 0.12 V		
300 kHz to 1 MHz	12 % of reading + 0.77 V		
(30 to 300) V			
(20 to 45) Hz	0.84 % of reading + 0.2 V		
(45 to 100) Hz	0.44 % of reading + 0.2 V		
(100 to 400) Hz	0.35 % of reading + 0.2 V		
400 Hz to 20 kHz	0.36 % of reading + 0.2 V		
(20 to 100) kHz	1.4 % of reading + 0.5 V		
(300 to 1 000) V			
45 Hz to 1 kHz	0.47 % of reading + 4.7 V		
(1 to 10) kHz	0.47 % of reading + 4.7 V		



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Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC High Voltage Measure <sup>1</sup>	(0 to 10) kV (50 to 60) Hz	1.2 % of reading + 6.6 V	149-10A High Voltage Meter
AC Voltage Source	(0.22 to 2.2) mV (10 to 20) Hz (20 to 50) Hz 50 Hz to 10 kHz (10 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 30) Hz (30 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100v kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) 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 220 mV to 2.2 V (10 Hz to 20) Hz (20 Hz to 40) Hz (40 Hz to 50) Hz (50 Hz to 60) Hz 60 Hz to 10 kHz	0.15 % of reading + 3.9 μV 0.11 % of reading + 3.9 μV 0.11 % of reading + 3.9 μV 0.11% of reading + 4.0 μV 0.19 % of reading + 3.9 μV 0.26 % of reading + 6.3 μV 0.45 % of reading + 12 μV 0.66 % of reading + 24 μV 0.85 % of reading + 31 μV 0.048 % of reading + 4.7 μV 0.021 % of reading + 4.7 μV 0.021 % of reading + 4.7 μV 0.013 % of reading + 4.7 μV 0.033 % of reading + 4.7 μV 0.075 % of reading + 6.2 μV 0.29 % of reading + 12 μV 0.31 % of reading + 24 μV 0.57 % of reading + 31 μV 0.047 % of reading + 13 μV 0.019 % of reading + 7.8 μV 0.009 % of reading + 7.8 μV 0.029 % of reading + 7.8 μV 0.07 % of reading + 24 μV 0.28 % of reading + 24 μV 0.3 % of reading + 31 μV 0.52 % of reading + 78 μV 0.047 % of reading + 78 μV 0.015 % of reading + 24 μV 0.007 % of reading + 6.2 μV 0.007 % of reading + 5.7 μV 0.007 % of reading + 5.6 μV	5700A/5522A Multi Product Calibrator



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Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage Source	220 mV to 2.2 V		5700A/5522A Multi Product Calibrator
	(10 to 20) kHz	0.007 % of reading + 5.7 $\mu$ V	
	(20 to 50) kHz	0.011 % of reading + 16 $\mu$ V	
	(50 to 100) kHz	0.022 % of reading + 62 $\mu$ V	
	(100 to 300) kHz	0.041 % of reading + 0.12 mV	
	(300 to 500) kHz	0.095 % of reading + 0.31 mV	
	500 kHz to 1 MHz	0.19 % of reading + 0.78 mV	
	2.2 to 22 V		
	10 Hz	0.047 % of reading + 0.79 mV	
	(10 to 20) Hz	0.047 % of reading + 0.78 mV	
	(20 to 30) Hz	0.014 % of reading + 0.24 mV	
	(30 to 40) Hz	0.014 % of reading + 0.24 mV	
	(40 to 50) Hz	0.007% of reading + 59 $\mu$ V	
	(50 to 60) Hz	0.007% of reading + 57 $\mu$ V	
	(60 to 400) Hz	0.007% of reading + 58 $\mu$ V	
	400 Hz to 1 kHz	0.007% of reading + 56 $\mu$ V	
	(1 to 5) kHz	0.007% of reading + 57 $\mu$ V	
	(5 to 10) kHz	0.007% of reading + 55 $\mu$ V	
	(10 to 20) kHz	0.007% of reading + 57 $\mu$ V	
	(20 to 50) kHz	0.012 % of reading + 0.16 mV	
	(50 to 100) kHz	0.022 % of reading + 0.31 mV	
	(100 to 300) kHz	0.053 % of reading + 1.4 mV	
	(300 to 500) kHz	0.12 % of reading + 3.9 mV	
	500 kHz to 1 MHz	0.24 % of reading + 7 mV	
	22 to 220 V		
	(10 to 20) Hz	0.047 % of reading + 7.8 mV	
	(20 to 40) Hz	0.015 % of reading + 2.4 mV	
	(40 to 50) Hz	0.0074 % of reading + 0.81 mV	
(50 to 60) Hz	0.0074 % of reading + 0.81 mV		
(60 to 400) Hz	0.0074 % of reading + 0.78 mV		
400 Hz to 1 kHz	0.0074 % of reading + 0.79 mV		
(1 to 5) kHz	0.0074 % of reading + 0.81 mV		
(5 to 10) kHz	0.0074 % of reading + 0.79 mV		
(10 to 20) kHz	0.0074 % of reading + 0.8 mV		
(20 to 50) kHz	0.02 % of reading + 3.1 mV		
(50 to 100) kHz	0.047 % of reading + 7.8 mV		

**Electrical – DC/Low Frequency**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage Source <sup>1</sup>	(1 to 33) mV		5522A Multi Product Calibrator
	(10 to 45) Hz	0.064 % of reading + 4.7 $\mu$ V	
	45 Hz to 10 kHz	0.017 % of reading + 4.7 $\mu$ V	
	(10 to 20) kHz	0.02 % of reading + 4.7 $\mu$ V	
	(20 to 50) kHz	0.08 % of reading + 4.8 $\mu$ V	
	(50 to 100) kHz	0.28 % of reading + 9.7 $\mu$ V	
	(100 to 450) kHz	0.63 % of reading + 39 $\mu$ V	
	(33 to 330) mV		
	(10 to 45) Hz	0.024 % of reading + 6.3 $\mu$ V	
	45 Hz to 10 kHz	0.012 % of reading + 6.3 $\mu$ V	
	(10 to 20) kHz	0.014% of reading + 6.3 $\mu$ V	
	(20 to 50) kHz	0.028% of reading + 6.3 $\mu$ V	
	(50 to 100) kHz	0.063 % of reading + 25 $\mu$ V	
	(100 to 500) kHz	0.16 % of reading + 55 $\mu$ V	
	330 mV to 3.3 V		
	(10 to 45) Hz	0.024 % of reading +43 $\mu$ V	
	45 Hz to 10 kHz	0.012 % of reading + 49 $\mu$ V	
	(10 to 20) kHz	0.015 % of reading + 50 $\mu$ V	
	(20 to 50) kHz	0.024 % of reading + 40 $\mu$ V	
	(50 to 100) kHz	0.055 % of reading + 99 $\mu$ V	
	(100 to 500) kHz	0.19 % of reading + 0.47 mV	
	(3.3 to 33) V		
	(10 to 45) Hz	0.024 % of reading + 0.51 mV	
	45 Hz to 10 kHz	0.012 % of reading + 0.47 mV	
(10 to 20) kHz	0.019 % of reading + 0.47 mV		
(20 to 50) kHz	0.028 % of reading + 0.47 mV		
(50 to 100) kHz	0.072 % of reading + 1.5 mV		
(33 to 330) V			
45 Hz to 1kHz	0.16 % of reading + 1.6 mV		
(1 to 10) kHz	0.016 % of reading + 4.7 mV		
(10 to 20) kHz	0.02 % of reading + 4.7 mV		
(20 to 50) kHz	0.024 % of reading + 4.7 mV		
(50 to 100) kHz	0.16 % of reading + 39 mV		
(330 to 1 000) V			
45 Hz to 1kHz	0.024 % of reading + 7.9 mV		
(1 to 5) kHz	0.02 % of reading + 8.4 mV		
(5 to 10) kHz	0.024 % of reading + 8 mV		

Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Millivolt Simulation of Thermocouple Temperature Measuring Instrumentation	Type B		5522A Multi Product Calibrator
	(600 to 800) °C	1.8 °C	
	(800 to 1 000) °C	1.8 °C	
	(1 000 to 1 500) °C	1.7 °C	
	(1 550 to 1 820) °C	1.8 °C	
	Type C		
	(0 to 150) °C	1.7 °C	
	(150 to 650) °C	1.7 °C	
	(650 to 1 000) °C	1.7 °C	
	(1 000 to 1 800) °C	1.8 °C	
	(1 800 to 2 316) °C	1.9 °C	
	Type E		
	(-250 to -100) °C	0.5 °C	
	(-100 to -25) °C	0.3 °C	
	(-25 to 350) °C	0.3 °C	
	(350 to 650) °C	0.3 °C	
	(650 to 1 000) °C	0.3 °C	
	Type J		
	(-210 to -100) °C	0.3 °C	
	(-100 to -30) °C	0.3 °C	
	(-30 to 150) °C	0.3 °C	
	(150 to 760) °C	0.3 °C	
	(760 to 1 200) °C	0.3 °C	
	Type K		
	(-200 to -100) °C	0.4 °C	
	(-100 to -25) °C	0.3 °C	
	(-25 to 120) °C	0.3 °C	
	(120 to 1 000) °C	0.4 °C	
(1 000 to 1 372) °C	0.4 °C		
Type L			
(-200 to -100) °C	1.8 °C		
(-100 to 800) °C	1.7 °C		
(800 to 900) °C	1.7 °C		
Type N			
(-200 to -100) °C	0.5 °C		
(-100 to -25) °C	0.4 °C		
(-25 to 120) °C	0.4 °C		
(120 to 410) °C	0.4 °C		
(410 to 1 300) °C	0.4 °C		



**Electrical – DC/Low Frequency**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Millivolt Simulation of Thermocouple Temperature Measuring Instrumentation	Type R (0 to 250) °C	2.5 °C	5522A Multi Product Calibrator
	(250 to 400) °C	2.4 °C	
	(400 to 1 000) °C	2.4 °C	
	(1 000 to 1 767) °C	2.4 °C	
	Type S (0 to 250) °C	2.4 °C	
	(250 to 1 000) °C	2.4 °C	
	(1 000 to 1 400) °C	2.4 °C	
	(1 400 to 1 767) °C	2.4 °C	
	Type T (-250 to -150) °C	0.6 °C	
	(-150 to 0) °C	0.3 °C	
	(0 to 120) °C	0.3 °C	
	(120 to 400) °C	0.3 °C	
	Type U (-200 to 0) °C	1.8 °C	
(0 to 600) °C	1.7 °C		
Source and Measure Millivolt Simulation of Thermocouple Temperature Measuring Instrumentation <sup>1</sup>	Type B (600 to 800) °C	3.2 °C	725 Process Calibrator
	(800 to 1 000) °C	2.8 °C	
	(1 000 to 1 800) °C	2.5 °C	
	Type E (-200 to 0) °C	1.1 °C	
	(0 to 950) °C	0.8 °C	
	Type J (-200 to 0) °C	1.2 °C	
	(0 to 1 200) °C	0.9 °C	
	Type K (-200 to 0) °C	1.4 °C	
	(0 to 1370) °C	1 °C	
	Type L (-200 to 0) °C	2 °C	
	(0 to 900) °C	1.9 °C	
	Type N (-200 to 0) °C	1.8 °C	
	(0 to 400) °C	1.1 °C	



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Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment	
Source and Measure Millivolt Simulation of Thermocouple Temperature Measuring Instrumentation <sup>1</sup>	Type R (-20 to 0) °C	3.9 °C	725 Process Calibrator	
	(0 to 500) °C	3.3 °C		
	(500 to 1 750) °C	3 °C		
	Type S (-20 to 0) °C	3.8 °C		
	(0 to 500) °C	3.3 °C		
	(500 to 1 750) °C	3.1 °C		
Type T (-200 to 0) °C	(0 to 400) °C	1.2 °C	5522A Multi Product Calibrator	
	(0 to 400) °C	1 °C		
	Type U (-200 to 0) °C	2.1 °C		
	(0 to 400) °C	1.9 °C		
	Capacitance Source <sup>1</sup> 10 Hz to 10 kHz (0.22 to 0.4) nF	2 % of reading + 7.8 pF		5522A Multi Product Calibrator
	10 Hz to 10 kHz (0.4 to 1.1) nF	0.63% of reading + 7.8 pF		
10 Hz to 3 kHz (1.1 to 3.3) nF	0.46 % of reading + 7.8 pF			
10 Hz to 1 kHz (3.3 to 11) nF	0.21 % of reading + 9.7 pF			
10 Hz to 1 kHz (11 to 110) nF	0.21 % of reading + 97 pF			
10 Hz to 1 kHz (110 to 330) nF	0.21 % of reading + 0.63 nF			
(10 to 600) Hz (0.33 to 1.1) μF	0.21 % of reading + 0.97 nF			
(10 to 300) Hz (1.1 to 3.3) μF	0.21 % of reading + 6.3 nF			
(10 to 150) Hz (3.3 to 11) μF	0.21 % of reading + 9.7 nF			
(10 to 120) Hz (11 to 33) μF	0.32 % of reading + 62 nF			
(10 to 80) Hz (33 to 110) μF	0.38 % of reading + 97 nF			
50 Hz (110 to 330) μF	0.37 % of reading + 0.63 μF			
20 Hz (0.33 to 1.1) mF	0.36 % of reading + 1.1 μF			
6 Hz (1.1 to 3.3) mF	0.35 % of reading + 6.3 μF			
2 Hz (3.3 to 11) mF	0.35 % of reading + 9.7 μF			
0.6 Hz (11 to 33) mF	0.59 % of reading + 24 μF			
0.2 Hz (33 to 110) mF	0.85 % of reading + 78 μF			
DC Power Source <sup>1</sup> PF = 1	(0 to 90) W	0.018 % of reading + 1 mW	5522A Multi Product Calibrator	
	(90 to 150) W	0.018 % of reading + 7.1 mW		
	(150 to 600) W	0.018 % of reading + 7.6 mW		
	600 W to 6 kW	0.055 % of reading + 58 mW		
	(6 to 12) kW	0.07 % of reading + 0.58 W		



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Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Power Source <sup>1</sup> (45 to 65) Hz PF = 1, Single Phase	(0 to 90) W (90 to 150) W (150 to 600) W 600 W to 6 kW (6 to 12) kW	0.071 % of reading + 2.2 mW 0.071 % of reading + 7.6 mW 0.079 % of reading + 12 mW 0.079 % of reading + 58 mW 0.079 % of reading + 0.58 W	5522A Multi Product Calibrator
LCR Meters <sup>1</sup> Capacitance (1 to 10) kHz (10.01 to 100) kHz (100 to 999.9) Hz (1 to 10) kHz (10.01 to 100) kHz (100 to 999.9) Hz (1 to 10) kHz (10.01 to 100) kHz (100 to 999.9) Hz (1 to 10) kHz (10.01 to 100) kHz (100 to 999.9) Hz (1 to 10) kHz (10.01 to 100) kHz 100 Hz to 10 kHz (10.01 to 100) kHz 100 Hz to 10 kHz 100 Hz to 10 kHz	1 pF 1 pF 10 pF 10 pF 10 pF 100 pF 100 pF 100 pF 1000 pF 1000 pF 1000 pF 10 nF 10 nF 100 nF 100 nF 100 nF 1 μF	0.12 % of reading + 0.000 14 pF 0.59 % of reading + 0.000 14 pF 0.12% of reading + 0.000 14 pF 0.12 % of reading + 0.000 14 pF 0.48 % of reading + 0.001 3 pF 0.12% of reading + 0.013 pF 0.12% of reading + 0.013 pF 0.37% of reading + 0.013 pF 0.12% of reading + 0.014 pF 0.12% of reading + 0.014 pF 0.36% of reading + 0.014 pF 0.12 % of reading + 0.001 3 nF 0.35 % of reading + 0.0013 nF 0.12 % of reading + 0.013 nF 0.19 % of reading + 0.14 nF	Standard Air Capacitor
LCR Meters <sup>1</sup> Resistance (100 to 999.9) Hz 1 kHz (>1 to 100) kHz (100 to 999.9) Hz 1 kHz >1 kHz to 100 kHz (100 to 999.9) Hz 1 kHz (>1 to 100) kHz (100 to 999.9) Hz 1 kHz 1 kHz	10 Ω 10 Ω 10 Ω 100 Ω 100 Ω 100 Ω 1 kΩ 1 kΩ 1 kΩ 10k Ω 10 kΩ 100 kΩ	0.033 % of reading + 2.4 mΩ 0.033 % of reading + 2.4 mΩ 0.33 % of reading + 2.4 mΩ 0.033 % of reading + 2.4 mΩ 0.033 % of reading + 2.4 mΩ 0.24% of reading + 2.4 mΩ 0.033 % of reading + 0.058 Ω 0.033% of reading + 0.058 Ω 0.24% of reading + 0.058 Ω 0.033 % of reading + 0.058 Ω 0.033 % of reading + 0.058 Ω 0.052 % of reading + 0.58 Ω	Decade Resistance Box
AC Inductance Measure/Decade Inductor <sup>1</sup>	(100 to 999.99) μH (1 to 9.99) mH (10 to 99.99) mH (100 to 999.99) mH (1 to 10) H	0.24 μH 2.6 μH 0.046 mH 0.12 mH 1.8 mH	LCR HiTester Hioki 3522-50 LCR Meter



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Electrical – DC/Low Frequency

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Capacitance Measure/Decade Capacitance <sup>1</sup>	(100 to 999.99) pF (1 to 9.99) nF (10 to 99.99) nF (100 to 999.99) nF (1 to 10) $\mu$ F	0.19 pF 1.00 pF 9.56 pF 0.095 nF 0.95 nF	LCR HiTester Hioki 3522-50 LCR Meter
AC Resistance Measure/Decade Resistance <sup>1</sup>	(10 to 99.99) m $\Omega$ (100 to 999.99) m $\Omega$ (1 to 9.99) $\Omega$ (10 to 99.99) $\Omega$ (100 to 999.99) $\Omega$ (1 to 10) k $\Omega$	0.012 m $\Omega$ 0.11 m $\Omega$ 1.1 m $\Omega$ 9.7 m $\Omega$ 0.097 $\Omega$ 0.97 $\Omega$	LCR HiTester Hioki 3522-50 LCR Meter
Oscilloscopes DC Signal 50 $\Omega$ Impedance 1 M $\Omega$ Impedance  Square Wave Signal 50 $\Omega$ at 1 kHz Source 1 M $\Omega$ at 1 kHz Source  Leveled Sine Wave Amplitude: 5 mVp-p to 5.5 Vp-p  Time Marker into 50 $\Omega$ <sup>2</sup>  Rise Time	(0 to $\pm$ 6.6) V (0 to $\pm$ 130) V  1 mVp-p to 6.6 Vp-p 1 mVp-p to 130 Vp-p  5 mVp-p to 5.5 Vp-p (50 kHz Reference) (50 kHz to 100 MHz) (100 to 300 MHz) (300 to 600 MHz)  5 s to 50 ms 20 ms to 2 ns  $\leq$ 300 ps	0.3 % of reading + 47 $\mu$ V 0.12 % of reading + 47 $\mu$ V  0.3 % of reading + 47 $\mu$ V 0.12 % of reading + 47 $\mu$ V  2.4 % of reading + 347 $\mu$ V 4.1 % of reading + 347 $\mu$ V 4.7 % of reading + 347 $\mu$ V 7 % of reading + 347 $\mu$ V  (23 + t*1 000) ps 2.9 ps  30 ps	Fluke 5522A Multi Product Calibrator
Gauss Tesla Meter	20 mT 100 mT 1 000 mT	0.23 mT 0.87 mT 5.8 mT	Reference Magnets

**Length – Dimensional Metrology**

**Bangkok, Thailand**

<b>Parameter / Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method and/or Equipment</b>
External Micrometers <sup>1</sup> Linearity	(0 to 300) mm (300 to 600) mm (600 to 1 000) mm	0.1 μm 1 μm 2 μm	Gauge Block
External Micrometers <sup>1</sup> Flatness Up to 25 mm diameter	(0 to 0.5) μm	0.2 μm	Optical Parallel or Optical Flat
External Micrometers <sup>1</sup> Parallelism Up to 50 mm diameter	(0 to 0.5) μm	0.2 μm	Optical Parallel
Calipers <sup>1</sup>	(0 to 1 000) mm (1 000 to 2 000) mm	1 μm 20 μm	Gauge Block and Caliper Checker
(Digital/Dial) Caliper Gauge <sup>1</sup>	(0 to 150) mm	0.001 mm	Gauge Block or Ring Gauge
Depth Micrometers	(0 to 300) mm	1 μm	Gauge Block
Stick/ Inside Micrometers	(0 to 600) mm	1 μm	Universal Length Measuring Machine (ULM)
Stick/ Inside Micrometers	(0 to 1 000) mm	3 μm	Gauge Blocks
Internal Micrometers 2 leg type	(0 to 200) mm	1 μm	Ring Gauge or Gauge Block
Micrometer Heads	(0 to 100) mm	1 μm	Universal Length Measuring Machine (ULM)
Micrometer Heads	(0 to 50) mm	1 μm	Gauge Blocks
Calibration Testers	(0 to 100) mm	0.7 μm	Linear Gauge and Gauge Block
Calibration Testers	(0 to 50) mm	0.7 μm	Gauge Blocks and Digimatic Indicator
Height Masters Micrometer Linearity Height Parallelism	(0 to 25) mm (0 to 300) mm (300 to 600) mm (0 to 0.02) mm	0.3 μm 0.7 μm 1.1 μm 0.2 μm	Comparison with Gauge Block
Screw Thread Micrometers	(0 to 100) mm	1 μm	Gauge Block or Pin Gauge
Caliper Checkers, Depth Micro Checker	(0 to 630) mm	0.6 μm	Comparison with Gauge Block

**Length – Dimensional Metrology**

**Bangkok, Thailand**

<b>Parameter / Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method and/or Equipment</b>
Height Gauges <sup>1</sup>	(0 to 1 000) mm	6 µm	Gauge Block or Caliper Checker
Linear Height Gauges <sup>1</sup>	(0 to 1 000) mm	1 µm	Gauge Block or Caliper Checker
Setting Master for Linear Height Gauges	(0 to 25) mm	0.4 µm	Gauge Block or Universal Length Measuring Machine (ULM)
Depth Gauges	(0 to 600) mm	5 µm	Gauge Block
MU Checker	Up to 5 mm	0.2 µm	Gauge Block or Calibration Tester
Dial Indicator	Up to 100 mm	0.5 µm	Dial Gauge Calibrator
Dial Test Indicator	Up to 3 mm	0.5 µm	Dial Gauge Calibrator
Digimatic Indicator <sup>1</sup> Linear Gauge	(0 to 30) mm (30 to 100) mm	0.2 µm	Gauge Block
Digital/Dial Thickness Gauges	(0 to 100) mm	1 µm	Gauge Block
Dial Gauge Calibrator <sup>1</sup>	(0 to 100) mm	0.2 µm	Gauge Block or Mu Checker
Dial Depth Gauges	(0 to 100) mm	2 µm	Gauge Block
Plain Plug Gauge / Pin Gauge Diameter	Up to 25 mm (25 to 50) mm (50 to 75) mm (75 to 100) mm (100 to 150) mm (150 to 200) mm (200 to 250) mm (250 to 300) mm (300 to 350) mm (350 to 400) mm	0.4 µm 0.5 µm 0.7 µm 0.9 µm 1.2 µm 1.6 µm 2 µm 2.3 µm 2.7 µm 3.1 µm	Universal Length Measuring Machine (ULM)
Pin Gauge Diameter	(0 to 25) mm	0.5 µm	Micrometer
Plain Plug Gauge / Pin Gauge Circularity	(0 to 1) mm	0.03 µm	Roundness Tester Machine
Thread Wires Diameter	Up to 10 mm	0.4 µm	Universal Length Measuring Machine (ULM)

**Length – Dimensional Metrology**

**Bangkok, Thailand**

<b>Parameter / Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method and/or Equipment</b>
Thread Wires Circularity	(0 to 1) mm	0.03 μm	Roundness Tester Machine
Plain Ring Gauges Diameter	(1 to 25) mm	0.5 μm	Universal Length Measuring Machine (ULM), Setting Ring Gauge
	(25 to 50) mm	0.6 μm	
	(50 to 75) mm	0.8 μm	
	(75 to 100) mm	0.9 μm	
	(100 to 125) mm	1.1 μm	
	(125 to 150) mm	1.3 μm	
	(150 to 175) mm	1.4 μm	
	(175 to 200) mm	1.6 μm	
	(200 to 225) mm	1.9 μm	
(225 to 250) mm	2 μm		
Plain Ring Gauges Circularity	(0 to 1) mm	0.03 μm	Roundness Tester Machine
Threaded Plug Gauges Major Diameter	(1 to 50) mm	0.8 μm	Universal Length Measuring Machine (ULM)
	(50 to 100) mm	1 μm	
	(100 to 150) mm	1.3 μm	
Tapered Ring Gauge Diameter	Up to 100 mm	1.3 μm	Universal Length Measuring Machine (ULM)
Tapered Ring Gauge Step Height	Up to 75mm	2 μm	Micrometer
Tapered Plug Gauge Diameter	Up to 75 mm	1.2 μm	Universal Length Measuring Machine (ULM)
Tapered Plug Gauge Step Height	Up to 75 mm	2 μm	Micrometer
Threaded Plug Gauges Pitch Diameter	(1 to 50) mm	1.2 μm	Universal Length Measuring Machine (ULM), Thread Wires
	(50 to 100) mm	1.4 μm	
	(100 to 150) mm	1.6 μm	
Tapered Thread Plug Gauges Pitch Diameter	Up to 150 mm	3.1 μm	Universal Length Measuring Machine (ULM)
Tapered Thread Plug Gauges Taper	(0 to 10) °	4 ‘	Profile Projector
Tapered Thread Plug Gauges Step Height	Up to 75 mm	2 μm	Micrometer

**Length – Dimensional Metrology**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Thread Ring Gauges Minor Diameter	Up to 50 mm (50 to 100) mm	2.5 µm 3.2 µm	Digimatic Holtest, Inside Micrometer
Thread Ring Gauges Pitch Diameter	Up to 50 mm (50 to 100) mm	1.1 µm 1.6 µm	Universal Length Measuring Machine (ULM) Master Thread Plug Gauge
	(1 to 3) mm	0.9 µm	
Tapered Thread Ring Gauges Step Height	Up to 75 mm	2 µm	Micrometer
Tapered Thread Ring Gauges Pitch Diameter	Up to 100 mm	1.6 µm	Universal Length Measuring Machine (ULM), Probing System
Feeler Gauges/ Shim Stock/ Calibration Foil	(0 to 5) mm	0.4 µm	Universal Length Measuring Machine (ULM) Outside Micrometer Gauge Block
Coating Thickness Gauge	Up to 1 500 µm	0.9 µm	Coating Thickness Standard
Surface Plates <sup>1</sup> Overall Flatness Local Area Flatness (Repeat Reading)	Up to 4 m Diagonal Up to 0.1 µm	1.5 µm 1 µm	Planekator (Straight Edge) or Mu-Checker Repeat-O-Meter
Dial Gauge Stands <sup>1</sup> Flatness	Up to 1 mm	0.3 µm	Mu-Checker or Dial Test Indicator
Profile Projectors <sup>1</sup> (Optical Comparators) Linearity (X, Y-axis) Magnification Angle	(0 to 500) mm 10X, 20X, 50X, 100X (0 to 180) °	1.3 µm 0.02 % magnification 1.5 ‘	Glass Scale Gauge Block
Measuring Microscopes <sup>1</sup> Linearity	X-axis (0 to 500) mm Y-axis (0 to 500) mm Z-axis (0 to 300) mm	2 µm 2 µm 2 µm	Glass Scale, Gauge Block
Bore Gauges	(0 to 300) mm	1 µm	Height Setting Micrometer or Micrometer
Holtest / Borematic	(2 to 50) mm	1 µm	Setting Ring Gauge
	(50 to 100) mm	1 µm	
	(100 to 150) mm	2 µm	
Straight Edges	Up to 1 000 mm	0.2 µm	Mu-Checker or Dial Test Indicator



**Length – Dimensional Metrology**

**Bangkok, Thailand**

<b>Parameter / Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method and/or Equipment</b>
Steel Rules	(0 to 1 500) mm (1 500 to 2 000) mm	0.01 mm 0.06 mm	Linear Scale or Profile Projector
Measuring Tape / Textile Tape	Up to 50 m	0.17 mm	Linear Scale
Squares To 450 mm / 18 in Lengths Parallelism/Straightness Squareness	(0 to 10) mm (0 to 450) mm	1.7 µm 3 µm	Granite Square
Universal Length Measuring Machines (ULM) <sup>1</sup>	(0 to 100) mm (100 to 125) mm (125 to 150) mm (150 to 175) mm (175 to 200) mm (200 to 250) mm (250 to 300) mm (300 to 400) mm (400 to 500) mm	0.26 µm 0.48 µm 0.54 µm 0.6 µm 0.67 µm 0.8 µm 0.93 µm 1.2 µm 1.5 µm	Gauge Block
Micrometer Setting (End) Rods	(25 to 1 00) mm (100 to 1 000) mm	0.3 µm 0.5 µm	Mu-Checker and Gauge Block
Bevel Protractors Up to 300 mm	0 to 360 °	3 ‘	Profile Projector or Angle Gauge
Inclinometers	(0 to 90) °	0.05 °	Angle Gauge
Analog Levels to 300 mm	(0 to 0.01) mm/m	0.01 mm/m	Sine bar and Gauge Block
Gauge Block Comparators <sup>1</sup>	(0.5 to 100) mm	0.05 µm	Gauge Block
Gauge Blocks (Dissimilar & Similar Material)	(0.5 to 10) mm (10 to 25) mm (25 to 50) mm (50 to 75) mm (75 to 100) mm	0.06 µm 0.07 µm 0.09 µm 0.11 µm 0.13 µm	Comparison with Grade K
Long Gage Blocks (Dissimilar & Similar Material)	125 mm 150 mm 175 mm	0.12 µm 0.13 µm 0.15 µm	Gauge Block Comparator

**Length – Dimensional Metrology**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Long Gage Blocks (Dissimilar & Similar Material)	125 mm 150 mm 175 mm 200 mm 250 mm 300 mm 400 mm 500 mm	0.31 μm 0.32 μm 0.32 μm 0.34 μm 0.36 μm 0.38 μm 0.43 μm 0.5 μm	Universal Length Measuring Machine (ULM)
Angle Block	(0.25 to 90) °	15 “	CMM
Optical Flats/Parallels Flatness Thickness Parallelism	To 10 μm  To 1 mm	0.1 μm 0.4 μm 0.1 μm	Optical Flat
Sine Bars Roll Distance Parallelism	(25 to 300) mm (0 to 0.01) mm	0.4 μm 1.8 μm	Gauge Block and Dial Test Indicator Universal Length Measuring Machine (ULM)
Vee Blocks To 150 mm Lengths Parallelism of Top Parallelism of Vee Squareness of Sides Centrality of Vee	(0 to 0.01) mm	1 μm	Dial Test Indicator
Parallels Straightedge	Up to 1 000 mm	1.7 μm	Dial Test Indicator and Surface Plate
Bench Centers Height Centrality	Up to 1 000 mm Up to 200 mm	2 μm	Concentric Gauge
Surface Roughness Testers <sup>1</sup>	Up to 1 000 μm	0.019 μm	Roughness Standard
Surface Roughness Standards	Up to 15 μm	0.02 μm	Roughness Tester
Roundness Machines <sup>1</sup>	Up to 200 mm	0.02 μm	Glass Hemisphere
Magnification Checker (for Roundness Machines)	(0 to 0.4) mm	0.7 μm	Mu Checker
Contour Measuring Machines <sup>1</sup> Straightness	X Axis Up to 100 mm Z Axis Up to 60 mm	0.3 μm 2.6 μm	Contour Standard
Radius	Up to 10 mm	0.5 μm	

**Length – Dimensional Metrology**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Air Gauges <sup>1</sup>	Up to 5 mm	0.5 µm	Gauge Block or Dial Gauge
Coordinate Measuring Machines <sup>1</sup> Length	X: (0 to 1 500) mm Y: (0 to 1 500) mm Z: (0 to 1 000) mm	1.5 µm	Gauge Blocks, Step Gage, Sphere
Probing Angle	(0 to 10) µm (0 to 90) °	0.04 µm 4 ''	
Glass Scale	(0 to 100) mm (0 to 200) mm (0 to 300) mm	1.4 µm 1.6 µm 2.1 µm	Profile Projector
Parallel Bar	Up to 300 mm	1 µm	Dial Test or Micrometer

**Mass and Mass Related**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Scales and Balances <sup>1,4</sup>	(0 to 20) g (20 to 200) g (200 to 400) g (400 to 1 000) g (1 000 to 5 000) g (5 to 10) kg (10 to 50) kg (50 to 300) kg (300 to 1 000) kg (1 000 to 2 000) kg	0.035 mg 0.28 mg 0.001 g 0.004 g 0.41 g 0.014 g 0.1 g 0.009 kg 0.04 kg 0.05 kg	Standard Weight
Torque Wrenches <sup>1</sup>	(0 to 10) N·m (10 to 50) N·m (50 to 200) N·m (200 to 500) N·m (500 to 1 000) N·m	0.014 N·m 0.3 N·m 0.61 N·m 1.5 N·m 3.5 N·m	Torque Transducer
Torque Meter / Gauge <sup>1</sup>	Up to 2 N·m Up to 10 N·m (10 to 100) N·m (100 to 1 000) N·m	0.06 cN·m 0.006 N·m 0.013 N·m 0.06 N·m	Torque Arm or Torque Transducer

**Mass and Mass Related**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Force Testing Machines <sup>1</sup> and Load Cells Compression and Tension <sup>1</sup>	(0 to 10) N (10 to 100) N (100 to 1 000) N (1 to 5) kN (5 to 10) kN (10 to 50) kN (50 to 100) kN (100 to 250) kN	0.006 N 0.06N 2.3 N 0.005 kN 0.001 kN 0.048 kN 0.11 kN 0.05 kN	Direct measurement to reference load cell or Standard Weight
Force Gauges	(0 to 100) N (100 to 200) N (200 to 500) N (500 to 1 000) N (1 000 to 5 000) N	0.007 N 0.07 N 0.07 N 0.7 N 1.1 N	Reference Masses
Rockwell Hardness Testers <sup>1</sup>	(10 to 100) HRBW (20 to 95) HRA (10 to 70) HRC	0.5 HRBW 0.5 HRA 0.5 HRC	Hardness Test Block
Brinell Hardness Testers <sup>1</sup>	(100 to 600) HBW	1.4 HBW	Hardness Test Block
Vickers Hardness Testers <sup>1</sup>	(100 to 1 000) HV	1.1 HV	Hardness Test Block
Durometer Force (expressed as degrees or percentage of scale pointer rotation)	(0 to 100) ° (%)	0.12 °(%)	Standard Weight
Pressure/Vacuum Gauges <sup>1</sup>	(-1 to 0) bar (0 to 0.7) bar (0.7 to 70) bar	0.006 bar 0.12 mbar 0.002 2 bar	Pneumatic Pressure Calibrator
	(70 to 1 500) bar	0.6 bar	Hydraulic Gage Comparison
Mass Artifacts	(1, 2, 5) mg 10 mg 20 mg 50 mg 100 mg (200, 500) mg, 1 g	0.008 mg 0.009 mg 0.009 mg 0.01 mg 0.01 mg 0.02 mg	OIML R111:2004 ABBA Method to Class F1

**Mass and Mass Related**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Mass Artifacts	2 g 5 g 10 g 20 g 50 g 100 g 200 g 500 g 1 kg 2 kg 5 kg 10 kg	0.03 mg 0.04 mg 0.04 mg 0.05 mg 0.07 mg 0.1 mg 0.2 mg 1.2 mg 1.3 mg 2 mg 5 mg 10 mg	OIML R111:2004 ABBA Method to Class F1
	20 kg	61 mg	OIML R111:2004 ABBA Method to Class F2
Mass Flow Rate <sup>1</sup>	(0.5 to 592) mg/min (0.5 to 59.2) g/min (60 to 592) g/min	0.8 % of reading + 2.5 mg/min 0.8 % of reading + 0.25 g/min 0.8 % of reading + 2.1 g/min	Standard Flow Meter
Volumetric Flow Rate <sup>1</sup> Gas	(5 to 500) SCCM (0.5 to 50) LPM (50 to 500) LPM	0.8 % of reading + 2 ml/min 0.6 % of reading + 0.21 l/min 0.8 % of reading + 1.8 l/min	Standard Flow Meter
Burette	(1 to 10) ml (>10 to 25) ml (>25 to 50) ml (>50 to 100) ml	0.003 7 ml 0.006 5 ml 0.01 ml 0.019 ml	Precision Balance ASTM E542-01
Graduated Pipette	(0.1 to 1) ml (>1 to 5) ml (>5 to 10) ml (>10 to 25) ml	0.002 6 ml 0.003 ml 0.041 ml 0.006 7 ml	Precision Balance ASTM E542-01
Measuring Cylinder	(1 to 25) ml (>25 to 50) ml (>50 to 100) ml (>100 to 200) ml (>200 to 500) ml (>500 to 1 000) ml (>1 000 to 2 000) ml	0.015 ml 0.021 ml 0.033 ml 0.046 ml 0.083 ml 0.17 ml 0.33 ml	Precision Balance ASTM E542-01

**Mass and Mass Related**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Volumetric Flask	(1 to 10) ml	0.006 ml	Precision Balance ASTM E542-01
	(>10 to 25) ml	0.006 8 ml	
	(>25 to 50) ml	0.011 ml	
	(>50 to 100) ml	0.018 ml	
	(>100 to 200) ml	0.029 ml	
	(>200 to 500) ml	0.064 ml	
	(>500 to 1 000) ml	0.13 ml	
	(>1 000 to 2 000) ml	0.26 ml	
Volumetric Pipette	(1 to 5) ml	0.003 ml	Precision Balance ASTM E542-01
	(>5 to 10) ml	0.003 9 ml	
	(>10 to 25) ml	0.006 5 ml	
	(>25 to 50) ml	0.011 ml	
	(>50 to 100) ml	0.017 ml	
Micropipette	(10 to 100) µl	0.12 µl	Precision Balance ISO 8655-6
	(>100 to 500) µl	0.21 µl	
	(>500 to 1 000) µl	0.5 µl	
	(>1 000 to 5 000) µl	0.74 µl	
	(>5 000 to 10 000) µl	1.1 µl	

**Photometry and Radiometry**

**Bangkok, Thailand**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Lux/Light Meter	(0 to 200) lux	2.9 lux	Lux Meter
	(200 to 1 000) lux	16 lux	
	(1 000 to 2 000) lux	31 lux	
	(2 000 to 36 000) lux	47 lux	

**Thermodynamic**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Temperature Measure <sup>1</sup> System Accuracy Tests of Chambers, Ovens, Freezers, Incubators, or Refrigerators	(-40 to 100) °C	0.9 °C	Datalogger with Thermocouple Sensors
	(100 to 200) °C	1.9 °C	
	(200 to 600) °C	3.5 °C	



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**Thermodynamic**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Humidity Measure 1 System Accuracy Tests of Chambers, Ovens, Freezers, Incubators, or Refrigerators	(20 to 85) %RH	3.5 %RH	Datalogger with Humidity Sensors
Temperature Measure 1 System Accuracy Tests of Enclosures or Furnaces	(-40 to 100) °C (100 to 200) °C (200 to 600) °C (600 to 1 000) °C	1 °C 1.8 °C 3.3 °C 2.8 °C	Datalogger with Thermocouple Sensors
Infrared (IR) Thermometers	50 °C 100 °C 150 °C 200 °C 250 °C 300 °C 350 °C 500 °C	2.4 °C 2.4 °C 2.4 °C 2.4 °C 2.4 °C 2.4 °C 2.4 °C 4 °C	Blackbody Source and reference thermocouple thermometer $\epsilon = 0.95, \lambda = (8 \text{ to } 14) \mu\text{m}$
Thermohygrometers	(30 to 95) %RH @ 25 °C (15 to 45) °C @ 50 %RH	1.5 %RH 0.1 °C	Rotronic Thermohygrometer Reference PRT with Yokogawa Display
RTD Based Temperature Measuring Systems 1	(-20 to 95) °C	0.06 °C	Temperature Baths
	(95 to 200) °C	0.08 °C	
	(-20 to 140) °C (140 to 400) °C (400 to 600) °C	0.22 °C 0.5 °C 1.5 °C	Dry Block
Dry Block Calibrators	(-20 to 400) °C (400 to 650) °C	0.17 °C 1.4 °C	Reference PRT
Surface Type Thermocouple Based Temperature Measuring Systems 1 (Up to 60 mm long)	(50 to 350) °C	2.3 °C	Surface Probe Calibrator
Base Metal Thermocouple Based Temperature Measuring Systems 1	Types E, J, K, N, & T (-20 to 95) °C	0.23 °C	Temperature Baths
	(95 to 200) °C	0.47 °C	
Base Metal Thermocouple Based Temperature Measuring Systems 1	Types E, J, K, N, & T (-20 to 140) °C	0.39 °C	Dry Block
	(140 to 400) °C	1 °C	
	(400 to 600) °C	2 °C	
	(600 to 1 000) °C	3.3 °C	
	(1 000 to 1 200) °C	4.9 °C	



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Thermodynamic

Bangkok, Thailand

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Noble Metal Thermocouple Based Temperature Measuring Systems <sup>1</sup>	Types B, R, & S (-20 to 95) °C (95 to 200) °C	0.1 °C 0.15 °C	Temperature Baths
Noble Metal Thermocouple Based Temperature Measuring Systems <sup>1</sup>	Types B, R, & S (-20 to 140) °C (140 to 400) °C (400 to 600) °C (600 to 1 000) °C (1 000 to 1 200) °C	0.24 °C 0.51 °C 1.5 °C 2.4 °C 4.1 °C	Dry Block
Thermocouple Sensors <sup>1</sup>	Type E (-20 to 140) °C (140 to 400) °C (400 to 600) °C (600 to 1 000) °C Type J (-20 to 140) °C (140 to 400) °C (400 to 600) °C (600 to 1 000) °C Type K (-20 to 140) °C (140 to 400) °C (400 to 600) °C (600 to 1 000) °C (1 000 to 1 200) °C Type N (-20 to 140) °C (140 to 400) °C (400 to 600) °C (600 to 1 000) °C	0.4 °C 1.1 °C 2 °C 3.5 °C 0.4 °C 1.1 °C 2 °C 3.3 °C 0.4 °C 1.1 °C 2 °C 3.3 °C 5 °C 0.4 °C 1.1 °C 2 °C 3.3 °C	Dry Block



**Thermodynamic**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Thermocouple Sensors <sup>1</sup>	Type R (-20 to 140) °C	0.24 °C	Dry Block
	(140 to 400) °C	0.55 °C	
	(400 to 600) °C	1.5 °C	
	(600 to 1 000) °C	2.4 °C	
	(1 000 to 1 200) °C	4.1 °C	
	Type S (-20 to 140) °C	0.24 °C	
	(140 to 400) °C	0.55 °C	
	(400 to 600) °C	1.5 °C	
	(600 to 1 000) °C	2.4 °C	
	(1 000 to 1 200) °C	4.1 °C	
	Type T (-20 to 140) °C	0.4 °C	
	(140 to 400) °C	1 °C	
Thermocouple Sensors <sup>1</sup>	Type E (-20 to 95) °C	0.24 °C	Temperature Baths
	(95 to 200) °C	0.47 °C	
	Type J (-20 to 95) °C	0.24 °C	
	(95 to 200) °C	0.47 °C	
	Type K (-20 to 95) °C	0.24 °C	
	(95 to 200) °C	0.47 °C	
	Type N (-20 to 95) °C	0.24 °C	
	(95 to 200) °C	0.47 °C	
	Type R (-20 to 95) °C	0.1 °C	
	(95 to 200) °C	0.16 °C	
	Type S (-20 to 95) °C	0.1 °C	
	(95 to 200) °C	0.16 °C	
	Type T (-20 to 95) °C	0.24 °C	
	(95 to 200) °C	0.47 °C	
Analog and Digital Thermometers <sup>1</sup>	(-20 to 95) °C	0.1 °C	Reference PRT with Temperature Baths
	(95 to 200) °C	0.1 °C	

**Thermodynamic**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Analog and Digital Thermometers <sup>1</sup>	(-20 to 140) °C (140 to 400) °C (400 to 600) °C (600 to 1 000) °C	0.2 °C 0.5 °C 1.5 °C 2.3 °C	Dry Block
Liquid in Glass Thermometers Scale Graduation: 0.1°C	(-20 to 200) °C	0.1 °C	Reference PRT with Temperature Baths

**Time and Frequency**

**Bangkok, Thailand**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Tachometers <sup>1</sup> RPM Meter Non-Contact	(1 to 999.99) rpm (1 000 to 9 999.9) rpm (10 000 to 99 999) rpm	0.006 rpm 0.06 rpm 0.6 rpm	Tachometer Frequency Source and LED
Tachometers Contact Type	(1 to 9 999.9) rpm (10 000 to 99 999) rpm	0.06 rpm 0.6 rpm	Digital Motor Monitored with non-contact Tachometer
Frequency Measuring Instruments <sup>1</sup>	(0.01 to 99.99) Hz (100 to 119.9) Hz (120 to 1 199.9) Hz (1.2 to 11.99) kHz (12 to 119.9) kHz 120 kHz to 1.19 MHz (1.2 to 2) MHz	1.6 µHz/Hz + 8.6 µHz 1.6 µHz/Hz + 71 µHz 1.6 µHz/Hz + 0.49 mHz 1.6 µHz/Hz + 4.9 mHz 1.6 µHz/Hz + 40 mHz 1.6 µHz/Hz + 0.49 Hz 1.6 µHz/Hz + 0.8 Hz	5522A Multi Product Calibrator
Timers and Stopwatches <sup>1</sup>	1 s to 120 min	0.11 s	Frequency Counter/Timer

**DIMENSIONAL MEASUREMENT**

**1 Dimensional**

**Bangkok, Thailand**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length <sup>3</sup>	X: (0 to 680) mm	0.4 µm	Universal Length Measuring Machine (ULM)

### 1 Dimensional

Bangkok, Thailand

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
1D Geometric Dimensional Measurements of Jigs, Fixtures, Gauges, and First Artefacts <sup>3</sup>	X: (0 to 700) mm Y: (0 to 600) mm Z: (0 to 600) mm	2.6 μm	Coordinate Measuring Machine (CMM)
Length	X: (0 to 680) mm	0.4 μm	Universal Length Measuring Machine (ULM)
Dimensional Measurements of Jigs, Fixtures, Gauges, and First Artifacts	X: (0 to 250) mm	2 μm	Micrometer

### 2 Dimensional

Bangkok, Thailand

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dimensional Measurements of Jigs, Fixtures, Gauges, and First Artefacts, Angle <sup>3</sup>	Angle: 180 °	3.5 ‘	Profile Projector (Optical Comparator)
Dimensional Measurements of Jigs, Fixtures, Gauges, and First Artefacts	X: (0 to 250) mm Y: (0 to 150) mm	2 μm	Profile Projector

### 3 Dimensional

Bangkok, Thailand

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
3D Geometric Dimensional Measurements of Jigs, Fixtures, Gauges, and First Artefacts <sup>3</sup>	X: (0 to 700) mm Y: (0 to 600) mm Z: (0 to 600) mm	2.6 μm	Coordinate Measuring Machine (CMM)

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