

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

<p>ESSCO CALIBRATION LABORATORY 27 Industrial Avenue, Unit #9 Chelmsford, MA 01824-3618 Mr. James Murphy Phone: 800-325-2201 Ext:156 Fax 978-256-1331 E-mail: jmurphy@esscolab.com URL: http://www.esscolab.com</p>	<p>Fields of Calibration Dimensional Electromagnetics – DC/Low Frequency Time and Frequency Mechanical Electromagnetics – RF/Microwave Thermodynamic</p> <p>This laboratory is compliant to ANSI/NCSL Z540-1-1994; Part 1. (NVLAP Code: 20/A01)</p>
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CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks
DIMENSIONAL			
GAGE BLOCKS (20/D03)			
Gage Block Calibration	0.01 in to 0.049 in 0.05 in to 0.5 in > 0.5 in to 1 in > 1 in to 2 in > 2 in to 3 in > 3 in to 4 in > 4 in to 5 in > 5 in to 6 in > 6 in to 8 in > 8 in to 10 in > 10 in to 12 in > 12 in to 16 in > 16 in to 20 in	2.8 µin 2.4 µin 3.0 µin 4.5 µin 5.1 µin 6.4 µin 9.0 µin 10 µin 11 µin 13 µin 15 µin 18 µin 22 µin	Comparison to master blocks
LENGTH & DIAMETER (20/D05)			
Length Standards, Rods	0.1 in to 40 in	2.0 µin/in + 9.6 µin	Comparison to gage blocks
Calipers ^{Note 4}	0 in to 120 in	9.6 µin/in + 290 µin	Comparison to gage blocks
Thickness Setting Discs	0.01 in to 0.24 in	21 µin	Comparison to gage blocks



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

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Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
Micrometer ^{Note 4}	0 in to 40 in	2.1 $\mu\text{in/in}$ + 28 μin	Comparison to gage blocks
Supermicrometer	0 in to 1 in	12 μin	Comparison to gage blocks
Anvil Parallelism ^{Note 4}	0 μin nominal	13 μin	Optical flat
Anvil Flatness ^{Note 4}	0 μin nominal	5.4 μin	Optical flat
Optical Flats & Parallels			
Flatness	0 μin nominal	2.3 μin	Comparison to standard flat
Parallelism	0 μin nominal	2.7 μin	Gage block comparator
Bore Micrometers and Gages	0.0625 in to 8 in	7.8 $\mu\text{in/in}$ + 47 μin	Comparison to master rings
Dial/Test Indicator ^{Note 4}	0 in to 12 in	1.7 $\mu\text{in/in}$ + 6.7 μin	Gage blocks or Micrometer head
Height Gages ^{Note 4}	0 in to 40 in	1.3 $\mu\text{in/in}$ + 17 μin	Comparison to gage blocks
Depth Gages ^{Note 4}	0 in to 12 in	2.3 $\mu\text{in/in}$ + 29 μin	Comparison to gage blocks
Feeler Gage	Up to 0.2 in	32 μin	Supermicrometer
Durometer (Indentor Length)	0.05 in 0.10 in 0.20 in	0.00019 in 0.00019 in 0.00022 in	Comparison to gage blocks (Note: Spring force component listed in mechanical section)
Electronic Gage Amplifier	0 in to 1 in	8.2 μin	Comparison to gage blocks
Crimp Tools – Crimp Height	0.011 to 1 in	0.00046 in	Indirect comparison to crimp micrometer
MEASURING WIRES (20/D07)			
Thread Wires	4 threads/in to 120 threads/in	8.9 μin	Labmaster, gage blocks

2024-06-06 through 2025-06-30
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CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

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OPTICAL REFERENCE PLANES (20/D08)			
Glass Reticules, Stage Micrometers	0 in to 1 in 1 in to 2 in	0.00021 in 0.00043 in	Microscope w/micrometer head
SPHERICAL DIAMETER, PLAIN PLUG/RINGS (20/D11)			
Pin Gages (Class Z & ZZ) ^{Note 4}	0.004 in to 1 in 0.004 in to 1 in	60 μ in 36 μ in/in + 7.9 μ in	Supermicrometer Laser Micrometer
Plain Plugs (Class Y to XXX)	0 in to 12 in	2.9 μ in/in + 3.1 μ in	Labmaster
Plain Ring Gages Discrete sizes	0.04 in 0.125 in 0.25 in 1.0 in 4.0 in	6.4 μ in 5.7 μ in 4.7 μ in 5.1 μ in 8.8 μ in	Comparison to master gages
Variable Range	0.040 in to 0.044 in > 0.044 in to 0.125 in >0.125 in to 0.186 in >0.186 in to 0.25 in >0.25 in to 0.628 in >0.628 in to 1.0 in >1.0 in to 1.628 in >1.628 in to 4.0 in >4.0 in to 12 in	1100 μ in/in - 33 μ in 21 μ in - 110 μ in/in 99 μ in/in - 5 μ in 34 μ in - 110 μ in/in 1.4 μ in + 19 μ in/in 23 μ in - 15 μ in/in 12 μ in/in - 4.2 μ in 16 μ in - 0.17 μ in/in 5 μ in + 2.6 μ in/in	Comparison to master gages
Crimp Tools – Die Dimension	0.005 in to 0.5 in	0.00062 in	Pin gages
SURVEYING RODS and TAPES (20/D13)			
Rules	0 in to 40 in > 40 in to 80 in > 80 in to 120 in > 120 in to 160 in	4.9 μ in/in + 170 μ in 4.9 μ in/in + 340 μ in 4.9 μ in/in + 500 μ in 4.9 μ in/in + 670 μ in	P & W LMU1000A with digital microscope
Tape Measures	0 ft to 100 ft	0.0062 in + 0.00040 in/ft	Tape-to-tape method



2024-06-06 through 2025-06-30
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For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

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Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks
THREADED PLUG/RINGS (20/D14)			
Thread Plugs – Pitch Diameter 6 TPI to 120 TPI 0.20 mm to 10 mm (Pitch)	0.01 in to 5 in 0.1 mm to 127 mm	89 µin 2.3 µm	Thread wires/ Supermicrometer
Adjustable Threaded Rings, Straight Thread – Pitch Diameter 6 TPI to 120 TPI 0.20 mm to 10 mm (Pitch)	0.01 in to 5 in	89 µin 2.3 µm	Ring is sized to a setting plug with plug's uncert. given

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

ELECTROMAGNETICS – DC/LOW FREQUENCY					
AC RESISTANCE and CURRENT (20/E02)					
AC Current – Generate					
Fluke 5730B/05 and 5725A Characterized With Fluke 5790B and A40Bs					
Range	10 to 20 Hz	20 to 40 Hz	0.040 to 1 kHz	1 to 5 kHz	5 to 10 kHz
0 to 220 µA	130 µA/A + 3.9 nA	72 µA/A + 3.9 nA	41 µA/A + 2.4 nA	46 µA/A + 16 nA	310 µA/A + 78 nA
0.22 to 1 mA	130 µA/A + 4.1 nA	74 µA/A + 4.4 nA	44 µA/A + 3.1 nA	53 µA/A + 15 nA	310 µA/A + 78 nA
1 to 2.2 mA	130 µA/A	71 µA/A + 3.7 nA	40 µA/A + 2.0 nA	50 µA/A + 13 nA	310 µA/A + 77 nA
2.2 to 10 mA	130 µA/A + 42 nA	71 µA/A + 45 nA	38 µA/A + 34 nA	46 µA/A + 380 nA	310 µA/A + 780 nA
10 to 20 mA	130 µA/A	71 µA/A + 37 nA	40 µA/A + 20 nA	50 µA/A + 350 nA	310 µA/A + 770 nA
20 to 22 mA	130 µA/A	72 µA/A	41 µA/A	50 µA/A + 340 nA	310 µA/A
22 to 50 mA	130 µA/A + 430 nA	70 µA/A + 470 nA	38 µA/A + 370 nA	47 µA/A + 2.3 µA	310 µA/A + 3.9 µA
50 to 100 mA	130 µA/A + 390 nA	71 µA/A + 410 nA	39 µA/A + 260 nA	48 µA/A + 2.2 µA	310 µA/A + 3.9 µA
100 to 200 mA	130 µA/A	71 µA/A + 370 nA	40 µA/A + 200 nA	50 µA/A + 2.1 µA	310 µA/A + 3.9 µA
200 to 220 mA	130 µA/A	72 µA/A	41 µA/A	51 µA/A + 2.0 µA	310 µA/A
220 to 500 mA			49 µA/A + 4.8 µA	68 µA/A + 16 µA	620 µA/A + 39 µA
0.5 to 1 A			51 µA/A + 3.9 µA	69 µA/A + 15 µA	620 µA/A + 39 µA
1 to 2 A			51 µA/A + 3.5 µA	72 µA/A + 14 µA	620 µA/A + 39 µA
2 to 5 A			54 µA/A + 3.1 µA	72 µA/A + 14 µA	620 µA/A
5 to 10 A			67 µA/A + 81 µA	84 µA/A + 120 µA	160 µA/A + 230 µA
10 to 11 A			70 µA/A + 73 µA	86 µA/A + 110 µA	160 µA/A + 230 µA



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0


CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks
AC Current – Generate (no field capability)	> 11 A to 20.5 A	45 Hz to 100 Hz > 100 Hz to 1 kHz > 1 kHz to 5 kHz	0.93 mA/A + 3.9 mA 1.2 mA/A + 3.9 mA 23 mA/A + 3.9 mA	Fluke 5522A
	20 A to 120 A	10 Hz to 65 Hz > 65 Hz to 300 Hz > 0.3 kHz to 1 kHz > 1 kHz to 3 kHz > 3 kHz to 6 kHz > 6 kHz to 10 kHz	1.3 mA/A 2.0 mA/A 6.3 mA/A 16 mA/A 33 mA/A 76 mA/A	Fluke 52120A/Fluke 5730A
Current Clamp, Non-Toroidal ^{Note 4}	20 A to 1000 A	45 Hz to 65 Hz > 65 Hz to 440 Hz	7.2 mA/A + 0.27 A 12 mA/A + 0.27 A	Fluke 5522A with 5500A/COIL
Current Clamp, Toroidal ^{Note 4}	20 A to 1000 A	45 Hz to 65 Hz > 65 Hz to 440 Hz	3.3 mA/A + 27 mA 9.2 mA/A + 29 mA	Fluke 5522A with 5500A/COIL
Current Clamp	0 A to 300 A	1 kHz to 3 kHz	6.7 mA/A	Fluke 5730A with Fluke 52120A, Fluke 52120A/Coil3kA
	120 A to 1000 A	0.3 kHz to 1 kHz	5.6 mA/A	
	120 A to 3000 A	10 Hz to 300 Hz	5.6 mA/A	

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Current – Measure				
Fluke 8508A				
Range	1 to 10 Hz	0.010 to 10 kHz	10 to 30 kHz	30 to 100 kHz
0 to 200 µA	0.25 mA/A + 20 nA	0.25 mA/A + 25 nA	0.60 mA/A + 78 nA	3.9 mA/A + 53 nA
0.200 to 2 mA	0.25 mA/A + 0.20 µA	0.25 mA/A + 0.20 µA	0.68 mA/A + 0.21 µA	4.0 mA/A + 0.21 µA
2 to 20 mA	0.25 mA/A + 2.0 µA	0.25 mA/A + 2.0 µA	0.68 mA/A + 2.1 µA	4.0 mA/A + 2.1 µA
20 to 200 mA	0.25 mA/A + 20 µA	0.25 mA/A + 20 µA	0.67 mA/A + 20 µA	
0.200 to 2 A	0.60 mA/A + 0.20 mA	0.70 mA/A + 0.20 mA	3.1 mA/A + 0.20 mA	
2 to 20 A	0.80 mA/A + 2.0 mA	2.5 mA/A + 2.0 mA		

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Current – Measure											
Fluke 5790B/05 With Fluke A40B Shunts											
Expanded uncertainties are in $\mu\text{A/A}$ for the level shown at left at indicated frequencies below											
Range	10 to 20Hz	20 to 40Hz	40 to 55Hz	55 to 400Hz	0.4 to 1kHz	1 to 10kHz	10 to 20kHz	20 to 30kHz	30 to 50kHz	50 to 70kHz	70 to 100kHz
0 to 1 mA	61	42	39	39	39	39	39	40	49	60	64
1 to 10 mA	56	35	32	32	32	32	33	33	37	51	55
10 to 20 mA	56	35	32	32	32	33	33	33	37	51	53
20 to 50 mA	57	36	33	33	33	33	37	37	37	51	55
50 to 100 mA	56	35	32	32	32	32	33	33	33	49	51
100 to 200 mA	56	35	32	32	32	32	33	33	33	49	50
200 to 500 mA	57	36	33	34	33	33	34	34	36	50	53
0.5 to 1 A	57	36	33	33	33	32	35	35	35	50	53
1 to 2 A	56	35	32	33	33	36	39	40	45	57	67
2 to 5 A	59	40	37	37	37	36	42	42	53	64	80
5 to 10 A	61	43	40	40	40	39	61	62	71	79	99
10 to 20 A	66	49	47	48	48	56	74	74	95	100	130
20 to 50 A	72	57	56	56	55	63	82	82	100	110	160
50 to 100 A	78	65	63	63	62	80	90	90	140	150	180

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
AC Resistance – Generate	0.1 Ω	> 0.1 Hz to 1 MHz	0.18 %	Agilent 16074A
		> 1 MHz to 13 MHz	0.27 %	
	1 Ω	> 0.1 Hz to 1 MHz	0.12 %	
		> 1 MHz to 13 MHz	0.12 %	
	10 Ω	> 0.1 Hz to 1 MHz	0.036 %	
> 1 MHz to 13 MHz		0.036 %		
100 Ω	> 0.1 Hz to 1 MHz	0.035 %		
	> 1 MHz to 13 MHz	0.036 %		



2024-06-06 through 2025-06-30
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CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

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	1 k Ω	> 0.1 Hz to 1 MHz	0.035 %	
	10 k Ω	> 1 MHz to 13 MHz	0.035 %	
		> 0.1 Hz to 1 MHz	0.040 %	
		> 1 MHz to 13 MHz	0.14 %	
	100 k Ω	> 0.1 Hz to 1 MHz	0.099 %	
		> 1 MHz to 13 MHz	0.62 %	
AC Resistance – Measure	0 Ω to 15 Ω	50 Hz to 1 MHz	0.14 %	Agilent 4284A
	15 Ω to 320 k Ω	100 Hz to 100 kHz	0.08 %	
	> 320 k Ω to 10 M Ω	100 Hz to 100 kHz	0.26 %	

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
DC RESISTANCE and CURRENT (20/E05)			
Direct Current – Generate ^{Note 4}	0 pA to 2 pA	4.9 fA/pA + 12 fA	Keithley 263 Characterized Fluke 5730A and Fluke 5725A
	> 2 pA to 20 pA	4.1 fA/pA + 17 fA	
	> 20 pA to 200 pA	2.9 fA/pA + 42 fA	
	> 0.2 nA to 2 nA	0.76 pA/nA + 0.12 pA	
	> 2 nA to 20 nA	0.76 pA/nA + 1.2 pA	
	> 20 nA to 200 nA	0.41 pA/nA + 12 pA	
	> 0.2 μ A to 2 μ A	0.29 nA/ μ A + 0.12 nA	
	> 2 μ A to 20 μ A	0.27 nA/ μ A + 1.7 nA	
	> 20 μ A to 200 μ A	0.29 nA/ μ A + 12 nA	
	> 0 μ A to 20 μ A	6 μ A/A + 1.2 nA	
	> 20 μ A to 220 μ A	7 μ A/A + 1.1 nA	
	> 220 μ A to 2.2 mA	9.6 μ A/A + 0.97 nA	
	> 2.2 mA to 22 mA	9.8 μ A/A + 4.9 nA	



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
Current Clamp – Non-Toroidal ^{Note 4}	> 22 mA to 220 mA > 220 mA to 2.2 A > 2.2 A to 7.5 A > 7.5 A to 11 A > 11 A to 20 A > 20 A to 100 A	13 μ A/A 19 μ A/A - 220 nA 56 μ A/A - 73 μ A 37 μ A/A + 100 μ A 0.77 mA/A + 0.77 mA 0.43 mA/A	Fluke 5522A Fluke 5730A with Fluke 52120A
	20 A to 1000 A	5.8 mA/A + 0.58 A	Fluke 5522A w/ 5500A/COIL
	1000 A to 2500 A	4.9 mA/A	Fluke 5730A with Fluke 52120A, Fluke 52120A/Coil3kA
Direct Current – Measure ^{Note 4}	0 pA to 2 pA > 2 pA to 20 pA > 20 pA to 200 pA > 200 pA to 2 nA > 2 nA to 20 nA	16 fA/A + 13 fA 14 fA/A + 110 fA 18 fA/A + 110 fA 2.6 pA/A + 1.3 pA 2.8 pA/A + 5.3 pA	Keithley 617
	> 20 nA to 100 nA > 100 nA to 1 μ A	34 μ A/A + 47 pA 17 μ A/A	HP 3458A/002
	1 μ A to 20 μ A 20 μ A to 200 μ A 200 μ A to 2 mA 2 mA to 20 mA 20 mA to 100 mA 100 mA to 200 mA 0.2 A to 7.5 A 7.5 A to 50 A 50 A to 200 A	3.2 μ A/A + 41 pA 4.9 μ A/A + 84 pA 4.7 μ A/A + 790 pA 4.6 μ A/A + 8 nA 5.9 μ A/A + 71 nA 6.1 μ A/A + 56 nA 13 μ A/A + 0.38 μ A 24 μ A/A + 1.4 μ A 8.9 μ A/A + 53 μ A	Fluke 8508A With Standard Resistors



2024-06-06 through 2025-06-30
Effective dates

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CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

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Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
Resistance – Variable Generate ^{Note 4}	0 Ω to 11 Ω	47 $\mu\Omega/\Omega$ + 1.2 m Ω	Fluke 5522A
	> 11 Ω to 33 Ω	40 $\mu\Omega/\Omega$ + 1.7 m Ω	
	> 33 Ω to 110 Ω	34 $\mu\Omega/\Omega$ + 1.8 m Ω	
	> 110 Ω to 330 Ω	34 $\mu\Omega/\Omega$ + 2.4 m Ω	
	> 330 Ω to 1.1 k Ω	34 $\mu\Omega/\Omega$ + 2.4 m Ω	
	> 1.1 k Ω to 3.3 k Ω	34 $\mu\Omega/\Omega$ + 22 m Ω	
	> 3.3 k Ω to 11 k Ω	34 $\mu\Omega/\Omega$ + 23 m Ω	
	> 11 k Ω to 33 k Ω	34 $\mu\Omega/\Omega$ + 0.22 Ω	
	> 33 k Ω to 110 k Ω	34 $\mu\Omega/\Omega$ + 0.24 Ω	
	> 110 k Ω to 330 k Ω	44 $\mu\Omega/\Omega$ + 1.6 Ω	
	> 330 k Ω to 1.1 M Ω	40 $\mu\Omega/\Omega$ + 3.0 Ω	
	> 1.1 M Ω to 3.3 M Ω	0.12 m Ω/Ω	
	> 3.3 M Ω to 11 M Ω	0.16 m Ω/Ω + 86 Ω	
Resistance – Variable Generate ^{Note 4}	> 11 M Ω to 33 M Ω	0.70 m Ω/Ω + 2.5 k Ω	
	> 33 M Ω to 110 M Ω	0.76 m Ω/Ω + 3.5 k Ω	
	> 110 M Ω to 330 M Ω	0.65 m Ω/Ω	
	> 330 M Ω to 1100 M Ω	15 m Ω/Ω + 730 k Ω	
Resistance – Fixed Generate Instrument-Based ^{Note 4}	1 Ω	28 $\mu\Omega/\Omega$	Fluke 5730A Characterized
	1.9 Ω	21 $\mu\Omega/\Omega$	
	10 Ω	5.6 $\mu\Omega/\Omega$	
	19 Ω	5.0 $\mu\Omega/\Omega$	
	100 Ω	3.1 $\mu\Omega/\Omega$	
	190 Ω	3.1 $\mu\Omega/\Omega$	
	1 k Ω	2.6 $\mu\Omega/\Omega$	
	1.9 k Ω	2.6 $\mu\Omega/\Omega$	
	10 k Ω	2.0 $\mu\Omega/\Omega$	
	19 k Ω	2.0 $\mu\Omega/\Omega$	
	100 k Ω	4.3 $\mu\Omega/\Omega$	
	190 k Ω	4.3 $\mu\Omega/\Omega$	
	1 M Ω	4.0 $\mu\Omega/\Omega$	
1.9 M Ω	4.1 $\mu\Omega/\Omega$		
10 M Ω	14 $\mu\Omega/\Omega$		
19 M Ω	19 $\mu\Omega/\Omega$		



2024-06-06 through 2025-06-30
Effective dates

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CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

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Fixed Resistor-Based	100 MΩ	42 μΩ/Ω	Keithley 263
	10 GΩ	35 mΩ/Ω	
	100 GΩ	35 mΩ/Ω	
	0.001 Ω	0.01 %	Ohms-Lab CS-200 Guildline 9230-100 Guildline 9230-15 Fluke 742A-1 Fluke 742A-1.9 Guildline 9334-10 Guildline 9334-100 Fluke 742A-1k Fluke 742A-10k Fluke 742A-100k Fluke 742A-1M Guildline 9334-10M Guildline 9330-100M Guildline 9334-1G IET VRS-100-10-1K-BP
	0.01 Ω	23 μΩ/Ω	
	0.1 Ω	12 μΩ/Ω	
	1 Ω	3.6 μΩ/Ω	
	1.9 Ω	1.1 μΩ/Ω	
	10 Ω	2.8 μΩ/Ω	
	100 Ω	2.6 μΩ/Ω	
	1 kΩ	1.9 μΩ/Ω	
	10 kΩ	1.1 μΩ/Ω	
	100 kΩ	4.0 μΩ/Ω	
	1 MΩ	2.9 μΩ/Ω	
	10 MΩ	11 μΩ/Ω	
	100 MΩ	13 μΩ/Ω	
	1 GΩ	20 μΩ/Ω	
10 GΩ	2.1 mΩ/Ω		
100 GΩ	0.99 mΩ/Ω		
1 TΩ	5.0 mΩ/Ω		
Resistance – Measure ^{Note 4}	0 Ω to 2 Ω	5.1 μΩ/Ω + 3.1 μΩ	Fluke 8508 transfer accuracy
	> 2 Ω to 20 Ω	3.1 μΩ/Ω + 7.6 μΩ	
	> 20 Ω to 200 Ω	2.6 μΩ/Ω + 6.7 μΩ	
	> 200 Ω to 2 kΩ	1.9 μΩ/Ω + 85 μΩ	
	> 2 kΩ to 20 kΩ	1.1 μΩ/Ω + 1.3 mΩ	
	> 20 kΩ to 200 kΩ	4.0 μΩ/Ω + 4.5 mΩ	
	> 200 kΩ to 2 MΩ	3.0 μΩ/Ω + 0.46 Ω	
	> 2 MΩ to 20 MΩ	11 μΩ/Ω + 1.7 Ω	
	> 20 MΩ to 200 MΩ	13 μΩ/Ω + 21 Ω	
	> 0.2 GΩ to 2 GΩ	70 μΩ/Ω + 68 kΩ	
	> 2 GΩ to 20 GΩ	0.69 mΩ/Ω + 9.5 MΩ	



2024-06-06 through 2025-06-30
Effective dates

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CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

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(No field capability above 20 G Ω)	> 20 G Ω to 200 G Ω > 200 G Ω to 2 T Ω > 2 T Ω to 20 T Ω > 20 T Ω to 200 T Ω	0.93 m Ω/Ω 1.4 m Ω/Ω 4.0 m Ω/Ω 6.9 m Ω/Ω	Guideline 6530B
DC VOLTAGE (20/E06)			
DC Voltage – Variable Generate ^{Note 4}	0 V to 220 mV > 0.22 V to 2.2 V > 2.2 V to 11 V > 11 V to 22 V > 22 V to 220 V > 220 V to 1.1 kV 1 kV to 50 kV > 50 kV to 70 kV	0.58 μ V/V + 330 nV 0.43 μ V/V + 1.3 μ V 0.29 μ V/V + 3.7 μ V 0.57 μ V/V + 3.2 μ V 0.54 μ V/V + 89 μ V 0.24 μ V/V + 760 μ V 0.49 mV/V + 0.21 V 0.47 mV/V + 1.4 V	Characterized Fluke 5730A Hipotronics Source and Vitrek
DC Voltage – Fixed Generate	10 V 100 mV 1 V 10 V 100 V 1000 V	0.43 μ V/V 2.8 μ V/V 1.1 μ V/V 0.62 μ V/V 0.88 μ V/V 0.92 μ V/V	Fluke 732A Characterized Fluke 5730A
DC Voltage – Fixed Measure ^{Note 4}	100 mV 1 V 10 V 100 V 1000 V	1.2 μ V/V 0.52 μ V/V 0.44 μ V/V 0.53 μ V/V 0.74 μ V/V	Agilent 34420A, Fluke 732A, 752A
DC Voltage – Variable Measure ^{Note 4}	0 V to 200 mV > 200 mV to 2 V > 2 V to 20 V > 20 V to 200 V > 200 V to 1000 V	1.3 μ V/V + 23 nV 0.56 μ V/V + 0.15 μ V 0.80 μ V/V + 1.3 μ V 0.49 μ V/V + 1.9 μ V 0.71 μ V/V + 13 μ V	Fluke 8508A w/732A,752A



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC VOLTAGE (20/E09)															
AC Voltage – Source/Measure															
Fluke 792A, Fluke 732A, Fluke 752A, Fluke 8508, Fluke 5730A/05, Fluke 5725A															
Expanded uncertainties are in $\mu\text{V/V}$ for the level shown at left at indicated frequencies below															
Range	Level	10 Hz	20 Hz	40 Hz	100 Hz	1k Hz	10 kHz	20 kHz	30 kHz	50 kHz	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
22 mV	2 mV	460	460	460	460	460	460	460		460	530	610	700	800	810
22 mV	6 mV	240	240	210	200	200	200	200		240	300	420	480	590	630
22 mV	10 mV	110	100	99	99	100	99	99		110	160	220	290	350	400
22 mV	20 mV	88	71	70	71	70	70	69		90	150	220	310	400	420
220 mV	20 mV	94	84	85	71	70	71	70		89	150	210	280	320	370
220 mV	50 mV	65	39	35	34	33	36	34		38	76	140	210	280	290
220 mV	100 mV	45	28	17	16	14	14	14		25	42	80	120	190	190
220 mV	200 mV	31	22	14	15	11	13	14		22	41	76	110	160	190
700 mV	200 mV	30	21	13	14	12	12	12		21	41	76	110	160	190
700 mV	600 mV	28	20	11	11	11	12	11		12	16	26	31	53	71
2.2 V	600 mV	26	16	6.9	6.9	6.8	6.9	7.7		8.3	11	22	26	32	42
2.2 V	1 V	25	15	7.2	5.6	5.7	5.7	5.9		7.7	11	21	25	31	41
2.2 V	2 V	26	15	7.7	5.8	5.5	5.5	5.6		5.5	10	20	25	31	42
7 V	2 V	25	16	8.4	5.5	5.6	5.8	5.9		6.7	11	21	26	30	41
7 V	6 V	25	15	5.8	5.7	5.5	5.5	5.4		6.3	7.4	20	25	31	41
22 V	6 V	29	17	5.9	5.4	5.3	5.8	5.4		6.3	7.5	20	25	30	40
22 V	10 V	29	17	5.8	5.5	5.3	5.6	5.7		6.2	8.3	20	25	30	40
22 V	20 V	29	17	6.7	6.2	6.2	6.5	6.3		7.2	10	20	25	31	42
70 V	20 V	26	16	6.5	7.2	6.5	6.7	6.5		7.5	10	25			
70 V	60 V	26	16	6.9	6.9	6.8	6.8	6.9		8.6	11	25			
220 V	60 V	25	16	7.3	7.2	7.1	7.3	7.3		9.4	11	30			
220 V	100 V	31	16	7.4	7.8	6.7	6.6	6.6		9.4	16				
220 V	200 V	40	16	9.1	9.6	8.6	8.5	8.4		11	16				
1000 V	200 V	40	16	9.4	9.1	8.4	8.9	8.9		12	31				
1000 V	600 V			12	12	11	12	12		17	42				
1000 V	1000 V			12	12	11	12	12	13						

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES


NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Voltage – Measure								
Fluke 5790B/05								
Range	10 to 20 Hz	20 to 40 Hz	0.040 to 20 kHz	20 to 50 kHz	50 to 100 kHz	100 to 300 kHz	300 to 500 kHz	0.500 to 1 MHz
0.6 to 2.2 mV	130 μ V/V + 0.99 μ V	95 μ V/V + 0.99 μ V	91 μ V/V + 0.99 μ V	82 μ V/V + 1.5 μ V	92 μ V/V + 1.9 μ V	200 μ V/V + 3.1 μ V	600 μ V/V + 6.2 μ V	2200 μ V/V + 6.1 μ V
2.2 to 7 mV	84 μ V/V + 0.99 μ V	50 μ V/V + 0.98 μ V	49 μ V/V + 0.98 μ V	48 μ V/V + 1.5 μ V	58 μ V/V + 1.9 μ V	150 μ V/V + 3 μ V	380 μ V/V + 6.2 μ V	1600 μ V/V + 6.1 μ V
7 to 22 mV	87 μ V/V + 0.88 μ V	49 μ V/V + 0.94 μ V	40 μ V/V + 0.96 μ V	48 μ V/V + 1.5 μ V	74 μ V/V + 1.8 μ V	170 μ V/V + 2.8 μ V	370 μ V/V + 5.9 μ V	1200 μ V/V + 6.1 μ V
22 to 70 mV	64 μ V/V + 0.98 μ V	39 μ V/V + 1 μ V	35 μ V/V + 1 μ V	43 μ V/V + 1.4 μ V	80 μ V/V + 1.6 μ V	160 μ V/V + 2.5 μ V	300 μ V/V + 5.6 μ V	800 μ V/V + 6.1 μ V
70 to 220 mV	68 μ V/V + 0.14 μ V	26 μ V/V + 1.1 μ V	23 μ V/V + 1.1 μ V	28 μ V/V + 1.3 μ V	57 μ V/V + 1.6 μ V	120 μ V/V + 2.7 μ V	250 μ V/V + 5.8 μ V	760 μ V/V + 6 μ V
220 to 700 mV	57 μ V/V	25 μ V/V + 1.1 μ V	22 μ V/V + 1.1 μ V	22 μ V/V + 1.4 μ V	44 μ V/V + 1.8 μ V	97 μ V/V + 3 μ V	210 μ V/V + 6.2 μ V	740 μ V/V + 6.2 μ V
0.7 to 2.2 V	67 μ V/V - 10 μ V	23 μ V/V	18 μ V/V	19 μ V/V	40 μ V/V	88 μ V/V	180 μ V/V	690 μ V/V
2.2 to 7 V	56 μ V/V - 11 μ V	23 μ V/V	18 μ V/V	21 μ V/V	50 μ V/V	120 μ V/V	300 μ V/V	930 μ V/V
7 to 22 V	70 μ V/V - 120 μ V	25 μ V/V	18 μ V/V	21 μ V/V	51 μ V/V	120 μ V/V	300 μ V/V	930 μ V/V
22 to 70 V	55 μ V/V - 73 μ V	25 μ V/V	21 μ V/V	23 μ V/V	54 μ V/V	120 μ V/V	300 μ V/V	930 μ V/V
70 to 220 V	68 μ V/V - 1000 μ V	27 μ V/V	21 μ V/V	29 μ V/V	56 μ V/V	130 μ V/V	370 μ V/V	
220 to 700 V	50 μ V/V + 200 μ V	29 μ V/V	23 μ V/V	87 μ V/V	390 μ V/V			
700 to 1100 V	50 μ V/V	29 μ V/V	24 μ V/V	87 μ V/V	390 μ V/V			

2024-06-06 through 2025-06-30

Effective dates



For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0


CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Voltage – Source								
Fluke 5730A/05 and Fluke 5725A Characterized with Fluke 5790B/05								
Range	10 to 20 Hz	20 to 40 Hz	0.040 to 20 kHz	20 to 50 kHz	50 to 100 kHz	100 to 300 kHz	300 to 500 kHz	0.500 to 1 MHz
0 to 2.2 mV	26 μ V/V + 5.9 μ V	18 μ V/V + 5.9 μ V	40 μ V/V + 2.5 μ V	46 μ V/V + 2.8 μ V	47 μ V/V + 4 μ V	140 μ V/V + 4.6 μ V	470 μ V/V + 8.5 μ V	1800 μ V/V + 8.3 μ V
2.2 to 22 mV	27 μ V/V + 5.9 μ V	11 μ V/V + 5.9 μ V	17 μ V/V + 2.6 μ V	29 μ V/V + 2.8 μ V	40 μ V/V + 4 μ V	96 μ V/V + 6.6 μ V	220 μ V/V + 13 μ V	800 μ V/V + 19 μ V
22 to 220 mV	180 μ V/V + 23 μ V	95 μ V/V + 17 μ V	25 μ V/V + 2.6 μ V	26 μ V/V + 3 μ V	54 μ V/V + 3.1 μ V	110 μ V/V + 5.8 μ V	260 μ V/V + 14 μ V	730 μ V/V + 26 μ V
0.22 to 2.2 V	190 μ V/V + 22 μ V	95 μ V/V + 17 μ V	22 μ V/V + 5 μ V	25 μ V/V + 6.6 μ V	41 μ V/V + 7.7 μ V	90 μ V/V + 15 μ V	190 μ V/V + 31 μ V	700 μ V/V + 44 μ V
2.2 to 22 V	190 μ V/V + 19 μ V	96 μ V/V + 16 μ V	23 μ V/V + 6.2 μ V	27 μ V/V + 5.2 μ V	55 μ V/V - 17 μ V	130 μ V/V - 60 μ V	320 μ V/V - 190 μ V	970 μ V/V - 490 μ V
22 to 220 V	190 μ V/V + 230 μ V	96 μ V/V + 160 μ V	26 μ V/V	35 μ V/V - 64 μ V	59 μ V/V - 63 μ V	140 μ V/V	370 μ V/V + 7700 μ V	840 μ V/V + 17 mV

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

AC Voltage – Source						
Fluke 5730A Characterized with Fluke 5790B Continued						
Range	15 to 40 Hz	0.040 to 1 kHz	1 to 20 kHz	20 to 30 kHz	30 to 50 kHz	50 to 100 kHz
220 to 750 V					120 μ V/V - 11 mV	540 μ V/V - 74 mV
220 to 1100 V	180 μ V/V	27 μ V/V - 310 μ V	30 μ V/V + 1200 μ V	100 μ V/V - 12 mV		

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
AC Voltage – Measure ^{Note 4}	1 mV to 10 mV	1 MHz to 4 MHz > 4 MHz to 8 MHz	54 mV/V + 11 µV 160 mV/V + 8.2 µV	HP 3458A
	> 10 mV to 100 mV	1 MHz to 2 MHz > 2 MHz to 4 MHz > 4 MHz to 8 MHz > 8 MHz to 10 MHz	12 mV/V + 19 µV 30 mV/V + 130 µV 30 mV/V + 220 µV 120 mV/V + 160 µV	
	> 0.1 V to 1 V	1 MHz to 2 MHz > 2 MHz to 4 MHz > 4 MHz to 8 MHz > 8 MHz to 10 MHz	12 mV/V + 110 µV 30 mV/V + 1.3 mV 30 mV/V + 2.2 mV 120 mV/V + 1.6 mV	
	> 1 V to 10 V	1 MHz to 2 MHz > 2 MHz to 4 MHz > 4 MHz to 8 MHz > 8 MHz to 10 MHz	12 mV/V + 1.2 mV 31 mV/V + 6.2 mV 31 mV/V + 7.9 mV 120 mV/V + 8.5 mV	
	1.1 kV to 5 kV > 5 kV to 44 kV	50 Hz to 60 Hz 50 Hz to 60 Hz	2.5 mV/V + 1.5 V 1.4 mV/V + 27 V	Quadtech Sentry 20 w/Vitretek 4700 & HLV70
	1.1 kV to 5 kV > 5 kV to 50 kV	50 Hz to 60 Hz 50 Hz to 60 Hz	2.5 mV/V + 1.5 V 1.4 mV/V + 27 V	Vitretek 4700 w/HLV70

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0


CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) Notes 1,2

AC Voltage – Wideband Generate							
Fluke 5730A/05							
Range	10 to 30 Hz	0.030 to 120 kHz	0.120 to 2 MHz	2 to 10 MHz	10 to 20 MHz	20 to 30 MHz	30 to 50 MHz
0.3 to 1.1 mV	0.24 %	0.085 %	0.39 %	0.55 %	0.71 %	2.3 %	3.6 %
1.1 to 3.3 mV	0.24 %	0.080 %	0.16 %	0.31 %	0.47 %	1.3 %	2.5 %
3.3 to 11 mV	0.23 %	0.079 %	0.10 %	0.18 %	0.35 %	0.82 %	1.7 %
11 to 33 mV	0.30 %	0.079 %	0.089 %	0.17 %	0.33 %	0.80 %	1.7 %
33 to 110 mV	0.23 %	0.083 %	0.083 %	0.16 %	0.33 %	0.80 %	1.7 %
110 to 330 mV	0.23 %	0.082 %	0.082 %	0.16 %	0.32 %	0.79 %	1.7 %
0.33 to 1.1 V	0.23 %	0.081 %	0.081 %	0.16 %	0.32 %	0.79 %	1.7 %
1.1 to 3.5 V	0.23 %	0.081 %	0.081 %	0.16 %	0.32 %	0.79 %	1.7 %

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) Notes 1,2

AC Voltage – Wideband Measure								
Fluke 5790B/05								
Range	10 to 30 Hz	0.030 to 120 kHz	120 to 500 kHz	0.5 to 2 MHz	2 to 10 MHz	10 to 20 MHz	20 to 30 MHz	30 to 50 MHz
0.1 to 2.2 mV	0.088 %	0.050 %	0.13 %	0.13 %	0.21 %	0.32 %	0.71 %	0.88 %
2.2 to 7 mV	0.082 %	0.051 %	0.079 %	0.080 %	0.11 %	0.17 %	0.42 %	0.46 %
7 to 22 mV	0.081 %	0.040 %	0.055 %	0.056 %	0.084 %	0.15 %	0.32 %	0.52 %
22 to 70 mV	0.10 %	0.040 %	0.040 %	0.042 %	0.084 %	0.12 %	0.31 %	0.51 %
70 to 220 mV	0.080 %	0.032 %	0.032 %	0.041 %	0.083 %	0.13 %	0.28 %	0.51 %
220 to 700 mV	0.079 %	0.025 %	0.025 %	0.041 %	0.083 %	0.13 %	0.30 %	0.51 %
0.7 to 2.2 V	0.080 %	0.025 %	0.025 %	0.041 %	0.10 %	0.13 %	0.30 %	0.50 %
2.2 to 7 V	0.080 %	0.024 %	0.024 %	0.041 %	0.083 %	0.13 %	0.30 %	0.50 %

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks	
CAPACITANCE (20/E10)					
Capacitance – Measure	0.001 nF to 1.2 μ F	100 Hz to 10 kHz	8 μ F/F	ESI 701B with GenRad 1404-A	
	1.2 μ F to 800 μ F		1.3 nF/ μ F	HP 4284A	
	> 800 μ F to 100 mF		1.7 μ F/mF + 4.3 nF		
	> 100 mF to 1000 mF		3.1 μ F/mF + 57 μ F		
	0.01 fF to 10 pF	20 Hz to 12.5 kHz	3.8 fF/pF + 3.1 aF	HP 4284A	
		> 12.5 kHz to 48 kHz	3.0 fF/pF + 3.5 aF		
		> 48 kHz to 96 kHz	3.4 fF/pF + 3.3 aF		
		> 96 kHz to 1 MHz	3.1 fF/pF + 3.5 aF		
		> 10 pF to 100 pF	20 Hz to 500 Hz	3.5 fF/pF + 38 fF	
			> 500 Hz to 1 kHz	3.4 fF/pF + 38 fF	
		> 1 kHz to 12.5 kHz	1.7 fF/pF + 19 fF		
		> 12.5 kHz to 48 kHz	2.0 fF/pF + 22 fF		
		> 48 kHz to 96 kHz	1.6 fF/pF + 18 fF		
		> 96 kHz to 1 MHz	1.5 fF/pF + 16 fF		
	> 100 pF to 1000 pF	20 Hz to 50 Hz	33 fF/pF + 3.7 pF		
		> 50 Hz to 500 Hz	3.3 fF/pF + 0.37 pF		
		> 500 Hz to 1 kHz	1.5 fF/pF + 0.17 pF		
		> 1 kHz to 12.5 kHz	1.6 fF/pF + 0.18 pF		
		> 12.5 kHz to 48 kHz	1.6 fF/pF + 0.18 pF		
		> 48 kHz to 96 kHz	1.7 fF/pF + 0.19 pF		
		> 96 kHz to 1 MHz	1.9 fF/pF + 0.21 pF		



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty ($k=2$) ^{Note 3}	Remarks
Capacitance – Generate Variable ^{Note 4}	1 fF to 110 pF	50 Hz to 0.5 kHz	3.9 aF/pF + 2.0 aF	Andeen-Hagerling AH2700A OPT. E
		> 0.5 kHz to 1.5 kHz	3.7 aF/pF + 1.3 aF	
		> 1.5 kHz to 10 kHz	4.8 aF/pF + 7.1 aF	
		> 10 kHz to 20 kHz	14 aF/pF + 0.21 fF	
	> 110 pF to 1 nF	50 Hz to 0.5 kHz	3.9 aF/pF + 4.2 aF	
		> 0.5 kHz to 1.5 kHz	3.9 aF/pF – 4.0 aF	
		> 1.5 kHz to 10 kHz	8.2 aF/pF – 0.33 fF	
		> 10 kHz to 20 kHz	7.8 aF/pF + 0.13 fF	
	> 1 nF to 10 nF	50 Hz to 0.5 kHz	3.7 fF/nF + 1.5 fF	
		> 0.5 kHz to 1.5 kHz	4.8 fF/nF + 0.16 fF	
		> 1.5 kHz to 10 kHz	5.7 fF/nF – 51 aF	
		> 10 kHz to 20 kHz	70 fF/nF – 0.71 fF	
	> 10 nF to 100 nF	50 Hz to 0.5 kHz	7.8 fF/nF – 0.64 fF	
		> 0.5 kHz to 1.5 kHz	9.6 fF/nF – 7.4 fF	
		> 1.5 kHz to 10 kHz	9.9 fF/nF – 7.5 fF	
		> 10 kHz to 20 kHz	0.22 pF/nF – 0.32 pF	
	> 100 nF to 1.2 μF	50 Hz to 0.5 kHz	13 fF/nF – 0.56 pF	
		> 0.5 kHz to 1.5 kHz	15 fF/nF – 0.38 pF	
		> 1.5 kHz to 10 kHz	23 fF/nF – 0.79 pF	
		> 10 kHz to 20 kHz	0.74 pF/nF – 34 pF	
0.19 nF to 0.39 nF 0.4 nF to 1.1 nF > 1.1 nF to 3.3 nF > 3.3 nF to 11 nF > 11 nF to 33 nF > 33 nF to 110 nF	10 Hz to 10 kHz	5.8 pF/nF + 12 pF	Fluke 5522A	
	10 Hz to 10 kHz	5.8 pF/nF + 12 pF		
	10 Hz to 3 kHz	5.8 pF/nF + 12 pF		
	10 Hz to 1 kHz	2.9 pF/nF + 12 pF		
	10 Hz to 1 kHz	2.9 pF/nF + 120 pF		
	10 Hz to 1 kHz	2.9 pF/nF + 120 pF		



2024-06-06 through 2025-06-30

Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks	
Capacitance – Generate, Fixed ^{Note 4}	> 110 nF to 330 nF	10 Hz to 1 kHz	2.9 pF/nF + 350 pF		
	> 0.33 μF to 1.1 μF	10 Hz to 600 Hz	2.9 nF/μF + 1.2 nF		
	> 1.1 μF to 3.3 μF	10 Hz to 300 Hz	2.9 nF/μF + 3.5 nF		
	> 3.3 μF to 11 μF	10 Hz to 150 Hz	2.9 nF/μF + 11 nF		
	> 11 μF to 33 μF	10 Hz to 120 Hz	4.7 nF/μF + 35 nF		
	> 33 μF to 110 μF	10 Hz to 80 Hz	5.2 nF/μF + 110 nF		
	> 110 μF to 330 μF	DC to 50 Hz	5.2 nF/μF + 350 nF		
	> 0.33 mF to 1.1 mF	DC to 20 Hz	5.2 μF/mF + 1.2 μF		
	> 1.1 mF to 3.3 mF	DC to 6 Hz	5.2 μF/mF + 3.5 μF		
	> 3.3 mF to 11 mF	DC to 2 Hz	5.2 μF/mF + 12 μF		
	> 11 mF to 33 mF	DC to 0.6 Hz	8.7 μF/mF + 35 μF		
	> 33 mF to 110 mF	DC to 0.2 Hz	13 μF/mF + 120 μF		
	1 pF	1 kHz	2.0 aF		Andeen-Hagerling AH1100
	10 pF		16 aF		
	100 pF		0.15 fF		
	1000 pF	1 kHz	24 fF		GenRad 1404-A
	0.001 μF	1 kHz	0.60 pF		GenRad 1409
	0.01 μF		6.0 pF		
	0.1 μF		410 pF		GenRad 1417
	1 μF		600 pF		
10 μF	100 Hz	4.6 nF			
10 μF	1 kHz	3.1 nF			
100 μF	100 Hz	76 nF			
100 μF	1 kHz	70 nF			
10 μF	100 Hz, 120 Hz, or 1 kHz	0.034 μF			
100 μF		0.34 μF			
1 mF		3.6 μF			
10 mF		52 μF			



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks		
	100 mF	100 Hz, 120 Hz	0.41 mF			
	1 F		5.8 mF			
	10 nF	120 Hz to 100 kHz	3.5 pF		HP 16385A	
	100 nF		35 pF		HP 16386A	
	1 μF		0.36 nF		HP 16387A	
	1 pF		1 kHz		0.083 fF	HP 16381A
			1 MHz		0.11 fF	
			2 MHz		0.24 fF	
			3 MHz		0.42 fF	
			4 MHz		0.63 fF	
			5 MHz		0.88 fF	
			10 MHz		2.5 fF	
			13 MHz		3.7 fF	
	10 pF		1 kHz		0.70 fF	HP 16382A
			1 MHz		0.70 fF	
			2 MHz		0.70 fF	
			3 MHz		0.72 fF	
			4 MHz		0.75 fF	
			5 MHz		0.79 fF	
			10 MHz		1.3 fF	
13 MHz			1.7 fF			
100 pF		1 kHz	7.0 fF	HP 16383A		
		1 MHz	7.1 fF			
		2 MHz	7.6 fF			
		3 MHz	8.9 fF			
		4 MHz	11 fF			
		5 MHz	14 fF			
		10 MHz	34 fF			
		13 MHz	49 fF			



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Frequency Range	Expanded Uncertainty (k=2) ^{Note 3}	Remarks
	1000 pF	1 kHz 1 MHz 2 MHz 3 MHz 4 MHz 5 MHz 10 MHz 13 MHz	71 fF 86 fF 0.16 pF 0.29 pF 0.44 pF 0.62 pF 1.9 pF 2.8 pF	HP 16384A
INDUCTANCE (20/E11)				
Inductance – Measure	10 nH to 10 H 10 µH to 10 H 0.1 mH to 0.5 mH > 0.5 mH to 2 mH > 2 mH to 10 mH > 10 mH to 50 mH > 50 mH to 200 mH > 200 mH to 1 H > 1 H to 5 H 5 H to 10 H	12 Hz to 100 kHz 100 Hz or 1 kHz 100 Hz to 1 kHz	2.2 mH/H + 4.8 nH 1.5 mH/H + 0.12 µH 49 µH/H + 0.49 µH 0.14 mH/H + 0.44 µH 0.24 mH/H + 0.24 µH 0.26 mH/H + 69 nH 0.26 mH/H + 1.8 nH 0.27 mH/H - 1.2 µH 0.37 mH/H - 0.11 mH 0.59 mH/H - 0.62 mH	GenRad 1693 HP 4284A ESI LCR Bridge w/ DT72A Transformer
Inductance – Generate ^{Note 4}	50 µH 100 µH 1 mH 10 mH 100 mH 1 H 10 H	100 Hz or 1 kHz	0.17 µH 0.12 µH 0.46 µH 1.7 µH 26 µH 0.99 mH 19 mH	GenRad 1482 Set

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
LF POWER & ENERGY (20/E12)			
DC Power – Generate ^{Note 4} 0.33 mA to 330 mA	11 μW to 1.1 mW	0.024 %	Fluke 5522A
	> 1.1 mW to 110 mW	0.027 %	
	> 0.11W to 110 W	0.024 %	
	> 110 W to 330 W	0.018 %	
> 0.33 A to 3 A	11 W to 110 mW	0.044 %	
	> 0.11 W to 990 W	0.053 %	
	> 0.99 kW to 3 kW	0.0096 %	
> 3 A to 20.5 A	0.099 W to 0.99 W	0.088 %	
	> 0.99 W to 6.8 kW	0.070 %	
	> 6.8 kW to 20.5 kW	0.040 %	
AC Power – Generate ^{Notes 4,7} (PF = 1, Φ = 0° at 10 Hz to 65 Hz)			Fluke 5522A
3.3 mA to 9 mA	0.11 mW to 3.0 mW	0.13%	
	> 3.0 mW to 9 W	0.077 %	
> 9 mA to 33 mA	0.3 mW to 10 mW	0.089 %	
	> 10 mW to 33 W	0.077 %	
> 33 mA to 90 mA	1 mW to 30 mW	0.071 %	
	> 30 mW to 90 W	0.057 %	
> 90 mA to 330 mA	3.0 mW to 100 mW	0.089 %	
	> 100 mW to 300 W	0.078 %	
> 0.33 A to 0.9 A	11 mW to 300 mW	0.071 %	
	> 300 mW to 900 W	0.058 %	
> 0.9 A to 2.2 A	30 mW to 720 mW	0.089 %	
	> 720 mW to 2 kW	0.079 %	



2024-06-06 through 2025-06-30

Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
> 2.2 A to 4.5 A	80 mW to 1.4 W > 1.4 W to 4.5 kW	0.088 % 0.05 %	
> 4.5 A to 20.5 A	150 mW to 6.7 W > 6.7 W to 20 kW	0.17 % 0.17 %	
PHASE (20/E15)			
Phase – Measure (10 mV to 630 V)	5 Hz to 2 kHz > 2 kHz to 5 kHz > 5 kHz to 10 kHz > 10 kHz to 50 kHz > 50 kHz to 1 MHz	0.032° 0.042° 0.058° 0.068° 0.0012°/kHz + 0.015°	Clark Hess 6000A
Phase – Generate ^{Note 4}	10 Hz to 65 Hz > 65 Hz to 500 Hz > 500 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz > 10 kHz to 30 kHz	0.14° 0.30° 0.58° 2.9° 5.8° 12°	Fluke 5522A
OSCILLOSCOPES (20/E20)			
Leveled Sine Amplitude	50 kHz reference 0.1 Hz to 6.4 GHz	17 μ V/mV + 1.9 nV 17 μ V/mV + 1.9 nV	Fluke 9500B / 9560
Leveled Sine Flatness ^{Note 4} 50 kHz – 10 MHz Reference	0.1 Hz to 300 MHz > 300 MHz to 550 MHz > 550 MHz to 3 GHz > 3 GHz to 6 GHz	0.20 dB 0.25 dB 0.30 dB 0.40 dB	Fluke 9500B/9560
Time Marker, 50 Ω ^{Note 4}	180.19 ps to 9.009 ns 9.0091 ns to 55 s	0.29 as/ns + 1.1 as 0.29 ns/ms – 1.7 as	Fluke 9500B /9560
CONDUCTANCE (20/E21)			
Conductivity ^{Note 4}	10 μ S/cm 100 μ S/cm 1000 μ S/cm	0.65 μ S/cm 1.3 μ S/cm 4.2 μ S/cm	Conductivity solutions



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
	10 000 µS/cm 100 000 µS/cm	36 µS/cm 0.33 mS/cm	
TIME and FREQUENCY			
FREQUENCY DISSEMINATION (20/F01)			
Frequency – Measure ^{Note 4}	100 µHz to 10 Hz > 10 Hz to 3 GHz > 3 GHz to 26.5 GHz > 26.5 GHz to 110 GHz	50 µHz 7.7 pHz/Hz 7.7 pHz/Hz 5.2 pHz/Hz	HP 58503A/53132A HP 58503A/53132A HP 58503A/53151A HP 58503A/EIP 578/EIP 590
Frequency – Generate ^{Note 4}	1 µHz to 20 MHz > 20 MHz to 50 GHz	6.7 pHz/Hz 6.7 pHz/Hz	HP 58503A/Keysight 33600A & Agilent 83650B
OSCILLATOR CHARACTERIZATION (20/F03)			
Harmonics ^{Note 4} 0 dBc to 80 dBc	20 Hz to 50 kHz > 50 kHz to 10 MHz > 10 MHz to 3.6 GHz > 3.6 GHz to 26.5 GHz	0.043 dB 0.043 dB 0.42 dB 1.5 dB	Keysight N9030B
Amplitude Modulation -- Measure & Generate ^{Note 4} 100 kHz to 3.6 GHz	1 % to 99 %	0.12 %	Keysight N5531X
> 3.6 GHz to 13.6 GHz	5 % to 99 %	0.15 %	
> 13.6 GHz to 17.1 GHz	5 % to 99 %	0.17 %	
> 17.1 GHz to 26.5 GHz	5 % to 99 %	0.19 %	
> 26.5 GHz to 34.5 GHz	5 % to 99 %	0.24 %	
> 34.5 GHz to 50 GHz	5 % to 99 %	0.46 %	

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Frequency Modulation – Generate and measure ^{Notes 4,8} 100 kHz to 3.6 GHz	0.2 < β ≤ 100	0.004 FM	Keysight N5531X
	β > 100	0.0092 FM	
	> 3.6 GHz to 8.4 GHz	0.0081 FM	
	β > 100	0.023 FM	
	> 8.4 GHz to 17.1 GHz	0.0081 FM	
> 17.1 GHz to 34.5 GHz	0.2 < β ≤ 100	0.0081 FM	Keysight N5531X
β > 100	0.029 FM		
> 34.5 GHz to 50 GHz	0.2 < β ≤ 100	0.0092 FM	
β > 100	0.035 FM		
> 17.1 GHz to 26.5 GHz	0.2 < β ≤ 100	0.016 FM	
> 26.5 GHz to 34.5 GHz	β > 100	0.046 FM	
Phase Modulation – Measure & Generate ^{Note 4}	100 kHz to 3.6 GHz	0.014 rad	Keysight N5531X
	> 3.6 GHz to 13.6 GHz	0.015 rad	
	> 13.6 GHz to 17.1 GHz	0.018 rad	
	> 17.1 GHz to 26.5 GHz	0.021 rad	
	> 26.5 GHz to 34.5 GHz	0.025 rad	
> 34.5 GHz to 50 GHz	0.027 rad		
PULSE WAVEFORM (20/F04)			
Rise Time – Generate	30 ps	18 ps	Tek 067-1338-00
	500 ps	49 ps	
	150 ps	20 ps	Fluke 9500B/9530
	70 ps	16 ps	
Rise Time – Measure	> 30 ps and <500 ps	24 ps	Fluke 9500B/9560
			HP 54750A/54751A



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
STOPWATCHES & TIMERS (20/F05)			
Time – Measure ^{Note 4}	Up to 19.99 s/day	0.059 s/day	Helmut Klein Timometer 4500
MECHANICAL			
AIRSPEED (20/M03)			
Air Velocity – Measure	400 ft/min to 800 ft/min	24 ft/min - 1.4 % of reading	Comparison of Pitot tube with
	800 ft/min to 9000 ft/min	5.7 ft/min + 0.94 % of reading	UUT using wind tunnel
FLOW RATE (20/M05)			
Gas Flow	Up to SCCM to 50 SCCM	0.26 % + 0.012 SCCM	Molbox1 & 5E1 Molbloc
	50 SCCM to 500 SCCM	0.26 % + 0.12 SCCM	Molbox1 & 5E2 Molbloc
	500 SCCM to 5 SLPM	0.26 % + 1.2 SCCM	Molbox1 & 5E3 Molbloc
	5 SLPM to 50 SLPM	0.26 % + 12 SCCM	Molbox1 & 3E4 Molbloc
	50 SLPM to 100 SLPM	0.52 % + 140 SCCM	Molbox1 & 1E5Molbloc
FORCE (20/M06)			
Crimp Tool – Pull Force	Up to 100 lbf	7.8 % of rdg. + 2.6 lbf	Crimp pull tester
Durometer – Spring Force	78 gf 113 gf 821 gf 4533 gf	3.1 gf 0.91 gf 5.4 gf 14 gf	Electronic balance
Supermicrometer Gaging Force	2 ozf 4 ozf 8 ozf 16 ozf 40 ozf	0.090 ozf 0.22 ozf 0.22 ozf 0.88 ozf 2.5 ozf	Gram gage Force gage

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) Notes 1,2

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) <small>Notes 3,5</small>	Remarks
Force Gages	0.03125 ozf to 8 ozf 0.5 lbf to 500 lbf 3.2 lbf to 300 lbf > 300 lbf to 1000 lbf > 1000 lbf to 10 000 lbf	0.056 % + 0.000024 ozf 0.055 % + 0.000023 lbf 0.010 % + 0.0064 lbf 0.012 % + 0.0012 lbf 0.010 % + 0.16 lbf	Class 6 Weights Class 7 Weights Morehouse HADI 300LBF Morehouse M4215A- 1000LBF Morehouse M4215A-10000LBF
MASS DISSEMINATION (20/M08)			
Mass – Measure	1 mg to 2 g > 2 g to 10 g > 10 g to 31 g > 31 g to 610 g > 610 g to 5 kg > 5 kg to 34 kg	3.1 µg + 2.4 µg/g 6.7 µg + 0.59 µg/g 7.3 µg + 0.53 µg/g 9.6 µg + 0.64 µg/g 0.23 mg + 0.53 µg/g 130 mg	Weights, MCM36 Balance Weights, MCM36 Balance Weights, MCM36 Balance Weights, MCM605 Balance Weights, CCE5004 Balance Weights, CPA34001S Balance
VIBRATION (20/M11)			
Accelerometers			
Voltage sensitivity	5 Hz – 10 Hz 10 Hz – 100 Hz 100 Hz – 2 kHz 2 kHz – 8 kHz 8 kHz – 10 kHz	3.3 % 2.2 % 1.9 % 3.1 % 3.3 %	Vibration Research VR9500, PCB 301A11, and ET-126-1HF
Up to 1000 mV/g			
Charge sensitivity	5 Hz – 10 Hz 10 Hz – 100 Hz 100 Hz – 2 kHz 2 kHz – 8 kHz 8 kHz – 10 kHz	3.5 % 2.5 % 2.2 % 3.3 % 3.5 %	VR9500, 301A11, ET-126-1HF, and PCB 422E53
Up to 1000 pC/g			
VOLUME & DENSITY (20/M12)			
Viscosity	100 cps 1000 cps 5000 cps 100 000 cps	0.33 % 0.50 % 0.45 % 0.60 %	Viscosity solutions

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
SPEED INDICATORS (20/M14)			
Photo ^{Note 4}	1 rpm to 100 000 rpm	8.6 E-6 rpm/rpm + 0.0058 rpm	Signal generator
Contact	10 rpm to 50 000 rpm	5.9 E-5 rpm/rpm + 0.012 rpm	Ideal Aerosmith 1921
TORQUE (20/M15)			
Torque – Generate	0.25 ozf-in to 40 ozf-in > 40 ozf-in to 20 lbf-in 0.035 Nm to 0.45 Nm 0.45 Nm to 3.3 Nm 3.3 Nm to 339 Nm 339 Nm to 2712 Nm	0.13 % 0.073 % 0.077 % 0.070 % 0.066 % 0.071 %	Torque wheel or arm with Class 6 weights
Torque – Measure	0.5 ozf-in to 2.5 ozf-in > 2.5 ozf-in to 10 ozf-in > 10 ozf-in to 15 ozf-in > 15 ozf-in to 200 ozf-in > 200 ozf-in to 50 lbf-in > 50 lbf-in to 150 lbf-in > 150 lbf-in to 400 lbf-in > 400 lbf-in to 1000 lbf-in > 1000 lbf-in to 125 lbf-ft > 125 lbf-ft to 250 lbf-ft > 250 lbf-ft to 600 lbf-ft > 600 lbf-ft to 1000 lbf-ft > 1000 lbf-ft to 2000 lbf-ft	0.51 % + 0.0022 ozf-in 0.51 % + 0.0086 ozf-in 0.58 % + 0.0035 ozf-in 0.29 % + 0.029 ozf-in 0.30 % + 0.0028 lbf-in 0.30 % + 0.0067 lbf-in 0.30 % + 0.026 lbf-in 0.30 % + 0.084 lbf-in 0.27 % + 0.036 lbf-ft 0.30 % + 0.013 lbf-ft 0.30 % + 0.031 lbf-ft 0.30 % + 0.083 lbf-ft 0.30 % + 0.042 lbf-ft	Waters 6500T4 Waters 6500T4 CDI 2000-4-02 CDI 2000-5-02 CDI 2000-6-02 CDI 2000-65-02 CDI 2000-7-02 CDI 2000-8-02 CDI 2000-10-02 CDI 2000-11-02 CDI 2000-12-02 CDI 2000-13-02 CDI 2000-14-02
WEIGHING INSTRUMENTS (20/M16)			
Scales & Balances ^{Note 4}	1 mg to 20 mg > 20 mg to 500 mg > 500 mg to 5 g > 5 g to 10 g	0.0023 mg 0.0030 mg 0.0081 mg 0.012 mg	Class 1 Weights



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
	> 10 g to 20 g > 20 g to 50 g > 50 g to 100 g > 100 g to 5 kg > 5 kg to 20 kg > 20 kg to 30 kg > 30 kg to 50 kg > 50 kg to 250 kg	0.017 mg 0.034 mg 0.068 mg 0.010 mg + 0.57 µg/g 0.59 µg/g 13 mg 18 mg 4.4 µg/g + 470 mg	Class F Weights
ELECTROMAGNETICS – RF/MICROWAVE			
RF/MICROWAVE POWER (20/R17)			
RF Absolute Power – Measure ^{Note 4}			
100 kHz to 2.6 GHz	-20 dBm to 30 dBm	0.15 dB	HP 8902A w/ 11722A
50 MHz to 1.3 GHz	-20 dBm to 30 dBm	0.15 dB	HP 8902A w/ 11792A
1.3 GHz to 18 GHz		0.25 dB	
18 GHz to 26.5 GHz		0.31 dB	
50 MHz to 100 MHz	-30 dBm to 20 dBm	0.14 dB	HP E4419B w/ HP N8487A
100 MHz to 2 GHz		0.12 dB	
2 GHz to 12.4 GHz		0.14 dB	
12.4 GHz to 18 GHz		0.15 dB	
18 GHz to 26.5 GHz		0.18 dB	
26.5 GHz to 40 GHz		0.22 dB	
40 GHz to 50 GHz		0.31 dB	
50 MHz to 100 MHz	-70 dBm to -20 dBm	0.15 dB	HP E4419B w/ HP 8487D
100 MHz to 2 GHz		0.16 dB	
2 GHz to 12.4 GHz		0.17 dB	
12.4 GHz to 18 GHz		0.20 dB	
18 GHz to 34 GHz		0.23 dB	
34 GHz to 40 GHz		0.29 dB	
40 GHz to 50 GHz		0.37 dB	



2024-06-06 through 2025-06-30

Effective dates

For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
30 MHz to 4 GHz 4 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	-70 dBm to -20 dBm	0.15 dB 0.16 dB 0.19 dB 0.21 dB	HP E4419B w/ HP 8481D
RF Absolute Power – Measure ^{Note 4} 9 kHz to 2 GHz 2 GHz to 6 GHz	-60 dBm to 20 dBm	0.15 dB 0.16 dB	HP E4419B w/ HP E9304A
50 MHz to 100 MHz 100 MHz to 8 GHz 8 GHz to 18 GHz 18 GHz to 26.5 GHz	-70 dBm to 20 dBm	0.21 dB 0.21 dB 0.22 dB 0.23 dB	HP E4419B w/ HP E4413A
50 MHz	1 mW	0.0033 mW	Tegam 1830A w/HP 478A-H76
Tuned RF Power – Absolute - Measure ^{Note 4} 100 kHz to 26.5 GHz	10 dBm to -22 dBm -22 dBm to -42 dBm -42 dBm to -50 dBm -50 dBm to -60 dBm -60 dBm to -72 dBm -72 dBm to -80 dBm -80 dBm to -92 dBm -92 dBm to -102 dBm -102 dBm to -110 dBm -110 dBm to -120 dBm -120 dBm to -127 dBm	0.14 dB 0.15 dB 0.17 dB 0.17 dB 0.19 dB 0.20 dB 0.21 dB 0.27 dB 0.32 dB 0.37 dB 0.43 dB	HP 8902 w/11722A or 11792A sensor

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Tuned RF Power – Relative Measure ^{Note 4} 100kHz to 26.5 GHz	10 dB to 2 dB	0.087 dB	HP 8902 w/11722A or 11792A sensor
	2 dB to -12 dB	0.099 dB	
	-12 dB to -22 dB	0.11 dB	
	-22 dB to -31 dB	0.11 dB	
	-31 dB to -40 dB	0.093 dB	
	-40 dB to -50 dB	0.10 dB	
	-50 dB to -61 dB	0.11 dB	
	-61 dB to -71 dB	0.12 dB	
	-71 dB to -80 dB	0.15 dB	
	-80 dB to -90 dB	0.16 dB	
	-90 dB to -100 dB	0.16 dB	
	-100 dB to -110 dB	0.20 dB	
	-110 dB to -120 dB	0.22 dB	
-120 dB to -127 dB	0.34 dB		
RF Power – Flatness ^{Note 4} 9kHz to 6 GHz	-60 to 20 dBm	0.041 dB	Agilent E4419B, Agilent E9304A

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

SCATTERING PARAMETERS (20/R18)				
S_{11} , S_{22} Parameters, Reflection Coefficient (0 to 1)				
HP 8757A w/85027B				
Return Loss	10 MHz to 8.4 GHz	8.4 GHz to 12 GHz	12 GHz to 20 GHz	20 GHz to 26.5 GHz
1 dB	0.067	0.16	0.069	0.027
2 dB	0.054	0.13	0.056	0.022
3 dB	0.044	0.10	0.047	0.018
4 dB	0.037	0.084	0.039	0.015
5 dB	0.031	0.068	0.034	0.12
6 dB	0.027	0.055	0.030	0.11
7 dB	0.026	0.047	0.032	0.11
8 dB	0.022	0.039	0.031	0.097
9 dB	0.022	0.034	0.030	0.092



2024-06-06 through 2025-06-30

Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0


CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

SCATTERING PARAMETERS (20/R18)				
S ₁₁ , S ₂₂ Parameters, Reflection Coefficient (0 to 1)				
HP 8757A w/85027B				
Return Loss	10 MHz to 8.4 GHz	8.4 GHz to 12 GHz	12 GHz to 20 GHz	20 GHz to 26.5 GHz
10 dB	0.022	0.030	0.029	0.089
11 dB	0.021	0.028	0.029	0.086
12 dB	0.021	0.026	0.028	0.085
20 dB	0.022	0.045	0.042	0.16
30 dB	0.017	0.068	0.10	0.44
40 dB	0.091	0.11	0.037	0.31

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Attenuation – Generate ^{Note 4} (50 Ω) 200 Hz to 80 MHz	0 dB to 38 dB 40 dB to 58 dB 60 dB to 98 dB	0.26 dB 0.32 dB 0.51 dB	HP 3335A (BNC F)
Attenuation – Generate ^{Note 4} (75 Ω) 200 Hz to 25 MHz > 25 MHz to 80 MHz 200 Hz to 25 MHz > 25 MHz to 80 MHz 200 Hz to 25 MHz > 25 MHz to 80 MHz	0 dB to 18 dB 20 dB to 58 dB 60 dB to 98 dB	0.28 dB 0.40 dB 0.39 dB 0.52 dB 0.47 dB 0.81 dB	
DC to 18 GHz (Fixed Value)	3 dB 6 dB 10 dB 20 dB	0.46 dB 0.46 dB 0.65 dB 0.65 dB	Weinschel 44 Series

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Attenuation – Generate ^{Note 4} 30 MHz	0 dB 10 dB 20 dB 30 dB 40 dB 50 dB	0.0040 dB 0.0083 dB 0.019 dB 0.020 dB 0.033 dB 0.022 dB	Agilent 11812A
Attenuation – Measure ^{Note 4} 2.5 MHz to 26.5 GHz	0 dB to 2 dB > 2 dB to -12 dB > -12 dB to -22 dB > -22 dB to -31 dB > -31 dB to -40 dB > -40 dB to -50 dB > -50 dB to -61 dB > -61 dB to -71 dB > -71 dB to -80 dB > -80 dB to -90 dB > -90 dB to -100 dB > -100 dB to -110 dB > -110 dB to -120 dB > -120 dB to -127 dB	0.081 dB 0.070 dB 0.081 dB 0.081 dB 0.093 dB 0.10 dB 0.11 dB 0.12 dB 0.15 dB 0.16 dB 0.16 dB 0.20 dB 0.22 dB 0.34 dB	HP8902 with 11722A or 11792A sensor
THERMODYNAMIC			
HUMIDITY (20/T02)			
Relative Humidity ^{Note 4}	10 % RH to 95 % RH	0.15 % RH + 0.29 % rdg.	Thunder Scientific 2500
LABORATORY THERMOMETERS (20/T03)			
Temperature – Generate & Measure	-197 °C -95 °C to -80 °C ≥ -80 °C to 0 °C 0.01 °C > 0 °C to 100 °C ≥ 100 °C to 250 °C	6.4 mK 13 mK 7.2 mK+ 0.014 mK/°C 4.4 mK 7.6 mK+ 0.018 mK/°C 6.3 mK+ 0.029 mK/°C	Additel ADT286 w/AccuMac 1960A or Fixed Point TPW



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty ($k=2$) ^{Notes 3,5}	Remarks
	> 250 °C to 660 °C > 660 °C to 700 °C > 700 °C to 1000 °C > 1000 °C to 1200 °C	20 mK+ 0.079 mK/°C 0.47 °C + 1.2 E-04 °C/°C 1.2 °C 0.85 °C + 7.6 E-04 °C/°C	Fluke 9118A w/AccuMac AM1210-20
Thermistor	0 °C to 100 °C	5.8 mK + 0.036 mK/°C	Fluke 5644S w/Additel ADT286
PRESSURE (20/T05)			
Pressure – Generate & Measure ^{Note 4}	0 Pa to 746 Pa > 746 Pa to 7460 Pa 1245 Pa to 10 kPa > 10 kPa to 62 kPa > 62 kPa to 689 kPa > 689 kPa to 6.89 MPa > 6.89 MPa to 20 MPa > 20 MPa to 68.9 MPa 69 MPa to 207 MPa	0.0048 % + 0.045 Pa 0.011 % - 0.00015 Pa 1.2 Pa 0.012 % 0.0098 % + 0.064 Pa 0.0098 % + 1.8 Pa 0.016 % + 1.4 Pa 0.017 % + 3.0 Pa 0.025 % + 17 Pa	Fluke 7250 LP Pressurements T3500/3 DHI RPM4-A700kp DHI RPM4-A7Mp DHI RPM4-A2Ms DHI RPM4-A70Ms Fluke/DHI E-DWT-H-A200Me-L
RADIATION THERMOMETRY (20/T06)			
Source ^{Note 4}	-15 °C to 120 °C 120 °C to 200 °C 200 °C to 500 °C	0.0012 °C /°C + 0.33 °C 0.0023 °C /°C + 0.17 °C 0.0028 °C /°C + 0.065 °C	Fluke 4180 infrared source Fluke 4181 infrared source
RESISTANCE THERMOMETRY (20/T07)			
Comparison – RTDs	-197 °C -95 °C to -80 °C ≥ -80 °C to 0 °C 0.01 °C > 0 °C to 100 °C ≥ 100 °C to 250 °C > 250 °C to 660 °C > 660 °C to 700 °C	6.4 mK 13 mK 7.2 mK+ 0.014 mK/°C 4.4 mK 7.6 mK+ 0.018 mK/°C 6.3 mK+ 0.029 mK/°C 20 mK+ 0.079 mK/°C 470 mK + 0.12 mK/°C	Additel ADT286 w/AccuMac 1960A or Fixed Point TPW



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
	> 700 °C to 1000 °C > 1000 °C to 1200 °C	1.2 °C 850 mK + 0.76 mK /°C	Fluke 9118A w/AccuMac AM1210-20
TEMPERATURE INDICATORS (20/T08)			
Thermocouple Simulation ^{Note 4}			
Type B	600 °C to 800 °C > 800 °C to 1000 °C > 1000 °C to 1550 °C > 1550 °C to 1820 °C	0.33 °C 0.26 °C 0.23 °C 0.20 °C	Fluke 5522A
Type C	0 °C to 150 °C > 150 °C to 650 °C > 650 °C to 1000 °C > 1000 °C to 1800 °C > 1800 °C to 2316 °C	0.18 °C 0.15 °C 0.18 °C 0.30 °C 0.49 °C	
Type E	-250 °C to -100 °C > -100 °C to -25 °C > -25 °C to 350 °C > 350 °C to 650 °C > 650 °C to 1000 °C	0.30 °C 0.093 °C 0.078 °C 0.093 °C 0.12 °C	
Type J	-210 °C to -100 °C > -100 °C to -30 °C > -30 °C to 150 °C > 150 °C to 760 °C > 760 °C to 1200 °C	0.16 °C 0.093 °C 0.078 °C 0.10 °C 0.14 °C	
Type K	-210 °C to -100 °C > -100 °C to -25 °C > -25 °C to 120 °C > 120 °C to 1000 °C > 1000 °C to 1372 °C	0.19 °C 0.11 °C 0.093 °C 0.15 °C 0.23 °C	



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Type L	-200 °C to -100 °C > -100 °C to 800 °C > 800 °C to 900 °C	0.29 °C 0.20 °C 0.13 °C	
Type N	-200 °C to -100 °C > -100 °C to -25 °C > -25 °C to 120 °C > 120 °C to 410 °C > 410 °C to 1300 °C	0.23 °C 0.13 °C 0.12 °C 0.11 °C 0.16 °C	
Type R	0 °C to 250 °C > 250 °C to 400 °C > 400 °C to 1000 °C > 1000 °C to 1767 °C	0.37 °C 0.22 °C 0.20 °C 0.23 °C	
Type S	0 °C to 250 °C > 250 °C to 1000 °C > 1000 °C to 1400 °C > 1400 °C to 1767 °C	0.36 °C 0.23 °C 0.23 °C 0.26 °C	
Type T	-250 °C to -150 °C > -150 °C to 0 °C > 0 °C to 120 °C > 120 °C to 400 °C	0.37 °C 0.14 °C 0.093 °C 0.078 °C	
Type U	-200 °C to 0 °C > 0 °C to 600 °C	0.43 °C 0.21 °C	
Half Junction Simulation			
Type E	-200 °C to 1000 °C	0.045 °C	
Type J	-210 °C to 1200 °C	0.093 °C	
Type K	-270 °C to 1373 °C	0.11 °C	



2024-06-06 through 2025-06-30
Effective dates

For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Type N	-270 °C to 1260 °C	0.092 °C	
Type S	-50 °C to 1480 °C	0.15 °C	
Type T	-200 °C to 400 °C	0.082 °C	
RTD Simulation ^{Note 4}			
Pt 385, 100 Ω	-200 °C to -80 °C	0.039 °C	
	> -80 °C to 0 °C	0.039 °C	
	> 0 °C to 100 °C	0.054 °C	
	> 100 °C to 300 °C	0.070 °C	
	> 300 °C to 400 °C	0.078 °C	
	> 400 °C to 630 °C	0.093 °C	
	> 630 °C to 800 °C	0.18 °C	
Pt 3926, 100 Ω	-200 °C to -80 °C	0.039 °C	
	> -80 °C to 0 °C	0.039 °C	
	> 0 °C to 100 °C	0.054 °C	
	> 100 °C to 300 °C	0.070 °C	
	> 300 °C to 400 °C	0.078 °C	
	> 400 °C to 630 °C	0.093 °C	
Pt 3916, 100 Ω	-200 °C to -190 °C	0.29 °C	
	> -190 °C to -80 °C	0.046 °C	
	> -80 °C to 0 °C	0.058 °C	
	> 0 °C to 100 °C	0.069 °C	
	> 100 °C to 260 °C	0.081 °C	
	> 260 °C to 300 °C	0.092 °C	
	> 300 °C to 400 °C	0.10 °C	
	> 400 °C to 600 °C	0.12 °C	
	> 600 °C to 630 °C	0.27 °C	
Pt 385, 200 Ω	-200 °C to -80 °C	0.031 °C	
	> -80 °C to 0 °C	0.031 °C	
	> 0 °C to 100 °C	0.031 °C	
	> 100 °C to 260 °C	0.039 °C	



2024-06-06 through 2025-06-30

Effective dates

For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
Pt 385, 500 Ω	> 260 °C to 300 °C	0.093 °C	
	> 300 °C to 400 °C	0.10 °C	
	> 400 °C to 600 °C	0.11 °C	
	> 600 °C to 630 °C	0.12 °C	
Pt 385, 1000 Ω	-200 °C to -80 °C	0.039 °C	
	> -80 °C to 0 °C	0.031 °C	
	> 0 °C to 100 °C	0.039 °C	
	> 100 °C to 260 °C	0.047 °C	
	> 260 °C to 300 °C	0.062 °C	
	> 300 °C to 400 °C	0.062 °C	
	> 400 °C to 600 °C	0.070 °C	
	> 600 °C to 630 °C	0.085 °C	
PtNi, 120 Ω	-200 °C to -80 °C	0.023 °C	
	> -80 °C to 0 °C	0.023 °C	
	> 0 °C to 100 °C	0.031 °C	
	> 100 °C to 260 °C	0.039 °C	
Cu 427, 10 Ω	> 260 °C to 300 °C	0.047 °C	
	> 300 °C to 400 °C	0.054 °C	
	> 400 °C to 600 °C	0.055 °C	
	> 600 °C to 630 °C	0.18 °C	
	-80 °C to 0 °C	0.062 °C	
	> 0 °C to 100 °C	0.062 °C	
	> 100 °C to 260 °C	0.11 °C	
	-100 °C to 260 °C	0.23 °C	
VACUUM & LOW PRESSURE GAGES (20/T09)			
Vacuum – Measure ^{Note 4}	0 mTorr to 1000 mTorr > 1 Torr to 10 Torr	0.14 mTorr + 1.3 % 0.0013 Torr + 1.3 %	MKS 390411-0-YE-T with: MKS 660B20/626C01TDE MKS660B10/626C11TQD

2024-06-06 through 2025-06-30
Effective dates



For the National Voluntary Laboratory Accreditation Program


CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) ^{Notes 1,2}

Measured Parameter or Device Calibrated	Range	Expanded Uncertainty (k=2) ^{Notes 3,5}	Remarks
THERMOCOUPLES (20/T11)			
Type E	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1000°C	0.14 °C 0.15 °C 0.17 °C + 0.092 mK/°C 1.2°C	Additel ADT286 w/ Fluke 5628 Accumac AM1210-20
Type J	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.14 °C 0.16 °C 0.18 °C + 0.077 mK/°C 1.2 °C 2.2 °C	
Type K	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.15 °C 0.16 °C 0.18 °C + 0.077 mK/°C 1.2 °C 2.2 °C	
Type N	-196°C > -95 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.15 °C 0.16 °C 0.18 °C + 0.077 mK/°C 1.2 °C 2.2 °C	
Type R	> -50 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.29°C – 1.3 mK/°C 0.23 °C 1.3 °C 2.2 °C	
Type S	> -50 °C to 50 °C > 50°C to 700°C > 700°C to 1093°C > 1093°C to 1200°C	0.28°C – 1.1 mK/°C 0.24 °C 1.3 °C 2.2 °C	
Type T	-196°C > -95 °C to 50 °C > 50°C to 400°C	0.15 °C 0.16 °C 0.18°C + 0.057 mK/°C	
END			

2024-06-06 through 2025-06-30
Effective dates


For the National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200972-0

Notes

Note 1: A Calibration and Measurement Capability (CMC) is a description of the best result of a calibration or measurement (result with the smallest uncertainty of measurement) that is available to the laboratory's customers under normal conditions, when performing more or less routine calibrations of nearly ideal measurement standards or instruments. The CMC is described in the laboratory's scope of accreditation by: the measurement parameter/device being calibrated, the measurement range, the uncertainty associated with that range (see note 3), and remarks on additional parameters, if applicable.

Note 2: Calibration and Measurement Capabilities are traceable to the national measurement standards of the U.S. or to the national measurement standards of other countries and are thus traceable to the internationally accepted representation of the appropriate SI (Système International) unit.

Note 3: The uncertainty associated with a measurement in a CMC is an expanded uncertainty with a level of confidence of approximately 95 %, typically using a coverage factor of $k = 2$. However, laboratories may report a coverage factor different than $k = 2$ to achieve the 95 % level of confidence. Units for the measurand and its uncertainty are to match. Exceptions to this occur when marketplace practice employs mixed units, such as when the artifact to be measured is labeled in non-SI units and the uncertainty is given in SI units (Example: 5 lb weight with uncertainty given in mg).

Note 3a: The uncertainty of a specific calibration by the laboratory may be greater than the uncertainty in the CMC due to the condition and behavior of the customer's device and specific circumstances of the calibration. The uncertainties quoted do not include possible effects on the calibrated device of transportation, long term stability, or intended use.

Note 3b: As the CMC represents the best measurement results achievable under normal conditions, the accredited calibration laboratory shall not report smaller uncertainty of measurement than that given in a CMC for calibrations or measurements covered by that CMC.

Note 3c: As described in Note 1, CMCs cover calibrations and measurements that are available to the laboratory's customers under *normal conditions*. However, the laboratory may have the capability to offer special tests, employing special conditions, which yield calibration or measurement results with lower uncertainties. Such special tests are not covered by the CMCs and are outside the laboratory's scope of accreditation. In this case, NVLAP requirements for the labeling, on calibration reports, of results outside the laboratory's scope of accreditation apply. These requirements are set out in Annex A.5 of NIST Handbook 150, Procedures and General Requirements.

Note 4: Uncertainties associated with field service calibration may be greater as they incorporate on-site environmental contributions, transportation effects, or other factors that affect the measurements. (This note applies only if marked in the body of the scope.)

Note 5: Values listed with percent (%) are percent of reading or generated value unless otherwise noted.

Note 6: NVLAP accreditation is the formal recognition of specific calibration capabilities. Neither NVLAP nor NIST guarantee the accuracy of individual calibrations made by accredited laboratories.

Note 7: Uncertainties are listed at optimal conditions ($PF = 1$, $\Phi = 0^\circ$ at 10 Hz - 65 Hz). Under different conditions, the uncertainty of the power measurement will vary based on the laboratory's AC voltage and current measurement uncertainties. PFs of less than one will increase the uncertainty of the power measurement, ramping up as PF approaches zero. Essco may also report reactive power, apparent power, and power factor under this accreditation. Uncertainties at other conditions can be obtained from the laboratory.

Note 8: Where *FM* is measured peak expressed in Hertz.

2024-06-06 through 2025-06-30

Effective dates



For the National Voluntary Laboratory Accreditation Program