Experior Laboratories, Inc
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# Experior Laboratories Raises the Bar
for
# Vibration and Shock Testing

Check out these demanding test levels that Experior Labs can now perform routinely using its high performance Unholtz-Dickie T2000 Shakers & mechanical pyroshock simulation system. The specific shaker examples below are max test levels with a **payload weight of 25 lbs added to the armature**.

| Test Type | Max Test Level |
|---|---|
| **Random Vibration** (20 Hz - 2,000 Hz) | 170 G rms |
| **Sine Sweep Vibration** (up to 2,000 Hz) | 185 G pk |
| **Classical Shock Pulse** (Halfsine or Sawtooth) | 500 G pk |
| **SRS Shaker Shock** (100 Hz – 10 KHz) | 3,500 G (SRS) |
| **SRS Pyroshock Simulation** (100 Hz – 10 KHz) | 30,000 G (SRS)* |

The key to achieving these extreme g-levels is the Model T2000 Shaker and its solid metal, inductively coupled armature. This unique **Induct-A-Ring armature** weighs only 110 lbs and can generate up to 25,000 lbs pk sine / 23,000 lbs rms random and 67,000 lbs pk shock force.

The following data screens illustrate a variety of actual tests conducted recently at Experior Labs in Oxnard, CA.

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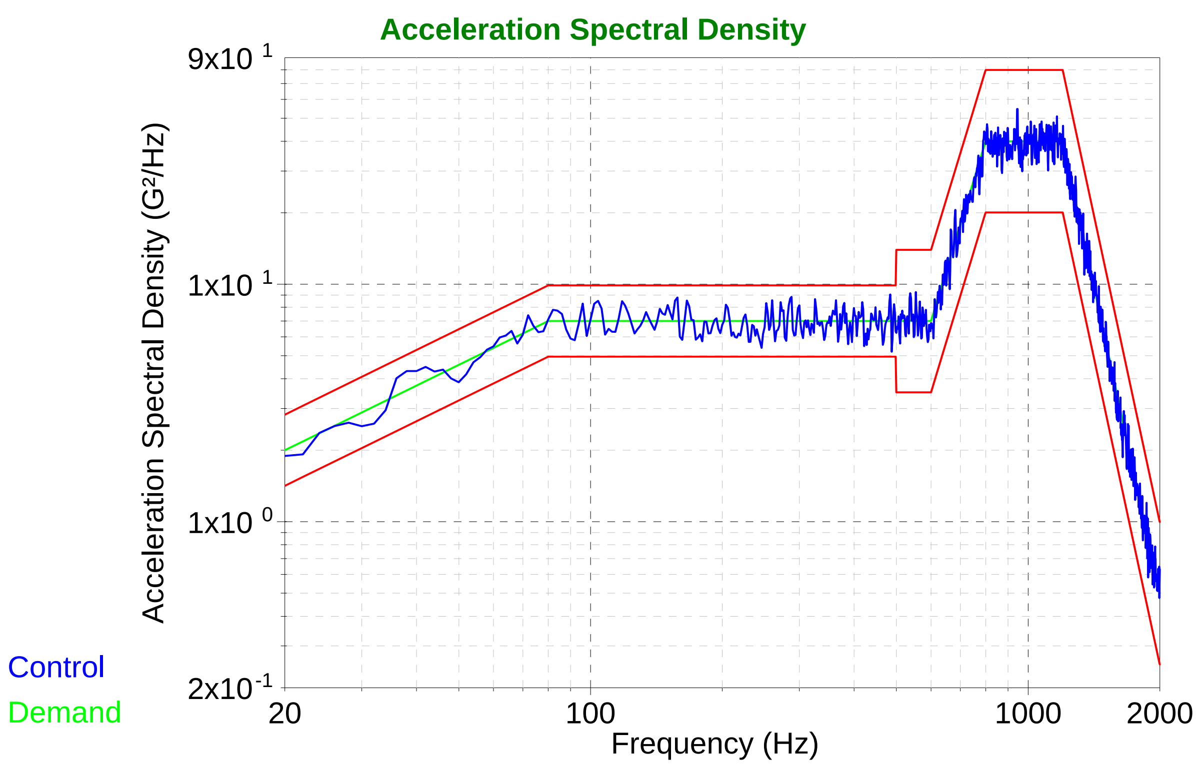


**Fig 1: Random PSD @ 173.4 G rms with 40.0 $g^2$/Hz in mid-band** (20 lb load)

The random vibration associated with a rocket launch is a brutal dynamic environment that often calls for highly shaped PSD profiles as seen in Figure 1. The shaped PSD profile shown here has a major concentration of g2/Hz energy in a part of the test spectrum where the electrodynamic shaker armature has a significant percentage of "resistive" impedance, which means that output current and voltage from the Power Amplifier in this resistive band must be "in-phase" – this in turn produces high heat loads for the shaker armature cooling system. A conservative shaker cooling system is essential.

Notice that the Fig. 1 PSD profile has reduced $g^2$/Hz demand in the 1,200 – 2,000 Hz band where most electrodynamic shakers exhibit armature resonance. This means that the full "resonant boost" from the shaker armature that you can count on with a flat PSD profile is not present when running a shaped PSD profile like Fig. 1. So to make up for this missing boost and to achieve the full 173.4 G rms level as shown, you must use a large KVA Power Amplifier to provide extra shaker drive.

No Band Splitting Needed: Most test labs have to run the Fig. 1 PSD profile as a series of split frequency band tests, due to the limitations of their Shaker and/or Power Amplifier equipment. **Experior Laboratories runs Fig. 1 as one continuous profile without any band splitting**, using the T2000 Shaker driven by a Power Amplifier rated at 240 KVA output.

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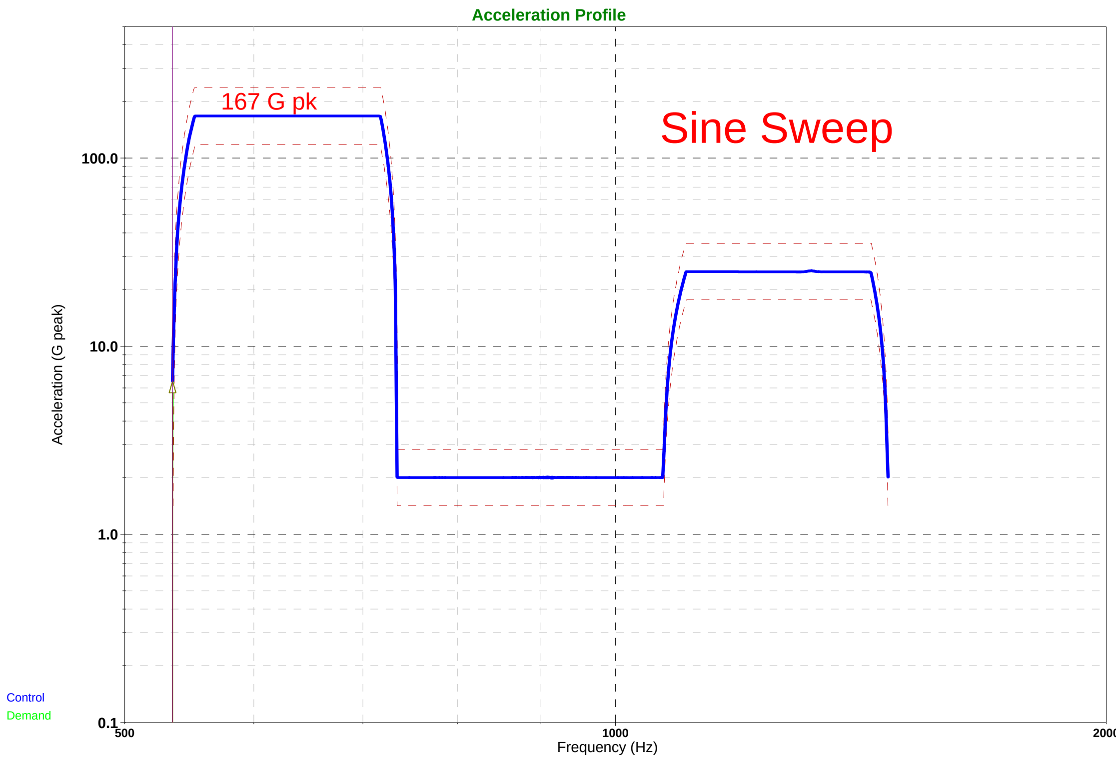


**Fig. 2: Sine Sweep Vibration @ 167 g pk** (550 Hz – 720 Hz segment)

The test shown in Fig. 2 is a demanding sine sweep at g-levels that exceed the max acceleration levels allowed by most electrodynamic shakers. The T2000 Shaker at Experior Labs can deliver this high level sine vibration performance based on the following combination of technical factors:

A. Lightweight Armature: 110 lbs
B. Sine Force Rating: 25,000 lbs pk
C. Solid Metal Induct-A-Ring Armature (no driver coil windings)

This same T2000 Induct-A-Ring Shaker also has excellent low frequency performance, delivering up to **3" pk-pk displacement** which supports low frequency sine testing to simulate windmilling vibration due to turbine engine fan blade out (FBO) conditions.

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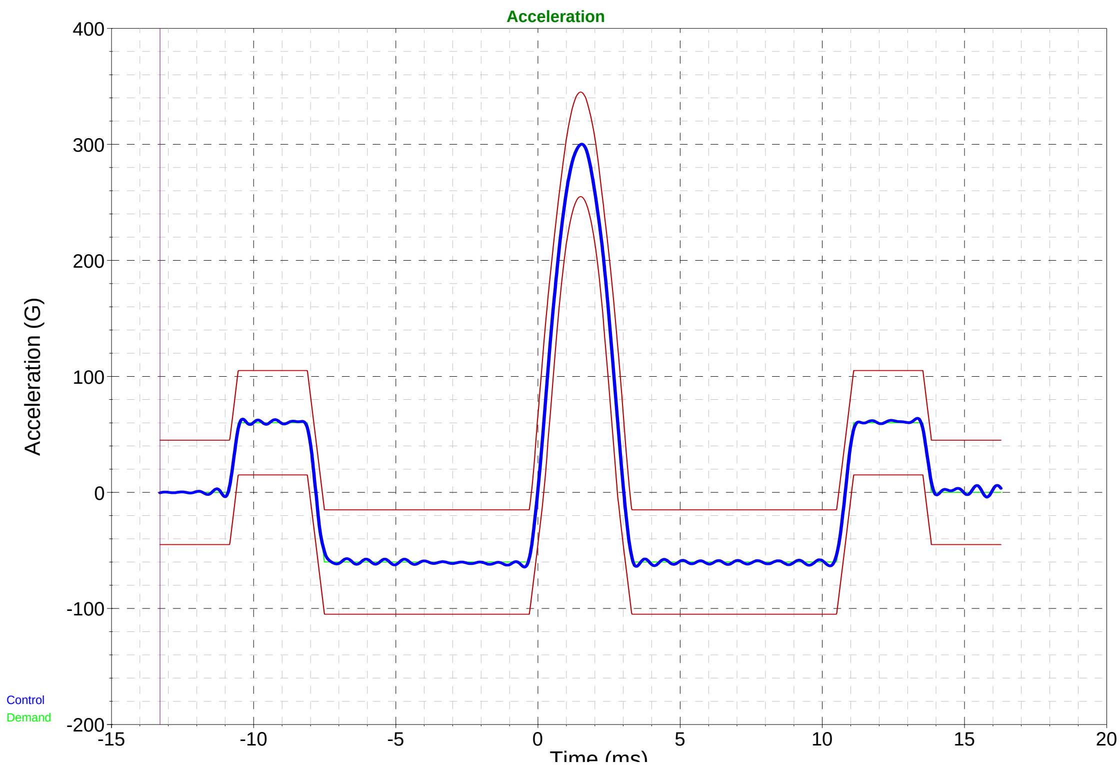


**Fig. 3: Classical Shock: 3 msec Half-sine pulse @ 300 g pk**

Classical shock pulse test specifications are becoming more demanding as ground vehicle and airborne service environments increase in severity. The 300 g pulse in Figure 3 is required for many military grade electrical connector test procedures.

Another demanding shock pulse that's often used for qualifying automotive hardware is called out in SAE specs as an 11 msec Half-sine @ 100 g pk. This pulse can be run on an electrodynamic system, if the shaker can produce 2.5" pk-pk stroke and +/- 135 inch/sec pk velocity. These required ratings rule out most of the electrodynamic shakers available at commercial test labs. But the T2000 Shaker at Experior Labs is rated at **3" pk-pk stroke** and **+/- 180 inch/sec velocity**, making the SAE 11 msec @ 100 g shock pulse a routine test.

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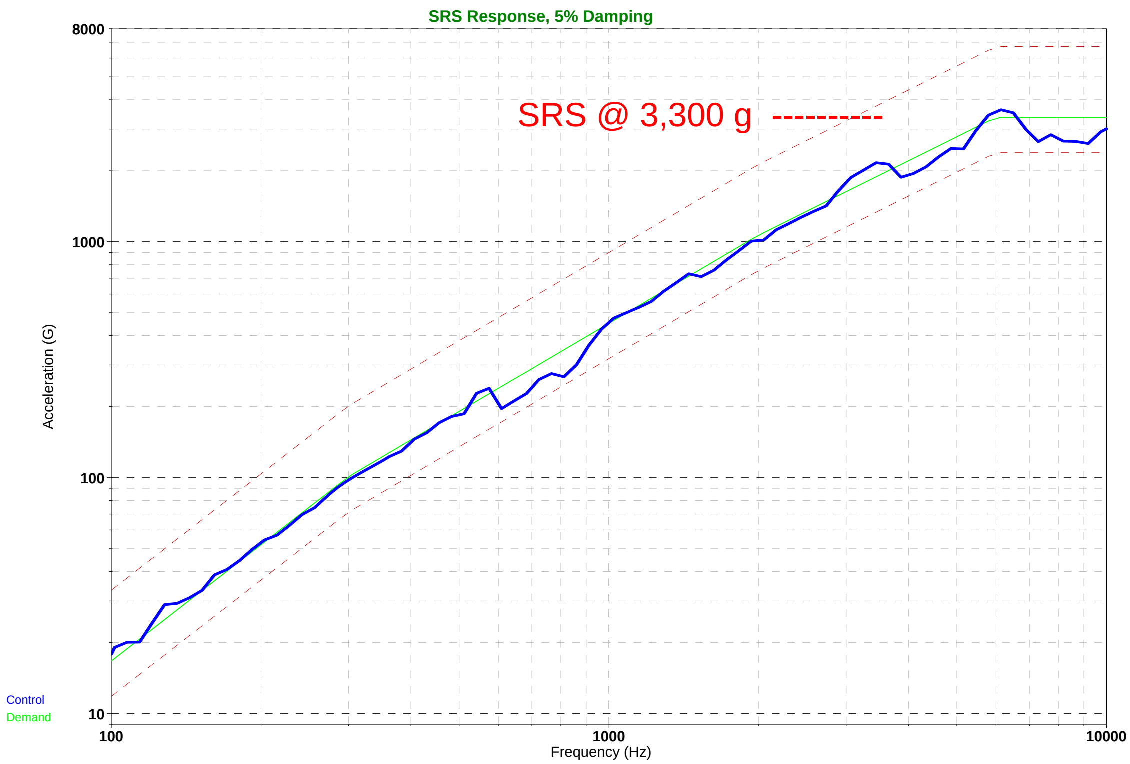


**Fig. 4: SRS Shaker Shock @ 3,300 g to 10 KHz** (6 KHz Knee Frequency)

**Far Field SRS**: Until recently, electrodynamic shakers have been limited to the category called "far field" SRS shock -- with a max frequency range of 3,000 Hz.

Far Field SRS tests performed with electrodynamic shakers at most test labs rarely exceed 1,000 g due to Shaker and Power Amplifier limitations.

This historically low ceiling for SRS shaker shock has been dramatically expanded by Experior Labs using its high performance T2000 Shakers. This major breakthrough in SRS shaker shock is linked to the following key factors:

A. T2000 Shaker rated up to 600 g real time armature acceleration (g vs. time)
B. Ultra-High peak current and voltage outputs from the 240 KVA Power Amplifier
C. Addition of a **shock impedance mode** internal to the T2000 Shaker to maximize power transfer between the 240 KVA Amplifier and the T2000 Shaker for SRS profiles that demand high drive voltage at the armature input terminals.

With these technical factors in play, SRS levels as high as 5,000 g have been achieved out to 10,000 Hz with lightweight payloads ( < 10 lbs), thus meeting most Far Field SRS specifications with considerable operating margin.

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**Advantages of SRS Shaker Shock** Shaker shock is performed using a PC Controller with accelerometer feedback to lock in the SRS profile as measured at the control accelerometer location. Once the control equalization is completed at low level (typically at -20 dB) the SRS test is brought to full level without overshoot and within relatively tight tolerance bands over the entire frequency range.

The drive spectrum then can be memorized by the Controller so that **multiple SRS shocks can be produced with essentially identical profiles.**

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The following graphs illustrate Experior Laboratories' capabilities to conduct SRS testing using our Kinetic Impact Pyroshock Simulation (**KIPS)** system that's rated up to 30,000g SRS to 10,000 Hz as required by many space hardware component test specifications covering launch and stage separation events.

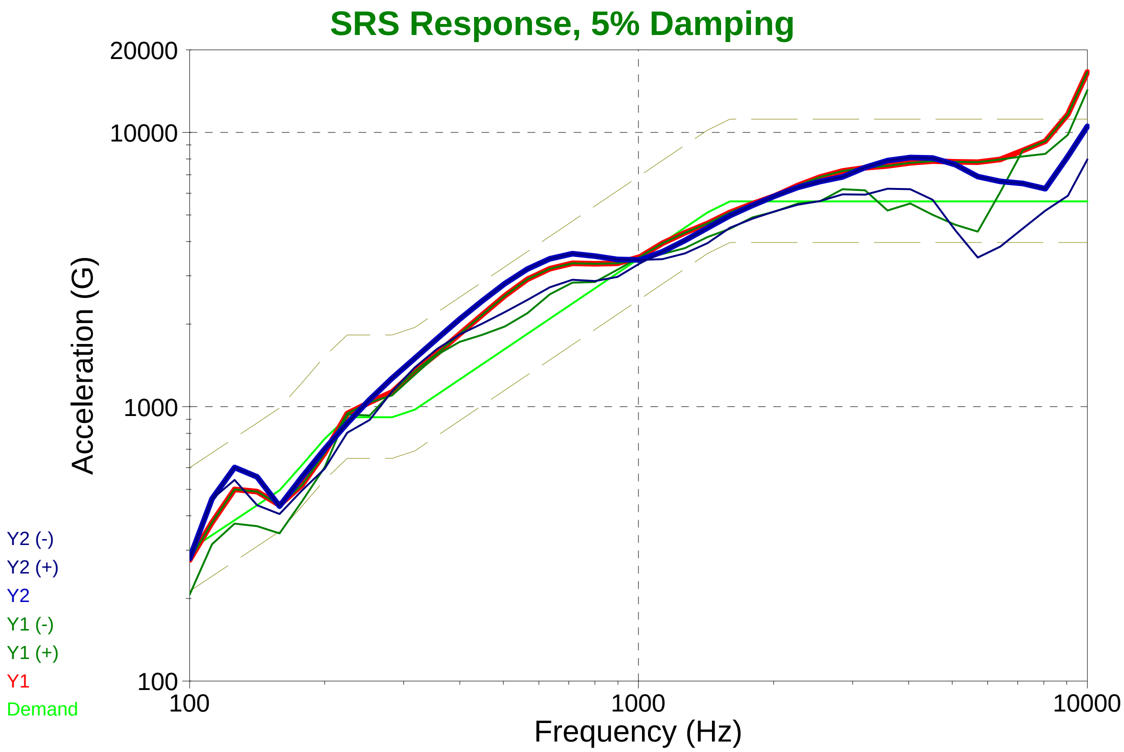


**Fig. 5: SRS Pyroshock Simulation** (300 g to 5,600 g profile with demanding positive, negative, and maxi-max tolerance requirements as measured from diametrically opposed accelerometers)

Our Kinetic Impact Pyroshock Simulation system generates near and mid field pyroshock using a mechanically excited tunable resonant fixture. By adjusting the impact force, location, and fixture damping, this platform allows for highly customizable shock generation.

The KIPS system boasts short transients, narrow differences between positive and negative SRS traces, and a uniform shock input, allowing for near-equal measurements from diametrically opposed accelerometers. The KIPS system also allows for separate custom X, Y, and Z axis SRS profiles with cross-axis acceleration monitoring to ensure that devices are not overtested.

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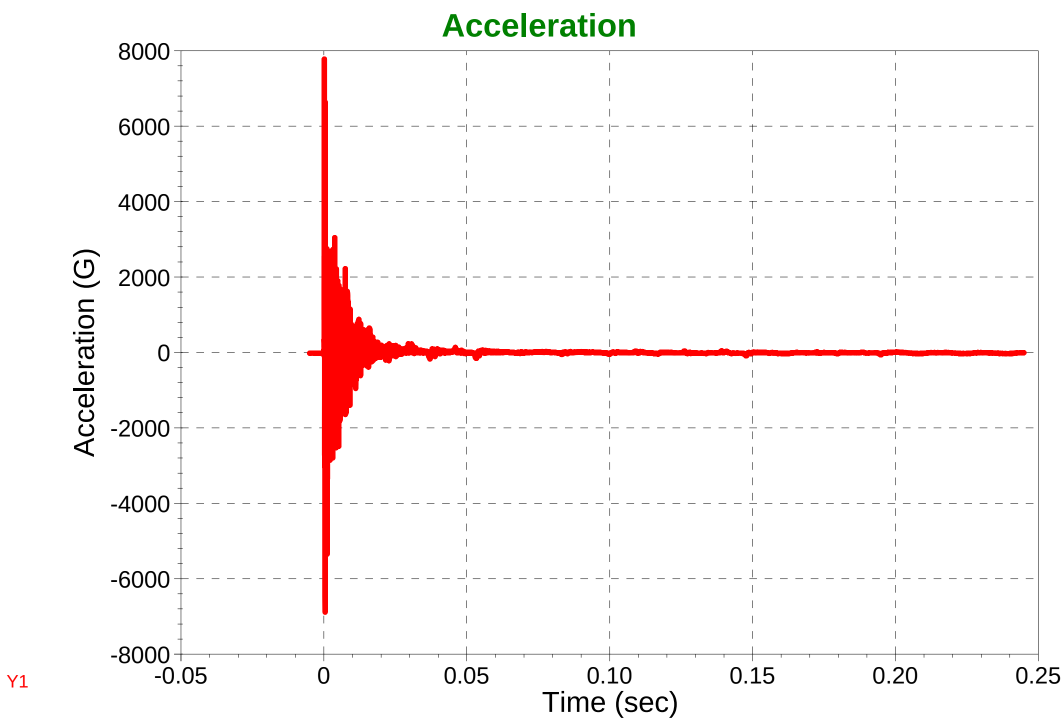


**Fig. 6: SRS Pyroshock Simulation** (Transient capture from SRS shock in Figure 5)

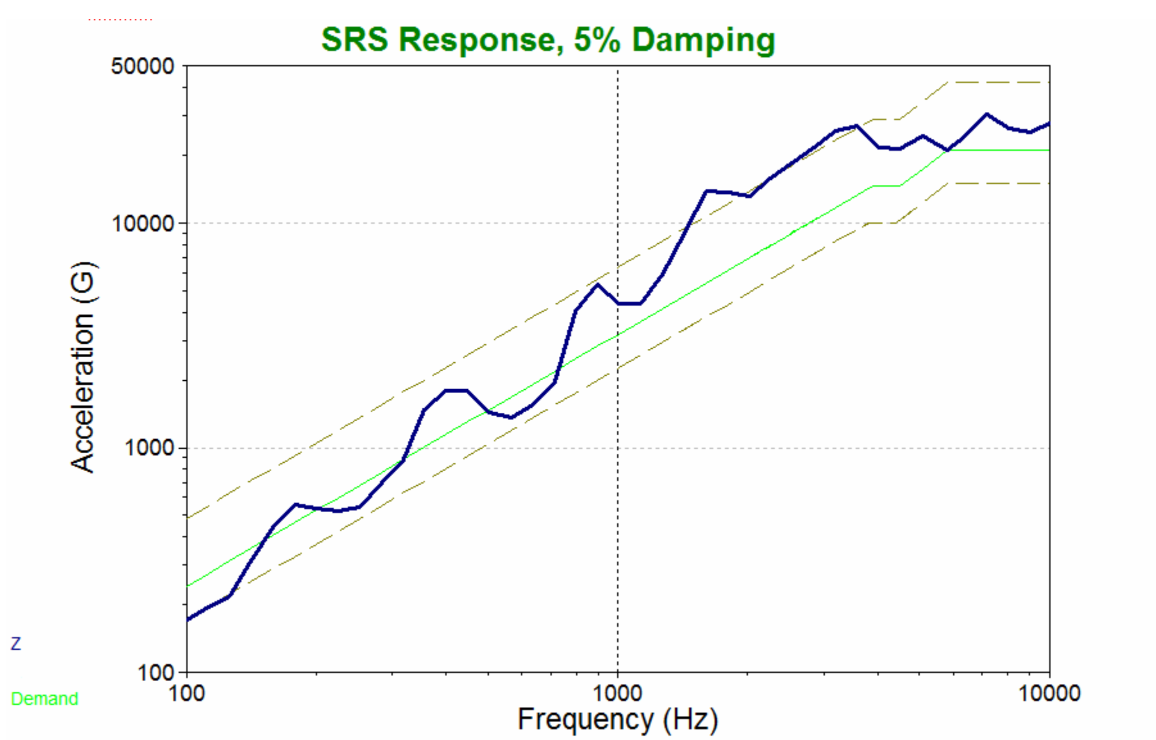


**Fig. 7: SRS Pyroshock Simulation** (250 - 20,000 g profile with 5 KHz knee)