

## **Course Outline's Brief Descriptions**

### **Equipment Reliability Institute (ERI) - Santa Barbara, California**

#### **ACO 501 - Basic Acoustics**

Basic acoustics, vibration and noise, instrumentation, measurement procedures and standards, test spaces, acoustic materials, laboratory demonstrations, data reduction, data analysis, setting up a test program, documentation and reporting.

#### **ACO 502 - Acoustical Training for HVAC Contractors**

Noise can cause problems which range in severity from irritation to hearing loss. Most noise can be substantially reduced at minimal cost with proper design. This course provides architects and construction managers with practical suggestions about sound transmission class (STC) walls and how to build them, types of non-hardening acoustical caulk touse, CMU walls, ASHRAE books and analytical programs.

#### **CAL 501 -Vibration measurements and calibration**

Gives an understanding of vibration theory and measurements, with focus on piezoelectric, piezoresistive and variable capacitor types of accelerometers. Also, correct usage of this equipment. What good are accelerometers and other vibration measuring instruments, unless readouts can be trusted?

#### **CAL 510 - Temperature and Pressure Calibration**

Basic theory, how sensors work, selecting sensors, calibration techniques, selecting calibration standards and references for further study if needed. Many "nuts and bolts" tips will improve cal lab productivity and repeatability. The course also includes a brief history of metrology, measurement systems, metrology management systems and requirements and software.

#### **CLI 501 - Climatic Environmental Testing**

Hardware must be used in unfavorable climatic conditions of high/low temperature, high/low humidity, at altitude, underwater, in sand-and-dust conditions and other potentially damaging situations. Using special-purpose environmental test chambers, the survivability of hardware is assessed.

#### **CLI 510 - Temperature, Altitude, Humidity Testing**

Of the wide-ranging variety (perhaps 8) of harmful natural or climatic environments, test protocols most commonly focus on these three.

#### **CLI 511 – Monitoring and Supervision of Climatics Testing**

Understanding MIL-STD-810G: Why does 810 exist? Why needed? What preceded 810? Who to conduct tests? When and where to conduct tests? When should tests be witnessed? Test what hardware? Using what tests? Does 810F verify design? How best to specify (to suppliers) environmental and test requirements? Who should witness tests? Pretest documentation.

#### **CLI 512 - Thermal and Random Vibration Stressing for HALT, ESS, HASS and COTS**

Testing Of the tools commonly used for HALT, ESS and HASS of hardware (mainly electronic hardware), thermal-ramp stressing and random vibration stressing are most commonly employed.

#### **CLI 513 - Witnessing Climatics Tests**

Most ERI courses are intended to train those who manage and who conduct tests, as well as those who design rugged products. This course is aimed instead at those who witness tests, as for example QARs employed by the Defense Logistics Agency. What is happening inside that chamber? What questions should I be asking?

**CLI 520 – Thermal Fatigue Damage in Electronic Hardware**

Failure mechanisms and environmental stress. Wearout modes in electronics – the life cycle bathtub curve. Latent defects in Systems and environmental stress. Military Handbook 217 and thermal fatigue failure mechanisms. Lifetimes of electronic hardware – effects of thermal stress on defects. Test Plans - Development and determination of thermal stimulus levels. Concerns and long-term improvements in Accelerated Stress Testing. Prediction from Thermal Fatigue Analysis. The advantages and limitations of testing for thermal fatigue weaknesses.

**CLI 530 - Maintenance of Environmental Test Chambers**

Fundamentals of refrigeration, basic thermodynamics: heat, heat measurement, heat transfer, sensible heat, latent heat, subcooled liquid, superheated vapor, pressure, fluid flow, refrigerants, refrigeration, reading refrigeration schematics, electrical operation, humidity theory and testing in chambers. Troubleshooting (classroom and hands-on) Preventive maintenance (classroom and hands-on).

**CLI 540 - Fundamentals of Climatics Testing, ESS, HALT & HASS**

Lectures and classroom discussion; factory or test lab visit. Live HALT/HASS demonstration, followed by close examination and discussion of the test equipment. Review of Climatics (specifically thermal) Testing. Today's ESS/HALT/HASS requirements. Multi-axis random vibration. Equipment and instrumentation required, test set-up, conduct of test and data recording. Possible to add Humidity and Altitude (low pressure) testing, Solar Radiation, Acceleration, Explosive Atmosphere, Salt Fog, Rain, Sand and Dust, Fungus, Icing and Combined Environments, when desired.

**CLI 550 - Temperature Calibration for the Standards Laboratory**

The success of any calibration or metrology program, where calibrating temperature instrumentation is a major portion of the workload, depends on the calibration of instruments, on the documentation, on data management and retention, on quality systems, and on communications within the organization.

Whether the prospective participant is an experienced metrologist or new to the field, this 2-day course will provide him/her with useful knowledge about not only temperature calibration but for any effective and compliant calibration program.

**CON 501 -Contaminants and Moisture can disrupt your electronics**

This course examines the chemical root cause (surface contamination) of many poorly understood electronic failures. Conformal coatings are not being tested realistically.

**CON 502 -Printed Circuit and System Weaknesses caused by Contaminants and Moisture Contaminants**

In the presence of moisture can degrade materials used in supposedly "high-rel" electronics. The result? Greatly reduced reliability and increased warranty expense. We will study the basic chemistry involved, study various failure modes and study tailoring effective testing methods associated with various contamination and moisture combinations. Both infant mortality (warranty) periods AND long term service problems are examined.

**COOL Series taught by Joel Newberger****COOL 501 - Thermal Design of Electronic Enclosures Exposed to Diurnal Cycles**

Considers solar illumination, nocturnal radiation to sky vault temperature; limiting internal ambient temperature, limiting internal condensation, estimating solar infiltration; strategic placement of insulation to minimize solar infiltration; learn how external surface emissivity and absorptivity affect enclosure thermal profiles; enclosure selection; using solar shields.

**COOL 502 - Cost-Effective Cooling of Electronics**

Commences with review of basic convection, conduction, and radiation heat transfer; natural and forced air and liquid cooling; predicting internal enclosure ambient temperature levels; estimating required fan flow to limit chip junction temperature to reliable levels; calculating system flow

impedance  $\Delta P$ ; and thermal design of air/liquid naturally/forced cooled heat sinks; indoor/outdoor thermal enclosure design. This is but one of a wide variety of courses dealing with cooling.

### **COOL 503 - Design of Air/Liquid Cooled Heat Sinks and Cold Plates**

You will learn about thermal design procedures associated with extruded, cast, and brazed heat sinks and cold plates; air/liquid coolants, estimating flow impedance  $\Delta P$ , generating thermal performance maps that allows predicting temperature at any induced flow rate; evaluating thermal spreading gradients with non-uniform heat loading; naturally-cooled/forced heat sink thermal designs based on empirical data.

### **COOL 504 - Design of Naturally-Cooled, Non-vented Enclosures**

We will discuss natural convection heat transfer and buoyancy relationships; calculating enclosure internal ambient temperature profiles using spread sheet format; learn how to estimate enclosure internal flow impedance  $\Delta P$ ; estimating induced buoyancy flow; evaluate enclosure surface thermal impedance when used as an external ambient heat sink; power supply enclosure placement; estimating enclosure daytime outdoor operation when solar illuminated and then chilled by night sky vault temperature.

### **COOL 505 - Design of Naturally-Cooled Vented Enclosures**

We will discuss natural convection heat transfer and buoyancy relationships; calculating enclosure internal ambient temperature profiles using spread sheet format; vent opening placement, estimating enclosure flow impedance at induced air flow powered by dissipated heat; utilizing cooling effects of infiltration/exfiltration thru vertical surface perfs (openings); estimate how enclosure thermal profiles are effected by altitude.

### **COOL 506 - Design of Forced (Fan) Cooled Enclosures**

Here we discuss forced convection heat transfer and fluid dynamics; you will learn how to estimate overall system flow impedance (spread sheet format); how to use multiple air movers when connected in parallel or in series, fan(s) performance curves, predicting system operating point with single or multiple fans; how to calculate required system flow based on PCB spacing, required slot air velocity, and allowable chip junction temperature; power supply placement; acoustical considerations when selecting air movers; calculating flow impedance associated with enclosure perforations (openings), dust and EMI filters.

### **COOL 507 - Design of Liquid-Cooled Enclosures**

You will learn about forced convection heat transfer and fluid dynamics; selecting a liquid coolant, learn to estimate local and overall flow impedance; using pump(s) performance and system flow impedance curves, determine system flow (in gallons or liters per minute); learn how to determine required filter capacity; conditioning enclosure recirculated coolant in an air/liquid heat exchanger; design/selection of liquid heat sinks and cold plates.

### **COOL 508 - Liquid Cooling for Electronics**

Participants in this wide-application course will learn about heat transfer and fluid dynamics; coolant selection, determine required coolant flow; estimate overall system flow impedance  $\Delta P$ ; evaluate pump characteristics and selection; determine system operating point; conditioning recirculated enclosure air in an air/liquid heat exchanger, conditioning enclosure recirculated liquid in an air/liquid heat exchanger; design and selection of liquid heat sinks and cold plates; determine when to consider immersion cooling, spray cooling, and evaporative cooling.

### **COOL 509 - Conduction-Cooled Circuit Boards Utilizing Thermal "Planes and Bridges"**

Here the primary topic is conduction heat transfer; you will learn to estimate thermal impedance levels associated with filled/unfilled plated thru hole vias, transverse/lateral thermal spreading gradients in embedded copper layers; how to thermally bridge component case and via when conformal coating is utilized as "filler" material; how to predict interstitial conductance between ground plane and heat sink; you will learn to estimate component case/junction temperature levels; how and when to use solid core conduction cooled cards; how to select card guides for industrial and MIL environments.

**COOL 510 - Airborne Ram Air-Cooled Equipment Design**

Learn cold plate/heat sink design configured for ram air cooling; evaluate types of ram air inlets, estimate ram air flush/scoop inlet pressure recovery factors, calculate available ram side pressure head, and system flow impedance  $\Delta P$ ; develop thermal performance maps for hot/cold day operation from sea level to high altitude, learn significance of the low Reynolds Number flow regime at high altitude and its effect on thermal design; examine methods for equipment thermal conditioning at ground static and end of runway.

**COOL 511 - Airborne Environmental Control System (ECS) Cooled Equipment Design**

Here we consider cold plate/heat sink design configured for aircraft supplied refrigerated coolant (air/liquid); you will learn to design heat exchange equipment when supplied with limited coolant flow proportional to heat load ; calculate air/liquid heat transfer coefficients and flow impedance  $\Delta$  when operating in flow regimes at low Reynolds Number; you will learn to develop thermal performance maps; you will learn to identify flow impedance  $\Delta$  inflection points and their effect on induced flow and thermal performance; also evaluate compartment ambient heat infiltration.

**COOL 512 - Fans and/or Heat Sinks - Design and Selection**

Learn how to design natural/forced cooled air-heat sinks using spread sheet format; calculation procedures are given for brazed/cast/ extruded/epoxied/machined type of heat sinks; learn how to evaluate heat sink thermal performance when operating from sea level to high altitude, using empirical data; learn criteria for fan(s) placement...blow or pull air thru heat sink! air-mover selection; develop thermal performance maps and flow impedance curves over range of altitude operation.

**COOL 513 - Pump/Cold Plate "Marriage"- Design and Selection**

Here participants consider liquid-cooled cold plate design; learn how to estimate cold plate flow impedance; learn to develop thermal performance maps; learn when to use brazed or extruded cold plate designs; learn how to calculate piping and quick disconnect flow impedance  $\Delta P$  losses; learn about pump performance characteristics; learn how to determine system operating point at various liquid density levels; learn to identify when fluxless rather than salt brazing should be used.

**COOL 514 - POD Thermal Management**

We commence with a cursory review of thermodynamic relationships associated with airborne platforms; static temperature, stagnation temperature, boundary layer temperature, cold/hot day environments; learn how to evaluate the performance of flush/scoop ram air inlets, pressure recovery, and over board "dump" loss; duct work, heat exchanger, and plenum flow impedance  $\Delta P$  levels; maximizing useful volume when LRUs are liquid cooled; learn design features associated with various POD cooling systems....ram air cooling, vapor cycle, expanded ram air cycle, mold line surface.

**COOL 515 - Phase Change Material (PCM) Cooling**

When packaging constraints impose thermally difficult situations, designers utilize solid to liquid or liquid to vapor phase cooling; participants will learn how to incorporate PCM into a packaged enclosure; they will learn about using evaporation, boiling and/or condensing heat transfer as the packaged primary cooling mode; they will learn how to design conditioning equipment utilizing PCM; they will learn about heat pipe technology and how/when to use it cost effectively; they will develop thermal performance maps and estimate required PCM charge as related to duty cycle.

**COOL 516 - Ground Mobile Shelter Air Conditioning**

Perhaps you need to estimate mobile shelter total cooling/heating thermal loads; learn how to calculate shelter roof/wall "UA" thermal conductance; evaluate packaged air conditioning performance during extreme hot/cold day operation ;when to use hot gas by-pass valve for load control; you will learn to design shelter air distribution ducts; also, how to estimate duct, plenum, and overall system flow impedance  $\Delta P$ ; shelter ductwork/cabinet(s) integration; incorporate "fail soft" shelter thermal conditioning; integrating liquid-cooled equipment and packaged liquid coolers.

**COOL 517 - Humidity and Psychometrics - Protecting Equipment**

Here we commence with a review of thermodynamic and psychometric fundamentals; relative humidity, absolute humidity, wet/dry bulb temperature, dew point temperature; world wide humidity extremes, humidity variation with altitude; methods for limiting moisture infiltration into electronic equipment; how to minimize risk during exposure to accelerated life MIL-STD-810 humidity testing; learn how to avoid "rain" on equipment when conducting humidity tests.

#### **COOL 518 - Air and Conduction Cooled Power Supplies**

We will discuss mechanical/thermal design of air and conduction-cooled power supplies; protecting discrete power devices; thermally integrating electrolytics and magnetics; advantages of conduction cooled power supplies when integrated into airborne platforms, ground based totally enclosed cabinets, and plastic enclosures; methods for limiting power device(s) junction temperature levels to safe and reliable levels.

#### **COOL 519 - Cooling Shipboard Electronics**

We will learn how to cool shipboard electronics when packaged in totally enclosed and ventilated cabinets; We will learn how to calculate enclosure thermal profiles when naturally or forced air cooled; we will learn when/how to use shipboard water for cabinet thermal conditioning; learn to estimate cabinet flow impedance, when to use multiple air movers; estimating induced buoyancy flow when naturally cooled or during operating mode with fan failure; we will discuss how to limit enclosure acoustical signatures and to minimize risks during exposure to accelerated life MILSTD-810 humidity testing.

#### **COOL 520 - Cooling of Electronic Assemblies**

Introduction to electronics heat sources, temperature limits; standards and specifications, terminology: thermal resistance; convection, radiation, and conduction, circuit board cooling, forced air cooling of enclosures, naturally cooled non-vented enclosures, naturally cooled vented enclosures, natural/forced air cooled heat sinks, electronics cooling in vacuum aboard space vehicles, humidity considerations/Understanding psychometrics, fundamentals of flow/thermal network modeling, "Rules of thumb" for electronic cooling, Problem solving, laboratory visit.

#### **COR 501 - Avoiding Corrosion**

Many naturally-occurring materials, as well as certain man-made materials, are known to attack man-made structures ranging from highway bridges to electronic hardware, particularly when moisture is present. We discuss how to avoid these problems.

#### **COR 502 - Corrosion Engineering Principles And Applications**

The course is designed to provide an overview of corrosion engineering applied to the identification and evaluation of corrosion problems and the development of solutions to real-world corrosion problems.

#### **COTS 501 - Accelerated Life Testing of COTS/NDE**

Aimed at forcing weak elements to reveal themselves by failing, in order that they can be strengthened. The goal is hardware (mainly electronic) that will not fail in military service.

#### **COTS 510 - Shock and Vibration Isolation of COTS Equipment**

Use of metallic or elastomeric cushioning (passive isolation) to protect commercial equipment against the rigors of military and naval transport and service.

#### **DATA 501 - Applied Measurement Engineering**

Basic measurement concepts, transfer functions and linearity, frequency content or waveshape reproduction? non-self generating sensors, the Wheatstone Bridge, self generating sensors, noise documentation and control, information conversion, sampled measurements, data validation.

#### **DATA 510 – Fundamentals of Dynamic Instrumentation and Data Acquisition**

Proper measurement of changes in position, velocity, acceleration, force and pressure. Sensors, cabling and signal processing all can contribute errors. This course helps you avoid those errors.

**DATA 511 – Railroad Dynamic Instrumentation And Data Acquisition**

This course examines the collection and use of test measurements in the rail environment. Rail vehicles and infrastructure must survive a challenging combination of little to no maintenance over service lives spanning several decades. Furthermore, metal-to-metal impacts are common at the wheel/rail interface and elsewhere in the railcar. This course will detail the precautionary steps to ensure accurate measurements and post-test analyses.

**DATA 512 - Fundamentals of Automotive Dynamic Instrumentation**

Proper automotive measurements: position, velocity, acceleration, force and pressure. Sensors, cabling and signal processing all can contribute errors. This course helps you avoid those errors.

**DATA 513 - Dynamic Pressure Instrumentation and Data Acquisition**

Proper measurement of changes in position, velocity, acceleration, force and pressure. Sensors, cabling and signal processing all can contribute errors. This course helps you avoid those errors.

**DES 501 –Design for Vibration and Shock Testing of Telecommunications Equipments**

For designers of products intended for harsh usage and transportation environments or whose prototypes will undergo accelerated stress testing (AST, ESS, HALT, HASS, etc.)

**DES 510 - Designing Telecom Equipment to withstand Vibration and Shock**

Design practice changes by which previously designed commercial telecom equipments can be made capable of surviving severe military usage.

**DES 511 - Designing Reliable & Rugged Electronics**

Workshop aimed at shortening the time required for reliable electronics design, vibration testing and (when weaknesses are found) corrective action. This course applies to vibration of electronics system, rack, box or circuit card level. Methods can also be used in the design and testing of electronic components to meet vibration standards or desired capabilities.

**DES 512 - Ruggedizing of Military COTS/NDE (Commercial off the shelf, non-developmental hardware)**

Helps designers and users of weapons systems to "toughen up" commercial equipment (mainly electronics) to withstand the rigors of military service.

**DES 520 - Product Design for Vibration and Shock**

Some hardware is used in conditions where vibration and shock threaten to shorten product useful life. Examples include laptop computers, automobile engine computers, aircraft radar antennas. This course teaches practicing designers how to "ruggedize" their products to survive in the field.

**DES 521 - Product Design for Vibration and Shock Testing**

Some hardware is used in conditions where vibration and shock threaten to shorten product useful life. Environmental vibration and shock tests verify strength. This course teaches practicing designers how to "ruggedize" their products to pass tests.

**DEV 501 - Reliability Improvement through Step Stress**

Stepwise increases of stress (most commonly random vibration and temperature) are applied to developmental hardware. The goal is to force weak elements to reveal themselves by failing. Once revealed, they can be strengthened.

**DEV 510 - Accelerated Test through Step Stress**

Dare we warrant this hardware for five years? What experiments will reveal weaknesses? This course teaches about stepwise increases of stress (most commonly random vibration and temperature), applying them to developmental hardware.

**EMC 510 - Electromagnetic Compatibility**

- To present and explain the essential concepts of EMI (electromagnetic interference) phenomena and control.
- To explain the strengths and shortcomings of EMI control methods and components.

- To present a number of EMI prediction tools.
- To demonstrate in the classroom a number of EMI troubleshooting and measurement techniques.
- To provide a workshop forum, wherein students will directly apply learned concepts, analysis methods, and remedial tools to actual problems from their home organization.

**ESD 501 - Electrostatic Discharge**

Whenever and wherever electronic hardware (particularly microelectronics) units are handled (as for example during manufacture), electrical static charges build up. Improperly discharged, they can seriously damage electronic devices.

**ESS 501 - Optimizing Environmental Stress Screening (ESS)**

Analysis of vibration-caused failures during HALT, ESS and HASS leads to significant savings in retest time and in design improvement.

**ESS 510 - Reliability Concepts and Practices**

Covers the basics of reliability theory and implementation for the design, quality and manufacturing engineer or manager with specific focus on Accelerated Testing and ESS.

**FIXT 501 - Vibration and Shock Test Fixture Design**

Emphasis will be on sinusoidal and random vibration testing; shock testing, vibration and shock test equipment, test standards, and vibration and shock test fixture design.

**HALT 510 - Highly Accelerated Life Testing, Highly Accelerated Stress Screening and Environmental Stress Screening - Fundamentals And Practice**

For electronics designers and production personnel seeking to reveal incipient failures in hardware (primarily electronic), primarily through the use of random vibration.

**HALT 511 - Step Stress for HALT, ESS and HASS**

Stepwise increases of stress applied to developmental hardware, aimed at forcing weak elements to reveal themselves by failing, such that they can be strengthened. The goal is hardware that will not fail!

**HALT 512 - Thermal and Random Vibration Stressing for HALT/ESS/HASS COTS Testing.**

This course commences with a careful review of the long-used thermal test activities required by MIL-STD-810F. It then shifts to rapid temperature ramping for HALT/ESS/HASS COTS is a relatively new extension. Multiple RS or repetitive shock pneumatic hammers are supplanting expensive multi-axis electrodynamic shakers. Other climatic test methods (humidity, altitude, salt spray, shock, etc.) fill the remaining time.

**HALT 531 - Practical HALT & HASS**

One day seminar covering Highly Accelerated Life Test (HALT) and Highly Accelerated Stress Screening (HASS). The course covers many practical aspects of the process. The emphasis is on practical.

**HALT 532 - HALT Training Seminar**

A two day very comprehensive seminar covering Highly Accelerated Life Test (HALT) and Highly Accelerated Stress Screening (HASS). The course covers many practical aspects of the process.

**HALT 533 - HALT/HASS/HASA and Practical Design FMEA**

A three day seminar covering Failure Modes & Effects Analysis (FMEA), with the last two days on Highly Accelerated Life Test (HALT) and Highly Accelerated Stress Screening (HASS).

FMEA is a structured process that focuses on design areas that may lead to early failures and it covers safety issues as well. The process can be applied to designs that are still on paper where early design changes are least expensive. HALT/HASS is a real world hands on environmental stress process that precipitates undiscovered weaknesses in a new design where they can be eliminated via design changes early in the development process.

**ISO 501 – Isolating Shipboard Electronic Equipment**

Vibration and shock, introduction and fundamentals, equipment in naval environments, Military Standard 167, MIL-S-901D requirements for the Navy light, medium weight hammer and barge shock qualification tests, the Floating Shock Platform (FSP). Shock response spectra (SRS), COTS applications, damage from ship's vibration, missile launch and gun firing, underwater explosions, other enemy action. Selecting and using shock and vibration isolators and isolation systems, analysis methods and response calculations. Selecting electronic enclosures. Installations describing isolators and isolation systems (details). Discussion of participants' applications and projects. Design review by technical specialists.

**ISO 510 – Isolating COTS Equipment aboard military vehicles**

Vibration and shock, introduction and fundamentals, equipment in Navy and commercial shipboard MIL-S-901D environments, military standards including Military Standard 810 G and, tracked and other land vehicles also missiles, aircraft, helicopters. Understanding vibration and shock test conditions. Vibration and shock data, sine and random vibration tests, shock response spectra (SRS), fragility and protection of equipment, guidelines for selecting isolation, proven design features. Examples of applications. Predicting shock and vibration response, analysis methods and evaluation of equipment. Discussion of individual projects.

**ISO 520 – Shock and Vibration Isolation for Packaging Engineers**

In most "isolation" courses engineers learn how to attach delicate electronic and other hardware onto such vibrating vehicles as helicopters, ships and land vehicles via flexible elements often called "isolators." In this "isolation" course, the attachment is temporary, and it's to the inside of a shipping container, in which it will travel safely to God knows where, ignoring the en route bumps and jiggles, ready to be unwrapped and used.

**ISO 540 – Isolating Military and Industrial Equipment for Severe Applications**

Vibration and shock control, introduction and fundamentals, equipment in severe commercial, industrial and military environments, review of military and Federal standards including Military Standard 810 and ATA 300 Fixed, mobile and airborne use including off-road, manufacturing facilities and industrial use. FEMA requirements. Seismic protection. Vibration and shock test methods. Handling and transportation conditions. Protection methods, examples of design applications. Vibration and shock data. Input and response, sine and random vibration, shock response spectra (SRS), guidelines for selecting isolation, proven design features. Predicting shock and vibration responses, analysis and evaluation of equipment. Discussion of individual projects.

**MHM 501 - Machinery health monitoring (condition monitoring) of rotating machinery**

For plant maintenance personnel (engineers and technicians) striving for highest plant reliability.

**MIL-STD 810G - Testing Understanding, Planning and Performing Climatic and Dynamic Tests**

This 4-day class will provide an understanding of the purpose of each test, the equipment required to perform each test, and the methodology to correctly apply the specified test environments.

**MOD 501 - Fundamentals of Modal Testing**

Modal testing involves deliberate exciting (shaking or bumping) a structure (or a model of a structure) such as a bridge, an airplane, an automobile. During and immediately after that excitation, we monitor the motion at numerous response points on the structure. Aided by a computer, we seek to understand the many patterns (modes) in which the structure responds easily. Hopefully, modal testing precedes production and avoids problems. Or modal testing may explain an observed misoperation.

**MOD 502 – Introduction to Modal Testing**

"What is a mode?" and "Why do I need to either calculate or measure our modes?" Do your engineers think they know the answers to these questions? Misconceptions abound. Calculating

or measuring modes cost time and money; the course presents trade offs that assist leader decision on amount of modal testing required.

**NOISE 501 - Intense Noise (Acoustic) Test**

Air-coupled dynamic excitation (at liftoff) of rocket and spacecraft hardware is better simulated with "super loudspeakers" than with electrodynamic shakers.

**NOISE 510 = ACO 501 - Basic Acoustics**

Basic acoustics, vibration and noise, instrumentation, measurement procedures and standards, test spaces, acoustic materials, laboratory demonstrations, data reduction, data analysis, setting up a test program, documentation and reporting.

**NSV 501 - Nonstationary Dynamic Loads\* Data Analysis (\*Mechanical Shock, Vibration, And Acoustic Environments)**

This course presents modern techniques for the practical analysis of nonstationary vibration and acoustic data, as well as transient (shock) data.

**NSV 502 -Analysis And Applications Of Random Vibration And Acoustic Data** This course details the analysis procedures and the applications of analyzed data for the solution of random vibration and acoustic induced problems in structures and equipment.

**PAR 501 - Airborne Particle Measurements**

Airborne particles are a "no no" in several engineering situations. These include "clean rooms" where microelectronics units are fabricated, food processing plants, pharmacological plants, etc. The number of particles per cubic meter must be accurately counted.

**PKG 501 - Packaging**

A pragmatic design approach to minimize costs of supply chain logistics through wiser product and packaging design and better test methods.

**PRE 501 - Dynamic Pressure Measurements And Calibration**

There are many ways to get bad data. This short course details how to avoid these sources of error in static and especially dynamic (changing) pressure situations. Topics include sensor selection, location, calibration and signal processing.

**PRE 510 - Pressure Calibration for the Standards Laboratory**

The success of any calibration or metrology program, where calibrating pressure instrumentation is a major portion of the workload, depends on the calibration of instruments, on the documentation, on data management and retention, on quality systems, and on communications within the organization.

Whether the prospective participant is an experienced metrologist or new to the field, this 2-day course will provide him/her with useful knowledge about not only pressure calibration but for any effective and compliant calibration program.

**PRO 501 - Selecting Shipboard Shock and Vibration Electronic Enclosures**

Lectures, PowerPoint slides, video clips and animations during this two-day course provide proven details of enclosure and isolation designs for COTS equipment. Also included: We will consider four basic stress categories that are known to degrade electronic equipment over time.

**REL 502 - Elements of Systems Reliability**

This seminar presents an introductory level course of how to organize a cost-effective Reliability Program that includes such tasks as Life Cycle Cost Analysis, Prediction, FMEA, Fault Tree, Failure Review Board, Failure Reporting and Corrective Action System.

**SGAGES 501 - Strain Gages**

Change in physical dimension, at particular locations on structures, tells us what the structure is doing, how it is responding to static or dynamic loading. Gages must be properly selected and

PROPERLY attached. Gages, cabling and readout to errors. This course helps you to avoid these errors.

### **SHAK 501 - Preventive Maintenance of Electrodynamical Shaker Systems**

Especially where many different engineers and technicians operate an electrodynamic shaker system, with none of them trained in correct operation nor responsible for maintenance, shaker systems are doomed to fail, usually during the year's most important vibration test. This short course alerts operators how to avoid damage. It also alerts non-specialist general-purpose maintenance people (who may be available in the event of trouble symptoms or actual failure) what not to do. Further, operators and non-specialist general-purpose maintenance people learn how to communicate their situation to specialists in shaker repair.

### **SHIP 501 - Introduction to Shock & Vibration Testing of Shipboard Equipment**

This course commences with a little theory, then discusses dynamic measurements aboard ship and during tests before considering the conduct of MIL-S-167 (vibration) and MIL-STD-901 (shock) tests on components of Navy ships.

### **SHK 510 – Mechanical Shock Characterization and Synthesis**

This is a two-day short course for the practicing professional who wants control over the shock synthesis process. The first day will present the theory behind the characterization and synthesis software. The second day will cover the application software provided as part of the course.

### **SHT 501 – Servohydraulic Testing Technology**

Test methods and practices used with servo-hydraulic testing during land vehicle product development; includes test design, setup and operation.

### **SPEC 501 – Developing Random Vibration Tests from Field Data**

This course guides engineers who are given field vibration data (spacecraft, launch vehicles, aircraft, land vehicles, sea vehicles) and who are tasked to develop a random vibration test.

### **Stress 501 – Introduction to Stress Analysis**

This course leads mechanical designers of such structures as buildings, vehicles and machinery an understanding of structural requirements and how to insure that those requirements are met. For practicing stress analysts, it provides a review. For recent engineering graduates it provides understanding of "the real world".

### **STRN 501 – Strengthen your products through use of Vibration and Shock Testing, HALT, ESS and HASS**

Before production commences is the best time to identify hardware (including electronic hardware) weaknesses. Despite designer protests, prototype samples of hardware should be exposed to many cycles of rapid heating alternating with rapid cooling. Other samples should also be exposed to multi-axis random vibration. Finally, some samples should be exposed to those stresses combined. Some samples will fail. It is the task of failure analysis to identify the weakness(es) so those weaknesses can be corrected. Further screening shows great improvement in product ability to survive. Then production can begin. Production samples should be screened.

### **V&S 501 - Basic Vibration Measurements**

For those involved in data acquisition, metrology, calibration and in MHM/CM (machinery health monitoring/condition monitoring) of machinery.

### **V&S 502 – Witnessing Vibration and Shock Tests – Also Environmental Stress Screening (ESS)**

Purpose of environmental testing, particularly vibration and shock. Purpose of environmental stress screening (ESS). Types of vibration tests: resonance search/dwell, fatigue, specification

### **V&S 510 - Aerospace Vibration and Shock Testing, Measurement, Analysis and Calibration also HALT, ESS and HASS**

For test personnel and designers in military, aircraft, satellite and missile fields, launch vehicle manufacturers and suppliers.

**V&S 511 - Land Vehicle Vibration and Shock, Buzz, Squeak & Rattle and Noise, Vibration & Harshness Testing**

For test personnel and designers in automobile, motor truck, bus and railway fields, vehicle manufacturers and suppliers.

**V&S 512 -Vibration and Shock Test, Fixture, Design, Fabrication and Usage**

Design, fabrication and proper usage and storage of structures needed to attach DUTs (devices under test) to shaker tables or shock machine platforms.

**V&S 513 - Total Quality Management of Vibration & Shock Testing**

Reliability and Quality specialists require training in order to communicate with product designers and with test personnel.

**V&S 514 – Human Vibration and Shock Measurement, Analysis and Testing**

How does the human body respond to vibration and to shock? Only rarely are experiments conducted on living people. Nearly all experiments are conducted on dummies .... highly instrumented manikins that resemble humans. These are built in a range of sizes to - hopefully - match - both statically and dynamically - living humans. Manikin responses are recorded. Those responses often lead to changes in the design of automobiles, railroad cars, aircraft, etc. This course deals with those measurements and resulting analysis, also with testing techniques.

**V&S 515 -Monitoring and Supervision of Dynamics Testing**

Contractor dynamic environmental tests per standards such as MIL-STD-810F should be monitored and supervised.

**V&S 516 – Shipboard Vibration and Shock Testing, Measurement, Analysis and Calibration also HALT, ESS and HASS**

For test personnel and designers of shipboard equipment.

**V&S 517 – Aerospace, Land and Sea Vehicle Vibration and Shock Testing, Measurement, Analysis and Calibration also HALT, ESS and HASS**

For test personnel and designers of equipment to be installed aboard air, land and sea vehicles.

**V&S 518 – Space Vehicle Vibration and Shock Testing, Measurement, Analysis and Calibration also HALT, ESS and HASS**

For test personnel and designers of equipment to be installed aboard space vehicles and there to survive launch and maneuvering.

**V&S 519 – Vibration and Shock Testing of Packages and Shipping Containers**

For test personnel and others involved with the safe transport of electronic and other hardware. Can include the selection of spring or elastomeric isolators for protecting delicate hardware.

**V&S 520 – Fundamentals of Vibration and Shock Testing of Military COTS/NDE (Commercial Off The Shelf, Non-Developmental Equipment) hardware**

Aimed at environmental test laboratory personnel faced with testing of non-military equipment that has been ruggedized for shipment and use in military environments. MIL-STD-810F is often followed.

**V&S 521 - Seismic Vibration and Shock Testing, Measurement, Analysis and Calibration**

How will equipment survive earthquakes? First we will examine some failures that occurred during real earthquakes. That history allows us to guess what will happen during future earthquakes. And to examine various experimental earthquakes, using mechanical, electrohydraulic (servohydraulic) and electrodynamic shaker systems. Single-frequency-at-a-time sinusoidal vibration testing assists in identifying resonances. Broad spectrum random vibration better simulates real-world vibration. Certain shock tests resemble seismic events.

**V&S 522 – HALT, ESS and HASS with emphasis on Random Vibration**

For test personnel and designers of equipment that must be made reliable.

**V&S 530 - Vibration and Shock Testing from Recorded Data**

Whereas most random vibration testing is still controlled in the frequency domain, using prescribed spectra, newer tests are controlled in the time domain, using recordings of actual service experience.

**V&S 540 - Calibration of Accelerometer Systems**

Aimed at those who calibrate accelerometers and force sensors.

**V&S 570 – Simultaneous Multiaxis Vibration and Shock Testing, Measurement, Analysis and Calibration also HALT, ESS and HASS**

At long last, Military Standard 810's "G" revision was released late in 2008. Among its noteworthy improvements is a new Test Method 527, calling for the greater realism multiexciter testing. Multiexciter testing with electrohydraulic (EH) or servoelexciters has long been practiced. However, multiexciter testing with electrodynamic (ED) shakers, while well established among Japanese automakers, is new to most of the world. A considerable advantage over multiaxis pneumatic vibration for HALT and HASS is the tighter spectral control of multiple ED shakers.