April 19, 2001

NTSB SE REGIONAL OFFICE
8405 NW 53TH ST
SUITE B-103
MIAMI, FL 33166

Attn: Mr. John Levell

Subject: Continuous Airworthiness Procedures for Lord Tail Rotor Teetering Bearing, P/N LB2-1056-1-9

Mr. Levell,

Following evaluation of the Lord Tail Rotor Teetering Bearing investigated in the mishap referenced in NTSB Report: MIA00TA200, Lord has reviewed the current inspection and maintenance practices found in the MD 500 Rotorcraft Flight Manual and Maintenance Manual for content and accuracy. Excerpts from both manuals pertaining to the elastomeric bearings are provided.

As a minimum requirement the bearings are to be inspected as a part of the “Daily Preflight Checks” in accordance with MD Helicopter Rotorcraft Flight Manual as follows:

Tail rotor drive for elastomeric bearings (if installed):

Note: Check bearing for general condition. Elastomeric bearings are suspected of being unserviceable if rubber deterioration or separation, or a vibration is noted. Evidence of light swelling, pock marks and crumbs are surface conditions and are not indications of bearing failure.

* Apply teetering force by hand to tail rotor blades (stop-to-stop). Check for fork-to-bearing bond failure. Failure is indicated by any motion between the outer bearing cage and fork (bearing turns in fork).

* Teeter blades stop-to-stop. Observe for radial molded ridges on each bearing as teetering takes place. If ridges assume continuous curved shape, bearings are intact. Discontinuity in molded ridges indicates bearing failure.
Furthermore, during each 100 Hour / Annual Inspection the bearings are inspected in accordance with the MD Maintenance Manual, CSP-HMI-2, as follows:

**ANTI-TORQUE**
* Tail Rotor System
* Drive fork for:

- Elastomeric bearing elements for bond failure.

* Apply teetering force by hand (stop-to-stop) to rotor blades and inspect elastomers for radial-molded ridges on each bearing face. Discontinuity in molded ridges indicates bearing failure. There should be no apparent motion between the cage and fork, observed motion indicates failure.

Note: Light swelling, pock marks and crumbs are surface conditions and do not indicate bearing failure.

The recommended interval and procedures for elastomeric fork bearing inspection outlined in the referenced manuals provide a sufficient methodology in determining bearing serviceability and if followed, assures there will not be long term operation of debonded bearings.

In conclusion, these continuous airworthiness instructions have been utilized for the past 20 years with no adverse airworthiness issues having been identified resulting from lack of inspection or maintenance. Therefore, there are no recommendations at this time to changes the existing maintenance procedures.

Should you have any questions or comments, please do not hesitate to contact me.

Regards,

[Signature]
Daniel L. Byers
Rotary Wing Product Support Manager
Lord Corporation
September 19, 2000

Boeing Mesa
5000 East McDowell Road
MC 530-B145
Mesa, AZ 85215-9797

Attention: Mr. Richard Nord

Reference: Lord PN LB2-1056-1-9, SN LK9236 and SN LK8149

Subject: Returned Material Analysis Report, RMA00-013, 9/11/00

Dear Mr. Nord:

Please find enclosed three color copies of the subject report. (Note: We also included the original signature page containing the Lord signatures. If you'd like, please sign that page, make your copies, and then return the original to me for our archives.) As we discussed today, Boeing, rather than Lord, will be submitting the report to Mr. John Levell at NTSB.

As we discussed during our meeting in August, Mr. Dan Byer, Lord Product Support, will be sending a separate letter, summarizing our comments, directly to Mr. Levell. We will provide you with a copy of this correspondence as well.

Once again, thank you for sharing your time and expertise during the investigation. Please contact me, extension 2314, if you have any questions or need additional information.

Sincerely,

Cynthia R. Fowle
Quality Manager, Erie Plant

cc. D. Byer
    M. Rose
    C. Garrett
    S. Redinger
    D. Russell

L/MP/CRF-037/2000
Date: 09/11/00  
RMA Number: RMA00-013  
Part Number: LB2-1056-1-9  
Qty. Returned: 2  
Date Returned: 08/22/00  
Cure Date: 1998  
Service Life: Unknown  
Customer: Florida Wildlife Service/Boeing Helicopters  

Service Requested: Document the service damage of two LB2-1056-1-9 elastomeric teetering bearings, both of which were involved in an aircraft incident on July 2, 2000.

COMMENTS FROM CUSTOMER

NTSB Identification: MIA00TA200

Accident occurred JUL-02-00 at DESTIN, FL
Aircraft: Hughes 369D, registration: N88MP
Injuries: 1 Uninjured.

This is preliminary information, subject to change, and may contain errors. Any errors in this report will be corrected when the final report has been completed.

On July 2, 2000, about 1150 central daylight time, a Hughes 369D, N88MP, registered to and operated by the Florida Fish and Wildlife Commission as a Title 14 CFR Part 91 public-use flight, experienced a tail boom separation while in flight, in Walton County, Florida. Visual meteorological conditions prevailed, and no flight plan was filed. The commercial-rated pilot was not injured. The flight originated in Panama City, Florida, the same day, about 0930. The pilot stated that the aircraft was in level flight at an altitude of 500 feet, an airspeed of 100 knots, and operating at 65 to 70 P.S.I. torque, when he felt a high frequency vibration coming through the antitorque pedals. The vibration became excessive, he heard a loud bang, and the aircraft yawed violently to the right, the nose pitched down, and manipulation of the antitorque pedals had no effect. The pilot executed an emergency autorotational landing in a clearing in the woods. Examination of the
The stabilizer, 90-degree gear box and 18-inch section of the hollow portion of the tail boom were located and retrieved. The tail rotor hub assembly (which contains the tail rotor blade assembly and tail rotor fork assembly with the LB2-1056-1-9 teetering bearings) and the 90-degree gearbox assembly were found intact. As noted in the incident report, the 90-degree gearbox was partially separated from the tail boom at the attachment bolts. Three of the four attachment bolts were fractured. The two LB2-1056-1-9 teeter bearings, which are located in the tail rotor fork assembly, accommodate blade flapping motions while reacting the axial out-of-plane tail rotor thrust loads and radial in-plane torque loads. The elastomeric bearing assemblies and the related hardware were found intact. Both of the elastomeric bearings were found to have damage in the elastomer section of the first layer which is adjacent to the inner most member.

Analysis was requested by the NTSB lead investigator, Mr. John Levell to determine the involvement of these two parts in the cause of the crash.

CONDITION OF PARTS AS RECEIVED AT LORD

From photographs taken after the crash incident, the installation orientation was determined. As seen in Figure 1, the inner member of one of the bearings, located on the bolt head side of the installation, has been displaced several thousandths of an inch toward the inboard side of the tail rotor fork housing. For convenience of reporting, this bearing is designated “bearing #1” throughout this report. The bearing located on the nut side of the installation shows no axial displacement of the inner member. Throughout this report, this bearing will be referenced as “bearing #2”. After disassembly of the tail rotor assembly at the investigation site, the inner members of both bearings were found to be separated at the first elastomer layer which is located between the inner member and first metal shim. Visual inspection of bearing #1 revealed that a portion of the elastomer layer between the inner member and the adjacent shim was missing, as seen in Figure 2. There was also evidence of metal to metal contact and wear at this location.

Both bearings were hand carried to Lord by Mr. R. J. Nord, Materials, Processes and Standards Dept. Metallurgist from Boeing, Mesa, Arizona for analysis. He remained and observed Lord’s analysis. During the analysis activity, the shim segments were cryogenically removed from their assembly so that additional testing could be performed. After analysis was completed at Lord, Mr. Nord carried all part segments back to Boeing for return to NTSB’s Mr. Levell.

ANALYSIS

1. **Bearing #1, S/N LK9236**: This part was manufactured in 1989 or earlier. Due to Lord’s seven year record retention policy for non-designated parts, no manufacturing records of its fabrication remain. The general appearance of the elastomer in other than the innermost layer was as expected for a part of this age and presumed service life. Oxidation and ozone cracking of the elastomer surface regions was noted. In general, these cracks extended less than 0.02 inch into the surface.
A summary of the probable damage sequence for this bearing follows:

a. The elastomer layer between the inner member and first metal shim cracks - cause unknown.
b. Normal continued operation results in relative motion between the fracture surfaces; this wears away the elastomer. The load orientation localizes wear damage to one quadrant, see Figure 2.
c. After local erosion of the elastomer layer, metal to metal contact occurs between the inner member and first shim. Continued operation results in galling of the two metal surfaces; the shim being damaged the most.
d. At this point, the amount of relative motion has increased such that other elements in the tail rotor assembly are subjected to increased vibrations and their resulting influences.

In the fracture layer, except in the local region where metal to metal contact had occurred, the primer and adhesive elements remained intact. Also, all observed fracture surfaces were contained within the elastomer layer and did not involve the primer or adhesive interfaces. This indicated that the part as manufactured had excellent bond integrity. Figure 3 shows a SEM image of the region surrounding the galled area. There were several layers noted as indicated by the various hues of gray. Energy Dispersive X-ray Spectrometry (EDS) microchemical analysis was conducted of each region to determine the exact exposed surface (i.e. bare metal, primer, adhesive or elastomer). Each of these regions is denoted in Figure 3 and the corresponding composition is presented in Figures 4, 5, 6, and 7.

<table>
<thead>
<tr>
<th>Figure 3 Location</th>
<th>Figure Number</th>
<th>Significant Elements</th>
<th>Characteristic Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Fig. 4</td>
<td>Fe, Cr, Ni, C</td>
<td>304 Stainless Steel</td>
</tr>
<tr>
<td>B</td>
<td>Fig. 5</td>
<td>C, Si, Cl, Ti, Zn</td>
<td>Primer Material</td>
</tr>
<tr>
<td>C</td>
<td>Fig. 6</td>
<td>C, Zn, Si, S, Cl</td>
<td>Adhesive Material</td>
</tr>
<tr>
<td>D</td>
<td>Fig. 7</td>
<td>C, Zn, S, Ca, Cl</td>
<td>Elastomer Material</td>
</tr>
</tbody>
</table>

Various photos were taken of the region where metal to metal contact had occurred. Figure 2B shows the galled condition of the inner member. The shim also exhibited galling as shown in Figure 8. On the galled shim surface, metal wear, cracking and minor fretting corrosion was noted. The galled region of the shim measured 0.006 to 0.009 inch, about 50% of the design tolerance of 0.013 to 0.017 inch. The inner member is fabricated from 17-4PH stainless steel heat-treated 145-175 ksi ultimate tensile strength with an expected average hardness value of Rc 35. The shim is fabricated from 304 stainless steel in the annealed condition; maximum hardness value of Rc 20. Therefore, the shim is the component that is expected to have greatest wear from galling.

The shim was sectioned into two halves so that the galled region could be further analyzed. Figure 9 shows the SEM image of the galled surface with regions of fretting corrosion noted. A representative discolored region was microchemically analyzed using
EDS. Figure 10 is the X-ray spectrum showing x-ray peaks for C, O, Cr, Fe, Cl and Ni. The high oxygen peak indicates probable corrosion products in this region.

When the removed shim's outside surface and its corresponding elastomer layer were examined, as seen in Figure 11, they revealed discoloration and thermally induced local bond separation where the galling had occurred on the inside surface. Further examination of the galled region revealed cracks, both transverse and circumferential throughout (see Figure 12). Also noted, as shown in Figure 13, was that the predominant direction of galling was in the circumferential, or torsion direction loading of the bearing.

The shim was then separated along the crack network so the crack surfaces could be examined. Figure 14 shows a typical crack surface. The cracks did not contain fatigue striations and several initiation sites were seen along the crack on the galled, or inside surface. As an example, Figure 15 shows that many of the crack surfaces also contained wear damage.

A cross section of the shim was taken in the region of galling. Figure 16 illustrates the reduced thickness of the shim as a result of the galling. In the galled region, several cracks were seen initiating from both the galled surface and outside surface of the shim (see Figure 17). After etching, the microstructure as shown in Figure 18 was found to be typical of 304 stainless steel, annealed. Also noted were changes in the microstructure at the galled surface, caused by the wear/abrasion action between the shim and inner member.

2 **Bearing #2 S/N LK 8149**: This part was manufactured in 1988 or 1989. Due to Lord's seven year record retention policy for non-designated parts, no manufacturing records of its fabrication remain. The general appearance of the elastomer in other than the innermost layer was as expected for a part of this age and presumed service life. Like bearing #1, oxidation and ozone cracking of the elastomer surface regions was noted. In general, these cracks also extended less than 0.02 inch into the surface. Figure 19 shows the two sections of the bearing, exhibiting the surface cracking and illustrating that the fracture is in the first elastomer layer. Examination of the fracture surface showed the crack to be torsion load induced. As shown in Figure 20, it progressed by fatigue and remained completely in the elastomer. A crack initiation location was near the shim on one portion and a second initiation location near the inner member approximately 180° around the circumference. A transition of the crack through the thickness of the elastomer layer occurred as the two fronts approached one another. Very little wear damage was seen on the fracture surface. The wear damage that was present was indicative of torsion induced fatigue. From the relative lack of fracture surface wear, this crack occurred very late in the total damage sequence.

**CONCLUSIONS**

1 Elastomer fatigue fracture occurred in bearing #1, S/N LK9753, followed by wear and galling from continued operation of the aircraft.

2 After localized torsion induced wear of the elastomer, metal to metal contact occurred between the inner member and the first shim. Galling of both metal surfaces resulted,
with the shim wearing to approximately one-half its original thickness. Wear and galling induced a local network of cracks through the thickness of the shim.

3 The extensive damage and heat induced discoloration of the shim on bearing #1 is an indication that the original crack initiation in the elastomer layer occurred well before the reported accident.

4 Elastomer fatigue fracture occurred in bearing #2, S/N LK8149. The fracture occurred later than the one in bearing #1. Only minimal wear of the fracture surface was observed.

5 No evidence of manufacturing anomalies was found in the investigation of these two bearings.

6 Minimal evidence was found to indicate solutions attack of the elastomer had occurred. Significant exposure of these two bearings to materials such as WD-40 has not occurred.
Figure 1. Assembled bearings after the incident.
Figure 2. Bearing #1 showing galling of A. first shim and B. inner member.
Figure 3. Bearing #1, shim 1 showing fracture surface and galled region.
Figure 4. Microchemical spectrum of galled region A in Figure 3.
Figure 5. Microchemical spectrum of primer, region B in Figure 3.
Figure 6. Microchemical spectrum of adhesive, region C in Figure 3.
Figure 7. Microchemical spectrum of rubber, region D in Figure 3.
Figure 8. Galled region of shim; A. near large diameter and B. near small diameter of conical shim.
Figure 9. SEM view of corrosion in galled region of shim.
Figure 10. Microchemical spectrum of discolored (corroded) area in galled region of shim.
Figure 11. Appearance of elastomer layer after freeze fracture removal.
Figure 12. Circumferential and transverse cracks in galled region of shim.
Figure 13. Direction of galling in the circumferential direction.
Figure 14. Examples of crack surfaces in galled region of shim.
Figure 15. Some crack surfaces show wear.
Figure 16. Shim cross section in galled region.
Figure 17. Cracks in galled region originating from both surfaces.
Figure 18. Etched microstructure of shim in galled region.
Figure 19. Bearing #2 fracture appearance showing 100% elastomer break.
Figure 20. Oxidation attack of elastomer surface; bearing #2.