



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

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CALIBRATION

Valid To: March 31, 2026

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 below^{1, 11, 12}:

I. Acoustical Quantities

Parameter/Range	Frequency	CMC ² (±)	Comments
Sound Level Meter – Free-Field Response Level – Acoustic /Sound Pressure Level Calibration Using Acoustic Signal (75 dB, 85 dB, 94 dB)	(10 to 20) Hz	0.4 dB	Type I reference microphone
	(20 to 50) Hz	0.4 dB	
	(50 to 3150) Hz	0.3 dB	
	(3150 to 8000) Hz	0.5 dB	
	(8000 to 12 500) Hz	0.7 dB	
	(20 to 50) Hz	0.5 dB	Type II reference microphone
	(50 to 3150) Hz	0.3 dB	
	(3150 to 12 500) Hz	0.6 dB	
	(12 500 to 20 000) Hz	0.9 dB	
	(10 to 20) Hz	0.4 dB	Type I reference microphone, at the exact frequency
	(20 to 50) Hz	0.5 dB	Type II reference microphone, at the exact frequency in the anechoic room
	(50 to 4000) Hz	0.4 dB	
	(4000 to 10 000) Hz	0.5 dB	
	(10 000 to 20 000) Hz	0.7 dB	
	125 Hz	0.4 dB	Type I reference microphone, at the nominal frequency in the anechoic chamber
	(500 to 1600) Hz	0.4 dB	
	4000 Hz	0.6 dB	
	8000 Hz	0.6 dB	

Parameter/Range	Frequency	CMC ² (±)	Comments
Sound Level Meter – (cont)			
Electrical Calibration (20 to 140) dB (Depending on the Sound Level Meter's Measurement Range)	(31.5 to 12 500) Hz	0.2 dB	Level linearity, scale error, level range control error
Acoustical Signal Tests of a Frequency Weighting/ Sound Pressure Level Calibration Using Acoustic Signal (75 dB, 85 dB)	125 Hz 1000 Hz 8000 Hz	0.4 dB 0.3 dB 0.5 dB	IEC 61672-3, periodic tests
Electrical Signal Tests of Frequency Weightings/ Calibration Level	(63 to 16 000) Hz	0.2 dB	IEC 61672-3, periodic tests
Frequency & Time Weightings at 1 kHz /Reference Sound Level	1000 Hz	0.1 dB	IEC 61672-3, periodic tests
Long-Term Stability /Reference Sound Level	1000 Hz	0.1 dB	IEC 61672-3, periodic tests
Level Linearity on the Reference Level Range/ Calibration Range Depends on the Sound Level Meter's Level Linearity Range	8000 Hz	0.2 dB	IEC 61672-3, periodic tests
Level Linearity Including the Level Range Control / Reference Sound Level	1000 Hz	0.2 dB	IEC 61672-3, periodic tests
Tone Burst Response /Calibration Level	4000 Hz	0.2 dB	IEC 61672-3, periodic tests
C-Weighted Peak Sound Level /Calibration Level	500 Hz, 8000 Hz	0.3 dB	IEC 61672-3, periodic tests
Overload Indication /Calibration Level	4000 Hz	0.2 dB	IEC 61672-3, periodic tests
High-Level Stability /Calibration Level	1000 Hz	0.1 dB	IEC 61672-3, periodic tests

Parameter/Range	Frequency	CMC ² (±)	Comments
Calibrator –			
Sound Pressure Level/ Acoustic Calibrator /Sound Pressure Level (94 dB, 104 dB, 114 dB, 124 dB)	250 Hz, 1000 Hz	0.09 dB	Type I reference microphone
	250 Hz, 1000 Hz	0.11 dB	Type II reference microphone
Sound Pressure Level/Multifunction Acoustic Calibrator /Sound Pressure Level (94 dB, 104 dB, 114 dB)	31.5 Hz	0.14 dB	
	63 Hz	0.12 dB	
	125 Hz	0.12 dB	
	250 Hz	0.12 dB	
	500 Hz	0.12 dB	
	1000 Hz	0.12 dB	
	2000 Hz	0.12 dB	
	4000 Hz	0.12 dB	
	8000 Hz	0.12 dB	
	12 500 Hz	0.13 dB	
	16 000 Hz	0.32 dB	
Frequency	(0.25 to 1) kHz	0.1 Hz	Frequency counter
Distortion	Up to 5 % THD, (0.25 to 1) kHz	0.2 %	Audio analyzer
Hydrophone – Voltage Sensitivity			
(10 to 10 ⁴) nV/Pa, 50 Ω Loaded	(0.5 to 1) MHz	10 %	Reference hydrophone
	(2 to 15) MHz	9 %	
	(16 to 18) MHz	10 %	
	(19 to 20) MHz	11 %	
Microphone –			
Type I Microphone Pressure Sensitivity / Pressure Sensitivity Level (-20 to -40) dB	(20 to 25) Hz	0.11 dB	Pressure calibration by reciprocity method
	(25 to 63) Hz	0.09 dB	
	(63 to 4000) Hz	0.08 dB	
	(4000 to 8000) Hz	0.14 dB	
	(8000 to 10 000) Hz	0.23 dB	
	(10 000 to 12 500) Hz	0.38 dB	

Parameter/Range	Frequency	CMC ² (±)	Comments
Microphone (cont) –			
Type II Microphone Pressure Sensitivity / Pressure Sensitivity Level (-30 to -40) dB	20 Hz (Exact Frequency) (20 to 31.5) Hz (31.5 to 63) Hz (63 to 125) Hz (125 to 500) Hz (500 to 8000) Hz (8000 to 10 000) Hz (10 000 to 20 000) Hz	0.20 dB 0.18 dB 0.13 dB 0.11 dB 0.10 dB 0.10 dB 0.12 dB 0.29 dB	Pressure calibration by reciprocity method
Type I Microphone Pressure Sensitivity / Pressure Sensitivity Level (-20 to -40) dB	(20 to 25) Hz (25 to 63) Hz (63 to 4000) Hz (4000 to 8000) Hz (8000 to 10 000) Hz (10 000 to 12 500) Hz	0.13 dB 0.11 dB 0.11 dB 0.18 dB 0.31 dB 0.47 dB	Pressure calibration by comparison method
Type II Microphone Pressure Sensitivity / Pressure Sensitivity Level (-30 to -40) dB	20 Hz (Exact Frequency) (20 to 31.5) Hz (31.5 to 63) Hz (63 to 12 500) Hz (12 500 to 20 000) Hz	0.24 dB 0.22 dB 0.15 dB 0.15 dB 0.39 dB	Pressure calibration by comparison method
Type I Microphone Pressure Sensitivity / Pressure Sensitivity Level (-20 to -40) dB	(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 / Pressure Sensitivity Level (-20 to -50) dB	(20 to 50) Hz (50 to 100) Hz (100 to 160) Hz (160 to 4000) Hz (4000 to 8000) Hz (8000 to 20 000) Hz	0.7 dB 0.5 dB 0.4 dB 0.3 dB 0.7 dB 1.3 dB	Pressure calibration by simplified comparison method
Type I Microphone Free-Field Sensitivity / Pressure Sensitivity Level (+10 to -40) dB	(20 to 4000) Hz (4000 to 8000) Hz (8000 to 10 000) Hz (10 000 to 12 500) Hz	0.3 dB 0.4 dB 0.5 dB 0.6 dB	Free field calibration by comparison method
Type II Microphone Free-Field Sensitivity / Pressure Sensitivity level (+10 to -50) dB	(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 0.6 dB 1.0 dB	Free field calibration by comparison method

Parameter/Range	Frequency	CMC ² (±)	Comments
Microphone – (cont)			
Reference Sound Source / Sound Power Level (Greater than 60 dB Reference to 1 pW)			
Sound Power Level in Frequency Bands (Greater than 60 dB Reference to 1 pW)	50 Hz	3.3 dB	Sound power level
	63 Hz	2.2 dB	
	(80 to 125) Hz	1.4 dB	
	(125 to 200) Hz	1.0 dB	
	(200 to 400) Hz	0.9 dB	
	(400 to 2000) Hz	0.8 dB	
	(2000 to 4000) Hz	1.0 dB	
	(4000 to 10 000) Hz	1.2 dB	
	12 500 Hz	1.6 dB	
	16 000 Hz	2.1 dB	
	20 000 Hz	2.4 dB	
Sound Power Level (Greater than 60 dB Reference to 1 pW)		0.4 dB	

II. Chemical Quantities

Parameter/Equipment	Range	CMC ² (±)	Comments
pH Indicator –			
Instrumental Error	(0 to 14) pH units	0.005 pH units	DC voltage
Linearity	(0 to 14) pH units	0.009 pH units	
Repeatability	(0 to 14) pH units	0.006 pH units	
pH Detector –			
Instrumental Error	4 pH units, 9 pH units	0.4 mV/pH	Standard solutions
Linearity	4 pH units, 7 pH units, 9 pH units	1.0 mV	
Repeatability	4 pH units, 7 pH units 9 pH units	1.1 mV 2.0 mV	

Parameter/Equipment	Range	CMC ² (±)	Comments
pH Meters –			
Three-Point Calibration Instrumental Error	4 pH units 7 pH units 9 pH units	0.010 pH units 0.011 pH units 0.030 pH units	Standard solutions
Two-Point Calibration Instrumental Error	4 pH units, 9 pH units 7 pH units	0.024 pH units 0.013 pH units	
One-Point Calibration Instrumental Error	4 pH units, 7 pH units, 9 pH units	0.18 pH units	
Light Scattering Airborne Particle Counter –			
Counting Efficiency	(0.050 to 0.080) µm	5.4 % of counting efficiency	JIS B 9921
	(0.080 to 0.100) µm	5.2 % of counting efficiency	Particle counters with standard particles
	(0.100 to 0.800) µm	5.0 % of counting efficiency	
	(0.500 to 10.0) µm	1.2 % of counting efficiency	ISO 21501-4 AMD 1 Inkjet aerosol generator
Air Flowrate	(0.1 to 1) L/min	1.9 % of reading	Film flow meter Wet gas meter, stop watch
	(1 to 10) L/min	2.1 % of reading	
	(10 to 30) L/min	1.7 % of reading	
Electrical Conductivity Meters –			
Fixed Points	14.7 mS/m 141 mS/m 1280 mS/m	2.9 % of reading 2.0 % of reading 2.0 % of reading	Standard conductivity solutions
	14.7 mS/m 141 mS/m 1280 mS/m	3.9 % of reading 2.5 % of reading 2.4 % of reading	Calibrated electrical conductivity meter

Parameter/Equipment	Range	CMC ^{2, 6} (±)	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 0.010 % 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 0.010 % CO ₂	Standard gas: CO ₂ in N ₂

III. Dimensional

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
Gage Blocks	(0.1 to 100) mm (100 to 250) mm (250 to 400) mm (400 to 800) mm (800 to 1000) mm (0.1 to 100) mm (100 to 500) mm (500 to 1000) mm	0.04 µm (0.01 + $L/3500$) µm (0.02 + $L/3400$) µm (0.02 + $L/3200$) µm (0.02 + $L/3100$) µm 0.07 µm (0.005 + $L/1800$) µm (0.025 + $L/1800$) µm	By interferometry, type GBI & NRLM-Tsugami By interferometry, type LGB By comparison
Step Height Gauges	(0.02 to 1000) µm	0.021 µm	By interferometry, type NRLM-Tsugami

Parameter/Equipment	Range	CMC ^{2, 4} ($\pm$)	Comments
Step Gages	Up to 1050 mm	$(0.2 + L/650) \mu\text{m}$	Comparison to gage blocks
633 nm Stabilized He-Ne Laser Wavelength ⁸	633 nm	42 pm/m	Comparison to laser standard
Line Standard Scales	Up to 200 mm (200 to 300) mm Up to 300 mm (300 to 1000) mm	1.0 μm 1.3 μm 0.4 μm $(0.2 + L/1500) \mu\text{m}$	Laser system By interferometry, type LST 1000
Plain Ring Gages	(0.1 to 100) mm (100 to 200) mm (200 to 250) mm	0.48 μm 1.5 μm 1.7 μm	Type IDM Laser system /ULM ULM
Cylinder Gages ³	Up to 1.2 mm	1.7 μm	Dial gage tester
Plug & Pin Gages	(0.1 to 250) mm	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 0.17 μm	Gage blocks
Calipers ³	Up to 200 mm (200 to 600) mm (600 to 2000) mm	0.04 mm 0.07 mm 0.10 mm	Gage blocks, Step gage
Centerline Caliper ³	Up to 300 mm (300 to 1000) mm	0.03 mm 0.04 mm	Centerline caliper checker
Micrometers ³	Up to 500 mm (500 to 1000) mm	$(2 + L/100) \mu\text{m}$ $(3 + L/100) \mu\text{m}$	Gage blocks

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
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 scan micrometer
Snap Gage ³	Up to 100 mm (100 to 200) mm	0.9 µm 1.0 µm	Gage blocks
Three Wires for Screw Thread Measuring	Up to 6 mm Up to 6 mm	0.33 µm 0.9 µm	Measure over roll ULM, Three Wires for Screw Thread Measuring
Standard Bar	(0.1 to 600) mm (600 to 1000) mm	(0.2 + L/650) µm (1.1 + L/5000) µm	Comparison to gage blocks
Dial Gage Tester	Up to 50 mm (50 to 100) mm	0.4 µm 0.5 µm	Laser system
Height Gages ³ – Vernier Digital & 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 (600 to 900) mm	4.0 µm 6.6 µm 9.4 µm	Gage blocks, step gages
Depth Gage ³ – Vernier Digital	 Up to 300 mm (300 to 600) mm Up to 300 mm (300 to 600) mm	 0.03 mm 0.09 mm 0.01 mm 0.03 mm	 Gage blocks, step gages

Parameter/Equipment	Range	CMC ² (±)	Comments
Microindicators	Up to 100 µm	0.3 µm	Gage blocks
Depth Micrometers ³	Up to 150 mm (150 to 300) mm	2.9 µm 3.4 µm	Gage blocks, Step gages
Inside Micrometers ³ – Caliper Type	Up to 300 mm	3.2 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	Up to 30 mm	0.09 µm	Electrical high- resolution length comparators
Flatness	Up to 30 mm	0.04 µm	Comparison to optical flat master
Hole Tester ³ – Analog	(2 to 20) mm (20 to 100) mm (100 to 200) mm	2.2 µm 3.7 µm 4.8 µm	Master rings
Digital	(2 to 20) mm (20 to 200) mm	2.2 µm 3.7 µm	
Digital Indicator & Linear Gages ³	Up to 50 mm (50 to 100) mm	0.4 µm 0.6 µm	Gage blocks, dial gages tester

Parameter/Equipment	Range	CMC ² (±)	Comments
Measuring Microscope ³ –			
Parallelism	Up to 300 mm	6.3 µm	Glass line standard scales, electrical comparators, square
Straightness in X-Y Plane	Up to 300 mm	2.2 µm	
X-Y Squareness	Up to 300 mm	2.5 µm	
Linear Accuracy	Up to 200 mm (200 to 300) mm	2.8 µm 3.0 µm	
Angle	Up to 360°	0.73'	
Dial Linear Gages ³ –	Up to 100 mm	0.7 µm	Gage blocks
Measuring Projectors ³ –			
Error of Magnification	Up to 600 mm	0.06 % of nominal magnification	Glass line standard scales
Linear Accuracy	Up to 100 mm (100 to 300) mm	2.7 µm 3.7 µm	
External Screw Threads –			
Standard Threads	Up to 120 mm	2.4 µm	Three-wire method
Parallel Whitworth	Up to 120 mm	2.5 µm	
Major Diameter	Up to 120 mm	0.8 µm	ULM
Extensometer ³	Up to 600 mm	0.80 µm	Reference to JIS B 7741, extensometer calibrator, gage blocks, digital linear height gage
	Up to 600 mm	0.80 µm	Reference to ASTM E83, extensometer calibrator, gage blocks, digital linear height gage

Parameter/Equipment	Range	CMC ^{2, 4} (±)	Comments
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, precision level
Index Master	Up to 260 µm	0.20 µm	Laser system
Laser Scan Micrometer	Up to 10 mm (10 to 50) mm	0.37 µm 1.5 µm	Pin gages
Coordinate Measuring Machine ³ – Each Axis In Space	Up to 3000 mm Up to 1000 mm (1000 to 1510) mm Up to 1000 mm (1000 to 1510) mm	(0.9 + L/2100) µm (1.8 + L/700) µm 7.7 µm 3.3 µm 8.0 µm	Laser system Step gage, gage blocks Step gage, gage blocks
Non-Contact Coordinate Measuring Machine ³ – X & Y Axis Z Axis	Up to 300 mm Up to 300 mm	2.5 µm 4.2 µm	Glass line, standard scales Gage blocks
Autocollimators	Up to ±3' ±(3 to 5)' ±(5 to 8)' ±(8 to 10)'	0.6" 0.8" 1.2" 1.5"	Laser system
Precision Levels	±2'	1"	Laser system
Moment Arms	Up to 200 mm (200 to 450) mm	0.011 mm 0.015 mm	633 nm He-Ne laser system, UMM, GB, micrometer, Vernier caliper, depth gauge, coordinate measuring machines

Parameter/Equipment	Range	CMC ² (±)	Comments
Universal Measuring Machines ³	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 0.6 µm 0.8 µm 0.9 µm 1.1 µm 1.3 µm 1.4 µm 1.6 µm 1.8 µm	Laser system
	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	0.5 µm 0.9 µm 1.2 µm 1.6 µm 2.0 µm 2.4 µm 2.8 µm 3.1 µm 3.5 µm 3.9 µm	Gage blocks
Non-Contact Angle Measuring Equipment	Up to ± 63.36" ± (63.36 to 3600)" ± (3600 to 36 000)"	0.22" 0.34" 12"	Rotary encoder calibration equipment
Polyhedrons	Up to 360°	0.7"	Rotary encoder, calibration equipment
	Up to 360°	1.3"	Indexing device
Rotating Platforms	Up to 360° (360 to 1800)°	1.0" 0.07°	Autocollimators, polygon mirror
Angle Meters	Up to 360°	0.02°	Rotary encoder, angle gauge blocks
Angle Gauges, Universal Protractors	Up to 360°	0.6'	Measuring microscope
Straightedge ³	Up to 1500 mm	0.5 µm	Autocollimators

Parameter/Equipment	Range	CMC ^{2, 6} ($\pm$)	Comments
Squareness	Up to 500 mm (500 to 700) mm (10 to 1000) mm Up to 700 mm	2.1 μ m 2.9 μ m 1.2 μ m 1.1 μ m	Standard square Electrical comparator Autocollimators
Contact Stylus Instrument ³	Ra: 3 μ m & below Rz: 10 μ m & below	5 % 6 %	Roughness measurement standard
Surface Texture – Roughness Depth Step	Ra: 5 μ m & below Rz: 20 μ m & below d: 21 μ m & below 500 μ m & below	0.12 μ m 0.19 μ m 0.12 μ m 0.15 μ m	Contact stylus instrument
Micrometerhead	Up to 50 mm	0.9 μ m	Gage blocks
Shaft Shape Measuring Machines ³ – Diameter Length	Up to 230 mm Up to 420 mm	1.7 μ m 6.5 μ m	Step masters
Coating Thickness Standards	Up to 5500 μ m	1.2 μ m	ULM, gage blocks, Liner gage
Coating Thickness Gages	Up to 1520 μ m	2.9 μ m	Coating thickness standards

IV. Dimensional Testing/Calibration¹⁰

Parameter/Equipment	Range	CMC ^{2, 14} ($\pm$)	Comments
Length – Measure	Up to 500 mm (500 to 1000) mm	5.6 μ m 7.5 μ m	Coordinate measuring machine
	Up to 200 mm	6.0 μ m	Measuring microscope
	Up to 200 mm	8.1 μ m	Image dimension measurement system
Angle – Measure	Up to 360°	3.9"	Coordinate measuring machine
	Up to 360°	12"	Measuring microscope
	Up to 360°	9.4"	Image dimension measurement system
Radius Measurement	500 mm $\times$ 400 mm $\times$ 400 mm	5.5 μ m	Coordinate measuring machine
	200 mm $\times$ 150 mm	5.7 μ m	Measuring microscope
	200 mm $\times$ 100 mm	14 μ m	Image dimension measurement system

V. Electrical – DC/Low Frequency

Parameter/Range	Frequency	CMC ^{2, 6, 13} ($\pm$)	Comments
AC/DC Difference – Measuring Equipment			
1 mV	50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz	77 μ V/V 78 μ V/V 78 μ V/V 74 μ V/V 91 μ V/V 0.015 %	Fluke 792A
10 mV	50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz	79 μ V/V 77 μ V/V 70 μ V/V 70 μ V/V 76 μ V/V 0.015 %	
0.1 V	10 Hz 50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz	0.026 % 48 μ V/V 67 μ V/V 67 μ V/V 67 μ V/V 68 μ V/V 67 μ V/V	
0.2 V	30 kHz 50 kHz 100 kHz 200 kHz 500 kHz 1 MHz	0.053 % 0.053 % 0.055 % 0.074 % 0.087 % 0.087 %	
0.3 V	10 Hz 40 Hz 50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz 30 kHz 50 kHz 100 kHz 500 kHz 1 MHz	0.024 % 0.024 % 47 μ V/V 47 μ V/V 40 μ V/V 40 μ V/V 40 μ V/V 40 μ V/V 60 μ V/V 60 μ V/V 76 μ V/V 0.030 % 0.030 %	

Parameter/Range	Frequency	CMC ^{2, 6, 13} (±)	Comments
AC/DC Difference – Measuring Equipment (cont)			
1 V	10 Hz 40 Hz 50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz 30 kHz 50 kHz 100 kHz 500 kHz 1 MHz	0.023 % 0.024 % 45 µV/V 45 µV/V 33 µV/V 32 µV/V 32 µV/V 32 µV/V 54 µV/V 54 µV/V 65 µV/V 0.030 % 0.030 %	Fluke 792A
10 V	10 Hz 40 Hz 50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz 30 kHz 50 kHz 100 kHz 500 kHz 1 MHz	0.023 % 0.024 % 44 µV/V 44 µV/V 33 µV/V 32 µV/V 32 µV/V 32 µV/V 54 µV/V 54 µV/V 64 µV/V 0.030 % 0.030 %	
20 V	500 kHz 1 MHz	0.030 % 0.030 %	
30 V	500 kHz	0.030 %	
50 V	200 kHz	0.030 %	
100 V	10 Hz 40 Hz 50 Hz 60 Hz 400 Hz 1 kHz 5 kHz 10 kHz 30 kHz 50 kHz 100 kHz 200 kHz	0.023 % 0.024 % 46 µV/V 46 µV/V 38 µV/V 38 µV/V 38 µV/V 38 µV/V 81 µV/V 81 µV/V 86 µV/V 0.030 %	

Parameter/Range	Frequency	CMC ^{2, 6, 13} (±)	Comments
AC/DC Difference – Measuring Equipment (cont)			
200 V	10 Hz 100 kHz	0.023 % 86 µV/V	Fluke 792A
600 V	40 Hz	0.024 %	
700 V	50 kHz 100 kHz	84 µV/V 0.014 %	
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, 13} (±)	Comments
DC Voltage – Generate ³	(0 to 2) mV (2 to 10) mV (10 to 100) mV 100 mV to 1 V (1 to 10) V 10 V 100 V 1000 V (10 to 100) V (100 to 1000) V	0.54 µV 0.027 % 54 µV/V 6.5 µV/V 2.1 µV/V 0.32 µV/V 1.7 µV/V 2.9 µV/V 2.1 µV/V 3.1 µV/V	Calibrator & decade voltage divider DC standard, reference divider & decade voltage divider
DC Voltage – Measure ³	(0 to 2) mV (2 to 10) mV (10 to 100) mV 100 mV to 1 V (1 to 10) V 10 V 100 V 1000 V (10 to 100) V (100 to 1000) V	0.54 µV 0.027 % 54 µV/V 6.4 µV/V 2.5 µV/V 0.33 µV/V 1.7 µV/V 2.9 µV/V 2.1 µV/V 3.1 µV/V	Calibrator & decade voltage divider Calibration of voltage generators using DC standard, reference divider, & decade voltage divider

Parameter/Equipment	Range	CMC ^{2, 6, 13} (±)	Comments
DC High Voltage – Measure & Generate	(1 to 5) kV (5 to 50) kV	0.17 % 0.22 %	CRV-M system, Keithley 2002 & DC PSU
DC High Voltage – Measure & Generate ³	(1 to 10) kV (10 to 30) kV	0.55 % 0.72 %	High voltage meter
DC Current – Generate ³	(0 to 100) pA 100 pA to 10 nA (10 to 100) nA 100 nA to 10 µA 10 µA to 100 mA 100 mA to 1 A (1 to 10) A (10 to 20) A (20 to 60) A (60 to 100) A (100 to 1000) A (100 to 2500) A (2500 to 5000) A	0.55 pA 0.55 % 0.51 % 0.0076 % 15 µA/A 19 µA/A 35 µA/A 50 µA/A 0.011 % 0.033 % 0.071 % 0.18 % 0.82 %	Calibrator, standard resistor, (high resistance meter) DC standard, DMM, standard resistor, shunt & CT Current generator & coil
DC Current – Measure ³	(0 to 100) pA (100 to 200) pA 200 pA to 2 nA (2 to 20) nA 20 nA to 2 µA (2 to 10) µA (1 to 10) µA 10 µA to 100 mA 100 mA to 1 A (1 to 10) A (10 to 20) A (20 to 60) A (60 to 100) A (100 to 1000) A (1000 to 2500) A	0.78 pA 0.78 % 0.69 % 0.66 % 0.16 % 0.14 % 0.010 % 15 µA/A 19 µA/A 35 µA/A 50 µA/A 0.011 % 0.032 % 0.070 % 0.17 %	High resistance meter Calibration of current generators using DC standard, DMM, standard resistor, shunt, CT & transconductance amplifier Current generator & coil
Integral DC Current – Measure & Generate			
0.417 mAh to 0.334 Ah 2.08 mAh to 1.67 Ah	25 mA to 20 A, 1 min 25 mA to 20 A, 5 min	2.0 % 0.39 %	Current generator & stopwatch

Parameter/Equipment	Range	CMC ^{2, 6, 13} ($\pm$)	Comments
DC Power ³ – Measure & Generate	(0 to 0.1) W	0.096 mW	DC voltage & current generators, transconductance amplifier, resistor
	(0.1 to 10) W	0.093 %	
	10 W to 60 kW	0.027 %	
	(60 to 100) kW	0.034 %	DC voltage current generators, transconductance amplifier & clamp meter
	(100 to 1000) kW	0.19 %	
	(1000 to 1500) kW	0.18 %	
	(1500 to 2500) kW	0.17 %	
DC Resistance – Generate ³			
Fixed Points	1 m Ω	15 $\mu\Omega/\Omega$	Standard fixed resistors
	10 m Ω	6.8 $\mu\Omega/\Omega$	
	100 m Ω	6.8 $\mu\Omega/\Omega$	
	1 Ω	2.1 $\mu\Omega/\Omega$	
	10 Ω	2.1 $\mu\Omega/\Omega$	
	100 Ω	1.9 $\mu\Omega/\Omega$	
	1 k Ω	2.7 $\mu\Omega/\Omega$	
	10 k Ω	2.1 $\mu\Omega/\Omega$	
	100 k Ω	2.7 $\mu\Omega/\Omega$	
	1 M Ω	4.7 $\mu\Omega/\Omega$	
	1 G Ω	0.41 %	
	10 G Ω	0.56 %	
	100 G Ω	0.56 %	
	1 T Ω	0.85 %	
	10 T Ω	2.2 %	
Ranges	(0.1 to 2) Ω	0.022 %	8508A & decade resistors
	(2 to 20) Ω	0.012 %	
	(20 to 200) Ω	0.012 %	
	(0.2 to 1) k Ω	0.012 %	
	(1 to 10) k Ω	0.010 %	
	(10 to 100) k Ω	0.012 %	
	(0.1 to 1) M Ω	0.056 %	
	(1 to 10) M Ω	0.056 %	
	(10 to 100) M Ω	0.056 %	
	(0.1 to 1) G Ω	0.59 %	
	(1 to 10) G Ω	0.69 %	
	(10 to 100) G Ω	0.91 %	

Parameter/Range	Frequency	CMC ^{2, 6, 13} ($\pm$)	Comments
Capacitance – Generate ³			
Fixed Points			
0.01 μ F 0.1 μ F 1 μ F	120 Hz	91 μ F/F 64 μ F/F 68 μ F/F	Standard capacitors
1 pF 10 pF 100 pF 1000 pF 0.01 μ F 0.1 μ F 1 μ F 10 μ F	1 kHz	50 μ F/F 48 μ F/F 44 μ F/F 45 μ F/F 55 μ F/F 46 μ F/F 48 μ F/F 0.012 %	
0.01 μ F 0.1 μ F 1 μ F	10 kHz	60 μ F/F 61 μ F/F 60 μ F/F	
0.01 μ F 0.1 μ F 1 μ F	100 kHz	61 μ F/F 59 μ F/F 0.012 %	
1 pF 10 pF 100 pF 1000 pF	1 MHz	0.011 % 58 μ F/F 56 μ F/F 74 μ F/F	
Ranges			
1 pF 10 pF 100 pF 1000 pF	1 kHz to 1 MHz	0.018 % 58 μ F/F 67 μ F/F 0.031 %	

Parameter/Range	Frequency	CMC ^{2, 6, 8, 13} (±)	Comments
Capacitance – Measure			
Fixed Points			
0.01 µF 0.1 µF 1 µF	120 Hz	0.01 % 76 µF/F 79 µF/F	Standard capacitors & 4294A
1 pF 10 pF 100 pF 1000 pF 0.01 µF 0.1 µF 1 µF 10 µF	1 kHz	54 µF/F 50 µF/F 46 µF/F 47 µF/F 57 µF/F 49 µF/F 54 µF/F 0.011 %	Standard capacitors, & 2500A, 4294A
0.01 µF 0.1 µF 1 µF	10 kHz	72 µF/F 73 µF/F 73 µF/F	Standard capacitors & 4294A
0.01 µF 0.1 µF 1 µF	100 kHz	73 µF/F 72 µF/F 0.013 %	Standard capacitors & 4294A
1 pF 10 pF 100 pF 1000 pF	1 MHz	0.012 % 68 µF/F 66 µF/F 82 µF/F	Standard capacitors & 4294A
Ranges			
1 pF to 1 µF	1 kHz	0.021 %	Standard capacitors & 2500A
1 pF 10 pF 100 pF 1000 pF	1 kHz to 1 MHz	0.019 % 68 µF/F 75 µF/F 0.031 %	Standard capacitors & 4294A

Parameter/Range	Frequency	CMC ^{2, 6, 8, 13} (±)	Comments
Inductance – Generate ³ , Fixed Points 100 µH 1 mH 10 mH 100 mH 1 H 10 H	1 kHz	0.62 % 0.024 % 0.014 % 0.014 % 0.015 % 0.25 %	Standard inductors
Inductance – Measure, Fixed Points 100 µH 1 mH 10 mH 100 mH 1 H 10 H	1 kHz	0.62 % 0.024 % 0.014 % 0.015 % 0.015 % 0.25 %	Standard inductors & 4294A
AC Resistance – Generate ³ Resistance Fixed Points 10 Ω to 100 kΩ Ranges 10 Ω to 100 kΩ Impedance Fixed Points 10 mΩ 50 mΩ 100 mΩ 1 Ω to 10 kΩ 100 kΩ Ranges 100 mΩ to 10 Ω (10 to 100) Ω 100 Ω to 10 kΩ (10 to 100) kΩ	1 kHz 1 kHz 50 Hz, 1 kHz 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 50 Hz to 1 kHz 1 kHz	0.020 % 0.052 % 0.21 % 0.31 % 1.6 % 0.089 % 0.083 % 0.082 % 0.093 % 0.053 % 0.086 % 0.089 %	Standard resistors & 4294A Standard resistors & 4294A Calibrator (5720A, 5520A) & measuring instruments (4294A, 8508A)

Parameter/Range	Frequency	CMC ^{2, 6, 8, 13} (±)	Comments
AC Resistance – Measure			
Resistance			
Fixed Points			
10 Ω to 100 kΩ	1 kHz	0.020 %	Standard resistors & 4294A
Ranges			
10 Ω to 100 kΩ	1 kHz	0.052 %	
Impedance			
Fixed Points			
10 mΩ	50 Hz to 1 kHz	0.089 %	Standard resistors & 4294A
100 mΩ to 10 Ω	50 Hz to 1 kHz	0.069 %	
100 Ω	50 Hz to 1 kHz	0.039 %	
(1 to 10) kΩ	50 Hz to 1 kHz	0.083 %	
100 kΩ	1 kHz	0.082 %	
Ranges			
100 mΩ to 10 Ω	50 Hz to 1 kHz	0.088 %	Calibrator (5720A, 5520A) & measuring instruments (4294A, 8508A)
(10 to 100) Ω	50 Hz to 1 kHz	0.043 %	
100 Ω to 10 kΩ	50 Hz to 1 kHz	0.090 %	
(10 to 100) kΩ	1 kHz	0.089 %	
AC Voltage – Measure ³			
(1 to 100) mV (0.1 to 1000) V	50 Hz	80 μV/V 50 μV/V	Calibration of voltage generators using AC/DC transfer standard, thermal converter, calibrator, & standard decade transformer
(1 to 100) mV (0.1 to 0.3) V (0.3 to 1000) V	60 Hz	80 μV/V 70 μV/V 50 μV/V	
(1 to 10) mV (10 to 300) mV (0.3 to 100) V (100 to 1000) V	400 Hz, 1 kHz	80 μV/V 70 μV/V 40 μV/V 50 μV/V	
(0.1 to 0.3) V (0.3 to 200) V	(10 to 40) Hz	0.026 % 0.024 %	
(0.1 to 0.3) V (0.3 to 600) V	(40 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 μV/V 50 μV/V	

Parameter/Range	Frequency	CMC ^{2, 6, 8, 13} ($\pm$)	Comments
AC High Voltage – Measure & Generate ³ (1 to 20) kV	 (50 & 60) Hz	 0.97 %	 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 (0.1 to 0.3) V (0.3 to 600) 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 (600 to 700) V (0.2 to 0.3) V (0.3 to 100) 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 40) Hz (40 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 μ V/V 50 μ V/V 50 μ V/V 50 μ V/V 40 μ V/V 50 μ V/V 0.026 % 0.024 % 0.026 % 0.024 % 0.015 % 50 μ V/V 0.06 % 60 μ V/V 85 μ V/V 0.06 % 60 μ V/V 85 μ V/V 0.06 % 80 μ V/V 90 μ V/V 0.014 % 0.08 % 0.03 % 0.08 % 0.03 % 0.09 % 0.03 %	 AC/DC transfer standard, thermal converter, calibrator, & standard decade transformer

Parameter/Range	Frequency	CMC ^{2, 6, 13} (±)	Comments
AC Power ³ – Measure & Generate			
1 PF 4 W to 6 kW	(50 & 60) Hz Single Phase	0.035 %	Calibrator
≤ 1000 V, ≤ 20 A (1 to 10) mW (10 mW to 20 kW) (173.21 μW to 34.641 kW)	400 Hz Single Phase Three Phase – Three Wire	0.32 % 0.19 % 0.56 %	Phase angle shifter, AC voltage current generators, phase meter
≤ 1000 V, ≤ 50 A (1 to 10) mW (10 mW to 50 kW) (173.21 μW to 86.603 kW)	(50 & 60) Hz Single Phase Three Phase – Three Wire	0.32 % 0.23 % 0.49 %	
≤ 1000 V, ≤ 1000 A (≤ 1 MW) ≤ 1000 V, ≤ 3000 A (≤ 3 MW)	(50 & 60) Hz Single Phase	0.24 % 0.37 %	Phase angle shifter, AC voltage current generators, current coil, phase meter
PF 0 (Lag) to 1 to 0 (Lead) ≤ 1000 V, ≤ 20 A (≤ 20 kW) (≤ 34.641 kW)	400 Hz Single Phase Three Phase – Three Wire	2.0 mW/(V·A) 5.6 mW/(V·A)	Phase angle shifter, AC voltage current generators, phase meter
≤ 1000 V, ≤ 50 A (≤ 50 kW) (≤ 86.603 kW)	(50 & 60) Hz Single Phase Three Phase – Three Wire	2.3 mW/(V·A) 4.9 mW/(V·A)	
≤ 1000 V, ≤ 1000 A (≤ 1 MW) ≤ 1000 V, ≤ 3000 A (≤ 3 MW)	(50 & 60) Hz Single Phase	2.4 mW/(V·A) 3.7 mW/(V·A)	Phase angle shifter, AC voltage current generators, current coil, phase meter

Parameter/Range	Frequency	CMC ^{2, 6, 13} (±)	Comments	
AC Current – Generate ³				
(100 to 329) µA	(10 to 45) Hz	0.49 %	AC/DC transfer standard, current shunt, calibrator, standard resistor	
(29 to 100) µA	(10 to 45) Hz	0.91 %		
329 µA to 2.19 A	(10 to 50) Hz	0.40 %		
(100 to 329) µA	(45 to 50) Hz	0.46 %		
(2.19 to 11) A	(45 to 50) Hz	0.24 %		
(29 to 100) µA	45 Hz to 1 kHz	1.2 %		
100 µA to 10 mA	50 Hz to 1 kHz	0.01 %		
(0.01 to 0.1) A	(50 to 60) Hz	0.010 %		
(0.1 to 20) A	(50 to 60) Hz	0.018 %		
(0.01 to 1) A	60 Hz to 1 kHz	0.017 %		
(1 to 20) A	60 Hz to 1 kHz	0.023 %		
(20 to 50) A	50 Hz, 60 Hz	0.05 %		
(50 to 60) A	50 Hz, 60 Hz	0.2 %		
(60 to 100) A	50 Hz, 60 Hz	0.19 %		Current transformer
(20 to 1000) A	(50 to 60) Hz	0.19 %		Current coil
(1000 to 2500) A		0.25 %		
(2500 to 3000) A		0.29 %		
(3000 to 5000) A		0.82 %		
(5000 to 6000) A		0.84 %		
AC Current – Measure ³				
100 µA to 10 mA	50 Hz to 1 kHz	0.01 %	Calibration of current generators using AC/DC transfer standard, current shunt, calibrator, standard resistor, current transformer	
(0.01 to 0.1) A	(50 to 60) Hz	0.010 %		
(0.1 to 20) A	(50 to 60) Hz	0.018 %		
(0.01 to 1) A	60 Hz to 1 kHz	0.017 %		
(1 to 20) A	60 Hz to 1 kHz	0.023 %		
(20 to 50) A	50 Hz, 60 Hz	0.05 %		
(50 to 60) A	50 Hz, 60 Hz	0.2 %		
(60 to 100) A	50 Hz, 60 Hz	0.19 %		
(20 to 1000) A	(50 to 60) Hz	0.19 %		Current coil
(1000 to 2500) A		0.25 %		
(2500 to 3000) A		0.29 %		
Integral AC Current – Measure & Generate				
	50 Hz, 60 Hz		Current generator & stopwatch	
0.417 mAh to 0.334 Ah	25 mA to 20 A, 1min	2.0 %		
2.08 mAh to 1.67 Ah	25 mA to 20 A, 5min	0.39 %		

Parameter/Range	Frequency	CMC ^{2, 6, 13} (±)	Comments
High Frequency – Voltage – Generate			
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 & 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	0.0051 %	Calibrator & AC/DC transfer standard, thermal converter
(0.3 to 20) V	100 kHz to 1 MHz	0.0094 %	
(0.3 to 2) V	(1 to 5) MHz (5 to 10) MHz (10 to 30) MHz (30 to 50) MHz	0.0087 % 0.016 % 0.045 % 0.17 %	
(0.3 to 1) V	(50 to 100) MHz	0.33 %	
(2 to 3) V	(1 to 5) MHz (5 to 10) MHz (10 to 30) MHz (30 to 50) MHz	0.12 % 0.12 % 0.24 % 0.61 %	
(3 to 4) V	(1 to 5) MHz (5 to 10) MHz (10 to 30) MHz (30 to 50) MHz	0.17 % 0.17 % 0.34 % 0.84 %	
(0.3 to 1) V	(50 to 500) MHz 500 MHz to 1 GHz	0.75 % 1.1 %	Thermistor mount
High Frequency – Voltage ³ – Measure			
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, 13} ($\pm$)	Comments
Oscilloscope Calibration – Generate ³			
DC Voltage – 50 Ω / 1 M Ω	$\pm$ (6 to 19) mV $\pm$ 19 mV to 1 kV	0.72 % 0.072 %	Fluke 5500, Fluke 9500
AC Voltage – 50 Ω / 1 M Ω			
50 Hz to 10 kHz	$\pm$ (2 to 14) mV	1.6 %	Fluke 5500, Fluke 9500, Datron 1281
50 Hz to 10 kHz	$\pm$ (14 to 140) mV	0.70 %	
10 Hz to 10 kHz	$\pm$ 140 mV to 5 V	0.70 %	
10 kHz to 1 MHz	$\pm$ 283 mV to 5 V	1.0 %	
AC Voltage – 1 M Ω			
10 Hz to 100 kHz	$\pm$ (5 to 42) V	0.70 %	Fluke 5500, Fluke 9500, Datron 1281
100 kHz to 1 MHz	$\pm$ (5 to 28) V	1.0 %	
50 Hz to 10 kHz	$\pm$ (28 to 710) V	0.70 %	
Time Markers	0.45 ns to 10 s	0.3 μ s/s	Fluke9500, SMA100
Sinewave Flatness 5 mV to 5.5 V	1 kHz to 100 kHz 100 kHz to 1 MHz (1 to 200) MHz 200 MHz to 1 GHz	0.78 % 1.0 % 4.0 % 2.7 %	Fluke 9500, measuring receiver, power meter & sensor, Fluke 5500
0 to -3 dB (Reference = 0 dB)	(1 to 12) GHz (12 to 18) GHz (18 to 40) GHz	0.4 dB 0.6 dB 0.8 dB	
Phase – Measure / Measuring Equipment			
(0 to 360) $^{\circ}$ Up to 650 V	20 Hz to 2 kHz (2 to 5) kHz (5 to 10) kHz (10 to 50) kHz	0.027 $^{\circ}$ 0.040 $^{\circ}$ 0.054 $^{\circ}$ 0.063 $^{\circ}$	Phase meter
Power Factor ³ 0 to 1	(50 to 65) Hz	$\cos(A) - \cos(A+0.14)$	Calibrator (A is the angle in degrees)

Parameter/Equipment	Range	CMC ² (±)	Comments
Electrical Calibration of Thermocouple Temperature Indicators ³ –			
Type E	(-260 to -250) °C (-250 to -220) °C (-220 to -200) °C (-200 to -100) °C (-100 to 1000) °C	4.5 °C 2.8 °C 1.4 °C 1.3 °C 0.72 °C	Multimeter, 34420A/SPRT , Fluke 7526A
Type J	(-210 to -200) °C (-200 to -100) °C (-100 to 0) °C (0 to 1200) °C	1.1 °C 0.89 °C 0.55 °C 0.45 °C	
Type K	(-260 to -250) °C (-250 to -240) °C (-240 to -200) °C (-200 to -150) °C (-150 to -100) °C (-100 to 1372) °C	7.7 °C 4.3 °C 3.0 °C 1.4 °C 1.1 °C 0.72 °C	
Type N	(-250 to -200) °C (-200 to -100) °C (-100 to 150) °C (150 to 1300) °C	8.0 °C 2.4 °C 1.2 °C 0.79 °C	
Type R	(-50 to -20) °C (-20 to 0) °C (0 to 100) °C (100 to 250) °C (250 to 400) °C (400 to 1000) °C (1000 to 1768) °C	4.3 °C 3.4 °C 2.8 °C 2.1 °C 1.7 °C 1.5 °C 1.4 °C	
Type S	(-50 to -20) °C (-20 to 0) °C (0 to 250) °C (250 to 1000) °C (1000 to 1600) °C (1600 to 1768) °C	3.7 °C 3.0 °C 2.5 °C 1.6 °C 1.3 °C 1.5 °C	
Type T	(-260 to -250) °C (-250 to -240) °C (-240 to -200) °C (-200 to -150) °C (-150 to -100) °C (-100 to 0) °C (0 to 400) °C	5.3 °C 3.3 °C 2.4 °C 1.4 °C 0.94 °C 0.75 °C 0.57 °C	

Parameter/Equipment	Range	CMC ^{2, 13} (±)	Comments
Electrical Calibration of Thermocouple Temperature Calibrator – Measure			
Type E	(-250 to -200) °C (-200 to -100) °C (-100 to -25) °C (-25 to 0) °C (0 to 350) °C (350 to 650) °C (650 to 1000) °C	1.4 °C 0.56 °C 0.34 °C 0.29 °C 0.28 °C 0.23 °C 0.24 °C	Multimeter, 34420A/SPRT
Type J	(-210 to -100) °C (-100 to -30) °C (-30 to 0) °C (0 to 150) °C (150 to 760) °C (760 to 800) °C (800 to 1200) °C	0.63 °C 0.33 °C 0.29 °C 0.28 °C 0.26 °C 0.24 °C 0.26 °C	
Type K	(-250 to -240) °C (-240 to -230) °C (-230 to -200) °C (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 800) °C (800 to 1000) °C (1000 to 1372) °C	2.0 °C 1.4 °C 1.1 °C 0.64 °C 0.33 °C 0.27 °C 0.25 °C 0.26 °C 0.30 °C	
Type N	(-250 to -200) °C (-200 to -100) °C (-100 to -25) °C (-25 to 100) °C (100 to 120) °C (120 to 410) °C (410 to 1300) °C	2.5 °C 0.74 °C 0.38 °C 0.32 °C 0.29 °C 0.28 °C 0.25 °C	
Type R	(-50 to -25) °C (-25 to 0) °C (0 to 100) °C (100 to 250) °C (250 to 400) °C (400 to 600) °C (600 to 1000) °C (1000 to 1600) °C (1600 to 1768) °C	1.3 °C 1.1 °C 0.90 °C 0.65 °C 0.53 °C 0.48 °C 0.44 °C 0.39 °C 0.41 °C	

Parameter/Equipment	Range	CMC ^{2,6} (±)	Comments
Electrical Calibration of Thermocouple Temperature Calibrator – Measure (cont)			
Type S	(-50 to -25) °C (-25 to -20) °C (-20 to 0) °C (0 to 100) °C (100 to 250) °C (250 to 400) °C (400 to 600) °C (600 to 1000) °C (1000 to 1400) °C (1400 to 1600) °C (1600 to 1768) °C	1.2 °C 1.0 °C 0.97 °C 0.88 °C 0.66 °C 0.55 °C 0.51 °C 0.49 °C 0.44 °C 0.43 °C 0.48 °C	Multimeter, 34420A/SPRT
Type T	(-250 to -200) °C (-200 to -150) °C (-150 to -100) °C (-100 to 0) °C (0 to 120) °C (120 to 200) °C (200 to 400) °C	1.6 °C 0.63 °C 0.46 °C 0.37 °C 0.29 °C 0.25 °C 0.24 °C	
Electrical Calibration of Strain Calibrators	(20 000 to 200 000)·10 ⁻⁶ (2000 to 20 000)·10 ⁻⁶ (200 to 2000)·10 ⁻⁶ (20 to 200)·10 ⁻⁶ (10 to 20)·10 ⁻⁶	0.42·10 ⁻⁶ 0.15·10 ⁻⁶ 0.13·10 ⁻⁶ 0.13·10 ⁻⁶ 0.22·10 ⁻⁶	Multimeter, calibrator mV/V (ratio)
Electrical Calibration of Strain Indicators ³	(10 000 to 200 000)·10 ⁻⁶ (1000 to 10 000)·10 ⁻⁶ (500 to 1000)·10 ⁻⁶ (200 to 500)·10 ⁻⁶ (100 to 200)·10 ⁻⁶ (50 to 100)·10 ⁻⁶ (20 to 50)·10 ⁻⁶	0.019 % 0.084 % 0.094 % 0.16 % 0.60 % 0.78 % 1.5 %	Strain calibrator mV/V (ratio)

VI. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ^{2, 6, 9, 13} (±)	Comments
RF Power – Calibration Factor			
1 mW	9 kHz to 10 MHz 10 MHz to 6 GHz (6 to 12) GHz (12 to 18) GHz (18 to 25) GHz (25 to 40) GHz	1.2 % 0.7 % 1.2 % 1.9 % 2.4 % 5.6 %	Power meter, power sensor, power splitter
RF Power – Generate			
1 mW	9 kHz to 10 MHz 10 MHz to 6 GHz (6 to 12) GHz (12 to 18) GHz (18 to 25) GHz (25 to 40) GHz	1.2 % 0.7 % 1.2 % 1.9 % 2.4 % 5.6 %	Power meter, power sensor, power splitter, attenuator, attenuator & signal calibrator
1 µW	10 MHz to 6 GHz (6 to 12) GHz (12 to 18) GHz	0.8 % 1.2 % 2.0 %	
10 pW to 10 nW	10 MHz to 12 GHz	1.8 %	
10 nW to 100 mW	100 kHz to 10 MHz	1.5 %	
10 nW to 50 mW	10 MHz to 6 GHz (6 to 12) GHz	1.6 % 1.6 %	
100 mW to 200 W	(1 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 %	
RF Power – Measure ³			
1 mW	50 MHz 100 kHz to 18 GHz (18 to 40) GHz	0.7 % 3.9 % 6.2 %	Power meter, power sensor, power splitter, measuring receiver with power sensor
10 pW to 100 mW	10 MHz to 12 GHz	3.4 %	
10 nW to 100 mW	100 kHz to 10 MHz	3.9 %	

Parameter/Range	Frequency	CMC ² (±)	Comments
Reflection Coefficient – Mag (lin)			
PC7: 0 to 0.05	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz	0.002 0.002 0.003 0.004	Vector network analyzer, impedance analyzer, VNA: 37269D, P5007A & E5061B impedance analyzer: 4192A with calibration / verification kits
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 0.003 0.004 0.005	
PC3.5: 0 to 0.05	(9 to 100) kHz 100 kHz to 40 MHz (40 to 100) MHz 100 MHz to 1 GHz (1 to 18) GHz (18 to 26.5) GHz	0.006 0.008 0.017 0.004 0.006 0.008	
0.05 to 0.3	(9 to 100) kHz 100 kHz to 40 MHz (40 to 100) MHz 100 MHz to 1 GHz (1 to 18) GHz (18 to 26.5) GHz	0.007 0.009 0.017 0.006 0.007 0.010	
K: 0 to 0.05	100 MHz to 1 GHz (1 to 20) GHz (20 to 40) GHz	0.010 0.014 0.012	
0.05 to 0.3	100 MHz to 1 GHz (1 to 20) GHz (20 to 40) GHz	0.011 0.014 0.014	
N50: 0 to 0.05	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz	0.003 0.004 0.005 0.007	
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 0.007 0.010 0.011	

Parameter/Range	Frequency	CMC ^{2,9} (±)	Comments
Reflection Coefficient – Mag (lin) (cont) N50: 0.3 to 1 N75: 0 to 0.05 0.05 to 0.3 Reflection Coefficient – Phase (°) N50/N75/PC7/ PC3.5/K	9 kHz to 40 MHz 40 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz 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 9 kHz to 40 GHz	0.008 0.010 0.014 0.020 0.009 0.006 0.011 0.009 0.011 0.014 $\sin^{-1} (U_{(\text{mag}(\text{lin})/ \Gamma)} \times 180/\pi)$	Vector network analyzer, impedance analyzer, VNA: 37269D, P5007A & E5061B impedance analyzer: 4192A with calibration / verification kits
Electromagnetic Wave Attenuation – Measure & Generate (0 to 60) dB (60 to 100) dB (0 to 60) dB (60 to 100) dB (0 to 40) dB (40 to 60) dB (60 to 80) dB (80 to 100) dB (0 to 40) dB (40 to 60) dB (60 to 80) dB (80 to 100) dB (0 to 40) dB (40 to 60) dB (60 to 80) dB (80 to 100) dB	50 Hz to 1 kHz 1 kHz to 10 MHz 10 MHz to 1 GHz (1 to 12) GHz (12 to 18) GHz (18 to 40) GHz	0.007 dB 0.010 dB 0.020 dB 0.027 dB 0.011 dB 0.014 dB 0.020 dB 0.031 dB 0.016 dB 0.018 dB 0.028 dB 0.037 dB 0.022 dB 0.024 dB 0.039 dB 0.046 dB 0.028 dB 0.054 dB	Standard decade transformer Attenuator Measuring receiver, attenuator, attenuator & signal generator calibrator, selective level meter, impedance analyzer, frequency response analyzer, vector network analyzer

Parameter/Range	Frequency	CMC ^{2,9} (±)	Comments
Magnetic Flux Density (0.1 to 0.5) T (0.5 to 1) T (1 to 2) T 1 µT, 10 µT, 100 µT	DC DC DC 50 Hz, 60 Hz	0.07 % 0.06 % 0.05 % 0.81 %	Magnetic field measuring instrument
EFT/Burst Simulators ³ – Peak Voltage (+ and -) 50 Ω Load 1 kΩ Load Rise Time 50 Ω Load 1 kΩ Load Impulse Duration 50 Ω Load 1 kΩ Load Burst Duration Burst Period Repetition Frequency Up to 4 kV	 (0.125 to 2) kV ± 10 % (0.24 to 3.8) kV ± 20 % (3.5 to 7) ns 5 ns ± 30 % (30 to 65) ns 50 ns -15 ns / +100 ns 15 ms ± 20 % @ 5 kHz 0.75 ms ± 20 % @ 100 kHz 300 ms ± 20 % 5 kHz ± 20 % 100 kHz ± 20 %	 3.0 % 4.0 % 120 ps 120 ps 1.0 ns 1.0 ns 120 µs 7.0 µs 2.0 ms 0.5 % 0.5 %	 Oscilloscope, Attenuator, IEC 61000-4-4: Ed2:2005 & Ed3:2014

Parameter/Range	Range	CMC ^{2,9} (±)	Comments
Surge Simulators ³ –			
Open Circuit Voltage Waveform			
Peak Voltage Under / Overshoot Voltage	±(0.5 to 7) kV ± 10 % ±(Up to 2.1) kV	4.0 % 4.0 % of Peak Voltage	Oscilloscope, differential probe, current probe
(1.2 µs/50 µs) Front Time Rise Time	1.2 µs ± 30 % 1 µs ± 30 %	10 ns 10 ns	IEC 61000-4-5: Ed2:2005 & Ed3:2014
Time to Half Value Duration Time	50 µs +10 µs / -35 µs 50 µs ± 20 %	0.20 µs 0.20 µs	
(10 µs/700 µs) Front Time Rise Time	10 µs ± 30 % 6.5 µs ± 30 %	0.05 µs 0.05 µs	
Time to Half Value/ Duration Time	700 µs ± 20 % 700 µs ± 20 %	5.0 µs 5.0 µs	
Short Circuit Current Waveform			
Peak Current Under / Over Shoot Current	± (12.5 A to 3.5 kA) ± 10 % ± (Up to 1.05) kA	4.0 % 4.0 % of Peak Current	
(8 µs/20 µs) Front Time	8 µs ± 20 % 2.5 µs ± 30 %	70 ns 80 ns	
Rise Time	6.4 µs ± 20 %	70 ns	
Time to Half Value	20 µs ± 20 %	0.08 µs	
Duration Time	25 µs ± 30 % 16 µs ± 20 %	0.15 µs 0.15 µs	
(5 µs/320 µs) Front Time Rise Time	5 µs ± 20 % 4 µs ± 20 %	50 ns 50 ns	
Time to Half Value Duration Time	320 µs ± 20 % 300 µs ± 20 %	2.0 µs 2.0 µs	
Phase Shifting	(0 to 360)°	1.0°	

VII. Optical Quantities

Parameter/Equipment	Range	CMC ^{2, 6, 14} ($\pm$)	Comments
Laser Beam Power – Measure			
100 μ W to 7 mW (50 to 100) μ W (10 to 50) μ W	(405, 660) nm band	0.29 % 0.36 % 0.9 %	Optical power meter
100 μ W to 200 mW (50 to 100) μ W (10 to 50) μ W	(488, 515) nm band	0.29 % 0.36 % 0.9 %	
100 μ W to 10 mW (50 to 100) μ W (10 to 50) μ W	(633, 780, 1064) nm band	0.29 % 0.36 % 0.9 %	
100 μ W to 3 mW (50 to 100) μ W (10 to 50) μ W	850 nm band	0.29 % 0.36 % 0.9 %	
100 μ W to 5 mW (50 to 100) μ W (10 to 50) μ W	(1280 to 1340) nm band (1520 to 1630) nm band	0.29 % 0.36 % 0.9 %	
Fiber Optic Power			
(100 to 200) μ W (50 to 100) μ W (10 to 50) μ W (-10 to -7) dBm (-13 to -10) dBm (-20 to -13) dBm	850 nm band	0.35 % 0.5 % 1.0 % 0.016 dB 0.022 dB 0.044 dB	
100 μ W to 10 mW (50 to 100) μ W (10 to 50) μ W (-10 to +10) dBm (-13 to -10) dBm (-20 to -13) dBm	(1280 to 1340) nm band (1520 to 1630) nm band	0.35 % 0.5 % 1.0 % 0.016 dB 0.022 dB 0.044 dB	
1 nW to 1 mW (-60 to 0) dBm	1310 nm band	0.49 % 0.022 dB	
1 nW to 1 mW (-60 to 0) dBm	1550 nm band	0.44 % 0.020 dB	

Parameter/Equipment	Range	CMC ^{2, 14} (±)	Comments
Linearity – Measure			
-10 dB -20 dB -30 dB -40 dB -50 dB -60 dB -70 dB -80 dB -90 dB	1310 nm band	0.0091 dB 0.0093 dB 0.0096 dB 0.0099 dB 0.011 dB 0.011 dB 0.014 dB 0.023 dB 0.078 dB	Optical power meter
-10 dB -20 dB -30 dB -40 dB -50 dB -60 dB -70 dB -80 dB -90 dB	1550 nm band	0.0056 dB 0.0057 dB 0.0058 dB 0.0059 dB 0.0061 dB 0.0070 dB 0.013 dB 0.017 dB 0.062 dB	
Optical Attenuation – Measure			
(10 to 30) dB (10 dB step) (40 to 50) dB (10 dB step) 60 dB (1 to 59) dB (1 dB step)	1550 nm band	0.006 dB 0.007 dB 0.008 dB 0.025 dB	Optical power meter
(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)	1310 nm band	0.010 dB 0.011 dB 0.012 dB 0.025 dB 0.026 dB	
(10 to 50) dB (10 dB step) 60 dB (1 to 59) dB (1 dB step)	(1520 to 1630) nm	0.011 dB 0.012 dB 0.026 dB	
(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)	(1280 to 1340) nm	0.010 dB 0.011 dB 0.012 dB 0.013 dB 0.026 dB 0.027 dB	

Parameter/Equipment	Range	CMC ^{2, 6, 14} (±)	Comments
Optical Wavelength – Measure/Generate	633 nm band 1310 nm band 1550 nm band	0.004 nm 0.010 nm 0.010 nm	Optical wavelength meter, He-Ne laser, interferometer
Optical Filters – Transmittance (0 to 100 %)			
Neutral Density Glass Filter JCRM101	(400.0 to 800.0) nm except for 400.0 nm 440.0 nm 465.0 nm 546.1 nm 590.0 nm 635.0 nm 700.0 nm 800.0 nm	8 % 7 % 3 % 3 % 3 % 3 % 3 % 3 % 3 %	Standard spectrophotometer CMC uncertainty is expressed as percentage of transmittance.
JCRM110	(400.0 to 800.0) nm except for 400.0 nm 440.0 nm 465.0 nm 546.1 nm 590.0 nm 635.0 nm 700.0 nm 800.0 nm	2.6 % 2.5 % 0.77 % 0.75 % 0.70 % 0.72 % 0.68 % 1.3 % 1.5 %	
JCRM120	(400.0 to 800.0) nm except for 400.0 nm 440.0 nm 465.0 nm 546.1 nm 590.0 nm 635.0 nm 700.0 nm 800.0 nm	1.9 % 1.8 % 0.58 % 0.47 % 0.55 % 0.58 % 0.56 % 1.1 % 1.1 %	
JCRM130	(400.0 to 800.0) nm except for 400.0 nm 440.0 nm 465.0 nm 546.1 nm 590.0 nm	1.4 % 1.2 % 0.48 % 0.44 % 0.50 % 0.49 %	

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Optical Filters – Transmittance (0 to 100 %) (cont)			
Neutral Density Glass Filter JCRM130	(400.0 to 800.0) nm except for 635.0 nm 700.0 nm 800.0 nm	1.4 % 0.50 % 0.66 % 0.68 %	Standard spectrophotometer CMC uncertainty is expressed as percentage of transmittance.
JCRM140	(400.0 to 800.0) nm except for 400.0 nm 440.0 nm 465.0 nm 546.1 nm 590.0 nm 635.0 nm 700.0 nm 800.0 nm	1.3 % 0.90 % 0.49 % 0.51 % 0.52 % 0.54 % 0.55 % 0.54 % 0.65 %	
JCRM150	(400.0 to 800.0) nm except for 400.0 nm 440.0 nm 465.0 nm 546.1 nm 590.0 nm 635.0 nm 700.0 nm 800.0 nm	1.2 % 0.87 % 0.46 % 0.41 % 0.40 % 0.46 % 0.41 % 0.59 % 0.66 %	
Ultraviolet Glass Filter JCRM210A	(200.0 to 225.0) nm (225.0 to 300.0) nm except for 225.0 nm 231.0 nm 245.0 nm 286.0 nm 300.0 nm	2.8 % 3.8 % 1.6 % 1.6 % 1.4 % 1.5 % 3.4 %	

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Optical Filters – Transmittance (0 to 100 %) (cont)			
Ultraviolet Glass Filter JCRM230A, 230S	(200.0 to 225.0) nm (225.0 to 300.0) nm except for 225.0 nm 231.0 nm 245.0 nm 286.0 nm 300.0 nm	2.1 % 2.3 % 1.2 % 1.2 % 1.2 % 1.2 % 1.9 %	Standard spectrophotometer CMC uncertainty is expressed as percentage of transmittance.
JCRM250A	(200.0 to 225.0) nm (225.0 to 300.0) nm except for 225.0 nm 231.0 nm 245.0 nm 286.0 nm 300.0 nm	1.8 % 1.6 % 0.86 % 0.87 % 0.87 % 0.87 % 1.3 %	
Near-Ultraviolet Glass Filter JCRM310	(300.0 to 400.0) nm except for 300.0 nm 318.0 nm 319.0 nm 350.0 nm 398.0 nm 400.0 nm	5.0 % 4.8 % 1.6 % 1.6 % 1.5 % 1.5 % 1.5 %	
JCRM330	(300.0 to 400.0) nm except for 300.0 nm 318.0 nm 319.0 nm 350.0 nm 398.0 nm 400.0 nm	3.2 % 2.8 % 1.2 % 1.2 % 1.2 % 1.2 % 1.2 %	
JCRM350	(300.0 to 400.0) nm except for 300.0 nm 318.0 nm 319.0 nm 350.0 nm 398.0 nm 400.0 nm	3.1 % 2.8 % 0.99 % 0.99 % 0.93 % 0.92 % 0.92 %	

Parameter/Equipment	Range	CMC ^{2, 14} (±)	Comments
Optical Filters – Wavelength			
Neodymium Glass Filter JCRM001	Nominal@ 473 nm, 514 nm, 529 nm, 573 nm, 586 nm	0.2 nm	Standard spectrophotometer
	Nominal@ 441 nm, 478 nm, 685 nm, 740 nm	0.3 nm	
Holmium Glass Filter JCRM002	Nominal@ 288 nm, 334 nm, 361 nm, 419 nm, 446 nm, 454 nm, 460 nm	0.2 nm	
	Nominal@ 279 nm, 386 nm, 536 nm	0.3 nm	

XI. Fluid Quantities

Parameter/Equipment	Range	CMC ^{2, 6, 14} (±)	Comments
Air Flowmeter & Air Flow Controller			
Air Flowmeter	(1 to 10) mL/min (10 to 100) mL/min (0.1 to 1) L/min (1 to 30) L/min (30 to 70) L/min	0.6 % 0.5 % 0.4 % 0.3 % 0.4 %	Standard Flowmeter Stopwatch
Air Flow Controller	(1 to 10) mL/min (10 to 1000) mL/min (1 to 60) L/min	1.0 % 0.9 % 0.6 %	
Rotational Viscometer – Viscosity	(150 ± 50) mPa·s (350 ± 100) mPa·s (700 ± 200) mPa·s (1500 ± 500) mPa·s (8000 ± 3000) mPa·s (35 ± 15) Pa·s	0.7 % 0.8 % 0.9 % 0.9 % 1.1 % 1.1 %	JCSS standard solutions

VIII. Mechanical

Parameter/Equipment	Range	CMC ^{2, 6, 7} ($\pm$)	Comments
Push Pull Gages ³ Force Gages ³	10 mN to 5 kN	0.10 % of measurement load	Calibration method per JIS B 7721, load cells & dead weight
Tension Gages ³ Compression Gages ³	10 mN to 5 kN	0.2 % F.S.	Calibration method per JIS B 7721, load cells & dead weight
Load Cell	10 mN to 5 kN	0.03 % of measurement load	Calibration method per JIS B 7728 (ISO 376) or JIS B 7602, load cells & dead weight
Uniaxial Testing Machines ³ –			
Tension Force	0.01 N to 100 kN	0.2 % of measurement load	Calibration method per JIS B 7721 (ISO 7500-1) force-proving instruments (load cells) & dead weights
Compression Force	0.01 N to 3 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) & dead weights
Compression Force	0.01 N to 3 MN	0.4 % of measurement load	
Crosshead Speed	(0.5 to 500) mm/min (>500 to 1000) mm/min	0.4 % 0.7 %	Displacement & speed measurement unit
	(0.5 to 500) mm/min	0.4 %	Height gauge & stopwatch, dial gauge, Digital Linear Gauge Displacement & speed measurement unit
Crosshead Distance	(1 to < 5) mm (5 to 600) mm	0.9 % 0.4 %	
	(0.5 to < 1) mm (1 to < 5) mm (5 to 600) mm	1.3 % 0.9 % 0.4 %	Height gauge, dial gauge, Digital Linear Gauge

Parameter/Equipment	Range	CMC ^{2, 6, 7} (±)	Comments
Direct Calibration of Rockwell and Rockwell Standardizing Hardness Testers ³ –			Direct calibration method per JIS B 7726 (ISO 6508-2), JIS B 7730 (ISO 6508-3), ASTM E18
Calibration of the Test Forces	98.07 N (588.4 to 1471) N 29.42 N (147.1 to 294.2) N	0.051 N 0.29 N 0.034 N 0.077 N	Calibration of test force is by load cell, loop dynamometer per the method of JIS B 7721, ASTM E4
Calibration of the Depth-Measuring Device	(0 to 260) µm	0.1 µm	Index master Gauge block
Calibration of Testing Cycle Time	Up to 30 s	0.035 s	Stopwatch
Speed	Up to 2 mm/s	0.09 mm/s	Dial gauge (linear gauge)
Hysteresis	(100 and 130) HR	0.10 HR	
Indirect Calibration of Rockwell Hardness Testers ³	HRA: Low Medium High HRB: Low Medium High HRC: Low Medium High	0.21 HRA 0.33 HRA 0.13 HRA 0.47 HRB(W) 0.35 HRB(W) 0.32 HRB(W) 0.24 HRC 0.20 HRC 0.18 HRC	Indirect calibration method per JIS B 7726 (ISO 6508-2), ASTM E18, ASTM E110
Indirect Calibration of Superficial Hardness Testers ³	HR15N: Low Medium High HR30N: Low Medium High	0.15 HR15N 0.14 HR15N 0.12 HR15N 0.21 HR30N 0.28 HR30N 0.18 HR30N	Indirect calibration method per JIS B 7726 (ISO 6508-2), ASTM E18, ASTM E110

Parameter/Equipment	Range	CMC ^{2, 6, 7} (±)	Comments
Indirect Calibration of Superficial Hardness Testers ³ (cont)	HR15T: Low Medium High HR30T: Low Medium High	0.23 HR15T(W) 0.29 HR15T(W) 0.13 HR15T(W) 0.29 HR30T(W) 0.25 HR30T(W) 0.21 HR30T(W)	Indirect calibration method per JIS B 7726 (ISO 6508-2), ASTM E18, ASTM E110
Direct Calibration Vickers and Knoop Hardness Testers ³ – Calibrations of the Test Forces Calibration of the Device for Measuring Indentation Diagonals	(0.09807 to 0.9807) N (1.961 to 9.807) N (19.61 to 98.07) N (196.1 to 490.3) N (0 to 1) mm	0.00022 N 0.052 N 0.32 N 1.8 N 0.57 µm	Direct calibration method per JISB7725 (ISO 6507-2), ASTM E92, JIS B 7734, ISO 4545-2. Note: this is only a partial direct calibration Calibration of test force is by load cells, loop dynamometer per the method of JIS B 7721, ASTM E4 Stage micrometer
Indirect Calibration of Vickers and Knoop Hardness Testers ³	<240 HV (240 to 600) HV >600 HV <240 HK (240 to 600) HK >600 HK	2.7 HV 5.9 HV 7.4 HV 1.9 HK 4.6 HK 7.6 HK	Indirect calibration method per JIS B 7725 (ISO 6507-2), ASTM E92 Indirect calibration method per JISB7734, ISO4545-2,ASTME92
Direct Calibration Brinell Hardness Testers ³ – Calibrations of the Test Forces Calibration of the Device for Measuring Indentation Diagonals	(0.2942 to 0.6129) kN (0.9807 to 1.839) kN (2.452 to 7.355) kN (9.807 to 29.42) kN (0 to 8) mm	0.00080 kN 0.0036 kN 0.012 kN 0.041 kN 2.4 µm	Direct calibration method per JIS B 7724 (ISO6506-2), ASTM E10 Calibration of test force is by load cells & loop dynamometer per the method of JIS B 7721, ASTM E4 Stage micrometer Note: This is only a partial direct calibration

Parameter/Equipment	Range	CMC ² (±)	Comments
Indirect Calibration of Brinell Hardness Testers ³	< 250 HBW (250 to 450) HBW	2.6 HBW 4.2 HBW	Indirect calibration method per JIS B 7724 (ISO 6506-2), ASTM E10, ASTM E110
Indirect Calibration of Shore Hardness Testers ³	(30 to 95) HS (VHS)	0.8 HS (VHS)	Indirect calibration method per JIS B 7727
Indirect Calibration of Leeb Hardness Testers ³	(400 to 800) HLD	11 HLD	ASTM A956/A956M
Indirect Calibration of UCI Hardness Testers ³	(200 to 800) HV (UCI) (20 to 70) HRC (UCI) (200 to 400) HBW (UCI)	14 HV (UCI) 0.3 HRC (UCI) 10 HBW (UCI)	ASTM A1038
Durometers –			ASTM D2240: A, B, D, C, D, DO, E, M, O, OO, OOO, OOO-S, RJIS K 7215: A, D JIS K 6253: A, D, E, AM JIS K 7312: A, C, D JIS K 6301: A, C
Distance Between Two Points	Up to 3 mm	6 µm	Measuring microscope
Angle	Up to 40°	0.10°	
Coordinates of Center of Circle	Up to 6 mm	6 µm	
Spring Force	Up to 50 N	0.02 N	Electric type balance mechanical type balance load cell
Indenter Display	Up to 100 H	0.02 H	Gage blocks
Examining Device of Durometer Spring Force –			
Mass Value	Up to 5 kg	0.14 g	Electric type balance
Test Force	Up to 50 N	0.0088 N	Load cell

Parameter/Equipment	Range	CMC ² (±)	Comments
Weights, Conventional Mass Value ³	50 kg Up to 50 kg 20 kg Up to 20 kg 10 kg Up to 10 kg 5 kg Up to 5 kg 3 kg Up to 3 kg 2 kg Up to 2 kg 1 kg Up to 1 kg 500 g	0.30 g 5.0 µg/g 6.0 mg 4.0 µg/g 2.1 mg 4.0 µg/g 1.1 mg 4.0 µg/g 1.5 mg 4.0 µg/g 0.42 mg 4.0 µg/g 0.16 mg 4.0 µg/g 0.085 mg	Direct comparison or subdivision/multiple method using precision balances & scales with standard weights
Weights, Conventional Mass Value	Up to 500 g 300 g Up to 300 g 200 g Up to 200 g 100 g Up to 100 g 50 g Up to 50 g 30 g Up to 30 g 20 g Up to 20 g 10 g Up to 10 g 5 g Up to 5 g 3 g Up to 3 g 2 g Up to 2 g 1 g Up to 1 g 500 mg Up to 500 mg 200 mg Up to 200 mg 100 mg Up to 100 mg 50 mg Up to 50 mg 20 mg	4.0 µg/g 0.15 mg 4.0 µg/g 0.035 mg 4.0 µg/g 0.019 mg 4.0 µg/g 0.010 mg 5.0 µg/g 0.026 mg 8.0 µg/g 0.0080 mg 9.0 µg/g 0.0060 mg 15 µg/g 0.0050 mg 32 µg/g 0.013 mg 25 µg/g 0.0040 mg 40 µg/g 0.0030 mg 50 µg/g 0.0025 mg 80 µg/g 0.0020 mg 0.16 mg/g 0.0015 mg 0.25 mg/g 0.0012 mg 0.45 mg/g 0.0010 mg	Direct comparison or subdivision/multiple method using precision balances & scales with standard weights

Parameter/Equipment	Range	CMC ² (±)	Comments
Weights, Conventional Mass Value (cont)	Up to 20 mg 10 mg Up to 10 mg 5 mg Up to 5 mg 2 mg Up to 2 mg 1 mg (0.05 Up to 1) mg	0.90 mg/g 0.000 80 mg 1.6 mg/g 0.000 60 mg 3.2 mg/g 0.000 60 mg 6.0 mg/g 0.000 60 mg 0.000 40 mg	Direct comparison or subdivision/multiple method using precision balances & scales with standard weights
Weights, True Mass Value	50 kg Up to 50 kg 20 kg Up to 20 kg 10 kg Up to 10 kg 5 kg Up to 5 kg 3 kg Up to 3 kg 2 kg Up to 2 kg 1 kg Up to 1 kg 500 g Up to 500 g 300 g Up to 300 g 200 g Up to 200 g 100 g Up to 100 g 50 g Up to 50 g 30 g Up to 30 g 20 g Up to 20 g 10 g Up to 10 g 5 g Up to 5 g 3 g Up to 3 g 2 g Up to 2 g 1 g	12 µg/g 12 µg/g 11 µg/g 11 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.0 µg/g 4.1 µg/g 4.7 µg/g 5.4 µg/g 9.0 µg/g 8.7 µg/g 10 µg/g 15 µg/g 17 µg/g 25 µg/g 35 µg/g 56 µg/g 28 µg/g 60 µg/g 60 µg/g 81 µg/g	Direct comparison or subdivision/multiple method using precision balances & scales with standard weights

Parameter/Equipment	Range	CMC ² (±)	Comments
Weights, True Mass Value (cont)	Up to 1 g 500 mg Up to 500 mg 200 mg Up to 200 mg 100 mg Up to 100 mg 50 mg Up to 50 mg 20 mg Up to 20 mg 10 mg Up to 10 mg 5 mg Up to 5 mg 2 mg Up to 2 mg 1 mg	90 µg/g 0.15 mg/g 0.15 mg/g 0.17 mg/g 0.20 mg/g 0.22 mg/g 0.30 mg/g 0.30 mg/g 0.45 mg/g 0.70 mg/g 0.90 mg/g 1.1 mg/g 1.6 mg/g 1.8 mg/g 3.2 mg/g 4.3 mg/g 6.0 mg/g 9.0 mg/g	Direct comparison or subdivision/multiple method using precision balances & scales with standard weights
Scales & Balances ³ , Electronic 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 20 000) g 20 kg (20 to 150) kg (150 to 600) kg (600 to 1500) kg	3.6 mg/g 1.8 mg/g 2.4 mg/g 0.71 mg/g 1.4 mg/g 0.47 mg/g 0.30 mg/g 0.36 mg/g 0.15 mg/g 0.22 mg/g 94 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 8.8 µg/g 3.6 µg/g 2.4 µg/g 2.8 µg/g 1.2 µg/g 1.8 µg/g 0.97 µg/g 1.1 µg/g 3.0 µg/g 9.6 µg/g 16 µg/g 18 µg/g	Calibrations performed using reference weights CMCs for the field calibrations assume that the environmental conditions are maintained as in the primary laboratory

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	Up to 1 µL Up to 2 µL Up to 5 µL Up to 10 µL Up to 100 µL Up to 500 µL Up to 1 mL Up to 2.5 mL Up to 5 mL Up to 10 mL Up to 30 mL Up to 60 mL Up to 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 & scales

Parameter/Equipment	Range	CMC ² (±)	Comments
Volumetric Ware –			
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 & 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	
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 & scales
Pressure Gauges –			
Air Pressure Gauge Pressure ³	(-95 to < -50) kPa (-50 to < -20) kPa (-20 to < -15) kPa (-15 to < -10) kPa (-10 to < -7) kPa (-7 to < -2) kPa (-2 to < 2) kPa (2 to < 7) kPa (7 to 20) kPa (20 to 50) kPa (50 to 100) kPa (100 to 150) kPa (150 to 350) kPa (350 to 500) kPa (500 to 1000) kPa (1000 to 5000) kPa	28 Pa 26 Pa 7.2 Pa 5.8 Pa 4.4 Pa 3.0 Pa 1.2 Pa 3.0 Pa 4.5 Pa 6.0 Pa 9.5 Pa 14 Pa Larger of 18 Pa or 0.0090 % 0.21 kPa 0.29 kPa Larger of 0.56 kPa or 0.028 %	Digital pressure gauge, pressure controller, pressure balance
Differential Pressure ³	(-20 to < -15) kPa (-15 to < -10) kPa (-10 to < -7) kPa (-7 to < -2) kPa (-2 to < 2) kPa (2 to < 7) kPa (7 to 10) kPa (10 to 15) kPa (15 to 20) kPa	7.2 Pa 5.8 Pa 4.4 Pa 3.0 Pa 1.2 Pa 3.0 Pa 4.4 Pa 5.8 Pa 7.2 Pa	[Line pressure 100 kPa ± 5 kPa (absolute pressure)]
Absolute Pressure	(8 to 100) kPa (100 to 150) kPa (150 to 350) kPa (350 to 500) kPa (500 to 1000) kPa (1000 to 5000) kPa	15 Pa 17 Pa Larger of 20 Pa or 0.010 % 0.21 kPa 0.29 kPa Larger of 0.56 kPa or 0.028 %	
Hydraulic Pressure Gauge Pressure	(0 to 5) MPa (5 to 10) MPa (10 to 20) MPa (20 to 100) MPa	2.3 kPa 2.5 kPa 2.8 kPa 28 kPa	

Parameter/Equipment	Range	CMC ^{2, 6} (±)	Comments
Torque Measuring Devices ³ – Torque Wrench Tester, Torque Analyzer, Torque Driver Tester, Torque Meter, Torque Gage	(1 to 5) mN·m	0.93 %	Lever mass system (moment arm & weights), reference torque meter, torque analyzer
	5 mN·m to 100 N·m	0.23 %	
	100 N·m to 1 kN·m	0.15 %	
Torque Tools ³ – Torque Wrench, Torque Screwdriver, Torque Gage	20 mN·m to 0.1 N·m	1.3 %	Torque wrench tester, torque analyzer, torque driver tester
	0.1 N·m to 1 kN·m	0.70 %	

Parameter/Equipment	Frequency	CMC ^{2, 6} (±)	Comments
Accelerometer Sensitivity – Voltage Sensitivity (10 ⁻⁴ to 10 ²) V/(m/s ²) (10 ⁻⁴ to 10 ²) V/(m/s ²) (10 ⁻⁴ to 10 ²) V/(m/s ²)	(0.5 to 0.63) Hz	1.2 %	Laser interferometry method
	(0.63 to 0.8) Hz	1.1 %	
	(0.8 to 1) Hz	1.0 %	
	(1 to 2) Hz	0.7 %	
	(2 to 20) Hz	0.6 %	
	(20 to 25) Hz	0.5 %	
	(25 to 160) Hz	0.4 %	
	(160 to 1600) Hz	0.5 %	
	(1.6 to 2) kHz	0.6 %	Secondary vibration calibration using single-ended accelerometer calibrated by NMIJ
	(20 to 2000) Hz	0.6 %	
	(2 to 5) kHz	0.7 %	
	(5 to 6.3) kHz	0.8 %	
	(6.3 to 8) kHz	0.9 %	
	(8 to 10) kHz	1.5 %	Secondary vibration calibration
	(0.5 to 0.63) Hz	1.8 %	
	(0.63 to 0.8) Hz	1.5 %	
	(0.8 to 1) Hz	1.4 %	
	(1 to 2) Hz	1.2 %	
	(2 to 20) Hz	1.0 %	
	(20 to 80) Hz	0.7 %	
	(80 to 160) Hz	0.6 %	
	(160 to 1600) Hz	0.7 %	
	(1.6 to 2) kHz	0.8 %	
	(2 to 5) kHz	0.9 %	
	(5 to 6.3) kHz	1.1 %	
	(6.3 to 8) kHz	1.2 %	
	(8 to 10) kHz	2.1 %	

Parameter/Equipment	Frequency	CMC ^{2, 6} (±)	Comments
Vibration Exciter with Accelerometer ³ –			Secondary vibration calibration
(0.1 to 3000) m/s ² (Peak)	(5 to 5000) Hz	2 %	Acceleration
(0.1 to 300) cm/s (Peak)	(5 to 2000) Hz (2 to 5) kHz	2 % 3 %	Velocity
(0.1 to 100) mm (pk-pk)	(5 to 315) Hz	2 %	Displacement
	5 Hz to 5 kHz	0.017 %	Frequency
Calibration Exciter			Secondary vibration calibration
(1 to 100) m/s ² (Peak)	(4 to 20) Hz (20 to 2000) Hz (2 to 5) kHz (5 to 10) kHz	1.2 % 0.9 % 1.0 % 2.2 %	Acceleration
(1 to 10) cm/s (Peak)	(20 to 2000) Hz (2 to 5) kHz (5 to 10) kHz	0.9 % 1.0 % 2.2 %	Velocity
10 µm to 20 mm (pk-pk)	(20 to 500) Hz	0.9 %	Displacement
(80 to 110) dB	(4 to 31.5) Hz	0.2 dB	Vibration level (acceleration)
	4 Hz to 10 kHz	0.0020 %	Frequency
Charge Amplifier			
Sensitivity (10 ⁻⁵ to 10) V/pC	(20 to 10000) Hz	0.4 %	Capacitor & multimeter
Impulse Hammer			
(1 to 200) N			
Voltage Sensitivity	(0.1 to 100) mV/N	4 %	Accelerometer & mass
Charge Sensitivity	(0.1 to 10) pC/N	4 %	
Impact Energy –			
Spring Hammer	(0.2 to 1.0) J	0.02 J	Calibration stand

IX. Thermodynamics

Parameter/Equipment	Range	CMC ^{2, 6, 14} (±)	Comments
Dew/Frost Point – Measuring Equipment	(-30 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/Frost Point – Measure ³	(-30 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	0.5 % RH 0.7 % RH 1.0 % RH	Two-pressure humidity generator (working standard)
Humidity – Measuring Equipment (Dew Point: 15 °C to 85 °C)	(5 to 35) % RH (>35 to 54) % RH (>54 to 98) % RH	1.6 % RH 2.0 % RH 2.8 % 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) % RH	1.6 % RH	Dew point hygrometer & reference PRT JTM K09, JTM K07 IEC 60068-3-6, IEC 60068-3-5
Temperature Installations – Furnaces, Ovens, Incubators, Stirred Water Baths, Fridges & Freezers ^{3, 8}	(-80 to <-50) °C (-50 to 100) °C (>100 to 300) °C (>300 to 950) °C	0.10 °C 0.05 °C 0.11 °C 2.5 °C	PRT (includes uncertainty of transfer from measurand) JTM K09, JTM K07, IEC 60068-3-6, IEC 60068-3-5, T/C's

Parameter/Equipment	Range	CMC ^{2, 14} (±)	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 freezing point
Digital Thermometer	About -196 °C (-100 to <-90) °C (-90 to <-80) °C (-80 to <100) °C 100 °C (>100 to 200) °C (>200 to 300) °C (>300 to 900) °C (>900 to 1100) °C (>1100 to 1200) °C	0.15 °C 0.12 °C 0.07 °C 0.03 °C 0.04 °C 0.05 °C 0.07 °C 1.2 °C 1.7 °C 2.5 °C	Platinum resistance thermometer in liquid bath, freezing point, furnace, boiling point of liquid nitrogen T/C with BlackStack for readings over 900°C dry-well:
Mechanical Thermometer	(-50 to 300) °C	0.6 °C	Environmental chambers & baths, freezing point
Temperature – Measuring Equipment ^{3, 8}			
Digital Thermometer	(-100 to -50) °C (>-50 to 60) °C (>60 to 155) °C (>155 to 300) °C (>300 to 950) °C	0.5 °C 0.6 °C 1.3 °C 2.6 °C 3.6 °C	Standard platinum resistance thermometer, standard thermocouple, dry-well
Thermocouple Sensor –			
Type E, J, K, T	About -196 °C (-50 to 300) °C (>300 to 900) °C (>900 to 1100) °C (>1100 to 1200) °C	0.4 °C 0.3 °C 1.8 °C 2.0 °C 2.6 °C	Indicating thermometers, freezing point, baths, furnace, boiling point of liquid nitrogen, voltage standard & voltmeter
Type N	About -196 °C (-50 to 300) °C (>300 to 900) °C (>900 to 1100) °C (>1100 to 1200) °C	1.5 °C 1.5 °C 2.3 °C 2.4 °C 3.0 °C	Standard platinum resistance thermometers, standard thermocouple thermometers, for high temperature
Type R	(-50 to 300) °C (>300 to 900) °C (>900 to 1100) °C (>1100 to 1200) °C	1.5 °C 2.3 °C 2.4 °C 3.0 °C	

Parameter/Equipment	Range	CMC ^{2, 14} ($\pm$)	Comments
Non-contact Type Thermometer (Radiation Thermometer, Infrared Thermograph, et. al.)	(-50 to <0) °C 0 °C (>0 to 50) °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, $\epsilon = 0.997$ 1.0 °C, $\epsilon = 0.9$ to 1.0 0.9 °C, $\epsilon = 0.9$ to 1.0 1.2 °C, $\epsilon = 0.9$ to 1.0 1.7 °C, $\epsilon = 0.9$ to 1.0 2.4 °C, $\epsilon = 0.9$ to 1.0 2.5 °C, $\epsilon = 0.9$ to 1.0	Blackbody, Tammann tube (Cavity), reference PRT & ice point
Infrared Calibrator	(-50 to <0) °C (0 to 100) °C (>100 to 200) °C (>200 to 300) °C (>300 to 400) °C (>400 to 500) °C	1.4 °C, $\epsilon = 0.997$ 1.1 °C, $\epsilon = 0.95$ 1.6 °C, $\epsilon = 0.95$ 2.9 °C, $\epsilon = 0.95$ 3.9 °C, $\epsilon = 0.95$ 4.1 °C, $\epsilon = 0.95$	Radiation thermometer
Digital Thermometer (Surface Probes)	(-50 to 50) °C (>50 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 3.8 °C	Reference PRT, surface plate & ice point

X. Time & Frequency

Parameter/Equipment	Range	CMC ^{2, 6, 14} ($\pm$)	Comments
Frequency – Measure & Generate	1 mHz to 1 Hz 1 Hz to 10 MHz 100 MHz (10 to 225) MHz 225 MHz to 1 GHz (1 to 10) GHz (10 to 18) GHz (18 to 40) GHz	9.4 parts in 10^8 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, counters & measuring receivers
Frequency ³ – Measure & Generate	1 mHz to 1 Hz 1 Hz to 6 GHz 6 GHz to 40 GHz	9.4 parts in 10^8 7.0 parts in 10^8 6.0 parts in 10^8	Frequency/signal generators, counters & measuring receivers
Stopwatches & Watches	(0 to 388.8) s/day	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 & Stroboscopes (Non- Contact)	(0.5 to 100) rpm (100 to 1000) rpm (1000 to 100 000) rpm (100 000 to 300 000) rpm	0.0008 rpm 0.008 rpm 0.08 rpm 0.62 rpm	Frequency counter/standard signal generator
Rise & Fall Time – Measure	(450 to 500) ps 500 ps to 10 ns (10 to 100) ns (0.1 to 1) μ s	70 ps 80 ps 0.1 % + 70 ps 0.13 % + 70 ps	Digital oscilloscope

SATELLITE LOCATION

TSURU EMC BRANCH TESTING DEPARTMENT

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I. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC ² (±)	Comments
Antenna Factor – Dipole Antenna			
2 m Height Reference Antenna Method Horizontal Polarization	(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 (800, 900, 1000) MHz	0.90 dB 1.0 dB	
Standard Site Method Horizontal Polarization	(30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300) MHz	1.2 dB	ANSI C63.5
	(400, 500, 600, 700) MHz	1.3 dB	
	(800, 900, 1000) MHz	1.4 dB	
Antenna Factor – Broadband & Antenna			
Standard Site Method Horizontal Polarization	(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 Antenna Method Horizontal Polarization 2 m Height	(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
	(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. 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 measured reflection coefficient; RF power does not include mismatch uncertainty.
- 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.
- ¹² This scope meets A2LA's *P112 Flexible Scope Policy*.
- ¹³ The stated measured values are determined using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure or generate the measured value in the ranges indicated. CMC's are expressed as either a specific value that covers the full range or as a percent or fraction of the reading plus a fixed floor specification.
- ¹⁴ The type of instrument or material being calibrated is defined by the parameter. This indicates the laboratory is capable of calibrating instruments that measure or generate the values in the ranges indicated for the listed measurement parameter.



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 17025:2017 *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 22nd day of March 2024.

A blue ink signature of Mr. Trace McInturff.

Mr. Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1400.01
Valid to March 31, 2026

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