



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

JAPAN QUALITY ASSURANCE ORGANIZATION
 Measurement and Calibration Center
 4-4-4, Minamiosawa, Hachioji-shi, Tokyo, 192-0364, Japan
 Yoshio Kobayashi Phone: 81 42 679 0144

CALIBRATION

Valid To: March 31, 2020

Certificate Number: 1400.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to the laboratory location listed above and as well as the one satellite location listed below¹:

I. Acoustical Quantities

Parameter/Range	Frequency	CMC ² (±)	Comments
Sound Level Meter – Free-Field Response Level – Acoustic	(10 to 20) Hz	0.5 dB	Type I reference microphone
	(20 to 50) Hz	0.4 dB	
	(50 to 3150) Hz	0.3 dB	Type II reference microphone
	(3150 to 8000) Hz	0.5 dB	
	(8000 to 12 500) Hz	0.6 dB	
	(20 to 50) Hz	0.4 dB	
	(50 to 3150) Hz	0.3 dB	
	(3150 to 12 500) Hz	0.5 dB	
	(12 500 to 20 000) Hz	0.8 dB	
	Electrical Calibration	31.5 Hz to 8 kHz	
Acoustical Signal Tests of a Frequency Weighting	125 Hz	0.4 dB	IEC 61672-3 Periodic tests
	1000 Hz	0.3 dB	
	8000 Hz	0.5 dB	
Electrical Signal Tests of Frequency Weightings	(63 to 16000) Hz	0.2 dB	IEC 61672-3 Periodic tests
Frequency and Time Weightings at 1 kHz	1000 Hz	0.1 dB	IEC 61672-3 Periodic tests
Long-Term Stability	1000 Hz	0.1 dB	IEC 61672-3 Periodic tests

Parameter/Range	Frequency	CMC ² (±)	Comments
Sound Level Meter – (cont)			
Level Linearity on the Reference Level Range	8000 Hz	0.2 dB	IEC 61672-3 Periodic tests
Level Linearity Including the Level Range Control	1000 Hz	0.2 dB	IEC 61672-3 Periodic tests
Toneburst Response	4000 Hz	0.2 dB	IEC 61672-3 Periodic tests
C-Weighted Peak Sound Level	500 Hz, 8000 Hz	0.3 dB	IEC 61672-3 Periodic tests
Overload Indication	4000 Hz	0.2 dB	IEC 61672-3 Periodic tests
High-Level Stability	1000 Hz	0.1 dB	IEC 61672-3 Periodic tests
Calibrator –			
Sound Pressure Level/Acoustic Calibrator	250 Hz, 1000 Hz	0.08 dB	Type I reference microphone
	250 Hz, 1000 Hz	0.09 dB	Type II reference microphone
Sound Pressure Level/Multifunction Acoustic Calibrator	31.5 Hz	0.11 dB	Type II reference microphone
	63 Hz	0.09 dB	
	125 Hz	0.09 dB	
	250 Hz	0.09 dB	
	500 Hz	0.09 dB	
	1000 Hz	0.09 dB	
	2000 Hz	0.09 dB	
	4000 Hz	0.09 dB	
	8000 Hz	0.09 dB	
	12 500 Hz	0.09 dB	
16 000 Hz	0.13 dB		
Frequency	(0.25 to 1) kHz	0.058 Hz	Frequency counter
Distortion	Up to 5 % THD, (0.25 to 1) kHz	3 %	Audio analyzer

Parameter/Range	Frequency	CMC ² (±)	Comments
Microphone –			
Type I Microphone Pressure Sensitivity	(20 to 8000) Hz (8000 to 10 000) Hz (10 000 to 12 500) Hz	0.07 dB 0.17 dB 0.33 dB	Pressure calibration by reciprocity method
Type II Microphone Pressure Sensitivity	(20 to 50) Hz (50 to 16 000) Hz (16 000 to 20 000) Hz	0.10 dB 0.07 dB 0.15 dB	Pressure calibration by reciprocity method
Type I Microphone Pressure Sensitivity	(20 to 4000) Hz (4000 to 10 000) Hz (10 000 to 12 500) Hz	0.10 dB 0.19 dB 0.56 dB	Pressure calibration by comparison method
Type II Microphone Pressure Sensitivity	(20 to 50) Hz (50 to 16 000) Hz (16 000 to 20 000) Hz	0.14 dB 0.11 dB 0.19 dB	Pressure calibration by comparison method
Type I Microphone Pressure Sensitivity	(20 to 100) Hz (100 to 1000) Hz	0.6 dB 0.2 dB	Pressure calibration by simplified comparison method
Type II Microphone Pressure Sensitivity	(20 to 100) Hz (100 to 4000) Hz (4000 to 8000) Hz (8000 to 16 000) Hz (16 000 to 20 000) Hz	0.7 dB 0.3 dB 0.7 dB 1.2 dB 1.4 dB	Pressure calibration by simplified comparison method
Type I Microphone Free-field Sensitivity	(20 to 4000) Hz (4000 to 10 000) Hz (10 000 to 12 500) Hz	0.3 dB 0.4 dB 0.6 dB	Free field calibration by comparison method
Type II Microphone Free-field Sensitivity	(20 to 4000) Hz (4000 to 9000) Hz (9000 to 16 000) Hz (16 000 to 20 000) Hz	0.3 dB 0.4 dB 0.5 dB 0.9 dB	Free field calibration by comparison method

II. Chemical Quantities

Parameter/Equipment	Range	CMC ² (±)	Comments
pH Indicator – Instrumental Error Linearity Repeatability	(0 to 14) pH units (0 to 14) pH units (0 to 14) pH units	0.005 pH units 0.009 pH units 0.006 pH units	DC voltage
pH Detector – Instrumental Error Linearity Repeatability	4 pH units, 9 pH units 4 pH units, 7 pH units, 9 pH units 4 pH units, 7 pH units 9 pH units	0.4 mV/pH 1.0 mV 1.1 mV 2.0 mV	Standard solutions
pH Meters – Three-Point Calibration Instrumental Error Two-Point Calibration Instrumental Error One-Point Calibration Instrumental Error	4 pH units 7 pH units 9 pH units 4 pH units, 9 pH units 7 pH units 4 pH units, 7 pH units 9 pH units	0.010 pH units 0.011 pH units 0.030 pH units 0.024 pH units 0.013 pH units 0.18 pH units 0.18 pH units	Standard solutions
Light Scattering Airborne Particle Counter – Counting Efficiency	(0.050 to 0.080) µm (0.080 to 0.100) µm (0.100 to 0.800) µm	5.4 % of counting efficiency 5.2 % of counting efficiency 5.0 % of counting efficiency	JIS B 9921 Particle counters with standard particles

Parameter/Equipment	Range	CMC ² (±)	Comments
CO ₂ Monitor – Diffusion Types	0 % CO ₂ (0.04 ± 0.004) % CO ₂ (0.07 ± 0.007) % CO ₂ (0.1 ± 0.01) % CO ₂ (0.2 ± 0.02) % CO ₂ (0.4 ± 0.04) % CO ₂ (0.5 ± 0.05) % CO ₂ (0.8 ± 0.08) % CO ₂ (1 ± 0.1) % CO ₂	0.001 % CO ₂ 0.001 % CO ₂ 0.001 % CO ₂ 0.002 % CO ₂ 0.003 % CO ₂ 0.005 % CO ₂ 0.005 % CO ₂ 0.008 % CO ₂ 0.01 % CO ₂	Standard gas: CO ₂ in N ₂
Probe Types, Suction Types	0 % CO ₂ (0.04 ± 0.004) % CO ₂ (0.07 ± 0.007) % CO ₂ (0.1 ± 0.01) % CO ₂ (0.2 ± 0.02) % CO ₂ (0.4 ± 0.04) % CO ₂ (0.5 ± 0.05) % CO ₂ (0.8 ± 0.08) % CO ₂ (1 ± 0.1) % CO ₂	0.002 % CO ₂ 0.002 % CO ₂ 0.002 % CO ₂ 0.002 % CO ₂ 0.003 % CO ₂ 0.004 % CO ₂ 0.005 % CO ₂ 0.008 % CO ₂ 0.01 % CO ₂	Standard gas: CO ₂ in N ₂
Electrical Conductivity Meters – Fixed Points	14.7 mS/m 141 mS/m 1280 mS/m 14.7 mS/m 141 mS/m 1280 mS/m	2.9 % 2.0 % 2.0 % 3.9 % 2.5 % 2.4 %	Standard conductivity solutions Calibrated electrical conductivity meter

III. Dimensional

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Gage Blocks	(0.1 to 100) mm (100 to 250) mm	0.04 μm (0.01 + L/3500) μm	By interferometry, type GBI and NRLM-Tsugami
	(250 to 400) mm (400 to 800) mm (800 to 1000) mm	(0.02 + L/3400) μm (0.02 + L/3200) μm (0.02 + L/3100) μm	By interferometry, type LGB
	(0.1 to 100) mm (100 to 500) mm (500 to 1000) mm	0.07 μm (0.005 + L/1800) μm (0.025 + L/1800) μm	By comparison
Step Height Gauges	(0.02 to 1000) μm (Mode of Silicon)	0.021 μm	By interferometry, type NRLM-Tsugami
Step Gages	Up to 1050 mm	(0.2 + L/650) μm	Comparison to gage blocks
633 nm Stabilized He-Ne Laser Wavelength ⁸	633 nm	4.2 parts in 10 ¹¹	Comparison to laser standard
Line Standard Scales	Up to 200 mm (200 to 300) mm	(1.0 + L/2000) μm (1.3 + L/1300) μm	Laser
	Up to 300 mm (300 to 1000) mm	0.4 μm (0.2 + L/1500) μm	By interferometry, type LST 1000
Plain Ring Gages	(0.1 to 100) mm	0.70 μm	Type IDM
	(100 to 200) mm	1.5 μm	Laser/ULM
	(200 to 250) mm	1.7 μm	ULM
Cylinder Gages ³	Up to 1.2 mm	1.6 μm	Dial gage tester

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Plug and Pin Gages	(0.1 to 100) mm (100 to 200) mm	0.7 µm 0.8 µm	ULM
Feeler Gages	(0.01 to 3.0) mm	1.3 µm	ULM
Electrical Comparators – Analog Digital	Up to 3 mm Up to 3 mm	2 % full scale 0.16 µm	Gage blocks
Calipers ³	Up to 200 mm (200 to 600) mm (600 to 2000) mm	0.04 mm 0.07 mm 0.1 mm	Gage blocks, step gage
Centerline Caliper ³	Up to 1000 mm	0.024 mm	Centerline caliper checker
Micrometers ³	Up to 500 mm	(2 + L/100) µm	Gage blocks
Dial Gages ³	Up to 25 mm (25 to 50) mm (50 to 100) mm	1.3 µm 1.3 µm 2.6 µm	Dial gages tester
Pin Gages	(0.1 to 10) mm (10 to 30) mm	0.6 µm 2.4 µm	Laser microscan
Snap Gage ³	Up to 200 mm	0.9 µm	Gage blocks
Three Wires for Screw Thread Measuring	Up to 6 mm	0.33 µm	Measure over roll
Standard Bar	(0.1 to 600) mm (600 to 1000) mm	(0.2+L/500) µm (1.1+L/5000) µm	Comparison to gage blocks

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Dial Gage Tester	Up to 50 mm (50 to 100) mm	0.6 μm 0.7 μm	Laser
Height Gages ³ – Analog Digital and Dial	Up to 600 mm Up to 600 mm	0.05 mm 0.02 mm	Gage blocks, step gages
Micro-Height Gages ³	Up to 300 mm (300 to 600) mm	4.1 μm 6.8 μm	Gage blocks
Depth Gage ³ – Vernier and Digital	Up to 300 mm Up to 300 mm	29 μm 9 μm	Gage blocks, step gages
Microindicators	Up to 100 μm	0.3 μm	Gage blocks
Depth Micrometers ³	Up to 50 mm (50 to 150) mm	2.6 μm 2.8 μm	Gage blocks, step gages
Inside Micrometers ³ – Caliper Type	Up to 300 mm	3.3 μm	Gage blocks
Dial Depth Indicator ³	Up to 100 mm	3 μm	Gage blocks
Optical Flats – Flatness	Up to 150 mm	0.02 μm	Comparison to optical flat masters
Optical Parallels – Parallelism Flatness	Up to 30 mm Up to 30 mm	0.09 μm 0.04 μm	Electrical high resolution length comparators Comparison to optical flat master

Parameter/Equipment	Range	CMC ² (±)	Comments
Hole Tester ³ – 3-Point ID Micrometer Analog Digital	(2 to 20) mm (20 to 100) mm (100 to 200) mm (100 to 200) mm	2.2 μm 3.6 μm 4.8 μm 3.7 μm	Master rings
Measuring Microscope ³ – Parallelism Straightness in X-Y Plane X-Y Squareness Linear Accuracy Angle	Up to 300 mm Up to 300 mm Up to 300 mm Up to 200 mm (200 to 300) mm Up to 360°	6.3 μm 2.2 μm 2.5 μm 2.8 μm 3.0 μm 0.73'	Glass line standard scales and electrical comparators Angle gauge blocks
Digital Indicator and Linear Gages ³	Up to 100 mm	0.6 μm	Gage blocks

Parameter/Equipment	Range	CMC ² (±)	Comments
Dial Linear Gages ³ – 1/100 mm 1/1000 mm	Up to 100 mm	5 µm 0.7 µm	Gage blocks
Measuring Projectors ³ – Error of Magnification Linear Accuracy	Up to 600 mm Up to 100 mm (100 to 300) mm	0.06 % of nominal magnification 2.7 µm 3.7 µm	Glass line standard scales
External Screw Threads – Standard Threads Parallel Whitworth Major Diameter	(1 to 50) mm (1 to 50) mm (1 to 50) mm	2 µm 2.1 µm 0.7 µm	Three-wire method ULM
Extensometer ³	Up to 600 mm Up to 600 mm	0.80 µm 0.80 µm	Reference to JIS B 7741, extensometer calibrator, gage blocks, digital linear height gage Reference to ASTM E83, extensometer calibrator, gage blocks, digital linear height gage
Precision Surface Plate ³ (Flatness Only)	Up to 450 mm (450 to 1300) mm (1300 to 2500) mm	1.8 µm 3.1 µm 3.2 µm	Photodetect autocollimator, laser, and precision level
Index Master	Up to 260 µm	0.20 µm	Laser
Laser Scan Micro	Up to 10 mm (10 to 50) mm	0.37 µm 1.5 µm	Pin gages

Parameter/Equipment	Range	CMC ^{2,4} (±)	Comments
Laser Displacement Meter	Up to 200 mm	2.7 μm	Universal measuring machine
	Up to 200 mm Up to 750 mm	6.3 μm 17 μm	Laser measurement
Thickness Gages ³	Up to 100 mm	10 μm	Gage blocks
Coordinate Measuring Machine ³ – Accuracy	(Each Axis) Up to 3000 mm	(0.9 + L/2100) μm	Laser measurement
	Up to 1000 mm (1000 to 1510) mm	(1.8 + L/700) μm 7.7 μm	Step gage or gage blocks
	(In Space) Up to 1000 mm (1000 to 1510) mm	3.3 μm 8.0 μm	Step gage
Universal Measuring Machines ³ – Indicating Accuracy	Up to 100 mm (100 to 200) mm (200 to 300) mm (300 to 400) mm (400 to 500) mm (500 to 600) mm (600 to 700) mm (700 to 800) mm (800 to 900) mm (900 to 1000) mm	0.4 μm 0.5 μm 0.7 μm 0.8 μm 1.0 μm 1.2 μm 1.3 μm 1.5 μm 1.7 μm 1.9 μm	Laser
	Up to 100 mm (100 to 200) mm (200 to 300) mm (300 to 400) mm (400 to 500) mm (500 to 600) mm (600 to 700) mm (700 to 800) mm (800 to 900) mm (900 to 1000) mm	0.6 μm 0.9 μm 1.3 μm 1.7 μm 2.1 μm 2.6 μm 3.0 μm 3.4 μm 3.8 μm 4.2 μm	Gage blocks
Autocollimators – Instrumental Error	Up to ± 3' ± (3 to 5)' ± (5 to 8)' ± (8 to 10)'	0.6" 0.8" 1.2" 1.5"	Laser system

Parameter/Equipment	Range	CMC ² (±)	Comments
Precision Levels	± 2'	1"	Laser system
Moment Arms	Up to 200 mm Up to 450 mm	0.011 mm 0.11 mm	633 nm He-Ne laser system, UMM, GB, micrometer, Vernier caliper, depth gauge, coordinate measuring machines
Non-Contact Angle Measuring Equipment	Up to ± 63.36" ± (63.36 to 3600)" ± (3600 to 36000)"	0.22" 0.34" 11"	Rotary encoder calibration equipment
Polyhedrons	Up to 360° Up to 360°	0.7" 1.3"	Rotary encoder, calibration equipment Indexing device
Rotating Platforms	Up to 360°	1.0"	Autocollimators polygon mirror
Angle Meters	Up to 360°	0.02°	Rotary encoder, angle gauge block
Angle Gauges, Universal protractors	Up to 360°	0.6'	Measuring microscope
Squareness	Up to 500 mm (500 to 700) mm (10 to 1000) mm Up to 700 mm	2.1 µm 2.9 µm 1.2 µm 1.1 µm	Standard square Electrical comparator Autocollimators
Straightedge ³	Up to 1500 mm	0.5 µm	Autocollimators

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Contact Stylus Instrument ³	Ra: 3 μm and below Rz: 10 μm and below	4 % 5 %	Roughness measurement standard
	d: 10 μm and below	0.33 %	Depth measurement standard
Surface Texture –			
Roughness	Ra: 5 μm and below Rz: 20 μm and below	0.12 μm 0.19 μm	Stylus instrument
Depth	d: 20 μm and below	0.12 μm	
Step	500 μm and below	0.15 μm	
Micrometerhead	Up to 50 mm	0.9 μm	Gage blocks

IV. Dimensional Testing/Calibration¹⁰

Parameter/Equipment	Range	CMC ² (±)	Comments
Length	Up to 500 mm	5.6 μm	Coordinate measuring machine
	Up to 200 mm	6.0 μm	Universal measuring machines
Angle	Up to 360°	3.7"	Coordinate measuring machine
	Up to 360°	12"	Universal measuring machines
R measurement	500 mm × 400 mm × 400 mm	5.5 μm	Coordinate measuring machine
	200 mm × 150 mm	5.7 μm	Universal measuring machines

V. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments	
AC/DC Difference –	1 mV	50 Hz	77 μV/V	Fluke 792A
		60 Hz	78 μV/V	
		400 Hz	78 μV/V	
		1 kHz	74 μV/V	
		5 kHz	91 μV/V	
		10 kHz	0.015 %	
		10 mV	50 Hz	
	60 Hz		77 μV/V	
	400 Hz		70 μV/V	
	1 kHz		70 μV/V	
	5 kHz		76 μV/V	
	10 kHz		0.015 %	
	0.1 V		10 Hz	
		50 Hz	48 μV/V	
		60 Hz	67 μV/V	
		400 Hz	67 μV/V	
		1 kHz	67 μV/V	
		5 kHz	68 μV/V	
		10 kHz	67 μV/V	
	0.2 V	30 kHz	0.053 %	
		50 kHz	0.053 %	
		100 kHz	0.055 %	
		200 kHz	0.074 %	
		500 kHz	0.087 %	
		1 MHz	0.087 %	
	0.3 V	10 Hz	0.024 %	
		50 Hz	47 μV/V	
		60 Hz	47 μV/V	
400 Hz		40 μV/V		
1 kHz		40 μV/V		
5 kHz		40 μV/V		
10 kHz		40 μV/V		
30 kHz		60 μV/V		
50 kHz		60 μV/V		
100 kHz		76 μV/V		
500 kHz		0.030 %		
1 MHz		0.030 %		

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments	
AC/DC Difference – (cont)				
1 V	10 Hz	0.023 %	Fluke 792A	
	50 Hz	45 µV/V		
	60 Hz	45 µV/V		
	400 Hz	33 µV/V		
	1 kHz	32 µV/V		
	5 kHz	32 µV/V		
	10 kHz	32 µV/V		
	30 kHz	54 µV/V		
	50 kHz	54 µV/V		
	100 kHz	65 µV/V		
	500 kHz	0.030 %		
	1 MHz	0.030 %		
	10 V	10 Hz		0.023 %
		50 Hz		44 µV/V
60 Hz		44 µV/V		
400 Hz		33 µV/V		
1 kHz		32 µV/V		
5 kHz		32 µV/V		
10 kHz		32 µV/V		
30 kHz		54 µV/V		
50 kHz		54 µV/V		
100 kHz		64 µV/V		
500 kHz		0.030 %		
1 MHz		0.030 %		
20 V		500 kHz	0.030 %	
		1 MHz	0.030 %	
30 V	500 kHz	0.030 %		
50 V	200 kHz	0.030 %		
100 V	10 Hz	0.023 %		
	50 Hz	46 µV/V		
	60 Hz	46 µV/V		
	400 Hz	38 µV/V		
	1 kHz	38 µV/V		
	5 kHz	38 µV/V		
	10 kHz	38 µV/V		
	30 kHz	81 µV/V		
	50 kHz	81 µV/V		
	100 kHz	86 µV/V		

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
AC/DC Difference – (cont)			
200 V	10 Hz 100 kHz	0.023 % 86 μV/V	Fluke 792A
700 V	50 kHz 100 kHz	84 μV/V 86 μV/V	
1000 V	50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz 30 kHz	48 μV/V 48 μV/V 47 μV/V 46 μV/V 46 μV/V 47 μV/V 76 μV/V	

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
DC Voltage – Generate ³	(0 to 1) mV	0.37 μV	Calibrator and decade voltage divider
	(1 to 10) mV (10 to 100) mV 100 mV to 1 V (1 to 10) V 10 V (10 to 100) V (100 to 1000) V	0.05 % 50 μV/V 5.9 μV/V 3.1 μV/V 2.4 μV/V 2.8 μV/V 3.7 μV/V	DC standard, reference divider and decade voltage divider
DC Voltage – Measure ³	(0 to 1) mV	0.38 μV	Calibrator and decade voltage divider
	(1 to 10) mV (10 to 100) mV 100 mV to 1 V (1 to 10) V 10 V (10 to 100) V (100 to 1000) V	0.038 % 40 μV/V 5.2 μV/V 2.9 μV/V 2.4 μV/V 2.6 μV/V 3.6 μV/V	Calibration of voltage generators using DC standard, reference divider, and decade voltage divider
DC High Voltage – Measure & Generate	(1 to 5) kV (5 to 50) kV	0.20 % 0.24 %	CRV-M system, Keithley 2002 and DC PSU

Parameter/Equipment	Range	CMC ^{2,6} (\pm)	Comments
DC High Voltage – Measure ³	(1 to 10) kV (10 to 30) kV	0.52 % 0.78 %	High voltage meter
DC Current – Generate ³	10 μ A to 100 mA 100 mA to 10 A (10 to 60) A (10 to 1000) A (1000 to 1500) A (1500 to 2500) A	20 μ A/A 30 μ A/A 0.015 % 0.27 % 0.27 % 0.49 %	DC standard, DMM, standard resistor Current generator and coil
DC Current – Measure ³	10 μ A to 100 mA 100 mA to 10 A (10 to 60) A (10 to 1000) A (1000 to 1500) A (1500 to 2000) A	20 μ A/A 30 μ A/A 0.015 % 0.27 % 0.27 % 0.49 %	Calibration of current generators using DC standard, DMM, standard resistor, and transconductance amplifier Current generator and coil
DC Power ³	(0 to 0.1) W (0.1 to 10) W 10 W to 60 kW (60 to 1000) kW (1000 to 1500) kW (1500 to 2500) kW	0.096 mW 0.087 % 0.027 % 0.19 % 0.27 % 0.47 %	DC voltage & current generators DC voltage current generators, trans- conductance amplifier and clamp meter

Parameter/Equipment	Range	CMC ^{2,6} (\pm)	Comments
DC Resistance – Generate ³			
Fixed Points	1 m Ω 10 m Ω 100 m Ω 1 Ω 10 Ω 100 Ω 1 k Ω 10 k Ω 100 k Ω 1 M Ω	35 $\mu\Omega/\Omega$ 9 $\mu\Omega/\Omega$ 9 $\mu\Omega/\Omega$ 3 $\mu\Omega/\Omega$ 3 $\mu\Omega/\Omega$ 3 $\mu\Omega/\Omega$ 3 $\mu\Omega/\Omega$ 3 $\mu\Omega/\Omega$ 3 $\mu\Omega/\Omega$ 3 $\mu\Omega/\Omega$ 26 $\mu\Omega/\Omega$	Standard fixed resistors
	(1 to 10) Ω (10 to 100) Ω (0.1 to 1) k Ω (1 to 10) k Ω (10 to 100) k Ω (0.1 to 1) M Ω	0.043 % 0.019 % 0.014 % 0.014 % 0.015 % 0.05 %	Decade resistors
	(1 to 10) M Ω (10 to 100) M Ω (0.1 to 1) G Ω (1 to 10) G Ω (10 to 100) G Ω 1 T Ω 10 T Ω	0.05 % 0.05 % 0.48 % 0.48 % 0.60 % 0.86 % 2.3 %	Standard resistors

Parameter/Equipment	Range	CMC ^{2, 6, 8} (\pm)	Comments
DC Resistance – Measure	(0.8 to 8) m Ω (8 to 80) m Ω (80 to 800) m Ω (0.8 to 6.3) Ω (6.3 to 107.5) Ω (0.1075 to 134) k Ω (0.134 to 1.075) M Ω (1.075 to 13.4) M Ω (13.4 to 107.5) M Ω	3.4 $\mu\Omega/\Omega$ 1.7 $\mu\Omega/\Omega$ 1.3 $\mu\Omega/\Omega$ 0.69 $\mu\Omega/\Omega$ 0.68 $\mu\Omega/\Omega$ 1.5 $\mu\Omega/\Omega$ 3.8 $\mu\Omega/\Omega$ 12 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$	Calibration of resistors using ratio comparison with standard resistors and comparator
Fixed Points	(0.1 to 1) G Ω (1 to 10) G Ω (10 to 100) G Ω (0.1 to 1) T Ω (1 to 10) T Ω 1 G Ω 10 G Ω 100 G Ω 1 T Ω 10 T Ω	0.87 % 0.93 % 0.96 % 1.2 % 2.5 % 0.60 % 0.63 % 0.63 % 0.9 % 1.4 %	Calibration of resistors using standard resistors and multimeter (high resistance meter)
Capacitance – Generate ³ , Fixed Points			
1 pF 10 pF 100 pF 1000 pF 0.01 μ F 0.1 μ F 1 μ F 10 μ F	1 kHz	48 μ F/F 46 μ F/F 42 μ F/F 43 μ F/F 53 μ F/F 43 μ F/F 46 μ F/F 0.012 %	Standard capacitors
1 pF 10 pF 100 pF 1000 pF	1 MHz	0.011 % 58 μ F/F 55 μ F/F 74 μ F/F	Standard capacitors

Parameter/Range	Frequency	CMC ^{2, 6, 8} (±)	Comments
Capacitance – Measure			
1 pF 10 pF 100 pF 1000 pF 0.01 μF 0.1 μF 1 μF 10 μF	1 kHz	49 μF/F 47 μF/F 43 μF/F 44 μF/F 54 μF/F 44 μF/F 50 μF/F 0.011 %	Standard capacitors and 2500A
1 pF 10 pF 100 pF 1000 pF	1 MHz	0.012 % 67 μF/F 65 μF/F 81 μF/F	Standard capacitors and 4294A
1 pF to 1 μF	1 kHz	0.021 %	Standard capacitors and 2500A
Inductance – Generate ³ , Fixed Points			
1 mH 10 mH 100 mH 1 H	1 kHz	0.024 % 0.012 % 0.011 % 0.012 %	Standard inductors

Parameter/Range	Frequency	CMC ^{2, 6, 8} (±)	Comments
Inductance – Measure, Fixed Points 1 mH 10 mH 100 mH 1 H	1 kHz	0.024 % 0.012 % 0.011 % 0.012 %	Standard inductors and 4294A
AC Resistance – Generate ³ 10 mΩ 50 mΩ 100 mΩ, 1 Ω 10 Ω to 10 kΩ 100 kΩ 100 mΩ to 10 Ω 10 Ω to 10 kΩ	50 Hz to 1 kHz 50 Hz, 60 Hz 50 Hz to 1 kHz 50 Hz to 1 kHz 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz	0.21 % 1.6 % 0.09 % 0.020 % 0.020 % 0.091 % 0.055 %	Standard resistors Calibrator (5720A) and measuring instruments (4294A, 8508A)
AC Resistance – Measure 10 mΩ 100 mΩ 1 Ω 10 Ω to 10 kΩ 100 kΩ 100 mΩ to 10 Ω 10 Ω to 10 kΩ	50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz 1 kHz 50 Hz to 1 kHz 50 Hz to 1 kHz	0.091 % 0.061 % 0.057 % 0.020 % 0.020 % 0.084 % 0.052 %	Standard resistors Calibrator (5720A) and measuring instruments (4294A, 8508A)

Parameter/Range	Frequency	CMC ^{2, 6, 8} (\pm)	Comments	
AC Voltage – Measure ³				
(1 to 100) mV (0.1 to 1000) V	50 Hz	80 μ V/V 50 μ V/V	Calibration of voltage generators using AC/DC transfer standard, thermal converter, calibrator, and standard decade transformer	
(1 to 100) mV (0.1 to 0.3) V (0.3 to 1000) V	60 Hz	80 μ V/V 70 μ V/V 50 μ V/V		
(1 to 10) mV (10 to 300) mV (0.3 to 100) V (100 to 1000) V	400 Hz, 1 kHz	80 μ V/V 70 μ V/V 40 μ V/V 50 μ V/V		
(0.1 to 0.3) V (0.3 to 200) V	(10 to 50) Hz	0.026 % 0.024 %		
(1 to 100) mV (0.1 to 0.3) V (0.3 to 1000) V	50 Hz to 10 kHz (Except 50, 60 Hz, 400 Hz, 1 kHz)	0.015 % 70 μ V/V 50 μ V/V		
(0.2 to 0.3) V (0.3 to 1) V (1 to 1000) V	(10 to 30) kHz	0.06 % 60 μ V/V 85 μ V/V		Calibration of voltage generators using AC/DC transfer standard, thermal converter, calibrator, and standard decade transformer
(0.2 to 0.3) V (0.3 to 1) V (1 to 700) V	(30 to 50) kHz	0.06 % 60 μ V/V 85 μ V/V		
(0.2 to 0.3) V (0.3 to 1) V (1 to 600) V	(50 to 100) kHz	0.06 % 80 μ V/V 90 μ V/V		
(0.2 to 0.3) V (0.3 to 50) V	(100 to 200) kHz	0.08 % 0.03 %		
(0.2 to 0.3) V (0.3 to 30) V	(200 to 500) kHz	0.08 % 0.03 %		
(0.2 to 0.3) V (0.3 to 20) V	500 kHz to 1 MHz	0.09 % 0.03 %		

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
AC High Voltage – Measure & Generate (1 to 30) kV	(50 and 60) Hz	0.42 %	CRV-M system DMM & AC PSU
AC High Voltage – Measure ³ (1 to 20) kV	(50 and 60) Hz	0.95 %	High voltage meter
AC Voltage – Generate ³ (1 to 10) mV 10 mV to 1000 V 1 mV to 1000 V (1 to 10) mV 10 mV to 100 V (100 to 1000) V (0.1 to 0.3) V (0.3 to 200) V (1 to 300) mV (0.3 to 1000) V (0.2 to 0.3) V (0.3 to 1) V (1 to 1000) V (0.2 to 0.3) V (0.3 to 1) V (1 to 700) V (0.2 to 0.3) V (0.3 to 1) V (1 to 600) V (0.2 to 0.3) V (0.3 to 50) V (0.2 to 0.3) V (0.3 to 30) V (0.2 to 0.3) V (0.3 to 20) V	50 Hz 60 Hz 400 Hz, 1 kHz (10 to 50) Hz 50 Hz to 10 kHz (Except 50, 60 Hz, 400 Hz, 1 kHz) (10 to 30) kHz (30 to 50) kHz (50 to 100) kHz (100 to 200) kHz (200 to 500) kHz 500 kHz to 1 MHz	70 µV/V 50 µV/V 50 µV/V 50 µV/V 40 µV/V 50 µV/V 0.026 % 0.024 % 0.015 % 50 µV/V 0.06 % 60 µV/V 85 µV/V 0.06 % 60 µV/V 85 µV/V 0.06 % 80 µV/V 90 µV/V 0.08 % 0.03 % 0.08 % 0.03 % 0.09 % 0.03 %	AC/DC transfer standard, thermal converter, calibrator, and standard decade transformer

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
AC Voltage – Generate ³			
(1 to 10) mV 10 mV to 1000 V	50 Hz	70 μV/V 50 μV/V	AC/DC transfer standard, thermal converter, calibrator, and standard decade transformer
1 mV to 1000 V	60 Hz	50 μV/V	
(1 to 10) mV 10 mV to 100 V (100 to 1000) V	400 Hz, 1 kHz	50 μV/V 40 μV/V 50 μV/V	
(0.1 to 0.3) V (0.3 to 200) V	(10 to 50) Hz	0.026 % 0.024 %	
(1 to 300) mV (0.3 to 1000) V	50 Hz to 10 kHz (Except 50, 60 Hz, 400 Hz, 1 kHz)	0.015 % 50 μV/V	
(0.2 to 0.3) V (0.3 to 1) V (1 to 1000) V	(10 to 30) kHz	0.06 % 60 μV/V 85 μV/V	
(0.2 to 0.3) V (0.3 to 1) V (1 to 700) V	(30 to 50) kHz	0.06 % 60 μV/V 85 μV/V	
(0.2 to 0.3) V (0.3 to 1) V (1 to 600) V	(50 to 100) kHz	0.06 % 80 μV/V 90 μV/V	
(0.2 to 0.3) V (0.3 to 50) V	(100 to 200) kHz	0.08 % 0.03 %	
(0.2 to 0.3) V (0.3 to 30) V	(200 to 500) kHz	0.08 % 0.03 %	
(0.2 to 0.3) V (0.3 to 20) V	500 kHz to 1 MHz	0.09 % 0.03 %	

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
AC Power ³ –			
4 W to 6 kW 1 PF	(50 and 60) Hz Single Phase	0.035 %	Power converter, digital multimeter
≤ 1000 V, ≤ 20 A (10 mW to 20 kW) (173.21mW to 34.641 kW)	400 Hz Single Phase Three Phase – Three Wire	0.20 % 0.40 %	Phase angle shifter, AC voltage current generators, phase meter
≤ 1000 V, ≤ 50 A (10 mW to 50 kW) (173.21mW to 86.603 kW)	(50 and 60) Hz Single Phase Three Phase – Three Wire	0.15 % 0.32 %	
≤ 1000 V, ≤ 1000 A (≤1 MW)	(50 and 60) Hz Single Phase	0.38 %	Phase angle shifter, AC voltage current generators, Current coil, phase meter
≤ 1000 V, ≤ 3000 A (≤3 MW)		0.43 %	
1 PF			
≤ 1000 V, ≤ 20 A (≤ 20 kW) (≤ 34.641 kW)	400 Hz Single Phase Three Phase – Three Wire	2.0 mW / (V·A) 4.0 mW / (V·A)	Phase angle shifter, AC voltage current generators, phase meter
≤ 1000 V, ≤ 50 A (≤ 50 kW) (≤ 86.603 kW)	(50 and 60) Hz Single Phase Three Phase – Three Wire	1.5 mW / (V·A) 3.2 mW / (V·A)	
≤ 1000 V, ≤ 1000 A (≤1 MW)	(50 and 60) Hz Single Phase	3.8 mW / (V·A)	Phase angle shifter, AC voltage current generators, Current coil, phase meter
≤ 1000 V, ≤ 3000 A (≤3 MW) PF 0(lag)~ 1~ 0(lead)		4.3 mW / (V·A)	

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
Energy – ≤ 1000 V, ≤ 30 A 0 W·h to 16.7 mW·h 16.7 mW·h to 5 kW·h ≤ 1000 V, ≤ 2500 A (5 to 417) kW·h	DC	0.067 mW·h 0.22 %	Phase angle shifter, Voltage current generators, Current coil, phase meter, stopwatch
≤ 1000 V, ≤ 20 A 1.7 mW·h to 20 kW·h 28.868 μW·h to 34.641 kW·h	400 Hz Single Phase Three Phase – Three Wire	0.28 % 0.4 %	
≤ 1000 V, ≤ 50 A (0.17 to 0.34) mW·h (0.34 to 0.84) mW·h (0.84 to 1.7) mW·h 1.7 mW·h 50 kW·h 28.868 μW·h to 86.603 kW·h	(50 and 60) Hz Single Phase Three Phase – Three Wire	2.0 % 0.98 % 0.42 % 0.25 % 0.4 %	
≤ 1000 V, ≤ 3000 A 50 kW·h to 3 MW·h 1 PF	(50 and 60) Hz Single Phase	0.47 %	
≤ 1000 V, ≤ 20 A ≤ 20 kW·h ≤ 34.641 kW·h	400 Hz Single Phase Three Phase – Three Wire	2.8 mW·h/V·A·h 4 mW·h/V·A·h	
≤ 1000 V, ≤ 50 A ≤ 0.34 mW·h ≤ 0.84 mW·h ≤ 1.7 mW·h ≤ 50 kW·h ≤ 86.603 kW·h	(50 and 60) Hz Single Phase Three Phase – Three Wire	20 mW·h/V·A·h 9.8 mW·h/V·A·h 4.2 mW·h/V·A·h 2.5 mW·h/V·A·h 4 mW·h/V·A·h	
≤ 1000 V, ≤ 3000 A ≤ 3 MW·h PF 0(lag)~ 1~ 0(lead)	(50 and 60) Hz Single Phase	4.7 mW·h/V·A·h	
Distortion ³ – (0.1 to 30) %	10 Hz to 60 kHz	1.8 %	

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments	
AC Current – Generate ³				
100 µA to 10 A (10 to 20) A	50 Hz to 1 kHz 50 Hz to 1 kHz	0.01 % 0.015 %	AC/DC transfer standard, current shunt, calibrator, standard resistor	
(20 to 50) A (50 to 60) A	50 Hz, 60 Hz 50 Hz, 60 Hz	0.05 % 0.2 %		
(10 to 50) A (50 to 1000) A (1000 to 3000) A	(50 to 60) Hz	0.22 % 0.25 % 0.31 %		Calibrator, amplifier, coils
AC Current – Measure ³				
100 µA to 10 A (10 to 20) A	50 Hz to 1 kHz 50 Hz to 1 kHz	0.01 % 0.015 %	Calibration of current generators using AC/DC transfer standard, current shunt, calibrator, standard resistor, current transformer	
(20 to 50) A (50 to 60) A	50 Hz, 60 Hz 50 Hz, 60 Hz	0.05 % 0.2 %		
(10 to 50) A (50 to 1000) A (1000 to 2000) A	(50 to 60) Hz	0.22 % 0.25 % 0.31 %		Calibrator, amplifier, coils

Parameter/Range	Frequency	CMC ^{2, 6} (±)	Comments
High Frequency – Voltage			
1 μV to 0.3 V	100 kHz to 10 MHz (10 to 500) MHz 500 MHz to 1 GHz	0.39 % 0.85 % 1.2 %	Thermistor mount and measuring receiver
(1 to 3) V	500 MHz to 1 GHz (50 to 100) MHz	1.2 % 1.2 %	
(0.3 to 50) V	10 Hz to 100 kHz	0.0054 %	
(0.3 to 20) V	100 kHz to 1 MHz	0.0092 %	
(0.3 to 2) V	(1 to 5) MHz (5 to 10) MHz (10 to 30) MHz (30 to 50) MHz	0.038 % 0.12 % 0.21 % 0.32 %	Calibrator and thermal converter
(2 to 3) V	(1 to 5) MHz (5 to 10) MHz (10 to 30) MHz (30 to 50) MHz	0.13 % 0.19 % 0.35 % 0.71 %	
(3 to 5) V	(1 to 5) MHz (5 to 10) MHz (10 to 30) MHz (30 to 50) MHz	0.19 % 0.24 % 0.47 % 1.0 %	
(0.3 to 1) V	(50 to 500) MHz 500 MHz to 1 GHz	0.75 % 1.1 %	
High Frequency – Voltage ³			
1 μV to 3 V	100 kHz to 1 GHz	2.8 %	Measuring receiver
(0.3 to 2.5) V	100 kHz to 1 MHz (1 to 10) MHz (10 to 30) MHz (30 to 50) MHz	0.47 % 0.33 % 0.56 % 1.5 %	Electronic voltmeter
(0.3 to 0.5) V	(50 to 500) MHz 500 MHz to 1 GHz	1.6 % 2.4 %	

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
Oscilloscope Calibration – Generate ³			
DC Voltage – 50 Ω / 1 MΩ	± (1 to 10) mV ± 10 mV to 1 kV	0.88 % 0.5 %	Fluke 5500, Fluke 9500
AC Voltage – 50 Ω / 1 MΩ			
50 Hz to 10 kHz	± (1 to 14) mV	1.6 %	Fluke 5500, Fluke 9500, Datron 1281
50 Hz to 10 kHz	± (14 to 140) mV	0.81 %	
10 Hz to 10 kHz	± 140 mV to 5 V	0.81 %	
10 kHz to 1 MHz	± 280 mV to 5 V	0.99 %	
AC Voltage – 1 MΩ			
10 Hz to 100 kHz	± (5 to 42) V	0.81 %	Fluke 5500, Fluke 9500, Datron 1281
100 kHz to 1 MHz	± (5 to 28) V	0.99 %	
50 Hz to 10 kHz	± (28 to 710) V	0.81 %	
Time Markers	0.45 ns to 10 s	0.3 μs/s	Fluke9500, SMA100
Sinewave Flatness	1 kHz to 100 kHz 100 kHz to 1 MHz (1 to 200) MHz 200 MHz to 1 GHz (1 to 12) GHz (12 to 18) GHz (18 to 40) GHz	0.81 % 0.99 % 2.9 % 2.7 % 0.4 dB 0.6 dB 0.8 dB	Fluke 9500, measuring receiver, power meter and sensor
Phase –			
(0 to 360)°	20 Hz to 1 kHz (1 to 10) kHz (10 to 40) kHz	0.038° 0.052° 0.063°	Phase meter
Power Factor	(50 to 65) Hz	cos (A) – cos (A+0.19)	Calibrator (A is the angle in degrees)

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple Temperature Indicators ³ –			
Type K	(-200 to -150) °C (-150 to 1100) °C (1100 to 1372) °C	0.8 °C 0.7 °C 0.8 °C	HANDY CAL
Type T	(-200 to -150) °C (-150 to 400) °C	0.8 °C 0.7 °C	
Type J	(-200 to -150) °C (-150 to 1200) °C	0.8 °C 0.7 °C	
Type E	(-200 to -150) °C (-150 to 1000) °C	0.8 °C 0.7 °C	



VI. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
High Frequency – Power			
1 mW	(9 to 100) kHz	2.2 %	Thermal converter
	100 kHz to 10 MHz	2.2 %	Power meter, power sensor, thermistor mount attenuator and signal generator calibrator, level, and calibrator
	10 MHz to 6 GHz	0.7 %	
	(6 to 12) GHz	1.2 %	
	(12 to 18) GHz	1.9 %	
	(18 to 25) GHz	2.4 %	
	(25 to 40) GHz	5.6 %	
1 μW	10 MHz to 6 GHz	0.8 %	
	(6 to 12) GHz	1.2 %	
	(12 to 18) GHz	2.0 %	
10 pW to 10 nW	10 MHz to 12 GHz	1.8 %	
10 nW to 100 mW	100 kHz to 10 MHz	3.3 %	
	10 MHz to 6 GHz	1.6 %	
10 nW to 50 mW	(6 to 12) GHz	1.6 %	
100 mW to 200 W	(1 to 10) MHz	3.7 %	
	(10 to 200) MHz	2.0 %	
100 mW to 160 W	200 MHz to 1 GHz	2.0 %	
100 mW to 30 W	(1 to 2) GHz	2.0 %	
1 mW	100 kHz to 18 GHz	3.7 %	Power meter, power sensor, measuring receiver
	(18 to 40) GHz	6.2 %	
10 pW to 100 mW	10 MHz to 12 GHz	3.4 %	
10 nW to 100 mW	100 kHz to 10 MHz	4.4 %	

Parameter/Range	Frequency	CMC ² (±)	Comments
Reflection Coefficient –			
PC7: Magnitude 0 to 0.05	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz	0.002 (Non-UNITS) 0.002 (Non-UNITS) 0.003 (Non-UNITS) 0.004 (Non-UNITS)	Vector network analyzer, impedance analyzer, VNA: 37269D, ZVRE and E5061B impedance analyzer: 4191A and 4192A with calibration / verification kits
Magnitude 0.05 to 0.3	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz	0.002 (Non-UNITS) 0.003 (Non-UNITS) 0.004 (Non-UNITS) 0.005 (Non-UNITS)	
PC3.5: Magnitude 0 to 0.05	100 MHz to 1 GHz (1 to 18) GHz (18 to 26.5) GHz	0.004 (Non-UNITS) 0.006 (Non-UNITS) 0.008 (Non-UNITS)	
Magnitude 0.05 to 0.3	100 MHz to 1 GHz (1 to 18) GHz (18 to 26.5) GHz	0.006 (Non-UNITS) 0.007 (Non-UNITS) 0.010 (Non-UNITS)	
K: Magnitude 0 to 0.05	100 MHz to 1 GHz (1 to 20) GHz (20 to 40) GHz	0.010 (Non-UNITS) 0.014 (Non-UNITS) 0.012 (Non-UNITS)	
Magnitude 0.05 to 0.3	100 MHz to 1 GHz (1 to 20) GHz (20 to 40) GHz	0.011 (Non-UNITS) 0.014 (Non-UNITS) 0.014 (Non-UNITS)	
N50: Magnitude 0 to 0.05	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz	0.003 (Non-UNITS) 0.004 (Non-UNITS) 0.005 (Non-UNITS) 0.007 (Non-UNITS)	
Magnitude 0.05 to 0.3	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz	0.005 (Non-UNITS) 0.007 (Non-UNITS) 0.010 (Non-UNITS) 0.011 (Non-UNITS)	
Magnitude 0.3 to 1	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz	0.008 (Non-UNITS) 0.010 (Non-UNITS) 0.014 (Non-UNITS) 0.020 (Non-UNITS)	
N75: Magnitude 0 to 0.05	9 kHz to 40 MHz 40 MHz to 2 GHz (2 to 3) GHz	0.009 (Non-UNITS) 0.006 (Non-UNITS) 0.011 (Non-UNITS)	

Parameter/Range	Frequency	CMC ^{2, 6, 9} (\pm)	Comments
Reflection Coefficient – (cont) N75: Magnitude 0.05 to 0.3 Magnitude 0.3 to 1 Phase	 9 kHz to 40 MHz 40 MHz to 2 GHz (2 to 3) GHz 9 kHz to 40 MHz 40 MHz to 2 GHz (2 to 3) GHz	 0.009 (Non-UNITS) 0.011 (Non-UNITS) 0.014 (Non-UNITS) 0.013 (Non-UNITS) 0.015 (Non-UNITS) 0.015 (Non-UNITS) $\text{Arcsin}(U_{(\text{magnitude})}/ T)$ ($^{\circ}$)	 Vector network analyzer, impedance analyzer, VNA: 37269D, ZVRE and E5061B impedance analyzer: 4191A and 4192A with calibration / verification kits
Electromagnetic Wave Attenuation – (0 to 60) dB (60 to 100) dB (0 to 60) dB (60 to 100) dB (0 to 40) dB (0 to 40) dB (40 to 80) dB (0 to 40) dB (40 to 60) dB (60 to 80) dB (0 to 40) dB (40 to 60) dB (0 to 30) dB	 50 Hz to 1 kHz 1 kHz to 10 MHz 30 MHz 10 MHz to 2 GHz (2 to 12) GHz (12 to 18) GHz (18 to 40) GHz	 0.007 dB 0.010 dB 0.020 dB 0.027 dB 0.007 dB 0.008 dB 0.013 dB 0.009 dB 0.015 dB 0.032 dB 0.016 dB 0.028 dB 0.066 dB	 Standard decade transformer Attenuator Measuring receiver, attenuator, attenuator and signal generator calibrator, selective level meter, impedance analyzer, frequency response analyzer, vector network analyzer
Magnetic Flux Density 1 μ T, 10 μ T, 100 μ T	50 Hz, 60 Hz	0.67 %	Magnetic field measuring instrument

VII. Optical Quantities

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Relative Spectral Responsivity	(≥ 400 to 430) nm (≥ 430 to 450) nm (≥ 450 to 510) nm (≥ 510 to 550) nm (≥ 550 to 600) nm (≥ 600 to 845) nm (> 845 to 945) nm (> 945 to 975) nm (> 975 to 1005) nm (> 1005 to 1030) nm (> 1030 to 1045) nm (> 1045 to 1055) nm (> 1055 to 1075) nm (> 1075 to 1090) nm (> 1090 to 1105) nm (> 1105 to 1115) nm (> 1115 to 1130) nm (> 1130 to 1140) nm (> 1140 to 1145) nm (> 1145 to 1150) nm	3.2 % 2.6 % 2.4 % 2.2 % 2.1 % 2.0 % 2.1 % 2.3 % 2.9 % 4.3 % 5.9 % 7.2 % 8.3 % 8.1 % 9.1 % 9.9 % 12 % 13 % 14 % 15 %	Relative spectral responsivity standard detector
Optical Attenuation – (10 to 30) dB, (10 dB step) (40 to 60) dB, (10 dB step) (1 to 59) dB, (1 dB step) (10 to 40) dB, (10 dB step) 50 dB 60 dB (1 to 19) dB, (1 dB step) (21 to 59) dB, (1 dB step) (10 to 50) dB, (10 dB step) 60 dB (1 to 59) dB, (1 dB step) (10 to 20) dB, (10 dB step) (30 to 40) dB, (10 dB step) 50 dB 60 dB (1 to 49) dB, (1 dB step) (51 to 59) dB, (1 dB step)	1550 nm 1310 nm (1520 to 1630) nm (1280 to 1340) nm	0.009 dB 0.010 dB 0.025 dB 0.010 dB 0.011 dB 0.012 dB 0.025 dB 0.026 dB 0.011 dB 0.012 dB 0.026 dB 0.010 dB 0.011 dB 0.012 dB 0.013 dB 0.026 dB 0.027 dB	Optical power meter

VIII. Mechanical

Parameter/Equipment	Range	CMC ^{2,7} (±)	Comments
Push Pull Gages ³	10 mN to 5 kN	0.10 % of measurement load	Calibration method per JIS B 7721, load Cells and dead weight
Force Gages ³	10 mN to 5 kN	0.10 % of measurement load	Calibration method per JIS B 7721, load cells and dead weight
Tension Gages ³	10 mN to 5 kN	0.2 % FS	Calibration method per JIS B 7721, load Cells and dead weight
Load Cell ³	10 mN to 5 kN	0.03 % of measurement load	Calibration method per JIS B 7728 (ISO 376) or JIS B 7602, load cells and dead weight
Uniaxial Testing Machines ³ –			
Tension Force	0.01 N to 100 kN	0.1 % of measurement load	Calibration method per JIS B 7721 (ISO 7500-1) force-proving instruments (load cells) and dead weights
Compression Force	0.01 N to 100 kN	0.1 % of measurement load	
	100 kN to 5 MN	0.2 % of measurement load	
Tension Force	0.01 N to 100 kN	0.3% of measurement load	Calibration method per ASTM E4 force-proving instruments (load cells) and dead weights
Compression Force	0.01 N to 2 MN	0.4 % of measurement load	

Parameter/Equipment	Range	CMC ² (±)	Comments
Direct Calibration of Rockwell Hardness Testers ³ –			Direct Calibration method per JIS B 7726 (ISO 6508-2) note: this is only a partial direct calibration
Calibration of the Test Forces	98.07 N (588.4 to 1471) N	0.16 N 0.65 N	Calibration of test force is by load cell, loop dynamometer per the method of JIS B 7721
	29.42 N (147.1 to 294.2) N	0.27 N 0.45 N	
Calibration of the Depth-Measuring Device	(0 to 250) μm	0.35 μm	Index master
Direct Calibration of Rockwell Hardness Testers ³ –			Direct calibration method per ASTM E18; Note: this is only a partial direct calibration
Calibration of the Test Forces A, B and C Scales	98.07 N (588.4 to 1471) N	0.20 N 0.80 N	Calibration of test force is by load cell, loop dynamometer per the method of ASTM E4
N15, N30, T15 and T30	29.42 N (147.1 to 294.2) N	0.10 N 0.20 N	
Calibration of the Depth-Measuring Device	(0 to 250) μm	0.25 μm	Index master
Indirect Calibration of Rockwell Hardness Testers ³	HRA Low Medium High HRB Low Medium High HRC Low Medium High	0.75 HRA 0.20 HRA 0.20 HRA 0.60 HRB 0.40 HRB 0.30 HRB 0.50 HRC 0.45 HRC 0.45 HRC	Indirect calibration method per JIS B 7726 (ISO 6508-2)

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Calibration of Rockwell Hardness Testers ³ (cont)	HRA Low Medium High HRB Low Medium High HRC Low Medium High	0.20 HRA 0.25 HRA 0.20 HRA 0.50 HRB 0.35 HRB 0.35 HRB 0.25 HRC 0.20 HRC 0.20 HRC	Indirect calibration method per ASTM E18
Indirect Calibration of Superficial Hardness Testers	HR15N Low Medium High HR30N Low Medium High HR15T Low Medium High HR30T Low Medium High	0.30 HR15N 0.45 HR15N 0.40 HR15N 0.40 HR30N 0.35 HR30N 0.40 HR30N 0.30 HR15T 0.35 HR15T 0.35 HR15T 0.40 HR30T 0.50 HR30T 0.40 HR30T	Indirect calibration method per JIS B 7726 (ISO 6508-2)

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Calibration of Superficial Hardness Testers	HR15N Low Medium High HR30N Low Medium High HR15T Low Medium High HR30T Low Medium High	0.15 HR15N 0.15 HR15N 0.15 HR15N 0.25 HR30N 0.25 HR30N 0.25 HR30N 0.25 HR15T 0.30 HR15T 0.15 HR15T 0.30 HR30T 0.25 HR30T 0.20 HR30T	Indirect calibration method per ASTM E18
Direct Calibration Vickers Hardness Testers ³ –			Direct calibration method per JIS B 7725 (ISO 6507-2). note: this is only a partial direct calibration
Calibrations of the Test Forces	(9.807 to 490.3) N	0.10 N	Calibration of test force is by load cells, loop dynamometer per the method of JIS B 7721
Calibration of the Device for Measuring Indentation Diagonals	(0 to 1) mm	1.2 μm	Stage micrometer
Direct Calibration Vickers Hardness Testers ³ –			Direct Calibration method per ASTM E92
Calibrations of the Test Forces	(9.807 to 490.3) N	0.10 N	Calibration of test force is by load cell per the method of ASTM E4
Calibration of the Device for Measuring Indentation Diagonals	(0 to 1) mm	1.2 μm	Stage micrometer

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Calibration of Vickers Hardness Testers	(100 to 800) HV	1.2 HV	Indirect calibration method per JIS B 7725 (ISO 6507-2)
Indirect Calibration of Vickers Hardness Testers	(100 to 800) HV (9.807 to 490.3) N	2.0 HV	Indirect calibration method per ASTM E92
Direct Calibration Vickers and Knoop Hardness Testers ³ –			Direct calibration method per JIS B 7725 (ISO 6507-2) or ISO 4545. Note: This is only a partial direct calibration
Calibrations of the Test Forces	(0.9807 to 9.807) N	0.50 mN	Calibration of test force is by load cell and weighing scales with electro-magnetic force compensation per the method of JIS B 7721
Calibration of the Device for Measuring Indentation Diagonals	(0 to 1) mm	1.1 µm	Stage micrometer
Direct Calibration Vickers and Knoop Hardness Testers ³ –			Direct calibration method per ASTM E92 or E384
Calibrations of the Test Forces	(0.09807 to 9.807) N	0.50 mN	Calibration of test force is by weighing scales with electro-magnetic force compensation per the method of ASTM E4
Calibration of the Device for Measuring Indentation Diagonals	(0 to 1) mm	1.1 µm	Stage micrometer
Indirect Calibration of Hardness Testers (Knoop and Vickers)	(100 to 800) HK (100 to 800) HV	3.9 HK 1.3 HV	Indirect calibration method per JIS B 7725 (ISO 6507-2) or ISO 4545

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Calibration of Knoop and Vickers Hardness Testers	(100 to 800) HK (100 to 800) HV (1.961 to 9.807) N	4.0 HK 2.0 HV	Indirect calibration method per ASTM E92 or E384
Direct Calibration Brinell Hardness Testers ³ – Calibrations of the Test Forces Calibration of the Device for Measuring Indentation Diagonals	(4.903 to 29.42) kN (0 to 8) mm	8.0 N 3.0 μm	Direct calibration method per JIS B 7724 (ISO 6506-2) Calibration of test force is by load cells and loop dynamometer per the method of JIS B 7721 Stage micrometer
Direct Calibration Brinell Hardness Testers ³ –	(4.903 to 29.42) kN (0 to 8) mm	8.0 N 3.0 μm	Direct calibration method per ASTM E10 Calibration of test force is by load cells and loop dynamometer per the method of ASTM E4 Stage micrometer
Indirect Calibration of Brinell Hardness Testers	≤ 250 HBW (250 to 450) HBW ≤ 225 HBW (300 to 400) HBW	2.0 HBW 2.1 HBW 2.0 HBW 3.0 HBW	Indirect calibration method per JIS B 7724 (ISO 6506-2) Indirect calibration method per ASTM E10 or E110
Indirect Calibration of Shore Hardness Testers ³	(30 to 95) HS	0.8 HS	Indirect calibration method per JIS B 7727

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Durometers, ASTM D2240: A, D, C, D, DO, E, M, O, OO, OOO, OOO-S, R JIS K 7215(ISO 868): A, D JIS K 6253 (ISO 18898): A, D, E, AM JIS K 7312: A, C, D			
Distance Between Two Points	≤ 3 mm	6 μm	Measuring microscope
Angle	≤ 40°	0.10°	
Coordinates of Center of Circle	≤ 6 mm	6 μm	
Spring Force	≤ 50 N	0.02 N	Weighing scales with electro-magnetic force compensation
Indenter Display	≤ 100 H	0.02 H	Gage blocks
Operating Stand of Durometer –			
Mass Value	≤ 5 kg	0.02 g	Weighing scales with electro-magnetic force compensation
Test Force	≤ 50 N	0.20 %	Load cell

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments	
Uniaxial Testing Machines ³ –	Speed	(0.5 to 1000) mm/min	0.4 %	
			0.4 %	
	Distance	(0 to 600) mm	0.4 %	Displacement and speed measurement unit
			0.4 %	Height gauge and stop watch
Weights, Conventional Mass Value ³	50 kg	0.30 g	Direct comparison or subdivision/multiple method using precision balances and scales with standard weights	
	< 50 kg	4.0 µg/g		
	20 kg	6.0 mg		
	< 20 kg	4.0 µg/g		
	10 kg	2.1 mg		
	< 10 kg	4.0 µg/g		
	5 kg	1.1 mg		
	< 5 kg	4.0 µg/g		
	3 kg	1.5 mg		
	< 3 kg	4.0 µg/g		
	2 kg	0.42 mg		
	< 2 kg	4.0 µg/g		
	1 kg	0.16 mg		
	< 1 kg	4.0 µg/g		
	500 g	0.085 mg		
	< 500 g	4.0 µg/g		
	300 g	0.15 mg		
	< 300 g	4.0 µg/g		
	200 g	0.035 mg		
	< 200 g	4.0 µg/g		
100 g	0.019 mg			

Parameter/Equipment	Range	CMC ² (±)	Comments
Weights, Conventional Mass Value	< 100 g	4.0 µg/g	Direct comparison or subdivision/multiple method using precision balances and scales with standard weights
	50 g	0.010 mg	
	< 50 g	5.0 µg/g	
	30 g	0.026 mg	
	< 30 g	8.0 µg/g	
	20 g	0.0080 mg	
	< 20 g	9.0 µg/g	
	10 g	0.0060 mg	
	< 10 g	15 µg/g	
	5 g	0.0050 mg	
	< 5 g	32 µg/g	
	3 g	0.013 mg	
	< 3 g	25 µg/g	
	2 g	0.0040 mg	
	< 2 g	40 µg/g	
	1 g	0.0030 mg	
	< 1 g	50 µg/g	
	500 mg	0.0025 mg	
	< 500 mg	80 µg/g	
	200 mg	0.0020 mg	
	< 200 mg	0.16 mg/g	
	100 mg	0.0015 mg	
	< 100 mg	0.25 mg/g	
	50 mg	0.0012 mg	
	< 50 mg	0.45 mg/g	
	20 mg	0.0010 mg	
	< 20 mg	0.90 mg/g	
	10 mg	0.00080 mg	
	< 10 mg	1.6 mg/g	
	5 mg	0.00060 mg	
< 5 mg	3.2 mg/g		
2 mg	0.00060 mg		
< 2 mg	6.0 mg/g		
1 mg	0.00060 mg		
(0.05 < 1) mg	0.00040 mg		

Parameter/Equipment	Range	CMC ² (±)	Comments
Weights, True Mass Value	50 kg	12 µg/g	Direct comparison or subdivision/multiple method using precision balances and scales with standard weights
	< 50 kg	11 µg/g	
	20 kg	11 µg/g	
	< 20 kg	11 µg/g	
	10 kg	4.0 µg/g	
	< 10 kg	4.0 µg/g	
	5 kg	4.0 µg/g	
	< 5 kg	4.0 µg/g	
	3 kg	4.0 µg/g	
	< 3 kg	4.0 µg/g	
	2 kg	4.0 µg/g	
	< 2 kg	4.0 µg/g	
	1 kg	4.0 µg/g	
	< 1 kg	4.0 µg/g	
	500 g	4.0 µg/g	
	< 500 g	4.0 µg/g	
	300 g	4.0 µg/g	
	< 300 g	4.0 µg/g	
	200 g	4.0 µg/g	
	< 200 g	4.0 µg/g	
	100 g	4.0 µg/g	
	< 100 g	4.0 µg/g	
	50 g	4.1 µg/g	
	< 50 g	4.7 µg/g	
	30 g	5.4 µg/g	
	< 30 g	9.0 µg/g	
	20 g	8.7 µg/g	
	< 20 g	10 µg/g	
	10 g	15 µg/g	
	< 10 g	17 µg/g	
	5 g	25 µg/g	
	< 5 g	35 µg/g	
	3 g	56 µg/g	
	< 3 g	28 µg/g	
	2 g	60 µg/g	
	< 2 g	60 µg/g	
	1 g	81 µg/g	
	< 1 g	90 µg/g	
	500 mg	0.15 mg/g	
	< 500 mg	0.15 mg/g	
200 mg	0.17 mg/g		
< 200 mg	0.20 mg/g		
100 mg	0.22 mg/g		
< 100 mg	0.30 mg/g		
50 mg	0.30 mg/g		
< 50 mg	0.45 mg/g		
20 mg	0.70 mg/g		
< 20 mg	0.90 mg/g		
10 mg	1.1 mg/g		
< 10 mg	1.6 mg/g		
5 mg	1.8 mg/g		
< 5 mg	3.2 mg/g		
2 mg	4.3 mg/g		
< 2 mg	6.0 mg/g		
1 mg	9.0 mg/g		



Parameter/Equipment	Range	CMC ² (±)	Comments
Scales & Balances ³ , Electronic Type	1 mg	3.6 mg/g	Calibrations performed using reference weights CMCs for the field calibrations assume that the environmental conditions are maintained as in the primary laboratory
	2 mg	1.8 mg/g	
	(2 to 5) mg	2.4 mg/g	
	5 mg	0.71 mg/g	
	(5 to 10) mg	1.4 mg/g	
	10 mg	0.47 mg/g	
	(10 to 20) mg	0.30 mg/g	
	(20 to 50) mg	0.36 mg/g	
	50 mg	0.15 mg/g	
	(50 to 100) mg	0.22 mg/g	
	100 mg	94 µg/g	
	(100 to 200) mg	59 µg/g	
	(200 to 500) mg	71 µg/g	
	500 mg	30 µg/g	
	(500 to 1000) mg	45 µg/g	
	1 g	18 µg/g	
	(1 to 2) g	12 µg/g	
	(2 to 5) g	14 µg/g	
	5 g	5.9 µg/g	
	(5 to 10) g	8.8 µg/g	
	10 g	3.6 µg/g	
	(10 to 20) g	2.4 µg/g	
	(20 to 50) g	2.8 µg/g	
50 g	1.2 µg/g		
(50 to 100) g	1.8 µg/g		
100 g	0.97 µg/g		
(100 to 20 000) g	1.1 µg/g		
20 kg	3.0 µg/g		
(20 to 150) kg	9.6 µg/g		
(150 to 600) kg	16 µg/g		
(600 to 1500) kg	18 µg/g		

Parameter/Equipment	Range	CMC ² (±)	Comments
Scales & Balances ³ , Mechanical Type	1 mg 2 mg (2 to 5) mg 5 mg (5 to 10) mg 10 mg (10 to 20) mg (20 to 50) mg 50 mg (50 to 100) mg 100 mg (100 to 200) mg (200 to 500) mg 500 mg (500 to 1000) mg 1 g (1 to 2) g (2 to 5) g 5 g (5 to 10) g 10 g (10 to 20) g (20 to 50) g 50 g (50 to 100) g 100 g (100 to 200) g (200 to 1000) g 1 kg (1 to 5) kg (5 to 6) kg (6 to 20) kg (20 to 600) kg (600 to 1000) kg (1000 to 1500) kg	3.8 mg/g 1.9 mg/g 2.4 mg/g 0.75 mg/g 1.4 mg/g 0.49 mg/g 0.30 mg/g 0.36 mg/g 0.15 mg/g 0.23 mg/g 95 µg/g 59 µg/g 71 µg/g 30 µg/g 45 µg/g 18 µg/g 12 µg/g 14 µg/g 5.9 µg/g 9.0 µg/g 3.9 µg/g 2.6 µg/g 12 µg/g 6.9 µg/g 4.3 µg/g 2.4 µg/g 1.8 µg/g 6.6 µg/g 2.4 µg/g 0.10 mg/g 0.29 mg/g 0.13 mg/g 0.21 mg/g 0.67 mg/g 0.17 mg/g	Calibrations performed using reference weights. CMCs for the field calibrations assume that the environmental conditions are maintained as in the primary laboratory
Piston-Operated Volumetric Apparatus	≤ 1 µL ≤ 2 µL ≤ 5 µL ≤ 10 µL ≤ 100 µL ≤ 500 µL ≤ 1 mL ≤ 2.5 mL ≤ 5 mL ≤ 10 mL ≤ 30 mL ≤ 60 mL ≤ 100 mL	0.050 µL 0.040 µL 0.075 µL 0.080 µL 0.10 µL 0.20 µL 2.0 µL 4.0 µL 8.0 µL 15 µL 50 µL 0.10 mL 0.20 mL	By comparison using precision balances and scales

Parameter/Equipment	Range	CMC ² (±)	Comments
Volumetric Glassware –			
One-Mark Pipettes	(0.1 to ≤ 0.5) mL ≤ 2 mL ≤ 5 mL ≤ 10 mL ≤ 20 mL ≤ 25 mL ≤ 50 mL ≤ 100 mL ≤ 200 mL	0.0030 mL 0.0059 mL 0.0088 mL 0.015 mL 0.019 mL 0.018 mL 0.030 mL 0.043 mL 0.062 mL	By comparison using precision balances and scales
Graduated Pipettes	(0.1 to ≤ 0.2) mL ≤ 0.5 mL ≤ 1 mL ≤ 2 mL ≤ 3 mL ≤ 5 mL ≤ 10 mL ≤ 20 mL ≤ 25 mL ≤ 50 mL	0.0024 mL 0.0030 mL 0.0059 mL 0.0087 mL 0.018 mL 0.018 mL 0.029 mL 0.044 mL 0.044 mL 0.088 mL	By comparison using precision balances and scales
Burettes	(1 to ≤ 2) mL ≤ 5 mL ≤ 10 mL ≤ 25 mL ≤ 50 mL ≤ 100 mL ≤ 2000 mL	0.0087 mL 0.0088 mL 0.018 mL 0.030 mL 0.046 mL 0.091 mL 0.06 % of total volume	
One-Mark Volumetric Flasks	≤ 5 mL ≤ 10 mL ≤ 20 mL ≤ 25 mL ≤ 50 mL ≤ 100 mL ≤ 200 mL ≤ 250 mL ≤ 300 mL ≤ 500 mL ≤ 1000 mL ≤ 2000 mL ≤ 2500 mL ≤ 3000 mL ≤ 5000 mL	0.018 mL 0.018 mL 0.030 mL 0.030 mL 0.046 mL 0.071 mL 0.086 mL 0.12 mL 0.15 mL 0.18 mL 0.30 mL 0.49 mL 0.88 mL 1.2 mL 1.3 mL	

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Graduated Measuring Cylinders	≤ 5 mL ≤ 50 mL ≤ 500 mL ≤ 5000 mL	1.0 % of total volume 0.5 % of total volume 0.4 % of total volume 0.25 % of total volume	By comparison using precision balances and scales
Pressure Gauges –			
Pneumatic Gauge Pressure ³	(-95 to -2) kPa	Larger of 0.039 kPa or 0.076 %	Digital pressure gauge, pressure controller
	(-2 to 2) kPa	3.6 Pa	
	(2 to 200) kPa	Larger of 0.038 kPa or 0.076 %	
	(200 to 2000) kPa	Larger of 0.21 kPa or 0.042 %	
Differential Pressure ³	(-2 to 2) kPa	3.6 Pa	
Absolute Pressure	(8 to 75) kPa (75 to 110) kPa (110 to 300) kPa	0.067 kPa 0.038 kPa Larger of 0.067 kPa or 0.034 %	
Hydraulic Gauge Pressure ³	(0 to 7) MPa (7 to 100) MPa	4.7 kPa Larger of 64 kPa or 0.16 %	
Accelerometer Sensitivity –			
Voltage Sensitivity (10 ⁻⁵ to 10 ³) V/(m/s ²)	(0.5 to 1) Hz (1 to 1.25) Hz (1.25 to 2.5) Hz (2.5 to 8) Hz (8 to 200) Hz (200 to 315) Hz (315 to 500) Hz (0.5 to 0.8) kHz (0.8 to 2) kHz (2 to 5) kHz (5 to 10) kHz	3.4 % 0.8 % 0.7 % 0.6 % 0.5 % 0.6 % 0.8 % 0.5 % 0.6 % 0.9 % 1.2 %	Laser interferometry method

Parameter/Range	Frequency	CMC ^{2, 6} (±)	Comments
Accelerometer Sensitivity – (cont)			
10 ⁻⁵ to 10 ³ V/(m/s ²)	(0.5 to 1) Hz (1 to 16) Hz (16 to 50) Hz (50 to 200) Hz (200 to 500) Hz (0.5 to 0.8) kHz (0.8 to 2) kHz (2 to 5) kHz (5 to 10) kHz	5.7 % 1.1 % 0.9 % 1.0 % 1.1 % 1.0 % 1.1 % 1.3 % 1.7 %	Secondary vibration calibration
Charge Sensitivity			
(10 ⁻⁴ to 10 ⁶) pC/(m/s ²)	(0.5 to 1) Hz (1 to 2) Hz (2 to 2.5) Hz (2.5 to 5) Hz (5 to 20) Hz (20 to 80) Hz (80 to 200) Hz (200 to 500) Hz (0.5 to 0.8) kHz (0.8 to 2) kHz (2 to 5) kHz (5 to 10) kHz	4.3 % 1.4 % 1.1 % 1.0 % 0.9 % 0.7 % 0.6 % 0.9 % 0.6 % 0.7 % 1.0 % 1.2 %	Laser interferometry method
(10 ⁻⁴ to 10 ⁶) pC/(m/s ²)	(0.5 to 1) Hz (1 to 2) Hz (2 to 16) Hz (16 to 100) Hz (100 to 200) Hz (0.2 to 2) kHz (2 to 5) kHz (5 to 10) kHz	6.2 % 1.6 % 1.3 % 1.2 % 1.0 % 1.2 % 1.4 % 1.8 %	Secondary vibration calibration
Vibration Meter –			
(0.1 to 500) m/s ²	(5 to 5000) Hz (5 to 10) kHz	2 % 3 %	Secondary vibration calibration Acceleration
(0.002 to 80) cm/s	(5 to 5000) Hz (5 to 10) kHz	2 % 3 %	Velocity
0.3 nm to 10 mm (peak)	(5 to 500) Hz	2 %	Displacement

Parameter/Range	Frequency	CMC ^{2,6} (±)	Comments
Vibration Exciter with Accelerometer ³ –			Secondary vibration calibration
(1 to 2000) m/s ²	(5 to 10) Hz (10 to 5000) Hz (5 to 10) kHz	4 % 3 % 4 %	Acceleration
(1 to 200) cm/s	(5 to 500) Hz (500 to 5000) Hz (5 to 10) kHz	3 % 4 % 10 %	Velocity
(0.5 to 30) mm (peak)	(5 to 40) Hz (40 to 80) Hz (80 to 160) Hz (160 to 315) Hz	3 % 4 % 7 % 15 %	Displacement

Parameter/Equipment	Range	CMC ² (±)	Comments
Torque Measuring Devices ³ – Torque Wrench Tester, Torque Analyzer, Torque Driver Tester, Torque Meter, Torque Gage	1 mN·m to 1 kN·m	0.12 % of measurement torque	Lever mass system (moment arm and weights), reference torque meter, torque analyzer
Torque Tools ³ – Torque Wrench, Torque Screwdriver, Torque Gage	20 mN·m to 1 kN·m	0.50 % of measurement torque	Torque wrench tester Torque analyzer Torque driver tester
Impact Energy – Spring Hammer	(0.2 to 1.0) J	0.02 J	Calibration stand

IX. Thermodynamic

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Dew Point – Measuring Equipment	(-32 to -10) °C (-10 to 50) °C (50 to 85) °C	0.17 °C 0.10 °C 0.11 °C	Dew point hygrometer (primary standard)
Dew Point – Measure ³	(-32 to -10) °C (-10 to 50) °C	0.17 °C 0.10 °C	Dew point hygrometer (primary standard)
Humidity – Measuring Equipment	(5 to 40) % RH (40 to 70) % RH (70 to 98) % RH (Dew Point: -10 °C to 50 °C)	0.5 % RH 0.7 % RH 1.0 % RH	Two-pressure humidity generator (working standard)
Humidity – Measuring Equipment	(10 to 98) % RH (Dew Point: 40 °C to 85 °C)	3.0 % RH	Dew point hygrometer
Humidity – Measure ³	(5 to 98) % RH	0.4 % RH	Dew point hygrometer (primary standard)
Humidity Controlled Chamber ^{3,8}	(10 to 98) %	1.6 %	Dew point hygrometer and Reference PRT JTM K09:2009, JTM K07:2007, IEC 60068-3-6, IEC 60068-3-5
Temperature Installations – Furnaces, Ovens, Incubators, Stirred Water Baths, Fridges and Freezers ^{3,8}	(-80 to -50) °C (-50 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 950) °C	0.08 °C 0.03 °C 0.04 °C 0.05 °C 1.7 °C	PRT (includes uncertainty of transfer from measurand) JTM K09:2009, JTM K07:2007, IEC 60068-3-6, IEC 60068-3-5, T/C's

Parameter/Equipment	Range	CMC ² (±)	Comments
Temperature – Measuring Equipment			
Liquid-In-Glass ⁵	(-50 to 0) °C (0 to 100) °C 100 °C (100 to 200) °C (200 to 300) °C	0.05 °C 0.04 °C 0.05 °C 0.07 °C 0.09 °C	Platinum resistance thermometer in liquid bath
Platinum Resistance (Indicator Plus Sensor)	(-100 to -50) °C (-50 to 0) °C (0 to 100) °C 100 °C (100 to 200) °C (200 to 300) °C (300 to 1100) °C	0.09 °C 0.03 °C 0.03 °C 0.04 °C 0.05 °C 0.08 °C 2.2 °C	Platinum resistance thermometer in liquid bath T/C with BlackStack for readings over 900°C dry-well
Thermistor (Indicator Plus Sensor)	(-100 to -50) °C (-50 to 0) °C (0 to 100) °C 100 °C (100 to 200) °C (200 to 300) °C	0.11 °C 0.07 °C 0.07 °C 0.07 °C 0.08 °C 0.10 °C	Platinum resistance thermometer in liquid bath
Thermocouple (Indicator Plus Sensor)	(-100 to -50) °C (-50 to 0) °C (0 to 100) °C 100 °C (100 to 200) °C (200 to 300) °C (300 to 1100) °C	0.43 °C 0.27 °C 0.24 °C 0.29 °C 0.37 °C 0.43 °C 2.2 °C	Platinum resistance thermometer in liquid bath T/C with BlackStack for readings over 900°C dry-well
Bimetallic	(-50 to 0) °C (0 to 100) °C (100 to 200) °C (200 to 300) °C	0.6 °C 1.2 °C 2.4 °C 4.7 °C	Environmental chambers and baths

Parameter/Equipment	Range	CMC ² (±)	Comments
Temperature – Measuring Equipment ^{3, 8}			
Platinum Resistance (Indicator Plus Sensor)	(-100 to 50) °C (50 to 300) °C (300 to 950) °C	0.3 °C 2.5 °C 2.9 °C	Standard platinum resistance thermometer, Standard thermocouple, Dry-Well
Thermistor (Indicator Plus Sensor)	(-100 to 50) °C (50 to 300) °C (300 to 950) °C	0.3 °C 2.5 °C 2.9 °C	
Thermocouple (Indicator Plus Sensor)	(-100 to 50) °C (50 to 300) °C (300 to 950) °C	0.4 °C 2.6 °C 2.9 °C	
Thermocouple Sensor –			
Type E, J, K, T	(-50 to 300) °C (300 to 600) °C (600 to 1100) °C	0.3 °C 1.8 °C 2.4 °C	Indicating thermometers, freezing point, baths, furnace, voltage standard and voltmeter
Type R	(-50 to 300) °C (300 to 600) °C (600 to 1100) °C	1.6 °C 2.3 °C 2.8 °C	Standard platinum resistance thermometers for high temperature
Non-contact Type Thermometer (Radiation Thermometer, Infrared Thermograph, et. al.)	(-50 to 0) °C (0 to 50) °C 0 °C (50 to 100) °C (100 to 200) °C (200 to 300) °C (300 to 400) °C (400 to 500) °C	1.0 °C $\epsilon = 0.997$ 0.9 °C $\epsilon = 0.95$ 0.9 °C $\epsilon = 0.997$ 0.8 °C $\epsilon = 0.95$ 1.2 °C $\epsilon = 0.95$ 1.7 °C $\epsilon = 0.95$ 2.4 °C $\epsilon = 0.95$ 2.5 °C $\epsilon = 0.95$	Blackbody, Tammann tube (Cavity), reference PRT and ice point
Infrared Calibrator	(-50 to -15) °C (-15 to 200) °C (200 to 300) °C (300 to 400) °C (400 to 500) °C	1.3 °C $\epsilon = 0.95$ 1.6 °C $\epsilon = 0.95$ 2.3 °C $\epsilon = 0.95$ 3.2 °C $\epsilon = 0.95$ 3.9 °C $\epsilon = 0.95$	Radiation thermometer
Contact Thermometry (Surface Probes)	(-50 to 50) °C (30 to 100) °C (100 to 200) °C (200 to 300) °C (300 to 400) °C (400 to 500) °C	1.0 °C 1.1 °C 1.7 °C 2.2 °C 2.8 °C 3.7 °C	Reference PRT, surface plate and ice point

X. Time & Frequency

Parameter/Equipment	Range	CMC ² (±)	Comments
Frequency ³ – Measuring Instruments	1 mHz to 1 Hz 1 Hz to 10 MHz 100 MHz 10 MHz to 225 MHz 225 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz (18 to 40) GHz	3.5 parts in 10 ¹¹ 1.8 parts in 10 ¹² 1.8 parts in 10 ¹² 4.7 parts in 10 ¹² 3.0 parts in 10 ¹⁰ 9.3 parts in 10 ¹¹ 7.3 parts in 10 ¹¹ 7.8 parts in 10 ¹¹	E-trace GPS with frequency/signal generators and counters
Frequency ³ – Measure	1 MHz, 2.5 MHz, 5 MHz, 10 MHz 1 mHz to 40 GHz	3.4 parts in 10 ⁹ 8.3 parts in 10 ⁸	Frequency standard Frequency counters
Stopwatches and Watches	(0 to 86 400) s	0.06 s/day	Quartz tester
Rotational Frequency (rpm) – Mechanical Tachometers, (Contact)	 (5 to 10 000) rpm (10 000 to 15 000) rpm	 1 rpm 3 rpm	 Frequency counter
Rotational Frequency (rpm) ³ – Optical Tachometers and Stroboscopes (Non-Contact)	 (1 to 100) rpm (100 to 1000) rpm (1000 to 100 000) rpm	 0.0008 rpm 0.008 rpm 0.08 rpm	 Frequency counter/standard signal generator

XI. Fluid Quantities

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Flow Meter – Air Flowrate	(5 to 7.5) mL/min (6.5 to 21) mL/min (20 to 75) mL/min (65 to 170) mL/min (165 to 375) mL/min (350 to 750) mL/min (600 to 1125) mL/min (900 to 2000) mL/min (1.7 to 10) L/min (1.7 to 10) L/min (1 to 10) mL/min (10 to 100) mL/min (100 to 1000) mL/min (1 to 20) L/min (3 to 50) L/min (7 to 60) L/min	0.81 % 0.60 % 0.48 % 0.41 % 0.40 % 0.39 % 0.40 % 0.41 % 0.94 % 0.90 % 0.4 % 0.3 % 0.3 % 0.3 % 0.3 % 0.3 % 0.4 %	Stop watch, Standard pipe prover 5 mL Standard pipe prover 10 mL Standard pipe prover 50 mL Standard pipe prover 100 mL Standard pipe prover 250 mL Standard pipe prover 500 mL Standard pipe prover 750 mL Standard pipe prover 1000 mL Standard wet gas meter of water seal, SUM intelligent counter Standard wet gas meter of oil seal, SUM intelligent counter 1E1-VCR-VQ 1E2-VCR-VQ 1E3-VCR-VQ 1E4-VCR-VQ 3E4-VCR-VQ 1E4-VCR-VQ + 3E4-VCR-VQ
Rotational Viscometer – Viscosity	JS 200 JS 500 JS 1000 JS 2000 JS 14 000 JS 52 000	0.7 % 0.8 % 0.8 % 0.9 % 1.0 % 1.1 %	JCSS standard solutions

Satellite Location:
 TSURU EMC BRANCH TESTING DEPARTMENT¹
 2096, Tambozawa, Ohata, Tsuru-shi
 Yamanashi 402-0045, Japan
 Yoshio Kobayashi Phone: +81 554 43 5517

I. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ² (±)	Comments	
Antenna Factor – Dipole antenna	2 m Height Reference Antenna Method	(30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300, 400, 500) MHz	0.80 dB	Standard reference dipole antenna SRD6500
		(600, 700) MHz	0.90 dB	
Standard Site Method		(800, 900, 1000) MHz	1.0 dB	ANSI C63.5
		(30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300) MHz	1.2 dB	
		(400, 500, 600, 700) MHz	1.3 dB	
		(800, 900, 1000) MHz	1.4 dB	



Parameter/Range	Frequency	CMC ² (±)	Comments
Antenna Factor – Broadband Antenna			
Standard Site Method	(30 to 1000) MHz	1.5 dB	ANSI C63.5
1 m Distance	(30 to 300) MHz (300 to 1000) MHz	1.2 dB 0.70 dB	SAE ARP958
Standard Site Method	(30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300, 400, 500, 600, 700) MHz	1.1 dB	Standard reference dipole antenna SRD6500
2 m Height	(800, 900, 1000) MHz	1.3 dB	

¹ This laboratory offers commercial and field calibration service.

² Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

³ Field calibration service is available for this calibration and this laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

⁴ In the statement of CMC, L is the numerical value of the nominal length of the device measured in millimeters.

⁵ The CMC for liquid-in-glass thermometers is based on a 0.1°C graduation. All thermometers with greater than 0.1°C graduation will have a larger CMC.

⁶ In the statement of CMC, percentages are to be read as percent of reading unless otherwise noted.

⁷ In the statement of CMC, FS is equal to full scale.

⁸ The contributions from the “best existing device” are not included in the CMC claim.

⁹ In the statement of CMC, the symbol Γ represents a ratio.

¹⁰ This laboratory meets R205 – Specific Requirements: Calibration Laboratory Accreditation Program for the types of dimensional calibrations listed above and is considered equivalent to that of a calibration.

¹¹ This accreditation covers calibrations performed at the main laboratory and the following satellite laboratory listed above.

A handwritten signature in black ink, appearing to be 'L. S. S.', located at the bottom center of the page.



Accredited Laboratory

A2LA has accredited

JAPAN QUALITY ASSURANCE ORGANIZATION

Tokyo, JAPAN

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets *R205 – Specific Requirements: Calibration Laboratory Accreditation Program*. 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).



Presented this 15th day of May 2018.

A handwritten signature in black ink, written over a horizontal line.

President and CEO
For the Accreditation Council
Certificate Number 1400.01
Valid to March 31, 2020

For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.