



**SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005  
& ANSI/NCSL Z540-1-1994 (R2002)**

**American Calibration Inc.**

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**CALIBRATION**

Valid to: **August 6, 2018**

Certificate Number: **ACT-1886**

**Acoustics and Vibration**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Accelerometer <sup>3</sup>	10 Hz to 100 Hz (Up to 10 g)	4.3 % of reading	Accelerometer Calibrator and Reference Accelerometer – Back to Back method
Voltage Sensitivity / Frequency Response  (100 mV/g)	100 Hz to 1 kHz (Up to 7 g)	5.3 % of reading	
	1 kHz to 10 kHz (Up to 3 g)	5.5 % of reading	
Sound Level Meters <sup>3</sup>	(94 and 114) dB 1 kHz	0.70 dB	Acoustic Calibrator

**Chemical Quantities**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
pH Meters <sup>3</sup>	4 pH 7 pH 10 pH	0.017 pH 0.023 pH 0.052 pH	Aqueous pH Solutions With or Without Fluoride
Conductivity Meters <sup>3</sup>	10 µS/cm 100 µS/cm 1 000 µS/cm 1 400 µS/cm 10 000 µS/cm 100 mS/cm	0.65 µS/cm 2.9 µS/cm 20 µS/cm 28 µS/cm 190 µS/cm 1.8 mS/cm	Aqueous Conductivity Solutions



**Chemical Quantities**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Ammonia Sensors <sup>3</sup>	100 ppm 250 ppm	12 ppm 29 ppm	Compressed Gas Mixture

**Electrical – DC/Low Frequency**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
DC Current Measure <sup>3</sup>	(10 to 100) $\mu$ A (0.1 to 1) mA (1 to 10) mA (10 to 100) mA 100 mA to 1.1 A	7.6 nA 35 nA 0.44 $\mu$ A 6.7 $\mu$ A 0.16 mA	Keysight 3458A
	(1.1 to 3) A	1.39 mA/A + 0.8 mA	Keysight 34401A
	(3 to 5) A (5 to 10) A	3.63 mA/A + 1.1 mA 3.5 mA/A + 1.7 mA	Fluke 289
DC Current Source <sup>3</sup>	Up to 330 $\mu$ A 330 $\mu$ A to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3) A (3 to 11) A (11 to 20.5) A	0.17 nA/ $\mu$ A + 23 nA 0.15 $\mu$ A/mA + 0.06 $\mu$ A 0.12 $\mu$ A/mA + 0.3 $\mu$ A 0.11 $\mu$ A/mA + 4.3 $\mu$ A 0.44 mA/A + 0.051 mA 0.43 mA/A + 0.1 mA 0.56 mA/A + 2.5 mA 0.39 mA/A + 56 mA	Fluke 5502A
DC Current Source <sup>3</sup> Clamp Meters	(12 to 1 000) A	0.54% of Reading + 0.53 A	Fluke 5502A with 50 turn coil



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current Measure <sup>3</sup>	<b>(0 to 1) A</b> (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	12 mA 40 mA 1.8 mA	Keysight 34401A          Fluke 289
	<b>(1 to 3) A</b> (3 to 5) Hz (5 to 10) Hz 10 Hz to 5 kHz	40 mA 14 mA 8.5 mA	
	<b>(3 to 5) A</b> (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	17.3 mA/A + 2.8 mA 9.3 mA/A + 3 mA 4.9 mA/A + 6.6 mA	
	<b>(5 to 10) A</b> (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz	17.3 mA/A + 6.3 mA 9.3 mA/A + 6.6 mA 4.9 mA/A + 12 mA	
	AC Current Measure Magnetic Inspection Unit <sup>3</sup>	(500 to 10 000) A	
AC Current Source <sup>3</sup>	<b>(29 to 330) µA</b> (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	2.3 nA/µA + 0.12 µA 1.7 nA/µA + 0.12 µA 1.4 nA/µA + 0.12 µA 3.5 nA/µA + 0.18 µA 9.2 nA/µA + 0.24 µA 18 nA/µA + 0.52 µA	Fluke 5502A
	<b>(0.33 to 3.3) mA</b> (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	2.3 µA/mA + 0.21 µA 1.4 µA/mA + 0.22 µA 1.1 µA/mA + 0.24 µA 2.3 µA/mA + 0.26 µA 5.8 µA/mA + 0.37 µA 12 µA/mA + 0.81 µA	
	<b>(3.3 to 33) mA</b> (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	2 µA/mA + 3.7 µA 1 µA/mA + 3.3 µA 0.39 µA/mA + 5.6 µA 0.77 µA/mA + 8.7 µA 2.2 µA/mA + 7.7 µA 4.5 µA/mA + 8.9 µA	



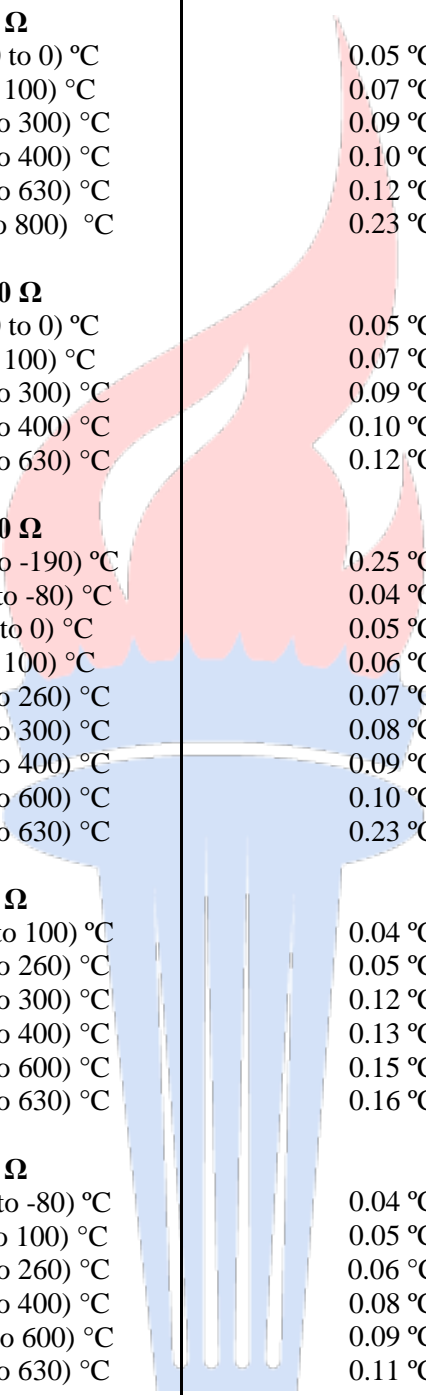
Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Current Source <sup>3</sup> (cont.)	<b>(33 to 330) mA</b> (10 to 20) Hz (20 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz <b>(0.33 to 1.1) A</b> (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz <b>(1.1 to 3) A</b> (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz <b>(3 to 11) A</b> (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz <b>(11 to 20.5) A</b> (45 to 100) Hz 100 Hz to 1 kHz (1 to 5) kHz	2 $\mu$ A/mA + 36 $\mu$ A 1 $\mu$ A/mA + 30 $\mu$ A 0.44 $\mu$ A/mA + 32 $\mu$ A 1.1 $\mu$ A/mA + 63 $\mu$ A 2.3 $\mu$ A/mA + 0.12 mA 4.6 $\mu$ A/mA + 0.23 mA 2 mA/A + 0.25 mA 0.55 mA/A + 0.16 mA 6.9 mA/A + 1.2 mA 29 mA/A + 5.8 mA 2 mA/A + 0.4 mA 0.67 mA/A + 0.2 mA 6.9 mA/A + 1.2 mA 29 mA/A + 5.9 mA 0.63 mA/A + 3.4 mA 1.1 mA/A + 2.8 mA 34 mA/A + 4.7 mA 1.3 mA/A + 11 mA 1.5 mA/A + 16 mA 35 mA/A + 10 mA	Fluke 5502A
AC Current Source <sup>3</sup> Clamp Meters	(12 to 1 000) A (60 Hz)	6.13 mA/A + 0.52 A	Fluke 5502A with 50 Turn Coil
Resistance Source <sup>3</sup>	0.1 m $\Omega$ @ 100 A 1 m $\Omega$ @ 30 A 10 m $\Omega$ @ 10 A 100 m $\Omega$ @ 3 A	58 n $\Omega$ 0.58 $\mu\Omega$ 5.8 $\mu\Omega$ 58 $\mu\Omega$	Precision Resistance Standard



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Resistance Source <sup>3</sup>	(0 to 11) Ω (11 to 33) Ω (33 to 110) Ω (110 to 330) Ω 330 Ω to 1.1 kΩ (1.1 to 3.3) kΩ (3.3 to 11) kΩ (11 to 33) kΩ (33 to 110) kΩ (110 to 330) kΩ 330 kΩ to 1.1 MΩ (1.1 to 3.3) MΩ (3.3 to 11) MΩ (11 to 33) MΩ (33 to 110) MΩ (110 to 330) MΩ 330 MΩ to 1.1 GΩ	0.14 mΩ/Ω + 1.2 mΩ 0.14 mΩ/Ω + 1.8 mΩ 0.1 mΩ/Ω + 1.9 mΩ 0.1 mΩ/Ω + 2.4 mΩ 0.1 Ω/kΩ + 2.3 mΩ 0.1 Ω/kΩ + 25 mΩ 0.1 Ω/kΩ + 24 mΩ 0.1 Ω/kΩ + 0.24 Ω 0.13 Ω/kΩ + 0.24 Ω 0.14 Ω/kΩ + 2.4 Ω 0.17 kΩ/MΩ + 2.7 Ω 0.17 kΩ/MΩ + 53 Ω 0.69 kΩ/MΩ + 59 Ω 1.2 kΩ/MΩ + 2.9 kΩ 5.7 kΩ/MΩ + 13 kΩ 5.8 kΩ/MΩ + 0.12 MΩ 17 MΩ/GΩ + 0.57 MΩ	Fluke 5502A
Resistance Source <sup>3</sup>	500 kΩ 1 MΩ 5 MΩ 10 MΩ 25 MΩ 50 MΩ 100 MΩ 500 MΩ 1 GΩ 2 GΩ 50 GΩ 100 GΩ 200 GΩ	5.8 kΩ 12 kΩ 58 kΩ 120 kΩ 290 kΩ 580 kΩ 1.2 MΩ 5.8 MΩ 12 MΩ 25 MΩ 580 MΩ 1.2 GΩ 2.3 GΩ	MegOhm Resistance Test Box
Inductance - Source <sup>3</sup>	(1 to 10) mH (10 to 100) mH 100 mH to 1 H (1 to 10) H	23 μH/mH 12 μH/mH 8.7 μH/mH 9 mH/H	Decade Inductance Substituter
Inductance – Measure 1 kHz	100 μH to 1 H	1.2 mH + 2.7 μH/mH	B&K Precision 885 LCR/ESR Meter

Resistance Temperature Simulation <sup>3,4</sup>	<p><b>Pt 385, 100 Ω</b></p> <p>(-200 to 0) °C      0.05 °C</p> <p>(0 to 100) °C      0.07 °C</p> <p>(100 to 300) °C      0.09 °C</p> <p>(300 to 400) °C      0.10 °C</p> <p>(400 to 630) °C      0.12 °C</p> <p>(630 to 800) °C      0.23 °C</p>		Fluke 5502A
	<p><b>Pt 3926, 100 Ω</b></p> <p>(-200 to 0) °C      0.05 °C</p> <p>(0 to 100) °C      0.07 °C</p> <p>(100 to 300) °C      0.09 °C</p> <p>(300 to 400) °C      0.10 °C</p> <p>(400 to 630) °C      0.12 °C</p>		
	<p><b>Pt 3916, 100 Ω</b></p> <p>(-200 to -190) °C      0.25 °C</p> <p>(-190 to -80) °C      0.04 °C</p> <p>(-80 to 0) °C      0.05 °C</p> <p>(0 to 100) °C      0.06 °C</p> <p>(100 to 260) °C      0.07 °C</p> <p>(260 to 300) °C      0.08 °C</p> <p>(300 to 400) °C      0.09 °C</p> <p>(400 to 600) °C      0.10 °C</p> <p>(600 to 630) °C      0.23 °C</p>		
	<p><b>Pt 385, 200 Ω</b></p> <p>(-200 to 100) °C      0.04 °C</p> <p>(100 to 260) °C      0.05 °C</p> <p>(260 to 300) °C      0.12 °C</p> <p>(300 to 400) °C      0.13 °C</p> <p>(400 to 600) °C      0.15 °C</p> <p>(600 to 630) °C      0.16 °C</p>		
	<p><b>Pt 385, 500 Ω</b></p> <p>(-200 to -80) °C      0.04 °C</p> <p>(-80 to 100) °C      0.05 °C</p> <p>(100 to 260) °C      0.06 °C</p> <p>(260 to 400) °C      0.08 °C</p> <p>(400 to 600) °C      0.09 °C</p> <p>(600 to 630) °C      0.11 °C</p>		



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Resistance Temperature Simulation (cont.) <sup>3,4</sup>	<b>Pt 385, 1 000 Ω</b> (-200 to 0) °C (0 to 100) °C (100 to 260) °C (260 to 300) °C (300 to 600) °C (600 to 630) °C	0.03 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.23 °C	Fluke 5502A
	<b>PtNi 385, 120 Ω</b> (-80 to 100) °C (100 to 260) °C	0.08 °C 0.14 °C	
	<b>Cu 427, 10 Ω</b> (-100 to 260) °C	0.3 °C	
Resistance - Measure <sup>3</sup>	(0 to 10) Ω (10 to 100) Ω 100 Ω to 1 kΩ (1 to 10) kΩ (10 to 100) kΩ 100 kΩ to 1 MΩ (1 to 10) MΩ	0.49 mΩ 3.5 mΩ 20 mΩ 0.19 Ω 2 Ω 31 Ω 0.94 kΩ	Keysight 3458A
Capacitance – Measure <sup>3</sup>	(1 to 5) nF (5 to 50) nF (50 to 500) nF 500 nF to 5 μF	0.1 nF 1 nF 10 nF 0.15 nF	Fluke 87
Capacitance – Measure <sup>3</sup> 1 kHz	100 pF to 1μF	1.2 nF + 5.65 pF/nF	B&K Precision 885 LCR/ESR Meter
DC Power - Source <sup>3,4</sup>	(0.01to 337) W (0.01to 3 060) W 0.1 W to 20.91 kW	0.043 % 0.042 % 0.09 %	Fluke 5502A
DC Voltage - Source <sup>3</sup>	(0 to 330) mV 330 mV to 3.3 V (3.3 to 33) V (33 to 330) V 330 V to 1 kV	0.069 μV/mV + 3.5 μV 58 μV/V + 5.9 μV 60 μV/V + 0.06 mV 64 μV/V + 0.6 mV 63 μV/V + 2 mV	Fluke 5502A
DC Voltage - Measure <sup>3</sup>	(1 to 100) mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV	3.1 μV 19 μV 0.18 mV 1.8 mV 19 mV	Keysight 3458A



Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Capacitance - Source <sup>3</sup>	(190 to 400) pF 400 pF to 1.1 nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 33) nF (33 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF 330 μF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	5.7 fF/pF + 12 pF 5.6 pF/nF + 12 pF 5.3 pF/nF + 15 pF 2.7 pF/nF + 15 pF 2.4 pF/nF + 0.16 nF 2.8 pF/nF + 0.14 nF 2 nF/nF + 1 nF 2.8 nF/μF + 1.5 nF 1.9 nF/μF + 11 nF 2.8 nF/μF + 15 nF 3.7 nF/μF + 93 nF 5.2 nF/μF + 0.14 μF 4.1 μF/μF + 1 μF 4.6 μF/mF + 2.2 μF 4.2 μF/mF + 9.1 μF 5 μF/mF + 15 μF 8 μF/mF + 68 μF 13 μF/mF + 0.13 mF	Fluke 5502A
AC Power - Source <sup>3,4</sup> (45 to 65) Hz, PF=1	(0.108 9 to 2.97) mW (0.297 to 10.89) mW (1.089 to 29.7) mW (2.97 to 108.9) mW (10.89 to 297) mW (29.7 to 726) mW 72.6 mW to 1.49 W 149 mW to 6.76 W 1.09 mW to 9.18 W 2.97 mW to 33.6 W 10.9 mW to 91.8 W 29.7 mW to 337 W 109 mW to 918 W 297 mW to 2244 W 72.6 mW to 4.59 kW 1.49 W to 20.91 kW	0.16 % of reading 0.12 % of reading 0.16 % of reading 0.12 % of reading 0.14 % of reading 0.10 % of reading 0.14 % of reading 0.10 % of reading 0.15 % of reading 0.13 % of reading 0.15 % of reading 0.13 % of reading 0.13 % of reading 0.11 % of reading 0.14 % of reading 0.12 % of reading	Fluke 5502A





Electrical – DC/Low Frequency

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
AC Voltage Source <sup>3</sup>	<b>(1 to 33) mV</b>		Fluke 5502A
	(10 to 45) Hz	1.7 $\mu\text{V/mV}$ + 24 $\mu\text{V}$	
	45 Hz to 10 kHz	1.2 $\mu\text{V/mV}$ + 23 $\mu\text{V}$	
	(10 to 20) kHz	1.6 $\mu\text{V/mV}$ + 31 $\mu\text{V}$	
	(20 to 50) kHz	2.3 $\mu\text{V/mV}$ + 23 $\mu\text{V}$	
	(50 to 100) kHz	4.0 $\mu\text{V/mV}$ + 38 $\mu\text{V}$	
	(100 to 500) kHz	11.4 $\mu\text{V/mV}$ + 73 $\mu\text{V}$	
	<b>(33 to 330) mV</b>		
	(10 to 45) Hz	0.57 $\mu\text{V/mV}$ + 25 $\mu\text{V}$	
	45 Hz to 10 kHz	0.34 $\mu\text{V/mV}$ + 25 $\mu\text{V}$	
	(10 to 20) kHz	0.8 $\mu\text{V/mV}$ + 25 $\mu\text{V}$	
	(20 to 50) kHz	1.2 $\mu\text{V/mV}$ + 48 $\mu\text{V}$	
	(50 to 100) kHz	2.7 $\mu\text{V/mV}$ + 200 $\mu\text{V}$	
	(100 to 500) kHz	5.8 $\mu\text{V/mV}$ + 380 $\mu\text{V}$	
	<b>(0.33 to 3.3) V</b>		
	(10 to 45) Hz	0.57 mV/V + 0.1 mV	
	45 Hz to 10 kHz	0.34 mV/V + 0.09 mV	
	(10 to 20) kHz	0.81 mV/V + 0.08 mV	
	(20 to 50) kHz	1.2 mV/V + 0.082 mV	
	(50 to 100) kHz	2.7 mV/V + 0.24 mV	
	(100 to 500) kHz	5.7 mV/V + 1.2 mV	
<b>(3.3 to 33) V</b>			
(10 to 45) Hz	0.57 mV/V + 1.3 mV		
45 Hz to 10 kHz	0.24 mV/V + 5.9 mV		
(10 to 20) kHz	0.8 mV/V + 1 mV		
(20 to 50) kHz	1.1 mV/V + 1.1 mV		
(50 to 100) kHz	2.6 mV/V + 2.7 mV		
<b>(33 to 330) V</b>			
(10 to 45) Hz	0.57 mV/V + 6.4 mV		
45 Hz to 10 kHz	0.92 mV/V + 11 mV		
(10 to 20) kHz	1 mV/V + 12 mV		
(20 to 50) kHz	1.4 mV/V + 15 mV		
(50 to 100) kHz	2.7 mV/V + 110 mV		
<b>330 V to 1 kV</b>			
45 Hz to 1 kHz	0.57 mV/V + 29 mV		
(1 to 5) kHz	0.92 mV/V + 29 mV		
(5 to 10) kHz	1 mV/V + 28 mV		

AC Voltage - Measure <sup>3</sup>	<b>(1 to 10) mV</b>	
	(1 to 40) Hz	15 μV
	40 Hz to 1 kHz	14 μV
	(1 to 20) kHz	15 μV
	(20 to 50) kHz	20 μV
	(50 to 100) kHz	61 μV
	(100 to 300) kHz	0.46 mV
	<b>(10 to 100) mV</b>	
	(1 to 40) Hz	27 μV
	40 Hz to 1 kHz	26 μV
	(1 to 20) kHz	30 μV
	(20 to 50) kHz	45 μV
	(50 to 100) kHz	98 μV
	(100 to 300) kHz	0.36 mV
	300 kHz to 1 MHz	1.2 mV
	<b>100 mV to 1 V</b>	
	(1 to 40) Hz	0.20 mV
	40 Hz to 1 kHz	0.18 mV
	(1 to 20) kHz	0.23 mV
	(20 to 50) kHz	0.41 mV
	(50 to 100) kHz	0.96 mV
	(100 to 300) kHz	3.6 mV
	300 kHz to 1 MHz	12 mV
	<b>(1 to 10) V</b>	
(1 to 40) Hz	2 mV	
40 Hz to 1 kHz	1.8 mV	
(1 to 20) kHz	2.3 mV	
(20 to 50) kHz	4.1 mV	
(50 to 100) kHz	9.6 mV	
(100 to 300) kHz	36 mV	
300 kHz to 1 MHz	0.12 V	
<b>(10 to 100) V</b>		
(1 to 40) Hz	31 mV	
40 Hz to 1 kHz	29 mV	
(1 to 20) kHz	30 mV	
(20 to 50) kHz	46 mV	
(50 to 100) kHz	0.14 V	
<b>(100 to 700) V</b>		
40 Hz to 1 kHz	0.37 V	
<b>10 V to 2 kV</b>		
60 Hz	0.97 mV/V + 2.3 V	
<b>(2 to 40) kV</b>		
60 Hz	4.8 mV/V + 69 V	
		Keysight 3458A



Thermocouple Temperature Simulation <sup>3</sup>			
Type B	(600 to 800) °C		0.54 °C
	(800 to 1 000) °C		0.42 °C
	(1 000 to 1 550) °C		0.38 °C
	(1 550 to 1 820) °C		0.40 °C
Type C	(0 to 150) °C		0.36 °C
	(150 to 650) °C		0.31 °C
	(650 to 1 000) °C		0.37 °C
	(1 000 to 1 800) °C		0.59 °C
	(1 800 to 2 316) °C		0.98 °C
Type E	(-250 to -100) °C		0.59 °C
	(-100 to -25) °C		0.19 °C
	(-25 to 350) °C		0.16 °C
	(350 to 650) °C		0.19 °C
	(650 to 1 000) °C		0.24 °C
Type J	(-210 to -100) °C		0.32 °C
	(-100 to -30) °C		0.19 °C
	(-30 to 150) °C		0.16 °C
	(150 to 760) °C		0.20 °C
	(760 to 1 200) °C		0.27 °C
Type K	(-200 to -100) °C		0.39 °C
	(-100 to -25) °C		0.21 °C
	(-25 to 120) °C		0.19 °C
	(120 to 1 000) °C		0.30 °C
	(1 000 to 1 372) °C		0.46 °C
Type N	(-200 to -100) °C		0.47 °C
	(-100 to -25) °C		0.26 °C
	(-25 to 120) °C		0.22 °C
	(120 to 410) °C		0.21 °C
	(410 to 1 300) °C		0.31 °C
Type R	(0 to 250) °C		0.69 °C
	(250 to 400) °C		0.42 °C
	(400 to 1 000) °C		0.41 °C
	(1 000 to 1 767) °C		0.48 °C

Fluke 5502A

**Electrical – DC/Low Frequency**

<b>Parameter / Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method and/or Equipment</b>
Thermocouple Temperature Simulation <sup>3</sup> (cont.) Type S  Type T	(0 to 250) °C (250 to 1 000) °C (1 000 to 1 400) °C (1 400 to 1 767) °C  (-200 to -150) °C (-150 to 0) °C (0 to 120) °C (120 to 400) °C	0.59 °C 0.44 °C 0.45 °C 0.55 °C  0.75 °C 0.28 °C 0.19 °C 0.16 °C	Fluke 5502A
<b>Oscilloscopes</b> Amplitude <sup>3</sup> 50 Ω Load 1 MΩ Load	1.8 mV to 2.2 V <sub>pk-pk</sub> 1.8 mV to 105 V <sub>pk-pk</sub>	810 μV + 2.3 mV/V 81 μV + 2.7 mV/V	Fluke 5500A w/SC300
<b>Oscilloscopes</b> Time Marker <sup>3</sup> 50 Ω Load	(2 to 10) ns (20 to 1000) ns (2 to 50) μs (0.1 to 200) ms 500 ms 1 s 2 s 5 s	3.5 ps/ns 3.5 ps/ns 3.5 ns/μs 3.5 μs/ms 3.6 μs/ms 3.7 ms/s 4.2 m/s 6.8 ms/s	Fluke 5500A w/SC300
<b>Oscilloscopes</b> Bandwidth <sup>3</sup> relative to 50 kHz 50 Ω load	50 kHz to 100 MHz 100 MHz to 300 MHz	380 mV + 5.2 % of Reading 370 mV + 5.9 % of Reading	Fluke 5500A w/SC300
<b>Oscilloscopes</b> Bandwidth <sup>3</sup> relative to 50 kHz 50 Ω load	0.3 GHz to 1 GHz	1.3 mV + 60 μV/mV	Tektronix SG504
Risetime <sup>3</sup> 50 Ω load	≤ 300 ps	100 ps	Fluke 5500A w/SC300



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
RF Absolute Power Measure <sup>3,6</sup> (-23 ≤ P < +10) dBm (0.005 ≤ P < 10) mW  10 dBm ≤ P ≤ 20 dBm (10 ≤ P ≤ 100) mW  (-30 ≤ P < -10) dBm (1 ≤ P < 100) μW  -10 dBm ≤ P < 20dBm (0.1 ≤ P < 100) mW	100 MHz ≤ f < 6 GHz 6 GHz ≤ f ≤ 18 GHz  100 MHz ≤ f < 500 MHz 500 MHz ≤ f < 1.2 GHz 1.2 GHz ≤ f < 6 GHz 6 GHz ≤ f ≤ 18 GHz  100 kHz ≤ f < 10 MHz 10 MHz ≤ f < 1.2 GHz 1.2 GHz ≤ f ≤ 4.2 GHz  100 kHz ≤ f < 10 MHz 10 MHz ≤ f < 1.2 GHz 1.2 GHz ≤ f ≤ 4.2 GHz	2.8 % of Reading 4.58 % of Reading  7.5 % of Reading 4.7 % of Reading 4.5 % of Reading 5.3 % of Reading  2.6 % of Reading 4.1 % of Reading 4.7 % of Reading  11 % of Reading 6.5 % of Reading 6.6 % of Reading	8481A RF Power Sensor w/E4418B RF Power Meter          8482A RF Power Sensor w/E4418B RF Power Meter
RF Frequency Measure <sup>3</sup> Into 50 Ω Into 1 M Ω   Into 50 Ω	(10 to 525) MHz 10 Hz to 80 MHz   (10 to 100) MHz (0.1 to 1) GHz (1 to 10) GHz (10 to 20) GHz	1.8 Hz + 10.7 mHz/Hz 1.2 Hz + 19.3 nHz/Hz   1 Hz + 1.2 Hz/MHz 1 Hz + 120 Hz/GHz 1 Hz + 1.2 kHz/GHz 1 Hz + 8 kHz/GHz	5350B Frequency Counter
Total Harmonic Distortion – Measure <sup>3</sup>	5 Hz to 20 kHz (20 to 100) kHz	1.2 dB 2.3 dB	8903B Audio Analyzer
Absolute Power – Source <sup>3,6</sup> Into 50 Ω (0.050 to 10) V pp	Up to 100 kHz 100 kHz to 1 MHz (1 to 15) MHz	0.06 Vrms 0.075 Vrms 0.15 Vrms	33120A Arbitrary Generator
Absolute Power – Measure <sup>3</sup> (-120 to 20) dBm	10 MHz to 1.3 GHz	1.0 dB	DSA1030A-TG Spectrum Analyzer
Tuned RF Power – Measure <sup>3</sup> 2.5 MHz to 1.3 GHz	(-115 to 0) dBm (-127 to -115) dBm	1.97 dB 1.3 dB	8902A Modulation Analyzer with 11722A Sensor
Generated Power Into 50 Ω <sup>3</sup> (-127 to 13) dBm (-127 to 10) dBm (-127 to 7) dBm	277 kHz to 1 MHz 1 MHz to 3 GHz 3 GHz to 4 GHz	0.74 dB 1.2 dB 1.4 dB	ESG D4000 Signal Generator



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Frequency Modulation – Measure <sup>3</sup> Rate: 20 Hz to 10 kHz Deviation: <= 40 kHz  Rate: 20 Hz to 100 kHz <= 400 kHz  Rate: 20 Hz to 200 kHz <= 400 kHz	250 kHz to 10 MHz	410 Hz	8902A Modulation Analyzer
	10 MHz to 1.3 GHz	1.5 kHz	
	10 MHz to 1.3 GHz	5.9 kHz	
Phase Modulation – Measure <sup>3</sup>	Rate: 200 Hz to 10 kHz 150 kHz <= f <sub>c</sub> < 10 MHz	1.6 rad	8902A Modulation Analyzer
	Rate: 200 Hz to 20 kHz 10 MHz <= f <sub>c</sub> < 1.3 GHz	0.58 rad	
RF Frequency Time Based Aging <sup>3</sup>	10 MHz	1.0 parts in 10 <sup>-12</sup>	Fluke 910R GPS Controlled Atomic Clock
Amplitude Modulation - Measure <sup>3</sup> rate: 50 Hz to 10 kHz, depth: 5% to 99%  rate: 20 Hz to 10 kHz, depth: to 99%  rate: 50 Hz to 50 kHz, depth: 5% to 99%  rate: 20 Hz to 100 kHz, depth: to 99%	150 kHz to 10 MHz	2.5%	8902A Modulation Analyzer
	150 kHz to 10 MHz	3.7%	
	10 MHz to 1.3 GHz	1.5%	
	10 MHz to 1.3 GHz	3.7%	



Electrical - RF/Microwave

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment						
Attenuation – Source Coaxial, Fixed <sup>3</sup>	3 dB	DC to 8 GHz, SWR < 1.25:1	0.35 dB	8491A Coaxial Fixed Attenuator with Type-N					
		(8 to 12.4) GHz, SWR < 1.3:1	0.35 dB						
	6 dB	DC to 8 GHz, SWR < 1.2:1	0.47 dB		8491A Coaxial Fixed Attenuator with Type-N				
		(8 to 12.4) GHz, SWR < 1.3:1	0.47 dB						
	10 dB	DC to 8 GHz, SWR < 1.2:1	0.7 dB			8491A Coaxial Fixed Attenuator with Type-N			
		(8 to 12.4) GHz, SWR < 1.3:1	0.7 dB						
	20 dB	DC to 8 GHz, SWR < 1.2:1	0.7 dB				8491A Coaxial Fixed Attenuator with Type-N		
		(8 to 12.4) GHz, SWR < 1.3:1	0.7 dB						
	30 dB	DC to 8 GHz, SWR < 1.2:1	1.2 dB					8491A Coaxial Fixed Attenuator with Type-N	
		(8 to 12.5) GHz, SWR < 1.3:1	1.2 dB						
	60 dB	DC to 8 GHz, SWR < 1.2:1	2.3 dB						8491A Coaxial Fixed Attenuator with Type-N
		(8 to 12.5) GHz, SWR < 1.3:1	2.3 dB						
S12 – Reflection Magnitude Uncertainty <sup>3</sup> (Linear)	3 MHz to 3 GHz @ 0 dB	0.025 dB	E5071B Network Analyzer (Corrected using 85032E Cal Kit)						
	3 GHz to 6 GHz @ 0 dB	0.043 dB							
S21 – Transmission Magnitude Uncertainty <sup>3</sup> (dB)	3 MHz to 6 GHz @ 0 dB	0.05 dB	E5071B Network Analyzer (Corrected using 85032E Cal Kit)						
Thermal Noise Figure System – Measure <sup>3</sup> (0 to 30 dB)	10 MHz to 1.5 GHz SWR 1.7:1 ENR (14 to 16) dB	0.3 dB	8970A Noise Figure Meter w/346B Noise Source						



**Electrical - RF/Microwave**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Thermal Noise Figure System – Generate <sup>3</sup> ENR (14 to 16) dB	10 MHz to 18 GHz SWR 1.25:1	0.27 dB + 0.00315 dB/GHz	346B Noise Source

**Length – Dimensional Metrology**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) <sup>8</sup>	Reference Standard, Method and/or Equipment
Inside Micrometers <sup>3</sup> (0.001 in Resolution)	(0 to 4) in (4 to 20) in (20 to 36) in (36 to 60) in	580 μin (560 + 2.1L) μin (500 + 4.6L) μin (400 + 6.7L) μin	Gage Blocks
Feeler Gages	(0 to 0.25) in (0 to 6) mm	20 μin 0.51 μm	Gages Blocks and ULM
Surveillance Micrometer Masters	(1 to 12) in (25 to 300) mm	(5.5 + 11L) μin (0.14 + 0.011L) μm	Gages Blocks and ULM
Taper Thread Plugs Pitch Diameter	Up to 3 in	130 μin	Thread Measuring Wires, Taper Block, ULM
Major Diameter		100 μin	Taper Block and ULM
Length at Notch		250 μin	Gage Blocks, Height Gage
Radius Gage	(0 to 0.5) in	260 μin	Vision System
Rulers	Up to 24 in	0.0058 in	Vision System
Steel Tape <sup>3</sup>	Up to 10 m	250 μm	Master Tape
Vision System <sup>3</sup> XY Linearity Z Linearity	Up to 18 in Up to 4 in	100 μin 52 μin	Master Grid, Gage Blocks
Refractometer <sup>3</sup>	(0 to 30) °Brix	0.94 °Brix	Reference Solutions
Levels <sup>3</sup> Base Flatness Parallelism	(0 to 12) in	100 μin	Height Transfer Standard, Gage Blocks, Surface Plate
Metal / X-Ray Detector Standards <sup>7</sup>	(0.0315 to 0.28) in	(5.5 + 11L) μin	ULM





Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) <sup>8</sup>	Reference Standard, Method and/or Equipment
Gage Blocks	(0.01 to 8) in	(5 + 2.2L) μin	Reference Blocks, Comparator
Laser Micrometer <sup>2</sup> (1 μin Resolution)	(0.01 to 2) in	23 μin	XXX Pin Gage
Angle Blocks	(1 to 45) °	3 arc seconds	Sine Block, Height Transfer Standard, Surface Plate
Bench / Super Micrometers / ULMs			
Linearity	(0 to 4) in	(3 + 22L) μin	Gage Blocks
Anvil Parallelism	25 μin TIR	4 μin	Optical Flats w/Monochromatic Light
Force	2 ozf 4 ozf 8 ozf 16 ozf 40 ozf	0.019 ozf 0.021 ozf 0.027 ozf 0.74 ozf 0.78 ozf	Digital Force Gage
Snap Gages <sup>3</sup>	(0.05 to 4) in	22 μin	Gage Blocks
Pin Gages / Plug Gages <sup>2</sup>	(0.01 to 2) in	46 μin	Laser Micrometer
Pin Gages / Plug Gages	Up to 2 in (1.9 to 18) in	(6.9 + 10D) μin (4.7 + 11D) μin	ULM
Plain Rings	(0.275 to 13.25) in	(41 + 11D) μin	Master Rings, ULM
Thread Wires	Up to 0.14434 in	(11 + 13D) μin	ULM
Measuring Rods	(1 to 12) in (12 to 18) in	(5.5 + 11L) μin (1.7 + 12L) μin	Gage Blocks, ULM
Height Masters Micrometer Linearity Step Height, Top Step Height, Bottom Step Parallelism	(0 to 1) in (1 to 24) in  (0 to 100) μin	66 μin (43 + 2L) μin  84 μin	Height Transfer Standard, Gage Blocks, Surface Plate
Thread Plugs Pitch Diameter (5 to 100) TPI	Up to 8 in	(76 + 7.7D) μin	Thread Wires, ULM



Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) <sup>8</sup>	Reference Standard, Method and/or Equipment
Thread Rings <sup>2</sup>	Up to 2 in	340 μin	Reference Thread Plugs
External Spline Gages Measurement over Pins Circular Tooth Thickness Major Diameter	Up to 8 in	(180 + 30D) μin (120 + 20L) μin (30 + 16D) μin	Wires and ULM Vision System ULM
Chamfer Gages / Countersink Gages <sup>2</sup>	Up to 3 in	540 μin	Master Plain Rings
Bore Gages <sup>3</sup> (0.000 1 in Resolution)	(1 to 8) in	0.0018 in + 0.002 % of Reading	Bore Gage Calibrator
Calipers <sup>3</sup> (0.000 5 in Resolution)  (0.001 in Resolution)	(0.05 to 24) in  (0.05 to 12) in (12 to 60) in	470 μin  800 μin 1 800 μin	Gage Blocks, End Measuring Rods, Surface Plate
Outside Micrometers <sup>3</sup> 50 μin Resolution 100 μin Resolution  0.001 in Resolution	Up to 1 in (1 to 12) in  (12 to 20) in	(56 + 26L) μin (770 + 26L) μin  (1 600 + 106L) μin	Gage Blocks, End Measuring Rods
Depth Micrometers <sup>3</sup> (0.0001 in Resolution) (0.001 in Resolution)	(0 to 12) in	(88 + 4L) μin (890 + 23L) μin	Gage Blocks, Surface Plate
V-Anvil Outside Micrometers <sup>3</sup> 100 μin Resolution 500 μin Resolution	(0.4 to 1) in (1.25 to 4) in	60 μin (330 + 54L) μin	Plug Gages
Ultrasonic Thickness Gage <sup>3</sup>	(0 to 12) in	(760 + 13L) μin	Gage Blocks



Length – Dimensional Metrology

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) <sup>8</sup>	Reference Standard, Method and/or Equipment
Dial & Digital Indicators <sup>3</sup> 10 μin Resolution 20 μin Resolution	(-0.015 to 0.015) in (-0.001 to 0.001) in	7.3 μin 13 μin	Gage Blocks
50 μin Resolution 100 μin Resolution 500 μin Resolution 0.001 in Resolution	(0 to 2) in	61 μin 110 μin 300 μin 1 200 μin	Indicator Calibrator, Surface Plate
Test Indicators <sup>2</sup>	50 μin to 0.01 in	61 μin	Indicator Calibrator, Surface Plate
Height Gages <sup>3</sup> 50 μin Resolution	(0 to 12) in (12 to 36) in	(59 + 5L) μin (93 + 39L) μin	Gage Blocks, Surface Plate Measuring Rods
Extensometers <sup>3</sup> 50 μin Resolution	Up to 2 in	140 μin	Micrometer Head
Linear Scales <sup>3</sup> 0.005 in Resolution	(1 to 142) in	0.0095 in + 7 μin/in	Measuring Rods
Optical Comparators <sup>3</sup> Magnification Linearity (10 μin Resolution) Angularity	10x to 100x (0 to 6) in 0° to 30°	210 μin 120 μin 0° 2' 10"	Glass Scale, Angle Blocks
Coating Thickness <sup>3</sup> Measuring Systems	Up to 0.018 in	7.65 % of reading	Ferrous Coated Thickness Standards
Protractors	0° to 180°	3 arc seconds	Height Transfer Standard, Sine Block, Surface Plate
Microscopes <sup>3</sup>	(0 to 2) in	160 μin	Glass Scale
Profilometers <sup>3</sup>	(118 and 123) μin	3.1 μin	Roughness Standard
Roundness Measuring System <sup>3</sup> Radial Error	Up to 360°	5.5 μin	Precision Ball
CMM Linear Accuracy <sup>3</sup>	(0.5 to 24.5) in	(90 + 9.24L) μin	Step Gage
CMM Volumetric Accuracy <sup>3</sup>	(9 to 25) in	(0.88 + 23.56L) μin	Ball Bars
CMM Squareness <sup>3</sup>	(0.25 to 11.75) in	210 μin	Square and Indicator



**Length – Dimensional Metrology**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) <sup>8</sup>	Reference Standard, Method and/or Equipment
Surface Plates – Flatness <sup>2,8</sup>	Up to 68 Inches Diagonal	$(5 + 0.5D) \mu\text{in}$	Optodyne LDDM Laser Measurement System
Repeatability <sup>2</sup>	0.03 inch	16 $\mu\text{in}$	Repeat Reading Gage
Optical Flats	N/A	5 $\mu\text{in}$	Optical Flat and Monochromatic Light
Inclinometers	$(0 \text{ to } 45)^\circ$	0.06°	Sine Plate and Gage Blocks

**Mass**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Liquid Flow Rate Inline <sup>3</sup>	(0 to 65) gpm (0 to 150) gpm	0.6 gpm + 0.2 % of reading 0.3 gpm + 0.2 % of reading	Coriolis Meter
Liquid Flow Rate Non-Intrusive <sup>3</sup>	(0 to 500) gpm (500 to 900) gpm	0.5 gpm + 0.3% of reading 1 gpm + 0.4% of reading	Ultrasonic Transducers
Gas Flowmeters and Rotameters	(0 to 10) sccm (0 to 100) sccm (0 to 50) slpm	0.6 sccm + 1% of reading 0.9 sccm + 1% of reading 0.4 slpm + 0.8% of reading	Thermal Mass Flow Sensors
Air Flow Rate	(50 to 6 000) fpm	2 fpm + 1.25% of reading	Anemometer & Open Jet Wind Tunnel
Metal Detectors – Magnetic Separation <sup>3</sup>	(0.5 to 6) lbf	0.37 lbf	Digital Magnetic Pull Tester
Force Gauges <sup>3</sup>	(0 to 21.5) lbf (10 to 110) lbf (110 to 1 100) lbf	0.000 93 lbf + 0.035 % of reading 0.007 3 lbf + 0.043 % of reading 1 lbf + 0.041 % of reading	NIST Class F Weights
Force Machines <sup>3</sup> Tension	(103 to 2 500) lbf (261 to 10 000) lbf (1.658 to 60) klb (60 to 120) klb	2 lbf 5 lbf 12 lbf 16 lbf + 0.3 mlbf/lbf	Comparison with ASTM E74 Load Cell and Indicator
Force Machines <sup>3</sup> Compression	(50 to 2 500) lbf (280 to 10) klb (1 to 60) klb (60 to 120) klb (52 to 800) klb	2 lbf 7.5 lbf 17 lbf 16 lbf + 0.3 mlbf/lbf 10 lbf + 0.000 3 lbf/lbf	



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Ductility Tester / Olsen Cup Tester <sup>3</sup>	(0.3 to 6) klf (6 to 30) klf	7.5 lbf 17 lbf	Comparison with ASTM E74 Load Cell and Indicator
Tension Load Cell <sup>3</sup>	(64 to 500) lbf (103 to 2 500) lbf (261 to 10 000) lbf (1.658 to 60) klf (60 to 120) klf	1.2 lbf 2 lbf 5 lbf 12 lbf 16 lbf + 0.3 mlbf/lbf	
Compression Load Cell <sup>3</sup>	(48 to 500) lbf (50 to 2 500) lbf (280 to 10) klf (1 to 60) klf (60 to 120) klf (52 to 800) klf	1.2 lbf 2 lbf 7.5 lbf 17 lbf 16 lbf + 0.3 mlbf/lbf 10 lbf + 0.0003 lbf/lbf	
Rockwell Hardness Testers <sup>3</sup>	HRA Low Middle High	0.44 HRA 0.38 HRA 0.26 HRA	
Rockwell Hardness Testers <sup>3</sup>	HRBw Low Middle High	0.74 HRBw 0.69 HRBw 0.59 HRBw	Hardness Standards
Rockwell Hardness Testers <sup>3</sup>	HRC Low Middle High	0.41 HRC 0.36 HRC 0.36 HRC	
Rockwell Hardness Testers <sup>3</sup>	HRE Low High	0.62 HRE 0.55 HRE	
Rockwell Hardness Testers <sup>3</sup>	HRFw Low High	0.69 HRF 0.62 HRF	
Superficial Rockwell Hardness Testers <sup>3</sup>	HR15N Low Middle High	0.13 HR15N 0.16 HR15N 0.10 HR15N	

**Mass**

<b>Parameter / Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method and/or Equipment</b>
Superficial Rockwell Hardness Testers <sup>3</sup>	HR30N Low Middle High	0.67 HR30N 0.59 HR30N 0.51 HR30N	Hardness Standard
Superficial Rockwell Hardness Testers <sup>3</sup>	HR45N Low Middle High	0.49 HR45N 0.57 HR45N 0.50 HR45N	
Superficial Rockwell Hardness Testers <sup>3</sup>	HR15Tw Low Middle High	0.69 HR15Tw 0.62 HR15Tw 0.40 HR15Tw	
Superficial Rockwell Hardness Testers <sup>3</sup>	HR30Tw Low Middle High	0.52 HR30Tw 0.45 HR30Tw 0.44 HR30Tw	
Superficial Rockwell Hardness Testers <sup>3</sup>	HR45Tw Low Middle High	0.49 HR45Tw 0.46 HR45Tw 0.62 HR45Tw	
Leeb Hardness <sup>3</sup>	784 LD	17 LD	
Brinell Hardness Testers <sup>3</sup>	(500 to 3 000) kgf	6.7 kgf	Proving Ring
Brinell Hardness Testers <sup>3</sup>	Repeatability Error Range	7.2 HBW 0.057 mm (500 to 3 000) kgf	Hardness Standards
Brinell Scope <sup>3</sup>	(0 to 7) mm	6.7 μm	Stage Micrometer

Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Vickers Hardness Tester Force <sup>3</sup>	10 gf	1.1 gf	Force Gage
	25 gf	1.1 gf	
	50 gf	1.1 gf	
	100 gf	1.1 gf	
	200 gf	1.1 gf	
	300 gf	2.3 gf	
	500 gf	3.4 gf	
	1 kgf	6.6 gf	
	2 kgf	13 gf	
	5 kgf	33 gf	
	10 kgf	66 gf	
	20 kgf	0.13 kgf	
	30 kgf	0.20 kgf	
	50 kgf	0.33 kgf	
Knoop Hardness Tester Force <sup>3</sup>	10 gf	1.1 gf	Force Gage
	25 gf	1.1 gf	
	50 gf	1.1 gf	
	100 gf	1.1 gf	
	200 gf	1.1 gf	
	300 gf	2.3 gf	
	500 gf	3.4 gf	
	1 kgf	6.1 gf	
	3 kgf	11 gf	
	10 kgf	11 gf	
	15 kgf	11 gf	
	30 kgf	11 gf	
	45 kgf	11 gf	
	60 kgf	33 gf	
	100 kgf	33 gf	
150 kgf	33 gf		

Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Vickers Hardness Tester <sup>3</sup>	< 240 HV 0.01 > 600 HV 0.01	12 HV 0.01 44 HV 0.01	Hardness Standards
	< 240 HV 0.025 > 600 HV 0.025	11 HV 0.025 33 HV 0.025	
	< 240 HV 0.05 > 600 HV 0.05	11 HV 0.05 30 HV 0.05	
	< 240 HV 0.1 > 600 HV 0.1	11 HV 0.1 28 HV 0.1	
	< 240 HV 0.2 > 600 HV 0.2	9 HV 0.2 22 HV 0.2	
	< 240 HV 0.3 > 600 HV 0.3	9 HV 0.3 21 HV 0.3	
	< 240 HV 0.5 > 600 HV 0.5	8 HV 0.5 20 HV 0.5	
	< 240 HV 1 > 600 HV 1	7 HV 1 17 HV 1	
	< 240 HV 5 240 to 600 HV 5 > 600 HV 5	6 HV 5 13 HV 5 22 HV 5	
	< 240 HV 10 240 to 600 HV 10 > 600 HV 10	5 HV 10 10 HV 10 17 HV 10	
	< 240 HV 30 240 to 600 HV 30 > 600 HV 30	7 HV 30 11 HV 30 18 HV 30	





Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment	
Knoop Hardness Tester <sup>3</sup>	< 250 HK 0.01 > 650 HK 0.01	9 HK 0.01 35 HK 0.01	Hardness Standards	
	< 250 HK 0.025 > 650 HK 0.025	9 HK 0.025 24 HK 0.025		
	< 250 HK 0.05 > 650 HK 0.05	9 HK 0.05 22 HK 0.05		
	< 250 HK 0.1 > 650 HK 0.1	9 HK 0.1 21 HK 0.1		
		< 250 HK 0.2 > 650 HK 0.2	7 HK 0.2 17 HK 0.2	Hardness Standards
		< 250 HK 0.3 > 650 HK 0.3	7 HK 0.3 21 HK 0.3	
		< 250 HK 0.5 > 650 HK 0.5	7 HK 0.5 18 HK 0.5	
		< 250 HK 1 > 650 HK 1	8 HK 1 18 HK 1	
	Pressure <sup>3</sup>	(20 to 200) in H <sub>2</sub> O	0.72 in H <sub>2</sub> O	Manometer Calibrator
(10 to 2000) psig (100 to 10 000) psig		0.27 psig + 0.18% of reading 0.52 psig + 0.075% of reading	Deadweight Testers	
(0 to 1 000) psig (10 000 to 100 000) psig		0.54 psig + 0.03% of reading 380 psig + 0.04% of reading	Pressure Calibrator/ Comparison to High Accuracy Gage	
Vacuum <sup>3</sup>	(-660 to 0) mmHg	0.83 mmHg + 0.68 % of reading	Pressure Calibrator	



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Conventional Mass NIST Class F	(1 to 40) g	20 µg + 6 µg/g	Comparison to ASTM Class 1 Weights
	(40 to 100) g	110 µg + 4 µg/g	
	(100 to 220) g	170 µg + 5 µg/g	
	(0.22 to 3.1) kg	36 mg + 0.001 24 mg/g	
	500 g	27 mg	
	1 kg	27 mg	
Conventional Mass NIST Class F	5 kg	36 mg	Comparison to ASTM Class 1 Weights
	10 kg	39 mg	
	20 kg	490 mg	
	0.5 lb	26 mg	
	1 lb	27 mg	
	2 lb	27 mg	
	5 lb	14 mg (0.45 oz)	
10 lb	21 mg (0.68 oz)		
Weighing Systems <sup>3</sup> 0.000 01 g Resolution	(0 to 40) g	15 µg + 5 µg / g	Comparison to ASTM Class 1 Weights
	(40 to 100) g	89 µg + 3 µg / g	
		140 µg + 4 µg/g	
	(100 to 220) g	120 µg + 8 µg/g	
	(0 to 310) g	4.6 mg + 2µg/g	
	(0 to 14 200) g	63 mg + 1.96µg/g	
Weighing Systems <sup>3</sup> 0.000 1g Resolution	(0 to 10) lb	0.0045 lb	Comparison to ASTM Class 3 & NIST Class F Weights
	(0 to 50) lb	0.07 oz + 0.013 % of reading	
	(25 to 250) lb	0.023 lb + 4 % of reading	
	(50 to 500) lb	0.082 lb + 0.29 % of reading	



Mass

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Weighing Systems <sup>3</sup> 0.2 lb Resolution	(100 to 1 000) lb	0.4 lb	Comparison to ASTM Class 3 & NIST Class F Weights
Moisture Analyzers <sup>3</sup>  Weighing System  Temperature	(0 to 220) g  160 °C	140 µg + 4 µg / g  2.5 °C	Comparison to ASTM Class 1 Weights  Reference Thermometer
Torque Watch <sup>3</sup>	(0.5 to 2.5) ozf·in (2 to 10) ozf·in (6 to 43) ozf·in (30 to 215) ozf·in	0.08 ozf·in + 0.3 % of reading 0.07 ozf·in + 0.2 % of reading 0.3 ozf·in + 0.2 % of reading 3 ozf·in + 0.2 % of reading	Torque Watch Calibrator
Torque Wrenches <sup>3</sup>	(2.5 to 25) lbf·in (25 to 250) lbf·in (100 to 1 000) lbf·in (25 to 250) lbf·ft (80 to 800) lbf·ft	0.05 lbf·in + 0.54 % of reading 0.02 lbf·in + 0.64 % of reading 0.24 lbf·in + 0.76 % of reading 0.05 lbf·in + 1.2 % of reading 2 lbf·ft	Torque Wrench Calibration System
Torque Analyzers, Transducers <sup>3</sup>	(2.5 to 25) lbf·in (25 to 250) lbf·in (100 to 1 000) lbf·in (300 to 3 000) lbf·in (100 to 1 200) lbf·ft	0.4 % of reading 0.0041% of reading + 0.13 lbf·in 0.06% of reading + 0.066 lbf·in 0.04% of reading + 0.11 lbf·in 0.024% of reading + 0.07 lbf·ft	Torque Arms with NIST Class F Weights
Torque Watch Calibrators <sup>3</sup>  Masses  Dial	0.5 oz 2 oz 8.5 oz 42.5 oz  13.25 ° 76.75 °	4 µoz 12 µoz 1.3 moz 1.4 moz  0.58 ° 0.58 °	Comparison to ASTM Class 1 Weights  Masses
Gloss Meters <sup>3</sup>	92.1 GU, 20 ° 94.9 GU, 60 ° 99.5 GU, 85 °	0.088 GU 0.8 GU 0.82 GU	Gloss Standard ASTM D523-08
Gauss Meters / Hall Effect Meters	(-5 to 5) Gauss (-10 to 10) Gauss (-20 to 20) Gauss (-50 to 50) Gauss (-100 to 100) Gauss	0.1 Gauss 0.2 Gauss 0.4 Gauss 1 Gauss 2 Gauss	Helmholtz Coil and Power Supply



**Mass**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Rotational Viscometers	(0 to 2 000) RPM	2.5 RPM + 0.67 % of reading	Optical Tachometer

**Photometry and Radiometry**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Spectrophotometers Total Hemispherical Diffuse Reflectance <sup>3</sup> (8°:t)	(360 to 830) nm	0.08 % Reflectance Value	Ceramic Reflectance Standards

**Thermodynamic**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Thermometers <sup>3</sup>	(-196 to 0) °C (0 to 420) °C	0.031 °C + 80 μK/°C 0.031 °C + 11μK/°C	SPRT
Humidity Indicators at 23 ± 5 °C <sup>3</sup>	11 % RH 33 % RH 75 % RH 98 % RH	1.7 % RH 1.5 % RH 1.9 % RH 2.8 % RH	Vaisala Humidity HMK15 Calibrator and Salts
Humidity Indicators	(10 to 95) %RH	0.16% of Reading + 0.67 %RH	Thunder Scientific 1200
Pyrometers - Source <sup>3</sup>	(100 to 982) °C	1.9 °C + 0.46 % of Reading	IR Blackbody ε = 0.99
Ovens, Incubators, Stirred Water Baths & Fridges <sup>3</sup>	(0 to 100) °C (0 to 600) °C (-190 to 1 300) °C  (-50 to 500) °C	2.8 °C + 0.16 % of Reading 2.8 °C + 0.5 % of Reading 3.9 °C + 0.6 % of Reading  1 °C + 0.5% of Reading	Process Calibrator and Thermocouple  Process Calibrator and Pt100 RTD Probe
Thermocouples and Thermometers <sup>3</sup>	(-15 to 110) °C (50 to 350) °C	0.41 °C 0.77 °C	Dry Block Calibrator
Air Probes	(-40 to 0) °C (0 to 100) °C (100 to 130) °C	3.2 °C + 0.3 % of Reading 3.2 °C + 0.4 % of Reading 3.2 °C + 0.6 % of Reading	Thermal Chamber



**Time and Frequency**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Optical Tachometer <sup>3</sup> (Non-Contact)	(60 to 100 000) rpm	0.025 % of reading	Function Generator and LED Light Source
Stopwatches and Timers <sup>3</sup>	Up to 48 hr	40 msec	Function Generator and Frequency Counter
Contact Tachometers <sup>3</sup>	(10 to 10 000) RPM	2.5 RPM + 0.67 % of reading	Tachometer Standard
Frequency - Source <sup>3</sup>	(0.01 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 12) kHz (12 to 120) kHz 120 kHz to 1.2 MHz (1.2 to 2) MHz	0.013 Hz 0.13 Hz 1.3 Hz 13 Hz 130 Hz 1.3 kHz	Fluke 5502A
Frequency - Source <sup>3</sup>	(2 to 8.4) GHz	12 Hz	Anritsu MG3691A

**Testing - Mechanical**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Rockwell Hardness	HRA, HRB, HRC	ASTM E18	Rockwell Hardness Tester
Rockwell Superficial Hardness	HR15N, HR30N, HR45N, HR15TW, HR30TW, HR45TW	ASTM E18	Rockwell Hardness Tester
Brinell Hardness	BHN	ASTM E10	Brinell Hardness Tester
MicroHardness	Knoop, Vickers	ASTM E384	MicroHardness Tester

**Testing – Dimensional Measurement/Testing**

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) <sup>8</sup>	Reference Standard, Method and/or Equipment
Length	(0 to 12) in (12 to 18) in	(5.5 + 11L) μin (2.7 + 12L) μin	ULM



Testing – Dimensional Measurement/Testing

Parameter / Equipment	Range	Expanded Uncertainty of Measurement (+/-) <sup>8</sup>	Reference Standard, Method and/or Equipment
Diameter/Radius	(0 to 24) in	(260 + 4D) μin	Vision System
Dimensional Measurement 3D	X = (0 to 18) in Y = (0 to 20) in Z = (0 to 16) in	(370 + 11L) μin	Coordinate Measuring Machine utilized as Reference Standard for Dimensional Measurement

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 (k=2), corresponding to a confidence level of approximately 95%.

Notes:

1. Calibration and Measurement Capabilities (Expanded Uncertainties) are based on approximately a 95% confidence interval, using a coverage of k=2.
2. This laboratory calibration services in its laboratory and on-site at customer-designated locations. Since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
3. On-site calibration service is offered for these parameters.
4. The uncertainty does not include gage R&R study, and the unit under test resolution. Larger measurement uncertainties are expected.
5. Sine wave relative to 1 kHz
6. P = Power in dBm
7. This calibration is only applicable to the dimensional properties. The metallurgical properties / composition of the test spheres are not tested.
8. L = Length in inches and D = Diameter in inches.
9. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1886.



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Vice President

