

# 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.

**CERTIFICATE PROGRAMS** This course may be used as an elective for any TTI [Specialist Certificate 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 157-5](#) 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.

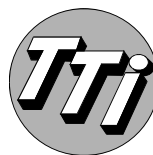
**TEXT** Each participant will receive a [course workbook](#), including most of the viewgraphs used during the classroom presentation.

**COURSE HOURS, CERTIFICATE AND CEUs** Open courses meet seven hours per day. Upcoming presentation dates can be found on our current [open course schedule](#). 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.

For [schedules](#), [general information](#) and [registration forms](#), see TTI's web site.

### 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



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