Professional Development Short Course On:

Vibration & Shock Measurement and Testing

Instructor:
Wayne Tustin
April 1-3, 2009
College Park, Maryland

April 14-16, 2009
Fullerton, California

May 11-13, 2009
Dayton, Ohio

$2595 (8:00am - 4:00pm)
“Also Available As A Distance Learning Course”
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“Register 3 or More & Receive $100 off Each Off The Course Tuition.”

Vibration and Shock Measurement & Testing
for Land, Sea, Air, Space Vehicles & Electronics Manufacture

Instructor
Wayne Tustin is President of Equipment Reliability Institute (ERI), a specialized engineering school and consultancy. His BSEE degree is from the University of Washington, Seattle. He is a licensed Professional Engineer - Quality in the State of California. Wayne’s first encounter with vibration was at Boeing/Seattle, performing what later came to be called modal tests, on the XB-52 prototype of that highly reliable platform. Subsequently he headed field service and technical training for a manufacturer of electrodynamic shakers, before establishing another specialized school on which he left his name. Wayne has written several books and hundreds of articles dealing with practical aspects of vibration and shock measurement and testing.

What You Will Learn
- How to plan, conduct and evaluate vibration and shock tests and screens.
- How to attack vibration and noise problems.
- How to make vibration isolation, damping and absorbers work for vibration and noise control.
- How noise is generated and radiated, and how it can be reduced.

From this course you will gain the ability to understand and communicate meaningfully with test personnel, perform basic engineering calculations, and evaluate tradeoffs between test equipment and procedures.

Summary
This three-day course is primarily designed for test personnel who conduct, supervise or "contract out" vibration and shock tests. It also benefits design, quality and reliability specialists who interface with vibration and shock test activities.

Each student receives the instructor's brand new, minimal-mathematics, minimal-theory hardbound text Random Vibration & Shock Testing, Measurement, Analysis & Calibration. This 444 page, 4-color book also includes a CD-ROM with video clips and animations.

Course Outline
1. Minimal math review of basics of vibration, commencing with uniaxial and torsional SDoF systems. Resonance. Vibration control.
2. Instrumentation. How to select and correctly use displacement, velocity and especially acceleration and force sensors and microphones. Minimizing mechanical and electrical errors. Sensor and system dynamic calibration.
3. Extension of SDoF to understand multi-resonant continuous systems encountered in land, sea, air and space vehicle structures and cargo, as well as in electronic products.
4. Types of shakers. Tradeoffs between mechanical, electrohydraulic (servohydraulic), electrodynamic (electromagnetic) and piezoelectric shakers and systems. Limitations. Diagnostics.
5. Sinusoidal one-frequency-at-a-time vibration testing. Interpreting sine test standards. Conducting tests.
7. Simultaneous multi-axis testing gradually replacing practice of reorienting device under test (DUT) on single-axis shakers.
8. Environmental stress screening (ESS) of electronics production. Extensions to highly accelerated stress screening (HASS) and to highly accelerated life testing (HALT).
9. Assisting designers to improve their designs by (a) substituting materials of greater damping or (b) adding damping or (c) avoiding “stacking” of resonances.
11. Intense noise (acoustic) testing of launch vehicles and spacecraft.
13. Shock response spectrum (SRS) for understanding effects of shock on hardware. Use of SRS in evaluating shock test methods, in specifying and in conducting shock tests.
14. Attaching DUT via vibration and shock test fixtures. Large DUTs may require head expanders and/or slip plates.
15. Modal testing. Assisting designers.
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We commence with the simple single-resonance SDoF or Single Degree of Freedom system and use it to learn about accelerometer construction, selection, proper usage and calibration. Our aim throughout this course is to emphasize practice of measurement, analysis, calibration and testing.
Figure 1  Piezoelectric Accelerometers

courtesy Endevco
Figure 2  Compression Piezoelectric Accelerometer
Figure 3  Back-to-Back Calibration

courtesy The Modal Shop
Then we examine simple beams and plates, more realistic in that each has several resonances.
Figure 4  Pair of Cantilever Beams in First Three Modes
Video Clip 1  Second Mode, with Strobe
Figure 5  Natural Modes Of A Cable
We spend several hours evaluating electrohydraulic (servohydraulic) shakers and their low-frequency long-stroke applications. Also electrodynamic shakers, whose operating principle resembles that of a loudspeaker, their power amplifiers and their digital controls.
Figure 6
Electrohydraulic (Servohydraulic) Shaker

Drive Signal Input

LVDT position sensor

LVDT position sensor

Vibration Table
Figure 7
Shaker/Wheel Interface
Figure 8 Cutaway Views of Electrodynanmic Shaker

courtesy MB Dynamics
Figure 9  Armature-guiding flexure

Courtesy Dynamic Solutions
Figure 10  System Block Diagram
Figure 11  Power Amplifier

(courtesy MB Dynamics)
Figure 12  Power Amplifier Module
Figure 13  Digital Sine Test Controls

(Courtesy Data Physics)
Finally, we are ready to commence our study of random (unpredictable in detail) vibration in rocketry, automotive and other applications. This includes understanding of PSD (Power Spectral Density) and its strange $g^2/\text{Hz}$ units.
Figure 14  “Random” means Unpredictable
Figure 15
Early Rocket Liftoff
Figure 16 Terrain Inputs are Random
Figure 17  Compact Data Acquisition
Not illustrated here: Day 3’s discussion of multi-axis vibration for HALT, ESS and HASS, principally aimed at electronics production, generally using multi-axis pneumatic “bangers” or RS repetitive shocks.

Nor the design, fabrication and use of fixtures for attaching test hardware to shakers.

Nor mechanical shock measurement, analysis and testing. Or modal testing.