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**CALIBRATION**

Valid to: **May 4, 2024**

Certificate Number: **AC-1452**

**Chemical Quantities**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
CO <sub>2</sub> Measurement <sup>1</sup>	1 % 5 % 10 %	0.4 % 0.4 % 0.5 %	GD444 CO2 Analyzer
CO <sub>2</sub> Analyzer	1 % 5 % 10 %	0.3 % 0.3 % 0.4 %	Certified gases

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometers <sup>1</sup>	Up to 1 in	74 μin	Gage Blocks
Calipers <sup>1</sup>	Up to 12 in (12.1 to 24) in	770 μin 740 μin	Gage Blocks
Pin and Plug Gages	Up to 0.03 in (0.04 to 4) in (4 to 6) in	11 μin 37 μin 55 μin	Gage Blocks LabMaster Universal

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Block	Up to 0.05 in (0.05 to 0.5) in (0.5 to 1) in (1 to 2) in (2 to 3) in (3 to 4) in (4 to 6) in	4.6 μin 6.2 μin 9.5 μin 18 μin 26 μin 27 μin 51 μin	Gage Blocks LabMaster Universal
Ring Gage	Up to 0.5 in (0.5 to 1) in (1 to 3) in	6.2 μin 12 μin 27 μin	Gage Blocks LabMaster Universal
Thread Plug Gage Major Diameter Pitch	(4 to 80) TPI Up to 4 in Up to 4 in	81 μin 38 μin	Gage Blocks LabMaster Universal Thread Measuring Wires

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pressure Gages <sup>1</sup>	Up to 15 psiv (-0.27 to -0.04) psia (-0.04 to 0.04) psia (0.04 to 0.27) psia Up to 60 psia Up to 5 psig (5 to 60) psig (60 to 200) psig (200 to 500) psig (500 to 3 000) psig (3 000 to 7 500) psig	0.005 5 psiv 0.000 4 psia 0.000 5 psia 0.000 4 psia 0.022 psia 0.003 1 psig 0.027 psi 0.072 psi 0.19 psi 1.1 psi 5.5 psi	Pressure Indicator and Modules
Laboratory Balance / Scale <sup>1</sup> (0.001 mg resolution)	0 to 5 g	0.044 mg	Class 1 Weights
(0.01 mg resolution)	0 to 62 g 0 to 300 g	0.25 mg 0.88 mg	
(0.1 mg resolution)	0 to 1 000 g	2.9 mg	
(0.01 g resolution)	0 to 6 000 g	120 mg	
(0.1 g resolution)	0 to 15 000 g	0.24 g	
(1 g resolution)	0 to 35 000 g	2.4 g	

### Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Industrial Scale <sup>1</sup> (0.01 kg resolution)	0 to 100 kg	0.012 kg	Class F Weights
(0.1 kg resolution)	0 to 250 kg	0.12 kg	
Pipettes	(0.2 to 100) $\mu$ L (100 to 1 000) $\mu$ L 1 000 $\mu$ L to 20 mL	0.052 $\mu$ L 0.37 $\mu$ L 1.8 $\mu$ L	Laboratory Balance

### Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure and Source <sup>1</sup>	(-196 to 0) °C (0 to 50) °C (50.1 to 100) °C (100.1 to 200) °C (200.1 to 300) °C	0.039 °C 0.036 °C 0.042 °C 0.044 °C 0.055 °C	Hart 1502A w/SPRT
Temperature-measure Thermocouples <sup>1</sup> Type J Type K Type T	(-196 to 400) °C (-196 to 400) °C (-196 to 400) °C	0.61 °C 0.65 °C 0.65 °C	HP 3457A w/Thermocouple Half Junction
Humidity Device Calibration	(5 to 95) % RH	0.7% RH	Dew Point Hygrometer
Humidity Measurement <sup>1</sup>	(0 to 90) % (90 to 100) %	1.8% RH 2.7% RH	Vaisala RH Meter

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source	Up to 330 mV 330 mV to 3.29 V (3.3 to 32.9) V (33 to 329) V (330 to 1000) V	0.009 mV 0.046 mV 0.49 mV 6.5 mV 23 mV	Fluke 5522A
DC Voltage – Measure	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V (100 to 1000) V	0.009 3 mV 0.005 8 mV 0.055 mV 0.78 mV 8.4 mV	HP 3458A Option 2
DC Current – Source	Up to 330 $\mu$ A 330 $\mu$ A to 3.3 mA (3.2 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3.0) A (3.0 to 11) A (11 to 20.5) A	0.081 $\mu$ A 0.45 $\mu$ A 0.004 2 mA 0.042 mA 0.000 26 A 0.001 4 A 0.006 4 A 0.024 A	Fluke 5522A
DC Current – Measure	Up to 100 $\mu$ A 100 $\mu$ A to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A (1 to 5) A (5 to 10) A (10 to 20) A	0.003 4 $\mu$ A 0.000 03 mA 0.000 3 mA 0.004 9 mA 0.000 14 A 0.16 A 0.002 3 A 0.002 3 A	HP 3458A Option 2 (Values over 1A shunted) Agilent 34330A Shunt
AC Voltage – Source	Up to 33 mV Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 450) kHz	0.038 mV 0.038 mV 0.013 mV 0.013 mV 0.015 mV 0.046 mV 0.15 mV 0.37 mV	Fluke 5522A

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source	33 to 330 mV Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 500) kHz	0.067 mV 0.06 mV 0.028 mV 0.028 mV 0.030 mV 0.052 mV 0.14 mV 0.33 mV	Fluke 5522A
	0.33 to 3.3 V Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 450) kHz	1.3 mV 1.2 mV 0.65 mV 0.65 mV 0.8 mV 1.3 mV 2.9 mV 9.9 mV	
	3.3 to 33 V Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 90) kHz	14 mV 13 mV 6.5 mV 6.5 mV 9.9 mV 15 mV 37 mV	
	33 to 330 V Up to 45 Hz 45 Hz to 1 kHz (1 to 10) kHz (10 to 20) kHz (20 to 50) kHz (50 to 100) kHz	76 mV 76 mV 84 mV 110 mV 34 mV 78 mV	
	330 to 1000 V Up to 45 Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	360 mV 360 mV 310 mV 360 mV	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	Up to 10 mV		HP 3458A Option 2
	Up to 20 Hz	0.084 mV	
	(20 to 40) Hz	0.047 mV	
	(40 to 100) Hz	0.036 mV	
	100 Hz to 20 kHz	0.032 mV	
	(20 to 50) kHz	0.047 mV	
	(50 to 100) kHz	0.13 mV	
	(100 to 250) kHz	0.55 mV	
	(10 to 100) mV		
	Up to 20 Hz	0.49 mV	
	(20 to 40) Hz	0.2 mV	
	(40 to 100) Hz	0.081 mV	
	100 Hz to 20 kHz	0.035 mV	
	(20 to 50) kHz	0.22 mV	
	(50 to 100) kHz	0.79 mV	
	(100 to 300) kHz	2.9 mV	
300 kHz to 1 MHz	8.1 mV		
(1 to 2) MHz	18 mV		
100 mV to 1 V			
Up to 20 Hz	4.9 mV		
(20 to 40) Hz	2 mV		
(40 to 100) Hz	0.81 mV		
100 Hz to 20 kHz	0.35 mV		
(20 to 50) kHz	2.2 mV		
(50 to 100) kHz	7.9 mV		
(100 to 300) kHz	29 mV		
(300 to 500) kHz	42 mV		
500 kHz to 1 MHz	81 mV		
(1 to 2) MHz	180 mV		
(1 to 10) V			
Up to 20 Hz	49 mV		
(20 to 40) Hz	20 mV		
(40 to 100) Hz	8.1 mV		
100 Hz to 20 kHz	3.5 mV		
(20 to 50) kHz	22 mV		
(50 to 100) kHz	79 mV		
(100 to 300) kHz	290 mV		
300 kHz to 1 MHz	810 mV		

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage - Measure	(10 to 100) V Up to 20 Hz (20 to 40) Hz (40 to 100) Hz 100 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.49 V 0.2 V 0.082 V 0.047 V 0.22 V 0.79 V 2.9 V 8.1 V	HP 3458A Option 2
	(100 to 1 000) V Up to 40 Hz (40 to 100) Hz 100 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz	2.3 V 1.2 V 0.93 V 2.2 V 9.3 V	
AC Current - Source	Up to 330 $\mu$ A Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.89 $\mu$ A 0.7 $\mu$ A 0.6 $\mu$ A 1.4 $\mu$ A 3.3 $\mu$ A 6.6 $\mu$ A	Fluke 5522A
	330 $\mu$ A to 3.3 mA Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.008 2 mA 0.005 3 mA 0.004 0 mA 0.007 9 mA 0.02 mA 0.039 mA	
	(3.3 to 33) mA Up to 10 Hz 10 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	0.071 mA 0.16 mA 0.31 mA 0.08 mA 0.16 mA	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current - Source	(33 to 330) mA Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (10 to 30) kHz	1.6 mA 0.6 mA 0.26 mA 0.18 mA 0.36 mA 1.8 mA	Fluke 5522A
	(0.33 to 1.1) A Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	7.1 mA 5.2 mA 2.2 mA 2.2 mA 7.1 mA	
	(1.1 to 3) A Up to 10 Hz (10 to 45) Hz 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	11 mA 35 mA 1.2 mA 2.2 mA 6.8 mA	
	(3 to 11) A Up to 45 Hz (45 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz	11 mA 11 mA 16 mA 16 mA 390 mA	
	(11 to 20.5) A Up to 45 Hz (45 to 65) Hz (65 to 500) Hz 500 Hz to 1 kHz (1 to 5) kHz	35 mA 35 mA 42 mA 42 mA 720 mA	
AC Current - Measure	Up to 100 $\mu$ A Up to 20 Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 1 kHz	0.5 $\mu$ A 0.21 $\mu$ A 0.11 $\mu$ A 0.11 $\mu$ A	HP 3458A Opt 2 w/ Agilent 34330A Current Shunt for values over 1 A



**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current - Measure	100 $\mu$ A to 100 mA Up to 20 Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz (20 to 50) kHz (50 to 100) kHz	0.49 mA 0.2 mA 0.093 mA 0.061 mA 0.51 mA 0.81 mA 0.81 mA	HP 3458A Opt 2 w/ Agilent 34330A Current Shunt for values over 1 A
	100 mA to 1 A Up to 20 Hz (20 to 45) Hz (45 to 100) Hz 100 Hz to 5 kHz (5 to 20) kHz	0.016 A 0.006 6 A 0.017 A 0.018 A 0.0073 A	
	(1 to 5) A Up to 1 kHz (1 to 5) kHz	0.17 A 0.17 A	
	(5 to 10) A Up to 1 kHz (1 to 5) kHz	0.029 A 0.15 A	
	(10 to 20) A Up to 1 kHz (1 to 5) kHz	0.0132A 0.15 A	
Resistance - Source	Up to 10 $\Omega$ (10 to 100) $\Omega$ 100 $\Omega$ to 1.0 k $\Omega$ (1.0 to 10.0) k $\Omega$ (10.0 to 100.0) k $\Omega$ 100.0 k $\Omega$ to 1.0 M $\Omega$ (1.0 to 10.0) M $\Omega$ (10.0 to 100.0) M $\Omega$ 100.0 to 1.0 G $\Omega$	0.012 $\Omega$ 0.005 $\Omega$ 0.000 095 k $\Omega$ 0.003 5 k $\Omega$ 0.003 6 k $\Omega$ 0.000 04 M $\Omega$ 0.001 M $\Omega$ 0.021 M $\Omega$ 0.003 6 G $\Omega$	Fluke 5522A
Resistance - Sense	Up to 10.0 $\Omega$ (10.0 to 100.0) $\Omega$ 100.0 $\Omega$ to 1.0 k $\Omega$ (1.0 to 10.0) k $\Omega$ (10.0 to 100.0) k $\Omega$ 100.0 k $\Omega$ to 1.0 M $\Omega$ (1.0 to 10.0) M $\Omega$ (10.0 to 100.0) M $\Omega$	0.000 26 $\Omega$ 0.002 2 $\Omega$ 0.007 1 $\Omega$ 0.000 13 k $\Omega$ 0.001 5 k $\Omega$ 0.000 023 M $\Omega$ 0.000 71 M $\Omega$ 0.059 M $\Omega$	HP 3458A Option 2

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Temperature Simulation Type B	(600 to 800) °C	0.38 °C	Fluke 5522A
	(800 to 1 000) °C	0.31 °C	
	(1 000 to 1 550) °C	0.27 °C	
	(1 550 to 1 820) °C	0.30 °C	
Type E	(-250 to -100) °C	0.41 °C	
	(-100 to -25) °C	0.18 °C	
	(-25 to 350) °C	0.17 °C	
	(350 to 650) °C	0.18 °C	
	(650 to 1 000) °C	0.21 °C	
Type J	(-210 to -100) °C	0.25 °C	
	(-100 to -30) °C	0.18 °C	
	(-30 to 150) °C	0.17 °C	
	(150 to 760) °C	0.18 °C	
	(760 to 1 200) °C	0.22 °C	
Type K	(-200 to -100) °C	0.29 °C	
	(-100 to -25) °C	0.19 °C	
	(-25 to 120) °C	0.18 °C	
	(120 to 1 000) °C	0.24 °C	
	(1 000 to 1 372) °C	0.34 °C	
Type N	(-200 to -100) °C	0.34 °C	Fluke 5522A
	(-100 to -25) °C	0.22 °C	
	(-25 to 120) °C	0.20 °C	
	(120 to 410) °C	0.19 °C	
	(410 to 1 300) °C	0.25 °C	
Type R	(0 to 250) °C	0.46 °C	
	(250 to 400) °C	0.30 °C	
	(400 to 1 000) °C	0.30 °C	
	(1 000 to 1767) °C	0.35 °C	
Type S	(0 to 250) °C	0.39 °C	
	(250 to 1000) °C	0.31 °C	
	(1 000 to 1 400) °C	0.33 °C	
	(1 400 to 1 767) °C	0.40 °C	
Type T	(-250 to -150) °C	0.51 °C	
	(-150 to 0) °C	0.24 °C	
	(0 to 120) °C	0.19 °C	
	(120 to 400) °C	0.19 °C	

**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RPM Measurement <sup>1</sup>	(6 to 8 300) RPM (8 300 to 19 000) RPM	2.2 RPM 2.9 RPM	Shimpo Tachometer
Optical Tachometer	(6 to 600) RPM (600 to 60 000) RPM	0.17 RPM 1.2 RPM	Agilent 53181A
Frequency Measure	Up to 1MHz 1 MHz to 100 MHz 100 MHz to 200 MHz 200 MHz to 225 MHz	0.002 2 Hz 0.071 Hz 0.14 Hz 0.16 Hz	Agilent 53181A
Frequency Source	Up to 119 Hz 119 Hz to 1199 Hz 1199 Hz to 11.99 kHz 11.99 kHz to 119.99 kHz 119.99 kHz to 500 kHz	0.000 32 Hz 0.003 Hz 0.032 Hz 0.3 Hz 1.3 Hz	Fluke 5520A w/ Agilent 53181A

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

Notes:

1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
2. This scope is formatted as part of a single document including Certificate of Accreditation No. AC-1452.



Jason Stine, Vice President