ANSI National Accreditation Board

CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Professional Calibration & Services Co., Ltd.
50/888-50/889 Moo 2, Rungsit-Nakornnayok Rd.
Bungyeetho, Thunyaburee, Pathumthani 12130, Thailand

Fulfills the requirements of

ISO/IEC 17025:2017

In the fields of

CALIBRATION and **DIMENSIONAL MEASUREMENT**

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.

Jason Stine, Vice President

Expiry Date: 07 June 2026
Certificate Number: AC-2590

ANSI National Accreditation Board

ilac-MRA

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

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CALIBRATION AND DIMENSIONAL MEASUREMENT

ISO/IEC 17025 Accreditation Granted: **07 June 2024**

Certificate Number: **AC-2590** Certificate Expiry Date: **07 June 2026**

CALIBRATION

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sound Level Meter/Calibrator Source/Measure [1]	94 dB 114 dB	0.17 dB 0.17 dB	Sound Level Calibrator, Sound Level Meter; CP-EL35: Direct and Comparison Measurement
Vibration Meters (160 Hz) [1]			Vibration Calibrator; CP-PL22: Direct Measurement
Acceleration (RMS)	Up to 1 m/s^2	0.068 m/s^2	
	(> 1 to 5) m/s^2	0.13 m/s^2	
	(> 5 to 10) m/s^2	0.24 m/s^2	
	(> 10 to 20) m/s^2	0.44 m/s^2	
	(> 20 to 30) m/s^2	0.63 m/s^2	
	(> 30 to 40) m/s^2	0.84 m/s^2	
	(> 40 to 50) m/s^2	1.1 m/s^2	
Velocity (RMS)	Up to 1 mm/s	0.066 mm/s	
	(> 1 to 5) mm/s	0.13 mm/s	
	(> 5 to 10) mm/s	0.24 mm/s	
	(> 10 to 20) mm/s	0.44 mm/s	
	(> 20 to 30) mm/s	0.63 mm/s	
	(> 30 to 40) mm/s	0.84 mm/s	
	(> 40 to 50) mm/s	1.1 mm/s	

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Vibration Meters (160 Hz) [1] Displacement (RMS)	Up to 1 µm	0.068 µm	Vibration Calibrator; CP-PL22: Direct Measurement
	(> 1 to 5) µm	0.13 µm	
	(> 5 to 10) µm	0.24 µm	
	(> 10 to 20) µm	0.44 µm	
	(> 20 to 30) µm	0.63 µm	
	(> 30 to 40) µm	0.84 µm	
	(> 40 to 50) µm	1.1 µm	

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Conductivity Meter [5]	0.83 µS/cm	0.042 µS/cm	Standard Conductivity Solution; CP-PL101: ASTM D 1125 and ASTM D 5391 (Direct Measure)
Conductivity Meter [1,5]	10 µS/cm	0.16 µS/cm	Standard Conductivity Solution; CP-PL58: ASTM D 1125 and ASTM D 5391 (Direct Measure)
	84 µS/cm	0.58 µS/cm	
	1 413 µS/cm	8.9 µS/cm	
	12.88 mS/cm	0.077 mS/cm	
	111.3 mS/cm	0.62 mS/cm	
Conductivity Meter [1]	0.83 µS/cm	7.8 % of reading	Conductivity Meter Standard Set; CP-PL102: Comparison Measurement
	(> 0.83 to 10) µS/cm	2.5 % of reading	
	(> 10 to 84) µS/cm	1.1 % of reading	
	(> 84 to 1 413) µS/cm	1 % of reading	
	(> 1.413 to 12.88) mS/cm	1.1 % of reading	
	(> 12.88 to 111.3) mS/cm	1.6 % of reading	
pH Meter [1,5]	2 pH	0.007 1 pH	Standard pH Buffer Solutions; CP-PL21; ASTM E70 and BS 1647
	4 pH	0.004 2 pH	
	7 pH	0.004 2 pH	
	9 pH	0.004 2 pH	
	10 pH	0.004 2 pH	
	12 pH	0.011 pH	
Turbidity Meter [1,5]	10 NTU	0.051 NTU	Standard Turbidity Solution; CP-PL30: Direct Measurement
	100 NTU	1.1 NTU	
	500 NTU	3.1 NTU	
	1 000 NTU	7.2 NTU	

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Ozone Source, Ozone Chamber Tester [1,5] Concentration by Volume	Up to 0.000 1 %	3.8 x 10^{-9} Concentration	2.B Tech 205 Dual Beam Monitor; CP-EL87: Comparison Measurement
	(> 0.000 1 to 0.025) %	2.4 % of reading + 4.7 x 10^{-9} Concentration	
Gas Detector/Analyzer [5]			Certified Reference Gases; CP-PL84: Direct Measurement
Hydrogen Sulfide in Nitrogen	25 µmol/mol	4.1 % of reading	
Carbon Monoxide in Nitrogen	100 µmol/mol	1.1 % of reading	
Methane in Nitrogen	50 % LEL	1.1 % of reading	
	0.022 mol/mol	1.1 % of reading	
Oxygen in Nitrogen	0.01 mol/mol	2.2 % of reading	
	0.18 mol/mol	0.7 % of reading	
	0.21 mol/mol	1.1 % of reading	
Propane in Nitrogen	50 % LEL	1.1 % of reading	
	8.5 mmol/mol	1.1 % of reading	
Refractometers [1,5] (Brix)	5 % Brix	0.021 % Brix	Sucrose Standard Solution; CP-PL80: Direct Measurement
	10 % Brix	0.021 % Brix	
	20 % Brix	0.051 % Brix	
	30 % Brix	0.061 % Brix	
	40 % Brix	0.071 % Brix	
	50 % Brix	0.091 % Brix	
	60 % Brix	0.091 % Brix	
Refractometers [1,5] (Refractive Index)	1.340 26 nD	0.000 091 nD	Sucrose Standard Solution; CP-PL80: Direct Measurement
	1.347 82 nD	0.000 091 nD	
	1.363 84 nD	0.000 091 nD	
	1.381 15 nD	0.000 091 nD	
	1.399 86 nD	0.000 091 nD	
	1.420 06 nD	0.000 011 nD	
	1.441 9 nD	0.000 011 nD	
TDS Meters [5]	11 mg/l	0.016 mg/l	TDS Solution; CP-PL81: Direct Measurement
	116 mg/l	0.52 mg/l	
	478 mg/l	2.1 mg/l	
	1 382 mg/l	3.9 mg/l	

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Salinity Meters [5]	0.3 g/L NaCl 3.0 g/L NaCl 58.4 g/L NaCl 125 g/L NaCl	1.2 mg/L NaCl 12 mg/L NaCl 0.25 g/L NaCl 0.75 g/L NaCl	Salinity Solution; CP-PL82: Direct Measurement
Dissolved Oxygen (DO) Meter	(6 to 13) mg/l	0.037 mg/l	Solubility of Oxygen in distilled water at various temperatures and pressure; CP-PL93: Direct Measurement
Particle Counter Meter [5]			
Air Flow Rate	2.83 lpm 28.3 lpm	0.06 lpm 0.06 lpm	Comparison to Flow Meter
Counting Efficiency	0.3 µm 0.5 µm 1 µm 3 µm 5 µm 10 µm	5.9 % of reading 6 % of reading 6.1 % of reading 7.3 % of reading 8.3 % of reading 17 % of reading	Comparison to Counter and Standard Monosized Polymer Microspheres; CP-PL-83: Comparison Measurement
Breath Alcohol Analyzer [5] (Dry Method)			
Screening	20 mg% 44 mg% 70 mg%	1.2 % of reading 1.2 % of reading 1.2 % of reading	Certified Reference Gases; CP-PL103: Direct Measurement
Evidential	20 mg% 44 mg% 70 mg%	3.8 % of reading 2 % of reading 1.5 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1]	(0 to 220) mV (0.22 to < 2.2 V) (2.2 to < 11 V) (11 to < 22 V) (22 to < 220 V) (220 to 1 100 V	9 µV/V + 0.7 µV 7.2 µV/V + 1.2 µV 7.2 µV/V + 5 µV 7.2 µV/V + 7 µV 8.2 µV/V + 90 µV 9.2 µV/V + 0.55 mV	Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source[1]	(0 to 330) mV (0.33 to < 3.3) V (3.3 to < 33) V (33 to < 330) V (330 to 1 020) V	24 µV/V + 2 µV 14 µV/V + 2.8 µV 15 µV/V + 24 µV 22 µV/V + 0.18 mV 22 µV/V + 1.8 mV	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
DC High Voltage – Source[1]	50 V to 1 kV (> 1 to 6) kV (> 6 to 10) kV	0.5 mV/V + 0.15 V 0.5 mV/V + 0.5 V 0.5 mV/V + 1.8 V	Vitrek 4700 High Voltage Meter, Rek RK2671AM High Voltage Tester CP-EL42: Comparison Measurement
DC Voltage – Measure[1]	(0 to 200) mV (0.2 to < 2) V (2 to < 20) V (20 to < 200) V (200 to 1 000) V	8.5 µV/V + 0.72 µV 7.1 µV/V + 1.2 µV 7.1 µV/V + 7.5 µV 12 µV/V + 92 µV 12 µV/V + 0.68 mV	Wavetek 1281 8.5 Digit Multimeter; CP-EL02: Direct Measurement
DC Voltage – Measure[1]	(0 to 100) mV (> 0.1 to 1) V (> 1 to 10) V (> 10 to 100) V (> 100 to 1 000) V	8.5 µV/V + 0.55 µV 7 µV/V + 0.55 µV 7 µV/V + 0.75 µV 9.5 µV/V + 4 µV 24 µV/V + 0.2 mV	Keysight 3458A 8.5 Digit Multimeter; CP-EL66: Direct Measurement
DC Voltage – Measure[1]	(0 to 15) V (> 15 to 30) V (> 30 to 60) V (> 60 to 150) V (> 150 to 300) V (> 300 to 600) V	2.4 mV/V + 54 mV 2.4 mV/V + 0.11 V 2.4 mV/V + 0.21 V 2.4 mV/V + 0.54 V 2.4 mV/V + 1.1 V 2.4 mV/V + 2.1 V	Yokogawa WT110 Power Meter; CP-EL04: Direct Measurement
DC High Voltage – Measure[1]	(0.5 to 5) kV (> 5 to 10) kV	0.35 mV/V + 0.5 V 0.35 mV/V + 0.8 V	Vitrek 4700 High Voltage Meter; CP-EL03: Direct Measurement
DC High Voltage – Measure[1]	(> 10 to 20) kV (> 20 to 40) kV (> 40 to 100) kV	1 mV/V + 4 V 1 mV/V + 15 V 1 mV/V + 0.24 kV	Vitrek 4700 High Voltage Meter, HLV-100G/HLV-150 High Voltage Divider; CP-EL03: Direct Measurement

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source [1]	(0 to 220) µA (0.22 to < 2.2) mA (2.2 to < 22) mA (22 to < 220) mA (0.22 to 2.2) A	52 µA/A + 8.1 nA 52 µA/A + 8.5 nA 52 µA/A + 85 nA 62 µA/A + 0.86 µA 82 µA/A + 26 µA	Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement
DC Current – Source [1]	(0 to 0.33) mA (0.33 to < 3.3) mA (3.3 to < 33) mA (33 to < 330) mA 330 mA to < 1.1 A (1.1 to < 3) A (3 to < 11) A (11 to 20.5) A	0.18 mA/A + 24 nA 0.12 mA/A + 59 nA 0.12 mA/A + 0.3 µA 0.12 mA/A + 3.1 µA 0.24 mA/A + 47 µA 0.44 mA/A + 48 µA 0.58 mA/A + 0.91 mA 1.2 mA/A + 1.2 mA	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
DC Current – Source [1]	(0 to 100) µA (> 0.1 to 1) mA (> 1 to 10) mA (> 10 to 50) mA (> 50 to 100) mA (> 100 to 200) mA (> 200 to 500) mA (> 0.5 to 1) A (> 1 to 3) A (> 3 to 20) A (> 20 to 30) A (> 30 to 200) A	60 µA/A + 30 pA 55 µA/A + 0.3 nA 55 µA/A + 3 nA 55 µA/A + 30 nA 60 µA/A + 0.2 µA 50 µA/A + 2 µA 50 µA/A + 15 µA 50 µA/A + 15 µA 50 µA/A + 0.15 mA 55 µA/A + 1.2 mA 3.5 mA/A + 1.2 mA 3 mA/A + 16 mA	Standard Resistor, Standard Shunt, Digital Multimeter; CP-EL57: Using Ohm's Law
DC Current – Source [1]	(0 to 30) mA (> 30 to 300) mA (> 0.3 to 3) A (> 3 to 30) A (> 30 to 100) A (> 100 to 200) A (> 200 to 220) A	0.1 mA/A + 0.15 µA 0.17 mA/A + 4 µA 0.25 mA/A + 35 µA 0.33 mA/A + 0.35 mA 0.44 mA/A + 3 mA 0.59 mA/A + 3 mA 0.95 mA/A + 3 mA	GW PCS-1000i Precision Current Shunt; CP-EL57: Using Comparison Measurement
DC Clamp-On Ammeters [1]	(20.5 to < 150) A (150 to 1 025) A	2.4 mA/A + 0.13 A 2.6 mA/A + 0.2 A	Fluke 5522A Multiproduct Calibrator, 50- turn coil; CP-EL01: Direct Measurement

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure [1]	(0 to 1) µA (> 1 to 10) µA (> 10 to 100) µA (> 0.1 to 1) mA (> 1 to 10) mA (> 10 to 100) mA (> 0.1 to 1) A	30 µA /A + 0.2 nA 30 µA /A + 0.2 nA 30 µA /A + 1 nA 30 µA /A + 6 nA 30 µA /A + 60 nA 50 µA /A + 0.6 µA 0.14 mA/A + 20 µA	Keysight 3458A 8.5 Digit Multimeter; CP-EL66: Direct Measurement
DC Current – Measure [1]	(0 to 0.5) A (> 0.5 to 1) A (> 1 to 2) A (> 2 to 5) A (> 5 to 10) A (> 10 to 20) A	2.4 mA/A + 2.9 mA 2.4 mA/A + 6 mA 2.4 mA/A + 7.3 mA 2.4 mA/A + 18 mA 2.4 mA/A + 37 mA 2.4 mA/A + 76 mA	Yokogawa WT110 Power Meter CP-EL04: Direct Measurement
DC Current – Measure [1]	(0 to 100) µA (> 0.1 to 1) mA (> 1 to 10) mA (> 10 to 50) mA (> 50 to 100) mA (> 100 to 200) mA (> 200 to 500) mA (> 0.5 to 1) A (> 1 to 3) A (> 3 to 10) A (> 10 to 20) A (> 20 to 50) A (> 50 to 100) A (> 100 to 500) A (> 500 to 1 000) A	60 µA/A + 30 pA 55 µA/A + 0.3 nA 55 µA/A + 3 nA 55 µA/A + 30 nA 60 µA/A + 0.2 µA 50 µA/A + 2 µA 50 µA/A + 15 µA 50 µA/A + 15 µA 50 µA/A + 0.12 mA 55 µA/A + 1.2 mA 55 µA/A + 1.2 mA 2.4 mA/A 2.4 mA/A 2.4 mA/A 5.8 mA/A	CCCP Standard Resistor Sets 1 mΩ to 100 kΩ Agilent 34330A Shunt, FL-2.0 class 0.5; CP-EL22: Using Ohm's Law
AC/DC Current – Measure [1] DC	Up to 20 A	0.15 mA/A	Holt Standard HCS-1AF current shunts, Digital multimeter; CP-EL22: Using Ohm's Law
AC	20 mA to 20 A 10 Hz to 10 kHz (> 10 to 50) kHz	 0.25 mA/A 1.2 mA/A	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC/DC Current – Measure [1]			GW Instek PCA-1000i Precision Current Shunt; CP-EL78: Direct Measurement
DC	(0 to 30) mA	0.012 % of reading + 2 µA	
	(> 30 to 300) mA	0.012 % of reading + 20 µA	
	(> 0.3 to 3) A	0.012 % of reading + 0.2 mA	
	(> 3 to 30) A	0.015 % of reading + 2 mA	
	(> 30 to 300) A	0.087 % of reading + 40 mA	
AC	(45 to 400) Hz		
	Up to 30 mA	0.58 % of reading + 20 µA	
	(> 30 to 300) mA	0.58 % of reading + 0.2 mA	
	(> 0.3 to 3) A	0.58 % of reading + 5 mA	
	(> 3 to 30) A	0.58 % of reading + 20 mA	
	(> 30 to 300) A	0.59 % of reading + 0.2 A	
AC/DC Current – Measure [1]			Fluke i1010 AC/DC Current Clamp & Fluke 287/289 Digital Multimeter; CP-EL78: Direct Measurement
DC	(> 300 to 1 000) A	2.4 % of reading + 0.65 A	
AC	(45 to 65) Hz		
	(> 300 to 600) A	2.4 % of reading + 3 A	
	(> 65 to 400) Hz		
	(> 300 to 600) A	2.5 % of reading + 3 A	
DC/AC Cutoff Current – Measure [1]			Fluke 289 Multimeter; CP-EL23: Direct Measurement
DC	(0 to 10) mA	0.87 mA/A + 17 µA	
	(> 10 to 100) mA	1.8 mA/A + 28 µA	
AC	(50, 60) Hz		
	20 µA to 10 mA	7 mA/ A + 26 µA	
	(> 10 to 100) mA	7 mA/ A + 60 µA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	(10 to 20) Hz		Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement
	Up to 2.2 mV	1.2 mV/V + 4.7 µV	
	(2.2 to < 22) mV	0.58 mV/V + 5.6 µV	
	(22 to < 220) mV	0.56 mV/V + 14 µV	
	(0.22 to < 2.2) V	0.51 mV/V + 90 µV	
	(2.2 to < 22) V	0.51 mV/V + 0.83 mV	
	(22 to < 220) V	0.51 mV/V + 8.2 mV	
	(> 20 to 40) Hz		
	Up to 2.2 mV	0.55 mV/V + 4.7 µV	
	(2.2 to < 22) mV	0.24 mV/V + 5.6 µV	
	(22 to < 220) mV	0.22 mV/V + 8.4 µV	
	(0.22 to < 2.2) V	0.17 mV/V + 32 µV	
	(2.2 to < 22) V	0.17 mV/V + 0.27 mV	
	(22 to < 220) V	0.17 mV/V + 3.1 mV	
	> 40 Hz to 20 kHz		
	Up to 2.2 mV	0.52 mV/V + 4.7 µV	
	(2.2 to < 22) mV	0.14 mV/V + 5.6 µV	
	(22 to < 220) mV	0.11 mV/V + 8.4 µV	
	(0.22 to < 2.2) V	79 µV/V + 14 µV	
	(2.2 to < 22) V	79 µV/V + 0.14 mV	
	(22 to < 220) V	83 µV/V + 1.4 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	(> 20 to 50) kHz		Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement
	Up to 2.2 mV	0.71 mV/V + 4.7 µV	
	(2.2 to < 22) mV	0.39 mV/V + 5.6 µV	
	(22 to < 220) mV	0.33 mV/V + 8.4 µV	
	(0.22 to < 2.2) V	0.13 mV/V + 22 µV	
	(2.2 to < 22) V	0.13 mV/V + 0.21 mV	
	(22 to < 220) V	0.23 mV/V + 4.5 mV	
	(> 50 to 100) kHz		
	Up to 2.2 mV	1.4 mV/V + 7.1 µV	
	(2.2 to < 22) mV	0.87 mV/V + 8.5 µV	
	(22 to < 220) mV	0.86 mV/V + 27 µV	
	(0.22 to < 2.2) V	0.26 mV/V + 74 µV	
	(2.2 to < 22) V	0.26 mV/V + 0.39 mV	
	(22 to < 220) V	0.51 mV/V + 9.8 mV	
	(> 100 to 300) kHz		
	Up to 2.2 mV	1.7 mV/V + 14 µV	
	(2.2 to < 22) mV	1.2 mV/V + 14 µV	
	(22 to < 220) mV	1.2 mV/V + 27 µV	
	(0.22 to < 2.2) V	0.44 mV/V + 0.17 mV	
	(2.2 to < 22) V	0.51 mV/V + 1.9 mV	
	(22 to < 220) V	1.6 mV/V + 91 mV	
	(> 300 to 500) kHz		
	Up to 2.2 mV	2.7 mV/V + 27 µV	
	(2.2 to < 22) mV	1.8 mV/V + 27 µV	
	(22 to < 220) mV	1.8 mV/V + 36 µV	
	(0.22 to < 2.2) V	1.1 mV/V + 0.37 mV	
	(2.2 to < 22) V	1.3 mV/V + 1.4 mV	
	(22 to < 220) V	4.8 mV/V + 91 mV	
	> 500 kHz to 1 MHz		
	Up to 2.2 mV	4.4 mV/V + 27 µV	
	(2.2 to < 22) mV	3.5 mV/V + 27 µV	
	(22 to < 220) mV	3.5 mV/V + 81 µV	
	(0.22 to < 2.2) V	2.3 mV/V + 0.87 mV	
	(2.2 to < 22) V	2.8 mV/V + 8.7 mV	
	(22 to < 220) V	12 mV/V + 0.2 V	
	(15 to 50) Hz		
	(220 to 250) V	0.41 mV/V + 18 mV	
	50 Hz to 1 kHz		
	(220 to 1100) V	82 µV/V + 3.8 mV	

AC Voltage – Source [1]	(10 to 45) Hz		Fluke 5522A Multiproduct Calibrator CP-EL01: Direct Measurement
	(1 to < 33) mV	0.95 mV/V + 7.1 µV	
	(33 to < 330) mV	0.37 mV/V + 9.6 µV	
	(0.33 to < 3.3) V	0.35 mV/V + 60 µV	
	(3.3 to < 33) V	0.36 mV/V + 0.77 mV	
	> 45 Hz to 10 kHz		
	(1 to < 33) mV	0.23 mV/V + 7.1 µV	
	(33 to < 330) mV	0.19 mV/V + 9.5 µV	
	(0.33 to < 3.3) V	0.18 mV/V + 70 µV	
	(3.3 to < 33) V	0.18 mV/V + 0.71 mV	
	(> 10 to 20) kHz		
	(1 to < 33) mV	0.28 mV/V + 7.1 µV	
	(33 to < 330) mV	0.21 mV/V + 9.5 µV	
	(0.33 to < 3.3) V	0.23 mV/V + 70 µV	
	(3.3 to < 33) V	0.28 mV/V + 0.71 mV	
	(> 20 to 50) kHz		
	(1 to < 33) mV	1.2 mV/V + 7.1 µV	
	(33 to < 330) mV	0.42 mV/V + 9.5 µV	
	(0.33 to < 3.3) V	0.36 mV/V + 60 µV	
	(3.3 to < 33) V	0.41mV/V + 0.71 mV	
	(33 to < 330) V	0.36 mV/V + 7 mV	
	(> 50 to 100) kHz		
	(1 to < 33) mV	4.1 mV/V + 14 µV	
	(33 to < 330) mV	0.94 mV/V + 38 µV	
	(0.33 to < 3.3) V	0.82 mV/V + 0.15 mV	
	(3.3 to < 33) V	1.1 mV/V + 1.9 mV	
	(33 to < 330) V	2.4 mV/V + 58 mV	
	(> 100 to 500) kHz		
	(1 to < 33) mV	9.3 mV/V + 58 µV	
	(33 to < 330) mV	2.4 mV/V + 81 µV	
	(0.33 to < 3.3) V	2.9 mV/V + 0.7 mV	
	45 Hz to 1 kHz		
	(33 to < 330) V	0.23 mV/V + 2.8 mV	
	(330 to 1 020) V	0.35 mV/V + 12 mV	
	(> 1 to 10) kHz		
	(33 to < 330) V	0.24 mV/V + 7.2 mV	
	(> 10 to 20) kHz		
	(33 to < 330) V	0.3 mV/V + 7.1 mV	
	(> 1 to 5) kHz		
	(330 to 1 020) V	0.3 mV/V + 12 mV	
	(> 5 to 10) kHz		
	(330 to 1 020) V	0.35 mV/V + 12 mV	
AC High Voltage – Source [1]	(50 to 60) Hz		Vitrek 4700 High Voltage Meter, Rek RK2671AM
	50 V to 1 kV	1.6 mV/V + 0.6 V	
	(> 1 to 6) kV	1.6 mV/V + 1.8 V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
	(> 6 to 10) kV	1.6 mV/V + 3.4 V	High Voltage Tester; CP-EL42: Direct Measurement
AC Voltage – Measure [1]	(20 to 40) Hz		Wavetek 1281 8.5 Digit Multimeter CP-EL02: Direct Measurement
	(10 to < 200) mV	0.27 mV/V + 4.7 μV	
	200 mV to < 2 V	0.2 mV/V + 25 μV	
	(2 to < 20) V	0.2 mV/V + 0.24 mV	
	(20 to < 200) V	0.2 mV/V + 2.5 mV	
	(200 to 1 000) V	0.2 mV/V + 14 mV	
	(> 40 to 100) Hz		
	(10 to < 200) mV	0.25 mV/V + 4.7 μV	
	200 mV to < 2 V	0.18 mV/V + 25 μV	
	(2 to < 20) V	0.18 mV/V + 0.24 mV	
	(20 to < 200) V	0.18 mV/V + 2.5 mV	
	(200 to 1 000) V	0.18 mV/V + 14 mV	
	> 100 Hz to 2 kHz		
	(10 to < 200) mV	0.25 mV/V + 2.5μV	
	200 mV to < 2 V	0.16 mV/V + 24 μV	
	(2 to < 20) V	0.16 mV/V + 0.24 mV	
	(20 to < 200) V	0.16 mV/V + 2.5 mV	
	(200 to 1 000) V	0.18 mV/V + 14 mV	
	(> 2 to 10) kHz		
	(10 to < 200) mV	0.25 mV/V + 4.7 μV	
	200 mV to < 2 V	0.18 mV/V + 24 μV	
	(2 to < 20) V	0.18 mV/V + 0.25 mV	
	(20 to < 200) V	0.18 mV/V + 2.6 mV	
	(200 to 1 000) V	0.18 mV/V + 14 mV	
	(> 10 to 30) kHz		
	(10 to < 200) mV	0.47 mV/V + 9.3 μV	
	200 mV to < 2 V	0.29 mV/V + 47 μV	
	(2 to < 20) V	0.29 mV/V + 0.47 mV	
	(20 to < 200) V	0.29 mV/V + 4.7 mV	
	(200 to 1 000) V	0.25 mV/V + 24 mV	
	(> 30 to 100) kHz		
	(10 to < 200) mV	0.82 mV/V + 24 μV	
	200 mV to < 2 V	0.58 mV/V + 0.24 mV	
	(2 to < 20) V	0.58 mV/V + 2.4 mV	
	(20 to < 200) V	0.58 mV/V + 24 mV	
	(200 to 1 000) V	0.58 mV/V + 0.12 V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(> 100 to 300) kHz		Wavetek 1281 8.5 Digit Multimeter CP-EL02: Direct Measurement
	200 mV to < 2 V	3.5 mV/V + 2.4 mV	
	(2 to < 20) V	3.5 mV/V + 24 mV	
	(20 to < 200) V	3.5 mV/V + 0.24 V	
	> 300 kHz to 1 MHz		
	(2 to < 20) V	12 mV/V + 1.2 V	
	(20 to < 200) V	12 mV/V + 2.4 V	
AC Voltage – Measure [1]	(10 to 20) Hz		Keysight 3458A 8.5 Digit Multimeter CP-EL66: Direct Measurement
	(1 to 10) mV	0.41 mV/V + 4 µV	
	(> 10 to 100) mV	0.11 mV/V + 5 µV	
	(> 0.1 to 1) V	0.1 mV/V + 50 µV	
	(> 1 to 10) V	0.1 mV/V + 0.5 mV	
	(> 10 to 100) V	0.24 mV/V + 5 mV	
	(> 20 to 40) Hz		
	(1 to 10) mV	0.38 mV/V + 4 µV	
	(> 10 to 100) mV	0.1 mV/V + 5 µV	
	(> 0.1 to 1) V	0.1 mV/V + 50 µV	
	(> 1 to 10) V	0.1 mV/V + 0.5 mV	
	(> 10 to 100) V	0.24 mV/V + 5 mV	
	> 40 Hz to 1 kHz		
	(1 to 10) mV	0.27 mV/V + 2 µV	
	(> 10 to 100) mV	0.1 mV/V + 3 µV	
	(0.1 to 1) V	0.1 mV/V + 30 µV	
	(> 1 to 10) V	0.1 mV/V + 0.3 mV	
	(> 10 to 100) V	0.24 mV/V + 3 mV	
	(> 100 to 700) V	0.47 mV/V + 30 mV	
	(> 1 to 20) kHz		
	(1 to 10) mV	0.38 mV/V + 4 µV	
	(> 10 to 100) mV	0.18 mV/V + 5 µV	
	(> 0.1 to 1) V	0.17 mV/V +30 µV	
	(> 1 to 10) V	0.18 mV/V + 0.3 mV	
	(> 10 to 100) V	0.24 mV/V + 3 mV	
	(> 100 to 700) V	0.7 mV/V + 30 mV	
	(> 20 to 50) kHz		
	(1 to 10) mV	1.2 mV/V + 2 µV	
	(> 10 to 100) mV	0.36 mV/V + 3 µV	
	(> 0.1 to 1) V	0.36 mV/V + 30 µV	
	(> 1 to 10) V	0.36 mV/V + 0.3 mV	
	(> 10 to 100) V	0.41 mV/V + 3 mV	
	(> 100 to 700) V	1.4 mV/V + 30 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(> 50 to 100) kHz		Keysight 3458A 8.5 Digit Multimeter CP-EL66: Direct Measurement
	(1 to 10) mV	5.8 mV/V + 2 µV	
	(> 10 to 100) mV	0.94 mV/V + 3 µV	
	(> 0.1 to 1) V	0.93 mV/V + 30 µV	
	(> 1 to 10) V	0.93 mV/V + 0.3 mV	
	(> 10 to 100) V	1.4 mV/V + 3 mV	
	(> 100 to 700) V	3.5 mV/V + 30 mV	
	(> 100 to 300) kHz		
	(1 to 10) mV	47 mV/V + 3 µV	
	(> 10 to 100) mV	3.5 mV/V + 20 µV	
	(> 0.1 to 1) V	3.5 mV/V + 0.2 mV	
	(> 1 to 10) V	3.5 mV/V + 2 mV	
	(> 300 to 500) kHz		
	(1 to 10) mV	15 mV/V + 6 µV	
	(>10 to 100) mV	12 mV/V + 20 µV	
	(>0.1 to 1) V	12 mV/V + 0.2 mV	
	(> 1 to 10) V	12 mV/V + 2 mV	
	(> 0.5 to 1) MHz		
	(1 to 10) mV	15 mV/V + 6 µV	
	(> 10 to 100) mV	12 mV/V + 20 µV	
	(> 0.1 to 1) V	12 mV/V + 0.2 mV	
	(> 1 to 10) V	12 mV/V + 2 mV	
	(> 1 to 4) MHz		
	(1 to 10) mV	82 mV/V + 9 µV	
	(> 10 to 100) mV	47 mV/V + 90 µV	
	(> 0.1 to 1) V	47 mV/V + 0.9 mV	
	(> 1 to 3) V	47 mV/V + 9 mV	
	(> 4 to 8) MHz		
	(10 to 100) mV	47 mV/V + 0.1 mV	
	(> 0.1 to 1) V	47 mV/V + 1 mV	
	(> 1 to 3) V	47 mV/V + 10 mV	
	(> 8 to 10) MHz		
	(10 to 100) mV	180 mV/V + 0.2 mV	
	(> 0.1 to 1) V	180 mV/V + 2 mV	
	(> 1 to 3) V	180 mV/V + 20 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure [1]	(45 to 66) Hz		Yokogawa WT110 Power Meter CP-EL04: Direct Measurement
	(1 to 15) V	1.8 mV/V + 34 mV	
	(> 15 to 30) V	1.8 mV/V + 62 mV	
	(> 30 to 60) V	1.8 mV/V + 0.13 V	
	(> 60 to 150) V	1.8 mV/V + 0.34 V	
	(> 150 to 300) V	1.8 mV/V + 0.62 V	
	(> 300 to 600) V	1.8 mV/V + 1.3 V	
	> 66 Hz to 1 kHz		
	(1 to 15) V	3.5 mV/V + 62 mV	
	(> 15 to 30) V	3.5 mV/V + 0.13 V	
	(> 30 to 60) V	3.5 mV/V + 0.25 V	
	(> 60 to 150) V	3.5 mV/V + 0.62 V	
	(> 150 to 300) V	3.5 mV/V + 1.3 V	
	(> 300 to 600) V	3.5 mV/V + 2.5 V	
AC High Voltage – Measure [1]	(50 to 60) Hz		Vitrek 4700 High Voltage Meter With High Voltage Divider HLV-150; CP-EL03: Direct Measurement
	500 V to 1 kV	1.4 mV/V + 0.6 V	
	(> 1 to 5) kV	1.4 mV/V + 1.6 V	
	(> 5 to 10) kV	1.4 mV/V + 3.4 V	
	(> 10 to 20) kV	5.8 mV/V + 41 V	
	(> 20 to 40) kV	5.8 mV/V + 80 V	
	(> 40 to 70) kV	5.8 mV/V + 0.15 kV	
	(> 70 to 100) kV	5.8 mV/V + 0.3 kV	
AC Current – Source [1]	(10 to 20) Hz		Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement
	Up to 220 µA	0.72 mA/A + 26 nA	
	(0.22 to < 2.2) mA	0.73 mA/A + 51 nA	
	(2.2 to < 22) mA	0.71 mA/A + 0.48 µA	
	(22 to < 220) mA	0.71 mA/A + 5 µA	
	(> 20 to 40) Hz		
	Up to 220 µA	0.37 mA/A + 21 nA	
	(0.22 to < 2.2) mA	0.37 mA/A + 42 nA	
	(2.2 to < 22) mA	0.36 mA/A + 0.48 µA	
	(22 to < 220) mA	0.36 mA/A + 4.4 µA	
	> 40 Hz to 1 kHz		
	Up to 220 µA	0.18 mA/A + 17 nA	
	(0.22 to < 2.2) mA	0.17 mA/A + 42 nA	
	(2.2 to < 22) mA	0.16 mA/A + 0.39 µA	
	(22 to < 220) mA	0.15 mA/A + 5 µA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1]	(> 1 to 5) kHz		Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement
	Up to 220 µA	0.62 mA/A + 42 nA	
	(0.22 to < 2.2) mA	0.61 mA/A + 0.41 µA	
	(2.2 to < 22) mA	0.61 mA/A + 4.2 µA	
	(22 to < 220) mA	0.61 mA/A + 42 µA	
	(0.22 to 2.2) A	0.76 mA/A + 95 µA	
	(> 5 to 10) kHz		
	Up to 220 µA	1.7 mA/A + 0.81 nA	
	(0.22 to < 2.2) mA	1.7 mA/A + 0.81 µA	
	(2.2 to < 22) mA	1.7 mA/A + 8.1 µA	
	(22 to < 220) mA	1.7 mA/A + 81 µA	
	(0.22 to 2.2) A	8.6 mA/A + 0.17 mA	
	20 Hz to 1 kHz		
	(0.22 to 2.2) A	0.66 mA/A + 43 µA	
AC Current – Source [1]	(10 to 20) Hz		Fluke 5522A Multiproduct Calibrator CP-EL01: Direct Measurement
	(29 to < 330) µA	2.4 mA/A + 0.12 µA	
	330 µA to < 3.3 mA	2.4 mA/A + 0.19 µA	
	(3.3 to < 33) mA	2.1 mA/A + 2.5 µA	
	(33 to < 330) mA	2.1 mA/A + 25 µA	
	(> 20 to 45) Hz		
	(29 to < 330) µA	1.8 mA/A + 0.12 µA	
	330 µA to < 3.3 mA	1.5 mA/A + 0.19 µA	
	(3.3 to < 33) mA	1.1 mA/A + 2.5 µA	
	(33 to < 330) mA	1.1 mA/A + 25 µA	
	> 45 Hz to 1 kHz		
	(29 to < 330) µA	1.5 mA/A + 0.12 µA	
	330 µA to < 3.3 mA	1.2 mA/A + 0.2 µA	
	(3.3 to < 33) mA	0.48 mA/A + 2.5 µA	
	(33 to < 330) mA	0.48 mA/A + 27 µA	
	330 mA to < 1.1 A	0.59 mA/A + 0.12 mA	
	(1.1 to < 3) A	0.7 mA/A + 0.14 mA	
	(> 1 to 5) kHz		
	(29 to < 330) µA	3.5 mA/A + 0.18 µA	
	330 µA to < 3.3 mA	2.4 mA/A + 0.26 µA	
	(3.3 to < 33) mA	0.93 mA/A + 2.6 µA	
	(33 to < 330) mA	1.2 mA/A + 59 µA	
	330 mA to < 1.1 A	7 mA/A + 1.2 mA	
	(1.1 to < 3) A	7 mA/A + 1.2 mA	
	(3 to < 11) A	35 mA/A + 2.7 mA	
	(11 to 20.5) A	35 mA/A + 5.9 mA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1]	(> 5 to 10) kHz		Fluke 5522A Multiproduct Calibrator CP-EL01: Direct Measurement
	(29 to < 330) µA	9.3 mA/A + 0.24 µA	
	330 µA to < 3.3 mA	5.8 mA/A + 0.37 µA	
	(3.3 to < 33) mA	2.4 mA/A + 3.8 µA	
	(33 to < 330) mA	2.4 mA/A + 0.12 mA	
	330 mA to < 1.1 A	29 mA/A + 5.8 mA	
	(1.1 to < 3) A	29 mA/A + 5.8 mA	
	(> 10 to 30) kHz		
	(29 to < 330) µA	19 mA/A + 0.47 µA	
	330 µA to < 3.3 mA	12 mA/A + 0.71 µA	
	(3.3 to < 33) mA	4.7 mA/A + 4.8 µA	
	(33 to < 330) mA	4.7 mA/A + 0.24 mA	
	(10 to 45) Hz		
	330 mA to < 1.1 A	2.1 mA/A + 0.12 mA	
	(1.1 to < 3) A	2.1 mA/A + 0.15 mA	
	(> 45 to 100) Hz		
	(3 to < 11) A	0.71 mA/A + 2.5 mA	
	(11 to 20.5) A	1.4 mA/A + 5.9 mA	
	> 100 Hz to 1 kHz		
	(3 to < 11) A	1.2 mA/A + 2.6 mA	
	(11 to 20.5) A	1.8 mA/A + 6 mA	
AC Clamp-On Ammeters [1]	(45 to 65) Hz		Fluke 5522A Multiproduct Calibrator, 50-turn Current Coil CP-EL01: Direct Measurement
	(20.5 to < 150) A	3.8 mA/A + 0.13 A	
	(150 to 1 025) A	3.8 mA/A + 0.2 A	
	(> 65 to 440) Hz		
	(20.5 to < 150) A	7 mA/A + 0.15 A	
	(> 65 to 100) Hz		
	(150 to 1 025) A	6 mA/A + 0.2 A	
AC Current – Measure [1]	10 Hz to 5 kHz		Wavetek 1281 8.5 Digit Multimeter CP-EL02: Direct Measurement
	(10 to < 200) µA	0.36 mA/A + 25 nA	
	200 µA to < 2 mA	0.35 mA/A + 0.25 µA	
	(2 to < 20) mA	0.35 mA/A + 2.5 µA	
	(20 to < 200) mA	0.35 mA/A + 25 µA	
	10 Hz to 1 kHz		
	200 mA to < 2 A	0.7 mA/A + 0.48 mA	
	(> 1 to 5) kHz		
	200 mA to < 2 A	2.4 mA/A + 0.94 mA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(10 to 20) Hz		Keysight 3458A 8.5 Digit Multimeter CP-EL66: Direct Measurement
	(1 to 100) µA	4.7 mA/A + 40 nA	
	(> 0.1 to 1) mA	4.7 mA/A + 0.3 µA	
	(> 1 to 10) mA	4.7 mA/A + 3 µA	
	(> 10 to 100) mA	4.7 mA/A + 30 µA	
	(> 0.1 to 1) A	4.7 mA/A + 0.3 mA	
	(> 20 to 45) Hz		
	(1 to 100) µA	1.8 mA/A + 40 nA	
	(> 0.1 to 1) mA	1.8 mA/A + 0.3 µA	
	(> 1 to 10) mA	1.8 mA/A + 3 µA	
	(> 10 to 100) mA	1.8 mA/A + 30 µA	
	(> 0.1 to 1) A	1.9 mA/A + 0.3 mA	
	(> 45 to 100) Hz		
	(1 to 100) µA	0.72 mA/A + 40 nA	
	(> 0.1 to 1) mA	0.7 mA/A + 0.3 µA	
	(> 1 to 10) mA	0.71 mA/A + 3 µA	
	(> 10 to 100) mA	0.71 mA/A + 30 µA	
	(> 0.1 to 1) A	0.94 mA/A + 0.3 mA	
	(> 100 to 1) kHz		
	(1 to 100) µA	0.72 mA/A + 40 nA	
	(> 0.1 to 1) mA	0.38 mA/A + 0.3 µA	
	(> 1 to 10) mA	0.36 mA/A + 3 µA	
	(> 10 to 100) mA	0.36 mA/A + 30 µA	
	(> 0.1 to 1) A	1.2 mA/A + 0.3 mA	
	(> 1 to 5) kHz		
	(1 to 100) µA	0.72 mA/A + 40 nA	
	(> 0.1 to 1) mA	0.38 mA/A + 0.3 µA	
	(> 1 to 10) mA	0.36 mA/A + 3 µA	
	(> 10 to 100) mA	0.36 mA/A + 30 µA	
	(> 0.1 to 1) A	1.2 mA/A + 0.3 mA	
	(> 5 to 20) kHz		
	(> 0.1 to 1) mA	0.72 mA/A + 0.3 µA	
	(> 1 to 10) mA	0.71 mA/A + 3 µA	
	(> 10 to 100) mA	0.71 mA/A + 30 µA	
	(> 0.1 to 1) A	3.5 mA/A + 0.3 mA	
	(>20 to 50) kHz		
	(> 0.1 to 1) mA	4.7 mA/A + 0.5 µA	
	(> 1 to 10) mA	4.7 mA/A + 5 µA	
	(> 10 to 100) mA	4.7 mA/A + 50 µA	
	(> 0.1 to 1) A	12 mA/A + 0.5 mA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(45 to 66) Hz		Yokogawa WT110 Power Meter CP-EL04: Direct Measurement
	1 mA to 0.5 A	1.8 mA/A + 1.1 mA	
	(> 0.5 to 1) A	1.8 mA/A + 2.4 mA	
	(> 1 to 2) A	1.8 mA/A + 4.6 mA	
	(> 2 to 5) A	1.8 mA/A + 12 mA	
	(> 5 to 10) A	1.8 mA/A + 24 mA	
	(> 10 to 20) A	1.8 mA/A + 51 mA	
	66 Hz to 1 kHz		
	1 mA to 0.5 A	3.5 mA/A + 2.1 mA	
	(> 0.5 to 1) A	3.5 mA/A + 4.3 mA	
	(> 1 to 2) A	3.5 mA/A + 8.4 mA	
	(> 2 to 5) A	3.5 mA/A + 23 mA	
	(> 5 to 10) A	3.5 mA/A + 46 mA	
	(> 10 to 20) A	3.5 mA/A + 96 mA	
AC Current – Measure [1]	Up to 1 kHz		Agilent 34330A Shunt, Digital Multimeter CP-EL22: Using Ohm's Law
	(> 1 to 30) A	3.5 mA/A	
	(> 1 to 5) kHz		
	(> 1 to 30) A	5.8 mA/A	
Weld Machine [1]			Miyachi MM-123A High Precision Weld Tester CP-EL70: Direct Measurement
DC	(0.1 to 2) kA	2.4 % of reading + 6 A	
	(> 2 to 20) kA	2.4 % of reading + 60 A	
	(> 20 to 200) kA	2.4 % of reading + 1.1 kA	
AC (50 or 60) Hz	(0.1 to 2) kA	2.4 % of reading + 6 A	
	(> 2 to 20) kA	2.4 % of reading + 60 A	
	(> 20 to 200) kA	2.4 % of reading + 0.6 kA	
DC Voltage – Source [1] (Fixed Points)	± 100 mV	11 µV/V	Keysight 3458A 8.5 Digit Multimeter, Fluke 5700A or Fluke 5522A Calibrator; CP-EL67: Comparison Measurement
	± 1 V	3.7 µV/V	
	± 10 V	3.2 µV/V	
	± 100 V	6.5 µV/V	
	± 1 000 V	6.5 µV/V	

AC Voltage – Source[1] (Fixed Points)	10 Hz		Keysight 3458A 8.5 Digit Multimeter, Fluke 5700A or Fluke 5522A Calibrator; CP-EL67: Comparison Measurement
	10 mV	0.61 mV/V	
	100 mV	0.13 mV/V	
	1 V	90 µV/V	
	10 V	80 µV/V	
	20 Hz		
	10 mV	0.36 mV/V	
	100 mV	0.12 mV/V	
	1 V	70 µV/V	
	10 V	80 µV/V	
	40 Hz		
	10 mV	0.36 mV/V	
	100 mV	0.1 mV/V	
	1 V	70 µV/V	
	10 V	75 µV/V	
	100 Hz		
	10 mV	0.33 mV/V	
	100 mV	0.1 mV/V	
	1 V	75 µV/V	
	10 V	80 µV/V	
	100 V	70 µV/V	
	700 V	80 µV/V	
	1 kHz		
	10 mV	0.31 mV/V	
	100 mV	0.1 mV/V	
	1 V	70 µV/V	
	10 V	75 µV/V	
	100 V	70 µV/V	
	700 V	70 µV/V	
	10 kHz		
	10 mV	0.31 mV/V	
	100 mV	0.1 mV/V	
	1 V	70 µV/V	
	10 V	75 µV/V	
	100 V	70 µV/V	
	700 V	70 µV/V	
	20 kHz		
	10 mV	0.31 mV/V	
	100 mV	0.1 mV/V	
	1 V	70 µV/V	
	10 V	75 µV/V	
	100 V	75 µV/V	
AC Voltage – Source[1] (Fixed Points)	50 kHz		Keysight 3458A 8.5 Digit Multimeter, Fluke 5700A or
	10 mV	0.38 mV/V	
	100 mV	0.12 mV/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
	1 V	90 µV/V	Fluke 5522A Calibrator; CP-EL67: Comparison Measurement
	10 V	95 µV/V	
	100 V	90 µV/V	
	100 kHz		
	10 mV	0.79 mV/V	
	100 mV	0.24 mV/V	
	1 V	0.2 mV/V	
	10 V	0.19 mV/V	
	100 V	0.21 mV/V	
	300 kHz		
	10 mV	1.1 mV/V	
	100 mV	0.79 mV/V	
	1 V	0.54 mV/V	
	500 kHz		
	10 mV	1.1 mV/V	
	100 mV	0.81 mV/V	
	1 V	0.69 mV/V	
	1 MHz		
	100 mV	7.2 mV/V	
	1 V	6.6 mV/V	
	2 MHz		
	3 V	5.6 mV/V	
	4 MHz		
	100 mV	7.2 mV/V	
	1 V	6.6 mV/V	
	3 V	5.6 mV/V	
	8 MHz		
	100 mV	7.2 mV/V	
	1 V	6.6 mV/V	
	3 V	5.6 mV/V	
	10 MHz		
	100 mV	7.2 mV/V	
	1 V	6.6 mV/V	
	3 V	5.6 mV/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Strain Gauge Indicator [1] 120 Ω, 350 Ω	(0 to 0.5) mV/V		Vishay BLH 625 Precision Calibrator CP-EL63: Direct Measurement
	0	60 nV	
	0.05	0.000 093 mV/V	
	0.1	0.000 13 mV/V	
	0.15	0.000 16 mV/V	
	0.2	0.000 19 mV/V	
	0.25	0.000 22 mV/V	
	0.3	0.000 26 mV/V	
	0.35	0.000 29 mV/V	
	0.4	0.000 32 mV/V	
	0.45	0.000 35 mV/V	
	0.5	0.000 39 mV/V	
	(0 to 1) mV/V		
	0	60 nV	
	0.1	0.000 13 mV/V	
	0.2	0.000 19 mV/V	
	0.3	0.000 26 mV/V	
	0.4	0.000 32 mV/V	
	0.5	0.000 39 mV/V	
	0.6	0.000 45 mV/V	
	0.7	0.000 52 mV/V	
	0.8	0.000 58 mV/V	
	0.9	0.000 65 mV/V	
	1	0.000 71 mV/V	
	(0 to 2) mV/V		
	0	60 nV	
	0.2	0.000 19 mV/V	
	0.4	0.000 32 mV/V	
	0.6	0.000 45 mV/V	
	0.8	0.000 58 mV/V	
	1	0.000 71 mV/V	
	1.2	0.000 84 mV/V	
	1.4	0.000 97 mV/V	
	1.6	0.001 1 mV/V	
	1.8	0.001 2 mV/V	
	2	0.001 4 mV/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Strain Gauge Indicator [1] 120 Ω, 350 Ω	(0 to 5) mV/V		Vishay BLH 625 Precision Calibrator CP-EL63: Direct Measurement
	0	60 nV	
	0.5	0.000 39 mV/V	
	1	0.000 71 mV/V	
	1.5	0.001 mV/V	
	2	0.001 4 mV/V	
	2.5	0.001 7 mV/V	
	3	0.002 mV/V	
	3.5	0.002 3 mV/V	
	4	0.002 7 mV/V	
	4.5	0.003 mV/V	
	5	0.003 3 mV/V	
	(0 to 10) mV/V		
	0	60 nV	
	1	0.000 71 mV/V	
	2	0.001 4 mV/V	
	3	0.002 mV/V	
	4	0.002 7 mV/V	
	5	0.003 3 mV/V	
	6	0.004 mV/V	
	7	0.004 6 mV/V	
	8	0.005 3 mV/V	
	9	0.005 9 mV/V	
	10	0.006 6 mV/V	
DC Current – Source [1] (Fixed Points)	± 100 µA	10 µA/A	Keysight 3458A 8.5 Digit Multimeter, Fluke 5700A or Fluke 5522A Calibrator; CP-EL67: Comparison Measurement
	± 1 mA	9 µA/A	
	± 10 mA	9 µA/A	
	± 100 mA	12 µA/A	
	± 1 A	25 µA/A	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1] (Fixed Points)	10 Hz		Keysight 3458A 8.5 Digit Multimeter, Fluke 5700A or Fluke 5522A Calibrator; CP-EL67: Comparison Measurement
	100 µA	0.28 mA/A	
	1 mA	0.28 mA/A	
	10 mA	0.12 mA/A	
	100 mA	0.11 mA/A	
	1 A	0.11 mA/A	
	45 Hz		
	100 µA	0.23 mA/A	
	1 mA	0.33 mA/A	
	10 mA	0.12 mA/A	
	100 mA	0.11 mA/A	
	1 A	0.11 mA/A	
	100 Hz		
	100 µA	0.22 mA/A	
	1 mA	0.22 mA/A	
	10 mA	0.12 mA/A	
	100 mA	0.11 mA/A	
	1 A	0.11 mA/A	
	1 kHz		
	100 µA	0.22 mA/A	
	1 mA	0.22 mA/A	
	10 mA	0.12 mA/A	
	100 mA	0.11 mA/A	
	1 A	0.11 mA/A	
DC Resistance – Source [1] (Fixed-Simulated Points)	10 Ω	14 µΩ/Ω	Keysight 3458A 8.5 Digit Multimeter, Fluke 5700A or Fluke 5522A Calibrator; CP-EL67: Comparison Measurement
	100 Ω	12 µΩ/Ω	
	1 kΩ	7 µΩ/Ω	
	10 kΩ	9 µΩ/Ω	
	100 kΩ	10 µΩ/Ω	
	1 MΩ	19 µΩ/Ω	
	10 MΩ	25 µΩ/Ω	
	100 MΩ	90 µΩ/Ω	
	1 GΩ	0.33 mΩ/Ω	
Resistance – Source [1] (Fixed Points)	0 Ω	59 µΩ	Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement
	1 Ω	96 µΩ/Ω + 0.95 µΩ	
	1.9 Ω	96 µΩ/Ω + 1.7 µΩ	
	10 Ω	29 µΩ/Ω + 3.5 µΩ	
	19 Ω	28 µΩ/Ω + 4 µΩ	
	100 Ω	18 µΩ/Ω + 34 µΩ	
	190 Ω	18 µΩ/Ω + 16 µΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source [1] (Fixed Points)	1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	14 µΩ/Ω + 0.3 mΩ 14 µΩ/Ω + 0.34 mΩ 13 µΩ/Ω + 2.9 mΩ 13 µΩ/Ω + 3.6 mΩ 15 µΩ/Ω + 20 mΩ 15 µΩ/Ω + 24 mΩ 22 µΩ/Ω + 0.22 Ω 23 µΩ/Ω + 0.3 Ω 42 µΩ/Ω + 6.4 Ω 48 µΩ/Ω + 8.4 Ω 0.12 mΩ/Ω + 70 Ω	Fluke 5700A Multifunction Calibrator; CP-EL79: Direct Measurement
Resistance – Source [1] (Simulated, 4-wire Mode)	(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	62 µΩ/Ω + 1.2 mΩ 53 µΩ/Ω + 1.8 mΩ 43 µΩ/Ω + 1.7 mΩ 36 µΩ/Ω + 2.4 mΩ 34 µΩ/Ω + 2.4 mΩ 35 µΩ/Ω + 24 mΩ 34 µΩ/Ω + 24 mΩ 35 µΩ/Ω + 0.24 Ω 34 µΩ/Ω + 0.24 Ω	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
Resistance – Source [1] (Simulated, 2-wire Mode)	(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 < 110) MΩ (110 to < 330) MΩ (330 to 1 100) MΩ	38 µΩ/Ω + 7.8 Ω 39 µΩ/Ω + 3.8 Ω 71 µΩ/Ω + 48 Ω 0.16 mΩ/Ω + 0.46 kΩ 0.3 mΩ/Ω + 3.3 kΩ 0.59 mΩ/Ω + 4.6 kΩ 3.5 mΩ/Ω + 0.23 MΩ 18 mΩ/Ω + 0.59 MΩ	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source [1] (Fixed Artifacts)	75 µΩ	5.8 mΩ/Ω + 60 nΩ	Red-China FL-2.0, Megger 249005, CCCP Standard Resistor Sets 1mΩ to 100kΩ; CP-EL24: Direct Measurement
	0.1 mΩ	3 mΩ/Ω + 60 nΩ	
	0.6 mΩ	5.9 mΩ/Ω + 0.1 µΩ	
	1 mΩ	55 µΩ/Ω + 80 nΩ	
	2 mΩ	2.4 mΩ/Ω + 0.1 µΩ	
	10 mΩ	50 µΩ/Ω + 0.1 µΩ	
	0.1 Ω	50 µΩ/Ω + 1 µΩ	
	1 Ω	50 µΩ/Ω + 10 µΩ	
	10 Ω	55 µΩ/Ω + 0.1 mΩ	
	0.1 kΩ	55 µΩ/Ω + 1 mΩ	
	1 kΩ	55 µΩ/Ω + 10 mΩ	
	10 kΩ	55 µΩ/Ω + 0.1 Ω	
	100 kΩ	57 µΩ/Ω + 1 Ω	
Resistance – Source [1] (Variable Artifacts)	100 mΩ to 1 Ω	0.13 mΩ/Ω + 0.27 mΩ	Yokogawa 2793, Yokogawa 2786, ESI DB62-11k, ESI DB62-11M Decade Resistors; CP-EL24: Direct Measurement
	(1 to 10) Ω	0.13 mΩ/Ω + 0.27 mΩ	
	(10 to 100) Ω	0.13 mΩ/Ω + 0.27 mΩ	
	(100 to 1 000) Ω	0.13 mΩ/Ω + 0.35 mΩ	
	(1 to 10) kΩ	0.13 mΩ/Ω + 1.8 mΩ	
	(10 to 100) kΩ	0.13 mΩ/Ω + 10 mΩ	
Resistance – Source [1] (Variable Artifacts)	100 kΩ to 1 MΩ	0.12 mΩ/Ω + 30 Ω	General Radio RDS67-A, ESI DB62-11M, Decade Resistor; CP-EL24: Direct Measurement
	(> 1 to 10) MΩ	0.12 mΩ/Ω + 0.6 kΩ	
	(> 10 to 100) MΩ	0.12 mΩ/Ω + 50 kΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
High Resistance – Source [1] (Insulation Resistance) (Artifacts) Test Voltage: ± (10 to 10 000) V	1 kΩ	1.8 Ω	Yokogawa 279303 Decade Resistance Box, Megger CB101 High Resistance Box, Ohmite SM1 Resistor, 1MΩ to 1TΩ Standard Resistance Box {1MΩ to 5 GΩ, (10 to 20) GΩ, 100 GΩ, and 1 TΩ}; CP-EL05: Direct Measurement
	10 kΩ	0.18 kΩ	
	100 kΩ	1.8 kΩ	
	1 MΩ	5.1 kΩ	
	2 MΩ	11 kΩ	
	5 MΩ	8.6 kΩ	
	10 MΩ	9.2 kΩ	
	20 MΩ	0.11 MΩ	
	50 MΩ	0.11 MΩ	
	100 MΩ	0.12 MΩ	
	200 MΩ	1.3 MΩ	
	300 MΩ	2.2 MΩ	
	400 MΩ	2.9 MΩ	
	500 MΩ	3.3 MΩ	
	1 GΩ	6.8 MΩ	
	2 GΩ	14 MΩ	
	5 GΩ	36 MΩ	
	10 GΩ	74 MΩ	
	20 GΩ	0.15 GΩ	
	100 GΩ	0.72 GΩ	
	1 TΩ	10 GΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surface Resistivity/Resistance Meter, Electrostatic Resistance [1] (Artifacts) Test Voltage: ± (Up to 100) V	1 kΩ	1.8 Ω	Yokogawa 279303 Decade Resistance Box, Megger CB101 High Resistance Box, Ohmite SM1 Resistor, 1MΩ to 1TΩ Standard Resistance Box {1MΩ to 5 GΩ, (10 to 20) GΩ, 100 GΩ, and 1 TΩ}; CP-EL05: Direct Measurement
	10 kΩ	0.18 kΩ	
	100 kΩ	1.8 kΩ	
	1 MΩ	5.1 kΩ	
	2 MΩ	11 kΩ	
	5 MΩ	8.6 kΩ	
	10 MΩ	9.2 kΩ	
	20 MΩ	0.11 MΩ	
	50 MΩ	0.11 MΩ	
	100 MΩ	0.12 MΩ	
	200 MΩ	1.3 MΩ	
	300 MΩ	2.2 MΩ	
	400 MΩ	2.9 MΩ	
	500 MΩ	3.3 MΩ	
	1 GΩ	6.8 MΩ	
	2 GΩ	14 MΩ	
	5 GΩ	36 MΩ	
	10 GΩ	74 MΩ	
	20 GΩ	0.15 GΩ	
	100 GΩ	0.72 GΩ	
	1 TΩ	10 GΩ	
Resistance – Measure [1]	(0 to 20) Ω	18 µΩ/Ω + 27 µΩ	Wavetek 1281 8.5 Digit Multimeter; CP-EL02: Direct Measurement
	(20 to < 200) Ω	13 µΩ/Ω + 0.12 mΩ	
	200 Ω to < 2 kΩ	11 µΩ/Ω + 1.1 mΩ	
	(2 to < 20) kΩ	11 µΩ/Ω + 12 mΩ	
	(20 to < 200) kΩ	11 µΩ/Ω + 0.14 Ω	
	200 kΩ to < 2 MΩ	17 µΩ/Ω + 5 Ω	
	(2 to < 20) MΩ	35 µΩ/Ω + 0.17 kΩ	
	(20 to < 200) MΩ	0.35 mΩ/Ω + 13 kΩ	
	200 MΩ to < 2 GΩ	3.5 mΩ/Ω + 1.1 MΩ	
Resistance – Measure [1]	(0 to 10) Ω	24 µΩ/Ω + 60 µΩ	Keysight 3458A 8.5 Digit Multimeter; CP-EL66: Direct Measurement
	(> 10 to 100) Ω	18 µΩ/Ω + 0.6 mΩ	
	> 100 Ω to 1 kΩ	16 µΩ/Ω + 0.6 mΩ	
	(> 1 to 10) kΩ	16 µΩ/Ω + 6 mΩ	
	(> 10 to 100) kΩ	16 µΩ/Ω + 60 mΩ	
	> 100 Ω to 1 MΩ	22 µΩ/Ω + 3 Ω	
	(> 1 to 10) MΩ	63 µΩ/Ω + 0.2 kΩ	
	(> 10 to 100) MΩ	0.59 mΩ/Ω + 2 kΩ	
	> 100 MΩ to 1 GΩ	5.8 mΩ/Ω + 20 kΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1] Test Current: 100 µA to 200 A	(10 to 75) µΩ (> 75 to 100) µΩ (> 0.1 to 1) mΩ (> 1 to 100) mΩ (> 0.1 to 1) Ω (> 1 to 100) Ω (> 0.1 to 100) kΩ	2 mΩ/Ω 1 mΩ/Ω 92 µΩ/Ω 65 µΩ/Ω 55 µΩ/Ω 60 µΩ/Ω 60 µΩ/Ω	Red-China FL-2.0, Megger 249005, CCCP Standard Resistor Sets 1mΩ-100kΩ, Wavetek 1281, Keysight 3458A, 8.5 Digit Multimeter; CP-EL58: Using DC Voltage Inter- Comparison
Resistance – Measure [1] Test Voltage: Up to 5 kV	(1 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 (> 20 to 200) GΩ > 200 GΩ to 1 TΩ	2.3 mΩ/Ω + 0.4 Ω 2.2 mΩ/Ω + 1 Ω 2.9 mΩ/Ω + 10 Ω 2.9 mΩ/Ω + 0.1 kΩ 2.9 mΩ/Ω + 1 kΩ 3.5 mΩ/Ω + 10 kΩ 3.8 mΩ/Ω + 0.1 MΩ 4.1 mΩ/Ω + 1 MΩ 4 mΩ/Ω + 10 MΩ 4.1 mΩ/Ω + 1 GΩ	Advantest R8252 Electrometer, Keysight 3458A 8.5 Digit Multimeter, Fluke 5522A, Fluke 5502A, Fluke 5700A Multiproduct Calibrator, Chroma 19073 Hipot Tester; CP-EL25: Using Ohm's Law
DC Electronic Load [1] Constant Voltage (CV) Constant Current (CC) and Constant Resistance (CR)	(0 to 100) mV (> 0.1 to 10) V (> 10 to 100) V (> 100 to 1000) V (0 to 100) mA (> 100 to 200) mA (> 0.2 to 1) A (> 1 to 3) A (> 3 to 20) A (> 20 to 30) A (> 30 to 300) A	20 µV/V 14 µV/V 15 µV/V 25 µV/V 73 µA/A 67 µA/A 77 µA/A 85 µA/A 0.12 mA/A 0.19 mA/A 0.36 mA/A	CCCP Standard Resistor Sets 1mΩ to 10kΩ, Keysight 3458A 8.5 Digit Multimeter, GW PCS-1000i Precision Current Shunt; CP-EL80: Using Comparison Measurement and Ohm's Law
AC/DC Current Shunt [1] DC	(0 to 30) mA (> 30 to 300) mA (> 0.3 to 3) A (> 3 to 30) A (> 30 to 200) A	0.02 % of reading 0.021 % of reading 0.021 % of reading 0.06 % of reading 0.19 % of reading	Keysight 3458A, 8.5 Digit Multimeter, GW PCS-1000i Precision Current Shunt; CP-EL82: Using In-direct Measurement

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC/DC Current Shunt[1] AC	(50 to 400) Hz Up to 300 mA (> 0.3 to 100) A	 0.64 % of reading 0.64 % of reading	Keysight 3458A, 8.5 Digit Multimeter, GW PCS-1000i Precision Current Shunt; CP-EL82: Using In-direct Measurement
Potential Transformer (PT)[1]	(45 to 65) Hz Primary Input: 330 mV to 1 000 V Secondary Output: Up to 500 V	0.2 mV/V	Fluke 5522A Multiproduct Calibrator, Calmet TS33, Calibrator, Keysight 3458A 8.5 Digit Multimeter, GW PCS-1000i Precision Current Shunt; CP-EL82: Using In-direct Measurement
Current Transformer (CT)[1]	(45 to 65) Hz Primary Input: 330 mA to 100 A Secondary Output: Up to 30 A	0.41 mA/A	
Current Coil[1] (2 to 50) turn Input: (0.2 to 20) A	DC (1 to 1 000) A	0.44 % of reading	Fluke 5522A Multiproduct Calibrator, Keysight 3458A 8.5 Digit Multimeter, Fluke i1010 AC/DC Current Clamp, Chauvin D30CN AC Current Clamp; CP-EL86: Using In-direct Measurement
Input: (0.2 to 10) A	(45 to 400) Hz (1 to 500) A	0.55 % of reading	
Input: (10 to 20) A	(45 to 400) Hz (> 500 to 1 000) A	0.62 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source [1] (Simulated)	5 kHz		Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
	(0.22 to < 0.4) nF	7.2 mF/F + 12 pF	
	1 kHz		
	(0.4 to < 1.1) nF	6.3 mF/F + 13 pF	
	(1.1 to < 3.3) nF	5.9 mF/F + 14 pF	
	(3.3 to < 11) nF	3 mF/F + 13 pF	
	(11 to < 33) nF	3 mF/F + 59 pF	
	(33 to < 110) nF	3 mF/F + 59 pF	
	(110 to < 330) nF	3 mF/F + 0.58 nF	
	100 Hz		
	330 nF to < 1.1 µF	3 mF/F + 1.4 nF	
	(1.1 to < 3.3) µF	3 mF/F + 6.8 nF	
	(3.3 to < 11) µF	3 mF/F + 13 nF	
	(11 to < 33) µF	4.7 mF/F + 68 nF	
Capacitance – Source [1] (Simulated)	50 Hz		Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
	(33 to < 110) µF	5.4 mF/F + 0.13 µF	
	DC		
	(110 to < 330) µF	5.4 mF/F + 0.68 µF	
	330 µF to < 1.1 mF	5.3 mF/F + 1.3 µF	
	(1.1 to < 3.3) mF	5.3 mF/F + 6.8 µF	
	(3.3 to < 11) mF	5.3 mF/F + 13 µF	
	(11 to < 33) mF	8.7 mF/F + 68 µF	
	(33 to 110) mF	13 mF/F + 0.14 mF	
Capacitance – Source [1] (Fixed Artifacts) Test Frequency: 120 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 5 MHz, 10 MHz, 13 MHz	1 pF	1.2 fF	General Radio 1409-F, 1409-L, and 1409-T Standard Capacitors; HP 16380A Standard Air Capacitor Set consisting of 16381A, 16382A, 16483A and 16384A; CP-EL26: Direct Measurement
	10 pF	12 fF	
	100 pF	0.12 pF	
	1 nF	1.2 pF	
	10 nF	1.2 pF	
	100 nF	1.2 pF	
Inductance – Source [1] (Fixed Artifacts) Test Frequency: 120 Hz	(10 µH, 100 µH, 1 mH)	4.2 mH/H	General Radio 1482-E, 1482-H Standard Inductors; CP-EL26: Direct Measurement
	(10 mH, 100 mH, 1 H)	1.5 mH/H	
1 kHz, 10 kHz	(1 µH, 10 µH, 100 µH)	2 mH/H	
	(1 mH, 10 mH, 100 mH)	1.5 mH/H	
	(1 H, 10 H)	1.2 mH/H	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Source/Measure [1] Test Frequency: 10 kHz to 1 MHz	Up to < 1 µH	3.5 mH/H + 0.1 nH	Standard Inductors, Decade Inductor, Keysight E4980AL Precision LCR Meter; CP-EL65: Resonant Method
	(1 to < 10) µH	3.5 mH/H + 0.2 nH	
	(10 to < 100) µH	3.5 mH/H + 2 nH	
	(100 to < 1 000) µH	1.2 mH/H + 20 nH	
	(1 to < 10) mH	1.2 mH/H + 0.2 µH	
(10 to 500) kHz			
	(10 to < 100) mH	1.2 mH/H + 2 µH	
(1 to 200) kHz	(100 to < 1 000) mH	1.2 mH/H + 20 µH	
(1 to 20) kHz	(1 to < 10) H	1.2 mH/H + 2 mH	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source/Measure [1]	20 Hz to < 1 kHz		Standard Capacitors, Keysight E4980AL Precision LCR Meter; CP-EL60: Direct and Comparison Measurement
	(10 to < 100) pF	8 fF	
	(100 to < 1 000) pF	15 fF	
	(1 to < 10) nF	0.15 pF	
	(10 to < 100) nF	1.5 pF	
	(100 to 1 000) nF	15 pF	
	(1 to < 10) kHz		
	(1 to < 10) pF	0.2 fF	
	(10 to < 100) pF	1.8 fF	
	(100 to < 1 000) pF	15 fF	
	(1 to < 10) nF	0.15 pF	
	(10 to < 100) nF	1.5 pF	
	(100 to 1 000) nF	15 pF	
	(10 to < 100) kHz		
	(1 to < 10) pF	0.25 fF	
	(10 to < 100) pF	1.6 fF	
	(100 to < 1 000) pF	15 fF	
	(1 to < 10) nF	0.15 pF	
	(10 to < 100) nF	1.5 pF	
	(100 to 1 000) nF	15 pF	
	(100 to < 300) kHz		
	(1 to < 10) pF	0.22 fF	
	(10 to < 100) pF	1.6 fF	
	(100 to < 1 000) pF	15 fF	
	(1 to < 10) nF	0.15 pF	
	(10 to < 100) nF	1.5 pF	
	(100 to 1 000) nF	15 pF	
	300 kHz to 1 MHz		
	(1 to < 10) pF	2.5 fF	
	(10 to < 100) pF	1.6 fF	
	(100 to < 1 000) pF	16 fF	
	(1 to < 10) nF	0.15 pF	
	(10 to < 100) nF	1.5 pF	
	(100 to 1 000) nF	15 pF	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source/Measure [1]	100 Hz to < 1 kHz		Standard Capacitors, Keysight E4980AL Precision LCR Meter; CP-EL60: Direct and Comparison Measurement
	(1 to < 10) µF	0.15 nF	
	(10 to < 100) µF	20 nF	
	100 Hz, 120 Hz		
	(0.1 to < 1) mF	0.15 µF	
	(1 to < 10) mF	5.5 µF	
	(10 to 100) mF	0.22 mF	
	1 kHz		
	(0.1 to < 1) mF	1 µF	
	(1 to 10) mF	10 µF	
Inductance – Source/Measure [1]	100 Hz to < 1 kHz		Standard Inductors, Keysight E4980AL Precision LCR Meter; CP-EL60: Direct and Comparison Measurement
	(10 to < 100) µH	0.4 µH	
	(100 to < 1 000) µH	6.5 µH	
	(1 to < 10) mH	6 µH	
	(10 to < 100) mH	18 µH	
	(100 to 1 000) mH	0.15 mH	
	(1 to 10) kHz		
	(10 to < 100) µH	0.2 µH	
	(100 to < 1 000) µH	0.2 µH	
	(1 to < 10) mH	1.7 µH	
	(10 to < 100) mH	6.5 µH	
	(100 to < 1 000) mH	95 µH	
	(100 to 1 000) Hz		
	(1 to 10) H	13 mH	
AC Resistance – Source/Measure [1]	10 mΩ		Standard Resistors, Keysight E4980AL Precision LCR Meter; CP-EL60: Direct and Comparison Measurement
	100 Hz	0.85 mΩ/Ω + 0.3 µΩ	
	(> 0.1 to 100) kHz	1.1 mΩ/Ω + 1 µΩ	
	(10 to 100) mΩ		
	100 Hz	0.56 mΩ/Ω + 3.5 µΩ	
	(> 0.1 to 100) kHz	0.56 mΩ/Ω + 15 µΩ	
	(0.1 to 1) Ω		
	(0.1 to 1) kHz	0.36 mΩ/Ω + 30 µΩ	
	(> 1 to 100) kHz	0.41 mΩ/Ω + 40 µΩ	
	(> 0.1 to 1) MHz	0.62 mΩ/Ω + 0.1 mΩ	
	(1 to 10) Ω		
	(0.1 to 1) kHz	0.2 mΩ/Ω + 30 µΩ	
	(> 1 to 100) kHz	0.92 mΩ/Ω + 80 µΩ	
	(> 0.1 to 1) MHz	0.71 mΩ/Ω + 0.15 mΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Resistance – Source/Measure [1]	100 Hz to < 10 kHz		Standard Resistors, Keysight E4980AL Precision LCR Meter; CP-EL60: Direct and Comparison Measurement
	(100 to < 1 000) mΩ	30 µΩ	
	(1 to < 10) Ω	0.22 mΩ	
	(10 to < 100) Ω	1 mΩ	
	(100 to < 1 000) Ω	10 mΩ	
	(1 to < 10) kΩ	1 Ω	
	(10 to 100) kΩ	1 Ω	
	(10 to < 300) kHz		
	(100 to < 1 000) mΩ	0.2 mΩ	
	(1 to < 10) Ω	0.25 mΩ	
	(10 to < 100) Ω	4.2 mΩ	
	(100 to < 1 000) Ω	40 mΩ	
	(1 to < 10) kΩ	0.4 Ω	
	(10 to 100) kΩ	5 Ω	
	300 kHz to 1 MHz		
	(10 to < 100) mΩ	15 mΩ/Ω + 0.1 µΩ	
	(100 to < 1000) mΩ	13 mΩ/Ω + 4 µΩ	
	(1 to < 10) Ω	1 mΩ/Ω + 10 µΩ	
	(10 to < 100) Ω	0.85 mΩ/Ω + 0.1 mΩ	
	(100 to < 1 000) Ω	0.85 mΩ/Ω + 1.5 mΩ	
	(1 to < 10) kΩ	0.85 mΩ/Ω + 10 mΩ	
	(10 to 100) kΩ	1.6 mΩ/Ω + 0.2 Ω	
High Capacitance – Measure [1] Test Current: Up to 27 mA, Measure voltage: Up to 10 V	(200 to 700) µF	0.16 mF/F	Fluke 5700A Calibrator, Keysight 3458A 8.5 Digit Multimeter; CP-EL83: Using In-direct Measurement
	(> 0.7 to 33) mF	0.14 mF/F	
	(> 33 to 110) mF	0.15 mF/F	
Dissipation Factor – Source / Measure [1,6]	1 pF		Capacitator Set, Keysight E4980A Precision LCR Meter; CP-EL81: Comparison Measurement
	1 kHz	0.12	
	10 kHz	0.011	
	100 kHz	0.001 9	
	300 kHz	0.004 4	
	1 MHz	0.001 1	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dissipation Factor – Source / Measure [1,6]	10 pF		Capacitator Set, Keysight E4980A Precision LCR Meter; CP-EL81: Comparison Measurement
	100 Hz	0.18	
	120 Hz	0.18	
	1 kHz	0.012	
	10 kHz	0.002	
	100 kHz	0.001 1	
	300 kHz	0.001 4	
	1 MHz	0.001 1	
	100 pF		
	100 Hz	0.003	
	120 Hz	0.003	
	1 kHz	0.001 7	
	10 kHz	0.001 1	
	100 kHz	0.000 51	
	300 kHz	0.000 54	
	1 MHz	0.000 52	
	1 nF		
	100 Hz	0.000 75	
	120 Hz	0.000 75	
	1 kHz	0.000 62	
	10 kHz	0.000 51	
	100 kHz	0.000 5	
	300 kHz	0.000 51	
	1 MHz	0.000 51	
	10 nF		
	100 Hz	0.000 53	
	120 Hz	0.000 53	
	1 kHz	0.000 51	
	10 kHz	0.000 5	
	100 kHz	0.000 51	
	300 kHz	0.000 52	
	1 MHz	0.001 1	
	100 nF		
	100 Hz	0.000 5	
	120 Hz	0.000 5	
	1 kHz	0.000 5	
	10 kHz	0.000 51	
	100 kHz	0.001 1	
	300 kHz	0.001 2	
	1 MHz	0.001 7	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dissipation Factor – Source / Measure [1,6]	1 µF		Capacitator Set, Keysight E4980A Precision LCR Meter; CP-EL81: Comparison Measurement
	100 Hz	0.000 51	
	120 Hz	0.000 51	
	1 kHz	0.000 51	
	10 kHz	0.001 1	
	100 kHz	0.001 7	
	300 kHz	0.002 8	
	1 MHz	0.005 7	
DC Power – Source [1]	0.108 9 mW to < 1.089 W (0.033 to < 33) V (3.3 to < 33) mA	0.2 mW/W + 90 µW	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
	1.089 mW to < 10.89 W (0.033 to < 33) V (33 to < 330) mA)	0.2 mW/W + 0.9 mW	
	10.89 mW to < 99 W (0.033 to < 33) V (0.33 to < 3) A	0.2 mW/W + 8 mW	
	99 mW to < 660 W (0.033 to < 33) V (3 to 20 A)	0.6 mW/W + 80 mW	
	(0.108 9 to < 33) W (33 to 1 000) V (3.3 to < 33) mA	0.2 mW/W + 0.9 mW	
	(1.089 to < 330) W (33 to 1 000) V (33 to < 330) mA	0.2 mW/W + 9 mW	
	10.89 W to < 3 kW (33 to 1 000) V (0.33 to < 3) A	0.2 mW/W + 90 mW	
	99 W to 20 kW (33 to 1 000) V (3 to 20) A	0.6 mW/W + 0.9 W	
	0.33 W to < 0.544 5 kW (0.033 to < 33) V, (10 to < 16.5) A	3.2 mW/W + 60 mW	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Power – Source [1]	0.544 5 W to < 4.95 kW (0.033 to < 33) V, (16.5 to < 150) A	3.2 mW/W + 0.6 W	Fluke 5522A Multiproduct Calibrator, 50-turn Coil; CP-EL01: Direct Measurement
	4.95 W to < 33.825 kW (0.033 to < 33) V, (150 to 1 025) A	3.2 mW/W + 6 W	
	(0.33 to < 16.83) kW (33 to 1 020) V, (10 to < 16.5) A	3.2 mW/W + 0.6 W	
	(0.544 5 to < 153) kW (33 to 1 020) V, 16.5 A to < 150 A)	3.2 mW/W + 6 W	
	4.95 kW to 1.045 5 MW (33 to 1 020) V, (150 to 1 025) A	3.2 mW/W + 60 W	
AC Power – Source [1] (45 to 65) Hz, PF = 1	(1.089 to < 29.7) mW (0.33 to < 3.3) V, (3.3 to < 9) mA	1.2 mW/W + 10 µW	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
	(2.97 to < 108.9) mW (0.33 to < 3.3) V, (9 to < 33) mA)	0.8 mW/W + 10 µW	
	(10.89 to < 297) mW (0.33 to < 3.3) V, (33 to < 90) mA)	1.2 mW/W + 0.1 mW	
	29.7 mW to < 1.089 W (0.33 to < 3.3) V, (90 to < 330) mA	0.8 mW/W + 0.1 mW	
	(0.108 9 to < 2.97) W (0.33 to < 3.3) V, (0.33 to < 0.9) A	1.1 mW/W + 1 mW	
	(0.297 to < 7.26) W (0.33 to < 3.3) V, (0.9 to < 2.2) A	0.9 mW/W + 1 mW	

AC Power – Source [1] (45 to 65) Hz, PF = 1	(0.726 to < 14.85) W (0.33 to < 3.3) V, (2.2 to < 4.5) A	1.2 mW/W + 1 mW	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
	(1.485 to < 66) W (0.33 to < 3.3) V, (4.5 to 20) A	1 mW/W + 10 mW	
	(10.89 to < 297) mW (3.3 to < 33) V, (3.3 to < 9) mA	1.2 mW/W + 10 µW	
	29.7 mW to < 1.089 W (3.3 to < 33) V, (9 to < 33) mA	0.8 mW/W + 0.1 mW	
	(0.108 9 to < 2.97) W (3.3 to < 33) V, (33 to < 90) mA	1.2 mW/W + 0.1 mW	
	(0.297 to < 10.89) W (3.3 to < 33) V, (90 to < 330) mA	0.8 mW/W + 1 mW	
	(1.089 to < 29.7) W (3.3 to < 33) V, (0.33 to < 0.9) A	1.1 mW/W + 1 mW	
	(2.97 to < 72.6) W (3.3 to < 33) V, (0.9 to < 2.2) A	0.9 mW/W + 10 mW	
	(7.26 to < 148.5) W (3.3 to < 33) V, (2.2 to < 4.5) A	1.2 mW/W + 10 mW	
	(14.85 to < 660) W (3.3 to < 33) V, (4.5 to 20) A	1 mW/W + 0.1 W	
	(0.108 9 to < 2.97) W (33 to < 330) V, (3.3 to < 9) mA	1.2 mW/W + 0.1 mW	
	(0.297 to < 10.89) W (33 to < 330) V, (9 to < 33) mA	0.8 mW/W + 1 mW	
	(1.089 to < 29.7) W (33 to < 330) V, (33 to < 90) mA	1.2 mW/W + 1 mW	
	(2.97 to < 108.9) W (33 to < 330) V, (90 to < 330) mA	0.8 mW/W + 10 mW	
AC Power – Source [1] (45 to 65) Hz, PF = 1	(10.89 to < 297) W (33 to < 330) V, (0.33 to < 0.9) A	1.1 mW/W + 10 mW	Fluke 5522A Multiproduct Calibrator;

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
	(29.7 to < 726) W (33 to < 330) V, (0.9 to < 2.2) A	0.9 mW/W + 0.1 W	CP-EL01: Direct Measurement
	(72.6 to < 1 485) W (33 to < 330) V, (2.2 to < 4.5) A	1.2 mW/W + 0.1 W	
	(148.5 to < 6 600) W (33 to < 330) V, (4.5 to 20) A	1 mW/W + 1 W	
	(1.089 to < 9) W (330 to 1 000) V, (3.3 to < 9) mA	1.2 mW/W + 0.1 mW	
	(2.97 to < 33) W (330 to 1 000) V, (9 to < 33) mA	0.8 mW/W + 1 mW	
	(10.89 to < 90) W (330 to 1 000) V, (33 to < 90) mA	1.2 mW/W + 1 mW	
	(29.7 to < 330) W (330 to 1 000) V, (90 to < 330) mA	0.8 mW/W + 10 mW	
	(108.9 to < 900) W (330 to 1 000) V, (0.33 to < 0.9) A	1.1 mW/W + 10 mW	
AC Power – Source [1] (45 to 65) Hz, PF = (0.5 to 0.999)	(0.545 to < 29.67) mW (0.33 to < 3.3) V, (3.3 to < 9) mA	4 mW/W + 10 µW	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
	(1.485 to < 108.8) mW (0.33 to < 3.3) V, (9 to < 33) mA	4 mW/W + 10 µW	
	(5.45 to < 296.7) mW (0.33 to < 3.3) V, (33 to < 90) mA	4 mW/W + 0.1 mW	
	14.85 mW to < 1.088 W (0.33 to < 3.3) V, (90 to < 330) mA	4 mW/W + 0.1 mW	
	(54.45 to < 2.967) W (0.33 to < 3.3) V, (0.33 to < 0.9) A	4 mW/W + 1 mW	

AC Power – Source [1] (45 to 65) Hz, PF = (0.5 to 0.999)	0.148 5 to < 7.252 7) W (0.33 to < 3.3) V, (0.9 to < 2.2) A	4 mW/W + 1 mW	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
	(0.363 to < 14.835) W (0.33 to < 3.3) V, (2.2 to < 4.5) A	4 mW/W + 1 mW	
	(0.742 5 to < 65.934) W (0.33 to < 3.3) V, (4.5 A to 20) A	4 mW/W + 10 mW	
	(5.45 to < 296.7) mW (3.3 to < 33) V, (3.3 to < 9) mA	4 mW/W + 10 µW	
	14.85 mW to < 1.088 W (3.3 to < 33) V, (9 to < 33) mA	4 mW/W + 0.1 mW	
	54.45 mW to < 2.967 W (3.3 to < 33) V, (33 to < 90) mA	4 mW/W + 0.1 mW	
	(0.148 5 to < 10.88) W (3.3 to < 33) V, (90 < 330) mA)	4 mW/W + 1 mW	
	(0.544 5 to < 29.67) W (3.3 to < 33) V, (0.33 to < 0.9) A	4 mW/W + 1 mW	
	(1.485 to < 72.527) W (3.3 to < 33) V, (0.9 to < 2.2) A	4 mW/W + 10 mW	
	(3.63 to < 148.35) W (3.3 to < 33) V, (2.2 to < 4.5) A	4 mW/W + 10 mW	
	(7.425 to < 659.34) W (3.3 to < 33) V, (4.5 to 20) A	4 mW/W + 0.1 W	
	54.45 mW to < 2.967 W (33 to < 330) V, (3.3 to < 9) mA	4 mW/W + 0.1 mW	
	(0.148 5 to < 10.88) W (to < 330) V, (9 to < 33) mA	4 mW/W + 1 mW	
	(0.544 5 to < 29.67) W (to < 330) V, (to < 90) mA	4 mW/W + 1 mW	
AC Power – Source [1] (45 to 65) Hz, PF: (0.5 to 0.999)	(1.485 to < 108.8) W (33 to < 330) V, (90 to < 330) mA	4 mW/W + 10 mW	Fluke 5522A Multiproduct Calibrator;

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
	(5.445 to < 296.7) W (33 to < 330) V, (0.33 to < 0.9) A	4 mW/W + 10 mW	CP-EL01: Direct Measurement
	(14.85 to < 725.27) W (33 to < 330) V, (0.9 to < 2.2) A	4 mW/W + 0.1 W	
	(36.3 to < 1483.5) W (33 to < 330) V, (2.2 to < 4.5) A	4 mW/W + 0.1 W	
	(74.25 to < 6593.4) W (33 to < 330) V, (4.5 to 20) A	4 mW/W +1 W	
	(0.544 5 to < 8.991) W (330 to 1000) V, (3.3 to < 9) mA	4 mW/W + 0.1 mW	
	(1.485 to < 32.97) W (330 to 1000) V, (9 to < 33) mA	4 mW/W + 1 mW	
	(5.445 to < 89.91) W (330 to 1 000) V, (33 to < 90) mA	4 mW/W + 1 mW	
	(14.85 to < 329.7) W (330 to 1 000) V, (90 to < 330) mA	4 mW/W + 10 mW	
	(54.45 to < 899.1) W (330 to 1 000) V, (0.33 to < 0.9) A	4 mW/W + 10 mW	
	(148.5 to < 2 197.8) W (330 to 1 000) V, (0.9 to < 2.2 A)	4 mW/W + 0.1 W	
	(363 to < 4 495.5) W (330 to 1 000) V, (2.2 to < 4.5) A	4 mW/W + 0.1 W	
	(742.5 to 19 980) W (330 to 1 000) V, (4.5 A to 20) A	4 mW/W + 1 W	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Power – Source [1] (45 to 65) Hz, PF: 1	3.3 W to < 16.83 kW (0.33 to 1 020) V, (10 to < 16.5) A 5.445 W to < 153 kW (0.33 to 1 020) V, (16.5 to < 150) A 49.5 W to 1.045 5 MW (0.33 to 1 020) V, (150 to 1 025) A	3.6 mW/W + 0.6 W 3.6 mW/W + 6 W 3.6 mW/W + 60 W	Fluke 5522A Multiproduct Calibrator, 50-turn Coil; CP-EL01: Direct Measurement
AC Power – Source [1] (45 to 65) Hz, Power factor: (0.5 to 0.999)	1.65 W to < 16.813 kW (0.33 to 1 020) V, (10 to < 16.5) A 2.723 W to < 152.85 kW (0.33 to 1 020) V, (16.5 to < 150) A 24.75 W to 1.044 4 MW (0.33 to 1 020) V, (150 to 1 025) A	5 mW/W + 0.6 W 5 mW/W + 6 W 5 mW/W + 60 W	Fluke 5522A Multiproduct Calibrator, 50-turn Coil; CP-EL01: Direct Measurement
Power Factor – Source 1,4	(45 to 65) Hz (0.174 to 0.485) (0.5 to 0.755) (0.766 to 0.934) (0.94 to 0.999) 1	 0.001 4 0.001 3 0.000 95 0.000 5 0.000 06	Fluke 5522A Multiproduct Calibrator CP-EL59: Direct Measurement
Phase – Measure [1]	Up to 360° 10 Hz to 10 kHz (10 to 100) kHz	 0.01° 0.063°	Agilent 53131A or Agilent 53132A Universal Counter; CP-EL36: Direct Measurement
AC Watt-hour Source [1] (Single Phase)	0.010 89 Wh to 200 kWh Voltage range (0.33 to 1 000) V (45 to 65) Hz, cos φ = 1.0 Current range 3.3 mA to 20 A	1 mWh/Wh	Fluke 5522A Multiproduct Calibrator, Casio HS-70W Stopwatch; CP-EL38: Direct Measurement

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Power Quality, Single and Three Phase [1,3,4]			Fluke 435II Power Quality Analyzer; CP-EL64: Comparison Measurement
Voltage – Measure	Up to 1000 V	0.12 % of reading + 5.8 mV	
Current – Measure	10 mA to 1 A	1.2 % of reading + 8.2 mA	
	(> 1 to 5) A	1.2 % of reading + 5.8 mA	
	(> 5 to 600) A	0.58 % of reading + 0.58 A	
	(> 600 to 6 000) A	0.58 % of reading + 5.8 A	
Power Watt (W)	6 000 MW, 50/60 Hz	0.44 % of reading + 0.1 W	
Power VA (VA)	6 000 MW, 50/60 Hz	0.44 % of reading + 0.1 VA	
Power Var	6 000 MW, 50/60 Hz	0.44 % of reading + 0.1 var	
Energy (kWh)	50/60 Hz	0.44 % of reading + 0.1 kWh	
Energy (kVAh)	50/60 Hz	0.44 % of reading + 0.1 kVAh	
Frequency	(42.5 to 69) Hz	1.5 mHz	
Phase Angle	Up to 360°	1.3°	
Power Factor	Up to 1 PF	0.12 % of reading + 0.000 58	
Charge Plate Monitor [1]	(-5 to -1) kV	12 mV/V + 2.6 V	Ion Monitor 91-0210 Charged Plate Monitor; CP-EL41: Direct Measurement
	-1 kV to 0 V	12 mV/V + 2.5 V	
	0 V to 1 kV	12 mV/V + 2.5 V	
	(1 to 5) kV	12 mV/V + 2.6 V	
	(> 5 to 10) kV	38 mV/V + 36 V	
Earth Ground Continuity, Ground Bond [1]			
Test Current: (3 to 30) A	0.01 Ω	0.45 mΩ/Ω + 0.6 mΩ	Standard Resistor DR30A, Current Shunt; CP-EL40: Direct Measurement
	0.1 Ω	0.45 mΩ/Ω + 0.6 mΩ	
	0.2 Ω	0.45 mΩ/Ω + 0.6 mΩ	
	0.5 Ω	0.45 mΩ/Ω + 0.6 mΩ	
	1 Ω	0.45 mΩ/Ω + 0.6 mΩ	
	5 Ω	0.45 mΩ/Ω + 0.6 mΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Transformer Ratio – Source [1]	(1 to 10 000 000) turns	0.000 12 % of reading	Tegam DT72A Ratio Transformer; CP-EL47: Direct Measurement
Gauss Meter, Tesla Meter [1] (North and South)	297 G 957 G 1 030 G 2 960 G 5 100 G 10 250 G	13 G 20 G 23 G 53 G 77 G 120 G	F.W. Bell Inc. VA-071A, VA-072A, Magnet 10000 G, Reference Magnet; CP-EL52: Direct Measurement
Gauss – Measure [1]	Up to 2 G (> 2 to 20) G (> 20 to 200) G (> 200 to 2 000) G (> 2 000 to 20 000) G	0.58 % of reading + 0.007 G 0.58 % of reading + 0.07G 0.58 % of reading + 0.3 G 0.58 % of reading + 3 G 0.58 % of reading + 30 G	F.W. Bell 9200, F.W. Bell 5180, Standard Gauss Meter; CP-EL61: Direct Measurement
Oscilloscopes [1] Square Wave Signal Impedance: 50 Ω @ 10 Hz to 10 kHz	1 mVp-p to 25 mVp-p 25 mVp-p to 110 mVp-p 110 mVp-p to 2.2 Vp-p 2.2 Vp-p to 6.6 Vp-p	2 mV/V + 35 µV 2 mV/V + 35 µV 2 mV/V + 50 µV 2 mV/V + 50 µV	Fluke 5820A Oscilloscope Calibrator; CP-EL28: Direct Measurement
Impedance: 1 MΩ 10 Hz to 1 kHz	1 mVp-p to 25 mVp-p 25 mVp-p to 110 mVp-p 110 mVp-p to 2.2 Vp-p 2.2 Vp-p to 11 Vp-p 11 Vp-p to 130 Vp-p	0.4 mV/V + 4 µV 0.4 mV/V + 4 µV 0.4 mV/V + 70 µV 0.4 mV/V + 0.6 mV 0.4 mV/V + 6 mV	
Impedance: 1 MΩ 1 kHz to 10 kHz	1 mVp-p to 25 mVp-p 25 mVp-p to 110 mVp-p 110 mVp-p to 2.2 Vp-p 2.2 Vp-p to 11 Vp-p 11 Vp-p to 130 Vp-p	2 mV/V + 32 µV 2 mV/V + 32 µV 2 mV/V + 70 µV 2 mV/V + 0.6 mV 2 mV/V + 6 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1]			Fluke 5820A Oscilloscope Calibrator; CP-EL28: Direct Measurement
DC Signal Impedance: 50 Ω	0 mV to 25 mV	2 mV/V + 35 µV	
	25 mV to 110 mV	2 mV/V + 35 µV	
	110 mV to 2.2 V	2 mV/V + 50 µV	
	2.2 V to 6.6 V	2 mV/V + 50 µV	
DC Signal Impedance: 1 MΩ	0 mV to 25 mV	0.2 mV/V + 20 µV	
	25 mV to 110 mV	0.2 mV/V + 20 µV	
	110 mV to 2.2 V	0.2 mV/V + 50 µV	
	2.2 V to 11 V	0.2 mV/V + 50 µV	
	11 V to 130 V	0.2 mV/V + 0.7 mV	
Oscilloscope Bandwidth [1]			Fluke 5820A Oscilloscope Calibrator; CP-EL28: Direct Measurement
5 mVp-p to 5.5 Vp-p	50 kHz to 100 MHz	26 mV/V + 80 µV	
	100 MHz to 300 MHz	28 mV/V + 80 µV	
	300 MHz to 500 MHz	36 mV/V + 80 µV	
	500 MHz to 600 MHz	39 mV/V + 80 µV	
5 mVp-p to 3.5 Vp-p	600 MHz to 1.1 GHz	45 mV/V + 80 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes[1] Horizontal Deflection Time Markers	5 s	2 µs/s + 0.1 ms	Fluke 5820A Oscilloscope Calibrator; CP-EL28: Direct Measurement
	2 s	2 µs/s + 20 µs	
	1 s	2 µs/s + 6 µs	
	0.5 s	2 µs/s + 2 µs	
	0.2 s	2 µs/s + 0.3 µs	
	0.1 s	2 µs/s + 0.2 µs	
	50 ms	2 µs/s + 20 ns	
	20 ms	0.26 µs/s + 6 ns	
	10 ms	0.26 µs/s + 6 ns	
	5 ms	0.26 µs/s + 0.6 ns	
	2 ms	0.26 µs/s + 0.6 ns	
	1 ms	0.26 µs/s + 0.6 ns	
	0.5 ms	0.26 µs/s + 60 ps	
	0.2 ms	0.26 µs/s + 60 ps	
	0.1 ms	0.26 µs/s + 60 ps	
	50 µs	0.26 µs/s + 6 ps	
	20 µs	0.26 µs/s + 6 ps	
	10 µs	0.26 µs/s + 6 ps	
	5 µs	0.26 µs/s + 0.6 ps	
	2 µs	0.26 µs/s + 0.6 ps	
	1 µs	0.26 µs/s + 0.6 ps	
	0.5 µs	0.26 µs/s + 60 fs	
	0.2 µs	0.26 µs/s + 60 fs	
	0.1 µs	0.26 µs/s + 60 fs	
Oscilloscopes[1] Horizontal Deflection Time Markers	50 ns	0.26 µs/s + 6 fs	Fluke 5820A Oscilloscope Calibrator; CP-EL28: Direct Measurement
	20 ns	0.26 µs/s + 6 fs	
	10 ns	0.26 µs/s + 6 fs	
	5 ns	0.26 µs/s + 0.6 fs	
	2 ns	0.26 µs/s + 0.6 fs	
Temperature – Simulation Resistance Temperature Detector[1]	Pt100 (385)		Fluke 5522A Multiproduct Calibrator; CP-EL08: Direct Measurement
	(-200 to - 80) °C	0.082 °C	
	(> - 80 to 0) °C	0.082 °C	
	(> 0 to 100) °C	0.1 °C	
	(> 100 to 300) °C	0.12 °C	
	(> 300 to 400) °C	0.13 °C	
	(> 400 to 630) °C	0.16 °C	
	(> 630 to 800) °C	0.28 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Simulation Thermocouple [1] (With Internal Cold Junction Compensation)	Type K		Comparison to Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter, Fluke 5618B PRT Standard; CP-EL09: Based on EURAMET cg-11
	(-200 to -100) °C	0.23 °C	
	(> -100 to -25) °C	0.21 °C	
	(> -25 to 120) °C	0.2 °C	
	(> 120 to 1 000) °C	0.21 °C	
	(> 1 000 to 1 372) °C	0.21 °C	
	Type J		
	(-210 to -100) °C	0.22 °C	
	(> -100 to -30) °C	0.2 °C	
	(> -30 to 150) °C	0.2 °C	
	(> 150 to 760) °C	0.2 °C	
	(> 760 to 1 200) °C	0.21 °C	
	Type T		
	(-250 to -150) °C	0.34 °C	
	(> -150 to 0) °C	0.21 °C	
	(> 0 to 120) °C	0.2 °C	
	(> 120 to 400) °C	0.2 °C	
	Type R		
	(0 to 250) °C	0.51 °C	
	(> 250 to 400) °C	0.43 °C	
	(> 400 to 1 000) °C	0.42 °C	
	(> 1 000 to 1 767) °C	0.44 °C	
	Type S		
	(0 to 250) °C	0.54 °C	
	(> 250 to 400) °C	0.48 °C	
	(> 400 to 1 000) °C	0.48 °C	
	(> 1 000 to 1 767) °C	0.49 °C	
Temperature – Simulation Thermocouple [1] (With Internal Cold Junction Compensation)	Type E		Comparison to Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter, Fluke 5618B PRT Standard; CP-EL09: Based on EURAMET cg-11
	(-250 to -100) °C	0.28 °C	
	(> -100 to -25) °C	0.21 °C	
	(> -25 to 350) °C	0.2 °C	
	(> 350 to 650) °C	0.2 °C	
	(> 650 to 1 000) °C	0.21 °C	
	Type N		
	(-200 to -100) °C	0.27 °C	
	(> -100 to -25) °C	0.22 °C	
	(> -25 to 120) °C	0.21 °C	
	(> 120 to 410) °C	0.21 °C	
	(> 410 to 1 300) °C	0.21 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Simulation Thermocouple [1] (With cold junction compensation)	Type K		Fluke 5522A Multiproduct Calibrator; CP-EL18: Based on EURAMET cg-11
	(-200 to -100) °C	0.3 °C	
	(> -100 to -25) °C	0.2 °C	
	(> -25 to 120) °C	0.19 °C	
	(> 120 to 1 000) °C	0.25 °C	
	(> 1 000 to 1 372) °C	0.35 °C	
	Type J		
	(-210 to -100) °C	0.26 °C	
	(> -100 to -30) °C	0.19 °C	
	(> -30 to 150) °C	0.18 °C	
	(> 150 to 760) °C	0.2 °C	
	(> 760 to 1 200) °C	0.23 °C	
	Type T		
	(-250 to -150) °C	0.52 °C	
	(> -150 to 0) °C	0.18 °C	
	(> 0 to 120) °C	0.47 °C	
	(> 120 to 400) °C	0.26 °C	
	Type R		
	(0 to 250) °C	0.48 °C	
	(> 250 to 400) °C	0.32 °C	
	(> 400 to 1 000) °C	0.3 °C	
	(> 1 000 to 1 767) °C	0.35 °C	
	Type S		
	(0 to 250) °C	0.4 °C	
	(> 250 to 400) °C	0.4 °C	
	(> 400 to 1 000) °C	0.32 °C	
	(> 1 000 to 1 767) °C	0.39 °C	
Temperature – Simulation Thermocouple [1] (With cold junction compensation)	Type E		Fluke 5522A Multiproduct Calibrator; CP-EL18: Based on EURAMET cg-11
	(-250 to -100) °C	0.42 °C	
	(> -100 to -25) °C	0.19 °C	
	(> -25 to 350) °C	0.18 °C	
	(> 350 to 650) °C	0.19 °C	
	(> 650 to 1 000) °C	0.22 °C	
	Type N		
	(-200 to -100) °C	0.35 °C	
	(> -100 to -25) °C	0.23 °C	
	(> -25 to 120) °C	0.21 °C	
	(> 120 to 410) °C	0.2 °C	
	(> 410 to 1 300) °C	0.26 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Transmitter [1] Electrical Output Current (0 to 20) mA, Thermocouple	Type E		Fluke 5522A Multiproduct Calibrator, Fluke 754 Documenting Process Calibrator; CP-EL77: Direct Measurement
	(-250 to -100) °C	0.41 °C	
	(> -100 to -25) °C	0.18 °C	
	(> -25 to 350) °C	0.18 °C	
	(> 350 to 650) °C	0.18°C	
	(> 650 to 1 000) °C	0.21 °C	
	Type N		
	(-200 to -100) °C	0.34 °C	
	(> -100 to -25) °C	0.21 °C	
	(> -25 to 120) °C	0.19 °C	
	(> 120 to 410) °C	0.19 °C	
	(> 410 to 1 300) °C	0.25 °C	
	Type J		
	(-210 to -100) °C	0.24 °C	
	(> -100 to -30) °C	0.18 °C	
	(> -30 to 150) °C	0.18 °C	
	(> 150 to 760) °C	0.18 °C	
	(> 760 to 1 200) °C	0.22 °C	
	Type K		
	(-200 to -100) °C	0.28 °C	
	(> -100 to -25) °C	0.18 °C	
	(> -25 to 120) °C	0.18 °C	
	(> 120 to 1 000) °C	0.24 °C	
	(> 1 000 to 1 372) °C	0.34 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Transmitter [1] Electrical Output Current (0 to 20) mA, Thermocouple	Type T		Fluke 5522A Multiproduct Calibrator, Fluke 754 Documenting Process Calibrator; CP-EL77: Direct Measurement
	(-250 to -150) °C	0.5 °C	
	(> -150 to 0) °C	0.22 °C	
	(> 0 to 120) °C	0.17 °C	
	(> 120 to 400) °C	0.17 °C	
	Type B		
	(600 to 800) °C	0.36 °C	
	(> 800 to 1 000) °C	0.29 °C	
	(> 1 000 to 1 550) °C	0.29 °C	
	(> 1 550 to 1 820) °C	0.29 °C	
	Type R		
	(0 to 250) °C	0.46 °C	
	(> 250 to 400) °C	0.3 °C	
	(> 400 to 1 000) °C	0.3 °C	
	(> 1 000 to 1 767) °C	0.34 °C	
	Type S		
	(0 to 250) °C	0.38 °C	
	(> 250 to 1 000) °C	0.31 °C	
	(> 1 000 to 1 400) °C	0.31 °C	
	(> 1 400 to 1 767) °C	0.38 °C	
Temperature Transmitter [1] Electrical Output Current (0 to 20) mA, Resistance Temperature Detector (RTD)	Pt 385, 100 Ω		Fluke 5522A Multiproduct Calibrator, Fluke 754 Documenting Process Calibrator; CP-EL77: Direct Measurement
	(-200 to -80) °C	0.11 °C	
	(> -80 to 0) °C	0.11 °C	
	(> 0 to 100) °C	0.13 °C	
	(> 100 to 300) °C	0.14 °C	
	(> 300 to 400) °C	0.15 °C	
	(> 400 to 630) °C	0.16 °C	
	(> 630 to 800) °C	0.22 °C	
	Pt 3916, 100 Ω (JPT)		
	(-200 to -190) °C	0.22 °C	
	(> -190 to -80) °C	0.12 °C	
	(> -80 to 0) °C	0.12 °C	
	(> 0 to 100) °C	0.13 °C	
	(> 100 to 260) °C	0.14 °C	
	(> 260 to 300) °C	0.14 °C	
	(> 300 to 400) °C	0.14 °C	
	(> 400 to 600) °C	0.15 °C	
	(> 600 to 630) °C	0.22 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Transmitter [1] Electrical Output Current (0 to 20) mA, Resistance Temperature Detector (RTD)	Pt 385, 1 000 Ω		Fluke 5522A Multiproduct Calibrator, Fluke 754 Documenting Process Calibrator; CP-EL77: Direct Measurement
	(-200 to -80) °C	0.11 °C	
	(> -80 to 0) °C	0.11 °C	
	(> 0 to 100) °C	0.12 °C	
	(> 100 to 260) °C	0.13 °C	
	(> 260 to 300) °C	0.13 °C	
	(> 300 to 400) °C	0.14 °C	
	(> 400 to 600) °C	0.14 °C	
	(> 600 to 630) °C	0.22 °C	
Temperature Transmitter [1] Electrical Output Voltage (0 to 10) V, Thermocouple	Type B		Fluke 5522A Multiproduct Calibrator, Fluke 754 Documenting Process Calibrator; CP-EL77: Direct Measurement
	(600 to 800) °C	0.35 °C	
	(> 800 to 1 000) °C	0.27 °C	
	(> 1 000 to 1 550) °C	0.27 °C	
	(> 1 550 to 1 820) °C	0.27 °C	
	Type E		
	(-250 to -100) °C	0.39 °C	
	(> -100 to -25) °C	0.13 °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	0.13 °C	
	(> -30 to 150) °C	0.13 °C	
	(> 150 to 760) °C	0.15 °C	
	(> 760 to 1 200) °C	0.2 °C	
	Type K		
	(-200 to -100) °C	0.26 °C	
	(> -100 to -25) °C	0.15 °C	
	(> -25 to 120) °C	0.15 °C	
	(> 120 to 1 000) °C	0.21 °C	
	(> 1 000 to 1 372) °C	0.32 °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	0.16 °C	
	(> 410 to 1 300) °C	0.22 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Transmitter [1] Electrical Output Voltage (0 to 10) V, Thermocouple	Type R		Fluke 5522A Multiproduct Calibrator, Fluke 754 Documenting Process Calibrator; CP-EL77: Direct Measurement
	(0 to 250) °C	0.45 °C	
	(> 250 to 400) °C	0.28 °C	
	(> 400 to 1 000) °C	0.28 °C	
	(> 1 000 to 1 767) °C	0.32 °C	
	Type S		
	(0 to 250) °C	0.37 °C	
	(> 250 to 1 000) °C	0.3 °C	
	(> 1 000 to 1 400) °C	0.3 °C	
	(> 1 400 to 1 767) °C	0.37 °C	
	Type T		
	(-250 to -150) °C	0.49 °C	
	(> -150 to 0) °C	0.19 °C	
	(> 0 to 120) °C	0.14 °C	
	(> 120 to 400) °C	0.13 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Transmitter [1] Electrical Output Voltage (0 to 10) V Resistance Temperature Detector (RTD)	Pt 385, 100 Ω		Fluke 5522A Multiproduct Calibrator, Fluke 754 Documenting Process Calibrator; CP-EL77: Direct Measurement
	(-200 to -80) °C	0.045 °C	
	(> -80 to 0) °C	0.046 °C	
	(> 0 to 100) °C	0.065 °C	
	(> 100 to 300) °C	0.082 °C	
	(> 300 to 400) °C	0.093 °C	
	(> 400 to 630) °C	0.12 °C	
	(> 630 to 800) °C	0.19 °C	
	Pt 3916, 100 Ω (JPT)		
	(-200 to -190) °C	0.2 °C	
	(> -190 to -80) °C	0.04 °C	
	(> -80 to 0) °C	0.06 °C	
	(> 0 to 100) °C	0.063 °C	
	(> 100 to 260) °C	0.075 °C	
	(> 260 to 300) °C	0.087 °C	
	(> 300 to 400) °C	0.092 °C	
	(> 400 to 600) °C	0.098 °C	
	(> 600 to 630) °C	0.19 °C	
	Pt 385, 1 000 Ω		
	(-200 to -80) °C	0.029 °C	
	(> -80 to 0) °C	0.034 °C	
	(> 0 to 100) °C	0.045 °C	
	(> 100 to 260) °C	0.057 °C	
	(> 260 to 300) °C	0.069 °C	
	(> 300 to 400) °C	0.081 °C	
	(> 400 to 600) °C	0.081 °C	
	(> 600 to 630) °C	0.19 °C	
Digital Multimeter: up to 7.5 Digits DC Voltage – Source	Up to 200 mV	8.5 µV/V + 0.72 µV	Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter CP-EL54: Comparison Measurement
	200 mV to < 2 V	7.1 µV/V + 1.2 µV	
	(2 to < 20) V	7.1 µV/V + 7.5 µV	
	(20 to < 200) V	12 µV/V + 92 µV	
	(200 to 1 000) V	12 µV/V + 0.68 mV	
Digital Multimeter: up to 7.5 Digits DC Current – Source	Up to 200 µA	0.12 mA/A + 5.9 nA	Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter CP-EL54: Comparison Measurement
	200 µA to < 2 mA	0.12 mA/A + 8.3 nA	
	(2 to < 20) mA	0.12 mA/A + 83 nA	
	(20 to < 200) mA	0.12 mA/A + 1.4 µA	
	200 mA to < 2 A	0.24 mA/A + 26 µA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Multimeter: up to 7.5 Digits AC Voltage – Source	(20 to 40) Hz		Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter CP-EL54: Comparison Measurement
	(10 to < 200) mV	0.27 mV/V + 4.7 µV	
	200 mV to < 2 V	0.2 mV/V + 25 µV	
	(2 to < 20) V	0.2 mV/V + 0.24 mV	
	(20 to < 200) V	0.2 mV/V + 2.5 mV	
	(200 to 1 000) V	0.2 mV/V + 14 mV	
	(> 40 to 100) Hz		
	(10 to < 200) mV	0.25 mV/V + 4.7 µV	
	200 mV to < 2 V	0.18 mV/V + 25 µV	
	2 to < 20) V	0.18 mV/V + 0.24 mV	
	(20 to < 200) V	0.18 mV/V + 2.5 mV	
	(200 to 1 000) V	0.18 mV/V + 14 mV	
	> 100 Hz to 2 kHz		
	(10 to < 200) mV	0.25 mV/V + 2.5µV	
	200 mV to < 2 V	0.16 mV/V + 24 µV	
	(2 to < 20) V	0.16 mV/V + 0.24 mV	
	(20 to < 200) V	0.16 mV/V + 2.5 mV	
	(200 to 1 000) V	0.18 mV/V + 14 mV	
	(2 to 10) kHz		
	(10 to < 200) mV	0.25 mV/V + 4.7 µV	
	200 mV to < 2 V	0.18 mV/V + 24 µV	
	(2 to < 20) V	0.18 mV/V + 0.25 mV	
	(20 to < 200) V	0.18 mV/V + 2.6 mV	
	(200 to 1 000) V	0.18 mV/V + 14 mV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Multimeter: up to 7.5 Digits AC Voltage – Source	(10 to 30) kHz		Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter CP-EL54: Comparison Measurement
	(10 to < 200) mV	0.47 mV/V + 9.3 μV	
	200 mV to < 2 V	0.29 mV/V + 47 μV	
	(2 to < 20) V	0.29 mV/V + 0.47 mV	
	(20 to < 200) V	0.29 mV/V + 4.7 mV	
	(200 to 1 000) V	0.25 mV/V + 24 mV	
	(> 30 to 100) kHz		
	(10 to < 200) mV	0.82 mV/V + 24 μV	
	200 mV to < 2 V	0.58 mV/V + 0.24 mV	
	(2 to < 20) V	0.58 mV/V + 2.4 mV	
	(20 to < 200) V	0.58 mV/V + 24 mV	
	(200 to 1 000) V	0.58 mV/V + 0.12 V	
	(> 100 to 300) kHz		
	200 mV to < 2 V	3.5 mV/V + 2.4 mV	
	(2 to < 20) V	3.5 mV/V + 24 mV	
	(20 to < 200) V	3.5 mV/V + 0.24 V	
	> 300 kHz to 1 MHz		
	(2 to < 20) V	12 mV/V + 1.2 V	
	(20 to < 200) V	12 mV/V + 2.4 V	
Digital Multimeter: up to 7.5 Digits AC Current – Source	10 Hz to 5 kHz		Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter CP-EL54: Comparison Measurement
	(10 to < 200) μA	0.36 mA/A + 25 nA	
	200 μA to < 2 mA	0.35 mA/A + 0.25 μA	
	(2 to < 20) mA	0.35 mA/A + 2.5 μA	
	(20 to < 200) mA	0.35 mA/A + 25 μA	
	10 Hz to 1 kHz		
	200 mA to < 2 A	0.7 mA/A + 0.48 mA	
	(> 1 to 5) kHz		
	200 mA to < 2 A	2.4 mA/A + 0.94 mA	
Digital Multimeter: up to 7.5 Digits Resistance – Source	Up to 20 Ω	18 μΩ/Ω + 27 μΩ	Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter CP-EL54: Comparison Measurement
	(20 to < 200) Ω	13 μΩ/Ω + 0.12 mΩ	
	200 Ω to < 2 kΩ	11 μΩ/Ω + 1.1 mΩ	
	(2 to < 20) kΩ	11 μΩ/Ω + 12 mΩ	
	(20 to < 200) kΩ	11 μΩ/Ω + 0.14 Ω	
	200 kΩ to < 2 MΩ	17 μΩ/Ω + 5 Ω	
	(2 to < 20) MΩ	35 μΩ/Ω + 0.17 kΩ	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Digital Multimeter: up to 7.5 Digits Resistance – Source [1]	(20 to < 200) MΩ 200 MΩ to < 2 GΩ	0.35 mΩ/Ω + 13 kΩ 3.5 mΩ/Ω + 1.1 MΩ	Fluke 5522A Multiproduct Calibrator, Wavetek 1281 8.5 Digit Multimeter CP-EL54: Comparison Measurement
Oscilloscope Calibrators [1] DCV Amplitude			Keysight 3458A 8.5 Digit Multimeter CP-EL71: Direct Measurement
1 MΩ load	Up to ± 100 mV	8.5 µV/V + 1 µV	
	± (> 0.1 to 1) mV	7.5 µV/V + 1 µV	
	± (> 1 to 10) V	7.5 µV/V + 5 µV	
	± (> 10 to 100) V	9.5 µV/V + 0.1 mV	
	± (> 100 to 130) V	10 µV/V + 2 mV	
50 Ω load	Up to ± 100 mV	0.12 mV/V + 1 µV	
	± (> 0.1 to 1) mV	0.12 mV/V + 1 µV	
	± (> 1 to 6.6) V	0.12 mV/V + 5 µV	
Oscilloscope Calibrators [1] AC Square Wave Amplitude			Keysight 3458A 8.5 Digit Multimeter; CP-EL71: Direct Measurement
1 MΩ load	at 10 Hz, 100 Hz		
	Up to 100 mVp-p	0.12 mV/V + 1 µV	
	(> 0.1 to 1) Vp-p	0.12 mV/V + 1 µV	
	(> 1 to 12) Vp-p	0.12 mV/V + 2 µV	
50 Ω load	at 1 kHz, 5 kHz, 10 kHz		
	Up to 100 mVp-p	0.19 mV/V + 1 µV	
	(> 0.1 to 1) Vp-p	0.12 mV/V + 1 µV	
	(> 1 to 12) Vp-p	0.12 mV/V + 2 µV	
Oscilloscope Calibrators [1] Edge Amplitude			Keysight 3458A 8.5 Digit Multimeter, (Top line & Base line DCV Measure) CP-EL71: Direct Measurement
50 Ω load	at 10 Hz, 100 Hz		
	Up to 100 mVp-p	0.12 mV/V + 1 µV	
	(> 0.1 to 1) Vp-p	0.12 mV/V + 20 µV	
	(> 1 to 12) Vp-p	0.12 mV/V + 20 µV	
	at 1 kHz, 5 kHz, 10 kHz		
	Up to 100 mVp-p	0.19 mV/V + 1 µV	
	(> 0.1 to 1) Vp-p	0.12 mV/V + 20 µV	
	(> 1 to 12) Vp-p	0.12 mV/V + 20 µV	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscope Calibrators [1]			Keysight 3458A 8.5 Digit Multimeter CP-EL71: Direct Measurement
Leveled Sine Wave			
Amplitude			
50 Ω load	Up to 10 mV		
	50 kHz	1.2 mV/V + 3 μV	
	(> 50 to 100) kHz	5.8 mV/V + 3 μV	
	(> 100 to 300) kHz	47 mV/V + 3 μV	
	(> 300 to 500) kHz	14 mV/V + 6 μV	
	> 500 kHz to 1 MHz	14 mV/V + 6 μV	
	(> 1 to 4) MHz	81 mV/V + 6 μV	
	(> 4 to 8) MHz	1.2 mV/V + 9 μV	
	(> 8 to 10) MHz	24 % of reading + 10 μV	
	(> 10 to 100) mV		
	50 kHz	0.38 mV/V + 3 μV	
	(> 50 to 100) kHz	0.94 mV/V + 3 μV	
	(> 100 to 300) kHz	3.5 mV/V + 20 μV	
	(> 300 to 500) kHz	12 mV/V + 20 μV	
	> 500 kHz to 1 MHz	12 mV/V + 20 μV	
	(> 1 to 4) MHz	47 mV/V + 90 μV	
	(> 4 to 8) MHz	47 mV/V + 0.1 mV	
	(> 8 to 10) MHz	18 % of reading + 0.2 mV	
	(> 0.1 to 1) V		
	50 kHz	0.38 mV/V + 30 μV	
	(> 50 to 100) kHz	0.94 mV/V + 30 μV	
	(> 100 to 300) kHz	3.5 mV/V + 0.2 mV	
	(> 300 to 500) kHz	12 mV/V + 0.2 mV	
	> 500 kHz to 1 MHz	12 mV/V + 0.2 mV	
	(> 1 to 4) MHz	47 mV/V + 0.9 mV	
	(> 4 to 8) MHz	47 mV/V + 1 mV	
	(> 8 to 10) MHz	18 % of reading + 2 mV	
	(> 1 to 12) V		
	50 kHz	0.38 mV/V + 0.3 mV	
	(> 50 to 100) kHz	0.94 mV/V + 0.3 mV	
	(> 100 to 300) kHz	3.5 mV/V + 2 mV	
	(> 300 to 500) kHz	12 mV/V + 2 mV	
	> 500 kHz to 1 MHz	12 mV/V + 2 mV	
	(> 1 to 4) MHz	47 mV/V + 0.9 mV	
	(> 4 to 8) MHz	47 mV/V + 10 mV	
	(> 8 to 10) MHz	18 % of reading + 20 mV	

Multifunction Energy Source/Generator [1,4] (45 to 65) Hz, (0.1 to 1) Power Factor			CALMET TS33 Three-phase Power/Energy Automatic Test System CP-EL72: Direct Measurement
AC Voltage	50 mV to 150 V (> 150 to 600) V	0.48 mV/V + 1.5 mV 0.48 mV/V + 15 mV	
AC Current	10 mA to 1 A (> 1 to 12) A (> 12 to 120) A	0.48 mA/A + 15 µA 0.48 mA/A + 0.15 mA 0.48 mA/A + 7.5 mA	
Frequency	50 mV to 600 V, 10 mA to 120 A (45 to 65) Hz	0.012 % of reading + 15 mHz	
Phase	50 mV to 600 V, 10 mA to 120 A (0 to 360)°	0.012 % of reading + 0.015°	
Power Factor	50 mV to 600 V, 10 mA to 120 A	0.012 % of reading + 0.001 5	
Active Power	50 mV to 600 V, 10 mA to 120 A 0.5 mW to 72 kW	0.05 % of reading	
Reactive Power	50 mV to 600 V, 10 mA to 120 A (0.000 5 to 72 000) Var	0.05 % of reading	
Apparent Power	50 mV to 600 V, 10 mA to 120 A (0.000 5 to 72 000) VA	0.05 % of reading	
Active Energy	50 mV to 600 V, 10 mA to 120 A 0.5 mWh to 72 kWh	0.05 % of reading	
Reactive Energy	50 mV to 600 V, 10 mA to 120 A (0.000 5 to 72 000) Var	0.05 % of reading	
Multifunction Energy Source/Generator [1] (45 to 65) Hz, (0.1 to 1) Power Factor			CALMET TS33 Three-phase Power/Energy Automatic Test System

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Apparent Energy	50 mV to 600 V, 10 mA to 120 A (0.000 5 to 72 000) Vah	0.05 % of reading	CP-EL72: Direct Measurement
Meter Error Calibration	50 mV to 600 V 10 mA to 120 A (0.000 5 to 72 000) VAh (0.000 5 to 72 000) Varh (0.000 5 to 72 000) Wh	0.05 % of reading 0.05 % of reading 0.05 % of reading	
Multifunction Energy – Measure [1,4] (45 to 65) Hz, (0.1 to 1) Power Factor AC Voltage	50 mV to 300 V > 300 V to 600 V	0.48 mV/V + 1 mV 0.48 mV/V + 2 mV	CALMET TS33, TE30 Three-phase Power/Energy Automatic Test System (Meter Error Calibration); CP-EL72: Direct Measurement
AC Current	10 mA to 0.12 A (> 0.12 to 1) A (> 1 to 12) A (> 12 to 120) A	0.48 mA/A + 2 µA 0.48 mA/A + 20 µA 0.48 mA/A + 0.2 mA 0.48 mA/A + 2 mA	
Frequency	50 mV to 600 V / 10 mA to 12 A (45 to 65) Hz	0.012% of reading + 15 mHz	
Phase	50 mV to 600 V / 10 mA to 12 A (0 to 360) °	0.012% of reading + 0.025 °	
Power Factor	50 mV to 600 V 10 mA to 12 A (0.1 to 1) PF	0.012 % of reading + 0.001 5	
Active Power	50 mV to 600 V 10 mA to 120 A 0.5 mW to 72 kW	0.05 % of reading	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Multifunction Energy – Measure [1] (45 to 65) Hz, (0.1 to 1) Power Factor			CALMET TS33, TE 30 Three-phase Power/Energy Automatic Test System (Meter Error Calibration); CP-EL72: Direct Measurement
Reactive Power	50 mV to 600 V / 10 mA to 120 A (0.5 to 72) kVar	0.05 % of reading	
Apparent Power	50 mV to 600 V / 10 mA to 120 A 0.5 mVA to 72 kVA	0.05 % of reading	
Active Energy	50 mV to 600 V / 10 mA to 120 A 0.5 mWh to 72 kWh	0.05 % of reading	
Reactive Energy	50 mV to 600 V / 10 mA to 120 A 0.5 mVarh to 72 kVarh	0.05 % of reading	
Apparent Energy	50 mV to 600 V 10 mA to 120 A 0.5 mVAh to 72 kVAh	0.05 % of reading	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tuned Absolute RF Power – Measure [1,2]	2.5 MHz to 1.3 GHz		HP 11722A Power Sensor, With Agilent 8902A Measuring Receiver; CP-EL31: Direct Measurement
	(-127 to < -120) dBm	0.3 dB	
	(-120 to < -110) dBm	0.2 dB	
	(-110 to < -90) dBm	0.19 dB	
	(-90 to < -80) dBm	0.18 dB	
	(-80 to < -60) dBm	0.16 dB	
	(-60 to < -40) dBm	0.15 dB	
	(-40 to < -10) dBm	0.13 dB	
	(-10 to 0) dBm	0.12 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tuned Absolute RF Power – Measure [1,2]	(> 1.3 to 2.6) GHz (-127 to < -120) dBm (-120 to < -110) dBm (-110 to < -90) dBm (-90 to < -80) dBm (-80 to < -60) dBm (-60 to < -40) dBm (-40 to < -10) dBm (-10 to 0) dBm	 0.3 dB 0.2 dB 0.19 dB 0.18 dB 0.16 dB 0.15 dB 0.13 dB 0.12 dB	HP 11722A Power Sensor, Agilent 11793A Down Converter, Agilent 8902A Measuring Receiver; CP-EL31: Direct Measurement
Tuned Absolute RF Power – Measure [1,2]	50 MHz to 1.3 GHz (-117 to < -110) dBm (-110 to < -90) dBm (-90 to < -80) dBm (-80 to < -60) dBm (-60 to < -40) dBm (-40 to < -10) dBm (-10 to 10) dBm	 0.2 dB 0.19 dB 0.18 dB 0.16 dB 0.15 dB 0.13 dB 0.12 dB	HP 11792A Power Sensor, Agilent 8902A Measuring Receiver; CP-EL31: Direct Measurement
Tuned Absolute RF Power – Measure [1,2]	(> 1.3 to 12.4) GHz (-105 to < -100) dBm (-100 to < -80) dBm (-80 to < -60) dBm (-60 to < -40) dBm (-40 to < -20) dBm (-20 to 5) dBm (> 12.4 to 18) GHz (-100 to < -80) dBm (-80 to < -50) dBm (-50 to < -40) dBm (-40 to 5) dBm	 0.23 dB 0.22 dB 0.2 dB 0.19 dB 0.18 dB 0.17 dB 0.27 dB 0.25 dB 0.24 dB 0.23 dB	HP 11792A Power Sensor, HP 11793A Down Converter, Agilent 8902A Measuring Receiver; CP-EL31: Direct Measurement

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tuned Relative RF Power/Attenuation – Measure [1,2] (0 dB Reference)	2.5 MHz to 18 GHz		HP 11793A Down Converter, Agilent 8902A Measuring Receiver; CP-EL31: Direct Measurement
	(-127 to < -120) dB	0.28 dB	
	(-120 to < -110) dB	0.17 dB	
	(-110 to < -90) dB	0.16 dB	
	(-90 to < -80) dB	0.15 dB	
	(-80 to < -70) dB	0.12 dB	
	(-70 to < -60) dB	0.12 dB	
	(-60 to < -50) dB	0.11 dB	
	(-50 to < -40) dB	0.1 dB	
	(-40 to < -30) dB	0.08 dB	
	(-30 to < -10) dB	0.07 dB	
	(-10 to 0) dB	0.06 dB	
Absolute Amplitude – Source [1,2]	10 Hz to 20.999 MHz (-70 to 8) dBm	0.12 dB	HP 3336C Signal Generator; CP-EL32: Direct Measurement
RF Absolute Power – Source [1,2]	250 kHz to 3 GHz		Agilent E4438C Vector Signal Generator; CP-EL32: Direct Measurement
	(-127 to < -110) dBm	1.2 dB	
	(-110 to < -50) dBm	0.94 dB	
	(-50 to 13) dBm	0.72 dB	
	(> 3 to 6) GHz		
	(-127 to < -110) dBm	1.8 dB	
	(-110 to < -50) dBm	1.1 dB	
	(-50 to 13) dBm	0.94 dB	
RF Absolute Power – Source [1,2]	(9 to < 250) kHz		HP 8648D Synthesized Signal Generator; CP-EL32: Direct Measurement
	(-136 to < -100) dBm	3.5 dB	
	(-100 to 13) dBm	1.2 dB	
	250 kHz to 2.5 GHz		
	(-136 to < -100) dBm	1.2 dB	
	(-100 to 13) dBm	1.2 dB	
	(> 2.5 to 3.2) GHz		
	(-136 to < -100) dBm	3.5 dB	
	(-100 to 13) dBm	1.8 dB	
	(> 3.2 to 4) GHz		
	(-136 to < -100) dBm	3.5 dB	
	(-100 to 13) dBm	2.4 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source [1,2]	(10 to 50) MHz (-124 to < -84) dBm (-84 to < -54) dBm (-54 to < -14) dBm (-14 to 13) dBm	 4.2 dB 3 dB 2.2 dB 1.6 dB	HP 83732B Synthesized Signal Generator, HP 8496B Attenuator; CP-EL32: Direct Measurement
RF Absolute Power – Source [1,2]	> 50 MHz to 12.4 GHz (-124 to < -84) dBm (-84 to < -54) dBm (-54 to < -14) dBm (-14 to 13) dBm (> 12.4 to 18) GHz (-124 to < -84) dBm (-84 to < -54) dBm (-54 to < -14) dBm (-14 to 13) dBm	 4.1 dB 2.9 dB 2.1 dB 1.3 dB 5.4 dB 3.7 dB 2.6 dB 1.3 dB	HP 83732B Synthesized Signal Generator, HP 8496B Attenuator; CP-EL32: Direct Measurement
RF Absolute Power – Source [1,2]	100 kHz to 2.6 GHz (-20 to < 20) dBm (20 to 30) dBm	 0.12 dB 0.15 dB	Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with HP 11722A Power Sensor, Agilent 8902A Measuring Receiver, and 11667A Power Splitters; CP-EL32: Comparison Measurement
RF Absolute Power – Source [1,2]	50 MHz to < 2 GHz (-20 to 20) dBm (20 to 30) dBm (2 to < 10) GHz (-20 to 20) dBm (20 to 30) dBm (10 to 18) GHz (-20 to 20) dBm (20 to 30) dBm	 0.13 dB 0.17 dB 0.21 dB 0.23 dB 0.25 dB 0.27 dB	Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with HP 11792A Power Sensor, Agilent 8902A Measuring Receiver, and 11667A Power Splitters; CP-EL32: Comparison Measurement

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source [1,2]	100 kHz to 4.2 GHz		Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with HP 11792A Power Sensor, Agilent 8902A Measuring Receiver, and 11667A Power Splitters; CP-EL32: Comparison Measurement
	(-10 to < 25) dBm	0.12 dB	
	(25 to 35) dBm	0.26 dB	
RF Absolute Power – Source [1,2]	(-60 to < -10) dBm		Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with Agilent E4412A Power Sensor, Agilent E4419B Power Meter, and 11667A Power Splitters; CP-EL32: Comparison Measurement.
	9 kHz to < 2 GHz	0.17 dB	
	(2 to < 4) GHz	0.18 dB	
	(4 to < 6) GHz	0.2 dB	
	(4 to < 8) GHz	0.21 dB	
	(8 to < 14) GHz	0.22 dB	
	(14 to < 16) GHz	0.26 dB	
	(16 to 18) GHz	0.27 dB	
	(-10 to 20) dBm		
	9 kHz to < 500 MHz	0.17 dB	
	500 MHz to < 1.2 GHz	0.17 dB	
	(1.2 to < 2) GHz	0.17 dB	
	(2 to < 4) GHz	0.17 dB	
	(4 to < 6) GHz	0.19 dB	
	(6 to < 8) GHz	0.2 dB	
	(8 to < 14) GHz	0.21 dB	
	(14 to < 16) GHz	0.25 dB	
	(16 to 18) GHz	0.26 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source [1,2]	(-70 to 10) dBm		Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with Agilent E4412A Power Sensor, Agilent E4419B Power Meter, and 11667A Power Splitters; CP-EL32: Comparison Measurement
	(10 to < 30) MHz	0.18 dB	
	30 MHz to < 2 GHz	0.18 dB	
	(2 to < 4) GHz	0.18 dB	
	(4 to < 6) GHz	0.2 dB	
	(6 to < 8) GHz	0.21 dB	
	(8 to < 11) GHz	0.22 dB	
	(11 to 18) GHz	0.28 dB	
	(> 10 to 20) dBm		
	(10 to < 30) MHz	0.24 dB	
	30 MHz to < 2 GHz	0.23 dB	
	(2 to < 4) GHz	0.25 dB	
	(4 to < 6) GHz	0.26 dB	
	(6 to < 8) GHz	0.26 dB	
	(8 to < 11) GHz	0.27 dB	
	(11 to 18) GHz	0.32 dB	
RF Absolute Power – Source [1,2]	2.5 MHz to 1.3 GHz		Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with HP 11722A Power Sensor, Agilent 8902A Measuring Receiver, and 11667A Power Splitters; CP-EL32: Comparison Measurement
	(-127 to < -120) dBm	0.35 dB	
	(-120 to < -100) dBm	0.27 dB	
	(-100 to < -80) dBm	0.26 dB	
	(-80 to < -50) dBm	0.24 dB	
	(-50 to < -40) dBm	0.23 dB	
	(-40 to 0) dBm	0.22 dB	
RF Absolute Power – Source [1,2]	(> 1.3 to 2.6) GHz		Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with HP 11722A Power Sensor, 11793A Down converter, Agilent 8902A Measuring Receiver, and 11667A Power Splitters; CP-EL32: Comparison Measurement
	(-127 to < -120) dBm	0.35 dB	
	(-120 to < -100) dBm	0.27 dB	
	(-100 to < -80) dBm	0.26 dB	
	(-80 to < -50) dBm	0.24 dB	
	(-50 to < -40) dBm	0.23 dB	
	(-40 to 0) dBm	0.22 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Source [1,2]	50 MHz to 1.3 GHz (-117 to < -110) dBm (-110 to < -90) dBm (-90 to < -80) dBm (-80 to < -60) dBm (-60 to < -40) dBm (-40 to 10) dBm	 0.27 dB 0.26 dB 0.25 dB 0.24 dB 0.23 dB 0.22 dB	Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with HP 11792A Power Sensor, Agilent 8902A Measuring Receiver, and 11667A Power Splitters; CP-EL32: Comparison Measurement
RF Absolute Power – Source [1,2]	(> 1.3 to 2) GHz (-105 to < -90) dBm (-90 to < -80) dBm (-80 to < -60) dBm (-60 to < -40) dBm (-40 to 5) dBm (> 2 to 4) GHz (-105 to < -80) dBm (-80 to < -50) dBm (-50 to < -40) dBm (-40 to 5) dBm (> 4 to 8) GHz (-105 to < -90) dBm (-90 to < -80) dBm (-80 to < -40) dBm (-40 to 5) dBm (> 8 to 12.4) GHz (-105 to < -80) dBm (-80 to < -50) dBm (-50 to < 5) dBm (> 12.4 to 18) GHz (-105 to < -80) dBm (-80 to < -40) dBm (-40 to < 5) dBm	 0.26 dB 0.25 dB 0.24 dB 0.23 dB 0.22 dB 0.27 dB 0.25 dB 0.24 dB 0.23 dB 0.34 dB 0.33 dB 0.32 dB 0.31 dB 0.39 dB 0.38 dB 0.37 dB 0.41 dB 0.4 dB 0.39 dB	Agilent E4438C, HP 8648D, HP 8665B, HP 83732B, Agilent N9310A Signal Generators with HP 11792A Power Sensor, 11793A Down converter, Agilent 8902A Measuring Receiver, and 11667A Power Splitters; CP-EL32: Comparison Measurement

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Low Frequency – Power Source[1]	(-100 to 23) dB		Agilent 33220A Arbitrary Function Generator, Attenuator; CP-EL73: Direct Measurement
	< 100 kHz	0.12 dB	
	100 kHz to 5 MHz	0.17 dB	
	(> 5 to 20) MHz	0.35 dB	
	10 mVp-p to 10 Vp-p		
	0.1 Hz to 20 MHz	1.2 % of reading + 1.2 mV	
	DC	2.3 % of reading + 2.3 mV	
RF Power Meter[1] (Instrumentation Accuracy)	Zero	6 nW	Keysight 11683A Power Meter Range calibrator; CP-EL43: Direct Measurement
	3.16 µW	10 nW	
	10 µW	40 nW	
	31.6 µW	0.1 µW	
	0.1 mW	0.4 µW	
	0.316 mW	1 µW	
	1 mW	4 µW	
	3.16 mW	10 µW	
	10 mW	40 µW	
	31.6 mW	0.1 mW	
	0.1 W	0.4 mW	
RF Power Meter[1] (Reference Power)	1 mW		Keysight 432A Power Meter, Keysight 478A Thermistor Mount, Keysight 3458A 8.5 Digit Multimeter; CP-EL43: Direct Measurement
	50 MHz	22 µW	
Output Signal Purity – Measure[1]			Keysight 8592L, Keysight 8591E Spectrum Analyzers; Keysight 8902A Measuring Receiver; Keysight 11722A, Keysight 11792A Power Sensors; CP-EL56: Direct Measurement
(0 to 100) % Distortion			
Harmonic	9 kHz to 18 GHz		
	(-130 to 30) dBm	1 dB	
Non-harmonic	9 kHz to 18 GHz		
	(-130 to 30) dBm	1 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Output Signal Purity – Measure [1] (0 to 100) % Distortion			Keysight 8592L, Keysight 8591E Spectrum Analyzers; Keysight 8902A Measuring Receiver; Keysight 11722A, Keysight 11792A Power Sensors; CP-EL56: Direct Measurement
Spurious Response	9 kHz to 18 GHz (-130 to 30) dBm	1 dB	
SSB Phase Noise	9 kHz to 18 GHz (-130 to 30) dBm	1 dB	
Residual FM	250 kHz to 18 GHz	1.4 Hz	
Residual AM	150 kHz to 18 GHz	0.014 % Depth	
Frequency Counter Sensitivity – Source [1]	(-36 to 0) dBm (3.54 to 224) mV 1 mHz to 20 MHz	0.4 dB	HP 33220A, HP 8665B, Agilent 9310A, HP 83732B, Agilent E4438C Signal Generators; CP-EL06: Direct Measurement
	(-50 to 0) dBm (0.707 to 224) mV 10 Hz to 21 MHz	0.1 dB	
	21 MHz to 3 GHz	0.71 dB	
	(> 3 to 6) GHz	0.94 dB	
	(> 6 to 18) GHz	1.3 dB	
Bandwidth – Source [1]			HP 83732B Synthesized Signal Generator, HP 8648D Synthesized RF Signal Generator, HP N9310A RF Signal Generator, HP 8665B Signal Generator, E4438C ESG Vector Signal Generator, Efratom PRFS-102 Frequency Standard; CP-EL55: Direct Measurement
Resolution Switching	1 Hz to 18 GHz	0.01 dB	
Noise Sideband	9 kHz to 18 GHz	0.16 dB	
Residual FM	9 kHz to 18 GHz	1 µHz/Hz	
Scale Fidelity	9 kHz to 18 GHz (-120 to 0) dB	0.12 dB	
Resolution Bandwidth	1 Hz to 18 GHz 3 dB Bandwidth	3.8 mHz/Hz	
Display Average Noise	9 kHz to 18 GHz	0.16 dB	
Residual Response	9 kHz to 18 GHz	0.16 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bandwidth – Source [1]			HP 83732B Synthesized Signal Generator, HP 8648D Synthesized RF Signal Generator, HP N9310A RF Signal Generator, HP 8665B Signal Generator, E4438C ESG Vector Signal Generator, Efratom PRFS-102 Frequency Standard; CP-EL55: Direct Measurement
Spurious Response	9 kHz to 18 GHz	0.16 dB	
Frequency Span	9 kHz to 18 GHz	0.78 nHz/Hz	
Input Attenuation Switching	9 kHz to 18 GHz (0 to 80) dB	0.01 dB	
Oscilloscope Bandwidth – Source [1]	2 mVrms to 1 Vrms		HP 8665B, HP E4438C, HP N9310A, HP 83732B, Agilent E4438C Signal Generators; HP E9304AH18, HP E4412A Power Sensors; CP-EL28: Comparison Measurement
	10 MHz to 2 GHz	16 mV/V + 9 mV	
	(2 to 6) GHz	20 mV/V + 9 mV	
	(6 to 18) GHz	30 mV/V + 9 mV	
Amplitude Modulation – Source [1] Frequency Carrier: 150 kHz to < 10 MHz			HP 8648D, Agilent E4438C Signal Generator with HP 8902A Measuring Receiver; CP-EL30: Comparison Measurement
	(5 to < 40) % Depth		
	Rate: (20 to < 50) Hz	3.5 % of reading + 0.014 % Depth	
	Rate: 50 Hz to 10 kHz	2.4 % of reading + 0.014 % Depth	
	(40 to 99) % Depth		
	Rate: (20 to < 50) Hz	3.5 % of reading + 0.14 % Depth	
	Rate: 50 Hz to 10 kHz	2.4 % of reading + 0.14 % Depth	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Source[1] Frequency Carrier: 10 MHz to 1.3 GHz	(5 to < 40) % Depth		HP83732B Signal Generator, 11793A Down converter with HP 8902A Measuring Receiver; CP-EL30: Comparison Measurement
	Rate: (20 to < 50) Hz	3.5 % of reading + 0.014 % Depth	
	Rate: 50 Hz to 10 kHz	1.3 % of reading + 0.014 % Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.014 % Depth	
	(40 to 99) % Depth		
	Rate: (20 to < 50) Hz	3.5 % of reading + 0.14 % Depth	
	Rate: 50 Hz to 10 kHz	1.3 % of reading + 0.14 % Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.14 % Depth	
Amplitude Modulation – Source[1] Frequency Carrier: (> 1.3 GHz to 20 GHz)	(5 to < 40) % Depth		HP 83732B Signal Generator, HP 11793A Down Converter with HP 8902A Measuring Receiver; CP-EL30: Comparison Measurement
	Rate: (20 to < 50 Hz)	3.5 % of reading + 0.014 % Depth	
	Rate: 50 Hz to 50 kHz	1.9 % of reading + 0.014% Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.014 % Depth	
	(40 to 99) % Depth		
	Rate: (20 to < 50 Hz)	3.5 % of reading + 0.14 % Depth	
	Rate: 50 Hz to 50 kHz	1.9 % of reading + 0.14 % Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.14 % Depth	
Frequency Modulation – Source[1] Frequency Carrier: > 250 kHz to 10 MHz	Deviation: < 5 kHz		HP 8648D, Agilent E4438C Signal Generator with HP 8902A Measuring Receiver; CP-EL30: Comparison Measurement
	Rate: 20 Hz to 10 kHz	2.4 % of reading + 1.4 Hz	
	Deviation: (5 to 40) kHz		
	Rate: 20 Hz to 10 kHz	2.4 % of reading + 14 Hz	
Frequency Carrier: > 10 MHz to 1.3 GHz	Deviation: < 5 kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 1.4 Hz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 1.4 Hz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 1.4 Hz	
	Deviation: (5 to < 40) kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 14 Hz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 14 Hz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 14 Hz	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Source [1]			HP 8648D Signal Generator, Agilent E4438C Generator, HP 83732B Signal Generator, HP 11793A Down Converter; Comparison Measurement with HP 8902A Measuring Receiver; CP-EL30: Comparison Measurement
Frequency Carrier: > 10 MHz to 1.3 GHz	Dev: (40 to 400) kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 0.14 kHz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 0.14 kHz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 0.14 kHz	
Frequency Carrier: (> 1.3 to 18) GHz	Deviation: < 5 kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 1.4 Hz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 1.4 Hz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 1.4 Hz	
	Deviation: (5 to < 40) kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 14 Hz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 14 Hz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 14 Hz	
	Dev: (40 to 400) kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 0.14 kHz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 0.14 kHz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 0.14 kHz	
Phase Modulation – Source [1]			Agilent E4438C, Agilent N9310A, HP 83732B Signal Generator with HP 8902A Measuring Receiver; CP-EL30: Comparison Measurement
Frequency Carrier: 250 kHz to 10 MHz	Rate: 200 Hz to 10 kHz		
	Deviation: (1 to 4) rad	4.7 % of reading + 0.001 4 rad	
	(4 to 40) rad	4.7 % of reading + 0.014 rad	
	(40 to 400) rad	4.7 % of reading + 0.14 rad	
Frequency Carrier: > 10 MHz to 18 GHz	Rate: 200 Hz to 10 kHz		
	Deviation: (1 to 4) rad	3.5 % of reading + 0.001 4 rad	
	(4 to 40) rad	3.5 % of reading + 0.014 rad	
	(40 to 400) rad	3.5 % of reading + 0.14 rad	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Distortion – Source [1]	(0.01 to 100) % Distortion 20 Hz to 20 kHz		HP 8903B Audio Analyzer, Agilent N9310A Generator, Fluke 5522A Multiproduct Calibrator, Wavetek 1281, 8.5 Digit Multimeter, HP34401A 6.5 Digit Multimeter; CP-EL75: Direct Measurement
	(-80 to < -70) dB	0.45 dB	
	(-70 to < -60) dB	0.31 dB	
	(-60 to < -50) dB	0.05 dB	
	(-50 to < -40) dB	0.03 dB	
	(-40 to 0) dB	0.03 dB	
	(0.01 to 100) % Distortion (> 20 to 100) kHz		
	(-80 to < -70) dB	0.48 dB	
	(-70 to < -60) dB	0.32 dB	
	(-60 to < -50) dB	0.07 dB	
	(-50 to < -40) dB	0.05 dB	
	(-40 to 0) dB	0.05 dB	
SINAD – Source [1]	20 Hz to 20 kHz		HP 8903B Audio Analyzer, Agilent N9310A Generator, Fluke 5522A Multiproduct Calibrator, Wavetek 1281, 8.5 Digit Multimeter, HP34401A 6.5 Digit Multimeter; CP-EL75: Direct Measurement
	(0 to 40) dB	0.03 dB	
	(> 40 to 50) dB	0.03 dB	
	(> 50 to 60) dB	0.05 dB	
	(> 60 to 70) dB	0.31 dB	
	(> 70 to 80) dB	0.45 dB	
	(> 20 to 100) kHz		
	(0 to 40) dB	0.05 dB	
	(> 40 to 50) dB	0.05 dB	
	(> 50 to 60) dB	0.07 dB	
	(> 60 to 70) dB	0.32 dB	
	(> 70 to 80) dB	0.48 dB	
Signal to Noise – Source [1]	20 Hz to 20 kHz		HP 8903B Audio Analyzer, Agilent N9310A Generator, Fluke 5522A Multiproduct Calibrator, Wavetek 1281, 8.5 Digit Multimeter, HP34401A 6.5 Digit Multimeter; CP-EL75: Direct Measurement
	(0 to 40) dB	0.03 dB	
	(> 40 to 50) dB	0.03 dB	
	(> 50 to 60) dB	0.05 dB	
	(> 60 to 70) dB	0.31 dB	
	(> 70 to 80) dB	0.45 dB	
	(> 20 to 100) kHz		
	(0 to 40) dB	0.05 dB	
	(> 40 to 50) dB	0.05 dB	
	(> 50 to 60) dB	0.07 dB	
	(> 60 to 70) dB	0.32 dB	
	(> 70 to 80) dB	0.48 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Measure [1] Frequency Carrier: 150 kHz to 10 MHz	(5 to < 40) % Depth		HP 8902A Measuring Receiver CP-EL29: Direct Measurement
	Rate: (20 to < 50) Hz	3.5 % of reading + 0.014 % Depth	
	Rate: 50 Hz to 10 kHz	2.4 % of reading + 0.014 % Depth	
	(40 to 99) % Depth		
	Rate: (20 to < 50) Hz	3.5 % of reading + 0.14 % Depth	
	Rate: 50 Hz to 10 kHz	2.4 % of reading + 0.14 % Depth	
Amplitude Modulation – Measure [1] Frequency Carrier: > 10 MHz to 1.3 GHz	(5 to < 40) % Depth		HP 8902A Measuring Receiver CP-EL29: Direct Measurement
	Rate: (20 to 50) Hz	3.5 % of reading + 0.014 % Depth	
	Rate: 50 Hz to 50 kHz	1.3 % of reading + 0.014 % Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.014 % Depth	
	(40 to 99) % Depth		
	Rate (20 to 50) Hz	3.5 % of reading + 0.14 % Depth	
	Rate: 50 Hz to 50 kHz	1.3 % of reading + 0.14 % Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.14 % Depth	
Amplitude Modulation – Measure [1] Frequency Carrier: (> 1.3 to 18) GHz	(5 to < 40) % Depth		HP 8902A Measuring Receiver, HP 11793A Down Converter CP-EL29: Direct Measurement
	Rate: (20 to 50) Hz	3.5 % of reading + 0.014 % Depth	
	Rate: > 50 Hz to 50 kHz	1.9 % of reading + 0.014% Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.014 % Depth	
	(> 40 to 99) % Depth		
	Rate: (20 to 50) Hz	3.5 % of reading + 0.14 % Depth	
	Rate: > 50 Hz to 50 kHz	1.9 % of reading + 0.14 % Depth	
	Rate: (> 50 to 100) kHz	3.5 % of reading + 0.14 % Depth	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Demodulated Distortion – Measure [1] Frequency Carrier: 150 kHz to < 1.3 GHz	Rate: 20 Hz to < 100 kHz ≤ 50 % Depth (> 50 to 95) % Depth	 0.35 % THD 0.7 % THD	HP 8902A Measuring Receiver, HP 11793A Down Converter; CP-EL29: Direct Measurement
(1.3 to 18) GHz	Rate: 20 Hz to < 100 kHz ≤ 50 % Depth (> 50 to 95) % Depth	 0.9 % THD 1.2 % THD	
Frequency Modulation – Measure [1] Frequency Carrier: > 250 kHz to 10 MHz	Deviation: < 5 kHz Rate: 20 Hz to 10 kHz Deviation: (5 to 40) kHz Rate: 20 Hz to 10 kHz	 2.4 % of reading + 1.4 Hz 2.4 % of reading + 14 Hz	HP 8902A Measuring Receiver; CP-EL29: Direct Measurement
Frequency Modulation – Measure [1] Frequency Carrier: > 10 MHz to 1.3 GHz	Deviation: < 5 kHz Rate: (20 to < 50) Hz Rate: 50 Hz to 100 kHz Rate: (> 100 to 200) kHz	 5.8 % of reading + 1.4 Hz 1.3 % of reading + 1.4 Hz 5.8 % of reading + 1.4 Hz	HP 8902A Measuring Receiver; CP-EL29: Direct Measurement
Frequency Modulation – Measure [1] Frequency Carrier: > 10 MHz to 1.3 GHz	Deviation: (5 to < 40) kHz Rate: (20 to < 50) Hz Rate: 50 Hz to 100 kHz Rate: (> 100 to 200) kHz Dev: (40 to 400) kHz Rate: (20 to < 50) Hz Rate: 50 Hz to 100 kHz Rate: (> 100 to 200) kHz	5.8 % of reading + 14 Hz 1.3 % of reading + 14 Hz 5.8 % of reading + 14 Hz 5.8 % of reading + 0.14 kHz 1.3 % of reading + 0.14 kHz 5.8 % of reading + 0.14 kHz	HP 8902A Measuring Receiver; CP-EL29: Direct Measurement

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Measure [1] Frequency Carrier: (> 1.3 to 18) GHz	Deviation: < 5 kHz		HP 8902A Measuring Receiver, HP 11793A Down Converter; CP-EL29: Direct Measurement
	Rate: (20 to < 50) Hz	5.8 % of reading + 1.4 Hz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 1.4 Hz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 1.4 Hz	
	Deviation: (5 to < 40) kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 14 Hz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 14 Hz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 14 Hz	
	Dev: (40 to 400) kHz		
	Rate: (20 to < 50) Hz	5.8 % of reading + 0.14 kHz	
	Rate: 50 Hz to 100 kHz	1.3 % of reading + 0.14 kHz	
	Rate: (> 100 to 200) kHz	5.8 % of reading + 0.14 kHz	
Frequency Demodulated Distortion – Measure [1] Frequency Carrier: 400 kHz to <10 MHz	Rate: 20 Hz to 10 kHz Deviation: ≤ 10 kHz	0.12 % THD	HP 8902A Measuring Receiver, HP 11793A Down Converter; CP-EL29: Direct Measurement
Frequency Carrier: 10 MHz to 18 GHz	Rate: 20 Hz to 100 kHz Deviation: ≤ 100 kHz	0.12 % THD	
Phase Modulation – Measure [1] Frequency Carrier: 250 kHz to 10 MHz	Rate: 200 Hz to 10 kHz		HP 8902A Measuring Receiver; CP-EL29: Direct Measurement
	Deviation: (1 to 4) rad	4.7 % of reading + 0.001 4 rad	
	(4 to 40) rad	4.7 % of reading + 0.014 rad	
	(40 to 400) rad	4.7 % of reading + 0.14 rad	
Frequency Carrier: > 10 MHz to 1.3 GHz	Rate: 200 Hz to 20 kHz		
	Deviation: (1 to 4) rad	3.5 % of reading + 0.001 4 rad	
	(4 to 40) rad	3.5 % of reading + 0.014 rad	
	(40 to 400) rad	3.5 % of reading + 0.14 rad	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Phase Modulation – Measure [1] Frequency Carrier: > 10 MHz to 20 GHz	Rate: 200 Hz to 20 kHz Deviation: (1 to 4) rad (4 to 40) rad (40 to 400) rad	3.5 % of reading + 0.001 4 rad 3.5 % of reading + 0.014 rad 3.5 % of reading + 0.14 rad	HP 8902A Measuring Receiver, HP 11793A Down Converter; CP-EL29: Direct Measurement
Phase Demodulated Distortion – Measure [1] Frequency Carrier: 150 kHz to < 10 MHz Frequency Carrier: 10 MHz to 18 GHz	Rate: 200 Hz to 10 kHz Deviation: ≤ 400 rad Rate: 200 Hz to 20 kHz Deviation: ≤ 400 rad	0.12 % THD 0.12 % THD	HP 8902A Measuring Receiver, HP 11793A Down Converter; CP-EL29: Direct Measurement
Distortion/SINAD/Signal to Noise – Measure 1 (0.001 to 100) % Distortion Distortion SINAD Signal-to-Noise	(-99.99 to 0) dB 20 Hz to 20 kHz (20 to 100) kHz (0 to 99.99) dB 20 Hz to 20 kHz (20 to 100) kHz (0 to 99.99) dB 50 Hz to 100 kHz	1.2 dB 2.4 dB 1.2 dB 2.4 dB 1.2 dB	HP 8903B Audio Analyzer; CP-EL74: Direct Measurement
RF Absolute Power – Measure [1,2]	100 kHz to 4.2 GHz (-10 to < 25) dBm (25 to 35) dBm	0.12 dB 0.25 dB	HP 8482H Power Sensor, Agilent E4419B Power Meter

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power- Measure [1,2]	(-60 to < -10) dBm		Agilent E9304AH18 Power Sensor, Agilent E4419B Power Meter; CP-EL33: Direct Measurement
	9 kHz to 2 GHz	0.17 dB	
	(2 to < 6) GHz	0.18 dB	
	(6 to < 14) GHz	0.19 dB	
	(14 to < 16) GHz	0.23 dB	
	(16 to 18) GHz	0.25 dB	
	(-10 to 20) dBm		
	9 kHz to < 500 MHz	0.16 dB	
	500 MHz to < 1.2 GHz	0.16 dB	
	(1.2 to < 2) GHz	0.16 dB	
	(2 to < 6) GHz	0.16 dB	
	(6 to < 14) GHz	0.18 dB	
	(14 to < 16) GHz	0.22 dB	
	(16 to 18) GHz	0.23 dB	
RF Absolute Power – Measure [1,2]	(> -70 to 10) dBm		Agilent E4412A Power Sensor and Agilent E4419B Power Meter; CP-EL33: Direct Measurement
	(10 to < 30) MHz	0.18 dB	
	30 MHz to < 2 GHz	0.17 dB	
	(2 to < 6) GHz	0.18 dB	
	(6 to < 11) GHz	0.19 dB	
	(11 to 18) GHz	0.25 dB	
	(> 10 to 20) dBm		
	(10 to < 30) MHz	0.24 dB	
	30 MHz to < 2 GHz	0.23 dB	
	(2 to < 6) GHz	0.23 dB	
	(6 to < 11) GHz	0.24 dB	
	(11 to 18) GHz	0.29 dB	
RF Absolute Power – Measure [1,2]	100 kHz to 2.6 GHz		HP 11722A Power Sensor, Agilent 8902A Measuring Receiver; CP-EL33: Direct Measurement
	(-20 to < 20) dBm	0.14 dB	
	(20 to 30) dBm	0.16 dB	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Absolute Power – Measure [1,2]	50 MHz to < 2 GHz		HP 11792A Power Sensor, Agilent 8902A Measuring Receiver; CP-EL33: Direct Measurement
	(-20 to < 20) dBm	0.15 dB	
	(20 to 30) dBm	0.13 dB	
	(2 to < 10) GHz		
	(-20 to < 20) dBm	0.18 dB	
	(20 to 30) dBm	0.16 dB	
	(10 to 18) GHz		
	(-20 to < 20) dBm	0.19 dB	
	(20 to 30) dBm	0.18 dB	
Keysight 11793A Microwave Down Converter [1,2]			HP 8902A Measuring Receiver, HP 11792A Sensor Module, HP 83731A, and HP 83732B Signal Sources; CP-EL76: Direct Measurement
Converted Band Test (Conversion Loss) (RF Frequency = LO Frequency minus 50 MHz)	Input level: -5 dBm LO level: +8 dBm Frequency: (2 to 18) GHz	1.5 dB	
Through Band Test (Insertion loss)	Input level: -5 dBm Frequency: 1.27 GHz	0.25 dB	

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gauge Blocks	(0.1 to 0.4) mm	0.13 µm	Gage Block Comparator, Universal Length Measuring Machine, Master Gauge Block Set; CP-PL23, CP-PL24: Comparison Measurement
	(> 0.4 to 10) mm	66 nm	
	(> 10 to 25) mm	76 nm	
	(> 25 to 50) mm	0.11 µm	
	(> 50 to 75) mm	0.13 µm	
	(> 75 to 100) mm	0.16 µm	
	(> 100 to 200) mm	0.3 µm	
	(> 200 to 300) mm	0.44 µm	
	(> 300 to 400) mm	0.58 µm	
	(> 400 to 500) mm	0.72 µm	
Gauge Block Comparator [1] (Length Linearity Only)	(0.5 to 100) mm	37 nm	Master Gauge Block Set; CP-PL105: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Caliper [1] (External/Internal/Depth)	Up to 300 mm (> 300 to 450) mm (> 450 to 600) mm (> 600 to 1 000) mm (>1 000 to 1 500) mm (>1 500 to 2 000) mm	5 µm 7 µm 9 µm 14 µm 21 µm 28 µm	Gauge Block Set; CP-PL01: Direct Measurement
Dial Gauge & Digital Indicator [1]	Up to 12.7 mm (> 12.7 to 25) mm (> 25 to 50) mm (> 50 to 75) mm (> 75 to 100) mm	0.9 µm 1 µm 1.2 µm 1.4 µm 1.7 µm	Dial Calibration Tester Stand M3; CP-PL14: Direct Measurement
Dial Test Indicator [1]	Up to 1.5 mm	0.7 µm	Dial Calibration Tester Stand M3; CP-PL15 Direct Measurement
Micro-indicator	(-1.5 to 1.5) mm	0.12 µm	Gauge Block Set; CP-PL06 Direct Measurement
Electrical Comparator/ Mu Checker [1]	Up to 500 µm > 500 µm to 1 mm (> 1 to 5) mm (> 5 to 10) mm	0.12 µm 0.14 µm 0.2 µm 0.3 µm	Gauge Block Set; CP-PL51: Direct Measurement
Cylinder Gauge/ Bore Gauge [1]	Up to 18 mm (> 18 to 35) mm (> 35 to 60) mm (> 60 to 100) mm (> 100 to 160) mm (> 160 to 250) mm (> 250 to 400) mm	0.65 µm 0.8 µm 1 µm 1.5 µm 2 µm 2.5 µm 3 µm	Universal Length Measuring Machine, CP-PL17: Direct Measurement based on JIS B 7515
Outside/Inside Micrometer [1]	Up 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	0.7 µm 0.8 µm 0.9 µm 1 µm 1.2 µm 1.3 µm 1.5 µm 1.6 µm	Gauge Block Set; CP-PL05: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Outside/Inside Micrometer [1]	(200 to 225) mm	1.8 µm	Gauge Block Set; CP-PL05: Direct Measurement
	(225 to 250) mm	1.9 µm	
	(250 to 275) mm	2.1 µm	
	(275 to 300) mm	2.2 µm	
	(300 to 325) mm	2.4 µm	
	(325 to 350) mm	2.5 µm	
	(350 to 375) mm	2.7 µm	
	(375 to 400) mm	3 µm	
	(400 to 425) mm	3 µm	
	(425 to 450) mm	3.2 µm	
	(450 to 475) mm	3.3 µm	
	(475 to 500) mm	3.5 µm	
	(500 to 525) mm	3.8 µm	
	(525 to 550) mm	4 µm	
	(550 to 575) mm	4.1 µm	
	(575 to 600) mm	4.3 µm	
	(600 to 625) mm	4.5 µm	
	(625 to 650) mm	4.6 µm	
	(650 to 675) mm	4.9 µm	
	(675 to 700) mm	5 µm	
	(700 to 725) mm	5.2 µm	
	(725 to 750) mm	5.4 µm	
	(750 to 775) mm	5.5 µm	
	(775 to 800) mm	5.6 µm	
	(800 to 825) mm	5.8 µm	
	(825 to 850) mm	6 µm	
	(850 to 875) mm	6.1 µm	
	(875 to 900) mm	6.5 µm	
	(900 to 925) mm	6.7 µm	
	(925 to 950) mm	6.8 µm	
	(950 to 975) mm	7 µm	
	(975 to 1 000) mm	7.1 µm	
High Accuracy Micrometer [1] (Resolution 0.000 1 mm)	Up to 7.7 mm	0.17 µm	Gauge Block Set; CP-PL75: Direct Measurement
	(>7.7 to 17.6) mm	0.27 µm	
	(>17.6 to 22.8) mm	0.33 µm	
	(>22.8 to 25) mm	0.36 µm	
V-Anvil Micrometer [1]	Up to 10 mm	1.2 µm	Standard Pin Gauges, Gauge Block Set; CP-PL74: Direct Measurement
	(> 10 to 25) mm	1.4 µm	
	(>25 to 40) mm	1.7 µm	

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Indicating Micrometer [1]	Up to 25 mm (> 25 to 50) mm (> 50 to 75) mm (> 75 to 100) mm	1.3 µm 1.6 µm 2.2 µm 2.8 µm	Gauge Block Set; CP-PL07: Direct Measurement
Depth Micrometer [1]	Up 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 300) mm	0.9 µm 1.3 µm 1.4 µm 1.6 µm 1.9 µm 2.2 µm 2.5 µm 2.8 µm 3.1 µm 3.3 µm 3.5 µm 3.8 µm	Gauge Block Set; CP-PL16: Direct Measurement
Gear Tooth Vernier Caliper [1]	Up to 60 mm	15 µm	Gauge Block Set; CP-PL28: Direct Measurement
Height Gauge [1]	Up to 300 mm (> 300 to 600) mm (> 600 to 1 000) mm	8 µm 11 µm 15 µm	Gauge Block Set; CP-PL02: Direct Measurement
Depth Gauge [1]	Up to 200 mm (> 200 to 300) mm (> 300 to 600) mm	7 µm 8 µm 11 µm	Gauge Block Set; CP-PL11: Direct Measurement
Feeler Gauge [1]	Up to 3 mm (> 3 to 20) mm	0.3 µm 0.6 µm	Universal Length Measuring Machine, High Accuracy Micrometer; CP-PL18: Direct Measurement
Thickness Plate [1] (Calibration Foil)	Up to 3 mm (> 3 to 20) mm	0.3 µm 0.6 µm	Universal Length Measuring Machine High Accuracy Micrometer; CP-PL19: Direct Measurement
Thickness Gauge [1]	Up to 12 mm (> 12 to 100) mm	0.7 µm 1.5 µm	Gauge Block Set; CP-PL13: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Holtest/Three-points Internal Micrometer [1]	(3 to 14) mm (> 14 to 20) mm (> 20 to 40) mm (> 40 to 50) mm (> 50 to 75) mm (> 75 to 100) mm (> 100 to 125) mm	1.5 µm 1.8 µm 2 µm 2.2 µm 2.8 µm 3.5 µm 4 µm	Ring Gauges; CP-PL38: Direct Measurement
Coating Thickness Gauge [1]	Up to 252 µm (252 to 2 074) µm (2 074 to 3 039) µm (3 039 to 4 824) µm (4 824 to 9 890) µm (9 890 to 14 000) µm	0.5 µm 0.8 µm 1.4 µm 1.5 µm 1.7 µm 2 µm	Calibration Foils; CP-PL50: Direct Measurement
Setting Rod for Micrometer	Up 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 300) mm	0.4 µm 0.5 µm 0.6 µm 0.7 µm 0.9 µm 1 µm 1.2 µm 1.4 µm 1.5 µm 1.7 µm 1.9 µm 2 µm	Gauge Block Set, Universal Length Measuring Machine; CP-PL37: Comparison Measurement
Setting Rod for Micrometer	(> 300 to 325) mm (> 325 to 350) mm (> 350 to 375) mm (> 375 to 400) mm (> 400 to 425) mm (> 425 to 450) mm (> 450 to 475) mm (> 475 to 500) mm	2.2 µm 2.4 µm 2.5 µm 2.7 µm 2.9 µm 3 µm 3.2 µm 3.4 µm	Gauge Block Set, Universal Length Measuring Machine; CP-PL37: Comparison Measurement
Micrometer Head [1]	Up to 13 mm (> 13 to 25) mm (> 25 to 50) mm	1 µm 1 µm 1.6 µm	Gauge Block Set; CP-PL12: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Universal Length Measuring Machine [1] (Length Linearity Only)	Up to 10 mm (> 10 to 25) mm (> 25 to 50) mm (> 50 to 75) mm (> 75 to 100) mm (> 100 to 600) mm	90 nm 0.17 µm 0.35 µm 0.5 µm 0.7 µm 0.85 µm	Gauge Block Set; CP-PL52: Direct Measurement
Caliper Gauge [1] (External/ Internal)	Up to 30 mm (> 30 to 100) mm	1.5 µm 3 µm	Gauge Block Set; CP-PL40: Direct Measurement
Caliper Checker, Check Master, Step Gauge	Up to 300 mm (> 300 to 400) mm (> 400 to 500) mm (> 500 to 670) mm	1.1 µm 1.2 µm 1.3 µm 1.4 µm	Gauge Blocks, Lever Probe with Display; CP-PL57: Direct Measurement
Height Master	Up to 300 mm (> 300 to 400) mm (> 400 to 500) mm (> 500 to 600) mm	1.1 µm 1.2 µm 1.3 µm 1.4 µm	Gauge Blocks, Lever Probe with Display; CP-PL92: Direct Measurement
Dial Gauge Tester/Calibration Tester	(> 0 to 5) mm (> 5 to 25) mm	0.5 µm 0.8 µm	Linear Length Gauge; CP-PL39: Direct Measurement
Micrometer Microscope [1]	Up to 10 mm	1 µm	Glass Scale; CP-PL35: Direct Measurement
Scale Loupe [1]	Up to 100 mm	1.4 µm	Glass Scale; CP-PL32: Direct Measurement
Profile Projector [1,3] X-axis, Y-axis	Up to 50 mm (> 50 to 100) mm (> 100 to 200) mm (> 200 to 300) mm (> 300 to 500) mm	1 µm 1.1 µm 1.2 µm 1.3 µm 2.1 µm	Glass Scale, Angle Blocks; CP-PL54: Direct Measurement
Angle	(0.25 to 90)°	10″	
Thread Plug Gauge	(> 1 to 60) mm (> 60 to 90) mm (> 90 to 125) mm (> 125 to 150) mm	2 µm 2.1 µm 2.2 µm 2.3 µm	Gauge Block Set, Universal Length Measuring Machine; CP-PL10: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Ring Gauge	(3 to 30) mm (>30 to 100) mm (> 100 to 150) mm	2 µm 2.1 µm 3.1 µm	Ring Gauge, Universal Length Measuring Machine; CP-PL08: Direct Measurement
Plain Ring Gauge	(1 to 50) mm (> 50 to 100) mm (> 100 to 125) mm (> 125 to 150) mm	0.9 µm 1.3 µm 1.5 µm 1.7 µm	Ring Gauge, Universal Length Measuring Machine; CP-PL36: Direct Measurement
Plain Plug Gauge, Pin Gauge, (3-wires) (Diameter Measurement)	Up to 10 mm (> 10 to 20) mm (> 20 to 30) mm (> 30 to 40) mm (> 40 to 50) mm (> 50 to 60) mm (> 60 to 70) mm (> 70 to 80) mm (> 80 to 90) mm (> 90 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	0.3 µm 0.4 µm 0.5 µm 0.5 µm 0.7 µm 0.7 µm 0.8 µm 1 µm 1 µm 1.1 µm 1.2 µm 1.3 µm 1.4 µm 1.5 µm 1.7 µm 2 µm	Gauge Block Set, Universal Length Measuring Machine; CP-PL09: Direct Measurement
Plain Snap Gauge, Gap Gauge (External/ Internal)	(1 to 25) mm (> 25 to 50) mm (> 50 to 75) mm (> 75 to 125) mm (> 125 to 175) mm (> 175 to 200) mm (> 200 to 250) mm (> 250 to 300) mm (> 300 to 400) mm (> 400 to 500) mm	0.51 µm 0.81 µm 1.2 µm 1.9 µm 2.7 µm 3.1 µm 3.8 µm 4.5 µm 6 µm 7.5 µm	Ring Gauge, Gauge Block Set, Universal Length Measuring Machine; CP-PL33: Direct Measurement
Laser Scan Micrometer [1]	(0.1 to 10) mm (> 10 to 60) mm	0.5 µm 0.7 µm	Pin Gauges, Gauge Block Set; CP-PL34: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surface Roughness Testers [1]	Ra 2.94 µm, Rz 9.3 µm	66 nm 0.26 µm	Roughness Specimen; CP-PL55: Direct Measurement
Roughness Specimens	Up to 4 µm (> 4 to 20) µm (> 20 to 100) µm	71 nm 0.28 µm 2.7 µm	Surface Texture Measuring Instrument; CP-PL90: Direct Measurement
Bevel Protractors [1]	Up to 360°	0.012°	Angle Blocks; CP-PL29: Direct Measurement
Measuring Tapes [1]	Up to 5 000 mm (> 5 000 to 10 000) mm (> 10 000 to 20 000) mm (> 20 000 to 30 000) mm (> 30 000 to 40 000) mm (> 40 000 to 50 000) mm	45 µm 46 µm 55 µm 65 µm 75 µm 90 µm	Tape & Scale Measuring Machine, Laser Distance; CP-PL45: Direct Measurement
Rulers [1]	Up to 1 000 mm (> 1 000 to 2 000) mm (> 2 000 to 3 000) mm	14 µm 27 µm 41 µm	Tape & Scale Measuring Machine, Laser Distance; CP-PL44: Direct Measurement
Contour Machines [1] Straightness	Up to 1 mm	0.8 µm	Gauge Blocks, Optical Flat; CP-PL42: Direct Measurement
X Axis, Z Axis	Up to 60 mm (> 60 to 100) mm	3 µm 3.5 µm	
Roundness Machines [1,3]	Up to 200 mm*D*	1.7 µm	Glass Hemisphere; CP-PL43: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Coordinate Measuring Machines[1] Linear Accuracy (X,Y,Z)	Up to 100 mm	0.4 µm	Gauge Blocks, Check Master, Master Ball; CP-PL41: Direct Measurement
	(>100 to 200) mm	0.8 µm	
	(>200 to 300) mm	1.1 µm	
	(> 300 to 400) mm	1.4 µm	
	(>400 to 500) mm	1.7 µm	
	(>500 to 600) mm	2 µm	
	(>600 to 700) mm	2.4 µm	
	(>700 to 800) mm	2.7 µm	
	(>800 to 900) mm	3.1 µm	
	(>900 to 1 000) mm	3.4 µm	
Chamfer Gauge	Up to 30 mm	1.6 µm	Vision Measuring Machine; CP-PL61: Direct Measurement
Pitch Gauge	Up to 10 mm	1.6 µm	Vision Measuring Machine; CP-PL62: Direct Measurement
Radius Gauge	Up to 50 mm (> 50 to 100) mm	1.6 µm 2 µm	Vision Measuring Machine; CP-PL63: Direct Measurement
Taper Gauge (Scale Type)	Up to 50 mm (> 50 to 100) mm	1.6 µm 2 µm	Vision Measuring Machine; CP-PL64: Direct Measurement
Test Sieve	Up to 50 mm	1.6 µm	Vision Measuring Machine; CP-PL65: Direct Measurement
Angle Block[3]	(0.25 to 90)°	14″	Angle Block, Vision Measuring Machine; CP-PL66: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sine Bars Roller Distance	Up to 100 mm (> 100 to 200) mm (> 200 to 300) mm	1.6 µm 2 µm 2.5 µm	Vision Measuring Machine, Mu Checker; CP-PL85: Direct Measurement
Parallelism	≤ 0.1 mm	1.2 µm	
Vee Blocks (to 250 mm) Flatness of Bottom Surface	≤ 0.1 mm	1.2 µm	Mu Checker; CP-PL86: Direct Measurement
Flatness of V Surface	≤ 0.1 mm	1.2 µm	
Parallelism Between Bottom Surface and Cylinder on V Surface	≤ 0.1 mm	1.2 µm	
Laser Distance Meter	Up to 10 000 mm (> 10 000 to 20 000) mm	1.3 mm 1.4 mm	Laser Distance Meter Calibration Set; CP-PL88: Comparison Measurement
Working Standard Scale, Glass Scale	Up to 1 mm (> 1 to 100) mm (> 100 to 200) mm (> 200 to 300) mm (> 300 to 500) mm	1 µm 1.1 µm 1.4 µm 1.6 µm 2.5 µm	Standard Scale, Image Measuring Instrument; CP-PL69: Direct and Comparison Measurement
Ultrasonic Thickness Gauge	Up to 50 mm (> 50 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	1.1 µm 2 µm 2.6 µm 3 µm 3.5 µm 4 µm 4.9 µm 5.9 µm 7.8 µm 9.7 µm	Gauge Blocks; CP-PL67: Comparison Measurement
Electronic Level	(0.01 to 5) mm/m	6.5 µm/m	Sine Bar, Gauge Blocks; CP-PL73: Direct Measurement

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Precision Level [1]	(0.02 to 0.1) mm/m (0.05 to 0.25) mm/m (0.1 to 0.5) mm/m	6 µm/m 15 µm/m 25 µm/m	Sine Bar, Gauge Blocks; CP-PL73: Direct Measurement
Surface Plates [1,3] Overall Flatness Only	Up to 7 000 mm*DL*	1.9 µm/m	Electronic Level System; CP-PL87: Direct Measurement
Level Transducer, Level Transmitter w/ Electrical Output	Up to 6 m	2.5 mm	Laser Distance Meter; CP-PL99: Comparison Measurement
Measuring Microscope, Tool Maker's Microscope [1] X-axis, Y-axis	Up to 50 mm (> 50 to 100) mm (> 100 to 200) mm (> 200 to 300) mm (> 300 to 400) mm (> 400 to 500) mm	1 µm 1.1 µm 1.2 µm 1.3 µm 3.1 µm 3.7 µm	Gauge Blocks, Glass Scale; CP-PL53: Direct Measurement
Z-axis	Up to 50 mm (> 50 to 100) mm (> 100 to 200) mm	1.1 µm 1.3 µm 1.7 µm	

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales and Balances [1]			OIML Class E2 weight set, OIML Class F1 weight set, OIML Class M1 weight set, and CP-PL04 based on UKAS LAB 14 utilized in the calibration of the weighing system.
Resolution 0.000 1 mg	Up to 2 mg	3.1 µg	
	(2 to 5) mg	3.1 µg	
	(5 to 10) mg	3.9 µg	
	(10 to 20) mg	4.6 µg	
	(20 to 50) mg	6.2 µg	
	(50 to 100) mg	7.7 µg	
	(100 to 200) mg	9.2 µg	
	(200 to 500) mg	13 µg	
	(500 to 1 000) mg	16 µg	
Resolution 0.001 mg	(1 to 2) g	19 µg	
	(2 to 5) g	25 µg	
	(5 to 10) g	31 µg	
	(10 to 20) g	39 µg	
	(20 to 50) g	46 µg	
Resolution 0.01 mg	(50 to 100) g	77 µg	
	(100 to 200) g	0.16 mg	
Resolution 0.1 mg	(200 to 500) g	0.4 mg	
	(500 to 1 000) g	0.77 mg	
	(1 to 2) kg	1.6 mg	
Resolution 0.001 g	(1 to 2) kg	2.5 mg	
	(2 to 3) kg	3.2 mg	
	(3 to 4) kg	4 mg	
	(4 to 5) kg	4.7 mg	
	(5 to 6) kg	5.5 mg	
	(6 to 7) kg	7.7 mg	
	(7 to 10) kg	9.3 mg	
	(10 to 12) kg	12 mg	
	(12 to 15) kg	16 mg	
Resolution 0.01 g	(20 to 25) kg	59 mg	
	(25 to 30) kg	71 mg	
	(30 to 40) kg	93 mg	
	(40 to 50) kg	0.12 g	

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales and Balances [1] Resolution 0.1 g	(50 to 100) kg	2.3 g	OIML Class E2 weight set, OIML Class F1 weight set, OIML Class M1 weight set, and CP-PL04 based on UKAS LAB 14 utilized in the calibration of the weighing system.
	(100 to 150) kg	3.5 g	
	(150 to 200) kg	4.6 g	
	(200 to 250) kg	5.8 g	
	(250 to 300) kg	6.9 g	
	(300 to 350) kg	8.1 g	
	(350 to 400) kg	9.2 g	
	(400 to 450) kg	11 g	
	(450 to 500) kg	12 g	
	(500 to 1 000) kg	85 g	
Automatic Weighing Instruments (AWIs) [1]	Up to 100 g	0.055 % of reading	Standard Weight Set, Electronic Balances; CP-PL106 based on EURAMET cg-26.
	(> 100 to 200) g	0.03 % of reading	
	(> 200 to 8 000) g	0.02 % of reading	
	(> 8 to 10) kg	0.015 % of reading	
	(> 10 to 15) kg	0.012 % of reading	
	(> 15 to 20) kg	0.005 % of reading	
	(> 20 to 30) kg	0.003 % of reading	
Mass Determination	1 mg	9 µg	Standard Weight Set, Electronic Balances; CP-PL60 based on OIML R-111-1.
	2 mg	9 µg	
	5 mg	9 µg	
	10 mg	10 µg	
	20 mg	10 µg	
	50 mg	11 µg	
	100 mg	12 µg	
	200 mg	13 µg	
	500 mg	27 µg	
	1 g	28 µg	
	2 g	30 µg	
	5 g	34 µg	
	10 g	40 µg	
	20 g	50 µg	
	50 g	77 µg	
	100 g	0.15 mg	

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass Determination	200 g	0.28 mg	Standard Weight Set, Electronic Balances; CP-PL60 based on OIML R-111-1.
	500 g	0.73 mg	
	1 kg	1.5 mg	
	2 kg	2.8 mg	
	5 kg	11 mg	
	10 kg	17 mg	
	20 kg	29 mg	
Non-OIML Weight [1]	(1 to 20) mg	10 µg	Standard Weight Set; CP-PL94: Base on OIML R-111-1
	(> 20 to 200) mg	15 µg	
	(> 0.2 to 2) g	30 µg	
	(> 2 to 10) g	50 µg	
	(> 10 to 50) g	80 µg	
	(> 50 to 100) g	0.15 mg	
	(> 100 to 200) g	0.3 mg	
	(> 200 to 500) g	0.8 mg	
	(> 0.5 to 1) kg	1.5 mg	
	(> 1 to 2) kg	3 mg	
	(> 2 to 5) kg	12 mg	
	(> 5 to 10) kg	17 mg	
	(> 10 to 20) kg	30 mg	
Universal Testing Machine [1] Compression	Up to 500 N	0.95 % of reading	Force Transducer, Standard Gauge Block Set, Dial Test Indicator, Laser Distance Meter, Stopwatch; CP-PL59 based on ISO 7500-1.
	(0.5 to 1) kN	0.55 % of reading	
	(1 to 2) kN	0.36 % of reading	
	(2 to 10) kN	0.17 % of reading	
	(10 to 50) kN	0.4 % of reading	
	(50 to 100) kN	0.05 % of reading	
	(100 to 200) kN	0.03 % of reading	

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Universal Testing Machine [1]			Force Transducer, Standard Gauge Block Set, Dial Test Indicator, Laser Distance Meter, Stopwatch; CP-PL59 based on ISO 7500-1.
Tension	Up to 1 kN (1 to 3) kN (3 to 50) kN (50 to 60) kN (60 to 100) kN (100 to 200) kN	1.1 % of reading 0.75 % of reading 0.28 % of reading 0.1 % of reading 0.09 % of reading 0.07 % of reading	
Length	Up to 100 mm (100 to 500) mm (500 to 2 000) mm	0.005 % of reading 0.002 % of reading 0.001 5 % of reading	
Speed	Up to 10 mm/min (10 to 20) mm/min (20 to 50) mm/min (50 to 500) mm/min	0.5 % of reading 0.25 % of reading 0.15 % of reading 0.1 % of reading	
Screen Tension Meter [1]	(7 to 10) N/cm (> 10 to 50) N/cm	0.5 % of reading + 0.07 N/cm 1 % of reading	Force Transducer; CP-PL107 based on DIN 16611.
Rockwell Hardness Testing Machine [1] (Force)	3 kgf 10 kgf 60 kgf 100 kgf 150 kgf	0.025 kgf 0.08 kgf 0.47 kgf 0.78 kgf 1.2 kgf	Direct verification using Force Transducer; CP-PL47 based on ISO 6508-2.
Rockwell Hardness Testing Machine [1]	30 HRC 45 HRC 60 HRC 32 HRBS 60 HRBS 92 HRBS	0.6 HRC 0.6 HRC 0.6 HRC 1 HRBS 0.7 HRBS 0.7 HRBS	Indirect verification using Hardness Test Blocks; CP-PL47 based on ISO 6508-2.

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Durometers [3] (Types A, B, C, D, E, M, O, DO, OO, OOO, OOO-S) Indenter Dimensions			Direct Verification per CP-PL48 using Image Measuring Machine
Length	Up to 20 mm	1.5 µm	
Diameter, Radius	Up to 20 mm	1.5 µm	
Angle	Up to 45°	16″	
Spring Force	Up to 79 gf	0.26 gf	Electronic Balance, Standard Weight (Based on ASTM D 2240)
	(> 79 to 114) gf	0.34 gf	
	(> 114 to 198) gf	0.57 gf	
	(> 198 to 821) gf	2.3 gf	
	(> 821 to 4 533) gf	13 gf	
Vickers Hardness Testers [1]	100 HV		Indirect Verification using Hardness Test Blocks; CP-PL46: Direct Measurement
	10 gf	8 HV	
	0.1 kgf	8 HV	
	1 kgf	8 HV	
	500 HV		
	10 gf	21 HV	
	0.1 kgf	21 HV	
	1 kgf	21 HV	
	700 HV		
	10 gf	24 HV	
	0.1 kgf	24 HV	
	1 kgf	24 HV	
Hand Torque Tools, Torque Wrench, Torque Driver, Torque Nut-runner [1]	Up to 10 N·m (> 10 to 1 000) N·m	1 % of reading 1.3 % of reading	Torque Tester; CP-PL03 based on ISO 6789.
Torque Meter, Torque Tester [1]	Up to 20 N·m (> 20 to 50) N·m (> 50 to 500) N·m	0.13 % of reading 0.16 % of reading 0.13 % of reading	Arm & Standard Weight Set, Torque Transfer Wrench; CP-PL25: Direct Measurement
Barometer	(60 to 110) kPa	0.012 kPa	Comparison to Digital Test Gauge; CP-PL100 based on DKD R-6-1

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Absolute Pressure	(0 to 110) kPa	0.012 kPa	Comparison to Digital Test Gauge; CP-PL104 based on DKD R-6-1
Pressure Transducers, Pressure Transmitters [1]			Comparison to Digital Test Gauge, Digital Multimeter; CP-PL96 based on DKD R-6-1 and DKD R-6-2
Electrical Output Current	(-95 to -0.25) kPa	50 Pa	
	(> -0.25 to 0.25) kPa	1.6 Pa	
	(> 0.25 to 69) kPa	0.11 kPa	
	(> 69 to 206.9) kPa	0.12 kPa	
	(> 206.9 to 689.5) kPa	0.39 kPa	
	(> 689.5 to 2 068.5) kPa	1.1 kPa	
	(> 2 068.5 to 6 895) kPa	4.2 kPa	
	(> 6.895 to 20.685) MPa	11 kPa	
	(> 20.685 to 34.474) MPa	19 kPa	
	(> 34.474 to 68.948) MPa	38 kPa	
Electrical Output Voltage	(-95 to -0.25) kPa	29 Pa	
	(> -0.25 to 0.25) kPa	1.6 Pa	
	(> 0.25 to 69) kPa	0.1 kPa	
	(> 69 to 206.9) kPa	68 Pa	
	(> 206.9 to 689.5) kPa	0.25 kPa	
	(> 689.5 to 2 068.5) kPa	0.66 kPa	
	(> 2 068.5 to 6 895) kPa	3 kPa	
	(> 6.895 to 20.685) MPa	6.6 kPa	
	(> 20.685 to 34.474) MPa	11 kPa	
	(> 34.474 to 68.948) MPa	24 kPa	
Pressure Switches [1]	(-95 to -0.25) kPa	10 Pa	Comparison to Digital Test Gauge, Digital Multimeter; CP-PL97 based on DKD R-6-1 and DKD R-6-2
	(> -0.25 to 0.25) kPa	1.6 Pa	
	(> 0.25 to 69) kPa	98 Pa	
	(> 69 to 206.9) kPa	43 Pa	
	(> 206.9 to 689.5) kPa	0.16 kPa	
	(> 689.5 to 2 068.5) kPa	0.27 kPa	
	(> 2 068.5 to 6 895) kPa	2.3 kPa	
	(> 6.895 to 20.685) MPa	2.7 kPa	
	(> 20.685 to 34.474) MPa	3.7 kPa	
	(> 34.474 to 68.948) MPa	13 kPa	

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure Gauges (Pneumatic &Hydraulic), Digital Pressure Gauges, Differential Pressure Gauges, Manometers, Vacuum Gauges [1]	(-95 to -0.25) kPa (> -0.25 to 0.25) kPa (> 0.25 to 69) kPa (> 69 to 206.9) kPa (> 206.9 to 689.5) kPa (> 689.5 to 2 068.5) kPa (> 2 068.5 to 6 895) kPa (> 6.895 to 20.685) MPa (> 20.685 to 34.474) MPa (> 34.474 to 68.948) MPa	11 Pa 1.6 Pa 98 Pa 70 Pa 0.16 kPa 0.27 kPa 2.3 kPa 2.7 kPa 3.7 kPa 13 kPa	Digital Test Gauge; CP-PL56 based on DKD R-6-1 and DKD R-6-2
Digital Force Gauges [1] (Tension and Compression)	Up to 2 N (2 to 5) N (5 to 10) N (10 to 20) N (20 to 50) N (50 to 100) N (100 to 200) N (200 to 300) N (300 to 500) N (500 to 1 000) N	0.18 mN 0.43 mN 1.1 mN 1.8 mN 4.3 mN 11 mN 18 mN 26 mN 51 mN 0.13 N	Standard Weight Set; CP-PL20: Direct Measurement
Digital Force Gauges [1] (Tension Only)	(1 000 to 3 000) N	1.3 N	Standard Weight Set; CP-PL20: Direct Measurement
Spring Tension Gauges [1]	Up to 0.1 N (0.1 to 0.5) N (0.5 to 1.1) N (1.1 to 3) N (3 to 5) N (5 to 10) N (10 to 40) N (40 to 50) N (50 to 200) N (200 to 300) N	0.57 mN 1.2 mN 2.4 mN 12 mN 24 mN 57 mN 0.12 N 0.24 N 0.57 N 1.2 N	Standard Weight Set; CP-PL20: Direct Measurement

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Dial Tension Gauges [1]	Up to 50 mN (50 to 100) mN (100 to 200) mN (200 to 300) mN (300 to 500) mN (0.5 to 1) N (1 to 1.5) N (1.5 to 3) N (3 to 5) N (5 to 10) N (10 to 20) N	0.37 mN 0.81 mN 1.7 mN 2.1 mN 3.7 mN 8.1 mN 11 mN 21 mN 37 mN 62 mN 0.13 N	Standard Weight Set; CP-PL20: Direct Measurement
Viscosity and Density Meters [1] (Dynamic Viscosity) (20 to 50) °C	(24 to 92) mPa·s (74 to 340) mPa·s (260 to 1 500) mPa·s (1 400 to 17 000) mPa·s (7 500 to 92 000) mPa·s	0.41 % of reading 0.49 % of reading 0.55 % of reading 0.79 % of reading 0.82 % of reading	Viscosity Standard Solution; CP-PL49 Direct Measurement
Viscosity and Density Meters [1] (Kinematic Viscosity) (20 to 50) °C	(30 to 110) mm²/s (90 to 400) mm²/s (300 to 1 740) mm²/s (1 600 to 20 000) mm²/s (8 500 to 103 000) mm²/s	0.41 % of reading 0.49 % of reading 0.55 % of reading 0.79 % of reading 0.82 % of reading	Viscosity Standard Solution; CP-PL49 Direct Measurement
Viscosity Cups – Kinematic Viscosity [1] (20 to 25) °C	ISO Cups (> 10 to 100) mm²/s (cSt) (> 100 to 1 000) mm²/s (cSt) Zahn Cups (> 10 to 100) mm²/s (cSt) (> 100 to 1 000) mm²/s (cSt) Ford Cups (> 10 to 100) mm²/s (cSt) (> 100 to 1 000) mm²/s (cSt) Shell Cups (> 10 to 100) mm²/s (cSt) (> 100 to 1 000) mm²/s (cSt) DIN Cups (> 10 to 100) mm²/s (cSt) (> 100 to 1 000) mm²/s (cSt)	 0.32 % of Reading 0.38 % of Reading 0.32 % of Reading 0.38 % of Reading 0.32 % of Reading 0.38 % of Reading 0.32 % of Reading 0.38 % of Reading 0.32 % of Reading 0.38 % of Reading	Viscosity Standard Solution; CP-PL72 Direct Measurement based on ASTM D 1200-94, ASTM D 4212-99, ISO 2431 and DIN 53211

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Viscosity Cups – Kinematic Viscosity [1] (20 to 50) °C	Other Cups Up to 10 s (> 10 to 30) s (> 30 to 50) s (> 50 to 60) s (> 60 to 70) s (> 70 to 80) s (> 80 to 90) s (> 90 to 100) s	 0.27 % of reading 4 % of reading 1.2 % of reading 1.6 % of reading 3.2 % of reading 4.7 % of reading 6.4 % of reading 10 % of reading	Viscosity Standard Solution; In-house Method CP-PL98 Direct Measurement
Hydrometer	(0.6 to 2) g/cm³	0.15 mg/cm³	Electronic Balance, Density Standard Ring, Tridecane Solution; CP-PL77 Cuckow Method.
Air Velocity [1]	0 m/s 2.5 m/s 5 m/s 10 m/s 15 m/s	0.01 m/s 0.05 m/s 0.1 m/s 0.19 m/s 0.28 m/s	Wind Tunnel, Standard Anemometer; CP-PL26: Comparison Measurement
Flow Meter (Air Flow)	Up to 10 slpm (> 10 to 30) slpm (> 30 to 100) slpm (> 100 to 200) slpm	0.018 slpm 0.35 slpm 2.7 slpm 3.5 slpm	Air Flow Calibrator; CP-PL78: Direct Measurement
Flow Meter (Air Flow)	Up to 270 L/s (> 270 to 2 700) L/s (> 2 700 to 5 400) L/s (> 5 400 to 8 100) L/s (> 8 100 to 12 150) L/s	75 L/s 78 L/s 83 L/s 125 L/s 140 L/s	Standard Flow Meter Fluke 922; CP-PL78: Direct Measurement
Flow Meter [1] (Liquid Flow)	Up to 4 400 L/min	0.13 % of reading	Ultrasonic Flow Meter; CP-PL31: Direct Measurement

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Volumetric Glass Ware, Volumetric Flask, Volumetric Pipettes, Measuring Pipettes, Piston Pipettes, Burettes, Graduated Cylinders, Beakers, Dilutors, Dispensers, Pycnometers, Piston Burette [1]	(10 to 50) µL	93 nL	Electronic Balances; CP-PL91 Gravimetric Method based on ASTM E 542-01 and ISO 8655-6
	(50 to 100) µL	0.36 µL	
	(100 to 200) µL	0.36 µL	
	(200 to 500) µL	0.38 µL	
	(500 to 1 000) µL	0.41 µL	
	(1 000 to 2 000) µL	0.46 µL	
	(2 000 to 5 000) µL	0.71 µL	
	(5 000 to 10 000) µL	1.3 µL	
	(10 000 to 20 000) µL	2.5 µL	
	(20 000 to 50 000) µL	6 µL	
	(50 to 100) mL	13 µL	
	(100 to 200) mL	25 µL	
	(200 to 500) mL	61 µL	
	(500 to 1 000) mL	0.12 mL	
	(1 000 to 2 000) mL	0.24 mL	

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Lux Meter	Up to 5 000 lux	1.6 % of reading	Digital Lux Meter; CP-PL27: Comparison Measurement
Laser Power – Source/Measure [1]	1 µW to 2.5 kW		Power Detector w/ Monitor; CP-EL51: Direct and Comparison Measurement
	(248 to < 308) nm	4 % of reading	
	(308 to 10 600) nm	1.7 % of reading	
UV Meter (UVA)	Up to 500 mW/cm^2 Up to 10 000 mJ/cm^2	2.9 % of reading	UV Meter Standard; CP-PL68: Comparison Measurement
UV Meter (UVC)	Up to 300 mW/cm^2 Up to 3 000 mJ/cm^2	2.9 % of reading	

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Total Solar Irradiance / Pyranometer [1] (Sensitivity or Calibration Factor)	(Sens. 1 to 200) μV/W/m^2 (Cal. Factor 0 to 1)	1.6 % of reading	Kipp & Zonan CMP11/21 and CMP22 Pyranometer; Wavetek 1281 8.5 Digit Multimeter, HP 34401A 6.5 Digit Multimeter, HP 34970A Data Logger; CP-EL53: Comparison Measurement
Gloss Meter [3]			AMECaL/GT-HG3 Gloss Tile; CP-PL76: Direct Measurement
20 °	87.7 GU	1 GU	
60 °	92.7 GU	1 GU	
85 °	99.2 GU	1.2 GU	
Luminance Meter	Up to 2 cd/m^2	1.1 % of reading + 0.000 58 cd/m^2	LS-65 Luminance Integrating Sphere Standard Light Source with Monitor Detector; CP-PL89: Direct Measurement
	(> 2 to 20) cd/m^2	1.1 % of reading + 0.005 8 cd/m^2	
	(> 20 to 150) cd/m^2	1.1 % of reading + 0.058 cd/m^2	
	(> 150 to 2 000) cd/m^2	1.1 % of reading + 0.58 cd/m^2	
Color Meter, Color Reader [6]	White		Standard Color Plate; CP-PL79: Direct Measurement
	L*	0.25	
	a*	0.1	
	b*	0.16	
	Y	0.6	
	x	0.006	
	y	0.006	
	Black		
	L*	0.4	
	a*	0.15	
	b*	0.32	
	Y	0.12	
	x	0.006	
	y	0.007	

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1] (Dry well, Dry Block)	(-30 to 0) °C (> 0 to 200) °C (> 200 to 450) °C (> 450 to 650) °C	0.13 °C 0.14 °C 0.18 °C 0.19 °C	Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Fluke 5650 TS Type S Thermocouple Probe, Hart 1560 Black Stack with 2562 Module, Wavetek 1281 8.5 Digit Multimeter; CP-EL13: Direct Measurement
Temperature – Measure [1] (Liquid Bath, Micro Bath)	(-40 to 0) °C (> 0 to 200) °C (> 200 to 450) °C (> 450 to 650) °C	0.05 °C 0.06 °C 0.09 °C 0.09 °C	Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Fluke 5650 TS Type S Thermocouple Probe, Hart 1560 Black Stack with 2562 Module, Wavetek 1281 8.5 Digit Multimeter; CP-EL13: Direct Measurement
Temperature Controlled Chamber Autoclave [1] (Measurement)	(100 to 140) °C	0.5 °C	MadgeTech HiTemp140 Datalogger; CP-EL37: Direct Measurement
Humidity Controlled Chamber [1] (Measurement)	(1 to 10) %RH (> 10 to 20) %RH (> 20 to 40) %RH (> 40 to 70) %RH (> 75 to 95) %RH	0.5 %RH 0.5 %RH 0.5 %RH 0.7 %RH 1 %RH	Baluntech BL783 Chilled Mirror Hygrometer, Temperature/ Humidity Data Logger; CP-EL62: Comparison Measurement
Humidity [1] (Thermo Hygrometer Measurement)	(20 to 40) %RH (> 40 to 60) %RH (> 60 to 80) %RH (> 80 to 95) %RH	2 %RH 1.7 %RH 1.8 %RH 1.9 %RH	Baluntech BL783 Precision Chilled Mirror Hygrometer, Rotronic HL-NT3-D Temperature/ Humidity Data Logger; CP-EL21: Comparison Measurement

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity – Source [1]	(20 to 40) %RH (> 40 to 60) %RH (> 60 to 80) %RH (> 80 to 95) %RH	2 %RH 1.7 %RH 1.8 %RH 1.9 %RH	Baluntech BL783 Precision Chilled Mirror Hygrometer, Rotronic HL-NT3-D Temperature/ Humidity Data Logger; Humidity Source; CP-EL21: Comparison Measurement
Temperature – Source [1]	(-10 to 0) °C (> 0 to 50) °C (> 50 to 100) °C (> 100 to 150) °C	0.15 °C 0.15 °C 0.34 °C 0.34 °C	Baluntech BL783 Precision Chilled Mirror Hygrometer, Rotronic HL-NT3-D Temperature/Humidity Data Logger; Heat Source; CP-EL21: Comparison Measurement
Temperature [1] (Thermo Hygrograph Measurement)	(-10 to 0) °C (> 0 to 50) °C (> 50 to 100) °C (> 100 to 150) °C	0.66 °C 0.66 °C 0.66 °C 0.66 °C	Comparison to Fluke 5618B PRT, Fluke 5614 PRT; Hart 1560 Black Stack with module 2562, Rotronic HL-NT3-D Temperature/ Humidity Data Logger; CP-EL21: Comparison Measurement
PRT Sensors [1]	(-30 to 0) °C (> 0 to 200) °C (> 200 to 450) °C (> 450 to 650) °C	0.047 °C 0.049 °C 0.077 °C 0.082 °C	Fluke 5609 SPRT, Hart 1560 Black Stack with module 2562, Thermometer Readout; Heat Source; CP-EL39: Comparison Measurement

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Controlled Chamber, Hot Air Oven, Incubator, Refrigerator, Low Temperature Furnace [1]	(-40 to 100) °C (> 100 to 200) °C (> 200 to 250) °C (> 250 to 450) °C	0.37 °C 0.40 °C 0.79 °C 1.1 °C	Agilent 34970A/34901A Datalogger ; CP-EL14: Direct Measurement
	(> 450 to 700) °C (> 700 to 1 000) °C (> 1 000 to 1 200) °C (> 1 200 to 1 500) °C	2.4 °C 2.6 °C 2.8 °C 5.4 °C	Fluke 5650 Type S Standard Thermocouple Probe, SANSEL MTC/S-Type (Temperature is at an empty volume at a single spot); CP-EL68: Direct Measurement
Infrared Thermometers [1]	(-15 to 0) °C (> 0 to 50) °C (> 50 to 100) °C (> 100 to 150) °C (> 150 to 200) °C (> 200 to 250) °C (> 250 to 300) °C (> 300 to 350) °C (> 350 to 400) °C (> 400 to 450) °C (> 450 to 500) °C (> 500 to 600) °C (> 600 to 700) °C (> 700 to 800) °C (> 800 to 900) °C (> 900 to 1000) °C (> 1 000 to 1 200) °C	0.95 °C 0.71 °C 1.3 °C 1.5 °C 1.8 °C 2.2 °C 2.5 °C 2.9 °C 3.3 °C 3.6 °C 4.2 °C 7.8 °C 8.3 °C 9 °C 9.5 °C 11 °C 12 °C	Fluke 5618B PRT, Hart 1560 Black Stack with 2562 Module, Omega BB701, CEM BX-500, SANSEL BCAL 1202 Infrared Calibrator (Flat Plate), $\mathcal{E} = 0.95$, $\lambda =(8\ \text{to}\ 14)$ µm; CP-EL16: Comparison Measurement
Temperature Indicator with Surface Sensor/Probe [1]	(35 to 200) °C (> 200 to 400) °C	0.45 °C 0.68 °C	Fluke 5618B PRT, Hart 1560 Black Stack with module 2562, Fluke 3125/2200 Surface Probe Calibrator

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Liquid-in-Glass Thermometers [1]	(-30 to 0) °C (> 0 to 40) °C (> 40 to 100) °C (> 100 to 200) °C	0.19 °C 0.18 °C 0.19 °C 0.2 °C	Fluke 5618B PRT, Fluke 5614 PRT, Hart 1560 Black Stack with module 2562; Heat Source; CP-EL15: Direct Measurement
Temperature Gauge, Dial Thermometer [1]	(-40 to 25) °C (> 25 to 100) °C (> 100 to 400) °C (> 400 to 650) °C	0.32 °C 0.32 °C 0.4 °C 0.41 °C	Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Hart 1560 Black Stack with module 2562; Heat Source; CP-EL20: Comparison Measurement
Temperature – Measure [1] (RTD)	(-200 to -80) °C (> -80 to 0) °C (> 0 to 100) °C (> 100 to 300) °C (> 300 to 400) °C (> 400 to 630) °C (> 630 to 800) °C	0.012 °C 0.012 °C 0.013 °C 0.021 °C 0.023 °C 0.028 °C 0.033 °C	Wavetek 1281 8.5 Digit Multimeter, Standard RTD; CP-EL19: Direct Measurement
Temperature – Measure [1]	(-40 to 0) °C (> 0 to 200) °C (> 200 to 450) °C (> 450 to 650) °C	0.13 °C 0.14 °C 0.18 °C 0.19 °C	Madgetech HiTemp140 Datalogger, Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Fluke 5650 Type S Thermocouple Probe, Hart 1560 Black Stack with module 2562, Wavetek 1281 8.5 Digit Multimeter; CP-EL13: Direct Measurement

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1] Temperature at Single Spot	(> 650 to 700) °C (> 700 to 1 000) °C (> 1 000 to 1 200) °C (> 1 200 to 1 500) °C	2.5 °C 2.5 °C 3.6 °C 5 °C	Madgetech HiTemp140 Datalogger, Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Fluke 5650 Type S Thermocouple Probe, Hart 1560 Black Stack with module 2562, Wavetek 1281 8.5 Digit Multimeter; CP-EL13: Direct Measurement
Temperature Indicator with Resistance Temperature Detector Sensors [1] (Pt 100-385, JPt 100-385, Pt 1000-385, Thermistor)	(-45 to 25) °C (> 25 to 100) °C (> 100 to 400) °C (> 400 to 650) °C	0.18 °C 0.19 °C 0.31 °C 0.36 °C	Comparison to Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Hart 1560 Black Stack with module 2562; Heat Source; CP-EL10: Comparison Measurement
Temperature Indicator with Thermocouple Sensors [1]	Type K (-45 to 25) °C (> 25 to 100) °C (> 100 to 400) °C (> 400 to 650) °C (> 650 to 1 200) °C Type J (-45 to 25) °C (> 25 to 100) °C (> 100 to 400) °C (> 400 to 650) °C (> 650 to 1 200) °C	 0.27 °C 0.3 °C 0.58 °C 0.9 °C 2.5 °C 0.29 °C 0.4 °C 1.3 °C 2 °C 4 °C	Comparison to Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Fluke 5650 TS Type S Thermocouple Probe, Hart 1560 Black Stack with module 2562; Heat Source; CP-EL11: Comparison Measurement

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Indicator with Thermocouple Sensors [1]	Type T		Comparison to Fluke 5609 PRT, Fluke 5618B PRT, Fluke 5614 PRT, Fluke 5650 TS Type S Thermocouple Probe, Hart 1560 Black Stack with module 2562; Heat Source; CP-EL11: Comparison Measurement
	(-45 to 25) °C	0.27 °C	
	(> 25 to 100) °C	0.4 °C	
	(> 100 to 400) °C	1.3 °C	
	Type R		
	(25 to 100) °C	0.24 °C	
	(> 100 to 400) °C	0.6 °C	
	(> 400 to 650) °C	0.6 °C	
	(> 650 to 1 200) °C	2.1 °C	
	(> 1 200 to 1 500) °C	6.5 °C	
	Type S		
	(25 to 100) °C	0.24 °C	
	(> 100 to 400) °C	0.6 °C	
	(> 400 to 650) °C	0.6 °C	
	(> 650 to 1 200) °C	2.1 °C	
	(> 1 200 to 1 500) °C	6.5 °C	
	Type E		
	(-45 to 25) °C	0.29 °C	
	(> 25 to 100) °C	0.4 °C	
	(> 100 to 400) °C	1.3 °C	
	(> 400 to 650) °C	2 °C	
	(> 650 to 1 000) °C	3.5 °C	
	Type N		
	(-30 to 25) °C	0.27 °C	
	(> 25 to 100) °C	0.3 °C	
	(> 100 to 400) °C	0.7 °C	
	(> 400 to 650) °C	0.9 °C	
	(> 650 to 1 000) °C	2.5 °C	

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Transmitter with Thermocouple Sensor [1] Electrical Output Current (0 to 20) mA	Types E, J, K, N		Fluke 754 Documenting Process Calibrator; Fluke 5609 PRT, Fluke 5618B, PRT Fluke 5628 PRT, Fluke 5650 TC Standard; Fluke 1560, Fluke 1502A, Temperature Source; CP-EL77: Comparison Measurement with PRT and Standard Thermocouple
	(-30 to 250) °C	0.48 °C	
	(> 250 to 500) °C	0.52 °C	
	(> 500 to 750) °C	1.5 °C	
	(> 750 to 1 000) °C	1.5 °C	
	Type T		
	(-30 to 250) °C	0.48 °C	
	(> 250 to 400) °C	0.52 °C	
	Type: B		
	(600 to 1 000) °C	1.5 °C	
	Type: R, S		
	(0 to 250) °C	0.48 °C	
	(> 250 to 500) °C	0.52 °C	
	(> 500 to 750) °C	1.5 °C	
	(> 750 to 1 000) °C	1.5 °C	
Temperature Transmitter with RTD Sensor [1] Electrical Output Current (0 to 20) mA	Type: Pt 385, 100 Ω		Fluke 754 Documenting Process Calibrator; Fluke 5609 PRT, Fluke 5618B, PRT Fluke 5628 PRT, Fluke 5650 TC Standard; Fluke 1560, Fluke 1502A, Temperature Source; CP-EL77: Comparison Measurement with PRT and Standard Thermocouple
	(-30 to 130) °C	0.28 °C	
	(> 130 to 300) °C	0.36 °C	
	(> 300 to 450) °C	0.4 °C	
	(> 450 to 600) °C	0.4 °C	

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Transmitter with Thermocouple Sensor [1] Electrical Output Voltage (0 to 10) V	Type: E, J, K, N (-30 to 250) °C (> 250 to 500) °C (> 500 to 750) °C (> 750 to 1 000) °C Type: T (-30 to 250) °C (> 250 to 400) °C Type: B (600 to 1 000) °C Type: R, S (0 to 250) °C (> 250 to 500) °C (> 500 to 750) °C (> 750 to 1 000) °C	0.23 °C 0.29 °C 1.5 °C 1.5 °C 0.23 °C 0.29 °C 1.5 °C 0.23 °C 0.29 °C 1.5 °C 1.5 °C	Fluke 754 Documenting Process Calibrator; Fluke 5609 PRT, Fluke 5618B, PRT Fluke 5628 PRT, Fluke 5650 TC Standard; Fluke 1560, Fluke 1502A, Temperature Source; CP-EL77: Comparison Measurement with PRT and Standard Thermocouple
Temperature Transmitter with RTD Sensor [1] Electrical Output Voltage (0 to 10) V	Type: Pt 385, 100 Ω (-30 to 130) °C (> 130 to 300) °C (> 300 to 450) °C (> 450 to 600) °C	0.085 °C 0.25 °C 0.28 °C 0.3 °C	Fluke 754 Documenting Process Calibrator; Fluke 5609 PRT, Fluke 5618B, PRT Fluke 5628 PRT, Fluke 5650 TC Standard; Fluke 1560, Fluke 1502A, Temperature Source; CP-EL77: Comparison Measurement with PRT and Standard Thermocouple

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1]	Type K		Hart 1560 Black Stack with module 2562; CP-EL19: Direct Measurement
	(-200 to -100) °C	0.33 °C	
	(> -100 to -25) °C	0.13 °C	
	(> 25 to 120) °C	0.13 °C	
	(> 120 to 1 000) °C	0.13 °C	
	(> 1 000 to 1 372) °C	0.28 °C	
	Type J		
	(-210 to -100) °C	0.26 °C	
	(> -100 to -30) °C	0.11 °C	
	(> -30 to 150) °C	0.089 °C	
	(> 150 to 760) °C	0.078 °C	
	(> 760 to 1 200) °C	0.17 °C	
Temperature – Measure [1]	Type T		Hart 1560 Black Stack with module 2562; CP-EL19: Direct Measurement
	(-250 to -150) °C	0.79 °C	
	(> -150 to 0)	0.13 °C	
	(> 0 to 120) °C	0.11 °C	
	(> 120 to 400) °C	0.08 °C	
	Type R		
	(0 to 250) °C	0.92 °C	
	(> 250 to 400) °C	0.47 °C	
	(> 400 to 1 000) °C	0.37 °C	
	(> 1 000 to 1 767) °C	0.4 °C	
	Type S		
	(0 to 250) °C	0.9 °C	
	(> 250 to 400) °C	0.51 °C	
	(> 400 to 1 000) °C	0.42 °C	
	(> 1 000 to 1 767) °C	0.47 °C	
	Type E		
	(-250 to -100) °C	0.52 °C	
	(> -100 to -25) °C	0.089 °C	
	(> -25 to 350) °C	0.065 °C	
	(> 350 to 650) °C	0.065 °C	
	(> 650 to 1 000) °C	0.13 °C	
	Type N		
	(-200 to -100) °C	0.5 °C	
	(> -100 to -25) °C	0.2 °C	
	(> -25 to 120) °C	0.16 °C	
	(> 120 to 410) °C	0.14 °C	
	(> 410 to 1 300) °C	0.14 °C	

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Stroboscopes [1,3]	(0 to 100) rpm (> 100 to 1 000) rpm (> 1 000 to 100 000) rpm	0.001 3 rpm 0.005 9 rpm 0.058 rpm	Agilent 34401A 6.5 Digit Multimeter; HP 53131A, HP 53132A Universal Counter; CP-EL49: Direct Measurement
Contact and Non-contact Tachometers [1,3]			LED, HP 33220A Function Generator, Fluke 5522A Multiproduct Calibrator; CP-EL48: Direct Measurement
Revolution	Up to 120 000 rpm	0.000 65 % of reading	
Surface Speed	Up to 2 000 m/min	0.000 65 % of reading	
Contact RPM – Measure [1,3]	(0 to 999) rpm (> 999 to 99 900) rpm	0.12 % of reading + 0.1 rpm 0.12 % of reading + 1 rpm	Non-contact Tachometer, CP-EL44: Direct Measurement
Accumulated – Measure [1]	Up to 4 999 count (5 000 to 90 000) count	0.03 % of reading + 1.3 count 0.03 % of reading + 2 count	Non-contact Tachometer, CP-EL44: Direct Measurement
Line Speed – Measure [1]	Up to 4 999 m/min (5 000 to 90 000) m/min	0.03 % of reading + 0.2 m/min 0.03 % of reading + 1 m/min	Non-contact Tachometer, CP-EL44: Direct Measurement
Frequency – Measure [1]	10 Hz to 1 MHz	0.21 µHz/Hz	Agilent 53181A, Agilent 53131A, Agilent 53132A Universal Counter; CP-EL28: Direct Measurement
Frequency – Source [1]	1 mHz to 20 GHz	0.4 nHz/Hz	Agilent 33220A, HP 8665B, HP 8648D, Agilent N9310A, HP 83732B, Agilent E4438C Signal Generators, with Efratom PRFS-102 Frequency Standard; CP-EL06: Direct Measurement

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source [1]	10 mHz to 120 Hz 120 Hz to < 1.2 kHz (1.2 to < 12) kHz (12 to < 120) kHz 120 kHz to < 1.2 MHz (1.2 to 2) MHz	2.9 µHz/Hz + 59 µHz 2.9 µHz/Hz + 0.59 mHz 2.9 µHz/Hz + 5.8 mHz 2.9 µHz/Hz + 58 mHz 2.9 µHz/Hz + 0.59 Hz 2.9 µHz/Hz + 5.8 Hz	Fluke 5522A Multiproduct Calibrator; CP-EL01: Direct Measurement
Frequency Display – Source [1]	1 mHz to 20 GHz	1.2 pHz/Hz	Agilent 33220A, HP 8665B, HP 8648D, Agilent N9310A, HP 83732B, Agilent E4438C Signal Generator; Time base (STD and UUC); CP-EL06: Direct Measurement
Frequency – Measure [1]	10 mV to 700 V or 0.1 mA to 1 A (1 to 40) Hz (> 40 to 1 000) Hz (> 1 to 10) kHz (> 10 to 100) kHz (> 0.1 to 1) MHz (> 1 to 10) MHz	 0.58 mHz/Hz + 0.12 mHz 0.12 mHz/Hz + 1.2 mHz 0.12 mHz/Hz + 0.12 Hz 0.12 mHz/Hz + 1.2 Hz 0.12 mHz/Hz + 12 Hz 0.12 mHz/Hz + 0.12 kHz	Keysight 3458A 8.5 Digit Multimeter; CP-EL66: Direct Measurement
Frequency – Measure [1]	100 mHz to 20 GHz	0.4 nHz/Hz	Agilent 53131A, Agilent 53132A, Agilent 53181A, HP 5350B Universal Counter; Efratom PRFS-102 Frequency Standard; CP-EL07: Direct Measurement
Frequency – Measure [1]	100 mHz to 10 Hz 10 Hz to 20 GHz	0.21 µHz/Hz 45 nHz/Hz	Agilent 53131A, Agilent 53132A, Agilent 53181A, HP 5350B Universal Counter using Internal Time Base; CP-EL07: Direct Measurement

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Display – Measure [1]	100 mHz to 12.4 GHz (12.4 to 20) GHz	20 pHz/Hz 85 pHz/Hz	Agilent 53131A, Agilent 53132A, Agilent 53181A, HP 5350B Universal Counter with together Time Base; CP-EL07: Direct Measurement
Timer, Sweep Time, Stopwatch [1]	Up to 86 400 s	11 ms/d	Heiwado HT-403 Quartz Timer; CP-EL34: Time Base Method
Timer, Sweep Time, Stopwatch [1]	Up to 86 400 s	11 µs/d	Agilent 53131A, Agilent 53132A Universal Counter; Agilent 33220A Function Generator, Digital Camera; CP-EL34: Photo Totalize Method
Timer, Sweep Time, Stopwatch [1]	Up to 86 400 s	1.2 s/d + 40 ms	Casio HS-70W Stopwatch; CP-EL34: Direct Measurement
AC Voltage/Current Frequency – Measure [1]	(10 to 40) Hz > 40 Hz to 1kHz (> 1 to 10) kHz (> 10 to 100) kHz (> 100 to 300) kHz	3.5 mHz/Hz + 90 µHz 1.2 mHz/Hz + 0.1 mHz 1.2 mHz/Hz + 9 mHz 1.2 mHz/Hz + 90 mHz 1.2 mHz/Hz + 0.9 Hz	HP 34401A 6.5 Digit Multimeter, Fluke 289 Digital Multimeter; CP-EL02: Direct Measurement
Pulse – Source [1]	(1 to 500 000) count	0.58 count	Keysight 33220A Signal Generator; CP-EL45: Direct Measurement
Pulse – Measure [1]	(1 to 500 000) count	0.58 count	Agilent 53131A, Agilent 53132A Universal Counter; CP-EL46: Direct Measurement

DIMENSIONAL MEASUREMENT

2 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
2-D Measurement[3] X-Y axis	Up to 300 mm (> 300 to 400) mm (> 400 to 500) mm	$(2 + 0.002L)$ µm $(5 + 0.002L)$ µm $(6 + 0.002L)$ µm	Vision Measuring Machine used as Reference; Customer Drawings and Vision Software; CP-PL70, CP-PL71: Direct Measurement

3 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
3-D Measurement[3]	X-axis: Up to 700 mm Y-axis: Up to 700 mm Z-axis: Up to 600 mm	$(0.8 + 0.008\ 2L)$ µm	Coordinate Measuring Machine used as Reference; Customer Drawings and CMM Software; CP-PL95: Direct Measurement

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. RF Power includes mismatch uncertainty and SWR assumption. mismatch calculation was based on specific SWR values. Customer values will vary.
3. *D* = diameter; ″ = arc-second; var = Volt-Ampere reactive (the SI allows this unit in lower case); ″ = arc-second; GU = gloss unit; *DL* = diagonal length; ″ = arc-second; rpm = revolutions per minute.
4. Power Factor (sometimes noted as PF) is a unitless number between -1 and 1.
5. The Range Values are approximate. Actual Certified Values will be utilized at the time of calibration.
6. The measurand is a unitless measurement.

Jason Stine, Vice President