



Certificate Number 3005.01

Metrology Services

ISO 17025 Accredited



Metrology Services

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Northrop Grumman provides advanced technology products and services for the automotive, space and defense and information technology markets worldwide.

Located in Redondo Beach, California, Northrop Grumman Corporation (NGC) produces, integrates and tests electronic space payloads; advanced microelectronics integrated circuits and modules for telecommunications; develops advanced space instruments and builds commercial and military lasers.

The 24,000 square feet Metrology Standards Lab and Test Engineering Asset Management (EAM) have supported internal technology for more than 50 years, developing an extensive range of capabilities.

Metrology Services were first offered outside the company in 1988 to extend internal capabilities as a resource to companies requiring additional calibration support. On-site calibration is available upon request.

Services & Specialized Consulting

- **Calibration & Repair**
- **Special Measurements:**
 - RF/millimeter wave development, phase noise evaluations, fiber optics, laser power
- **Metrology Engineering Consulting:**
 - Characterization and Validation
 - Phase Noise
 - Millimeter Wave Measurements
 - Software development (HP VEE, Visual Basic)
- **Customized Training Programs:**
 - Metrology Fundamentals, Calibration & Repair, HP VEE
- **Measurement and Test Development:**
 - Methodologies, System Design, Automation and Procedures
 - **Calibration, Procedures and Systems for AS9100 / ISO 900X**
 - Metrology Training for Calibration Technicians
 - Uncertainty, Environmental and Interval Analysis, Measurement Technique, Dimensional, Physical, DC/Low Frequency and RF/Microwave
 - Develop calibration and recall system
 - Review and generate calibration procedures, standard operating procedures and command media.
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- **Managing Test Equipment**
 - Consulting offered to help you attain superior financial returns on your investment in technology assets
 - Assessment of processes from Acquisitions thru Disposal, with follow-on Strategies and Training of key personnel
 - Optional Software tools

TYPICAL INSTRUMENTATION SERVICED

<p>ADAPTER COAXIAL TO COAXIAL WAVEGUIDE TO COAXIAL WAVEGUIDE TO WAVEGUIDE</p> <p>AIR LINE COAXIAL</p> <p>AMPLIFIER CHARGE DATA GENERAL PURPOSE LOCK-IN POWER PULSE</p> <p>ANALYZER GAS MOISTURE OXYGEN</p> <p>ANALYZER (ELECTRONIC) DATACOMM, DIGITAL DISTORTION NETWORK SPECTRUM WAVE</p> <p>ANEMOMETER THERMAL VANE</p> <p>ATTENUATOR FIXED VARIABLE</p> <p>BALANCE ANALYTICAL LABORATORY TOP LOADING</p> <p>BATH (CONSTANT TEMP) LIQUID</p> <p>BEND WAVEGUIDE</p> <p>BIAS NETWORK MICROWAVE</p> <p>BLOCK GAGE, ANGLE SET GAGE, SET MAGNETIC VEE</p> <p>BRIDGE CAPACITANCE CONDUCTIVITY IMPEDANCE INDUCTANCE</p>	<p>BRIDGE RESISTANCE TEMPERATURE, OHMS READING</p> <p>CALIBRATOR FLOW, GAS PRESSURE, DEAD WEIGHT</p> <p>CALIBRATOR (ELECTRONIC) ATTENUATOR AUDIO/MICROPHONE OHMS POWER METER</p> <p>CALIBRATOR (VOLTS/AMPS) AC CURRENT AC VOLTAGE DC CURRENT DC VOLTAGE</p> <p>CALORIMETER LASER</p> <p>CAPACITOR DECADE FIXED VARIABLE</p> <p>CHAMBER FREEZER FURNACE OVEN TEMPERATURE TEMPERATURE/HUMIDITY</p> <p>CONTROLLER (ELECTRONIC) TEMPERATURE</p> <p>CONVERTER (SIGNAL) AC/DC TO LOGARITHMIC ANALOG TO DIGITAL DIGITAL TO ANALOG FREQUENCY TO VOLTAGE VOLTAGE-TO-FREQUENCY VOLTAGE, THERMAL</p> <p>COUNTER (ELECTRONIC) AUTOMATIC COMPUTING FREQUENCY UNIVERSAL PRESET REVERSIBLE TIME INTERVAL TOTALIZER</p> <p>COUPLER DIRECTIONAL HYBRID</p> <p>DATA ACQUISITION SYSTEM DIGITAL/ANALOG</p>	<p>DELAY LINE FIXED VARIABLE</p> <p>DENSITOMETER OPTICAL</p> <p>DETECTOR LEAK MICROWAVE</p> <p>DISPLAY DIGITAL, MODULAR</p> <p>DIVIDER POWER, MICROWAVE</p> <p>DIVIDER, DC/AC VOLTAGE</p> <p>DIVIDER, AC VOLTAGE RATIO TRANSFORMER</p> <p>DOSIMETER NUCLEAR</p> <p>FILTER BAND PASS, FIXED BAND PASS, VARIABLE BAND REJECT, FIXED BAND REJECT, VARIABLE HIGH PASS LOW PASS MULTIFUNCTION NOTCH</p> <p>FLOW MEASUREMENT FLOWMETER, GAS</p> <p>GAGE (DIMENSIONAL) HEIGHT CYLINDRICAL PLUG</p> <p>GAGE (ELECTRONIC) VACUUM</p> <p>GAGE (INDICATOR TYPE) FORCE PRESSURE PRESSURE, ABSOLUTE PRESSURE, COMPOUND PRESSURE, DIFFERENTIAL PRESSURE, GAS PRESSURE, LIQUID VACUUM</p> <p>GAGE/CONTROLLER (ELEC) VACUUM, ANALOG VACUUM, DIGITAL</p>
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<p>GENERATOR (ELECTRONIC) DELAY FREQUENCY STANDARD FREQUENCY SYNTHESIZER FUNCTION TIME MARK NOISE NOISE SOURCE OSCILLATOR POWER PULSE POWER SIGNAL PULSE RATE SIGNAL SQUARE WAVE SWEEP WORD/DATA</p> <p>HYGROMETER DEW POINT DIRECT READING</p> <p>INDICATOR (ELECTRONIC) LINEAR DISPLACEMENT PRESSURE, ANALOG STRAIN TRANSDUCER, UNIVERSAL</p> <p>INDUCTOR DECADE FIXED</p> <p>ISOLATOR MICROWAVE</p> <p>LOAD (ELECTRONIC) ACTIVE</p> <p>MANOMETER ANALOG DIGITAL FLUID</p> <p>MEASURING SYSTEM COORDINATE</p> <p>METER FIELD INTENSITY FREQUENCY GAS, WET TEST ILLUMINANCE/FOOT CANDLE LASER POWER MODULATION FM/AM NOISE FIGURE NULL</p>	<p>METER PEAK MEMORY VOLTMETER PH PHASE POWER SOUND LEVEL SOUNDING WAVE RATIO (SWR)</p> <p>METER (RCL) CAPACITANCE IMPEDANCE IMPEDANCE, VECTOR INDUCTANCE Q</p> <p>METER (VOA) AMMETER, AC AMMETER, AC/DC AMMETER, DC ELECTROMETER MULTIMETER OHMMETER VOLT, DIGITAL, PANEL DC VOLTMETER, AC VOLTMETER, AC/RF VOLTMETER, DC VOLTMETER, DIFFERENTIAL AC/DC VOLTMETER, DIFFERENTIAL DC VOLTMETER, DIGITAL AC/DC VOLTMETER, DIGITAL DC VOLTMETER, TRUE RMS VOLTMETER, VECTOR</p> <p>MICROMETER BORE/HOLE SET DEPTH INSIDE OUTSIDE</p> <p>MICROPHONE</p> <p>MICROSCOPE BINOCULAR MEASURING METALLOGRAPH METALLURGICAL STEREO</p> <p>MISMATCH MICROWAVE</p> <p>MIXER (ELECTRONIC) MICROWAVE</p> <p>MONITOR RADIATION, NUCLEAR PARTICLE COUNTER</p> <p>MULTIPLIER FREQUENCY</p>	<p>OPTICAL AUTOCOLLIMATOR CATHETOMETER CLINOMETER COM PARATOR FLAT</p> <p>OSCILLOSCOPE DIGITAL STORAGE DISPLAY UNIT DISPLAY UNIT, STORAGE DUAL BEAM GENERAL PURPOSE SAMPLING STORAGE</p> <p>OSCILLOSCOPE ACCESSORY CALIBRATOR, AMPLITUDE UNINTERRUPTIBLE (UPS) NORMALIZER PLUG-IN, COUNTER PLUG-IN, DIFFERENTIAL PLUG-IN, DMM PLUG-IN, DUAL TRACE PLUG-IN, FOUR TRACE PLUG-IN, LOGIC ANALYZER PLUG-IN, SAMPLING PLUG-IN, SAMPLING SWEEP PLUG-IN, SAMPLING/TDR PLUG-IN, SINGLE TRACE PLUG-IN SPECTRUM ANALYZER PLUG-IN, SWEPT FREQUENCY PLUG-IN, TIME BASE SAMPLING HEAD TRIGGER COUNTDOWN</p> <p>PHASE SHIFTER MICROWAVE</p> <p>PHOTOMETER OPTICAL</p> <p>PLATE ANGLE SINE SURFACE</p> <p>POTENTIOMETER PRECISION TEMPERATURE DIRECT READING</p> <p>POWER INVERTER</p>
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<p>POWER SUPPLY AC DC COMPUTER CONTROLLED DC CURRENT REGULATED DC GENERAL PURPOSE DC PRECISION KLYSTRON MODULAR PLATING PULSE, CURRENT REGULATOR, VOLTAGE, AC UNINTERRUPTIBLE (UPS)</p> <p>PRESS LABORATORY</p> <p>PROBE CURRENT VOLTAGE</p> <p>PXI / SCXI MODULE</p> <p>PYROMETER INFARED OPTICAL</p> <p>RADIOMETER OPTICAL</p> <p>RADIOMETER ACCESSORY DETECTOR</p> <p>RATEMETER NUCLEAR</p> <p>RECORDER ANALOG TAPE DIGITAL PRINTER OSCILLOGRAPH (LIGHT BEAM) OSCILLOGRAPHIC STRIP CHART XY</p> <p>RECORDER (ENVIRONMENTAL) HYGRO-THERMOGRAPH TEMPERATURE</p> <p>RECORDER/CONTROLLER TEMPERATURE</p> <p>REFERENCE JUNCTION TEMPERATURE</p> <p>REGULATOR PRESSURE</p> <p>RESISTOR DECADE FIXED VARIABLE</p> <p>ROTARY JOINTS MICROWAVE</p>	<p>SCALE PRECISION</p> <p>SECTION WAVEGUIDE</p> <p>SHORT SHUNT SLOTTED LINE MICROWAVE</p> <p>SOURCE BLACKBODY INFARED</p> <p>SPECTROPHOTOMETER</p> <p>SQUARE CYLINDRICAL</p> <p>STROBOSCOPE INDICATOR, ANALOG</p> <p>SURVEY METER NUCLEAR</p> <p>SWITCH</p> <p>SYCHRO/RESOLVER STANDARD</p> <p>TABLE ROTARY</p> <p>TEE MICROWAVE HYBRID</p> <p>TELEMETRY RECEIVER</p> <p>TELEMETRY ACCESSORY CHANNEL SELECTOR DEMODULATOR, PHASE DISCRIMINATOR SYNCHRONIZER, BIT TUNER VCO</p> <p>TERMINATION POWER</p> <p>TESTER HARDNESS TENSILE/COMPRESSION TORQUE</p>	<p>TESTER (ELECTRONIC) CURVE TRACER EDDY CURRENT</p> <p>TESTER (ELECTRONIC) ERROR RATE, COMMUNICATION INSULATION LOGIC CIRCUIT ANALYZER LOGIC PROBE SEMICONDUCTOR TRANSMISSION LINE</p> <p>THERMOMETER DIAL GAGE DIGITAL GLASS INDICATOR, ANALOG PROBE, RESISTANCE TEMP PROBE, THERMOCOUPLE</p> <p>TIME CODE GENERATOR/TRANSLATOR TRANSLATOR</p> <p>TIMER ELECTRONIC</p> <p>TORQUE WRENCH/GAGE</p> <p>TRANSDUCER ACCELEROMETER DISPLACEMENT, ANGULAR DISPLACEMENT, LINEAR EXTENSOMETER LOAD CELL PRESSURE TORQUE</p> <p>TRANSFORMER CURRENT ISOLATION MATCHING VARIABLE</p> <p>TRANSITION WAVEGUIDE TO WAVEGUIDE</p> <p>TUNER MICROWAVE</p> <p>WEIGHT SET</p>
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Measurement Capabilities, Ranges & Uncertainties

Notes

- Northrop Grumman is AS9100 certified. Measurements and calibrations are performed in compliance with ANSI/NCSL Z540-1-1994, ANSI/NCSL Z540.3-2006, and/or ISO 17025 based on customer request. Accredited ISO 17025 calibrations are available based on current scope of accreditation based on customer request.
- **ISO 17025 Accredited Calibrations**
 - S-Parameters 45 MHz to 110 GHz
 - RF Power 100 KHz to 110 GHz
 - RF Noise 10 MHz to 110 GHz
 - Time and Frequency
 - DC Voltage
 - AC Voltage
 - Resistance
 - Torque
 - Temperature
 - Pressure
- Measurements and calibrations are directly traceable to NIST (National Institute of Standards and Technology) or other recognized National Standards.
- The ***Uncertainty Values*** listed are for standard calibrations and are intended as a reference only. Actual uncertainties may vary and lower uncertainty values can be achieved in most disciplines upon request.

DC/LOW FREQUENCY

Discipline	Nominal Value or Range	Uncertainty
AC VOLTAGE*	10 mV 10 Hz – 100 kHz	0.05 %
	100 mV 10 Hz – 40 Hz 40 Hz – 20 kHz 20 kHz – 300 kHz 300 kHz – 1MHz	0.03 % 0.005 % 0.03 % 0.04 %
	1 V 10 Hz – 20 Hz 20 Hz – 40 Hz 40 Hz- 100 Hz 100 Hz – 20 kHz 20 kHz – 100 kHz 100 kHz – 1 MHz	0.02 % 0.003 % 0.002 % 0.002 % 0.005 % 0.013 %
	10 V 10 Hz – 20 Hz 40 Hz – 100 Hz 100 Hz – 20 kHz 20 kHz – 100 kHz 100 kHz – 1MHz	0.02 % 0.003 % 0.002 % 0.005 % 0.013 %
	100 V 10 Hz – 20 Hz 40 Hz – 20 kHz 50 kHz – 100 kHz 300 kHz	0.02 % 0.003 % 0.007 % 0.013 %
	1000 V 10 Hz – 20 Hz 40 Hz – 20 kHz 50 kHz – 100 kHz	0.02 % 0.003 % 0.007 %

*ISO 17025 accredited calibration

DC/LOW FREQUENCY

Discipline	Nominal Value or Range	Uncertainty
AC CURRENT	0.01 A	
	1 kHz, 10 kHz	0.005 %
	0.02 A	
	1 kHz, 10 kHz	0.005 %
	0.03 A	
	1 kHz, 10 kHz	0.005 %
	0.05 A	
	1 kHz, 10 kHz	0.005 %
	0.1 A	
	1 kHz, 10 kHz	0.005 %
	0.2 A	
	1 kHz, 10 kHz	0.005 %
	0.3 A	
	1 kHz, 10 kHz	0.005 %
	0.5 A	
	1 kHz, 10 kHz	0.005 %
	AC VOLTAGE	1.0 A
1 kHz, 10 kHz		0.005 %
	2.0 A	
	1 kHz, 10 kHz	0.005 %
	3.0 A	
	1 kHz, 10 kHz	0.005 %
	5.0 A	
	1 kHz, 10 kHz	0.005 %
	10.0 A	
	1 kHz, 20 kHz	0.01 %
	20 A	
	1 kHz, 10 kHz	0.01 %
	0 – 350V	
	at 1 kHz	1 ppm

DC/LOW FREQUENCY

Discipline	Nominal Value or Range	Uncertainty
CAPACITANCE	1 pF @ 1 kHz	0.0003 %
	10 pF @ 1 kHz	0.0002 %
	100 pF @ 1 kHz	0.0002 %
	1000 pF @ 1 kHz	0.0005 %
	0.01 μ F @ 1 kHz	0.05 %
	0.1 μ F @ 1 kHz	0.05 %
	1.0 μ F @ 1 kHz	0.053 %
	10 μ F @ 1 kHz	0.25 %
	Steps of 10 μ f @ 1 kHz	.25% per step
	INDUCTANCE	10 μ H @ 100 Hz & 1 kHz
1 mH @ 100 Hz & 1 kHz		0.02 %, 0.05 %
10 mH @ 100 Hz & 1 kHz		0.02 %
100 mH @ 100 Hz & 1 kHz		0.02 %
1 H @ 100 Hz & 1 kHz		0.02 %, 0.05 %
10 H @ 100 Hz & 1 kHz		0.02 %, 0.2 %
RESISTANCE*	10 $\mu\Omega$ – 100 $\mu\Omega$	10 $\mu\Omega/\Omega$
	100 $\mu\Omega$ – 1 m Ω	5 $\mu\Omega/\Omega$
	1 m Ω – 10 m Ω	2 $\mu\Omega/\Omega$
	10 m Ω – 100 m Ω	1 $\mu\Omega/\Omega$
	1 Ω	0.3 $\mu\Omega/\Omega$
	1 Ω – 10 Ω	0.5 $\mu\Omega/\Omega$
	10 Ω – 100 Ω	0.5 $\mu\Omega/\Omega$
	100 Ω – 1 k Ω	0.5 $\mu\Omega/\Omega$
	10 k Ω – 100 k Ω	1 $\mu\Omega/\Omega$
		0.3 $\mu\Omega/\Omega$
	100 k Ω – 1 M Ω	2 $\mu\Omega/\Omega$
	1 M Ω – 10 M Ω	5 $\mu\Omega/\Omega$
	10 M Ω – 100 M Ω	10 $\mu\Omega/\Omega$
	100 M Ω – 1 G Ω	15 $\mu\Omega/\Omega$
	1 G Ω – 10 G Ω	700 $\mu\Omega/\Omega$
	10 G Ω – 100 G Ω	1000 $\mu\Omega/\Omega$
	100 G Ω – 1 T Ω	2000 $\mu\Omega/\Omega$
	1 T Ω – 10 T Ω	3000 $\mu\Omega/\Omega$

* ISO 17025 accredited calibration

DC/LOW FREQUENCY

Discipline	Nominal Value or Range	Uncertainty
PHASE	0° - 360° @ 400 Hz	0.005°
	0° - 360° @ 50kHz	0.005°
FREQUENCY RESPONSE	0.2 V	
	1.0 – 1 MHz	0.05 %
	10 MHz	0.1 %
	30 MHz	0.2 %
	100 MHz	1.0 %
	1.0 V, 3.0 V	
	0.03 – 1 MHz	0.05 %
	2 – 10 MHz	0.1 %
	20 – 30 MHz	0.2 %
	40 MHz	0.4 %
	60 MHz	0.6 %
	80 MHz	0.8 %
	100 MHz	1 %
	RISETIME	≤ 14.7 pS
DC VOLT*	1 uV	10 %
	10 uV	1.0 %
	100 uV	0.1 %
	1 mV	0.01 %
	10 mV	10 ppm
	100 mV	0.8 ppm
	1V	0.5 ppm
	10 V	0.3 ppm
	100 V	0.5 ppm
	1000 V	0.8 ppm
	2000 V	0.02 %
	30000 V	0.02 %
	50000 V	0.02 %
DC CURRENT	2 pA	1 %
	20 pA	0.5 %
	200 pA	0.3 %
	2nA – 20 nA	0.07 %
	200 nA	0.04 %
	2 μA – 20 μA	0.03 %
	100 μA – 1A	0.00065 %
	1 A – 10 A	0.005 %
	10A – 100A	0.005 %

*ISO 17025 accredited calibration

RF/MICROWAVE

Discipline	Range	**Frequency	Measurement Uncertainty
RF POWER*			
Coaxial	* 0.01 – 1.0 mW	0.001 – 67.0 GHz	±(1.5 – 6.0 %)
Waveguide	* 0.01 – 1.0 mW	18.0 – 50.0 GHz	±(2.0 – 4.5 %)
	* 0.01 – 1.0 mW	50.0 – 75.0 GHz	±(2.0 – 5.0 %)
	* 0.01 – 1.0 mW	75 – 110 GHz	±(4.0 – 7.0 %)
** Other power levels are available upon request			

*ISO 17025 accredited calibration

RF/MICROWAVE

Discipline	Frequency	NF Meas. Uncertainty	ENR Measurement Uncertainty
NOISE FIGURE (NF)/EXCESS NOISE RATIO (ENR)*			
Coaxial	0.01 – 50 GHz	± 0.10 – ± 0.50 dB	± (0.12 dB – 0.55 dB)
Waveguide	18 – 50 GHz 50 – 75 GHz	± 0.25 – ± 0.35 dB ± 0.35 – ± 0.75 dB	± (0.28 dB – 0.40 dB) ± (0.35 to ± 0.45 dB)
WAVEGUIDE	18.0 – 26.5 GHz 26.5 – 40.0 GHz 33.0 – 50.0 GHz 50.0 – 75.0 GHz 75.0 – 100.0 GHz	± .25 - ± .30 ± .17 - ± .22 ± .17 - ± .30 ± .20 - ± .35 ± .35 - ± .58	± .25 - ± .35 ± .19 - ± .36 ± .25 - ± .35 ± .22 - ± .45 ± .40 - ± 0.70

** Service is available using Hot and Cold Y-factor techniques for NF (dB0 and ENR (dB)).
NIST service is not available*

*ISO 17025 accredited calibration

RF MICROWAVE

Discipline	Range	Measurement Uncertainty
NETWORK ANALYSIS* All 4 S-Parameters Magnitude & Phase	300 kHz – 110 GHz	Dependent on system used
FREQUENCY* Cesium Primary Frequency Standard	10 MHz, 5 MHz, 1 MHz, 100 KHz outputs	$\pm 1 \times 10^{-12}$
TIME* Relative with respect to GPS	1 pps output	± 30 n Sec RMS

*ISO 17025 accredited calibration

PHYSICAL

Discipline	Range	Measurement Uncertainty
FLOW GAS	50 – 50,000 scc/min	± 01.15 % of reading (k=2)
VISCOSITY	Up to 1000 mm ² /s 1000 – 10,000 mm ² /s Greater than 10,000 mm ² /s	0.29% of actual viscosity 0.38% of actual viscosity 0.44% of actual viscosity
MASS	10 g – 50 g 100 g – 1 kg 5 kg – 30 kg	±0.010 mg ±0.050 mg ± 1ppm
FORCE		
Deadweights	Up to 300 lbf	± 0.097% to scale**
Load Cells	0 – 50,000 lbf	± 0.1% of full scale* (k=2)
TORQUE*		
Transducers	Up to 1,000 ft lb	± .025% of Full Scale
Wrenches/Screwdrivers	5 – 200 in oz 5 – 50 in lb 40 – 1,4000 in lb	± 0.033 in-oz ± 0.011 in-lbs ± 0.39 in-lbs ± 0.65 ft-lbs
	25 – 600 ft lb	

**** The combined system uncertainty includes uncertainty as calculated in accordance with ASTM E 74, drift due to temperature variations, drift over time, and indicator uncertainty.**

*ISO 17025 accredited calibration, 5-200 in oz

PHYSICAL

Discipline	Range	Measurement Uncertainty
VIBRATION	100 Hz, (2 pk g) 20 Hz to <100 Hz, (2 pk g) >100 Hz to 2,000 Hz, (2 pk g) >2,000 Hz to 10,000 Hz, (2 pk g)	$\pm 1.6\%$ (k=2) $\pm 2.1\%$ (k=2) $\pm 1.9\%$ (k=2) $\pm 2.9\%$ (k=2)
PRESSURE*		
Portable Pressure Calibrator	0 – 0.8 in H2O 0 – 8 in H2O	$\pm 0.1\%$ of reading + 1 digit $\pm 0.1\%$ of reading + 1 digit
Capacitance Manometer	0.001 – 4 Torr 4 – 1000 Torr	± 0.004 Torr $\pm 0.1\%$ of reading
Pneumatic Piston Gage	0.2 – 25 psi 25 – 1,000 psi 1,000 – 10,000 psi	$\pm 0.0015\%$ of reading $\pm 0.005\%$ of reading $\pm 0.01\%$ of reading
Hydraulic Piston Gage	0 – 1,000 psi 1,000 – 10,000 psi	$\pm 0.011\%$ of reading $\pm 0.06\%$ of reading
Absolute (Ps) Differential (Qc)	0.5 – 32 in Hg 0.5 – 100 in Hg	0.003% of FS + 0.005% of reading 0.003% of FS + 0.005% of reading
VACUUM	1 E-6 – 1 E-4 Torr	$\pm 4.0\%$ of reading (k=2)

*ISO 17025 accredited calibration, 0 – 1000 psig

PHYSICAL

Discipline	Range	Measurement Uncertainty
TEMPERATURE*		
Bath Calibration	-195 – 550° C	± 0.005° C
Blackbody Source	35 – 500° C	± 0.5° C
Electrical Substitution LN2 Comparison Calibrator	-270 – 2,300° C -196° C	± 0.02% ±0.005°C
Intrinsic Standards		
Triple Point of Water	0.01 ° C	± 0.005° C
Tin	231.9 ° C	± 0.08° C
Zinc	419.5 ° C	± 0.18° C
Aluminum	660.3 ° C	± 0.5° C
HUMIDITY		
Dewpoint	-80 - + 20° C	± 1° C
Relative Humidity	20 – 90% RH	± 0.5% RH
GAS ANALYZERS		
Oxygen Analyzers	0, 400 ppm 10%, 19.5%, 20.9%	± 1% of Stated Value ± 1% of Stated Value
AIR VELOCITY		
Thermal Anemometers	50 – 250 ft/min 250 – 1,500 ft/min 1,500 – 6,000 ft/min	± (2% reading + 2 digits) ± (2% reading + 5 digits) ± (1% reading + 15 digits)
Vane Anemometers	50 – 4,000 ft/min	± (1% reading + 1 digits)
pH	4, 7, and 10 pH	± 0.024 pH (k=2)
CONDUCTIVITY	1,000 – 10,000 & 100,000µS/cm	± 2% at 25° C
NUCLEAR RADIATION		
Gamma Radiation	0.013 – 3,500 milliroentgens/hr	± 5.0% of reading

*ISO 17025 accredited calibration, -90 to 110 ° C

DIMENSIONAL

Discipline	Range	Measurement Uncertainty
LENGTH		
Gage Blocks	<0.250 in 0.250 – 4.000 in 5.000 – 20.000 in	$\pm 3.6\mu$ in ± 2.2 in ± 0.93 ppm $4.3+0.18^*L \mu$ in 1 ppm
Cylindrical Ring Gages	0.10 – 6 in	26 μ in
Cylindrical Plug Gages	0.01 – 6 in	5 μ in ± 1 ppm
Outside Micrometers	0.5 – 20 in (any inch)	± 0.00005 in
Inside Micrometers	0.1 – 6 in (any inch)	± 0.0001 in
Vernier Gages	0.01 – 36 in (any inch)	± 0.0001 in
Measuring Microscopes	0.01 – 3.0 in (Glass scale)	± 0.0001 in
Coordinating Measuring Machines	Scales to 17 in Ball Bar Test	± 0.00001 in ± 1.7 ppm ± 0.0001 in
Thread Plug & Set Gages	4 – 80 pitch	± 0.00005 in
Thread Wires	4 – 80 pitch	$\pm 18.3 \mu$ in
Scales (metal)	Up to 12 ft	± 0.0003 in / ft
SURFACE ROUGHNESS		
Surface Roughness Systems	0.000001 – 0.0001 in Ra 0.0001 – 0.001 in Ra	$\pm 2.5 \mu$ in Ra $\pm 4 \mu$ in Ra
Surface Roughness Standards	0.000001 – 0.0001 in Ra 0.0001 – 0.001 in Ra	$\pm 7.3 \%$ $\pm 7.3 \%$
ROUNDNESS		
Cylindrical Squares	0.5 – 6 in	$\pm 11.6 \mu$ in
FLATNESS		
Optical Flats	All Standard Sizes (Plano-Interferometer)	$\pm 0.63 \mu$
Surface Plates Plate/Anvils	All Standard Sizes All via Electronic Height Gage and AA Surface Plate	0.000060 in / ft ± 0.00005 in
OPTICAL-DIMENSIONAL		
Theodolites	0 – 360 degrees	± 2 arcsec
Jig Transits	0 – 360 degrees	± 5 arcsec

DIMENSIONAL

Discipline	Range	Measurement Uncertainty
<p>ANGLE</p> <p>Angle Gage Blocks Rotary Tables Autocollimators Levels Sine Bars Optical Cubes 12 Sided Optical Polygons</p> <p>HARDNESS</p> <p>Rockwell Hardness Testers</p>	<p>1 sec – 45 degrees 0 – 360 degrees 0 – 20 arcmin 0 – 20 arcsec 0 – 20 arcmin 90 degrees 0 – 360 degrees</p> <p>0.1 – 100 pts Rc (B, C, E, N, & T Scales)</p>	<p>± 0.54 arcsec ± 0.63 arcsec ± 0.2 % of reading ± 0.5 arcsec ± 0.5 arcsec ± 1.6 arcsec ± 0.5 arcsec</p> <p>± 1.0 -2.0 pts Rc *</p> <p>varies with test specimen</p>

** Traceable to NIST via force, rate of application and depth. (Hardness Test Specimens)*

ELECTRO-OPTICS/FIBER OPTICS

Discipline	Range	Measurement Uncertainty
LASER POWER Laser Power Meter	632.8 nm	± 1.09%
Laser Power Meter (Electrical Substitution)	10 μ W – 3 mW Flat Response 1 mW – 50 W	± 0.5%
SPECTRAL RESPONSIVITY	200nm 205nm - 215nm 220nm – 260nm 265nm – 345nm 350nm – 380nm 385nm – 450nm 455nm – 950nm 955nm – 1000nm 1005nm – 1050nm 1055nm – 1100nm	± 6.0% ± 4.0% ± 1.2% ± 1.1% ± 0.50% ± 0.35% ± 0.20% ± 0.78% ± 1.50% ± 2.5%
PHOTOGRAPHIC STEP TABLET		
Optical Density	0.05 OD – 4.3 OD	± 0.02 O.D. or ± 1.1%
DENSITOMETERS		
Optical Density	0.05 OD – 4.3 OD	± 0.02 O.D. or ± 1.1%
NEUTRAL DENSITY FILTERS		
Optical Density	0.01 OD – 10.0 OD	± 0.005 OD
COLOR FILTERS / INTERFERENCE		
Transmission	300nm – 1700nm	See Spectral Irradiance
PHOTOMETRY		
Illuminance (footcandle)	0.5 fc - 4000 fc	± 1.45%
Illuminance (Lux)	5 Lux - 43000 Lux	± 1.45%
Luminance (footlambert)	1 fl - 500 fl	± 1.52%
Luminance (cd/m ²)	3.426 cd/m ² - 1700 cd/m ²	± 1.52%
COLORIMETRY		
Chromaticity coordinates	432nm - 647nm	± 1.0 nm
ULTRA-VIOLET (UVA)		
Irradiance, 365nm	1 μ W/cm ² - 28 mW/cm ²	± 1.94%



ELECTRO-OPTICS/FIBER OPTICS

Discipline	Range	Measurement Uncertainty
SPECTRAL IRRADIANCE	300nm – 500nm	± 1.83%
	500nm – 750nm	± 1.56%
	750nm – 1100nm	± 2.05%
	1100nm – 1500nm	± 1.89%
	1500nm – 1700nm	± 2.26%
FIBER OPTIC		
F/O Power Meter		
Accuracy	FP 860 nm,	± 1.23%
Single Mode, Multi-Mode	-5 – -50dBm	
	FP 1303nm,	± 1.18%
	-5 – -50dBm	
	FP 1545nm,	± 1.17%
	-5 – -50dBm	
	DFB 1450nm – 1550nm,	± 1.17%
	+3 – -50dBm	
F/O Laser Source		
Output Power	600nm – 1550nm	± 1.18%
Single Mode, Multi-Mode	+10 – -50dBm	
Wavelength Accuracy	600nm – 700nm	± 0.16%
	700nm – 1650nm	± 0.0003%
F/O Attenuator		
Accuracy	0dB – -60dB	± 0.01dB
(see power meter wavelengths)		
Insertion Loss	0dB – -60dB	± 0.08dB
Repeatability	0dB – -60dB	± 0.008dB
F/O Optical / Electrical Converter		(Call for specific capability)
Power monitor	1303nm	± 1.18%
Pulse Width	1300nm	≤ 40ps
F/O Optical Spectrum Analyzer		
Wavelength	632.8nm	Natural Physical Constant
	860nm, 1450 – 1550nm	± 0.0003%
Amplitude	632.8nm / 860nm, 1450 – 1550nm	± 1.18%
GLOSS / REFLECTANCE		
Specular Gloss	1.5 GU – 30.3 GU	± 2 GU
	6.9 GU – 40.7 GU	± 2 GU
	85.8 GU – 99.3 GU	± 1 GU
ACCOUSTICS		
Sound Level Meter (type0,1,2)		
A,B,C,Lin weighting Accuracy	110dB	ANSI S1.6-1967, ± 0.11 dB
(125Hz – 2000Hz)		
Linearity	-80 dB – 130 dB	± 0.11 dB
Sound Pressure Level Calibrators		
Sound Pressure Level	-80 dB – 130 dB	± 0.11 dB
Frequency	125Hz – 2000Hz	± 0.01%
Distortion (THD)	-80 – 0 dB (.01 to 100%)	± 1.0 dB

SPECIAL ENGINEERING CAPABILITIES

PHASE NOISE	
Automated Phase Noise	Fully automated Phase Noise measurements are performed using the HP/Agilent E5504 system supplemented by the HP/Agilent 8566B. The HP/Agilent E5504 covers the base band ranges: 0.01 Hz to 100 MHz. The HP/Agilent 8566B is used to extend the base band range to 800 MHz.
Two Oscillator Technique	RF frequency is limited by the availability of a reference oscillator. The HP/Agilent 8663A/70427A is used at RF frequencies to 26.5 GHz. Capability is enhanced if better reference oscillators are provided. State-of-the-art 5 MHz oscillators are available offering – 128 dBc/Hz at 1 Hz Fourier frequency.
Single Oscillator	Variations of the Single Oscillator (FM Discriminator) can measure at RF frequencies from 200 MHz to the millimeter wave, waveguide bands.
<p><i>* Measurement uncertainties for special measurements shown vary with test and/or test configuration.</i></p>	

Northrop Grumman Calibration

Full Capabilities

Full Compliance

Excellent Turnaround Time

Calibration You Can Trust