Fixture Design for Vibration and Shock Testing

Course No. 157-3

APPLICATIONS A fixture designer must be able to design a test fixture that will transmit the intended input forces directly to the Device Under Test. To accomplish this, a designer must have specific skills as well as an understanding of vibration and shock, structures, dynamic theory, materials, fabrication and welding.

FOR WHOM INTENDED This seminar is intended for dynamics test and evaluation personnel who need to understand practical approaches to the design and fabrication of test fixtures used in vibration and shock testing. Tooling Engineers responsible for fixture design need this training. QA and Reliability specialists will find the course useful. Writers of specifications for environmental tests will benefit from understanding practical limitations. Designers seeking vibration and shock solutions will also benefit.

BRIEF COURSE DESCRIPTION The course begins with an introduction to vibration and then covers basic dynamics theory including relationships between displacement, velocity and acceleration. Dunkerley's and Rayleigh's methods are introduced, with examples. Damping, transmissibility ratio and resonance stacking are addressed. The course covers basic structural theory: tension, compression, stress, strain, torsion and moments of inertia. Examples show the torsional shape factors of different structures. The instructor addresses frequency and stiffness of beams, plates and gussets, providing useful graphs, formulas and examples.

Bolted connections are covered next. Useful data on structures, bolted connections etc., is included in the course workbook which will be an invaluable reference tool back at the workbench. Material selection is then covered, with information on overall and design-limiting material properties. Tools are provided for comparing different materials.

The course then moves into Fixture Design, outlining a variety of strategies for attaching test items to fixtures, from adaptor plates to massive custom-designed cast and welded fixtures. Instrumentation and sinusoidal vibration testing are introduced, as they apply to the fixture design and evaluation process. Practical simplified designs and fabrication techniques are discussed and class projects are undertaken to design some typical fixtures.

DIPLOMA PROGRAMS This course is an optional course for TTi's Specialist Diploma programs. It is most applicable to the Dynamic Test Specialist (DTS) diploma program.

RELATED COURSES The design portion of this course is available separately as TTi's Course 310, Mechanical Design for Product Reliability, which goes into greater detail on design issues such as modal analysis, fatigue, accelerated testing and electronics chassis design. Course 157 combines the complete contents of course 310 with full coverage of fixture design.

PREREQUISITES: Prior participation in TTi's *Fundamentals of Vibration* or the equivalent would be helpful. Participants will need first-year college mathematics (or equivalent experience) and some facility with fundamental engineering computations. Familiarity with electrical and mechanical measurements will be helpful, as will an understanding of and familiarity with tooling and manufacturing.

TEXT Each student will receive 180 days access to the on-line electronic course workbook. Renewals and printed textbooks are available for an additional fee.

COURSE HOURS, CERTIFICATE AND CEUs This course is only available as an on-site course. Class hours/ days for on-site courses can vary from 14–35 hours over 2–5 days as requested by our clients. Upon successful course completion, each participant receives a certificate of completion and one Continuing Education Unit (CEU) for every ten class hours.

OnDemand Course 157 is available as an OnDemand Complete Internet course.

Course Outline

Introduction to Vibration
Dynamic Force and Motion: Laws of Motion, Weight vs. Mass
- Gravity • Density • Force, Mass and Acceleration
- Degrees of Freedom • Displacement • Velocity • Acceleration
- Natural Frequency • Complex (MDoF) Systems
- Dunkerley's and Rayleigh's Methods
- Transmissibility • Isolation • Damping • Examples

Review of Structural Design Fundamentals
- Material Properties • Tension and Compression
- Stress and Strain • Shear • Torque • Moments of inertia
- Torsional Stiffness • Torsional Shape Factors
- Bending Stiffness • Instability of beams and flanges

Frequency and stiffness: Beams, Plates, Gussets
- Natural frequency and stiffness graphs for various structures
- Beam Formulas • Plate frequency parameters, examples
- Column and Axial Resonance • Stresses in a Loaded Beam

Bolted Connections • Preload • Data on Bolts
- Design of Bolted Joints • Material thickness, stiffness

Material Selection in Engineering Design
- Overall & Design-Limiting Material Properties
- Application-Specific Material Properties
- Example: Optimization of Shaker Table

Design Suggestions: Overcoming Problems • Design Guidelines
- Structural rules of thumb • Stresses in Printed Circuit Boards

Introduction to Fixture Design: Purpose of the Fixture
- Fixture Performance • Considerations in Fixture Design

Vibration Test Fixtures—General Remarks
- Difficulty in achieving identical motion at all attach points
- Required information about test item, test program and shaker
- Bolting to the shaker table • Example of successful redesign
- Weight: Fixture vs. DUT • Fixtures for combined environments

Interface Items: Introduction • Table expanders
- Horizontal oil-film slip tables • Connecting slip tables to shakers
- Hydrostatic bearings • Misuse of horizontal accessory tables
- Avoid using bolts in shear • A note of warning on wide plates

Measurement of Sinusoidal Vibration/Accelerometer Systems
- Accelerometers • Amplifiers • Frequency response
- Effect of Mounting on frequency response • Cable routing
- Cross-axis sensitivity • Readout and recording devices
- Oscilloscopes and oscillographs • Decibel scaling
- Use of Tracking filter in Fixture evaluation • MEMS devices

Basic Fixture Types: Introduction • Adapter plates • Cube fixtures
- Hemispheres • Conical fixtures • Enclosed box fixtures
- Drum fixtures • L-type fixtures • T-type fixtures
- Open box fixtures

Fixture Fabrication Methods: Materials for fixtures
- Machining fixtures from solid stock • Bolted fixtures
- Cast fixtures • Welded fixtures • Bonded fixtures
- Laminated fixtures • Epoxy formed fixtures • Potted fixtures
- Foamed plastics for damping • Inserts

Analysis of an L-Fixture
Class Project: Design of a Cubical test fixture
Summary • Final Review
Award of Certificates for successful completion

Technology Training, Inc.
(a tti group company)
Toll-free tel: 866-884-4338 (866-TTi-4edu)
International Tel. 805-845-5050
E-mail: Training@ttiedu.com
www.ttiedu.com