SINUSOIDAL VIBRATION

Practice:

Subject assemblies and the full-up flight system to swept sinusoidal vibration.

Benefit:

Certain failures are not normally exposed by random vibration. Sinusoidal vibration permits greater displacement excitation of the test item in the lower frequencies.

Programs Which Certified Usage:

Mariner Series, Viking, Voyager, Galileo

Center to Contact for Information:

Jet Propulsion Laboratory (JPL)

Implementation Method:

Apply sinusoidal vibration to the test item by sweeping over a frequency range beginning at $\approx$ 10 Hz ($\pm$ one octave) up to $\approx$ 100 Hz ($\pm$ one octave). Sweep the frequency range at a logarithmic rate (i.e. $\Delta f/f$ is constant). Sinusoidal vibration is performed with the same fixturing and concurrent with random vibration.

Technical Rationale:

Sinusoidal vibration is employed to simulate the effects of significant flight environment launch transients. These transients typically produce the dominant loading on primary and secondary structure and many of the larger subsystems and assemblies. Sinusoidal vibration is the only widespread current method of adequately exciting the lower frequency dynamic modes-- particularly those below $\approx$ 40 Hz. Sweeping at a log rate between 1 octave/minute and 6 octaves/minute should avoid application of excessive fatigue cycles. The higher rate is near the upper limit which most control systems can accommodate without experiencing some instability. The use of logarithmic sweep rates has the advantage in that a nearly equal time is spent at resonance for a given Q, independent of frequency.

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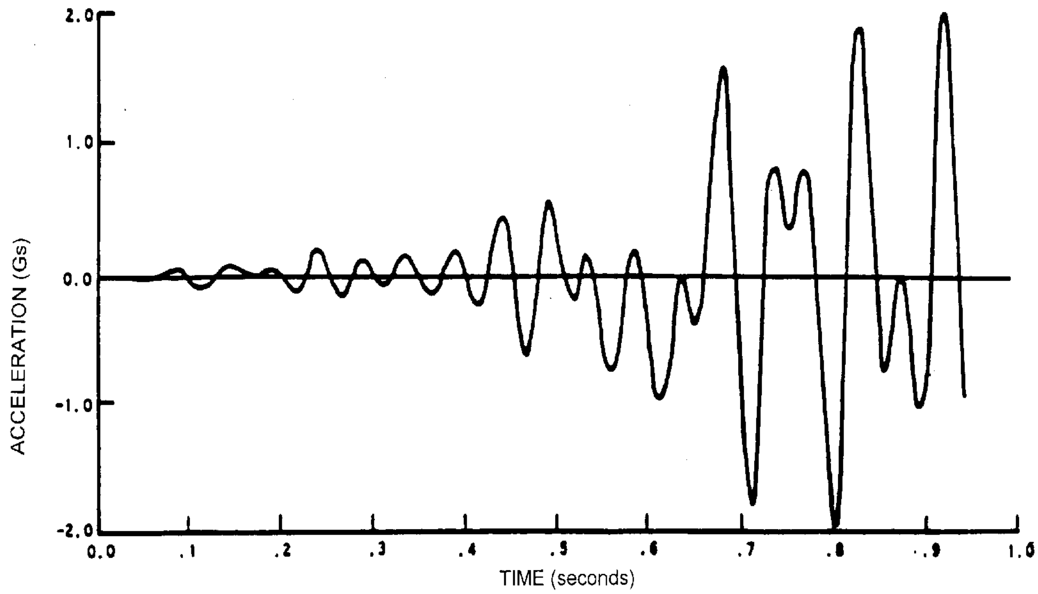
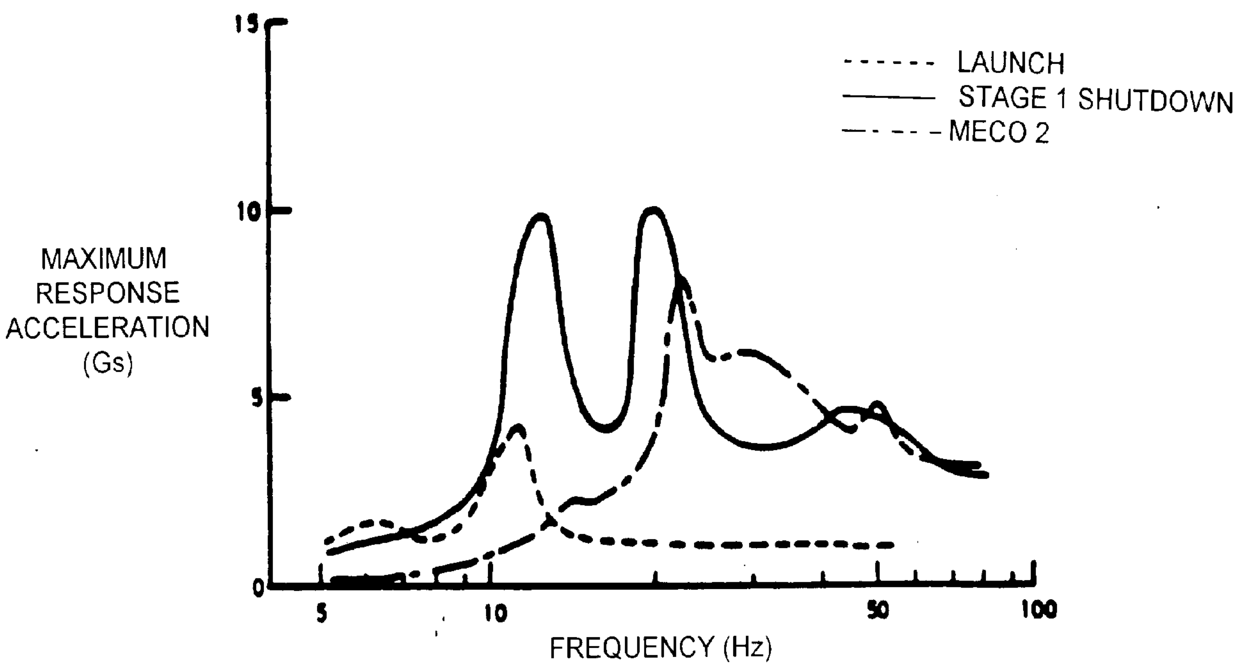
Sinusoidal vibration levels can be derived as in the following example:

Step 1. Create analytically derived transient waveforms from various flight events:



Step 2. Compute the shock spectra for each of the waveforms in Step 1:



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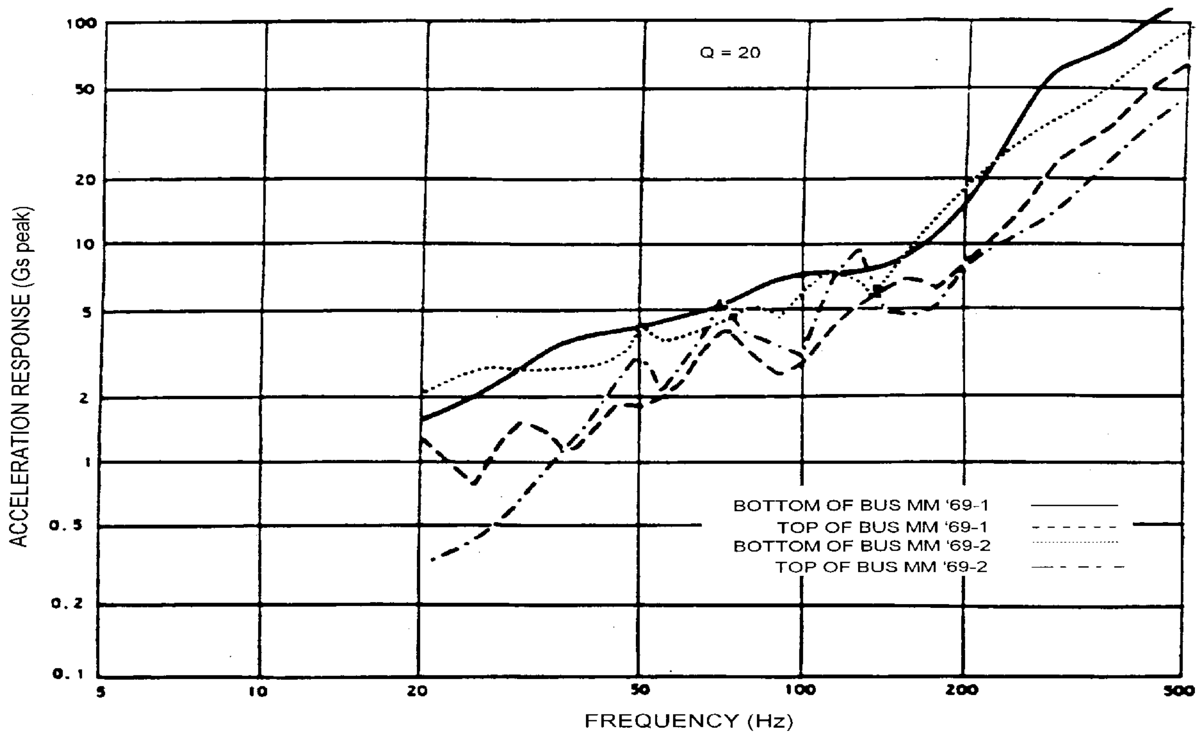
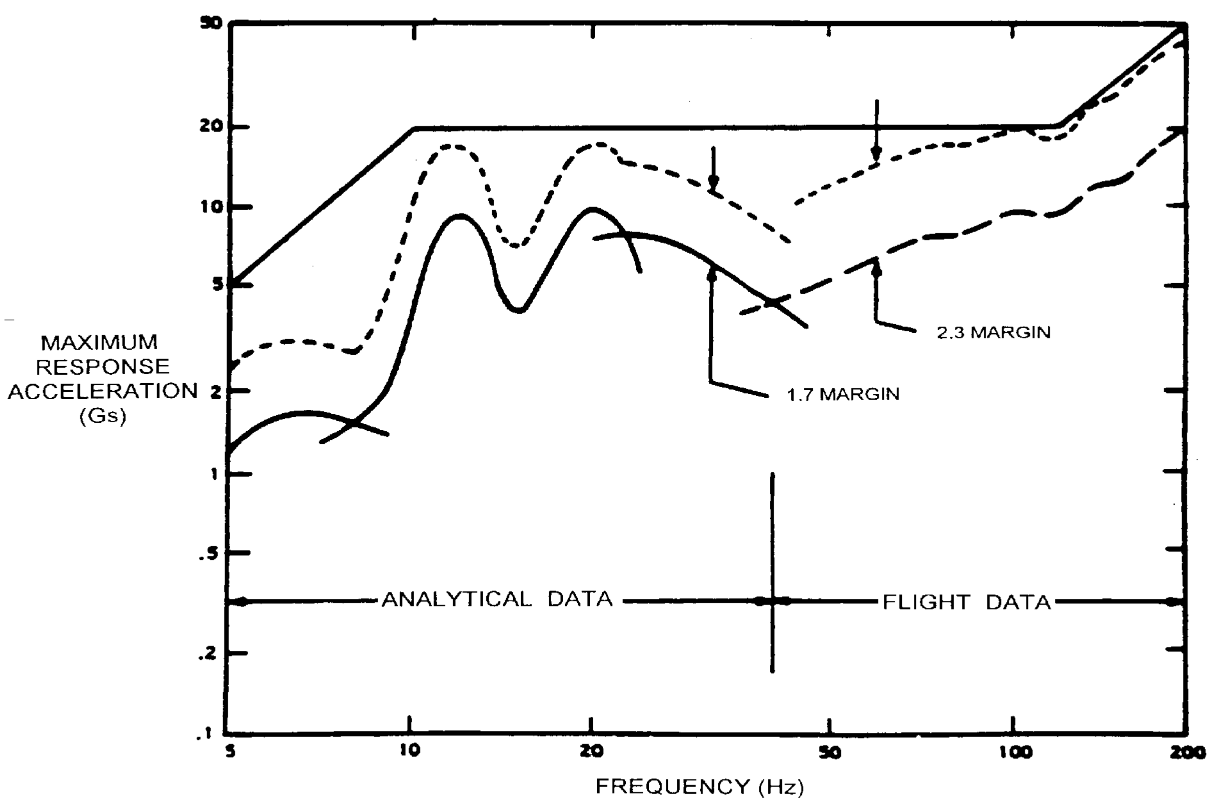
Step 3.	Take data from previous flight measurements:



Step 4.	Combine results from steps 2, and 3 and envelope:



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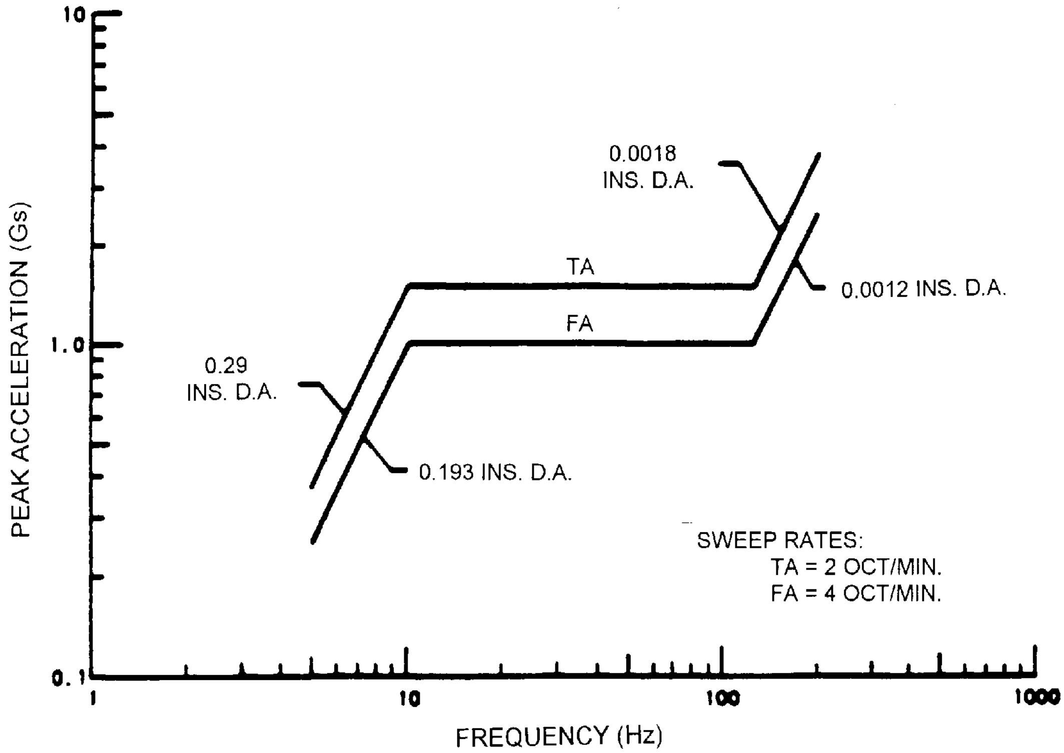
Step 5. Convert to a sine amplitude equivalent vs. frequency by dividing Shock Response Spectrum envelope in Step 4 by Q:



Alternatives to the use of swept sine vibration testing are currently under development which address several of the objections to this method. In particular, the problem of excessive resonance build-up in a sinusoidal vibration sweep relative to the flight transient environment may be alleviated by any of the following tests:

- Narrow band swept random.
- Discrete frequency sinusoidal pulses applied at regular frequency intervals.
- Complex waveform pulses representative of a composite of the various launch transient events.

Impact of Non-Practice:

Probability of failure is increased in flight due to low frequency transient environment. Some workmanship defects in large structures and full-up systems may go undetected.