

Ideal Aerosmith's Inertial Test Laboratory

SUMMARY

Ideal Aerosmith has set up an Inertial Test Laboratory (ITL) to provide testing solutions for customers and projects that require short-term, periodic, or custom motion simulation capabilities without the full cost of acquisition and ownership. This testing-as-a-service offering enables faster development and time to market for our clients. We can help established manufacturers and integrators when production facilities are tied up, as well as new developers with immediate access to inertial test equipment. The ITL is conveniently located at our facility in Phoenix, AZ.

DESCRIPTION

Ideal Aerosmith has been working to support diverse customer needs since 1938. Over the years, Ideal Aerosmith has grown from a small avionics instrument lab equipment supplier to become the premier provider of turnkey solutions, custom products and services, with an expertise in motion simulation, build-to-print, and automated test equipment (ATE).

The needs of the Positioning, Navigation and Timing (PNT) industry are central to our mission. We offer a range of products: 1-, 2- and 3-axis rate table systems for inertial sensors and systems testing, flight motion simulators for hardware-in-the-loop (HWIL) testing for missiles, and complex avionics test equipment.

To support the needs of our clients and to keep up with the speed of technology developments, Ideal Aerosmith offers a number of complementary services dedicated to support short development and production cycles. These include built-to-print services with fast turnarounds, testing-as-a-service in a fully equipped Inertial Testing Lab (ITL) in Phoenix, AZ, and complete turnkey solutions for a variety of applications, from inertial systems testing and aircraft component functional checks to slipping testers and whole field sensor calibration routines for directional drilling.

Of particular interest for PNT clients is the establishment of the Inertial Testing Laboratory. It is designed to help experienced manufacturers and integrators when production facilities are over capacity and to help new developers with immediate access to inertial test equipment. It also saves the clients early/unnecessary capital acquisition and ownership costs. The ITL is organized on a principle of one client at a time, so our customers are able to safely and securely conduct tests that are competition-sensitive, or export controlled. Duration of the tests is also flexible, as the ITL is available for a day-long test, one that takes several weeks or everything in between. Periodic tests with safe keeping of the equipment/UUTs is another option.

Ideal Aerosmith has equipped the ITL with its own high performance 3-Axis Rate Table, Model 2003HP. In addition to precision motion stimuli, this rate table features a thermal chamber heated with resistive heaters and cooled by liquid Nitrogen (LN₂) to allow testing over a wide range of different thermal profiles with fast cooling and heating rates. This rate table is suitable to test almost all known inertial sensors and systems: from consumer to navigation grade gyros and accelerometers, as well as inertial systems, including Inertial Measurement Units (IMU's) and Inertial Navigation Systems (INS). The test system also

allows for testing of the inertial systems coupled with Global Navigation Satellite System (GNSS) modules, such as GPS navigation devices.

To enable our clients' access to full characterization of the inertial systems, the ITL is also equipped with a linear shaker to ascertain Unit Under Test (UUT) performance under various vibratory environments. In attempt to support all of our customers' testing needs, Ideal Aerosmith is also researching adding shock and angular vibration capabilities to further enhance our offering.

While geared toward the community of inertial manufacturers and integrators, the ITL can also be useful for anyone who is in need of testing precise rotational motion and positioning or vibration and shock testing, such as battery testing. The mounting platform (table top) inside the thermal chamber is 24 inches in diameter enabling UUT's of differing sizes to be easily accommodated for motion testing, while the shaker is capable of supporting a 200 lb payload, including the fixture weight.

CAPABILITIES

In addition to sophisticated test equipment, Ideal Aerosmith employs experts in inertial testing with over 20 years of combined experience. This enables us to provide as much or as little assistance to our clients as needed. A part of the customizable approach, clients can run all aspects of testing on their own, with only safety support provided by Ideal Aerosmith personnel, or they can go for full turnkey testing. For the latter, Ideal Aerosmith prepares a statement of work (SOW), devises the test plan, prepares and conducts tests, and processes and analyzes acquired data. Electrical and mechanical interfaces can also be designed and manufactured by Ideal Aerosmith. Data acquisition and storage is provided for most standard data formats and analog outputs.

Ideal Aerosmith is an active participant in the Gyro and Accelerometer Panel (GAP). The GAP is the Technical Panel of the IEEE Aerospace and Electronics Systems Society. The Panel's purpose is to create standard terminology, specification formats, and test procedures for inertial sensors. Over the years the GAP has released a number of IEEE standards pertaining to the inertial devices. Some of the standards are listed below:

- 647-2006 IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Laser Gyros
- 671-1985 IEEE Standard Specification Format Guide and Test Procedure for Nongyroscopic Inertial Angular Sensors: Jerk, Acceleration, Velocity, and Displacement
- 813-1988 IEEE Specification Format Guide and Test Procedure for Two-Degree-of-Freedom Dynamically Tuned Gyros
- 836-2009 IEEE Recommended Practice for Precision Centrifuge Testing of Linear Accelerometers
- 952-1997 IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Interferometric Fiber Optic Gyros
- 1293-1998 IEEE Standard Specification Format Guide and Test Procedure for Linear, Single-Axis, Nongyroscopic Accelerometers
- 431-2004 Specification Format Guide and Test Procedure for Coriolis Vibratory Gyros
- 1554-2005 (R2011) Recommended Practice for Inertial Sensor Test Equipment, Instrumentation, Data Acquisition, and Analysis.

Ideal Aerosmith incorporates procedure and terminology recommendations from the above standards in our test plans, as applicable to the particular UUT. This way, the data collected from such tests is standardized and easily comparable to other data sets, if, for example, a client is cross-testing various inertial sensors and making a decision on which type to use in his/her application.

Additionally, with the test equipment available, the ITL can be used to perform a significant portion of the environmental tests contained in the standards MIL-STD-810, RTCA/DO-160 and similar.

When it comes to characterizing inertial sensors and systems in particular, testing in our lab provides relevant information on many parameters instrumental in describing performance of the said sensors and systems. The ITL is capable of providing a customer with the following evaluations:

- Bias over temperature
- Scale Factor error (including repeatability, asymmetry, and linearity)
- Misalignment
- Allan Variance (including Noise, Angular Random Walk, Velocity Random Walk)
- Cross-axis sensitivity
- Long term Drift
- Bias G-sensitivity
- In-run bias stability
- Turn on/off testing
- Bias turn-on to turn-on
- Vibration Rectification
- Sine Sweeps, Sine on Random and similar vibration tests
- Long term performance testing



Figure 1 Model 2003HP 3-Axis Rate Table at the Inertial Test Lab

Depending on the needs and requirements or types of sensors tested, a subset of these parameters might be sufficient to characterize UUT's for a specific application. Ideal Aerosmith will work with the customer to ensure necessary tests are performed. In addition to performance tests above, the ITL offers Highly Accelerated Life Testing/Highly Accelerated Stress Screening (HALT/HASS) testing to evaluate product reliability by finding defects in products so they are fixed prior to becoming expensive field issues.

If a client is a system integrator looking to select inertial sensors or systems for their application/product, Ideal Aerosmith can perform comparative testing of different devices based on client's requirements and the performance tests listed above. This will assure the most appropriate sensors are selected for a specific application, as there is no need to interpolate performance from often confusing datasheets. The

tests eliminate concerns whether devices meet the published specs and, utilizing the rate table's high capacity, different types of sensors can be tested at the same time thus providing identical test conditions.

Another use for the ITL is to conduct Validation and Verification testing as the part of the product development cycle. Often lengthy, yet infrequent tests lend themselves well to the lab core mission. To stay in compliance with your quality processes, periodic tests can be conducted until a redesign that would merit a new round of Validation and Verification tests is needed. For manufacturers looking to introduce contingency planning to their production forecast in the event of production facility issues, or if in need of urgent production ramp up, the ITL can be used as scalable additional production capacity. Necessary components can be stocked in the lab, facilitating an even faster turnaround.

Finally, inertial experts at Ideal Aerosmith can help with the inertial test development either in our facility or at the client's facility. We can help with preparing Statement of Work, Test Plan, Test Description, Script development, test setup including electrical and mechanical interfaces, data acquisition, and motion and thermal profiles automation. We can also devise data processing modules, including data analysis, model application, Go/No Go results. The results would be compiled in a comprehensive test report. Based on our experience, the error compensation models for thermal, bias, scale factor, and misalignment corrections specific to your sensors and systems can be developed to enhance performance of inertial sensors over varied environments.

If you have any questions or are in need of services described herein, please contact us at sales@idealaero.com, or at 701-757-3400. The ITL facility is located at:

Ideal Aerosmith
2205 West Lone Cactus Dr, Suite 7
Phoenix, AZ 85027

We look forward to working with you.



Figure 2 Model Unholtz-Dickie S092 Linear Shaker at the Inertial Test Lab

Inertial Test Lab Equipment – Ideal Aerosmith 2003HP 3-Axis Rate Table

DUT Interfaces			
Available Envelope			
- Table Top diameter (in)	24		
- Maximum Height (in)	17.3		
- Maximum Payload (lb)	165		
Electrical Interface	180 User lines, 3A per line 1 RF Line		
Performance Specifications			
	Inner Axis	Middle Axis	Outer Axis
Axis Wobble, arc sec (deg)	3 (0.0008)	3 (0.0008)	3 (0.0008)
Axis Orthogonality, arc sec (deg)	± 5 (0.0014) between consecutive axes		
Range of Motion, deg	unlimited	unlimited	unlimited
Position			
Accuracy, absolute, arc sec (deg)	± 1 (0.00028)	± 1 (0.00028)	± 1 (0.00028)
Repeatability, arc sec (deg)	± 1 (0.00028)	± 1 (0.00028)	± 1 (0.00028)
Encoder Resolution, deg (approx.)	0.000001	0.000001	0.000001
Rotation Rate			
Maximum, deg/sec	± 2000	± 500	± 500
Command Resolution, deg/sec (approx.)	0.00001	0.00001	0.00001
Accuracy, (average of 10 readings, measured over 1 rev)	0.0001% ± Resolution	0.0001% ± Resolution	0.0001% ± Resolution
Stability (measured over 1 rev)	0.0001%	0.0001%	0.0001%
Peak Acceleration (2 sec. duration), deg/sec ² <small>Peak accelerations listed are for no load and a maximum rate of 980 deg/sec for the inner axis, 480 deg/sec for the middle axis and 350 deg/sec for the outer axis. Performance diminishes at higher rates.</small>	7500	525	250
Maximum Continuous Acceleration, deg/sec ²	1800	170	150
Bandwidth, -3dB (no load)	75 Hz	17.5 Hz	15 Hz
Thermal Chamber Specifications			
Temperature Range (°C)	-65 to 85		
Thermal Slew Rate (°C/min)	5		
Temperature Stability (°C)	±1		

Inertial Test Lab Equipment – Unholtz-Dickie Corp. Model S092 Linear Shaker

DUT Interfaces	
Available Envelope	
- Mounting head (in dia)	7
- Maximum Height (in)	18
- Maximum Payload (lb)	200
Performance Specifications	
Continuous Force Rating (lbf)	
Sine	800
Random	800
Armature Weight with Inserts (lb)	10
Maximum Shock, 0.5 ms, 2 lb payload (g)	450
Displacement (in)	2
Frequency Range (Hz)	10-3000