

LR TECHNOLOGIES

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Vibration Basics and Shaker Selection

Determining Shaker Sizing

Proper Shaker selection requires application of Newton's Second Law of Motion:

$$\text{Force} = \text{Mass} \times \text{Acceleration} \quad (F=MA)$$

- ◆ Vibration systems have output forces ratings defined in terms of:

Sine force: lbs (kN) peak

Random force: lbs (kN) rms

Shock force: lbs (kN) peak

Applying Newton's Law

In Shaker Selection

Suitability of a Specific Test System can be evaluated in terms of the following:

Force Requirement (lbf)

- ◆ $UUT + Fixture + Armature \times G = F \times 1.30 = \text{Desired Force Shaker System}$

Maximum Displacement

- ◆ Determined by test environment

Maximum Velocity

- ◆ Determined by test environment

$$F = ma$$

Determining Moving MASS

- ◆ The mass value (M) in the initial formula of $F = MA$ **must include all moving masses** attached to the shaker armature surface including the armature mass itself: shaker armature + head expander or slip plate with its driver bar + test specimen + specimen interface fixture, including bolts and bearing stiction if the system is driving a horizontal plate using hydrostatic bearings.

Determining and Evaluating Mass

Test Articles, Slip Tables, Head Expanders and Fixtures

- ◆ Size, Mass and Frequency Response
- ◆ Overturning Moment/Guidance Issues
 $(UUT + \text{Fixture}) \times CG \times G \times Q = I_{bin}$
- ◆ Slide Plate: $L \times W \times PSI (14) \times \text{effective area} = I_{bin}$
- ◆ Desired Resonance:
 $\text{Frequency} \times (L \times W) / 209000 = \text{Thickness}$

Specimen Specifics

In addition to your test specification, the following test article data is required to determine the appropriate system for your test requirements:

- ◆ Specimen Description
- ◆ Specimen Test Mass
- ◆ Specimen Dimensions
- ◆ Specimen Center of Gravity (CG)
- ◆ Specimen Mounting Considerations

Fixture Specifics

Test fixtures effect mass and resonance and must be considered carefully. The following concerns should be addressed in selecting a shaker system:

- ◆ Do your fixtures exist or will they require design and fabrication?
- ◆ What are or will be the approximate dimensions (estimate if necessary) of the fixturing?
- ◆ What is or will be the approximate mass (estimate if necessary) of the fixturing?
- ◆ Are there any mounting issues (bolt pattern, size)?
- ◆ Will a head expander be required?

F=ma

Test Specifications

- ◆ The maximum Acceleration for the $F = MA$ estimate is derived from the test specification:
 - for Sine vibration (G-peak)
 - for Random vibration (G-rms)
 - for Classical Shock pulses (G-peak)
- ◆ The operator must be cognizant of the maximum displacement and velocity of any given test parameter to insure they don't exceed the systems capabilities

Evaluating the Test Specifications

- ◆ Waveform:
 - Sine
 - Random
 - Classical Waveform Shock
 - SRS Shock
 - Mixed Mode (Sine on Random and Random on Random)
- ◆ Time Replication
- ◆ Test Magnitude
- ◆ Test Frequency Range
- ◆ Test Duration
- ◆ Three Axis Testing Required ?

Understanding Random Vibration

Random vibration stated force ratings are determined with guidance of ISO 5344. ISO 5344 specifies use of a flat 20 Hz to 2000 Hz spectrum with a test load of three to four times the armature mass. This is done to achieve continuity of ratings between different manufacturers. By use of the non-resonant three to four time armature mass load the resonant frequency of the shaker armature under test typically will fall below 2000 Hz. This enables the system to gain free energy at the higher frequencies.

Real World Random Vibration

Typical “real life” Random tests don’t always have test loads of three to four times the armature weight and test input profiles are gaussian in nature rather than flat. Narrow band Random profiles that don’t excite the armature resonance and have test fixtures that are highly damped may require system de-rating of up to 30%.

Effects of Resonance

- ◆ **Every mechanical structure has a resonant frequency**, which may result in a significant dynamic force absorber at certain frequencies. This phenomena must be taken into account during the estimating process. The force rating defined by the manufacture is rated at the armature surface. If the test system has associated fixtures, head expanders, slip tables, etc. that act as force absorbers and have been defined as a control accelerometer locations, then the shaker may be over driven. **It is always advisable to have monitor accelerometer attached to the armature surface** to determine the “true force” that is being achieved.

$$F = ma$$

Calculating Required Force

- ◆ Double Click on our Microsoft Excel® Shaker Selection Calculator (next slide) for determining the minimum system force rating requirements needed for your application
- ◆ Fill in all applicable RED field values
- ◆ It is always recommended that you verify your calculations with a sales engineer prior to purchasing a system

Note: Input applicable values in fields shaded **RED**

$$\underline{F = MA}$$

Mass (M)

Acceleration (A)

Vertical Testing:

Test Specimen Mass: 0.0
 Specimen Interface Fixture Mass: 0.0

Test Levels:

Random (Grms): 0.0
 Sine (Gpk): 0.0

Please Double Click on "Paperclip" to the right to open Spreadsheet:



Note: You will need Excel to Open this Spreadsheet.

Horizontal Testing:

Test Specimen Mass: 0.0
 Specimen Interface Fixture Mass: 0.0
 Armature Mass: 0.0
 Drive Bar Mass: 0.0
 Horizontal Slip Table Mass: 0.0
 Bearing Line Table Effective Moving Mass: 0.0
 Associated Mounting Hardware (Estimate): 0.0
 Total Moving Mass: 0.0

Minimum lbf. Rating Required (F):

- 0 lbf. Sine
- 0 lbf. Random
- 0 lbf. Shock

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