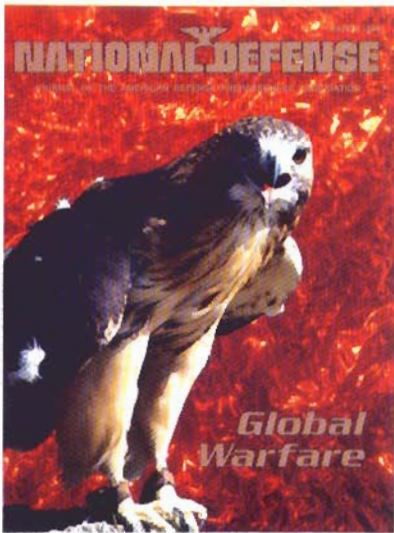


Designing Shock and Vibration Isolators for Military Applications

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The manufacturer of a missile component is nearing completion of qualification tests. All functional checks have been successful, as have thermal cycling, thermal shock, mechanical shock, and acceleration tests. However, during random vibration tests, performance is below specification. Investigation indicates the problem is due to a structural resonance. Attempts to modify the resonant member result in some improvement, but performance does not meet specification requirements.

With final deadlines approaching, an isolation mount manufacturer is consulted. It is learned that additional space is required to provide an isolator with the necessary performance and life. This time, the manufacturer is lucky—machining one fitting instead of casting it will provide the required clearance without compromising the structural integrity of the component.

This scenario and others like it are not uncommon.

A manufacturer of military products has to meet established standards for controlling the effects of vibration, impact shock, and structureborne noise. He wants isolators of top-quality ma-

terials that provide maximum performance, efficiency, and length of service. In procuring isolators, he wants to eliminate the possibility of critical lost time, needless expense, and a lot of human stress and strain.

An example makes a basic point. Engineers of a major defense contractor approached us at an early stage of a new program. The problem was to design an isolation system for shipboard use for electronics cabinets. The system would have to protect the equipment from the vibration inputs described in MIL-STD-167 and from the shock inputs of MIL-S-901C. Further, construction had to be of nonmagnetic materials.

In this case, our engineers were able to take one of our standard system designs and modify it. That system protects the equipment from both vibration and shock. All structural components are fabricated from nonmagnetic 300 series stainless steel. All hardware is the same 300 series stainless steel or aluminum. The system met all requirements, passed its tests and evaluation, and is now in use.

The time and cost savings were substantial. It costs no more, and

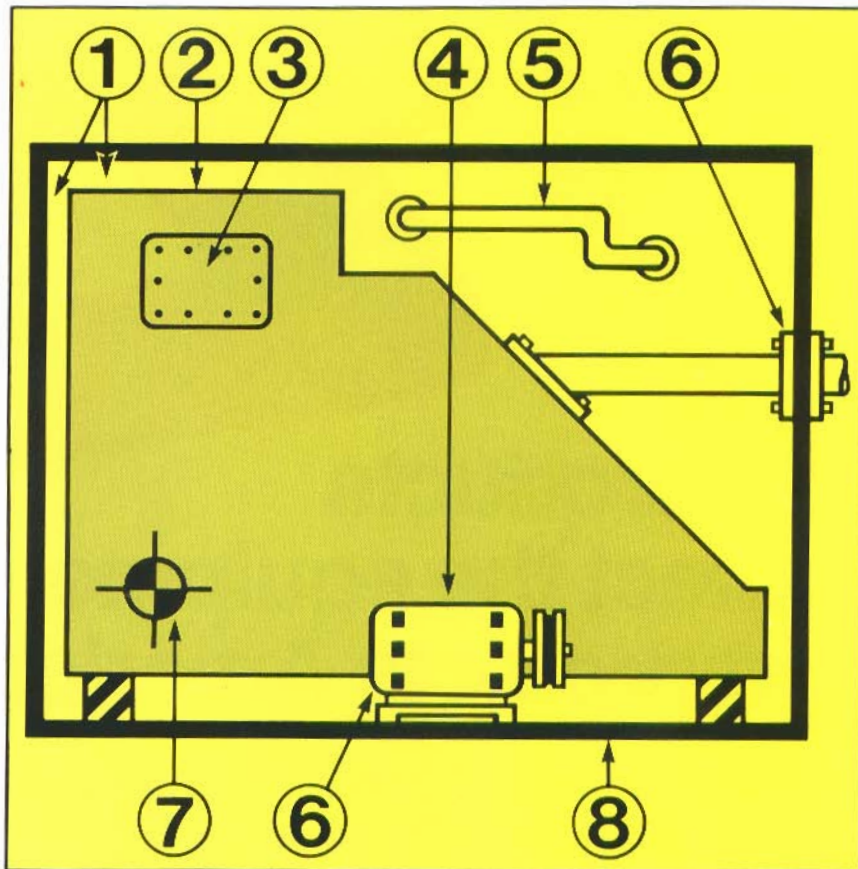
can save a lot, to call in a qualified company with technically competent isolation engineers at the early stages of a design effort.

Let's look more closely, first, at why early effort is more crucial than ever; second, specifically how to speed up procurement of isolators; and third, the advantages derived from understanding how to make the fullest use of an isolator company's capabilities to produce custom-designed isolators.

Why Work on Isolators at the Design Stage?

Isolator technology has become highly specialized and innovative as the sophistication of military and NASA products has increased. The technology is applied, according to military specifications, in such areas as military aircraft, vessels, ground vehicles, and special ground installations, as well as to NASA and other aerospace equipment. Typically it is applied both to the integral components of an aircraft or vessel, and to the sensitive equipment it uses (such as radar or communications gear).

Isolators must meet demanding standards in absorbing the destructive energy of dynamic forces



This illustration shows some of the more serious problems that can arise when shock and vibration specialists are called in late to advise on solutions.

1) **SWAY SPACE/DYNAMIC ENVELOPE.** "There is no protection without deflection." Enough room has to be left to allow the source of disturbance or the affected component (whichever is to be isolated) to move. If there isn't enough room, the components may bump against the walls of the package.

2) **STATIC ENVELOPE.** There may not be enough room in the package to accommodate the isolators. This is particularly likely to happen in designs in which miniaturization is an important consideration. Isolators, however small, need additional space, and often the lack of available room results in a performance compromise or the need to redesign the package.

3) **ACCESS FOR MAINTENANCE.** A component located for ease of inspection, maintenance, or replacement may become less accessible after isolators are installed. Taking the location and size of the isolators into account in the early stages of the design will help alleviate this potential problem.

4) **PROXIMITY TO DISTURBANCES.** The location of the disturbance, particularly when it comes from an internal component such as motor, may have to be changed in order to maximize the effectiveness of the isolation solution.

5) **ENVIRONMENTAL CONSIDERATIONS.** Isolators can be as sensitive to hostile environments as any other component. Isolation systems installed late in the design stage may require special, more expensive materials to resist damaging ambient conditions, such as chemicals and high temperatures.

6) **MECHANICAL SHORT CIRCUITS.** Isolation means "isolation." Any mechanical connection between the isolated component and the surrounding cabinetry will most likely provide an alternate path for shock and vibration. The isolator supplier can advise you on the best way to avoid this condition.

7) **CENTER OF GRAVITY LOCATION.** Location of the center of gravity relative to the isolation system is important to proper performance. Particularly in the case of an eccentric CG, the need to accommodate unbalanced loads, and to "focus" the system can lead to complex design problems.

8) **FATIGUE LIFE.** An isolation system usually increases the fatigue life of equipment. In fact, this is one of the major advantages of vibration isolation. However, some modifications may have to be made to the support structure to keep the characteristic movement of the isolators from having the opposite effect on the support structure.

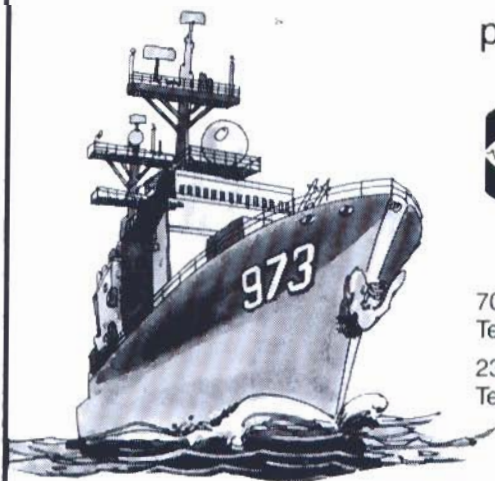


Our products protect the equipment that protects America...

Barry isolators that control vibration, structureborne noise, and shock, protect military equipment — from the most sensitive electronic components to the most powerful engines. They virtually guarantee equipment and engine performance and they do it economically by keeping maintenance costs low.

We have designed and developed specialized isolators that have kept pace with the sophisticated electronics of modern weapon systems which require ever-increasing protection to ensure reliability under hazardous conditions.

When performance depends on protection — contact Barry Controls.



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and motions. They must not exceed a certain weight or certain dimensions, and they must meet further requirements dictated by the laws of physics. Frequently they must also be designed to withstand deterioration by lubricants, fuels, hydraulic fluids, chemicals, sunlight, ozone, humidity, corrosive atmosphere, sand and dust, and extremes of heat and cold.

Military applications for isolators are, for obvious reasons, far more demanding than for the general run of industrial applications. Our company is a leading supplier of isolators for military use, and we have found a substantial number of military applications require custom design isolators.

The likelihood of being able to use standard isolators, as they are or as modified, is increased when an isolator company is consulted at the design stage. For example, the manufacturer has the best chance of designing his product so that space and correct locations are provided for off-the-shelf isolators, possibly reducing the need for custom-designed isolators.

Sometimes modifications are elaborate, and even ongoing. Martin Marietta engineers needed an isolation system to hold the space shuttle manned maneuvering unit (MMU) to the inside bay of the shuttle during launch. The engineers decided to incorporate a special modification of the Barry cupmount (2000 series).

We developed design modifications and fabricated and tested eight parts, then submitted them to Martin Marietta for qualification tests. The elaborate modifications included a complex machined shaft (15-5 PH Cres.), a machined spacer nut (A286 Cres.), and formed stationary cups and outer cups (A286 Cres.). Special elastomer controls were required, and parts were subjected to 100 per cent load deflection and resonant frequency tests. The original units passed all tests. After a final decision to increase the safety and performance factors,

the system was redesigned and fabricated, tested and shipped. It passed all specification requirements and is now in use.

As a rule, the trickier the manufacturer's vibration design problem, the more important it is for the isolator company to work at the manufacturer's design stage. A cryogenic engine manufacturer gave us this problem: piston-to-cylinder contact in the cryogenic unit of an engine resulted in destructive acoustical emissions. The isolator space envelope was rigidly defined by specifications which allowed for a maximum diameter of $.195 \pm .005$ and a maximum height of $.140 \pm .005$ with a perpendicularity and parallelism of $.002$.

This severe size constraint, coupled with demanding performance criteria, made this design a formidable task. Extraordinarily tight tolerances on damping and stiffness parameters were necessary to ensure conformance with the applicable requirements. We were eventually able to design, manufacture, and test, and to deliver this unit for further testing, evaluation, and use. The unit is the smallest isolator produced in our company's 40-year history.

Early-stage consultation with an isolator company helps avoid costly design, prototype, and even manufacturing changes. It also means isolator requirements can be properly scheduled and assigned correct priority to help avoid bottlenecks and meet deadlines.

How to Speed Up Customized Isolator Procurement

What does an isolator company need to know from a manufacturer in order to recommend standard isolators, modify existing isolators, or design new ones?

Assuming contact is made at the design stage, isolator procurement can be sped up by giving the isolator company the fullest pos-

sible information about item requirements. Then what kind of information is required?

This is a problem statement about an aircraft manufacturer's requirements for isolators for an air conditioning pack (ACP) for B-52 aircraft:

To design and manufacture an isolation system which must not exhibit any resonances below 13 Hz, yet provides at least 50 per cent isolation by 100 Hz when exposed to the random vibration environment that exists in the wheel wells of the B-52 (ACP location). Overall grms reduction must be 50 per cent, minimum. These performance criteria must be met after and/or during exposure to the fluids encountered during possible hydraulic line leaks, 15g 11 msec half-sine shocks, and an operating temperature range of -65°F to 160°F . The allowable unit isolator envelope must be limited, considering the relatively high static loading.

To generate requirements this specific, the steps involved and factors considered are these:*

- General statement of the problem and the product application
- Personnel and/or equipment to be protected
- Sources of vibration, shock, and noise
- Other destructive forces
- Applicable specifications with anticipated

* Each of these factors necessary for determining isolator choice or design requirements is discussed in an article by Dr. R. Racca, Sr., a Barry senior project engineer, entitled "How to Select Isolators for a Long Service Life," available from Barry Controls.

vibration, shock, and noise input levels

- Recommended natural frequency of the isolator
- Type of loading
- Type of elastomer or other material
- Strain on the mount
- Stress on the mount

Our project engineers work to a form that calls for:

- Problem statement
- Vibration input
- Vibration fragility level
- Shock input
- Shock fragility level
- Temperature range
- Environmental exposure
- Special requirements
- Isolator attaching points
- Equipment weight
- Dimensions
- C.G. location
- Moments of inertia (if known)
- Space available for isolators

When the isolator company project engineer and the manufacturing company engineer work through the general steps to determine the precise information required, they can make a statement of the problem that specifies the requirements of the isolation system. The isolator company then makes its recommendations and proceeds when authorized.

This is a brief description of the solution for the B-52 ACP:

Barry designed high pressure molded, cylindrical, laminated rod ends to replace the "rigid" rod ends originally intended to suspend the ACP. Eight isolators are used per ACP: four for vertical support, two for lateral stability, and two for longitudinal stability. One "large" rod end is used as a vertical support at the most heavily loaded position. The smaller rod ends are located at all of the other positions.

A laminated design is utilized to reduce dynamic strain to acceptable levels and to keep system resonances above 13 Hz, despite the compact size of the isolators. Special Barry LT elastomer blended for fungus and ozone resistance is incorporated into the design to provide high strength and high flexibility at low temperatures.

The isolators successfully passed all manufacturer and Air Force flight tests and are now in use.

We know that the information-gathering steps described are inevitably necessary, whether for a system that protects sensitive equipment in the Sparrow AIM-7M or a system that isolates a cruise missile in a TRIDENT submarine.

How to Use an Isolator Company's Full Capabilities

The more known about a particular isolator company, the more clearly can be determined what is wanted and required from the company. When you understand the extent of its capabilities, you can speedily decide whether you or the company, or both, will assume or share certain responsibilities in the information-gathering steps.

Several aspects of your needs are certain. You want fast turn-around. You want the widest range of design solutions to your problems. You want comprehensive capabilities that range from design engineering and manufacturing, through quality control and testing, to ongoing supply and supportive services. This was the case with a large military product supplier and the Multiple Launch Rocket System and Launch Pod Container.

The launch pod consists of six missiles packaged in a container

that is loaded onto a launcher for missile firing. The container is transported by rail, truck, or ship, which results in shock and vibration that must be isolated using a low-cost shock mount.

Barry developed a one-piece skidmount, 22.3" x 5.1" x 4.5" high that is attached at each corner of the launch pod container. The one-piece molded construction, using a stainless top plate and aluminum bottom plate, minimizes assembly procedures and permits the production of parts that are consistent in quality and dynamic properties. In addition, the one-piece construction proved to be the most economical solution to the problem. Barry was authorized to undertake engineering, tooling, initial development parts, then production tooling and production of a quantity of isolators.

The skidmount met all the Army Missile Command requirements. A four-cavity mold was built to run on our 36" 1,200-ton press. Production began to manufacture a large number of units, and the units are now in use. Back of such programs, in a qualified isolator company, are highly skilled, experienced, and creative isolation engineers and other specialists: advanced equipment from CAD-CAM for design and other functions, laboratory quality control and testing equipment, the latest NC and CNC equipment for use in manufacturing, and a dedicated R&D program searching for solutions to anticipated future requirements of manufacturers. This makes possible the utilization of the broadest range of resilient materials and damping media available. ■

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