PREFERRED
RELIABILITY
PRACTICES

DESIGN OF A SMALL APPARATUS FOR IMPROVED VIBRATION/THERMAL TESTING

Practice:

A small test fixture has been specifically designed for conducting vibration/thermal tests on small test specimens such as ignitors and detonators. This test fixture creates much smaller loads and less hostile thermal environments for the vibrator table armature thus creating a more reliable test set up. In addition, this small test fixture provides much more rapid and accurate thermal transfer to a test specimen which results in more data points for the same test times and more accuracy and reliability in the test data.

Benefits:

This new environmental fixture is much smaller than other larger, bulky environmental fixture that requires long soaking times for even temperature stability over the entire fixture and sample. The smaller fixture has less weight and requires little temperature soaking time for obtaining fixture and specimen temperature stability. This improves the reliability of the test set up as low, long term soaking temperatures can cause armature brittleness and subsequent failure while long term heat soaking of the armature can cause vibrator shaker shutdown. In addition, more data points can be obtained in a shorter period of time with better thermal resolution.

Programs That Certified Usage:

Vibration/Thermal Testing of the NASA Standard Initiator (NSI) and the NASA Standard Detonator (NSD). [NOTE: Testing of armed NASA Standard Initiators or NASA Standard Detonators is a highly dangerous undertaking and proper safety precautions should always be observed. For more safety information on testing these devices, please contact the Johnson Space Center (JSC)].

Center to Contact for More Information:

Johnson Space Center (JSC)

Implementation Method:

Two small thermal control and conditioning test apparatus' have been developed and utilized in vibration/thermal testing at JSC for NSI and NSD explosive components. These devices are applicable to all fixturing designs which utilize a flow through manifold for the thermal medium. Although these fixtures were designed specifically for vibrating explosive components under extreme conditions the application could be altered by fabricating fixture(s) to incorporate any type device to be thermally conditioned and/or vibrated.

Photographs of these apparatus' are shown in Figures 1 and 2. Each are fabricated

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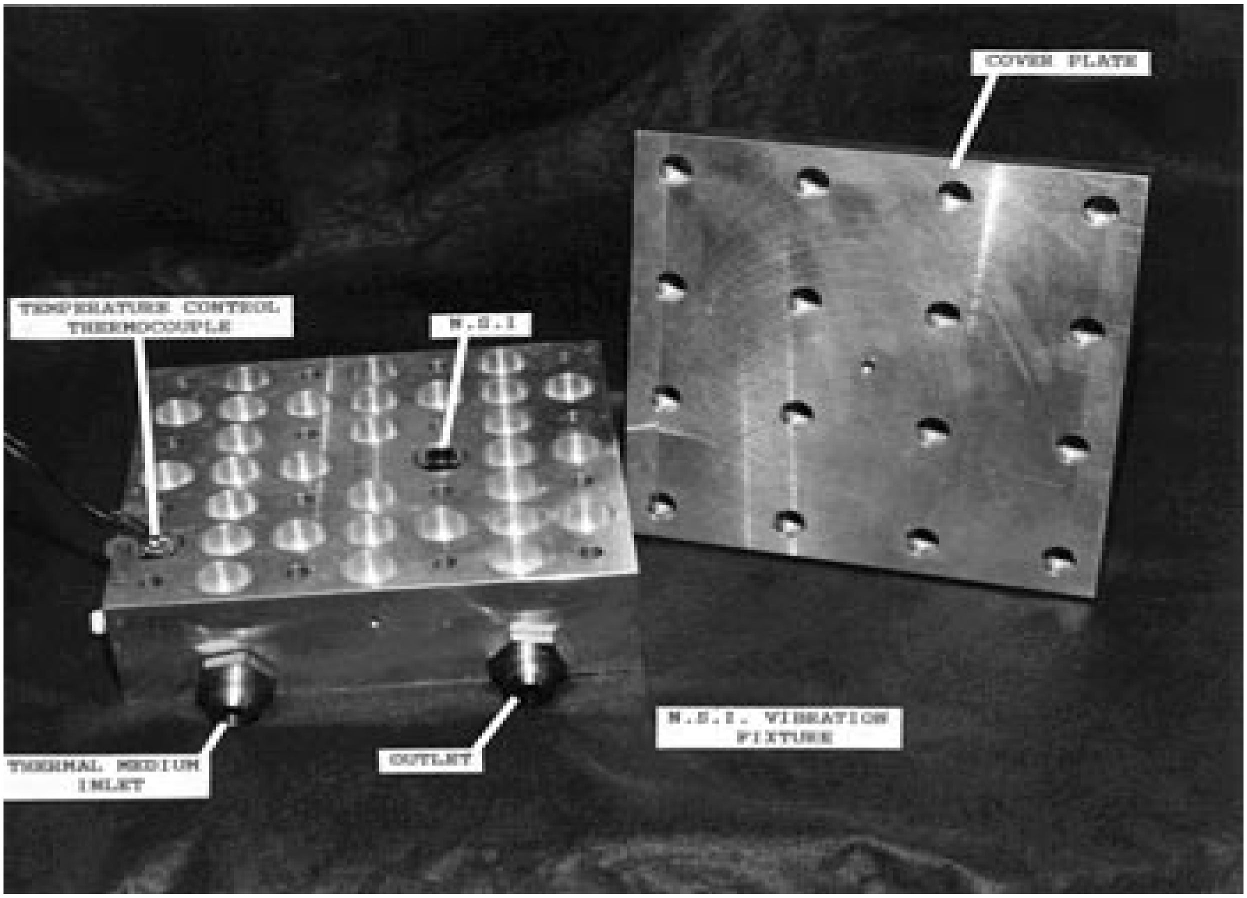

Figure 1. **Fixture for NSI Thermal/Vibration Testing**

out of aluminum and differ in several ways. Each is fabricated for its appropriate thread type, mounting hole pattern and thermal medium flow manifold. In addition, the NSI fixture has a cover plate where the NSD fixture does not. The reason for this is to minimize the amount of mass the armature has to move during the NSD vibration profile. One main difference between the two fixtures is the transition of the explosive components from one axis to another.

In each apparatus, liquid nitrogen is used for cold conditioning the explosive component during vibration testing and is controlled as shown in a block diagram in Figure 3. The system is capable

of establishing thermal fixture temperatures as low as -310 degrees F with a temperature gradient across the fixture not exceeding 5 degrees F. A glycol/water solution is used for hot temperature conditioning. The solution is circulated through the fixture(s) with a Neslab high temperature bath and control circuit with system capabilities of up to 400 degrees F and thermal gradients not exceeding 3 degrees F. Both apparatus' utilize a phenolic insulator plate to minimize thermal soaking to the armature and an armaflex cap to minimize thermal losses. This prevents soak-out and shutdown problems associated with the armature.

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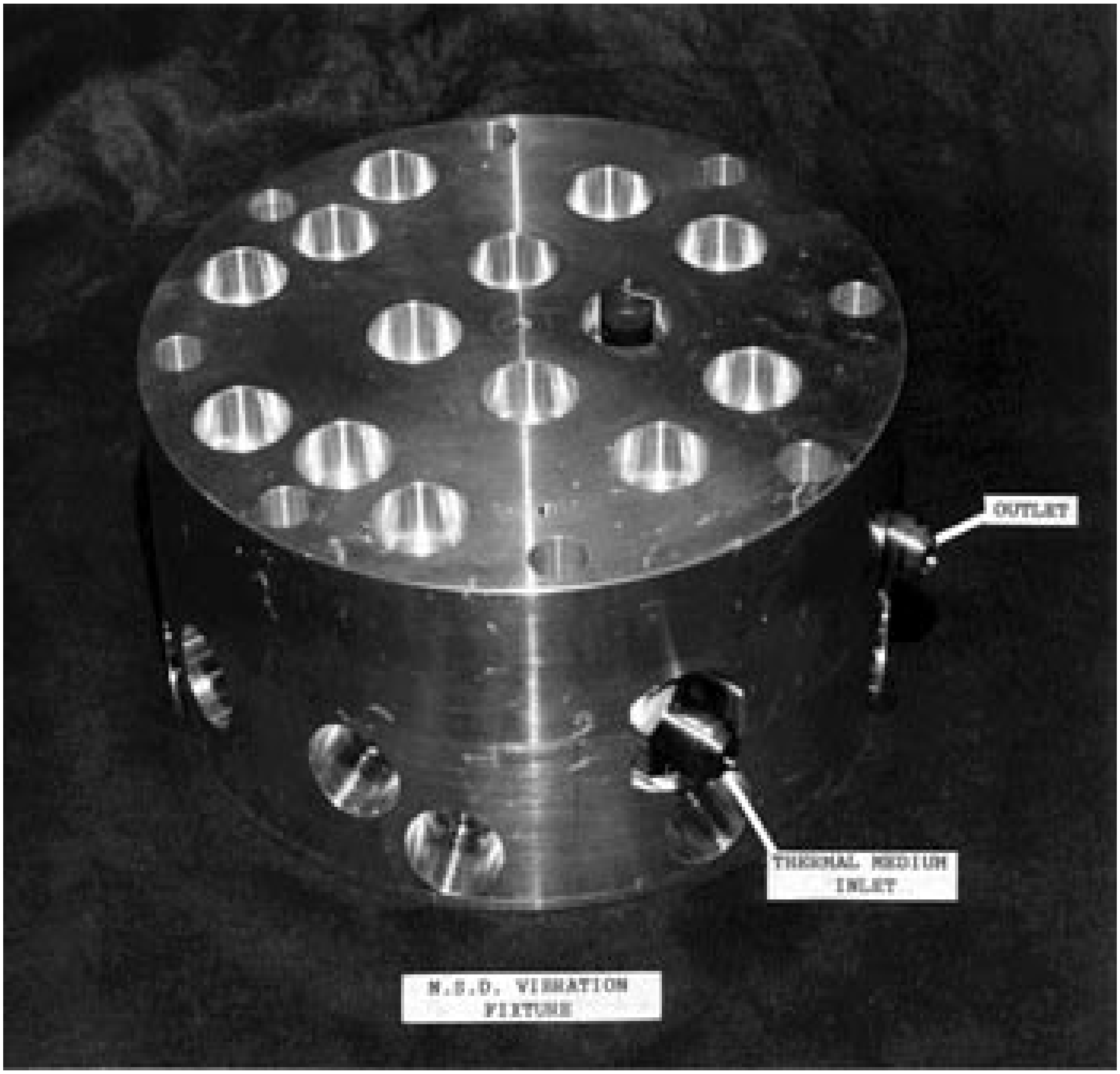
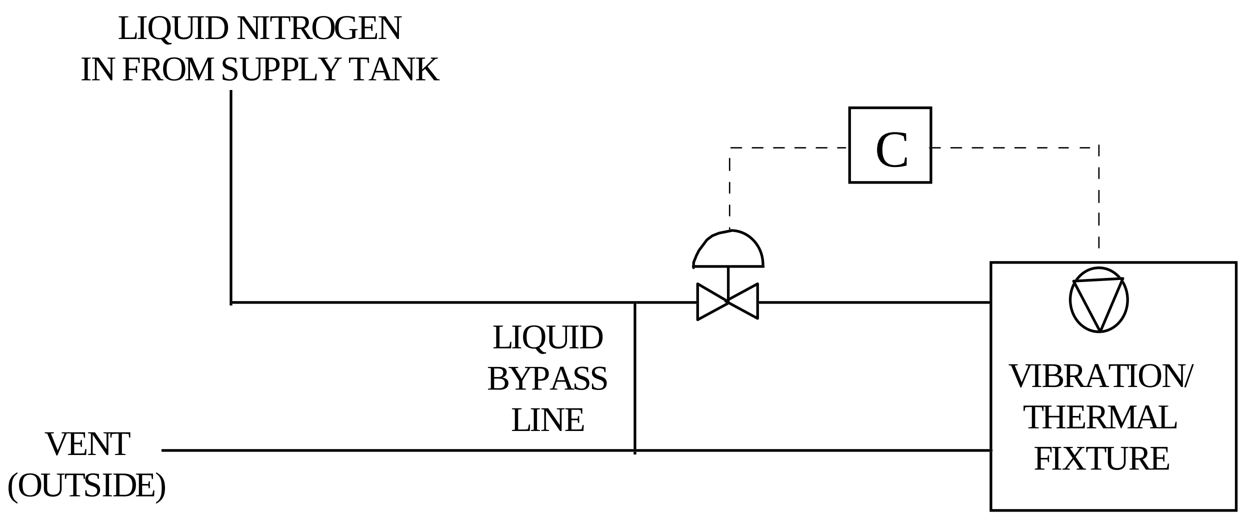


Figure 2. Fixture for NSD Thermal/Vibration Testing

Because of the dynamics of the NSI vibration profile a secondary fixture was used to transition from one axis to another. This fixture allows the transition of the thermal fixture from a horizontal plane to a vertical one. This secondary transition fixture is pictured in Figures 4 and 5 with the NSI thermal/vibration fixture attached in the X and Y vibration planes, respectively. Because of the dynamics of the NSD vibration profile on the other hand, the amount of mass resting on top of the armature is critical, since the profile is demanding close to full power output of the vibration amplifier system. Thus the fixture was designed to have a transition from one axis to another of the explosive components without any extra fixturing. This is done by utilizing both the top and side of the fixture to accomplish the X and Y axes. A 0.018 inch thick shim is used to offset the

COLD CONDITIONING (USING LN2)
CONTROL SCHEMATIC



HOT CONDITIONING
(USING GLYCOL/WATER)
CONTROL SCHEMATIC

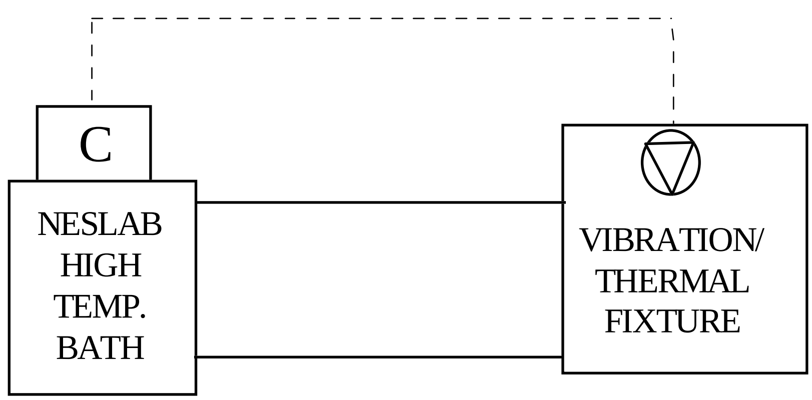


Figure 3. Block Diagram of Thermal Control of Cooling and Heating Medium

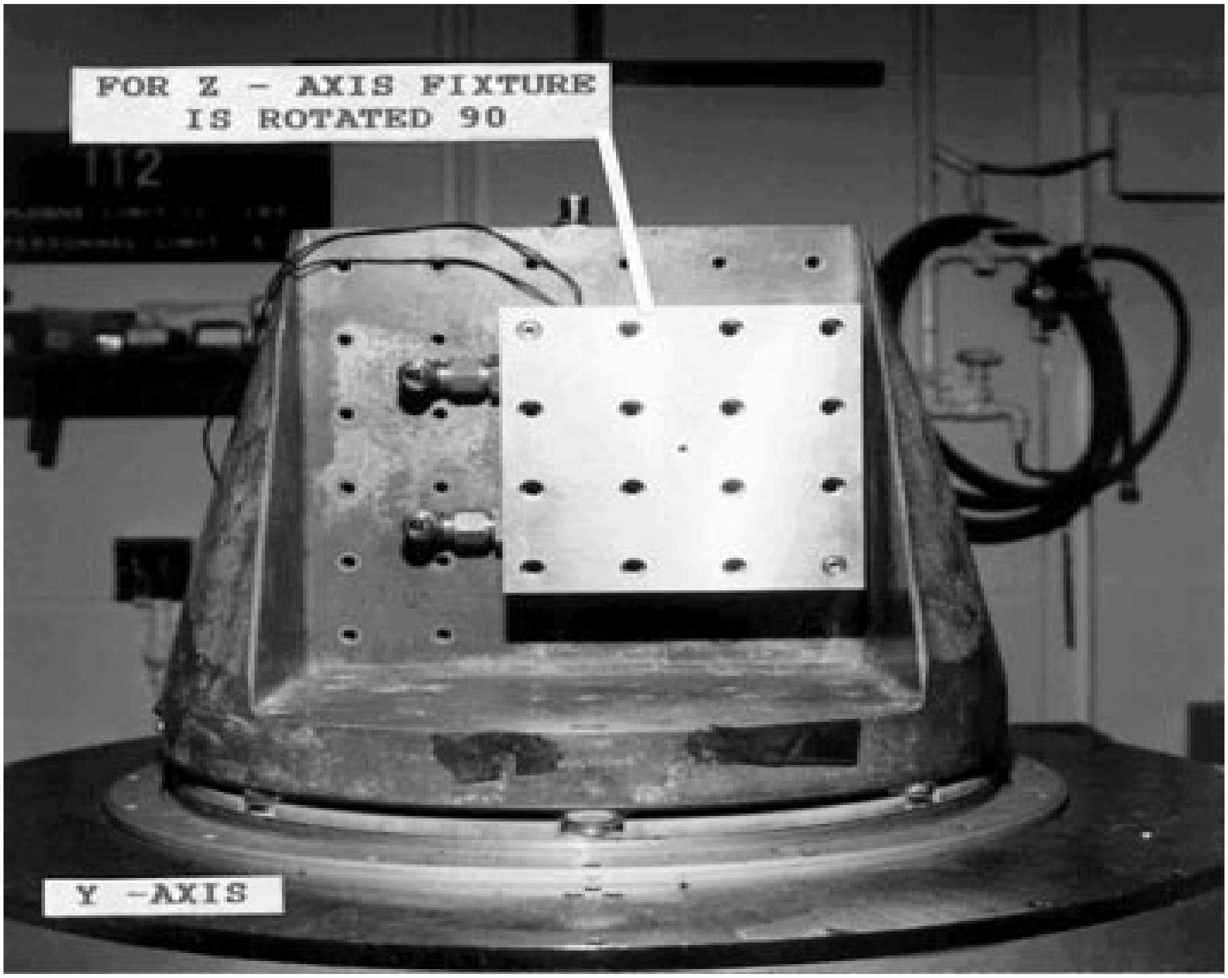


Figure 4. Secondary Transition Fixture with NSI Thermal/Vibration Fixture Attached in X Vibration Plane

explosive devices 90 degrees to accomplish the Z axis.

Technical Rationale:

A thermal environmental chamber has been previously used at JSC to thermally condition explosive components that could be mounted to a shaker head and vibrated in three axes (X, Y, & Z). These prior set-ups had utilized a bulky and heavy environmental chamber which required structural supports and bracing to hold it over the shaker head. Liquid nitrogen was used as a cold temperature conditioning media and electric heaters were used for hot temperature conditioning. The environmental chamber had a large air space which created temperature gradients throughout the chamber. Therefore, obtaining a stable thermal condition for the test subject required a great deal of thermal “soaking” time.

The time requirement for conditioning the test subject was also increased at cold temperatures

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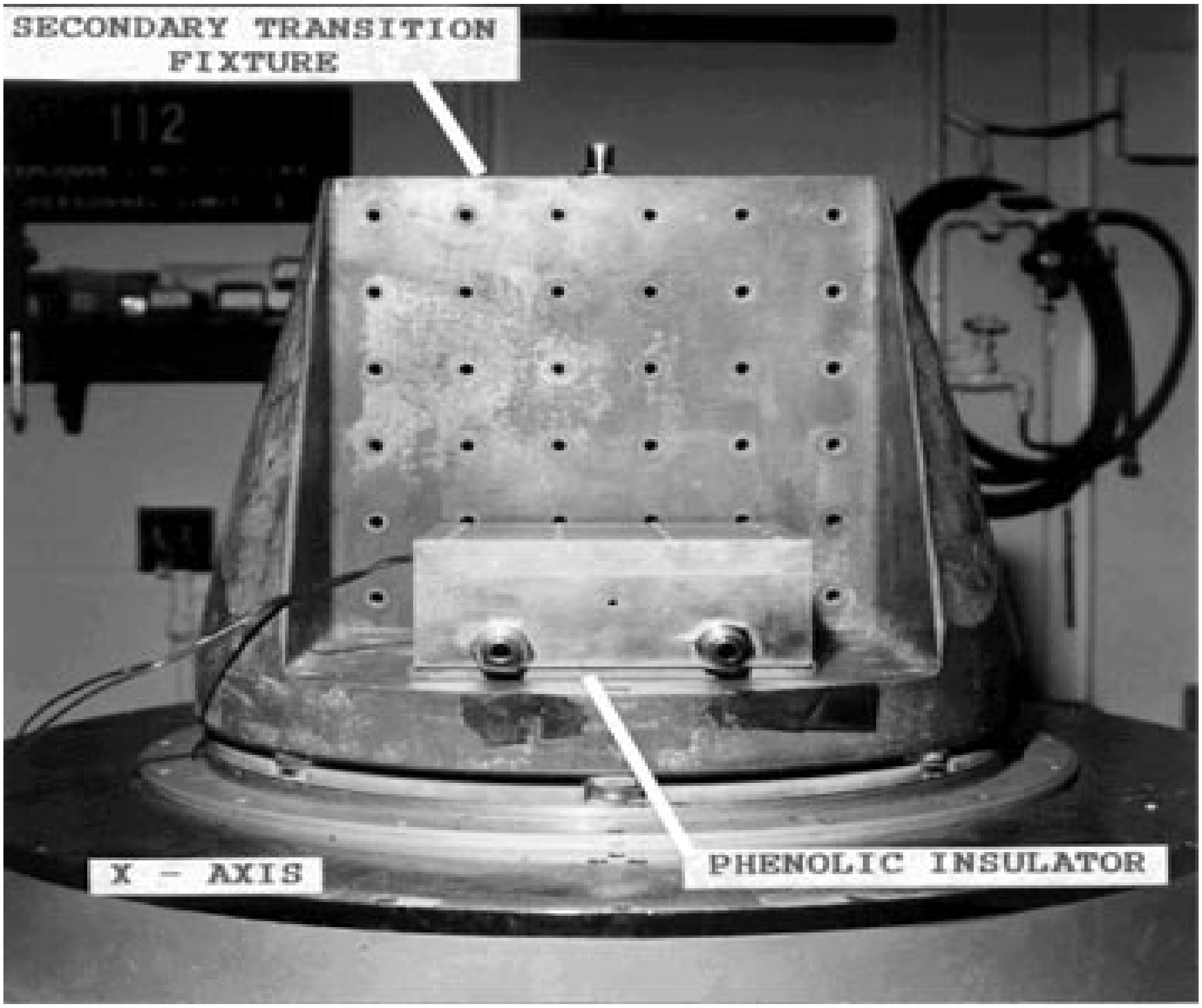

Figure 5. Secondary Transition Fixture with NSI Thermal/Vibration Fixture Attached in Y Vibration Plane

because of the need for more thermal accuracy and stability in this test range. This thermal "soaking" acted as a detriment to the shaker armature components which also "soaked out" to the required temperature causing them to become brittle and more susceptible to damage and/or breakage during the vibration process. Also, when conditioning the test component to a hot condition, the armature ran hotter. If the cooling capacity of the shaker system couldn't keep up with the influx of heat to the armature during the "hot" test, then the system over-temperature protect circuit shut the vibration test down.

All these limitations and inconveniences of the larger environmental chamber led to the development of the smaller, controllable, environmental fixture for vibration/thermal testing which is the subject of this practice.

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Impact of Nonpractice:

The impact of non-practice is that the larger environmental chamber could be used which would increase costs and time to perform vibration/thermal testing. This would expose the shaker armature to more weight and cold soak temperature extremes. The additional weight can cause armature failure while the lower temperatures can cause armature brittleness and subsequent failure and the higher temperatures can cause vibration shaker shutdown.

Related Practices:

1. PT-TE-1402, Thermal Cycling

2. PT-TE-1405, Powered-On Vibration

3. PT-TE-1406, Sinusoidal Vibration

4. PT-TE-1413, Random Vibration Testing

References:

None.