National Voluntary Laboratory Accreditation Program

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

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CALIBRATION LABORATORIES **NVLAP LAB CODE 105002-0**

DIMENSIONAL

NVLAP Code: 20/D01
Angular

Range	*Best Uncertainty (±)* [note 1]	*Remarks*
Angle Blocks	0.47 arc second	Standard Sizes, 1 arc second to 45°
Optical Squares	0.46 arc second	
True Squares	0.28 arc second	

Angular/Rotary Index Tables and Optical Polygons

Range	*Best Uncertainty (±)* [notes 1, 2]	*Remarks*
30° increments	0.08 arc second	Stack method
30° increments	0.50 arc second	Comparison method

NVLAP Code: 20/D03
Gage Blocks

Range	*Best Uncertainty (±)* [notes 1, 6]	*Remarks*
to 100 mm	(35 + 0.53 L) nm, L in mm	Interferometry, single wring
to 4 in	(1.38 + 0.53 L) µin, L in inches	Interferometry, single wring
< 1 mm	42 nm	Mechanical comparison to masters [notes 2, 3, 4]
< 0.04 in	1.65 µin	Mechanical comparison to masters [notes 2, 3, 4]

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1 mm to 100 mm	(37 + 0.60 L) nm, L in mm	Mechanical comparison to masters *notes 2, 3, 4*
0.04 in to 4 in	(1.46 + 0.60 L) µin, L in inches	Mechanical comparison to masters *notes 2, 3, 4*
125 mm to 500 mm	(127 + 0.30 L) nm, L in mm	Mechanical comparison to masters *notes 2, 3, 4*
5 in to 20 in	(5.0 + 0.30 L) µin, L in inches	Mechanical comparison to masters *notes 2, 3,* 4

NVLAP Code: 20/D07
Thread Measuring Wires

Range	***Best Uncertainty (±)*** *notes 1, 2*	***Remarks***
All Standard 29° and 60°	160 nm (6.3 µin)	Comparison to NIST-calibrated masters

NVLAP Code: 20/D08
Optical Reference Planes

Range	***Best Uncertainty (±)*** *notes 1, 2*	***Remarks***
to 10 inch diameter	1.2 µin (30 nm)	Comparison to NIST-calibrated masters

NVLAP Code: 20/D09
Roundness

Range - Diameter	***Best Uncertainty (±)*** *notes 1, 2*	***Remarks***
to 100 mm	5.4 nm + 5.1% of value	Spindle error deconvolution at limited points.
to 4 in	0.2 µin + 5.1% of value	Spindle error deconvolution at limited points.
to 350 mm	10.6 nm + 6.8% of value	Spindle-compensated trace. Uncertainty will increase for large artifacts.
to 14 in	0.42 µin + 6.8% of value	Spindle-compensated trace. Uncertainty will increase for large artifacts.

NVLAP Code: 20/D11
Spherical Diameter; Plug/Ring Gages

Range	***Best Uncertainty (±)*** *notes 1, 2*	***Remarks***
1 mm to 25 mm	150 nm	Gaging Balls Calibration Spheres; Comparison to NIST-calibrated masters
0.03125 in to 1 in	5.91 µin	Gaging Balls Calibration Spheres; Comparison to NIST-calibrated masters
to 250 mm	(230 + 17 L) nm, L in mm	Plain plug/ring gages

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to 10 in	(9.0 + 1.7 L) µin, L in inches	Plain plug/ring gages

NVLAP Code: 20/D12
Surface Texture

Range	***Best Uncertainty (±)*** *notes 1, 2*	***Remarks***
0.5 µin to 500 µin (0.0125 µm to 12.5 µm)		
0.5 µin	0.1 µin	Step Height Standards
15 µin	0.3 µin	Step Height Standards
100 µin	2.0 µin	Step Height Standards
500 µin	8.0 µin	Step Height Standards
0.5 µin to 125 µin (0.0125 µm to 3.1 µm)		
0.5 µin	0.1 µin	Roughness Average (Ra)
15 µin	0.6 µin	Roughness Average (Ra)
100 µin	2.7 µin	Roughness Average (Ra)

DC/LOW FREQUENCY

NVLAP Code: 20/E01
Current/AC-DC Difference

	Best Uncertainty (±) in ppm *note 1* ***Frequency in Hertz***		
Range	***100***	***50 k***	***100 k***
10 mA	55	99	134
25 mA	54	99	134
50 mA	58	100	140
100 mA	59	107	149
250 mA	56	109	155
0.5 A	56	136	162
1.0 A	58	119	171
2.5 A	80	130	182

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5.0 A	68	159	212
10.0 A	77	176	248
16.0 A	100	216	279

NVLAP Code: 20/E03
Capacitance Voltage Dividers - Pulsed High-Voltage Condition

Range	***Best Uncertainty (±) in percent*** [note 1]	***Remarks***
1 kV to 350 kV	2.0	1 μs to 30 μs Pulse

NVLAP Code: 20/E05
DC Resistance

Range in ohms	***Best Uncertainty (±) in ppm*** [note 1]	***Remarks***
0.0001 to 0.001	5	6010 + 6011 System Time of Test
0.001 to 0.01	0.35	6010 + 6011System Time of Test
0.01 to 0.1	0.29	6010 + 6011 System Time of Test
0.1 to 1	0.21	6010 + 6011 System Time of Test
1	0.055	6010 + 4220 + double substitution Time of Test
1 to 10	0.076	6010 + 4220 System Time of Test
10 to 100	0.09	6010 + 4220 System Time of Test
100 to 1000	0.11	6010 + 4220 System Time of Test
1000 to 10 k	0.15	6010 + 4220 System Time of Test
10^4 to 10^5	0.20	6000 + 4220A System Time of Test
10^5 to 10^6	0.25	6000 + 4220A System Time of Test
10^6 to 10^7	0.29	6000 + 4220A System Time of Test
10^7 to 10^8	0.58	6010 + 4220 System Time of Test
10^8 to 10^9	5.0	6000 + 4220A System Time of Test
10^9 to 10^{10}	470	Terraohm Meter
10^{10} to 10^{11}	670	Terraohm Meter
10^{11} to 10^{12}	1400	Terraohm Meter
10^{12} to 10^{13}	2000	Terraohm Meter
10^{13} to 10^{14}	3300	Terraohm Meter
10^{14} to 10^{15}	6700	Terraohm Meter
10^{15} to 10^{16}	7.0%	Terraohm Meter

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Shunts

Range	*Best Uncertainty (±) in ppm* [note 1]	*Remarks*
100 mA to 2500 A	2.5	

Range (nominal values) in ohms	*Best Uncertainty (±) in ppm* [note 1]	*Remarks*
1 and 1.9	97	Comparison method
10 and 19	23	Comparison method
100 and 190	10	Comparison method
1 k, 1.9 k, 10 k, 19 k	9	Comparison method
100 k and 190 k	11	Comparison method
1 M and 1.9 M	21	Comparison method
10 M and 19 M	51	Comparison method
100 M	102	Comparison method

DC Current

Range	*Best Uncertainty (±)* [note 1]	*Remarks*
220 µA	43 ppm + 6 nA	Comparison method
2.2 mA	37 ppm + 7 nA	Comparison method
22 mA	35 ppm + 40 nA	Comparison method
220 mA	48 ppm + 0.7 µA	Comparison method
2.2 A	89 ppm + 12 µA	Comparison method
11 A	367 ppm + 490 µA	Comparison method

NVLAP Code: 20/E06
DC Voltage

Range in Volts	*Best Uncertainty (±) in ppm* [note 1]	*Remarks*
1.0 to 1.018	0.14	Josephson Array Systems, Zeners, and DVMs
10.0	0.017	Josephson Array Systems, Zeners, and DVMs

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Pressure coefficient of Voltage for Solid State Voltage Standards

Pressure Coefficient of Voltage	***Best Uncertainty (±)[note 1]***	***Remarks***
> 5 nV/hPa	2 nV/hPa	- 2000 m to + 3000 m elevation (Difference Measurement)
0 nV/hPa to 5 nV/hPa	0.1 nV/hPa	- 2000 m to + 3000 elevation (Josephson Array Measurement)

Voltage divider - Potentiometer combination

1.5 V to 1500 V	2.5 ppm	Volt Box-Potentiometer, k = 2
x1.0 range to 1.05 V	0.5 ppm of reading + 0.1 μV	Potentiometer only, k = 3
x1.0 range above 1.05 V	1.0 ppm of reading + 0.1 μV	Potentiometer only, k = 3
x0.1 range	1.5 ppm of reading + 0.01 μV	Potentiometer only, k = 3
x0.01 range	2.5 ppm of reading + 0.005 μV	Potentiometer only, k = 3

Automated Intermediate Voltage System

0 V to 10.0 V	0.5 ppm + 0.2 μV	Automated Potentiometer System
10 V to 30 V	1.4 ppm	Automated Potentiometer System
300 V to 1200 V	4.0 ppm	Automated Potentiometer System

High Voltage - Electrostatic Voltmeters, etc.

Range in kV	***Best Uncertainty (±) [note 1]***	***Remarks***
to 100	106 ppm	200 kV system
100 to 200	140 ppm	200 kV system
to 10	2000 ppm	10 kV system

Ratio/Bridges

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1:1 to 1:100 000	.05 (ratio)	For ratio based on 20 step first dial (k = 3). For bridges, uncertainty combines ratio and resistance uncertainties

Range	*Best Uncertainty (±) in ppm + µV* [note 1]	*Remarks*
220 mV	12.0 + 0.4	Comparison method
2.2 V	5.8 + 0.7	Comparison method
11 V	4.3 + 2.5	Comparison method
22 V	4.3 + 4	Comparison method
220 V	6.1 + 40	Comparison method
1100 V	7.3 + 400	Comparison method

NVLAP Code: 20/E08
Inductive Voltage Dividers

Range in Volts	*Best Uncertainty (±) in ppm* [note 1]	*Remarks*
15, 35 and 100	55	@ 60 Hz, 1 kHz and 10 kHz

NVLAP Code: 20/E09
Voltage/AC-DC Difference

	Best Uncertainty (±) in ppm [note 1] *Frequency in Hertz*											
Range in Volts	*10*	*20*	*50*	*100*	*200*	*500*	*1 k*	*2 k*	*5 k*	*10 k*	*20 k*	*50 k*
1	21	12	11	8	7	5	6	5	6	5	7	8
2	16	16	10	8	6	5	8	7	15	13	6	7
3	16	14	11	6	6	6	10	10	10	9	9	9
4	18	13	11	7	6	6	8	6	6	7	8	7
6	23	15	14	13	15	14	13	10	10	9	8	8
10	17	13	11	8	10	7	11	11	13	13	12	13
12	19	13	11	8	10	11	10	11	10	10	11	9
20	31	14	11	6	6	7	7	8	7	8	9	9
30	19	15	11	8	6	8	8	9	8	8	9	12
40	30	14	11	17	6	8	18	9	8	8	16	21
60	20	14	13	7	7	9	8	8	8	8	9	12
100	35	14	12	7	7	8	9	8	8	8	10	13
120	102	23	21	22	21	9	10	9	9	9	11	15

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200	101	21	21	22	21	10	12	12	13	11	15	23
300	101	21	21	21	21	12	14	14	11	11	14	24
400	101	21	21	23	21	13	14	15	15	15	18	28
600	102	22	21	21	21	16	16	15	16	15	21	32
1200	102	21	22	22	21	17	18	17	22	19	22	26

LF AC Voltage

	Best Uncertainty (±) in ppm [note 1] ***Frequency in Hertz***			
Range in Volts	***100 k***	***200 k***	***500 k***	***1 M***
1	4	75	82	86
2	10	74	74	76
3	11	72	77	81
4	10	71	71	71
6	9	73	75	81
10	11	72	71	74
12	13	72	73	72
20	11	71	72	71
30	14	72	77	78
40	21	91	106	71
60	14	72	74	73
100	23	90	91	134
120	19			
200	35			
300	45			
400	51			
600	59			
1200	49			

AC Voltage

	Best Uncertainty (±) in ppm + µV(below 2.2V) [note 1] ***Frequency in Hertz***							
Range	***10 to 20***	***20 to 40***	***40 to 20 k***	***20 k to 50 k***	***50 k to 100 k***	***100 k to 300 k***	***300 k to 500 k***	***500 k to 1 M***
2.2 mV	1700 + 1.3	770 + 1.3	500 + 1.3	990 + 2.0	1500 + 2.5	2600 + 4.0	2700 + 8.0	3700 + 8.0

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7 mV	880 + 1.3	430 + 1.3	350 + 1.3	700 + 2.0	1100 + 2.5	1800 + 4.0	1800 + 8.0	2600 + 8.0
22 mV	380 + 1.3	290 + 1.3	250 + 1.3	610 + 2.0	970 + 2.5	1500 + 4.0	1600 + 8.0	2100 + 8.0
70 mV	260 + 1.5	120 + 1.5	81 + 1.5	130 + 2.0	260 + 2.5	540 + 4.0	690 + 8.0	1100 + 8.0
220 mV	230 + 1.5	92 + 1.5	62 + 1.5	78 + 2.0	170 + 2.5	310 + 4.0	420 + 8.0	1010 + 8.0
700 mV	230 + 1.5	83 + 1.5	65 + 1.5	110 + 2.0	110 + 2.5	320 + 4.0	400 + 8.0	1000 + 8.0
2.2 V	220	69	45	110	110	310	370	940
7 V	210	70	50	90	140	200	440	1300
22 V	210	72	50	90	140	200	440	1300
70 V	230	100	80	120	200	820	900	1400
220 V	230	100	80	130	200	830	940	
700 V	210	120	100	170	520			
1000 V	210	120	100	190	520			

AC Current

	Best Uncertainty (±) in ppm + nA [note 1] ***Frequency in Hertz***				
Range	***10 to 20***	***20 to 40***	***40 to 1 k***	***1 k to 5 k***	***5 k to 10 k***
220 µA	250 + 16	160 + 10	130 + 8	280 + 12	1100 + 65
2.2 mA	250 + 40	160 + 35	120 + 35	200 + 110	1100 + 650
22 mA	250 + 400	160 + 350	130 + 350	210 + 550	1100 + 5000
220 mA	250 + 4000	160 + 3500	170 + 2500	230 + 3500	1200 + 10000

	Best Uncertainty (±) in ppm + µA [note 1] ***Frequency in Hertz***		
Range	***20 to 1 K***	***1 k to 5 k***	***5 k to 10 k***
2.2 A	260 + 35	530 + 80	700 + 160

NVLAP Code: 20/E10
LF Capacitance

Range in pF	***Best Uncertainty (±) in ppm*** [note 1]	***Remarks***
0.01 to 1000	5	@ 1 kHz

NVLAP Code: 20/E11
LF Inductance

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	Best Uncertainty (±) in % note 12 *Frequency in Hertz*		
Range	***100***	***1 k***	***10 k***
50 µH	0.40	0.31	0.31
100 µH	0.18	0.16	0.16
200 µH	0.094	0.076	0.075
500 µH	0.037	0.035	0.081
1 mH	0.032	0.032	0.080
2 mH	0.042	0.040	0.083
5 mH	0.034	0.034	0.080
10 mH	0.032	0.031	0.080
20 mH	0.032	0.033	0.089
50 mH	0.031	0.031	0.077
100 mH	0.032	0.034	0.090
200 mH	0.03	0.03	
500 mH	0.03	0.03	
1 H	0.03	0.081	
2 H	0.032	0.075	
5 H	0.031	0.157	
10 H	0.032	0.31	

NVLAP Code: 20/E18
Resistive Voltage Dividers - Pulsed High-Voltage Condition

Range in kV	***Best Uncertainty (±) in % note 1***	***Remarks***
1 to 350	1.0	1 µs to 30 µs Pulse

NVLAP Code: 20/E20
Oscilloscopes
Pulse Amplitude (digitized waveform)

Range	***Best Uncertainty (±) note 1***	***Remarks***
0.1 V to 200 V	0.25 % of pulse amplitude	NIST VPMS

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TIME AND FREQUENCY

NVLAP Code: 20/F01
Frequency Dissemination

Range in MHz	***Best Uncertainty (±)*** [note 1]	***Remarks***
0.1	5×10^{-13}	NIST FMAS
1	5×10^{-13}	NIST FMAS
5	5×10^{-13}	NIST FMAS
10	5×10^{-13}	NIST FMAS

NVLAP Code: 20/F04
Oscillator Characterization

Range	***Best Uncertainty (±)*** [note 1]	***Remarks***
Phase -180° to 360°	± 0.005°	

NVLAP Code: 20/F04
Pulse Waveform
Transition Duration

Range	***Best Uncertainty (±)*** [note 1]	***Remarks***
< 17.5 ps	5 ps	Fast Rise Pulse
Time Interval		
> 500 ps	500 ps	

NVLAP Code: 20/F05
Stopwatches and Timers

Range	***Best Uncertainty (±)*** [note 1]	***Remarks***

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1 s to 24 hrs	0.05 s/day	Time base methods

IONIZING RADIATION

NVLAP Code: 20/I04
Radioactive Sources

Range	***Best Uncertainty (±)*** [note 1]	***Remarks***
1 Bq to 2 x 10^5 Bq into 2 π	2.0%	Alpha Emission Rate
10 Bq to 10^4 Bq into 2π	4.0%	Beta Emission Rate
3 MeV to 8 MeV	30 keV	Alpha Energy

MECHANICAL

NVLAP Code: 20/M05
Gas Flow

Range	***Best Uncertainty (±)*** [note 1]
50 cc/min to 1200 L/min	0.5%

NVLAP Code: 20/M06
Force

Range in lbf	***Best Uncertainty (±) in %*** [notes 1, 2, 5]	***Remarks***
100 to 1000	0.0052	Primary Standard (Deadweight)
1000 to 100 000	0.025	Secondary Standards

NVLAP Code: 20/M08
Mass – Metric

Range	***Best Uncertainty (±) in mg (k=2)***	***Remarks***
25 kg	18	Echelon II
20 kg	12	Echelon II
10 kg	4	Echelon II
5 kg	1.7	Echelon II
3 kg	0.7	Echelon II
2 kg	0.6	Echelon II

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1 kg	0.11	Echelon II
500 g	0.061	Echelon II
300 g	0.069	Echelon II
200 g	0.037	Echelon II
100 g	0.033	Echelon II
50 g	0.021	Echelon II
30 g	0.020	Echelon II
20 g	0.013	Echelon II
10 g	0.0098	Echelon II
5 g	0.0061	Echelon II
3 g	0.0086	Echelon II
2 g	0.0050	Echelon II
1 g	0.0050	Echelon II
500 mg	0.0033	Echelon II
300 mg	0.0031	Echelon II
200 mg	0.0030	Echelon II
100 mg	0.0029	Echelon II
50 mg	0.0027	Echelon II
30 mg	0.0026	Echelon II
20 mg	0.0025	Echelon II
10 mg	0.0023	Echelon II
5 mg	0.0020	Echelon II
3 mg	0.0018	Echelon II
2 mg	0.0016	Echelon II
1 mg	0.0014	Echelon II

NVLAP Code: 20/M11
Acceleration / Vibration

Range in gn	***Frequency in Hz***	***Best Uncertainty (±) in %*** [note 1]
1 to 50	10 to 10 000	2.5
Acceleration / Vibration – Adding Long Stroke Capability		
0.05	1	2.5
0.2	2	2.5

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1	5	2.5

Shock

Range in gn	*Best Uncertainty (±) in % note 1*	*Remarks*
500 to 10 000	4	

Static Acceleration - Centrifuge

Range in gn	*Best Uncertainty (±) in % note 1*	*Remarks*
25 to 1000	0.5	

RF MICROWAVE

NVLAP Code: 20/R05
HF Capacitance

	Best Uncertainty (±) in percent note 1 *Frequency in Hertz*			
Range in pF	*100*	*1 k*	*10 k*	*100 k*	*1 M*
0.01		0.20		1.3	
0.1		0.05		1.3	
1		0.02		0.04	
10		0.01		0.02	
100		0.01		0.01	
1000		0.01		0.03	
1		0.02		0.2	0.30
2		0.02		0.35	0.60
5		0.02		0.22	0.26
10		0.10		0.14	0.15
20		0.10		0.13	0.11
50				0.03	0.02
100				0.02	0.02
200				0.01	0.01

500				0.02	0.01
1000				0.02	0.03
10		0.0001			
100		0.0001			
1	0.01	0.002	0.006	0.02	0.18
10	0.01	0.002	0.0025	0.0025	0.003
100	0.01	0.002	0.0044	0.0044	0.004
1000	0.01	0.002	0.0043	0.0048	0.003

NVLAP Code: 20/R06
HF Inductance

		Best Uncertainty (±) in percent [note 1] ***Frequency in Hertz***		
Range	***10 k***	***100 k***	***1 M***	***10 M***
0.1 µH		3.13	4.72	
0.2 µH		1.63	1.67	
0.5 µH		0.93	0.97	
1 µH		0.75	0.77	
2 µH		0.36	0.76	
5 µH		0.27	0.69	
10 µH		0.29	0.72	
25 µH		0.27	0.65	
50 µH		0.22	0.68	
100 µH		0.21	0.62	
250 µH		0.26	0.22	
500 µH		0.26	0.3	
1 mH		0.29		
2.5 mH		0.25		
5 mH		0.18		
10 mH		0.17		
25 mH		0.25		
0.25 µH	1.2	1.4	1.7	0.8

1 μH	0.4	0.5	0.9	0.6
10 μH	0.4	0.4	0.6	0.1
100 μH	0.2	0.2	0.2	

NVLAP Code: 20/R10
Q Standards

Range	***Best Uncertainty (±) in%*** [note 1]	***Remarks***
Selected values from 95 to 607	1.2 to 4.5 dependent on Q value and frequency	Frequency range 50 kHz to 45 MHz

NVLAP Code: 20/R11
Voltage/RF-DC Difference
High Frequency TVC

	Best Uncertainty (±) in percent [note 1] ***Frequency in Hertz***										
Range	***1M***	***10 M***	***20 M***	***30 M***	***40 M***	***5 M***	***60 M***	***70 M***	***80 M***	***90 M***	***100 M***
0.5V	0.03	0.05	0.06	0.13	0.12	0.21	0.24	0.30	0.38	0.39	0.41
1V	0.03	0.05	0.06	0.08	0.12	0.19	0.23	0.30	0.38	0.39	0.75
2V	0.03	0.05	0.06	0.09	0.12	0.19	0.23	0.29	0.37	0.37	0.71
3V	0.03	0.05	0.06	0.09	0.12	0.17	0.23	0.29	0.37	0.37	0.55
5V	0.03	0.05	0.06	0.14	0.51	0.17	0.24	0.30	0.38	0.39	0.44
10 V	0.03	0.06	0.06	0.10	0.12	0.18	0.25	0.31	0.39	0.41	0.43
20 V	0.04	0.06	0.07	0.10	0.12	0.18	0.24	0.30	0.38	0.38	0.45
50V	0.04	0.06		1.15		0.34					0.93

NVLAP Code: 20/R12
RF/Microwave Bolometer Units
Expanded Uncertainties [notes 1, 2, 3] on Effective Efficiency & Calibration Factor of HP bolometric power sensors

			Frequency (MHz)			
Connector Type	***Quantity***	***Quantity Range***	***10 - 2000***	***2000 - 8000***	***8000 - 12 000***	***12 000 - 18 000***
N	Calibration Factor	0.9 to 1	0.003 - 0.008	0.003 - 0.006	0.004 - 0.007	0.005 - 0.010

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APC-3.5	Calibration Factor	0.9 to 1	-----	0.007 - 0.009	0.009 - 0.010	0.010 - 0.011
N	Effective Efficiency	0.9 to 1	0.003 - 0.008	0.003 - 0.005	0.004 - 0.006	0.005 - 0.010
APC-3.5	Effective Efficiency	0.9 to 1	-----	0.007 - 0.008	0.008 - 0.009	0.009 - 0.010

NVLAP Code: 20/R13
RF/Microwave Attenuators

Reflection Coefficient (or Scattering Parameter S_{ii})

A. HP8510 Vector Network Analyzer Uncertainties

1. Expanded Uncertainties *notes 1, 2, 3* on one-port or two-port devices

			Frequency (MHz)			
Connector Type	***Quantity***	***Quantity Range***	***50-2000***	***2000-8000***	***8000-18 000***	***18 000- 50 000***
N	| Sii|	0 to 1	0.001 - 0.003	0.001 - 0.009	0.004 - 0.021	-----
APC-7	| Sii|	0 to 1	0.001 - 0.007	0.001 - 0.003	0.001 - 0.007	-----
APC-3.5	| Sii|	0 to 1	0.001 - 0.007	0.004 - 0.020	0.004 - 0.020	0.004 - 0.020 (to 26.5 GHz)
2.4 mm	| Sii|	0 to 1	0.002 - 0.006	0.001 - 0.007	0.001 - 0.010	0.001 - 0.032
N	Arg(Sii)	- 180º to + 180º	0.05 - 180	0.36 - 180	1.34 - 180	-----
APC-7	Arg(Sii)	- 180º to + 180º	0.15 - 180	0.16 - 180	0.33 - 180	-----
APC-3.5	Arg(Sii)	- 180º to + 180º	0.53 - 180	0.33 - 180	0.33 - 180	0.33 - 180 (to 26.5 GHz)

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2.4 mm	Arg(Sii)	-	180º to + 180º	0.13 - 180	0.24 - 180	0.14 - 180	0.58 - 180

2. HP8510 Expanded Uncertainties *notes 1, 2, 3* on three-port or four-port devices

			Frequency (MHz)			
Connector Type	***Quantity***	***Quantity Range***	***50 - 2000***	***2000 - 8000***	***8000 - 18 000***	***18 000 – 50 000***
N	$\|S_{ii}\|$	0 to 0.3	0.001 - 0.006	0.001 - 0.006	0.002 - 0.014	-----
N	$Arg(S_{ii})$	- 180º to + 180º	0.13 - 180	0.23 - 180	0.57 - 180	-----
N	$\|\Gamma_{ge}\|$	0 to 0.3	0.001 - 0.014	0.002 - 0.019	0.004 - 0.019	-----
N	$Arg(\Gamma_{ge})$	- 180º to + 180º	10 - 180	4.6 - 180	6.3 - 180	-----
N	SR wcΔρ *note 9*	0 to 0.2	0.002 - 0.02	0.002 – 0.5	0.004 – 0.05	-----
APC-7	$\|S_{ii}\|$	0 to 0.3	0.001 - 0.005	0.001 - 0.005	0.001 - 0.01	-----
APC-7	$Arg(S_{ii})$	- 180º to + 180º	0.15 - 180	0.16 - 180	0.5 - 180	-----
APC-7	$\|\Gamma_{ge}\|$	0 to 0.3	0.001 - 0.005	0.001 - 0.007	0.003 - 0.012	-----
APC-7	$Arg(\Gamma_{ge})$	- 180º to + 180º	3 - 180	3 – 180	3 - 180	-----
APC-7	SR wcΔρ *note 9*	0 to 0.2	0.002 - 0.02	0.002 – 0.05	0.004 - 0.05	-----
APC-3.5	$\|S_{ii}\|$	0 to 0.3	0.002 - 0.007	0.003 - 0.007	0.003 - 0.01	-----
APC-3.5	$Arg(S_{ii})$	- 180º to + 180º	0.6 - 180	0.6 - 180	0.6 - 180	-----
APC-3.5	$\|\Gamma_{ge}\|$	0 to 0.3	0.003 - 0.013	0.004 - 0.012	0.004 - 0.12	-----
APC-3.5	$Arg(\Gamma_{ge})$	- 180º to + 180º	3 - 180	3 – 180	3 - 180	-----
2.4 mm	$\|S_{ii}\|$	0 to 0.3	-----	0.001 - 0.007	0.001 - 0.01	0.003 - 0.02

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2.4 mm	Arg(S_{ii})	- 180º to + 180º	-----	0.24 - 180	0.14 - 180	0.33 - 180
2.4 mm	$\|\Gamma_{ge}\|$	0 to 0.3	-----	0.002 – 0.01	0.003 - 0.12	0.003 - 0.03
2.4 mm	Arg(Γ_{ge})	- 180º to + 180º	-----	3 – 180	3 - 180	3 – 180

B. HP8753 Vector Network Analyzer Expanded Uncertainties *notes 1, 2, 3*

1. One-port or two-port devices

			Frequency (MHz)		
Connector Type	***Quantity***	***Quantity Range***	***0.3 – 25***	***25 - 1000***	***1000 - 3000***
N	$\|S_{ii}\|$	0 to 1	0.001 - 0.013	0.001 - 0.009	0.003 - 0.016
APC-7	$\|S_{ii}\|$	0 to 1	0.002 - 0.007	0.002 - 0.04	0.002 - 0.004
APC-3.5	$\|S_{ii}\|$	0 to 1	0.001 - 0.004	0.006 - 0.02	0.006 - 0.035
N	Arg(S_{ii})	- 180° to + 180°	0.06 – 180	0.2 - 70	1 - 180
APC-7	Arg(S_{ii})	- 180° to + 180°	0.27 - 180	0.3 - 180	0.2 - 180
APC-3.5	Arg(S_{ii})	- 180° to + 180°	0.27 - 180	1 - 180	1.6 – 180

2. Three-port or four-port devices *notes 1, 2, 3*

			Frequency (MHz)	
Connector Type	***Quantity***	***Quantity Range***	***0.3 - 25***	***25 - 3000 (MHz)***
N, APC-7, APC-3.5	$\|S_{ii}\|$	0 to 0.3	0.001 - 0.006	0.001 - 0.020
N, APC-7, APC-3.5	Arg(S_{ii})	- 180° to + 180°	0.10 - 180	0.09 - 180
N, APC-7, APC-3.5	$\|\Gamma_{ge}\|$	0 to 0.3	0.003 - 0.005	0.002 - 0.03
N, APC-7, APC-3.5	Arg(Γ_{ge})	- 180° to + 180°	10 - 180	1.9 – 180
N, APC-7	SR wc$\Delta\rho$ *note 9*	0 to 0.2	0.001 - 0.006	0.001 - 0.020

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Attenuation (or Scattering Parameter Sij)

A. HP8510 Vector Network Analyzer Uncertainties

1. Expanded Uncertainties [notes 1, 2, 3] on two-port devices

			Frequency (MHz)			
Connector Type	***Quantity***	***Quantity Range in dB***	***50 - 2000***	***2000 - 8000***	***8000 - 18 000***	***18 000 – 50 000***
N	$\|S_{ij}\|$	0 to 60	0.01 - 0.12	0.02 - 0.17	0.03 - 0.48	-----
APC-7	$\|S_{ij}\|$	0 to 60	0.01 - 0.08	0.01 - 0.13	0.01 - 0.18	-----
APC-3.5	$\|S_{ij}\|$	0 to 60	0.01 - 0.12	0.02 - 0.22	0.04 - 0.49	-----
2.4 mm	$\|S_{ij}\|$	0 to 60	0.02 - 0.15	0.02 - 0.22	0.03 - 0.34	0.05 - 2.7
N	$Arg(S_{ij})$	0° to 360° $\|Sij\| < 60$	0.22 - 1.19	0.32 - 1.27	0.36 - 3.46	-----
APC-7	$Arg(S_{ij})$	0° to 360° $\|Sij\| < 60$	0.22 - 0.73	0.25 - 1.21	0.41 - 2.85	-----
APC-3.5	$Arg(S_{ij})$	0° to 360° $\|Sij\| < 60$	0.45 - 0.80	0.35 - 1.39	0.41 - 3.17	-----
2.4 mm	$Arg(S_{ij})$	0° to 360° $\|Sij\| < 60$	-----	1.1 - 1.7	1.1 - 1.7	1.3 - 21.0

2. HP8510 Expanded Uncertainties [notes 1, 2, 3] on three-port or four-port devices

			Frequency (MHz)			
Connector Type	***Quantity***	***Quantity Range in dB***	***50 - 2000***	***2000 - 8000***	***8000 – 18 000***	***18 000 – 50 000***
N, APC-7, APC-3.5	Mainline/ Coupling $\|S_{ij}\|$	0 to 40	0.01 - 0.12	0.02 - 0.12	0.01 - 0.43	-----
N, APC-7, APC-3.5	Isolation $\|S_{ij}\|$	40 to 80	0.2 - 16	0.4 - 9	0.9 - 17	-----
2.4 mm	Mainline/ Coupling $\|S_{ij}\|$	0 to 40	-----	0.03 - 0.15	0.04 - 0.5	0.05 - 0.6
2.4 mm	Isolation $\|S_{ij}\|$	40 to 85	-----	0.4 - 10	1.0 - 12	1.5 - 15

B. HP8753 Vector Network Analyzer Expanded Uncertainties [notes 1, 2, 3]

1. Two-port devices

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			Frequency (MHz)		
Connector Type	***Quantity***	***Quantity Range***	***0.3 - 25***	***25 - 1000***	***1000 - 3000***
N	$\|S_{ij}\|$	0 dB to 60 dB	0.02 - 0.25	0.003 - 0.5	0.004 - 1.2
APC-7	$\|S_{ij}\|$	0 dB to 60 dB	0.01 - 0.16	0.002 - 0.6	0.003 - 0.9
APC-3.5	$\|S_{ij}\|$	0 dB to 60 dB	0.01 - 0.22	0.003 - 0.6	0.003 - 1.0
N, APC-7, APC-3.5	$Arg(S_{ij})$	- 180° to + 180°	1.4 - 13	0.4 - 10	0.4 - 10

2. Three-port or four-port devices

			Frequency (MHz)	
Connector Type	***Quantity***	***Quantity Range in dB***	***0.3 to 25***	***25 to 3000***
N, APC-7, APC-3.5	Mainline/Coupling $\|S_{ij}\|$	0 to 40	0.008 to 0.2	0.020 to 0.3
N, APC-7, APC-3.5	Isolation $\|S_{ij}\|$	40 to 87	0.1 to 13.6	0.1 to 13.8

C. Power Ratio Attenuation Expanded Uncertainties *notes 1, 2, 3*

			Frequency (MHz)			
Connector Type	***Quantity***	***Quantity Range in dB***	***10 - 2000***	***2000 - 8000***	***8000 - 12 000***	***12 000 – 18 000***
Fixed Attenuators						
N, APC-7, APC-3.5	$\|S_{ij}\|$	0 to 11	0.007 - 0.014	0.008 - 0.021	0.010 - 0.025	0.016 - 0.026
Isolated Step/Variable Attenuators						
N, APC-7, APC-3.5	$\|S_{ij}\|$	0 to 11	0.007 - 0.014	0.007 - 0.016	0.007 - 0.015	0.007 - 0.018

NVLAP Code: 20/R16

Group Delay Expanded Uncertainties *notes 1, 2, 3, 4*

			Frequency (MHz)	
Connector Type	***Typical Atten. (dB)***	***Delay (ns)***	***50 - 1000***	***1000 - 50 000***

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APC-7, N, APC-3.5, 2.4 mm	0 - 10	5 - 500	0.2 - 0.5	0.02 - 1.0

NVLAP Code: 20/R17
RF/Microwave Power Meters
Power Meter Certification Uncertainties *notes 2, 3, 4, 10*

A. Low to Medium Power CW Microwave Power Meters at Type N Connector

		Frequency (MHz)			
k = 3 uncertainties Quantity	***Quantity Range in dBm***	***10 to 2000***	***2000 to 4000***	***4000 to 12 400***	***12 400 to 18 000***
Power (dBm)	- 30 to – 10	0.09 to 0.41	0.13 to 0.41	0.14 to 0.34	0.16 to 0.46
Power (dBm)	- 10 to 10	0.06 to 0.27	0.10 to 0.25	0.11 to 0.30	-----
Power (dBm)	10 to 30	0.06 to 0.25	0.10 to 0.21	0.11 to 0.24	-----

B. Low Power, Wide Range, CW Microwave Power Meters at Type N Connector

		Frequency (MHz)		
k = 3 uncertainties Quantity	***Quantity Range in dBm***	***10 to 4000***	***4000 to 8000***	***8000 to 18 000***
Power (dBm)	- 60 to - 50	0.20 to 0.48	0.24 to 0.43	0.24 to 0.43
Power (dBm)	- 50 to - 40	0.17 to 0.33	0.20 to 0.35	0.20 to 0.42
Power (dBm)	- 40 to - 30	0.14 to 0.27	0.16 to 0.32	0.20 to 0.36
Power (dBm)	- 30 to - 20	0.14 to 0.26	0.14 to 0.27	0.18 to 0.35

C. Medium Power CW Microwave Power Meters at Type N Connector

		Frequency (MHz)	
k = 3 uncertainties Quantity	***Quantity Range***	***10 to 2000***	***2000 to 2500***
Power (mW)	1 to 10	1.76 % to 3.30 %	-----
Power (mW)	1 to 160	-----	1.95 % to 4.29 %

D. Medium Power CW Microwave Power Meters at APC-3.5 Connector

Frequency (MHz)

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k = 3 uncertainties *Quantity*	*Quantity Range*	*2000 to 4000*	*4000 to 8000*	*8000 to 18 000*
Power (mW)	0.1 to 8	2.81 % to 4.02 %	2.99 % to 4.92 %	3.97 % to 5.83 %

E. High Power CW Microwave Power Meters at APC 3.5 Connector

		Frequency (MHz)	
k = 3 uncertainties *Quantity*	*Quantity Range*	*10 to 300*	*300 to 3000*
Power (Watts)	0.2 to 10	8.97 % to 9.1 %	3.26 % to 10.61 %
Power (Watts)	10 to 200	4.36 % to 10.13 %	9.60 % to 10.60 %

F. Pulse Power Meters at Type N Connector

k = 3 uncertainties *Quantity*	*Quantity Range*	*Pulse Width Range*	*PRF Range*	*2000 to 18 000*
Power (mW)	10 to 100	0.2 µs to 5 µs	1 Hz to 20 kHz	7.32 % to 8.16 %

THERMODYNAMICS

NVLAP Code: 20/T02

Humidity – High

Range in % rH	*Best Uncertainty (±) in % rH* note 1	*Remarks*
10 to 50	0.5	
50 to 95	1.0	

Dew Point

Range	*Best Uncertainty (±)* note 1	*Remarks*
(-15 to +20)° C	0.1° C	

Humidity – Low

Range	*Best Uncertainty (±)* note 1	*Remarks*

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(-80 to 0) ° C Frost Point	0.25 °C

NVLAP Code: 20/T04
Leak Artifacts

Range	***Best Uncertainty (±) in percent*** [note 1]	***Remarks***
Gas Leak - PΔV Technique		
1×10^{-7} moles/s	0.7	Total gas measurement
1×10^{-8} moles/s	0.9	Total gas measurement
1×10^{-9} moles/s	1.0	Total gas measurement
1×10^{-10} moles/s	1.0	Total gas measurement
Gas Leak - Accumulate - Dump Technique		
1×10^{-10} moles/s to 1×10^{-14} moles/s	1.0	1 to 200 Atomic Mass Units for any non-reactive, non-hazardous, non-radioactive gas
Gas Leak - Comparison Technique		
1×10^{-10} moles/s	2.5	Helium
1×10^{-11} moles/s	2.4	Helium
1×10^{-12} moles/s	2.3	Helium
1×10^{-13} moles/s	2.3	Helium
1×10^{-14} moles/s	7.0	Helium

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NVLAP Code: 20/T05
Pressure

Range	***Best Uncertainty (±) in ppm*** [note 1]	***Remarks***
Pneumatic Deadweight Piston Gauges (absolute mode) - Direct Pressure Comparison		
0.2 psia to 24 psia [≈ 1.4 kPa to 170 kPa]	31	Nitrogen
2.0 psia to 70 psia [≈ 14 kPa to 480 kPa]	28	Nitrogen
52 psia to 1000 psia [≈ 0.4 MPa to 7.0 MPa]	46	Nitrogen
Pneumatic Deadweight Piston Gauges (gauge mode) - Direct Pressure Comparison		
0.2 psig to 24 psig [≈ 1.4 kPa to 170 kPa]	29	Nitrogen
2.0 psig to 70 psig [≈ 14 kPa to 480 kPa]	26	Nitrogen
52 psig to 1000 psig [≈ 0.4 MPa to 7.0 MPa]	44	Nitrogen
Hydraulic Deadweight Piston Gauges (gauge mode) - Direct Pressure Comparison		
0.4 kpsig to 4.0 kpsig [≈ 2.8 MPa to 28 MPa]	44	Oil
2.0 kpsig to 20 kpsig [≈ 14 MPa to 140 MPa]	61	Oil
4.0 kpsig to 40 kpsig [≈ 28 MPa to 280 MPa]	59	Oil
Pneumatic Deadweight Piston Gauges - Cross Float (effective area)		
0.2 psig to 24 psig [≈ 14 kPa to 170 kPa]	35	Nitrogen
2.0 psig to 70 psig [≈ 14 kPa to 480 kPa]	33	Nitrogen
52 psig to 1000 psig [≈ 0.4 MPa to 7.0 MPa]	46	Nitrogen
Hydraulic Deadweight Piston Gauges - Cross Float (effective area)		
0.4 kpsig to 4.0 kpsig [≈ 2.8 MPa to 28 MPa]	46	Oil
2.0 kpsig to 20 kpsig [≈ 14 MPa to 140 MPa]	67	Oil
4.0 kpsig to 40 kpsig [≈ 28 MPa to 280 MPa]	61	Oil
Secondary Pressure - Low Range Absolute		
Range	***Best Uncertainty (±) in psia*** [note 1]	***Remarks***

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0.2 psia [≈ 1.4 kPa]	0.0013	Nitrogen
1.0 psia [≈ 7.0 kPa]	0.0013	Nitrogen
6.0 psia [≈ 41 kPa]	0.0017	Nitrogen
10 psia [≈ 70 kPa]	0.0021	Nitrogen
15 psia [≈ 100 kPa]	0.0028	Nitrogen

Secondary Pressure - Low Range Gauge or Absolute

Range	***Best Uncertainty (±) in psi*** [note 1]	***Remarks***
20 psi [≈ 140 kPa]	0.009	Nitrogen
40 psi [≈ 280 kPa]	0.010	Nitrogen
60 psi [≈ 410 kPa]	0.011	Nitrogen
80 psi [≈ 550 kPa]	0.013	Nitrogen
100 psi [≈ 690 kPa]	0.014	Nitrogen

Secondary Pressure - Mid-Range Gauge or Absolute

200 psi [≈ 1.4 MPa]	0.137	Nitrogen
500 psi [≈ 3.4 MPa]	0.157	Nitrogen
1.0 kpsi [≈ 7.0 MPa]	0.201	Nitrogen
1.5 kpsi [≈ 10 MPa]	0.247	Nitrogen
2.0 psi [≈ 14 MPa]	0.280	Nitrogen
4.0 kpsi [≈ 28 MPa]	0.6	Nitrogen
6.0 kpsi [≈ 41 MPa]	0.8	Nitrogen
8.0 kpsi [≈ 55 MPa]	1.0	Nitrogen
10 kpsi [≈ 70 MPa]	1.0	Nitrogen

NVLAP Code: 20/T07
Resistance Thermometry

Range in °C	***Best Uncertainty (±) in m °C*** [note 1]	***Material/Equilibrium State***
- 189.3442	0.53	Ar/Triple Point
- 38.8344	0.30	Hg/Triple Point

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0.01	0.16	H_2O/Triple Point
29.7646	0.12	Ga/Melting Point
156.5985	2.00	In/Freezing Point
231.928	0.92	Sn/Freezing Point
419.527	1.10	Zn/Freezing Point
660.323	5.0	Al/Freezing Point

Standard Platinum Resistance Thermometer Calibrations

- 189.3442	1.6	Ar/Triple Point
- 38.8344	0.7	Hg/Triple Point
0.01	0.6	H_2O/Triple Point
29.7646	1.0	Ga/Melting Point
156.5985	2.6	In/Freezing Point
231.928	1.8	Sn/Freezing Point
419.527	2.1	Zn/Freezing Point
660.323	5.2	Al/Freezing Point

Comparison Calibrations

Range in °C	***Best Uncertainty (±) in °C*** [note 1]	***Type of Device***
- 80 to 0	0.10	Thermocouples
10 to 150	0.10	Thermocouples
150 to 660	0.22	Thermocouples
660 to 700	0.47	Thermocouples
700 to 1100	2.5	Thermocouples
1100 to 1300	2.8	Thermocouples
- 80 to 0	0.06	RTD/IPRT/PRT
10 to 150	0.09	RTD/IPRT/PRT
150 to 660	0.21	RTD/IPRT/PRT
- 80 to 0	0.05	Liquid in Glass
10 to 150	0.06	Liquid in Glass
- 80 to 0	0.06	Thermistors
10 to 150	0.09	Thermistors

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Thermocouple Simulator/Readout Calibration Methods

Type	*ITS-90 Temperature Range (°C)*	*Best Uncertainty (±) in °C* [notes 1,7]	*NIST Monograph 175 Reference Table* [note 8]
K	- 200 to 1370	0.10 to 0.30	7.3.3
J	- 200 to 1200	0.08 to 0.22	6.3.3
E	- 240 to 1000	0.07 to 0.38	5.3.3
T	- 240 to 400	0.09 to 0.53	9.3.3
R	- 50 to 1750	0.38 to 1.09	3.3.3
S	- 50 to 1750	0.43 to 1.02	4.3.3
B	100 to 1750	0.43 to 4.45	2.3.3
C	0 to 2300	0.24 to 0.82	
N	-200 to 1300	0.5	8.3.3

NVLAP Code: 20/T10
Vacuum

Range	*Best Uncertainty (±) in percent* [note 1]	*Remarks*
Ionization Gage Reference for direct comparison		
1.3×10^{-6} Pa < reading ≤ 1.3×10^{-5} Pa	4.8	N_2; 10^{-8} Torr
1.3×10^{-5} Pa < reading ≤ 1.3×10^{-4} Pa	4.7	N_2; 10^{-7} Torr
1.3×10^{-4} Pa < reading ≤ 1.3×10^{-3} Pa	4.7 to 2.5	N_2; 10^{-6} Torr
Spinning Rotor Gage Reference for direct comparison		
1.3×10^{-4} Pa < reading ≤ 1.3×10^{-3} Pa	4.3 to 2.1	N_2; 10^{-6} Torr
1.3×10^{-3} Pa < reading ≤ 1.3 Pa	2.1	N_2; 10^{-5} Torr to 10^{-3} Torr
1.3 Pa ≤ reading ≤ 13. Pa	2.2	N_2; 10^{-3} Torr
Capacitance Diaphragm Gage Reference for direct comparison		
1.3×10^{-1} Pa ≤ reading ≤ 13.3 Pa	2.1 to 0.7	N_2; 0.1 Torr

Force Balance and Deadweight Piston Gauges - direct pressure comparison (Absolute, Absolute Differential and Gauges Modes)

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Range	*Best Uncertainty (±)* [note 1]	*Remarks*
0.3 Pa to < 6.0 Pa	30 ppm + 0.025 Pa	N_2; 0.1 Torr range
> 6.0 Pa to 15.0 kPa	30 ppm + 0.008 Pa	N_2; 0.1, 1, 10 100 Torr range
15.0 kPa to 133.3 kPa	31 ppm	N_2; 1000 Torr range

Secondary Capacitance Diaphragm Gages Reference for direct comparison (Note: uncertainty in % of reading)

Range	*Best Uncertainty (±)in percent* [note 1]	*Remarks*
1.3×10^{-1} Pa ≤ 13.3 Pa	2.3 to 0.5	N_2; 0.1 Torr range
13.3 Pa ≤ reading ≤ 133.3	0.6	N_2; 1 Torr range
133.3 Pa ≤ reading ≤ 1.3 kPa	0.4	N_2; 10 Torr range
1.3 kPa ≤ reading ≤ 13.3 kPa	0.3	N_2; 100 Torr range
13.3 kPa ≤ reading ≤ 133.3 kPa	0.3 to 0.05	N_2; 1000 Torr range

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1. Represents uncertainty with coverage factor of k = 2, unless otherwise specified.
2. Approximate value. Actual value determined by test results.
3. The uncertainty ranges are the lowest and highest uncertainty (±) values within the specified frequency range and quantity range.
4. Certification uncertainty consists of an appropriate combination of the measurement uncertainty (which includes all significant sources of uncertainty associated with the calibration process) and uncertainties due to use, environment, handling or variation with time over the certification interval.
5. ASTM loading range classes (e.g., A, AA) are not used or reported.
6. Uncertainties listed are linearized forms (A' + B'L) of uncertainties calculated as root sum squares of constant and length-dependent terms $\{A^2 + (BL)^2\}^{½}$. A' and B' are calculated by fitting a straight line through the RSS uncertainty values at the upper and lower limits of range.
7. Uncertainty is dependent on the specific temperature point tested.

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8. Referenced tables in NIST Monograph 175 (April 1993) provide values for emf E output/input of the thermocouple simulator/readout and the Seebeck coefficient S for the specific temperature points with the specified ranges. The best uncertainty (at k = 2) of the emf E in μV is equal to the product of U * S, where U is the best uncertainty (at k = 2) of the temperature point tested.
9. SR wcΔρ is the worst-case error in measurement of reflection coefficient, ρ,($0.5 \geq \rho \geq 0$) as made by a 4-port scalar reflectometer which has rf access to all 4 ports. Uncertainty shown in the table is the uncertainty on value of SR wcΔρ.
10. User mismatch uncertainty not included.
11. Using multiple double substitutions or redundant weighing designs.
12. Represents uncertainty with coverage factor of k = 3.