LORD WHITE PAPER

Elastomeric Bearings, Dampers and Isolators: "Comfort, Care and Feeding"

By LORD Corporation, Rotary Wing Business Unit

LORD
Ask Us How™

What should you expect an elastomeric component to do in your aircraft? And how can you help them to last longer and perform optimally?

Helicopters are recognized as one of the great engineering marvels of our time. In fact, there are those who would argue that their ability to function is scarcely believable. In spite of critics and nay-sayers, however, there continues to be a steady growth of owners, operators and passengers of helicopters all over the world. Many technical hurdles have been successfully conquered in order to achieve this commercial success. **Elastomeric components** are part of that solution.

The most serious issues with regard to the operation of helicopters are those involving **reliability/maintainability, noise and vibration**. Elastomeric bearings, isolators and dampers have been enabling devices in the development of quieter, more comfortable and more reliable aircraft, reducing both Direct Operating Cost (DOC), and interior noise and vibration, and thereby increasing the acceptability of helicopter transportation.

How is this so?

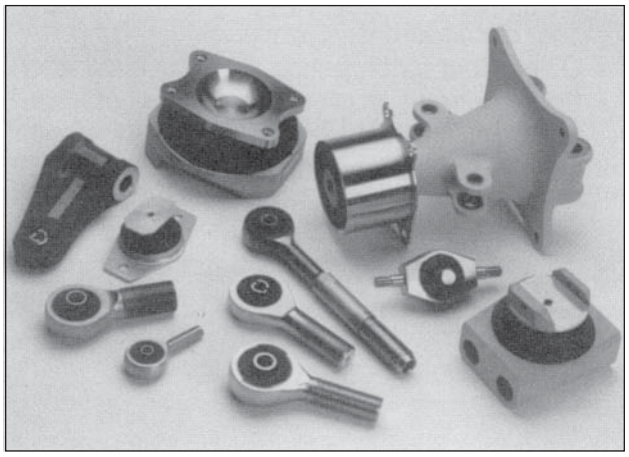
A bearing is a mechanical device that accommodates dynamic motions. The term "bearing" is often used to refer to shaft-supports, which allow continuous rotation. **Elastomeric bearings** also allow rotational motion, but are limited to oscillatory motions (from 10 to 90 degrees, or up to ±1 inch). They also offer some clear advantages over "hard bearings."

- The elastomer layer(s) add a "spring" effect, tending to restore the angular motion back to the undeflected position.
- Elastomeric bearings have no "clearance," and therefore no "chatter" or possible fretting, and also no increase in clearance as they wear. This results in smooth performance throughout the life of the part.
- The degradation of elastomeric bearings is gradual and fail-safe.
- Elastomeric bearings are maintenance-free. One significant specific example: Unlike hard bearings, elastomerics are unaffected by airborne particles of sand and dirt, which notoriously cause accelerated wear in hard bearings.
- On-condition removal criteria are determined during bench-testing. This allows the wear patterns and limits to be quantified and helps avoid premature removal of adequately functioning parts, saving DOC.
- The elastomer in the bearing smooths the operation of the dynamic system, which inherently reduces vibration and often improves control system response.

An **Isolator** is a device installed in a load path to minimize the transmission of dynamic loads or motions through it. Isolators can be made with various elastomers or with an elastomer/fluid (LORD Fluidlastic®) device, creating optimal isolation at the primary vibration frequencies.

Dampers are used to attenuate dynamic motions in the aircraft, most often in the rotor. Elastomeric dampers can be used with or without special fluids, which have the added advantages of more **damping force** for a given dynamic motion and consistent performance within wide ranges of temperature and dynamic motions. Both Elastomeric and LORD Fluidlastic dampers have demonstrated superior performance and cost effectiveness, with smaller size and weight, when compared to hydraulic dampers.

Figure 1 – Collection of LORD Elastomeric Bearings used in helicopters, including shear restraints used in bearingless rotors, main rotor bearings and pitch link rod end bearings



How to Care for Elastomerics

The three types of elastomeric helicopter components have similar inspection and care guidelines. Through long-term testing at LORD Corporation as well as inspection of returned-from-service parts from civilian and military aircraft, the primary forms of degradation have been identified:

- Elastomer fatigue from dynamic loading
- Overload or inappropriate loading (Foreign Object Damage, Tool Damage or Tension Loading)
- Oil or other incompatible fluid contamination
- Environmental degradation (effects of heat, ozone)
- Loss of fluid or pressure in LORD Fluidlastic Isolators or Dampers

How can you identify these degradation modes, and which ones can you prevent?

Fatigue

Elastomer fatigue is the normal degradation mode of a bearing in oscillatory loading. A part can experience a surprising amount of crumbing, cracking and rubber loss before there is noticeable performance impact.

As an elastomeric component is used, small surface cracks eventually form, starting in the highest strain region of the part. The crack edges rub together, growing slowly, and the abrasion causes what is most typically observed as “crumbing” (like eraser crumbs). See Figure 2. The cracks continue to grow and join together over time, and small segments of elastomer may also be extruded from the layer(s). Eventually, either a substantial portion of the rubber will be extruded, or the cracks will grow to a removable condition. Other indications the part should be removed include increased vibration, touching or cracked metal shims. The applicable Component Repair & Overhaul (CR&O) Manual or Maintenance Manual is the definitive source for specific removal criteria for each application.

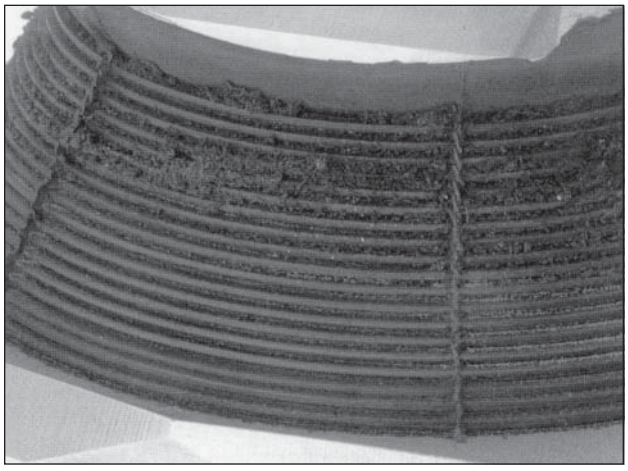
Dampers, which are often made with higher damped LORD BTR® elastomer, show the same degradation modes. Fatigue damage is generally not preventable, but is a function of the amount of time that the aircraft is operating at the most strenuous conditions.

Overload or Tension Loading

Elastomeric parts are designed to operate generally in COMPRESSION, and/or SHEAR. Main Rotor Bearings, for example, normally carry loads in compression, and accommodate motion in shear. Compression loading occurs when the forces on the part are in a direction that tends to “squash” the material. In fact, elastomeric parts may show “bulging” of the elastomer around the edges when they are loaded. Shear loading occurs when the load on the part tends to stretch the elastomer in a direction perpendicular to its smallest dimension or parallel to the “bond line.” See Figure 3.

In the event that a part is placed in TENSION (which occurs when the elastomer is stretched, like a rubber band or a balloon), the elastomer has less strength, and will tend to crack and wear much more quickly. Both bearings and dampers are designed to avoid being placed in tension. When a part experiences a shear or tension load for which it was not designed, the tear

Figure 2 – Typical fatigue “crumbing”



This part is still completely functional.

Figure 3 – Shear sample before load is applied

strength of the elastomer or the metal-to-rubber bond may be exceeded. This may result in large clean cracks in the layers, complete separation of the layers, or damaged metal shims (bending or cracking).

Damage to a part during installation – due to contact with a sharp object, placing the part in tension or applying inappropriate forces or motions – can shorten the life of the elastomeric component. Special care should be taken to prevent the slicing, puncturing or gouging of the elastomer or bond line in any elastomeric part. Also whenever possible, it is desirable to remove any large static loads from elastomeric bearings when the aircraft is in storage. Blade folding and tie-down, for example, may include very high cocking motions to some rotor bearings. Finally, care should also be taken to protect the edges of the thin metal laminates (shims) from nicks or other damage, since this can significantly reduce the fatigue life of the part. Figure 4 shows a part that experienced overload after the elastomer section had been damaged.

Oil or Other Incompatible Fluid Contamination

Elastomeric materials have been developed to improve resistance to various aircraft fluids, solvents and detergents. Still, petroleum-based oils, fuels, hydraulic fluids and greases can have a devastating effect on the elastomer and the bond, and can very quickly cause weakening, swelling and extrusion.

Parts exposed to oils, greases and hydraulic fluids should be washed in mild detergent and water or denatured alcohol to prevent further damage. In the event of exposure to more volatile fluids such as fuel, solvents or cleaning fluids, the parts should be dried, and the fluid allowed to evaporate. To prevent this serious and avoidable degradation, special care should be taken to cover the elastomer surface when cleaning equipment nearby.

Environmental Degradation (Effects of Heat, Ozone)

Daily exposure to sunlight, heat and ozone can also cause surface cracking, often appearing perpendicular to the load in the elastomer. These surface cracks are small, and are not cause for removal. As the part is cycled, these may become sites for initiation of the expected fatigue cracks. Electric generators and motors as well as bright sunlight increase the presence of ozone.

Most elastomers contain waxes designed to offer protection from ozone. The waxes are designed to come to the surface of the part over time and provide a protective layer, (called wax bloom), which often appears gray or brown, and may flake or crumb as the part is exercised.

Excessive heat will cause most bearings and isolators to become brittle on the exposed surfaces. (Heat does not normally cause the elastomer to “melt” or soften). The rubber-to-metal adhesives are also sensitive to heat, and performance of the part can be degraded as a result

Figure 4 – Helicopter Landing Gear Mount that has experienced damage from a tool

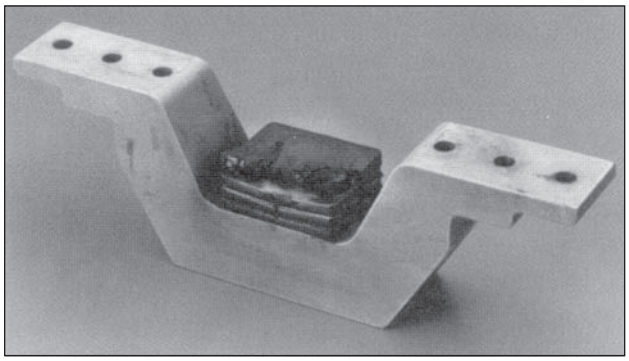
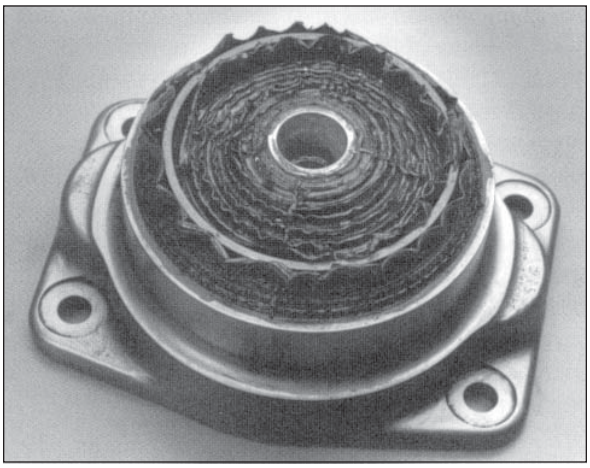


Figure 5 – Engine isolator with severe oil contamination



Note the wavy edges and the de-bonded layers. This part is no longer operational.

of prolonged exposure to high temperatures. Prolonged exposure or storage at high temperatures (above 125°F [52°C]) also may contribute to stiffening of the elastomer, as well as compression or torsion "set" or "drift" in parts that have steady static loads. Certainly, material and adhesive selections are determined based on the expected environment and usage of the parts. If you have an environment that could be considered unusual, it may be necessary to perform more frequent inspections.

LORD BTR elastomers have been developed to reduce the effects of heat, chemicals and ozone, and they are used where there is known exposure to these effects.

Loss of Fluid or Pressure in LORD Fluidlastic Isolators or Dampers

LORD Fluidlastic devices have many of the same wear modes as typical elastomerics. They are completely sealed, and there is generally no requirement to monitor, fill, pressurize or meddle with the fluid. The fluids used are not harmful, in the event of accidental exposure. There is generally no provision for anyone other than LORD Corporation to repair, refill or maintain the part. For certain applications in which dynamic performance is considered critical, pressure or leak detection methods have been incorporated or are being requested to provide positive assurance that the dampers or isolators are completely functional. The applicable CR&O Manuals or Maintenance Manuals provide all of the information necessary for such applications.

Summary

Elastomeric and LORD Fluidlastic Dampers, Isolators and Bearings have become important elements of the modern helicopter. They offer unique advantages in performance, enabling several new rotor design concepts, while reducing DOC, noise and vibration. Their inspection and appropriate replacement are key to obtaining maximum life and usage from each one.

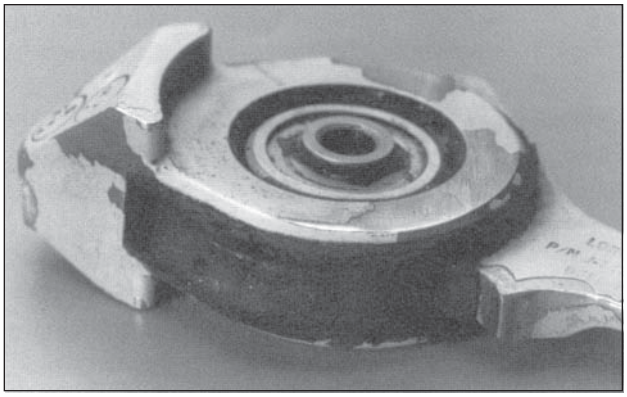
LORD Suggested Removal Criteria

While an understanding of the degradation modes of elastomeric bearings is valuable in and of itself, the critical question posed by most operators is "How do I determine if the bearing is still serviceable?" The photos presented in this article are intended to help you decide in the majority of cases.

Because of the wide variety of applications, bearing geometry and operators, there may not be a simple answer. In every case in which removal criteria exist in a maintenance manual, it should be followed. However, when the elastomeric bearing is not covered by a maintenance manual, the following general guidelines may be used:

- If the bearing is visibly degraded to such a degree that it allows excessive motion or vibration, remove and replace it.
- If the bearing has visible compression set, and it appears this will lead to difficulty in installation or increased vibration, remove and replace it.

Figure 6 – Typical ozone "checking" on a part



The small cracks have no measurable depth.

Figure 7 – Unacceptable fatigue and fluid contamination on Turboprop Engine Mounting (DeHavilland Dash 8)

- If enough elastomer has been extruded to allow the shims to touch or if there are any cracked shims, remove and replace the bearing.
- If the bearing is separated (due to fatigue or bond line damage) over more than 25% of the bonded area, remove and replace it.
- If the bearing is "oil" contaminated to a slight degree, it should be cleaned with a water-based detergent, rinsed and dried. If the contamination damage is extensive, removal and replacement are required.
- If the bearing exhibits a very unusual damage condition, it should be returned to the OEM Product Support Organization for further analysis.

Again, the best removal criteria are always based on the maintenance manual and experience. However, when in doubt, take it out!

Where to Go for More Information

LORD has complete maintenance manual instructions available for most helicopter and fixed wing aircraft applications. If a maintenance manual is not available, our team of product support specialists will respond to your request.

Figure 8 – Acceptable fatigue on Helicopter Nodal Beam (Bell 214 Type)

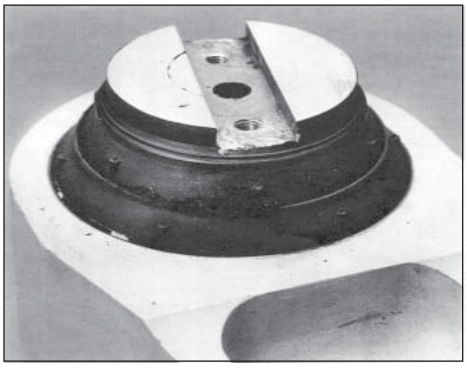


Figure 9 – Acceptable heat exposure on Engine Mounting for Turboprop Aircraft (DeHavilland Dash 8)

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