ENCLOSURE 2

Inspection of Motor Operated Valve Limitorque AC Motors with Magnesium Rotors

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Inspection of Motor Operated Valve Limitorque AC Motors with Magnesium Rotors

A Technical Product of the BWR Owners Group
Valve Technical Resolution Group

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NOTICE

This guideline contains information for inspection of Reliance AC MOV motors with magnesium rotors, based on industry operating experience and the collective engineering expertise of the BWROG Valve Technical Resolution Group. It is the decision of each member utility to implement any or all of these guidelines.

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Participating Utilities

The Valve Technical Resolution Group is a non-generic committee and all BWROG members participated, at the time of this report the BWROG membership included:

Utility (Members)

Constellation – NMP	Exelon (P/L)
DTE Energy – Fermi	FPL - DAEC
Energy Northwest – Columbia	FirstEnergy – Perry
Entergy – Fitzpatrick	NPPD – Cooper
Entergy – Pilgrim	NMC – Monticello
Entergy – VY	PPL – Susquehanna
Entergy – RB/GG	PSEG – Hope Creek
Exelon (Clinton)	Progress Energy – Brunswick
Exelon (OC)	SNC – Hatch
Exelon (D/Q/L)	TVA – Browns Ferry

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1. EXECUTIVE SUMMARY

Recent US Nuclear industry motor operated valve (MOV) failures due to magnesium motor rotor degradation warrant additional action to better monitor and evaluate magnesium rotors installed in Reliance MOV AC motor applications. Internal inspection of motor rotors by use of a borescope or via motor disassembly is recommended. Using the standardized acceptance and inspection schedule prioritization criteria described herein, motors will be scheduled, inspected and evaluated as Failed (Unacceptable), Degraded or Acceptable. This recommended approach is especially paramount for high-risk applications of motors that are not accessible during normal plant operations. This document provides recommendations for inspecting susceptible MOV motors for BWROG members and its affiliates.

2. INTRODUCTION

MOV operators supplied with Reliance AC motors with magnesium rotors are susceptible to catastrophic failure of the motor rotor and stator preventing the actuator from being able to perform its intended safety function. Motors supplied with aluminum rotors are not subject to the same failure mechanisms. This document was produced as a users guide to better understand rotor failure, methods of inspection, inspection criteria, examples of satisfactory and unsatisfactory conditions, and MOV programmatic implementation.

3. HOW TO DETERMINE IF A MOTOR HAS A MAGNESIUM ROTOR

3.1 Electric Apparatus, Paramount and Peerless Motors

Some Limitorque operators were supplied with electric motors manufactured by Electric Apparatus, Paramount and Peerless. It has been confirmed by Limitorque that motors supplied by Electric Apparatus, Paramount and Peerless do not have magnesium rotors, they were supplied with aluminum rotors. Therefore, all such motors are not susceptible to the failure mechanisms covered in this report.

See Reference 13.7, Limitorque Technical Updated 08-01 concerning rotor material of Electric Apparatus, Paramount and Peerless motors.

3.2 Reliance Electric Motors

Baldor Electric Motor Company purchased Reliance Electric and now produces and supports the Reliance electric motor line. For the purpose of this document, all MOV motors will be referred to as manufactured by Reliance, which is now Baldor/Reliance.

Limitorque operators supplied with Reliance motors can have magnesium rotors. This is dependent upon frame size; start torque; and speed of the motor. Limitorque has provided the industry with Technical Update 08-01 (Reference 13.7) which provides a general classification for Reliance motors supplied with magnesium rotors.

3.2.1 48 and 56 Frame Motors

All 48 and 56 frame size motors supplied by Reliance were constructed with aluminum alloy rotors.

Frame Size	Speed (RPM)	Start Torque (lb-ft)	Rotor Construction
48	All	All	Aluminum Alloy
56	All	All	Aluminum Alloy

3.2.2 180 and Larger Frame Motors

Frame sizes 180 and larger were all constructed with magnesium alloy rotors prior to the early 1990's. Certain frame sizes have been converted to aluminum alloy rotors since that time. The following tables provide a general guideline on motors that have been converted to aluminum alloy rotors. The recommended method of determining rotor material is to contact Limitorque directly with the serial number/nameplate information.

Motors Converted to Aluminum Alloy Rotors in Early 1990's			
Frame Size	Speed (RPM)	Start Torque (lb-ft)	Rotor Construction
180	1800	40	Aluminum Alloy
180	3600	40	Aluminum Alloy
184	1800	60	Aluminum Alloy
210	1800	100	Aluminum Alloy

Motors Presently Available with Aluminum Alloy Rotors *			
Frame Size	Speed (RPM)	Start Torque (lb-ft)	Rotor Construction
210	3600	60	Aluminum Alloy
210	1800	80	Aluminum Alloy
210	3600	80	Aluminum Alloy
256	1800	150	Aluminum Alloy
256	1800	200	Aluminum Alloy

* Notes

1. If an aluminum alloy rotor motor is supplied, the speed/torque/current curve could be different from the original magnesium rotor motor. This should be evaluated in the utility MOV program.

2. The list of large frame motors available in aluminum is subject to change. Contact Limitorque directly for the latest information.

3.2.3 Reliance Electric Motor Corporate Date Code

Appendix 1 is the Reliance Electric Motor Corporate Date Code which determines the month and year of manufacture of the electric motor. This chart should be used in conjunction with the nameplate information on the motor.

Figure 1 – Month and year of manufacture can be determined by the last two alpha characters in the Identification Number field. This motor has a data code of HC, which corresponds to a manufacturing date of August 2000 as shown on Appendix 1, Reliance Electric Motor Corporate Date Code.

3.2.4 If uncertain as to the rotor type of a Reliance supplied motor, contact the Limitorque Corporation with the motor serial number and nameplate information to determine if the motor was supplied with a magnesium alloy or aluminum alloy rotor. The results of rotor type should be documented in the utilities' MOV program.

4. DEGRADATION MECHANISMS

The causal factors (degradation mechanisms) leading to magnesium rotor failure have been documented by many sources including NRC Information Notice (IN) 2006-06, Failure of Magnesium Rotors in Motor-Operated Valve Actuators (Reference 13.1) and IEEE Transactions on Energy Conversion, Vol. 3, No. 1, "An Investigation of Magnesium Rotors in Motor Operated Valve Actuators", March 1988 (Reference 13.4). The following is a summary of causes from these sources.

The typical magnesium rotor is made of stacked, steel punched core plates with AM100A magnesium alloy (approximately 90% magnesium, 10% aluminum, 0.1% manganese) components—the conductor bars, end rings, and cooling fan blades—cast to complete the rotor. While magnesium provides higher torque, as compared to aluminum, through its higher resistivity, this relatively brittle cast alloy is susceptible to shrinkage cracking and gas porosity. Specifically, magnesium rotors are susceptible to three main degradation mechanisms: galvanic corrosion, general corrosion, and thermally induced stress.

4.1 Galvanic Corrosion

Following manufacture, the electrical potential difference between the cast magnesium and the steel core is 1.9 volts creating the conditions for galvanic corrosion, with the most vulnerable area being the interface between the steel core and the magnesium end ring. Galvanic corrosion will occur at this interface under humid/moist conditions. Most manufacturers alleviate this by protecting the magnesium end rings with a paint and/or lacquer coating. Though the rotor might be initially protected, even the smallest scratch or chip in this exterior coating will cause localized, accelerated corrosion in the form of magnesium hydroxide (MgOH) powder. The formation of MgOH powder leads to rotor cracks that add to the existing problems of shrinkage cracking, gas porosity, and MgOH volume difference. Motor overheating events (typically due to locked rotor conditions) accelerate this coating degradation. A propagating crack at the interface between the stacked core and the end ring causes a high resistance connection with the end ring, which in turn causes a high current density (due to current redistribution) on the opposite side of the rotor. This increased current density increases the temperature on that side of the rotor resulting in thermal stress. At the steel-magnesium interface, the higher temperature may melt the magnesium into small beads. These thermally-stressed rotor areas and the melted magnesium beads then provide new opportunities for coating degradation and cracking resulting in new areas of high resistance between the stacked core and end ring and new areas of the rotor with a higher current density. This cycle of events can then repeat around the rotor.

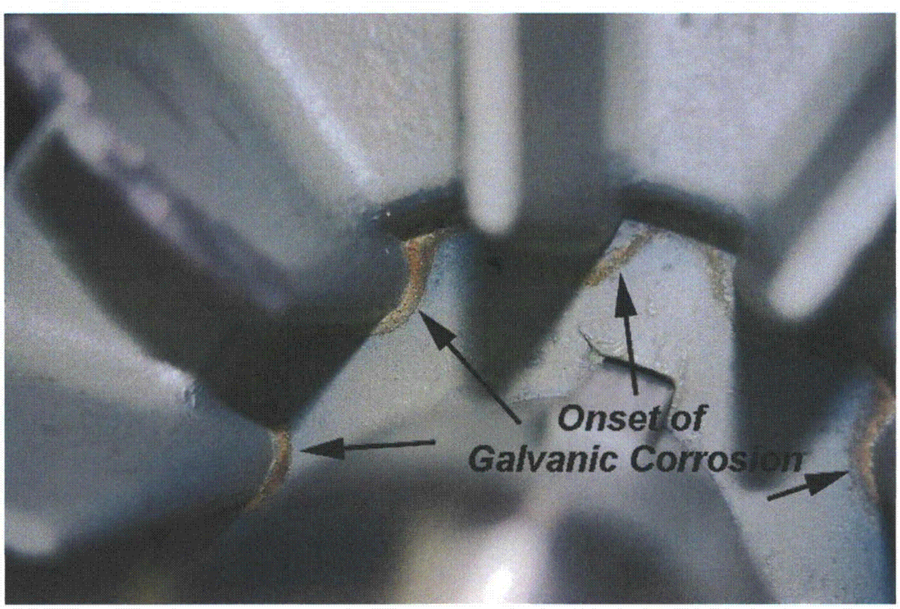

Figure 2 – Onset of galvanic corrosion between magnesium end ring and end lamination.

4.2 General Corrosion

The second major degradation mechanism affecting magnesium rotors is general corrosion. Many actuator motors for safety related MOVs are located in high humidity plant areas. Consequently, some moisture intrusion into the motors is expected via motor T-Drains and the unsealed motor lead passageway. Moisture in contact with magnesium leads to the formation of MgOH and magnesium oxide (MgO_2). The white MgOH powder can form a light haze on the inside of the motor without impacting its operation. However, MgOH and MgO_2 can form corrosion between core plates (from the magnesium conductor bars) and at the interface between the stacked core and the end ring, causing high resistance points and the high current density phenomena stated above and even further cracking. The rate of general corrosion increases with higher humidity.

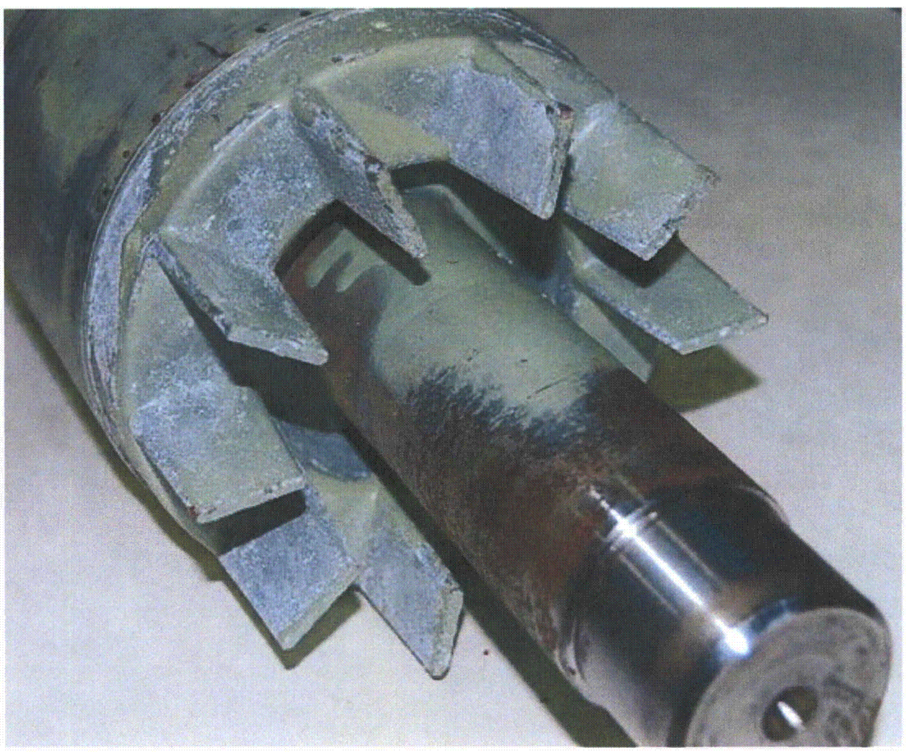

Figure 3 – General corrosion on magnesium end ring.

4.3 Thermally Induced Stress

The third major degradation mechanism affecting magnesium rotors is thermally induced stress which reveals itself in several different ways. First, because galvanic corrosion is thermally catalyzed, the corrosion rate increases with temperature, with a significant increase in the corrosion rate occurring at temperatures above approximately 93 C (200 F). The rate of galvanic corrosion increases when the motor is located in a higher temperature environment, as well as during general motor high-current conditions and/or within the high current density regions mentioned earlier. Secondly, magnesium has twice the thermal expansion coefficient of steel. This produces uneven axial and radial forces across the rotor causing further cracks in the magnesium and its paint and/or lacquer coating. Excessive motor cycling and inadvertent motor stalls are the most likely cause of thermally induced stress. For example, some rotors reach 700°F (371° C) in 15 seconds, and temperatures of 700°F to 850° F (371° C to 454° C) cause a significant loss of magnesium yield strength.

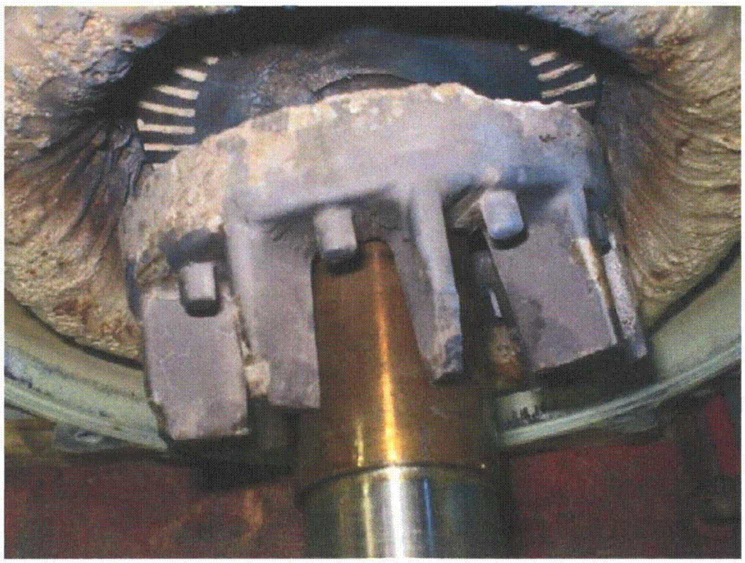

Figure 4 - Thermally induced stress failure of 150 lb-ft magnesium rotor. This motor was automatically energized by the control system at locked rotor conditions for approximately 0.4 seconds followed by six seconds of not being energized. This continued for approximately 90 minutes. The valve was bound in place so the motor rotor did not turn (operated at locked rotor condition). After approximately 90 minutes, the motor stator winding failed and a ground fault indication tripped the motor control center supply breaker.

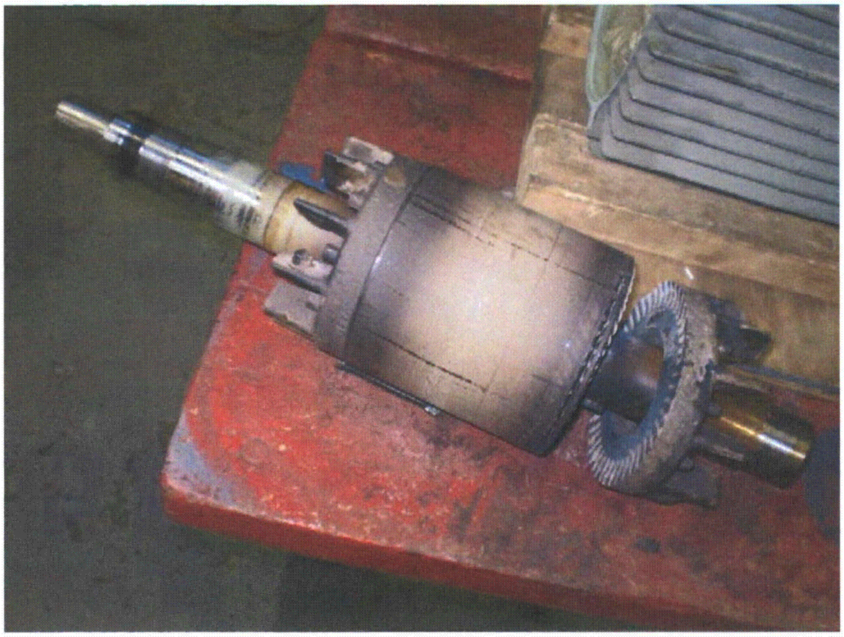

Figure 5 – 150 lb-ft magnesium rotor after removal from stator frame. Note the heavy heat damage on the magnesium rotor end rings as compared to that apparent on the center body of the rotor.

5. FAILURE MECHANISMS OF MAGNESIUM ROTORS

Magnesium rotors have two failure mechanisms. The motor rotor can fail due to deflection of the rotor cooling fins insofar that the fins contact the stator windings and cause an electrical failure of the motor. The second failure mechanism is the failure of the magnesium end ring and/or rotor bars by overheating. This causes beads of molten magnesium to form and become foreign material in the motor internals which can interfere with the rotor causing seizure and/or reduce the available torque of the motor to a fraction of nameplate torque.

5.1 Rotor Cooling Fin Interference with Stator Winding

When the interface between the magnesium rotor and the end lamination corrodes due to galvanic corrosion, corrosion products build up between these two components. The corrosion product causes the magnesium end ring to deflect radially outwards. This deflection can be so great that it causes the cooling fins of the rotor to come in contact with the stationary stator windings.

After the rotor comes in contact with the stator, it will cause mechanical damage to the stator and a turn-to-turn or turn-to-ground electrical failure occurs.

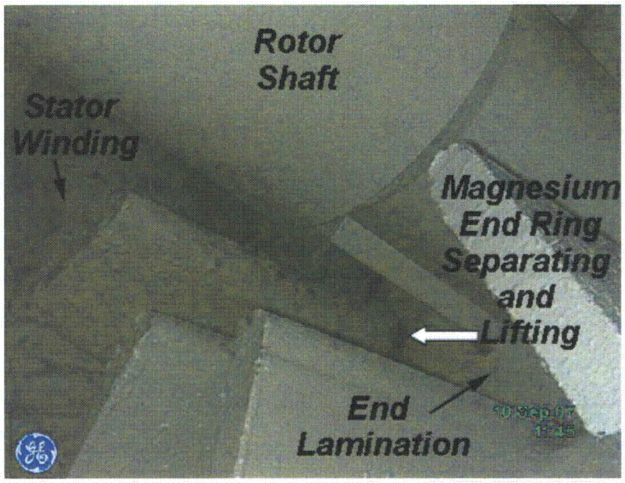

Figure 6 - Onset of magnesium end ring separating from rotor end lamination. The cooling fin has deflected outwards towards the stator winding but has not yet come in contact with the stator winding. This motor would not meet borescope inspection acceptance criteria.

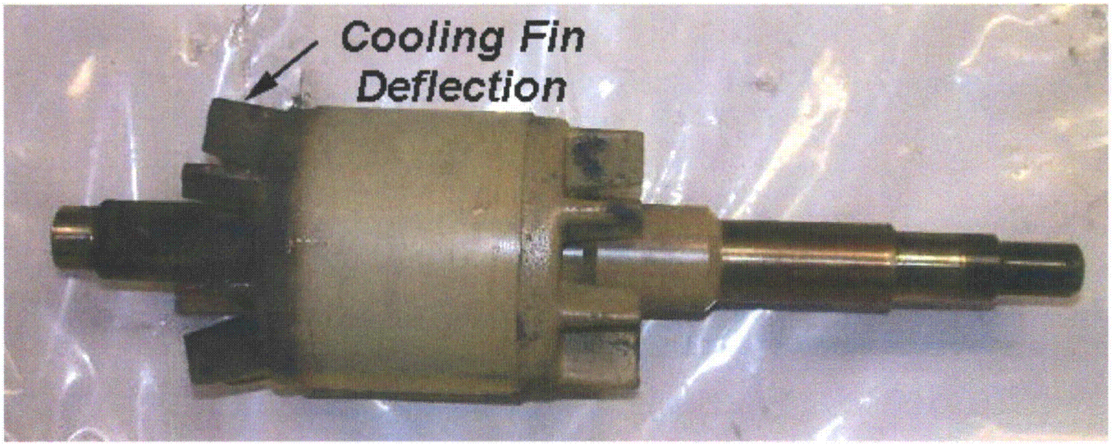

Figure 7 - Magnesium rotor with cooling fins deflected due to the growth of corrosion products between the end lamination and magnesium end ring. The rotor cooling fin came in contact with the stator winding and caused the motor to fail.

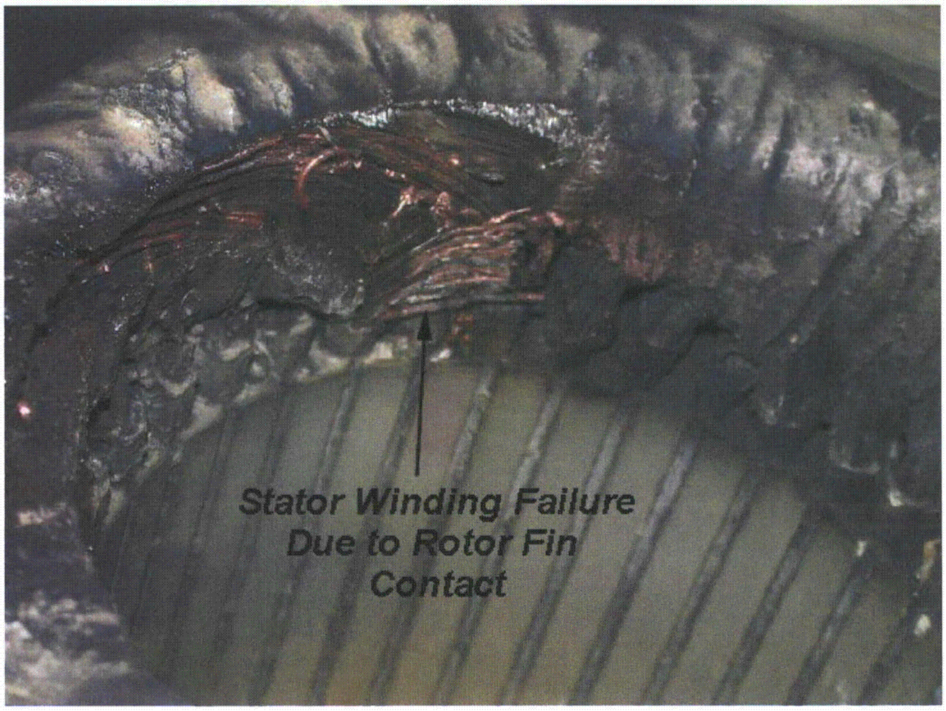

Figure 8 - Motor stator winding failure due to motor rotor cooling fins contacting the stator winding during operation. The cooling fins were deflected due to corrosion products between the end lamination and magnesium end ring.

5.2 Magnesium End Ring/Rotor Bar Failure

The second type of degradation of a magnesium rotor motor is when the rotor catastrophically fails due to the magnesium end ring and rotor bars melting. This can cause the rotor to no longer produce nameplate torque due to the failure of the rotor bars and shorting rings. It may also cause loose magnesium foreign material to enter the air gap between the rotor and stator. This can cause the rotor to abruptly seize in the stator bore.

In the case of this type of failure, there is a possibility that the degraded rotor condition could be evaluated by non-intrusive testing of the MOV at the motor control center. One diagnostic technique involves a standard fast Fourier transform of the reactive motor power data in the running load region. The difference in magnitude between the line frequency and the pole pass modulation frequency can be used to determine the likelihood of motor rotor bar degradation[1].

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[1] Motor Operated Valve User Group File 95S-P25, Magnesium Motor Testing Case Study, J Arnold (ComEd), M Delzingaro (Liberty Technology), July 1995

This condition can normally be associated with a locked rotor condition or severe excessive stroking of the operator. If the motor rotor has some level of galvanic corrosion in place, the safe stall time of the motor is most likely reduced making the motor more susceptible to this failure.

Figure 9 - Catastrophic failure of magnesium rotor where the magnesium casting melted during a locked rotor condition.

6. MOTOR INSPECTION PRIORITY

Visual inspection via borescope or disassembly is required to properly inspect the condition of a magnesium rotor to determine its acceptability of continued use. Other non-intrusive methods of inspection alone have not been proven to determine the acceptability of magnesium rotors susceptible to degradation factors discussed in section 5 of this document.

[[

[2] OE 27927, Magnesium rotor failure on main feedwater block valve (Crystal River 3)

{3}]]

7. REQUIRED EQUIPMENT FOR INSPECTION

7.1 Assembled Motors

To inspect assembled motors in the field installed on an operator or for motors in onsite storage, a videoscope/borescope is required to inspect the motor internals. The motor internals will be inspected via the access provided by removing the installed "T" drains or pipe plugs.

7.1.1 Video and Image Capture

Borescopes that will be used for inspection of the motor internals that can capture images are normally videoscopes, i.e. they capture videos (.avi, .mpg format) during the inspection. Some borescopes have the ability to capture both video and still images (.bmp, .jpg). Image quality is not compromised if using video or image formats. Each borescope system has a built in video/image quality built into it. Systems with a VGA (640 x 480 pixels or better) should be considered.

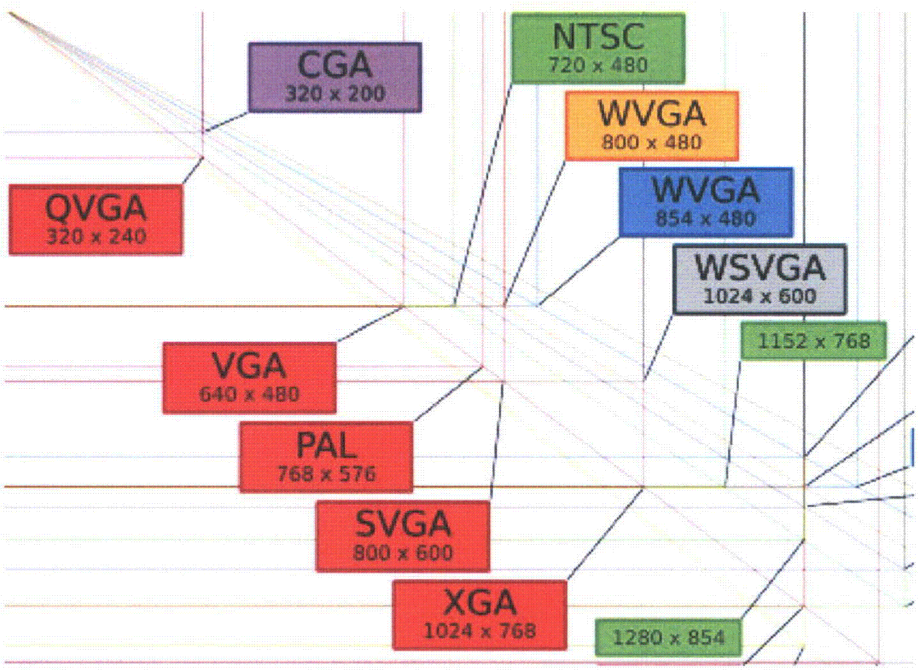

Figure 10 - Display Type vs. Pixel Size. When procuring a videoscope/borescope, one with VGA display and recording ability should be considered. Borescopes with a QVGA resolution (320 x 240) are not recommended.

If a videoscope is used, captured videos can be converted into still images by transferring the file to a PC, and playing the video back with proper software. The video can be paused and a still shot captured. When taking video of motor internals, if an area of concern is found, the videoscope should be paused while videoing the area. This will result is a high-quality still image without distortion from camera movement.

7.1.2 Borescope/Videoscope Minimum Requirements

The borescope/videoscope should have the following minimum requirements:

- Articulating Probe
- Probe length of 1-2 meters
- 6 or 8 mm probe size (6 mm is preferred)
- 90 degree side view tip
- Light source for probe
- VGA viewing screen
- Portable
- Battery operated for field use
- Battery operated light source for field use

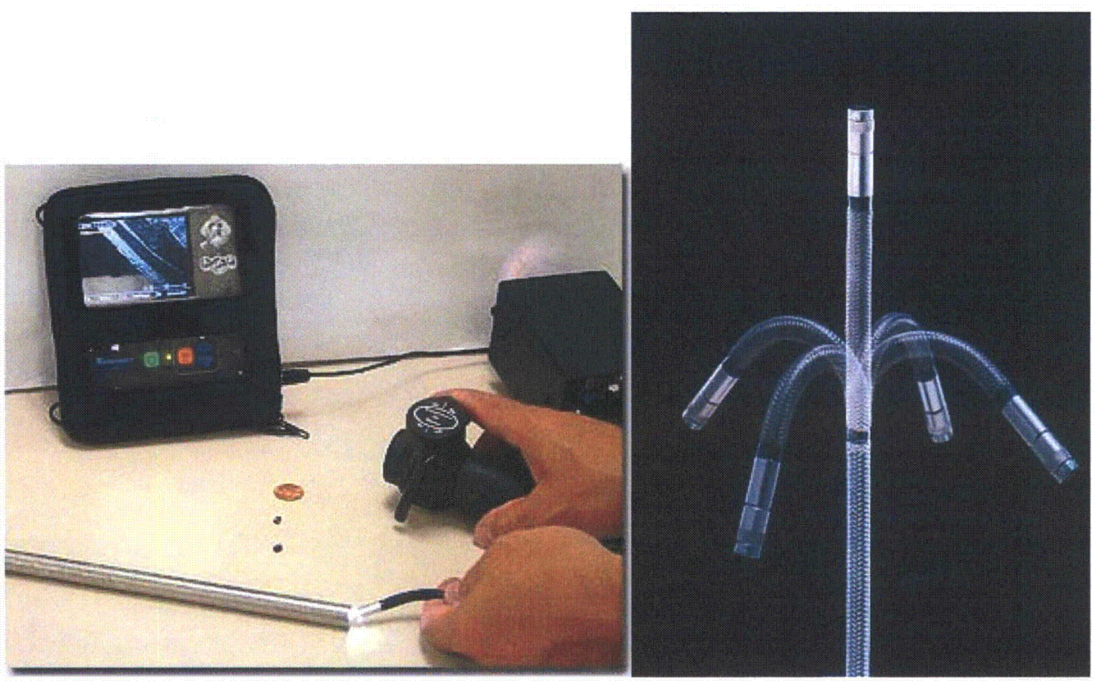

Figure 11 - ForeEyes™ 2020 videoscope with 6mm articulating probe. A compact unit such as this is recommended for field inspections. The image on the left shows the operator moving the articulating four way probe by turning the control wheel. Image on the right is possible positions of a four way video probe.

There are many manufacturers of borescope equipment on the market today. A small, easy to handle, portable unit that can easily download videos/images to a PC should be considered. A unit with a large amount of memory is an advantage when taking videos.

An articulating probe is required for inspection. Once the probe is inside the motor, the operator maneuvers it with a thumbwheel control while viewing the screen. The video/images can be downloaded via memory module to a PC for viewing and storage. If the device is only a videoscope such as the ForeEyesX2™ 2020 unit, in order to look at still pictures, the video must be downloaded to a PC. It can then be viewed with viewing software and the video stopped to capture a specific frame. Borescope/videoscope images are not normally larger than 640 x 480 pixels (VGA). Borescope/videoscopes with 320 x 240 pixels (QVGA) should not be considered for this application due to the low resolution.

Figure 12 – iTool videoscope. It consists of the computer, the light source (cylinder on left hand side) and four way articulating probe.

Figure 13 - GE XL Go™ Video Probe
Another example of a handheld videoscope. Dimensions are 3.75" x 5.25" x 13.5"

7.1.3 Borescope Catalog Information

See Reference 13.9 for Danatronics, iTool and GE videoscope catalog information. This information is not meant to be a recommendation, but general information and specification for a portable unit.

7.1.4 Borescope/Videoscope Cost

The cost for a high-quality borescope/videoscope with required accessories can range from approximately $15,000 to as much as $40,000.

7.2 Disassembled Motors

For disassembled motors, a borescope could be required if the bearings/bearing brackets are not removed from the rotor shaft; however, a digital camera is most likely the only tool required. The images should be saved for later comparison against future inspections of the same motor rotor and for comparison against other motor rotors.

8. VISUAL AND BORESCOPE INSPECTION PROCEDURE

8.1 Type LR Motors

Type LR motors cannot be inspected via borescope (type can be found on the nameplate of the motor under "insulation type"). This is due to an internal shield installed between the bearing bracket and motor rotor. These motors require disassembly to be inspected.

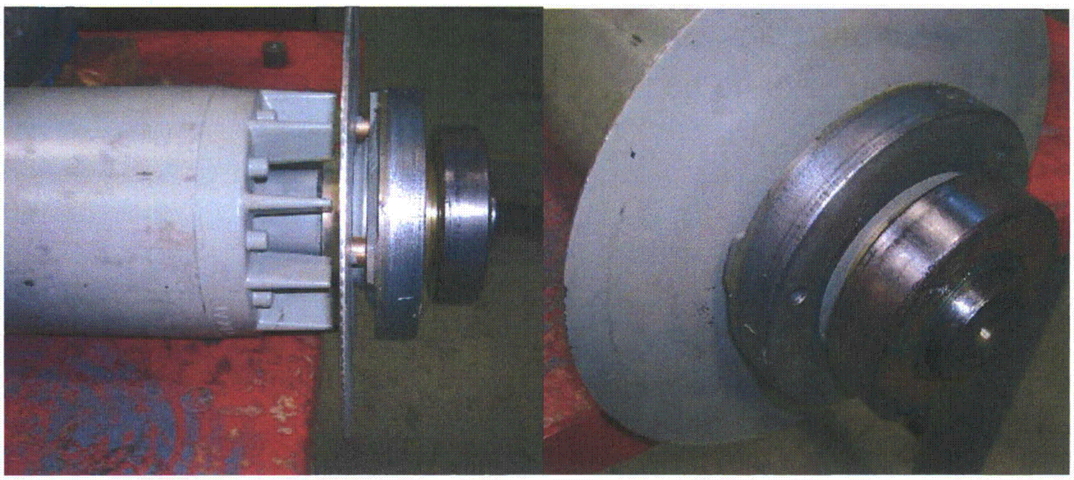

Figure 14 - Type LR motor rotor. Note the large shield inboard of the bearing. This prevents field inspection of the rotor via borescope.

8.2 Installed "T" Drains

Motors shall be inspected in-situ by use of a borescope for motors that have "T" drains installed. Removal of the "T" drains will allow inspection of the rotor/internals of the motor.

NOTE ON "T" DRAINS:
Limitorque installed "T" drains on some MOV motors during the environmental qualification process to allow for pressure equalization of the motor. In these cases, "T" drains must be installed to maintain the qualification of the actuator/motor.[3]

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[3] Limitorque Valve Actuator Qualification for Nuclear Power Station Service Report B0058, Section 3.2.3 and 4.1.2

It should be noted that some plants and/or end use applications do not require the use of "T" drains and utilize pipe plugs instead. In these cases, "T" drains are not required to maintain the environmental qualification status of the motor.

The number, location, and arrangement of motor "T" drains should be maintained in accordance with the plant EQ Program requirements.

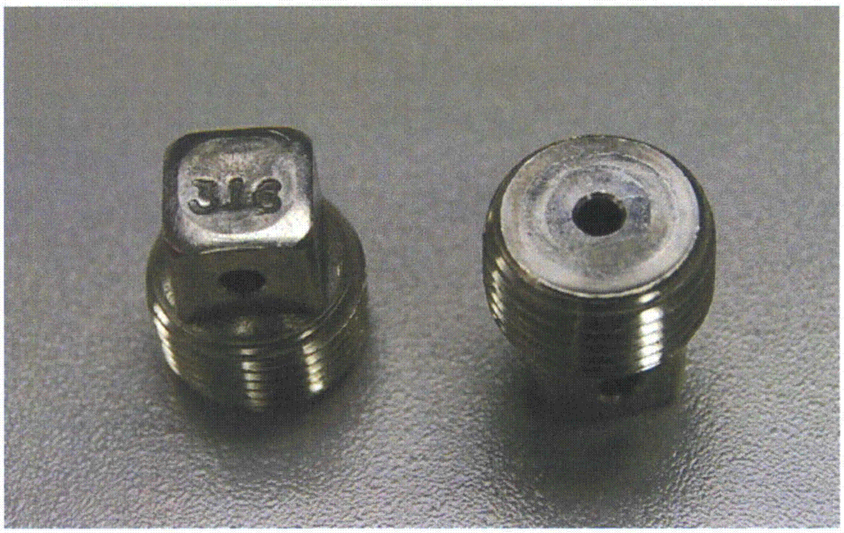


Figure 15 – "T" drain plugs supplied with environmentally qualified MOV motors from Limitorque. These plugs must be installed to maintain environmental qualification of the motor. They shall be oriented at the lowest point of the motor, one on each bearing bracket.

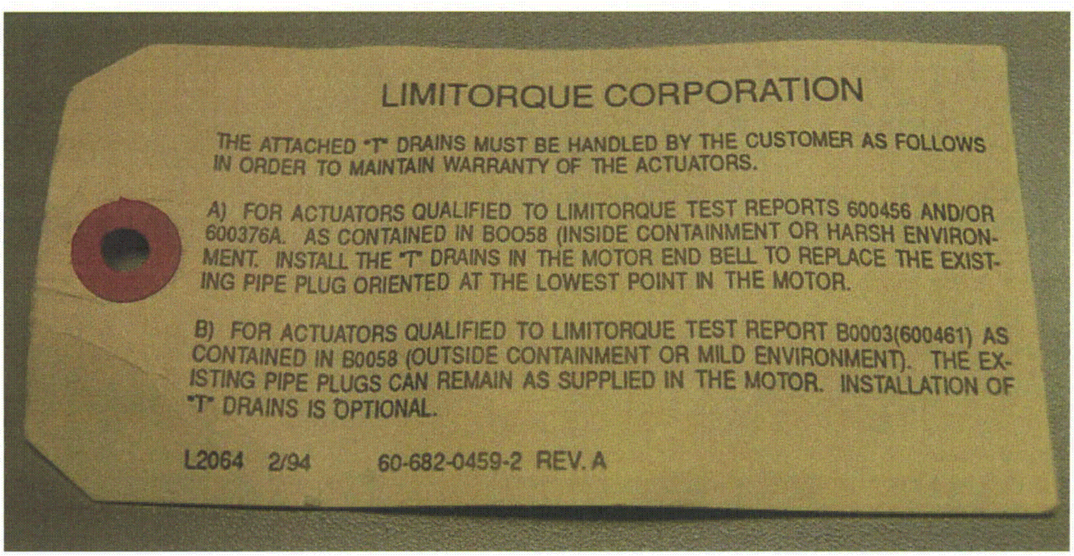


Figure 16 - Label attached to Limitorque motors. For non environmentally qualified applications, the "T" drain plugs are not required to be installed.

Remove the "T" drain fittings from both the drive end and opposite drive end bearing brackets.

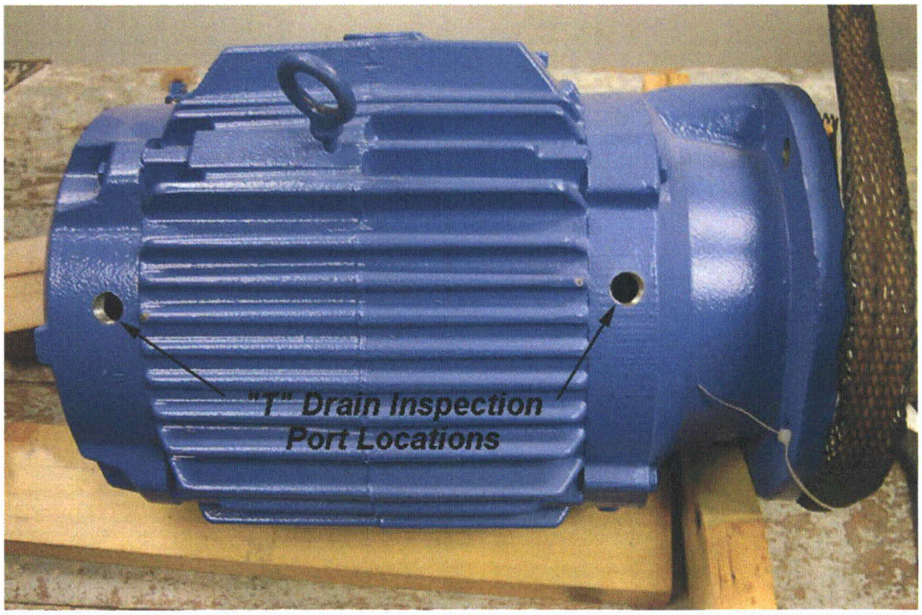


Figure 17 - "T" drain inspection port locations. There are other locations clocked on the bearing brackets that have NPT pipe plugs inserted. Use the "T" drain and other pipe plug locations for borescope inspection.

Insert the borescope/videoscope in the "T" drain and pipe plug locations to inspect the motor rotor. If the motor is not attached to an actuator, the shaft can be easily spun to aid inspection of the rotor. If performing the inspection in the field, the borescope will have to be snaked around the rotor through multiple inspection ports to completely inspect the rotor because the shaft will not turn. Using the different ports and articulating the borescope probe allows for complete inspection. Capture images or video of the motor rotor internals. If using a videoscope, pause at locations to capture the video, especially areas of concern. This will create high quality still images at a later time due to lack of distortion of the image from video probe movement.

Inspection must be completed on both the drive end and opposite drive end of the motor. Rotor degradation can occur on one end of the rotor as viewed by visual or borescope inspection, but appear normal on the other end.

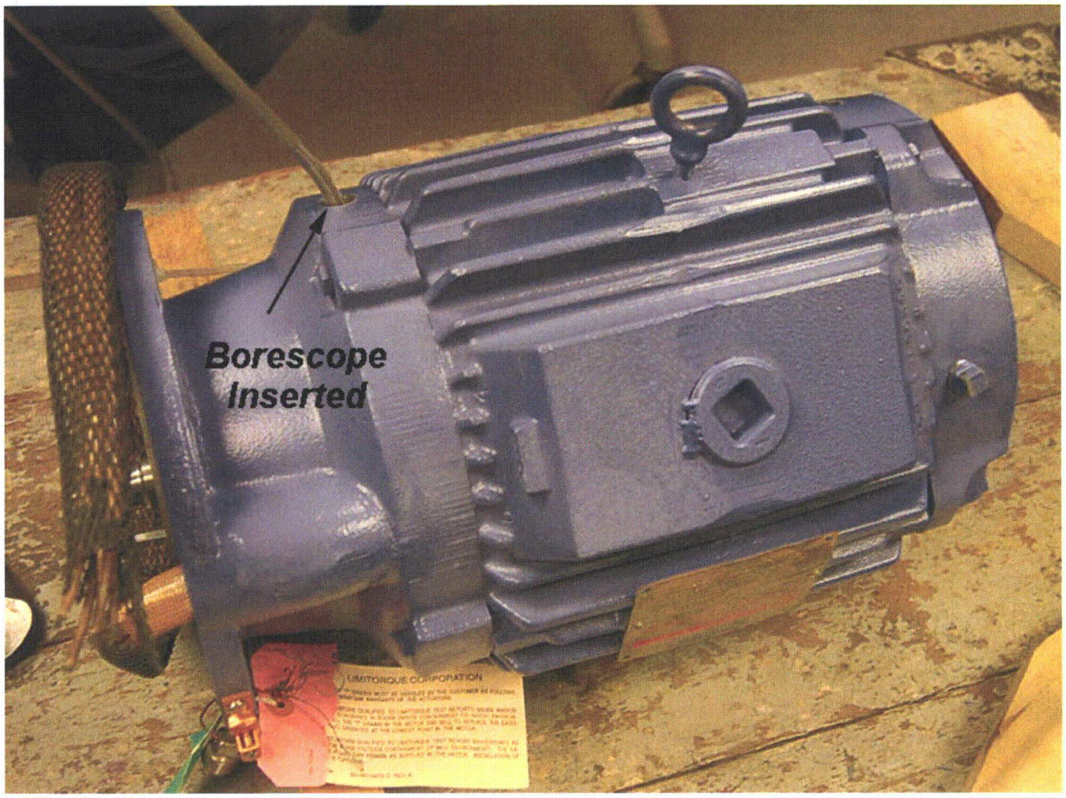


Figure 18- Borescope probe inserted for inspection through "T" drain opening

8.3 Internal Motor Components

The following are internal motor components that will be visible during the borescope inspection. For more pictures of borescope/videoscope inspections, see HTML format on supplied disc.

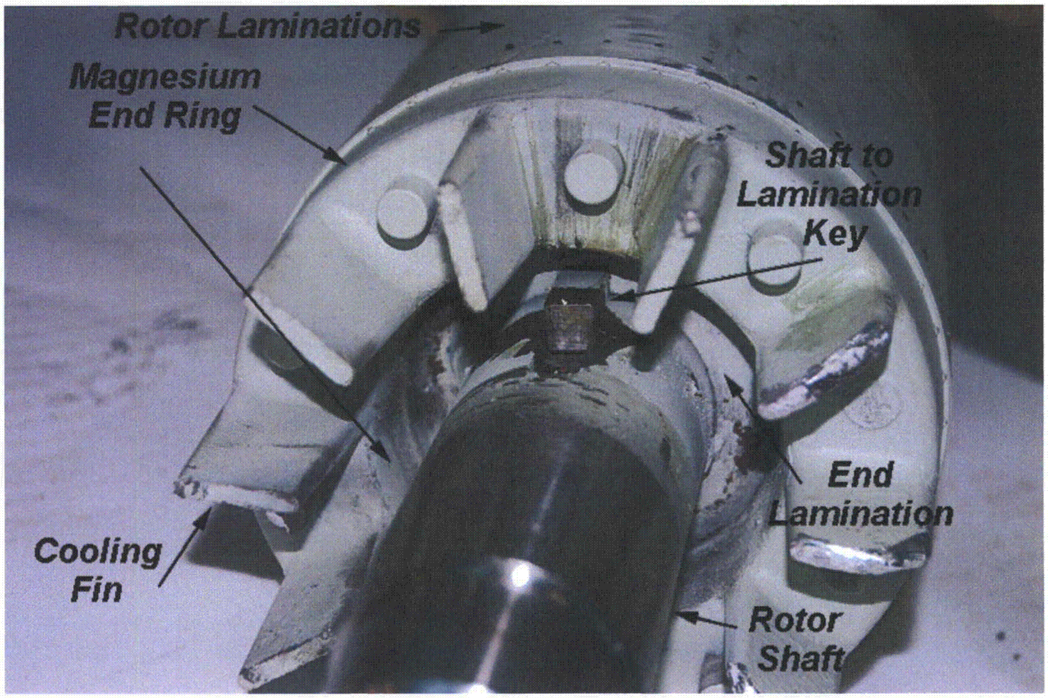


Figure 19 - Rotor Assembly. Note where balancing of the rotor was accomplished at 3 o'clock position. The balance nubs were removed and the cooling fins were ground down to remove weight from this area of the rotor. After balancing, the rotor fins were not coated. Also note the lack of coating on the magnesium in general. Note black discoloration at the 10 o'clock position. This could be corrosion products or lack of coating.

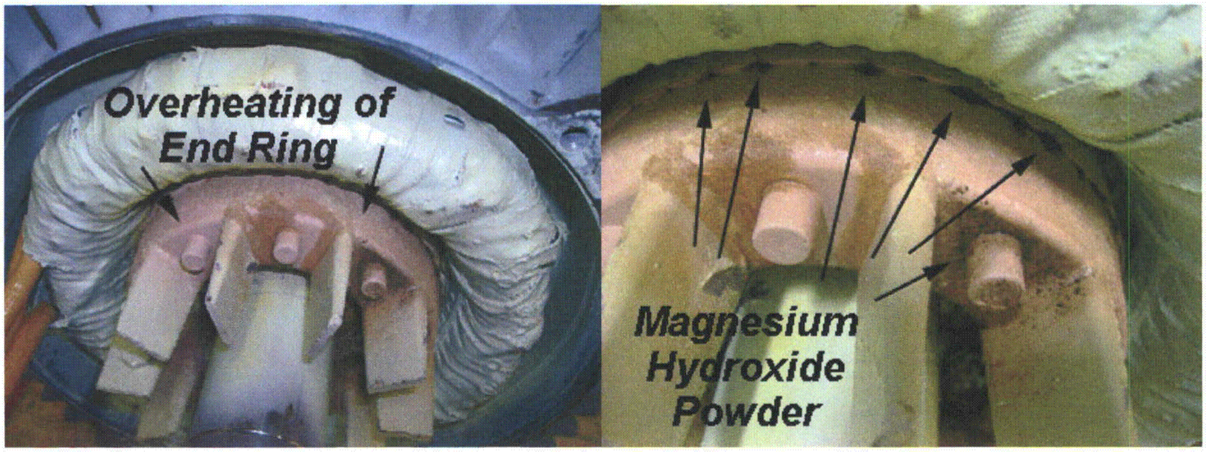


Figure 20 - Rotor still installed in motor stator. The magnesium hydroxide powder can be seen at the O.D. of the rotor and at the balance nub at the 1 o'clock position. The magnesium end ring is overheated and discolored from the original insulating paint color of light green. The formation of magnesium hydroxide powder in this example is most likely due to thermally induced stress.

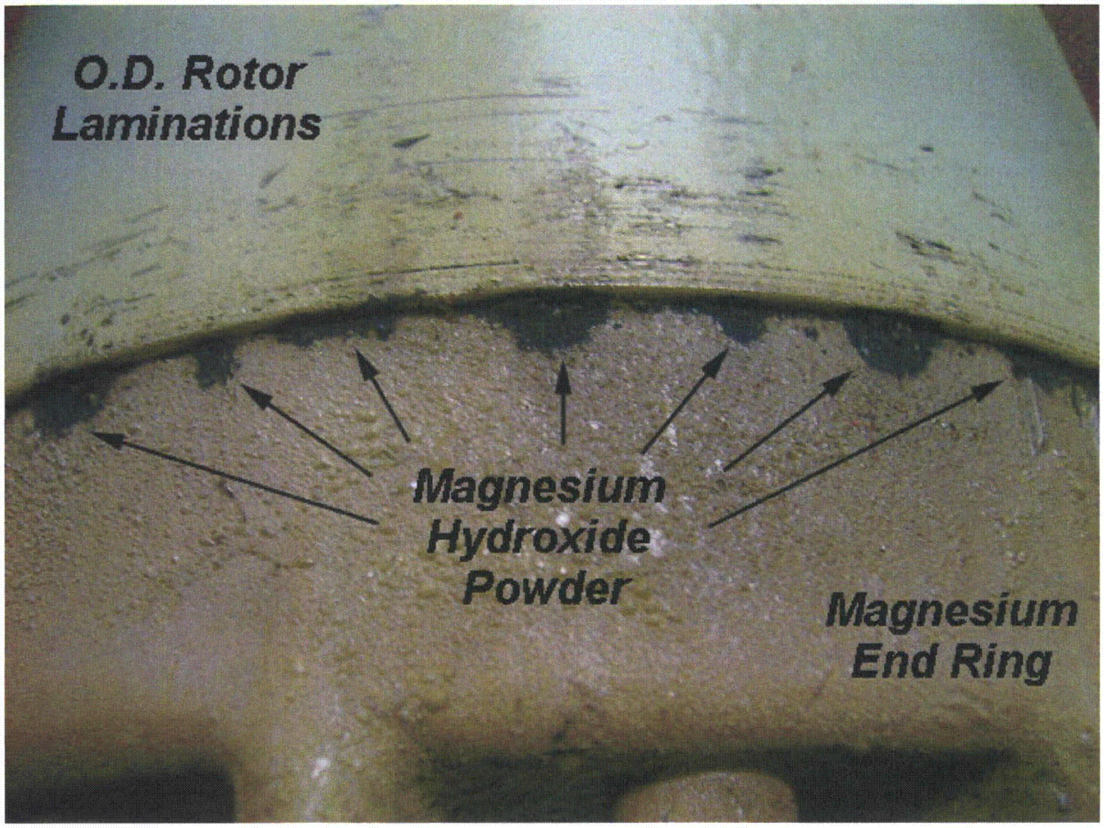


Figure 21 - Outside diameter of motor rotor removed from the motor stator. Note the magnesium hydroxide powder at the interface of the end lamination and the magnesium end ring. This is caused by galvanic corrosion across the interface. Note the overall color of the magnesium end ring; it is darkened in color, which can be seen better in the next image.

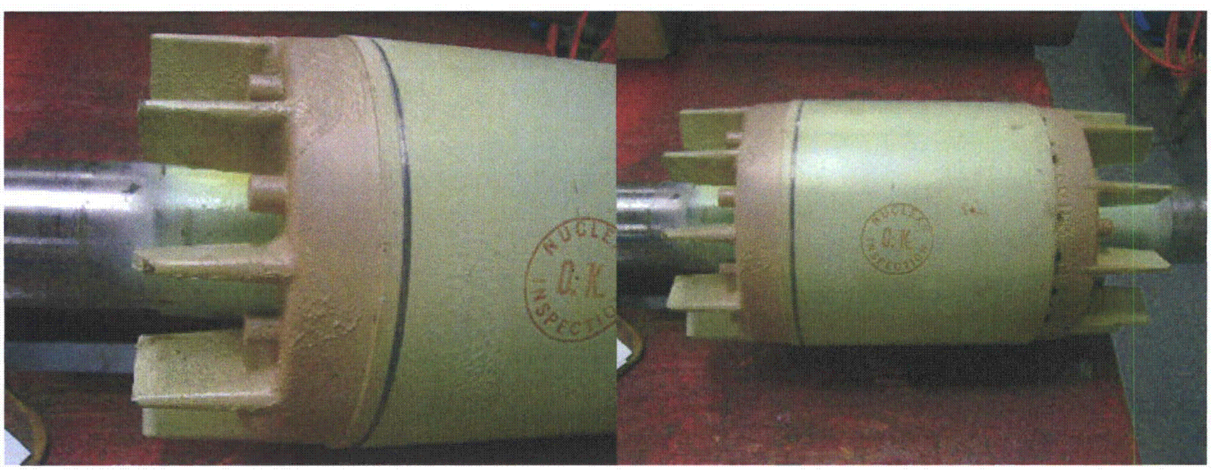


Figure 22 - Magnesium rotor with indications of thermally induced stress at the end rings on both sides. This can be seen by the brown discoloration of the end rings, which were originally the light green color. Magnesium hydroxide powder can be seen on the right hand end lamination to end ring interface. The left side had a small rub between the rotor laminations and stator, causing the paint to be removed where the stripe can be seen.

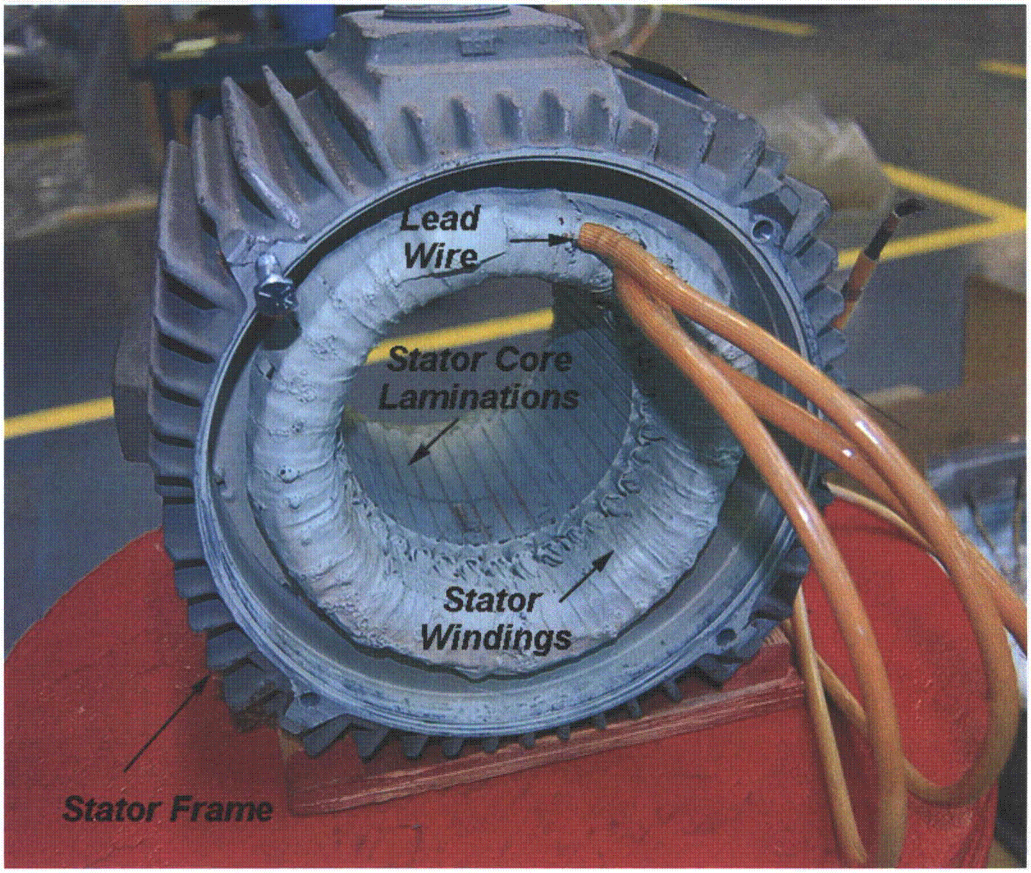


Figure 23 - Stator Frame Assembly

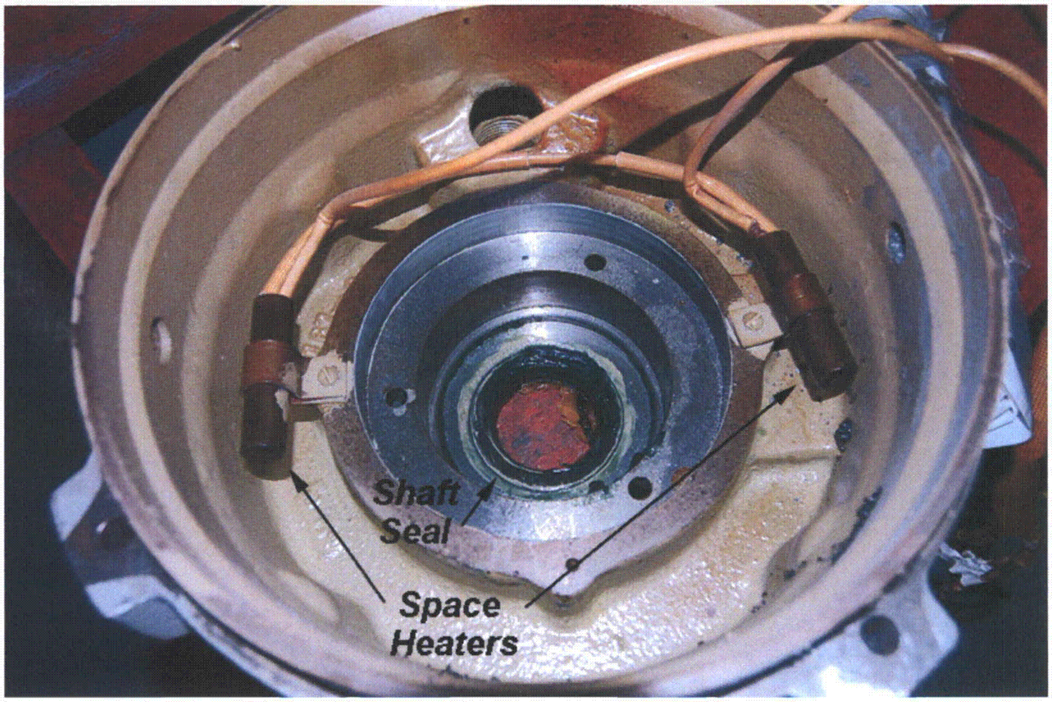


Figure 24 - Drive End Bearing Bracket with space heaters installed. Space heaters are installed in the drive end only. Bearing cap not shown installed.

The motor rotor should be inspected via borescope at the junction of the outboard-most electrical steel rotor lamination where it comes in contact with the magnesium end ring. This is the most common place for galvanic corrosion to occur, which forms magnesium hydroxide (MgOH) powder. Once the MgOH powder is present, it is relatively easy to see.

The interface of the magnesium end ring to lamination is of utmost importance. This interface is where galvanic corrosion occurs and the corrosion products are deposited. Once deposited, these corrosion products push the magnesium end ring, which skews the rotor fan blades relative to the rotor body. The area between the magnesium end ring and the end lamination must be inspected for a gap, corrosion products or paint deterioration.

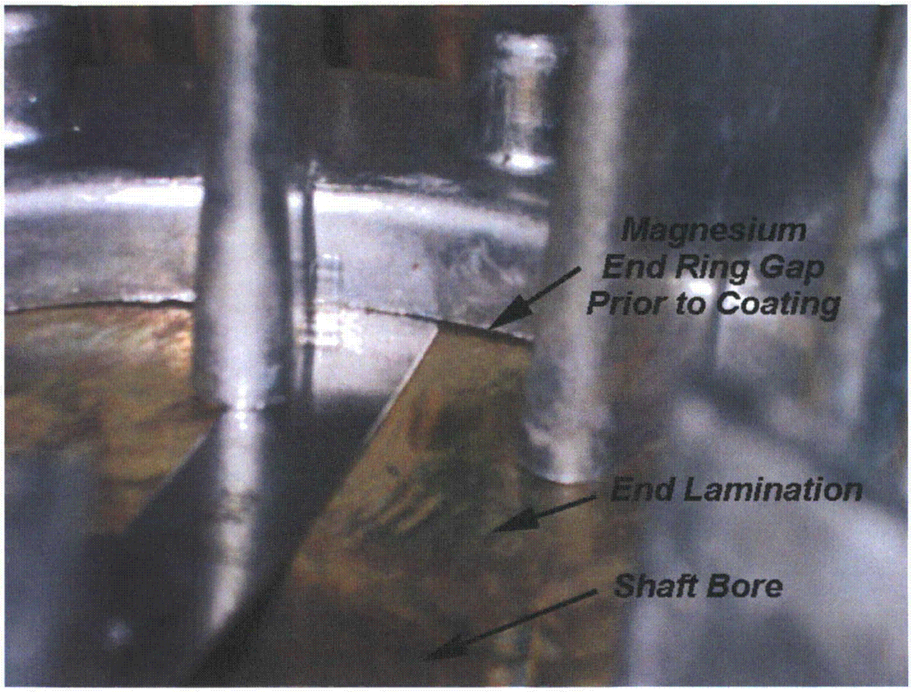


Figure 25 – Unpainted magnesium rotor after casting and quenching process.

It should be noted that it is normal to have some separation of the magnesium end ring relative to the end lamination. According to the motor manufacturer, the rotor manufacturing process calls for quenching after the magnesium casting process to assist in the surface separation of these materials to improve motor efficiency. The gap is the result of this process and alone is not cause for motor rejection during inspection. This gap is normally 0.030" but can vary from this average value. The image above shows a type end ring separation between the magnesium end ring and end lamination.

8.4 Acceptance Criteria

The following items should be inspected during either an in-situ or disassembled test. The motor shall be free of any defects listed in Table 2 below (Failure Criteria) or Table 3 (Degradation Criteria).

Table 2 – Motor Inspection Failure Criteria

Figure	Item	Identified	
		Yes	No
6, 25, 32	Any observed gap or separation between the rotor end lamination and the magnesium end ring with evidence of corrosion at or near the gap interface.		
6, 7, 28	Any outward spreading or radial misalignment of any cooling fin. This would normally be found in conjunction with the item above.		
36	Black corrosion product build-up between the rotor end lamination and the magnesium end ring.		
21	Black corrosion product build-up at outside diameter of rotor at magnesium end ring.		
22	Indication of thermally induced stress. Obvious darkening or discoloration of the magnesium end ring adjacent to the rotor end lamination.		
26	Balance nubs or outside edges of the cooling fins are corroded away. This should not be confused with the factory removal of balance nubs or grinding of the cooling fins during the rotor balance process.		
27, 29	The magnesium end ring is broken or has missing sections. Pieces of the magnesium end ring or cooling fins are found detached within the motor housing.		
30	Globular or molten metallic deposits appear anywhere on the surface of the magnesium end ring and/or cooling fins.		
31	Any cracking in the magnesium end ring or the cooling fins, particularly where the cooling fins join the magnesium end ring.		
8	Any evidence of contact between the rotor cooling fins and the stator windings.		
26	Excessive corrosion or bubbling of the magnesium end ring or cooling fins.		

Note: For Group A Motors (Section 6.3.1) found to have one or more of the above indications shall be considered failed and the motor should be replaced or reconditioned. For Group B motors (Section 6.3.2) found to have one or more of the above indications shall be dispositioned by a formal engineering evaluation or replaced or reconditioned prior to return to service.

Table 3 – Motor Inspection Degradation Criteria

Figure	Item	Identified	
		Yes	No
34	Slight blistering of the protective coating of the magnesium end ring or the cooling fins.		
2, 3, 33	Minor pockets of corrosion on the magnesium end ring and/or the cooling fins.		
2, 33	Minor galvanic corrosion at the interface of the magnesium end ring and end lamination.		

Note: For Group A Motors (Section 6.3.1) found to have one or more of the above indications shall be considered failed and the motor should be replaced or reconditioned. For Group B Motors (Section 6.3.2) found to have one or more of the above indications should be considered degraded and scheduled for another inspection or replacement or reconditioning within the greater of the end of the next fuel cycle or 24 months.

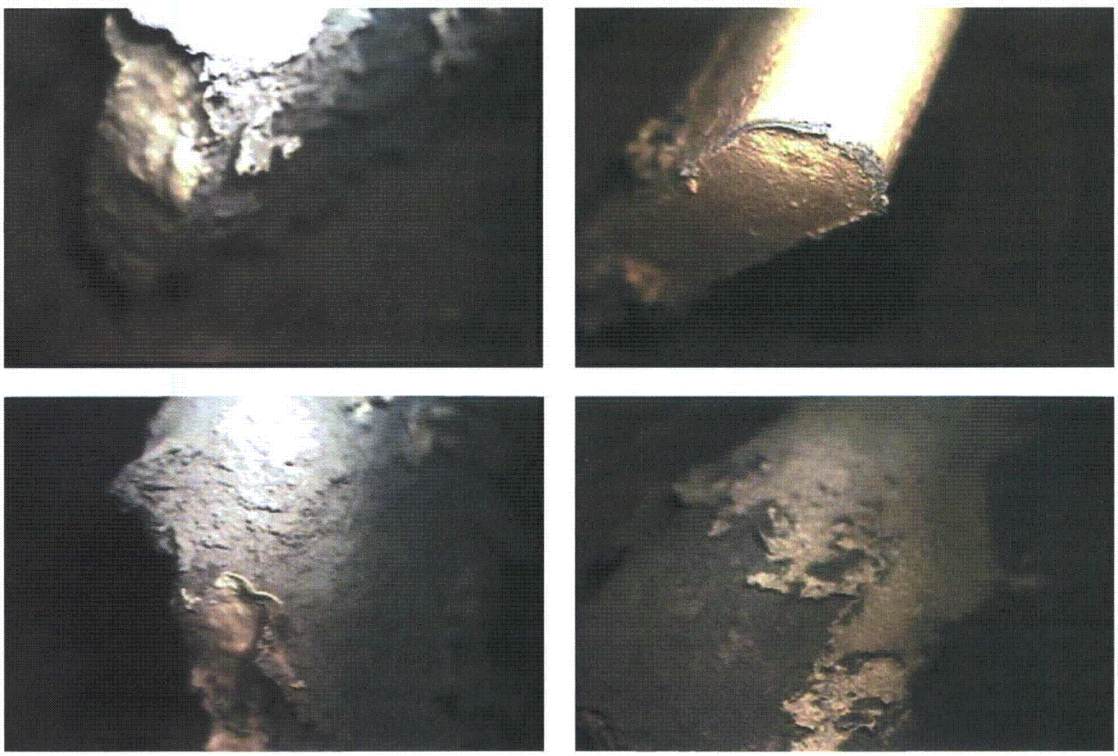


Figure 26 – Example of excessive corrosion on rotor cooling fins.

Figure 27 – Rotor with cooling fan/magnesium end ring detached.

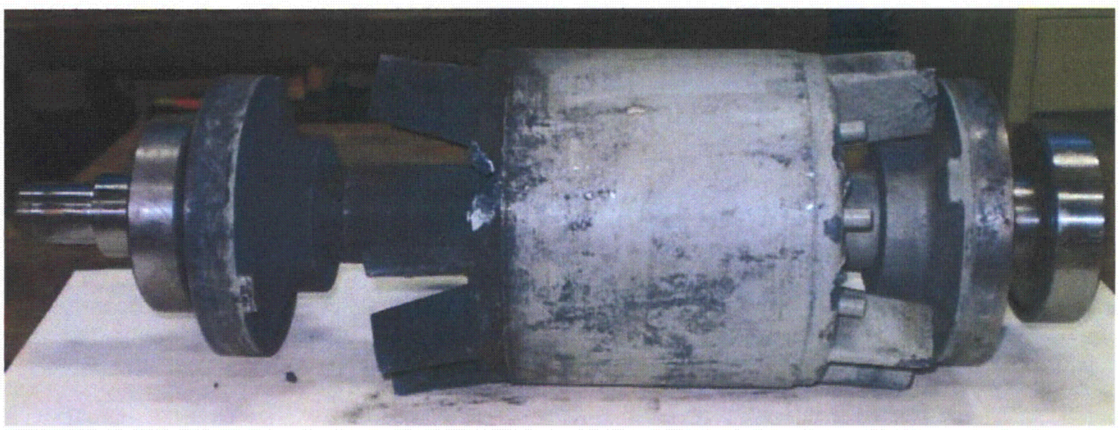


Figure 28 – Excessive corrosion of magnesium end ring combined with the cooling fins being deflected outwards from the body of the rotor.

Figure 29 – Catastrophic failure of magnesium end ring.

Figure 30 - Failed magnesium rotor. Note angularity of rotor fins relative to shaft and globs of molten magnesium. Note this is shown with the bearing bracket removed in a shop environment.

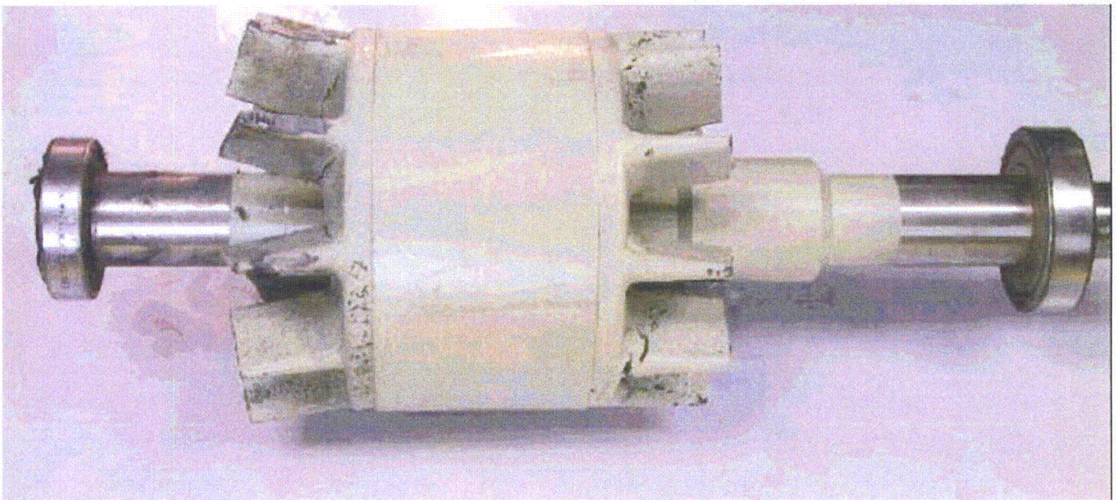


Figure 31 – Deflected cooling fins on left hand side with cracking evident. Right hand side cooling fins also demonstrate cracking.

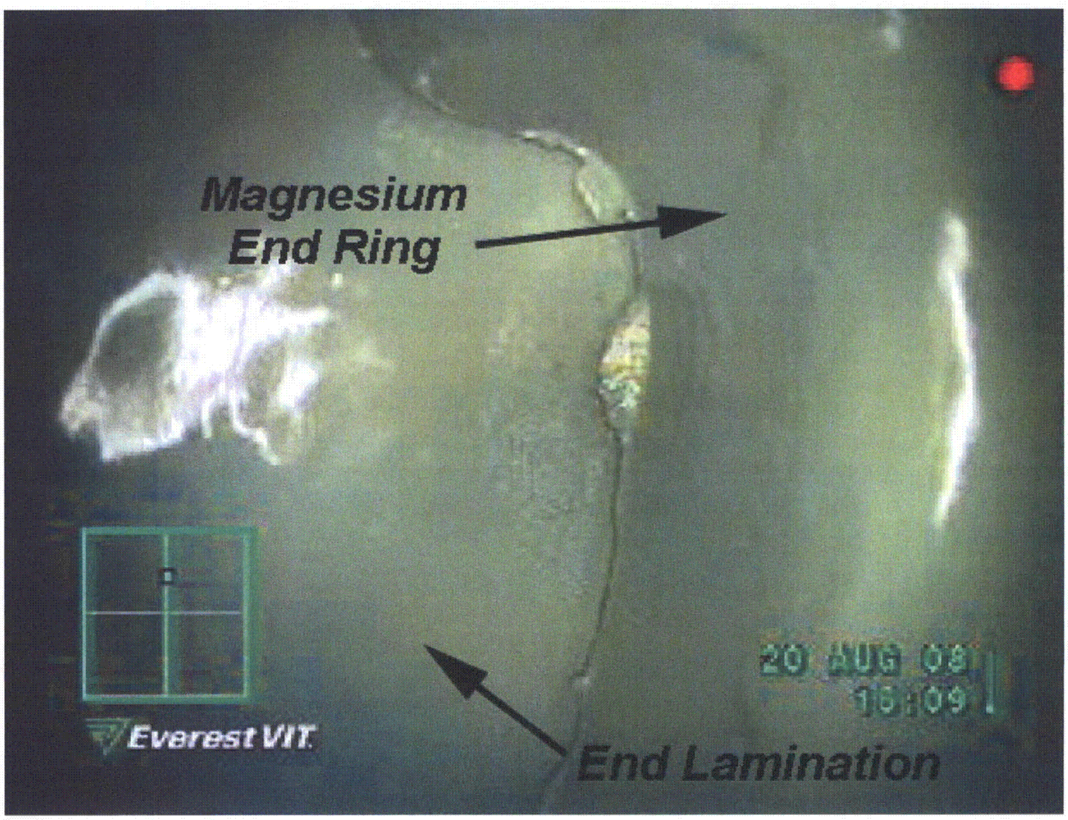


Figure 32 – Acceptable separation and paint cracking between magnesium end ring and end lamination with no corrosion present.

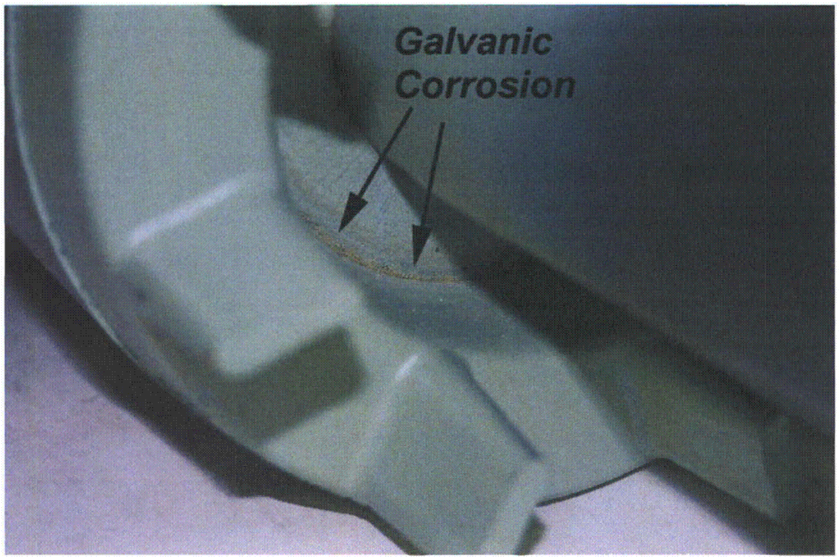


Figure 33 – Minor galvanic corrosion at the interference of the magnesium end ring and end lamination.

Figure 34 – Slight blistering onset of corrosion of the magnesium end ring/cooling fins coating.

9. NEW MOTOR INSPECTION CRITERA

New motors should be inspected prior to placing them in service. This can be completed by borescope/videoscope inspection or by disassembly and inspection. All criteria for in-situ or disassembled motor inspection are applicable for new motors. The motor rotor should be in excellent condition with a proper coating. If the coating is compromised, consideration should be given to motor disassembly and rotor recoating.

The motor rotor can be cleaned by glass bead blasting and coating with Ranvar B-5-346 or BT-7455A air dry primer. This is the coating used by the motor OEM to coat magnesium rotors. Two coats should be used to achieve a proper coating with no visible magnesium showing.

Reference 13.10 is the technical data sheet for Ranvar B-5-346A and BT-7455A air dry primer.

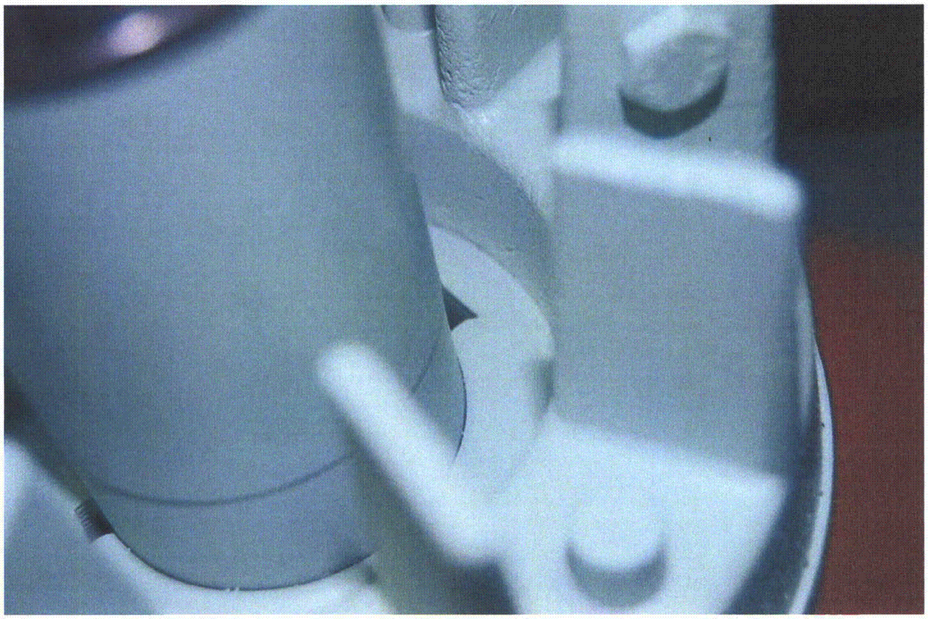


Figure 35 – Properly coated rotor at magnesium end ring to lamination interface.

Figure 36 – Magnesium rotor with black corrosion product build-up between the rotor end lamination and the magnesium end ring. NOTE: one cooling fin has broken off the end ring.

10. MAINTAINING ENVIRONMENTAL AND SEISMIC QUALIFICATION

Limitorque actuators and motors can be supplied as environmentally qualified (EQ). The environmental qualification status must be maintained if the motor is disassembled for inspection or other corrective action. The actuators and motors were qualified by Limitorque Corporation to the requirements of IEEE382-1977; IEEE 323-1974 and IEEE 344-1975 as delineated in the following qualification reports[4]:

- Report B0058 – Limitorque Valve Actuator Qualification for Nuclear Power Station Service, Dated 1/11/1980.
- Project 600376A Report F-C3441 – BWR Containment Qualification, Dated 5/13/1976.
- Project Report 600456 – PWR Containment Qualification, Dated 12/09/1975 (M)
- Project 600461 Report B0003 – Outside Containment Qualification, Dated 6/02/1976.
- Project 600426 Report B0009 – DC Actuator Qualification, Dated 4/30/1976
- Project 600508 Report B0027 – Superheat Temperature Test, Dated 8/31/1978
- Project Report B0212 – LR Type Motor PWR Qualification, Dated 4/10/1985 (M)

(M) – These tests included a magnesium rotor motor

Reference 13.6 specifically discusses magnesium rotor aspects with respect to Limitorque Equipment Qualification. Below is an excerpt from Reference 13.6.

"Magnesium rotors only exist on certain Reliance AC motors. Both aluminum and magnesium rotor motors have been tested as tabulated below. Since magnesium rotor motors acceptably passed the 600456 and B0212 steam test conditions, Limitorque has concluded that rotor materials do not affect the level of motor qualification (FN4). Limitorque certifies the performance of magnesium rotor motors to all referenced tests."

---

[4] There have been other entities that have environmentally qualified Limitorque MOV Actuators and Motors. For purposes of this section, only Limitorque EQ reports are listed.

Magnesium Rotor Motor Data:

EQ Test Rpt	Rotor Material
(1) 600456:	Magnesium
(2) B0212:	Aluminum (connected to actuator)
	Magnesium (operated in test chamber)
(3) All Others:	Aluminum

FN4 - A magnesium rotor motor as part of the B0212 test program was successfully tested to the transient portion of the same profile reported in the B0212 test report. The results are not published in the B0212 test report, however, this information is on file and available for audit at Limitorque.

A review of the subject reports was performed to determine the potential impact of disassembly upon magnesium rotor motors qualified for EQ applications. Based upon the review of the subject reports, it was concluded that there are two subcomponents that could potentially impact the EQ status of the motor by the disassembly, inspection and reassembly process. This assumes that the motor is disassembled and reassembled properly and the bearings are not removed from the shaft. The two components identified are the motors shaft seal and the bearing bracket o-rings. It is also important to understand the function and safety classification of these subcomponents.

There were no subcomponents identified during the review that could potentially affect the seismic qualification status of the motor.

10.1 Design Function of Shaft Seals and Bearing Bracket O-rings

The shaft seal and bearing bracket o-rings are manufactured from an elastomeric material. The design function of the shaft seal and bearing bracket o-rings is to prevent external environmental contaminants (e.g. dirt, dust and grease) from entering the motor internals. This is considered good engineering practice in motor design.

The shaft seal is subject to shaft rotational forces. Upon disassembly, the seal should be inspected for possible wear and/or loss of elasticity which could result in failure of the shaft seal to perform its design function. If the seal condition is suspect, then the seal should be replaced prior to reassembly.

The bearing bracket o-rings are installed between the bearing bracket and motor stator and are loaded in compression. Upon disassembly, the o-rings should be inspected for possible compression set and/or loss of elasticity. If the o-ring condition is suspect, then the o-rings should be replaced prior to reassembly. It is generally considered good maintenance practice to replace o-rings that are installed in compression applications whenever equipment is disassembled.

10.2 Material of Construction and Environmental Considerations

The shaft seal and bearing bracket o-rings are manufactured from a fluoroelastomer commonly known as viton. All elastomers are subject to some degradation at elevated temperatures and when exposed to radiation. Generally, volume change, increase in hardness and compression set are characteristics that are most affected. The shaft seal and bearing bracket o-rings could be exposed to high temperature and radiation environments due to the motors inherent end use application. The amount of degradation also increases with exposure duration and increase in environmental stressors. Consideration of these factors should be taken into account when evaluating possible replacement of these components during disassembly and inspection of motor magnesium rotors.

10.3 Safety Function and EQ Status of Shaft Seals and Bearing Bracket O-rings

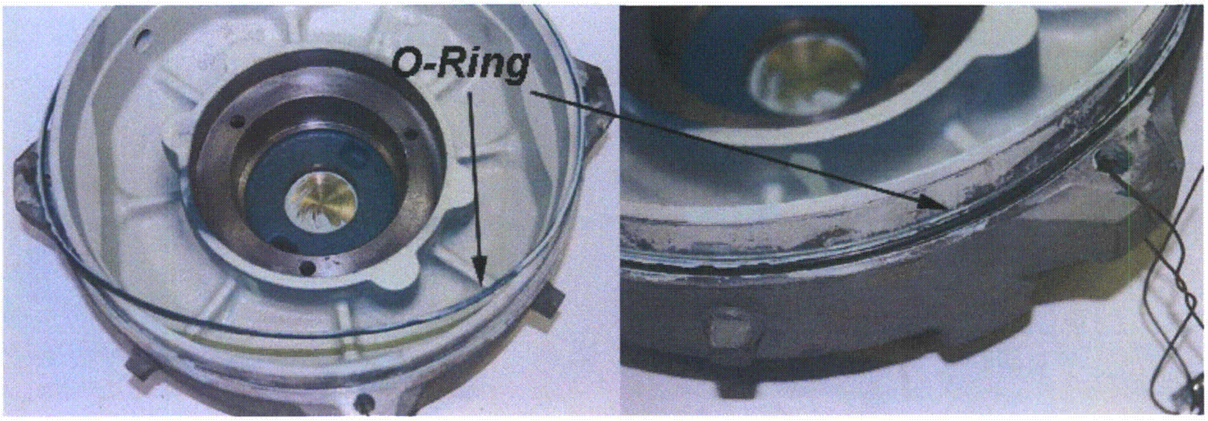
Limitorque Report B0058, Sec. 3.2., "Seals" states, "Limitorque actuators for nuclear plant applications are designed to permit them to survive normal and accident conditions without depending on absolute sealing. In fact, the ambient is not absolutely restricted from entering the actuator. The seals are of no importance for qualification and, therefore, required no consideration for the qualification." Limitorque Report B0058, Sec. 4.1.2, "Design Philosophy", further states, "In all cases, the philosophy of using an actuator that did not require complete integrity of sealing was used. In fact, containment units include "T" drains to permit them to breathe."

"Limitorque adopted this philosophy to minimize maintenance man-hours in a containment chamber which would be necessary to replace seals on a periodic schedule and the extremely difficult chore of assuring the actuator doesn't leak when exposed to an external pressure which would actually be the responsibility of the utility once the actuator shipped from the manufacturer's plant."

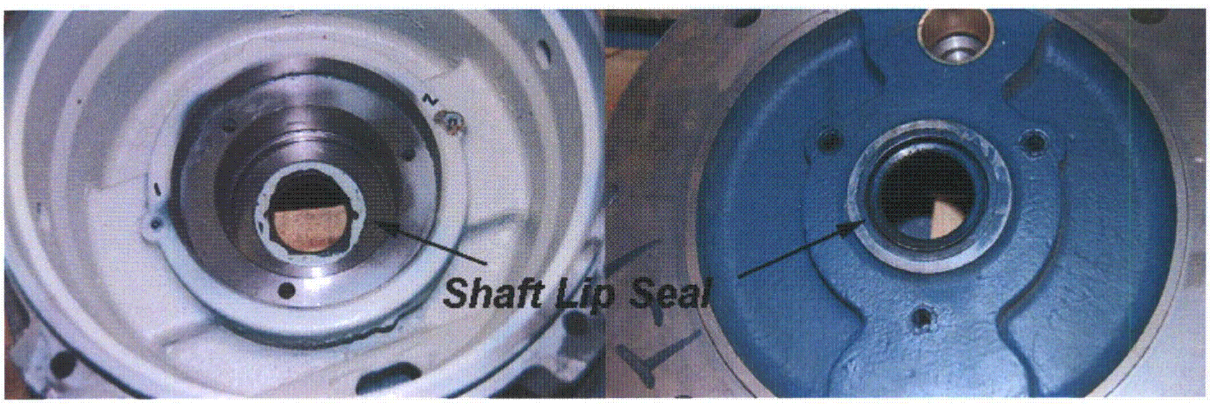
"The second reason for adopting this philosophy is to provide additional confidence in Limitorque valve actuators by eliminating the concern that any one of the several seals or gaskets might start leaking during plant operation which in all probability would assure failure of a "sealed" actuator in event of a DBE."

Based upon the above, it could be concluded that the shaft seal and bearing bracket o-rings are considered non-safety related and therefore not considered EQ. However, some end users may consider the shaft seal and end bracket o-rings to be safety related and/or environmentally qualified. It is ultimately the end users responsibility to determine the safety classification and EQ status of the shaft seal and end bracket o-rings in accordance with each plant's individual requirements.

It is therefore also incumbent upon each end user to effectively maintain the EQ status of their respective magnesium rotor motors. If the end user maintains that the shaft seals and bearing bracket o-rings are considered EQ, then the replacement shaft seal and o-rings must be evaluated for the environmental parameters of the host component end use application. If the shaft seal and bearing bracket are considered non-safety related, then it recommended that the replacement seal and o-ring be manufactured from fluoroelastomer material with the same dimensions as the original.



Bearing Bracket, opposite drive end (ODE). Both drive end (DE) and opposite drive end bearing brackets have a o-ring installed that sits in a machined fit in the bearing bracket. This creates a seal with stator frame.



Shaft lip seal. Shown from the inside of the pulley end motor bearing bracket on the left (bearing and bearing cap removed) and from the outside of the drive end bearing bracket on the right.

11. PHOTOS

Photos of motor rotor inspections has been compiled in HTML format and can be found on the CD ROM with this document. It must be viewed with a browser such as Windows Internet Explorer or Mozillia Firefox. The following examples are included:

- Borescope Inspection Pictures and Notes
- Shop Inspection Pictures and Notes
- Motor and Rotor Failures

12. APPENDICES

12.1 Limitorque Electric Motor Corporate Date Code

12.2 Motor Disassembly and Reassembly Procedure

12.3 Motor Inspection Failure and Degradation Criteria Tables

13. REFERENCES

13.1 NRC Information Notice (IN) 2006-26: Failure of Magnesium Rotors in Motor-Operated Valve Actuators

13.2 NRC Information Notice (IN) 1986-02: Failure of Valve Operator Motor during Environmental Qualification Testing

13.3 NRC Information Notice (IN) 2008-20: Failure of Motor Operated Valve Actuator Motors with Magnesium Alloy Rotors

13.4 IEEE Transaction on Energy Conversions, Vol. 3, No. 1, March 1988, An Investigation of Magnesium Rotors in Motor Operated Valve Actuators.

13.5 GE SIL 425

13.6 Nuclear Utility Group on Equipment Qualification – Clarification of Information to the Environmental Qualification of Limitorque Motorized Valve Operators, August 1989. (Limitorque Approved September 1989)

13.7 Limitorque Technical Update 08-01, Reliance Motors/Magnesium Rotors

13.8 AREA NP Document 54-9078869-001, Criteria for the Videoscope Inspection of New Safety-Related Baldor AC Motors Used with Flowserve MOV Actuators

13.9 Borescope Equipment Catalog Sheets

13.10 Technical Data Sheet Ranvar B-5-346 (M-32250 NH) and Ranvar BT-7455A Air Dry Primer

13.11 Flowserve Acceptance Letter of Document with Exceptions

Appendix 1 Limitorque Electric Motor Corporate Date Code

Limitorque Electric Motor Corporate Date Code

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971	AW	BW	CW	DW	EW	FW	GW	HW	JW	KW	LW	MW
1972	AX	BX	CX	DX	EX	FX	GX	HX	JX	KX	LX	MX
1973	AY	BY	CY	DY	EY	FY	GY	HY	JY	KY	LY	MY
1974	AZ	BZ	CZ	DZ	EZ	FZ	GZ	HZ	JZ	KZ	L	MZ
1975	NA	PA	QA	RA	SA	TA	UA	VA	WA	XA	YA	ZA
1976	NB	PB	QB	RB	SB	TB	UB	VB	WB	XB	YB	ZB
1977	NC	PC	QC	RC	SC	TC	UC	VC	WC	XC	YC	ZC
1978	ND	PD	QD	RD	SD	TD	UD	VD	WD	XD	YD	ZD
1979	NE	PE	QE	RE	SE	TE	UE	VE	WE	XE	YE	ZE
1980	NF	PF	QF	RF	SF	TF	UF	VF	WF	XF	YF	ZF
1981	NG	PG	QG	RG	SG	TG	UG	VG	WG	XG	YG	ZG
1982	NH	PH	QH	RH	SH	TH	UH	VH	WH	XH	YH	ZH
1983	NJ	PJ	QJ	RJ	SJ	TJ	UJ	VJ	WJ	XJ	YJ	ZJ
1984	NK	PK	QK	RK	SK	TK	UK	VK	WK	XK	YK	ZK
1985	NL	PL	QL	RL	SL	TL	UL	VL	WL	XL	YL	ZL
1986	NM	PM	QM	RM	SM	TM	UM	VM	WM	XM	YM	ZM
1987	NN	PN	QN	RN	SN	TN	UN	VN	WN	XN	YN	ZN
1988	NP	PP	QP	RP	SP	TP	UP	VP	WP	XP	YP	ZP
1989	NQ	PQ	QQ	RQ	SQ	TQ	UQ	VQ	WQ	XQ	YQ	ZQ
1990	NR	PR	QR	RR	SR	TR	UR	VR	WR	XR	YR	ZR
1991	NS	PS	QS	RS	SS	TS	US	VS	WS	XS	YS	ZS
1992	NT	PT	QT	RT	ST	TT	UT	VT	WT	XT	YT	ZT
1993	NU	PU	QU	RU	SU	TU	UU	VU	WU	XU	YU	ZU
1994	NW	PW	QW	RW	SW	TW	UW	VW	WW	XW	YW	ZW
1995	NX	PX	QX	RX	SX	TX	UX	VX	WX	XX	YX	ZX
1996	NY	PY	QY	RY	SY	TY	UY	VY	WY	XY	YY	ZY
1997	NZ	PZ	QZ	RZ	SZ	TZ	UZ	VZ	WZ	XZ	YZ	ZZ
1998	AA	BA	CA	DA	EA	FA	GA	HA	JA	KA	LA	MA
1999	AB	BB	CB	DB	EB	FB	GB	HB	JB	KB	LB	MB
2000	AC	BC	CC	DC	EC	FC	GC	HC	JC	KC	LC	MC
2001	AD	BD	CD	DD	ED	FD	GD	HD	JD	KD	LD	MD
2002	AE	BE	CE	DE	EE	FE	GE	HE	JE	KE	LE	ME
2003	AF	BF	CF	DF	EF	FF	GF	HF	JF	KF	LF	MF
2004	AG	BG	CG	DG	EG	FG	GG	HG	JG	KG	LG	MG
2005	AH	BH	CH	DH	EH	FH	GH	HH	JH	KH	LH	MH
2006	AJ	BJ	CJ	DJ	EJ	JF	GJ	HJ	JJ	KJ	LJ	MJ
2007	AK	BK	CK	DK	EK	FK	GK	HK	JK	KK	LK	MK
2008	AL	BL	CL	DL	EL	FL	GL	HL	JL	KL	LL	ML
2009	AM	BM	CM	DM	EM	FM	GM	HM	JM	KM	LM	MM
2010	AN	BN	CN	DN	EN	FN	GN	HN	JN	KN	LN	MN

Appendix 2

Disassembly and Re-Assembly Procedure
Adding Inspection Ports

The following procedure should be used to disassemble motors removed from their operators for rotor inspection. The end user should determine which portions of this procedure are applicable to their application. This procedure assumes the motor will be disassembled, reassembled and tested. If only performing disassembly for inspection, certain steps may be omitted. This procedure also includes provisions for installing borescope inspection ports in the bearing brackets.

This procedure does not cover:

- Repair of shaft to bearing ID fit
- Repair of bearing OD to bearing bracket fit
- Any other repairs to the motor

Tools Required

- Various wrenches
- Mallet to tap bearing brackets
- Bearing puller to pull bearings
- Induction bearing heater to install new bearings

Precautions and Limitations

- When removing the rotor from the stator bore, care must be taken not to drag the rotor across the stator windings at the end turn area. This can nick the windings and require the stator to be rewound.
- Means for tagging all removed parts shall be established and followed.

1. DISASSEMBLY PROCEDURE

1.1 Preliminary Electrical and Mechanical Tests

1.1.1 Measure the stator insulation resistance. Record results. Acceptance Criteria: > 5 M Ohms

1.1.2 Measure the winding resistance of all three phases. Record results. Acceptance Criteria: All phases within 5% of each other

1.1.3 Measure the polarization index. Record results. Acceptance Criteria: >2 $\leq$ 6

1.1.4 Measure the shaft extension runout. Record results. Acceptance Criteria: < 0.002"

1.1.5 Measure the shaft endplay. Record results. Acceptance Criteria: None, this is for information only

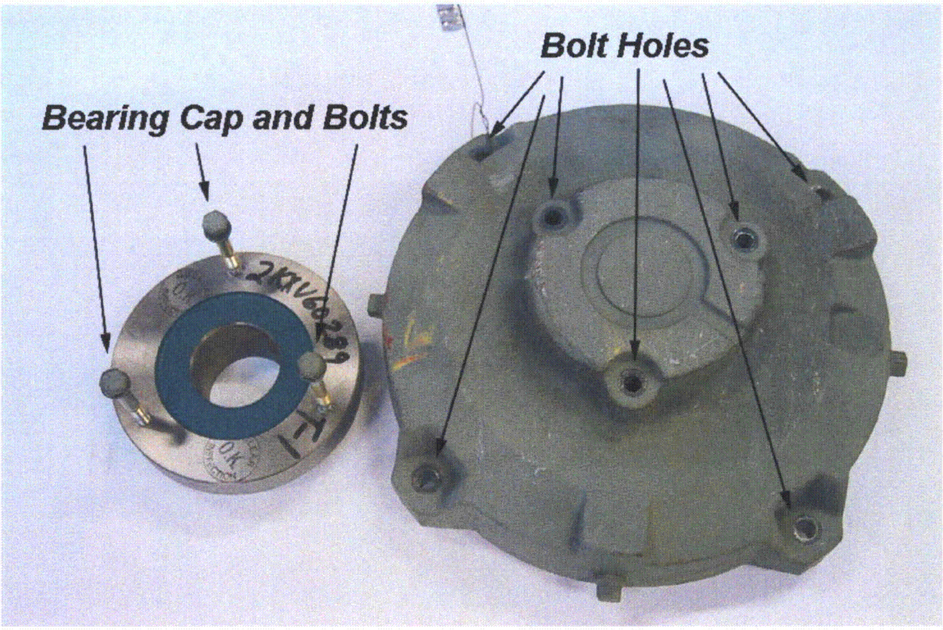
1.2 Disassembly

1.2.1 Match-mark all interfacing components before disassembly to ensure proper reassembly. Sketches should be made of item interfaces that may not be obvious to the mechanic assembling the unit. If the unit is already match-marked, record the marks on the job's paperwork if different from conventional marking system. Take pictures of match-marks if in a complex configuration or if difficult to discern pattern.

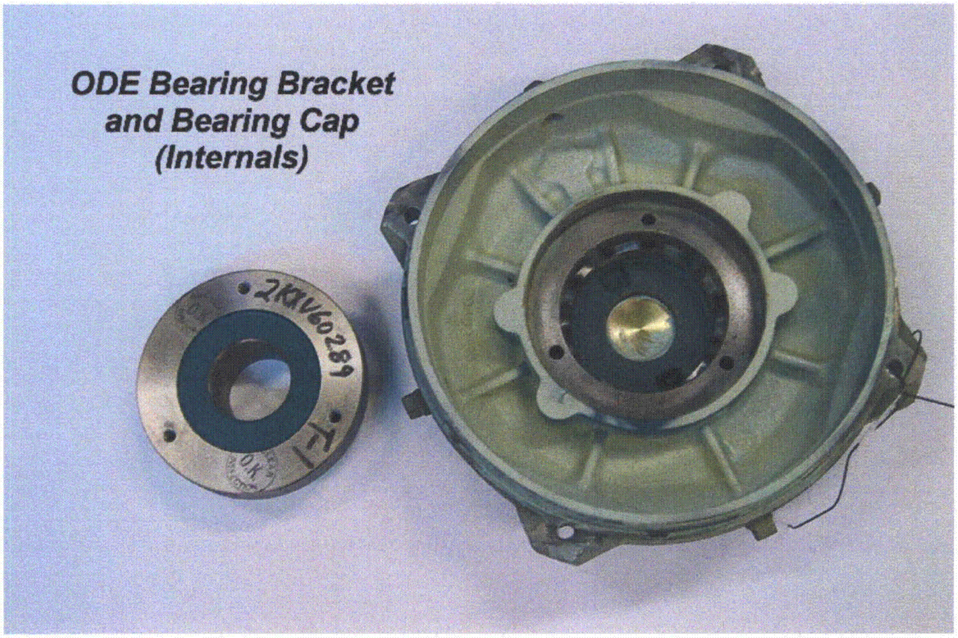
Punch Mark Convention		
Single Shaft Extension	DE: 2 marks	ODE: 3 marks

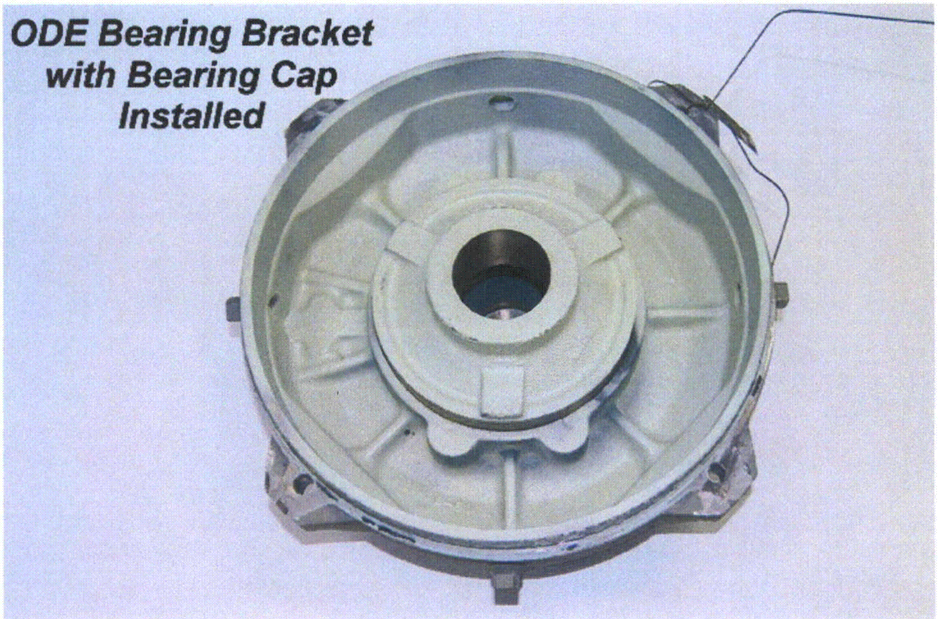
Note: Some Limitorque motors have lead-exit sealant material (generically referred to as "Chico," which is in fact a specific product of the Crouse-Hinds Corporation) which is used to seal the lead exit at the pulley end bearing bracket. If lead-exit sealant material is found, the drive end bearing bracket cannot be removed without possible permanent damage to the lead wire. However, the motor can still be disassembled, but the drive end bearing bracket must be left in place. Therefore, only the opposite drive end can be inspected.

1.2.2 With the motor on its side, remove the opposite drive end (ODE) bearing bracket bolts (4). Remove the ODE bearing cap bolts (3). *NOTE: Not all MOV motors have bearing caps installed. If bearing caps are not installed, no bearing cap bolts will be present.* Remove the ODE bearing bracket. Tapping it with a mallet will most likely be required to break the seal with between the bearing bracket and stator frame. Once the seal is broken, use a prying device as required to remove the bearing bracket. If a prying device is used, work it from side to side to ensure the bearing bracket does not cock in the stator frame. The ODE bearing and bearing cap will remain on the shaft.

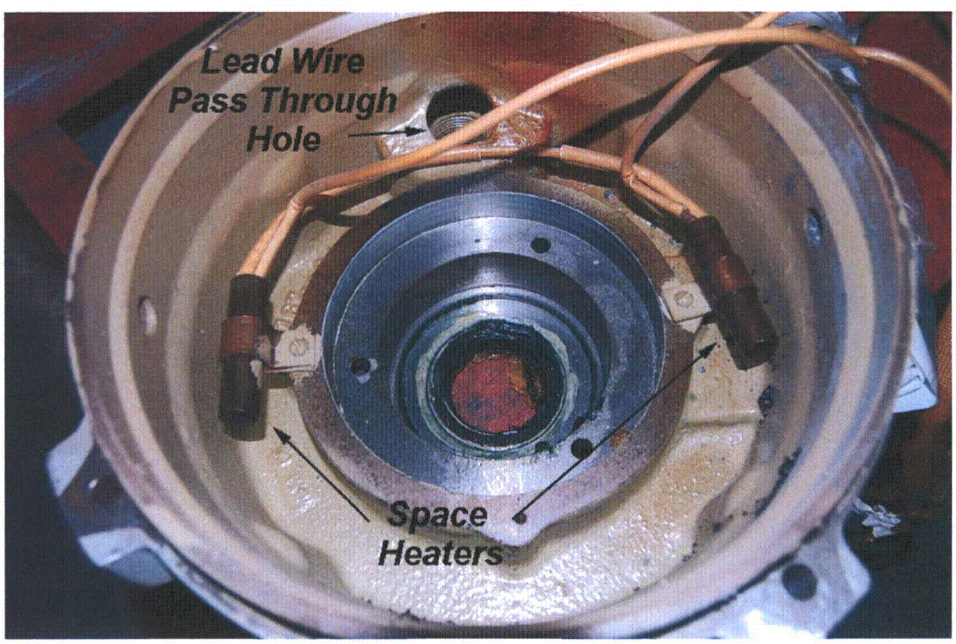


Opposite drive end (ODE) bearing bracket and bearing cap/bolts. The bearing bracket captures the bearing in the bearing bracket.





1.2.3 Remove the drive end bearing bracket bolts (3). Remove DE bearing bracket. This is completed in the same fashion as the ODE bearing bracket. When removing the DE bracket, feed the heater and stator leads through the opening in the bearing bracket.



*DE Bearing Bracket as viewed from the inside of the motor.
Bearing cap not installed.*

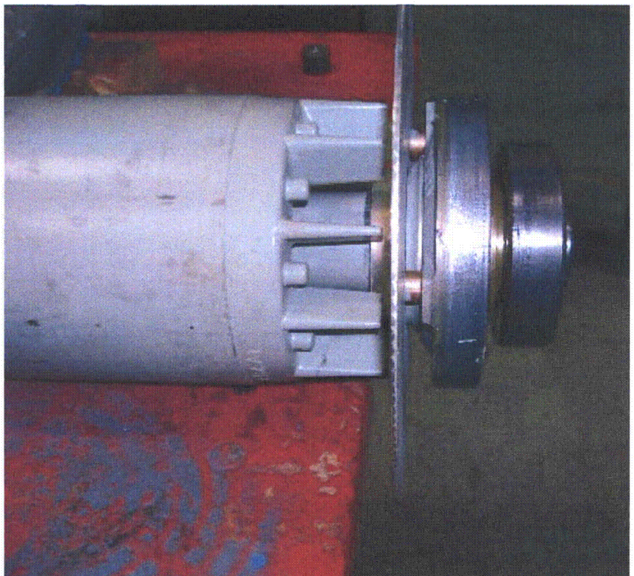
1.2.4 Once both bearing brackets are removed from the stator frame, remove the rotor by CAREFULLY pulling it out of the stator bore. CAUTION: Do not drag the rotor body over the stator windings otherwise damage to the stator windings could occur.

1.2.5 The rotor can now be inspected.

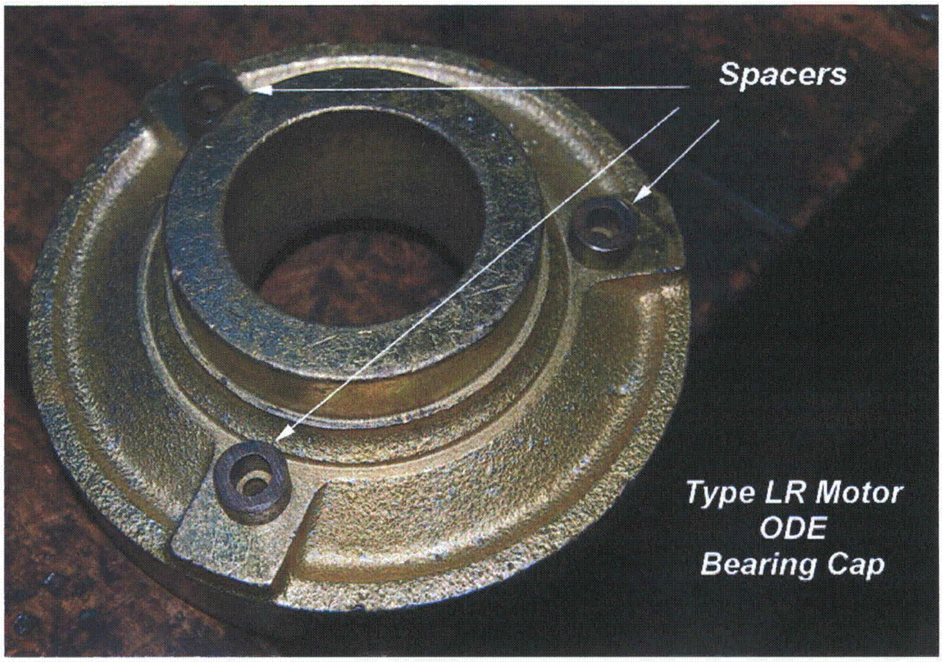
1.3 LR Motor Components

LR motor type can be determined by nameplate information. In the “Ins. Type” block, the letters “LR” will be written. These motors have internal shields on both the DE and ODE end.

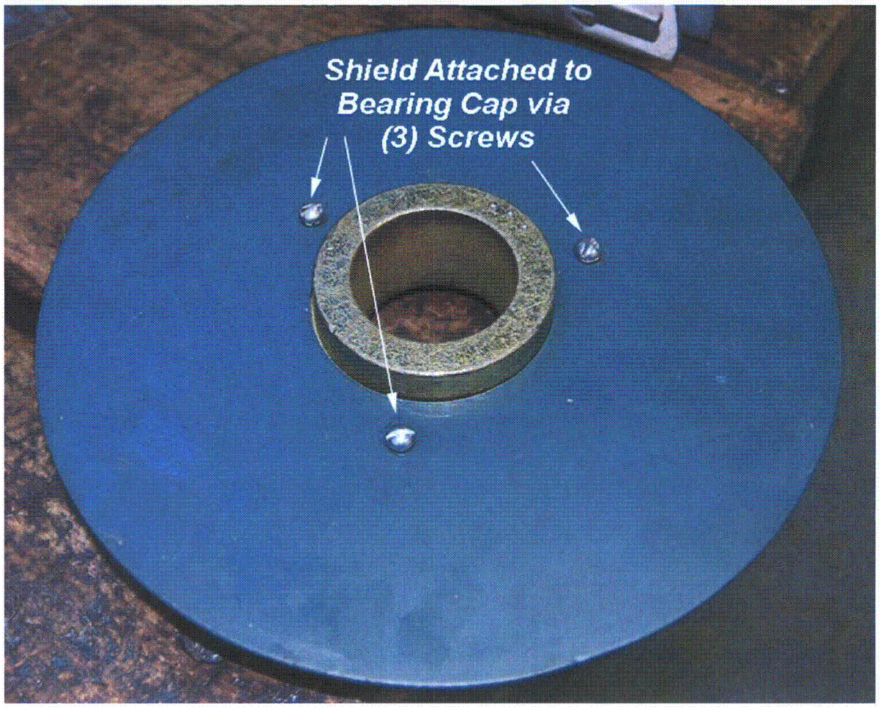
1.3.1 ODE Components. The ODE has a shield attached to the bearing cap with spacers. If the rotor is to be pulled out from the DE side, the shield must be removed before the rotor can be pulled through the stator bore. If removing the rotor from the ODE side, the rotor can be removed and the shield then removed from the bearing cap. The ODE bearing WILL REQUIRE removal from the shaft in order to remove the shield.



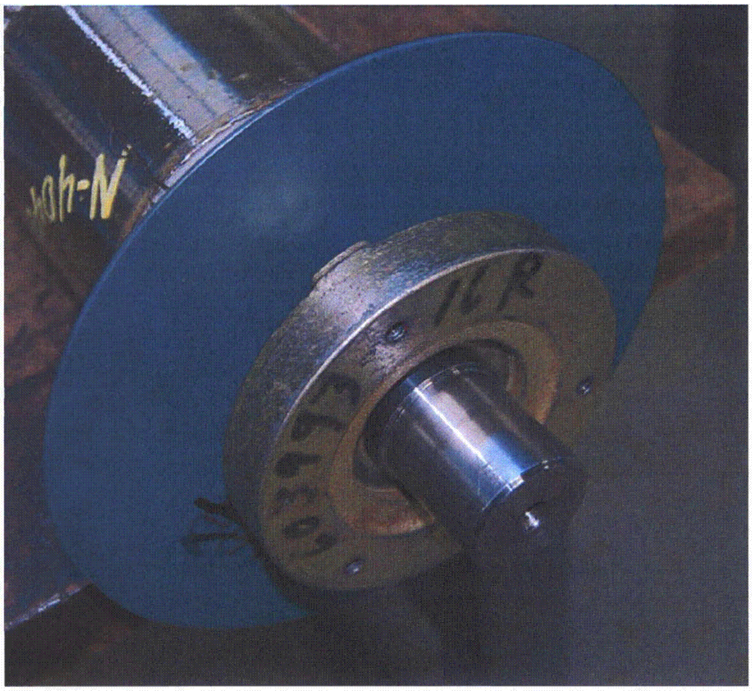
Type LR motor rotor/shield/bearing assembly. These motors have a large shield inboard of the bearing that precludes inspection of the motor rotor via borescope.



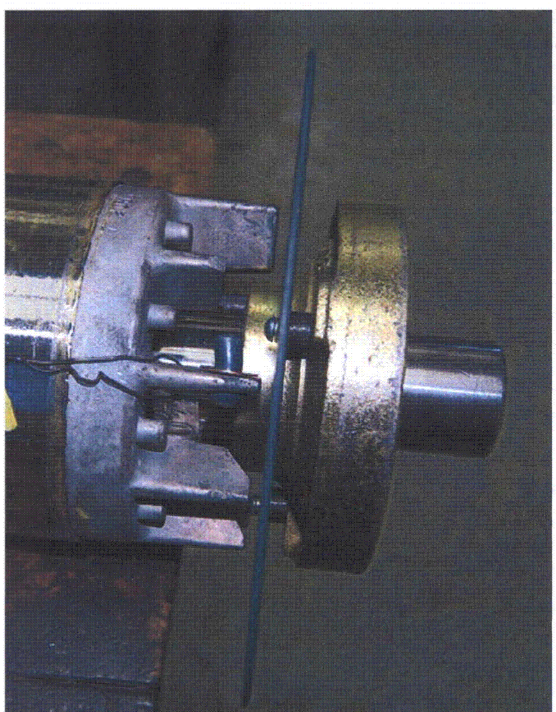
ODE Bearing Cap. This cap is similar to type RH insulation motors but have three additional tapped holes on the stator side of the cap to capture the shield.
There are normally spacers between the cap and the shield as shown above.



Shield attached to bearing cap with three screws.
Spacers are located between the bearing cap and the shield.

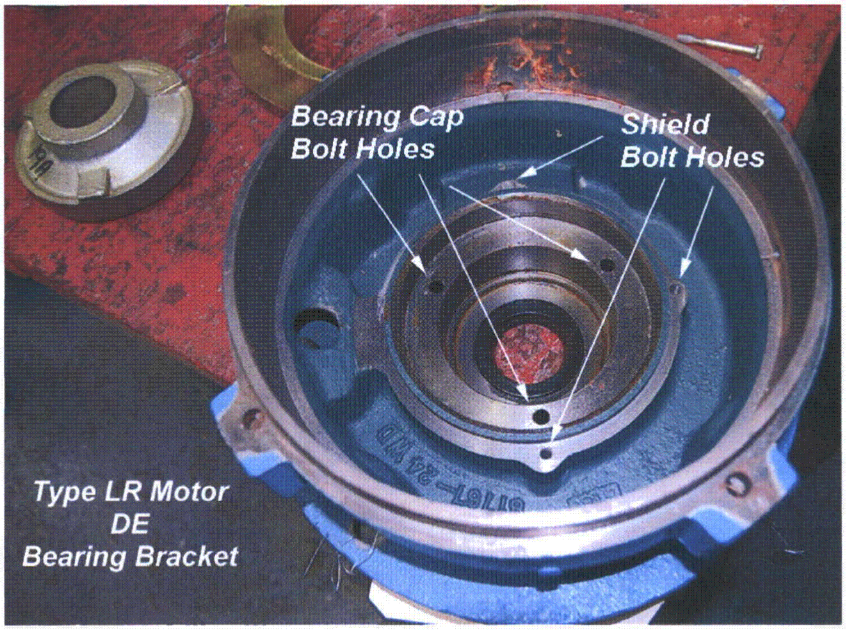


Bearing bracket installed on shaft (clearance fit). The bearing is then fit to the shaft and the bearing bracket installed and the cap/shield assembly is captured via (3) bolts.

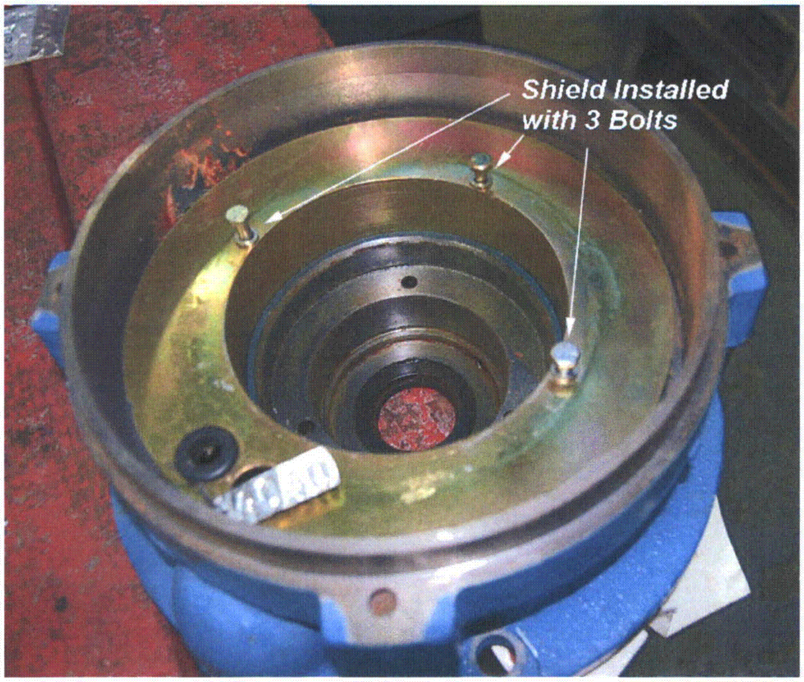


ODE bearing bracket/shield assembly on motor shaft. ODE bearing NOT shown installed.

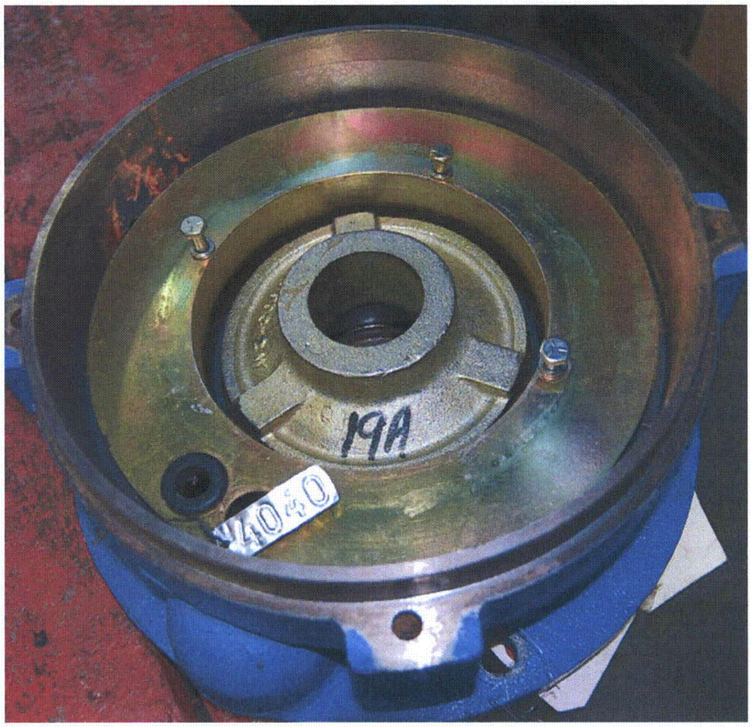
1.3.2 DE Components. The DE has a shield mounted into the DE bearing bracket. It is held in place with 3 bolts. The bearing cap is separate from the shield. The rotor can be removed from the stator bore by removing it from the ODE end.



DE Bearing Bracket



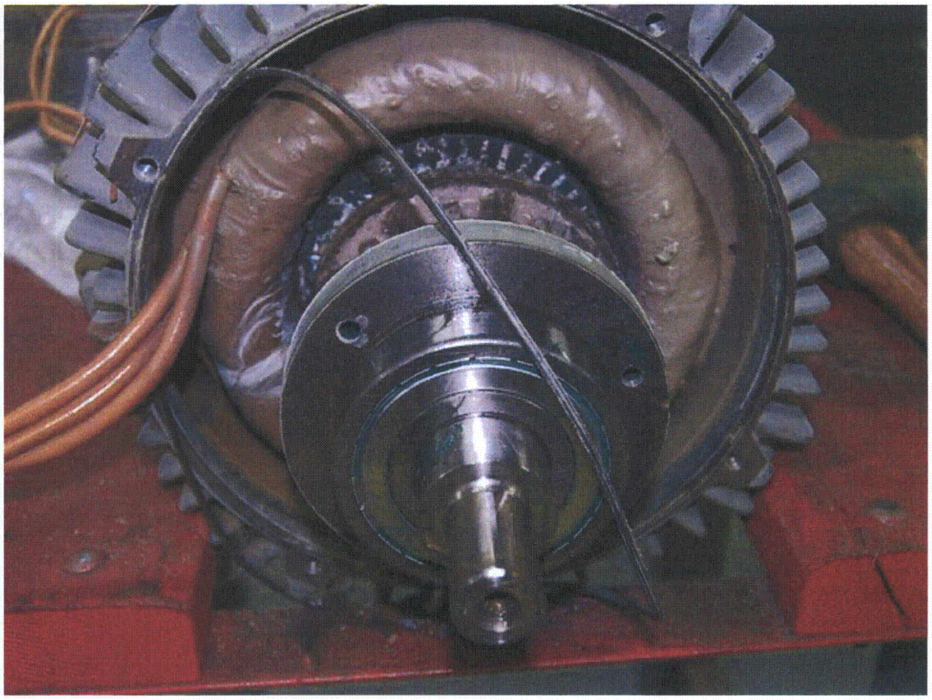
DE bearing bracket with shield installed. Bolts are shown NOT screwed all the way in.



*DE bearing bracket with shield installed and bearing cap in place.
Shield bolts are shown NOT screwed all the way in.*

2. BEARING FITS

2.1 The bearings do not have to be removed from the shaft in order to inspect the rotor. If they are to be replaced, they will need to be removed from the shaft by use of a puller, and fits checked.



Drive end of failed MOV motor. The bearing and bearing cap are installed on the shaft. A puller must be used to remove the bearing.

2.2 If the bearings are to be removed and replaced, the fit of the shaft to inside diameter (ID) and bearing bracket housing to bearing outside diameter (OD) must be checked for a proper fit. This procedure does not cover corrective action for out-of-tolerance fits.

2.3 Bearing Fits

The following table should be used for bearing fit acceptance criteria. Once the bearing size is determined, consult a bearing catalog to determine acceptance criteria for bearing fits.

Shaft to Bearing Inside Diameter Fit

Bearing ID (mm)	Bearing Fit/Tolerance Symbol
≤ 18	j5
(18) – 100	k5

Bearing Outside Diameter to Housing Fit

Bearing OD (mm)	Bearing Fit/Tolerance Symbol
All	H6

3. ASSEMBLY

3.1 If bearings were removed from the shaft, install the bearing caps (if motor is equipped with bearing caps) on the shaft and install bearings on the shaft. Ensure the bearings meet the fit criteria above prior to installation.

3.2 To capture the bearing caps, use a longer length bearing cap bolts to capture the bearing cap after the bearing bracket is installed. This allows the bearing cap to be drawn into place. Once the bolt bottoms out, remove one of the longer bolts, and install the original bearing cap bolt. Repeat with other bolts.

3.3 Repeat for other bearing bracket.

3.4 Perform Final Electrical and Mechanical Tests

3.4.1 Measure the stator insulation resistance. Record results.

3.4.2 Measure the winding resistance of all three phases. Record results.

3.4.3 Measure the polarization index. Record results.

3.4.4 Measure the shaft extension runout. Record results.

3.4.5 Measure the shaft endplay. Record results.

Perform no load operational test and record: Voltage, current, speed and vibration levels.

4. INSTALLATION OF BORESCOPE INSPECTION PORTS

Some Limitorque motors were supplied without "T" drains/drain plugs installed on the bearing brackets. The following procedure should be used as a general guideline for drilling and tapping new holes for pipe plug fittings which can be used for borescope inspection ports.

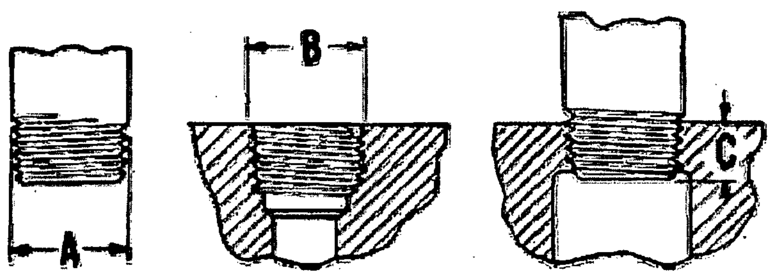
Motors that were supplied with pipe plugs have 3/8"-18 threads per inch (TPI) NPT pipe plugs installed. These same pipe plugs will be retrofitted to existing motors without pipe plugs.

NOTE: This is not applicable to type LR motors due to the internal baffles installed in the motors. Type LR motors can only be inspected via disassembly.

Tools and Materials Required

- Drill Press
- Clamping Device for Bearing Bracket
- 3/8"-18 TPI NPT Pipe Tap
- 3/8"-18 TPI NPT Pipe Plugs (up to 7 per motor)
- 37/64" Drill Bit
- Center Punch
- Thread Cutting Oil

It should be noted that pipe sizes do not refer to any physical dimensions. For example, a 3/8" NPT pipe thread has an outside diameter of 0.675". Each thread size has a defined number of threads per inch (TPI). The 3/8" NPT pipe thread has 18 threads per inch. Both the TPI and OD of the thread are required for positive identification of thread size because several sizes have the same TPI.



Nominal Dimensions for 3/8" Pipe Fitting

Dimension	Value
A: Male Thread O.D.	0.675"
B: Female Thread I.D.	0.675"
C: Nominal Engagement for Tight Joint	0.410
Threads Per Inch	18

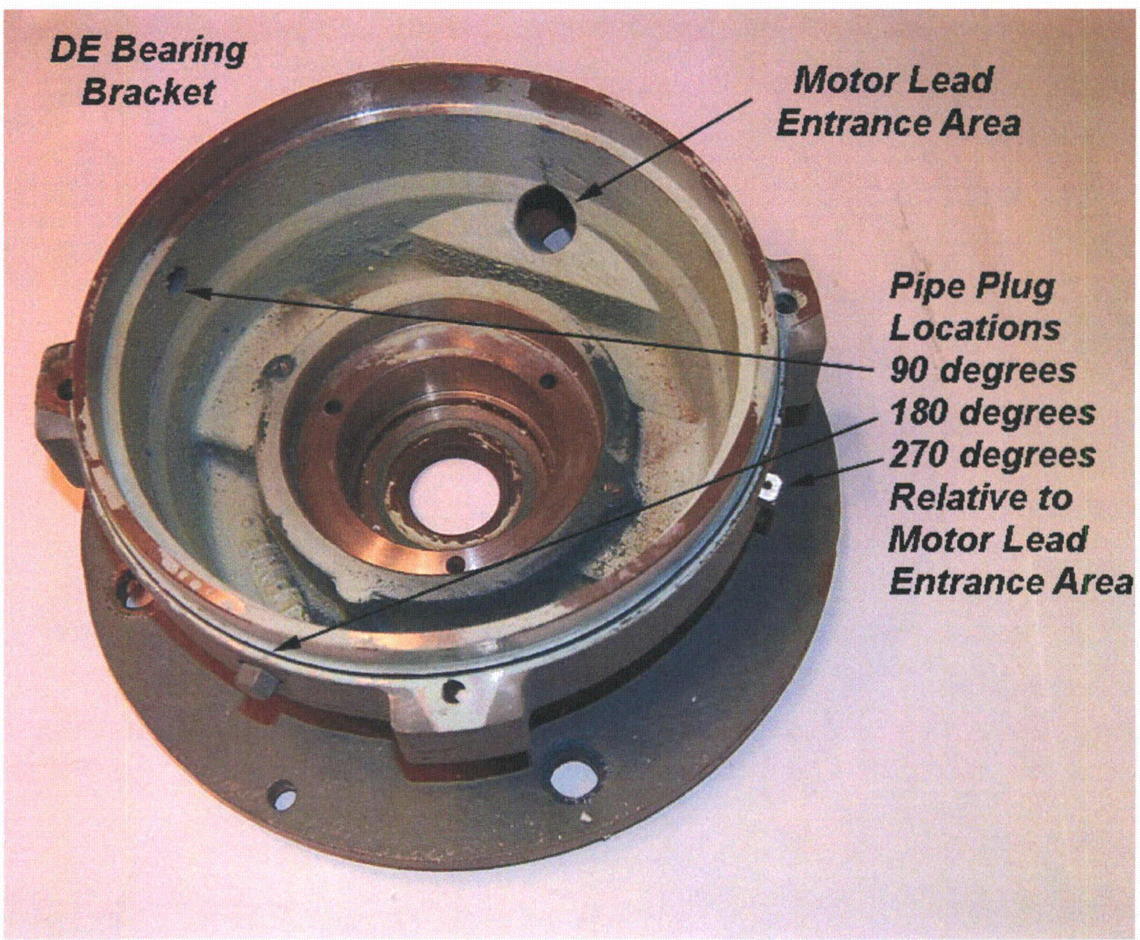
Precaution: The following procedure and hole locations are based on bearing brackets that were supplied with pipe plug installed at the factory. The user must determine the suitability of location of pipe plug holes for motors that were not supplied with "T" drains/pipe plugs. Use caution when determining drilling locations to ensure that there will not be interference with other components or degradation of bearing bracket strength due to hole location.

4.1 Disassemble the motor and clean the DE and ODE bearing brackets of any dirt or grease. Remove space heaters from DE bearing bracket, if installed.

4.2 Determine location for bearing bracket pipe plugs.

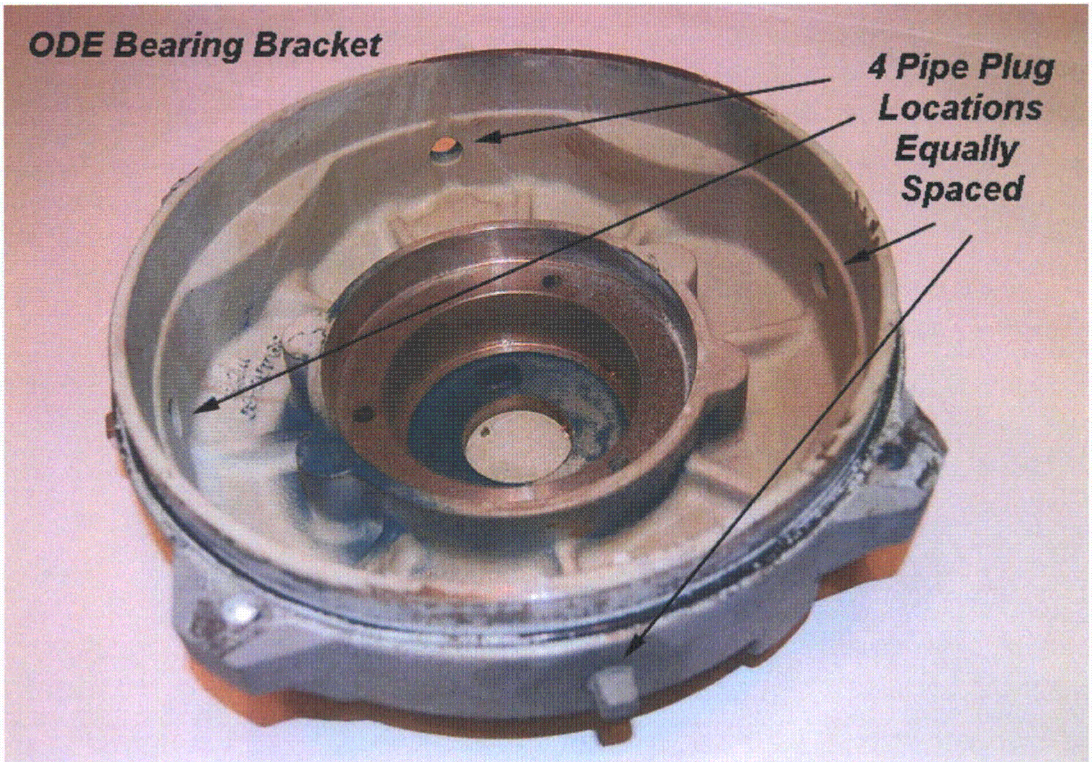
4.2.1 Drive End Bearing Bracket

The DE bearing bracket will have no more than three holes drilled. These holes should be 180 degrees across from the motor lead entrance area (1 hole) and (2) holes 90 degrees relative to the lead entrance area. Once the hole location is determined, mark location with a center punch.

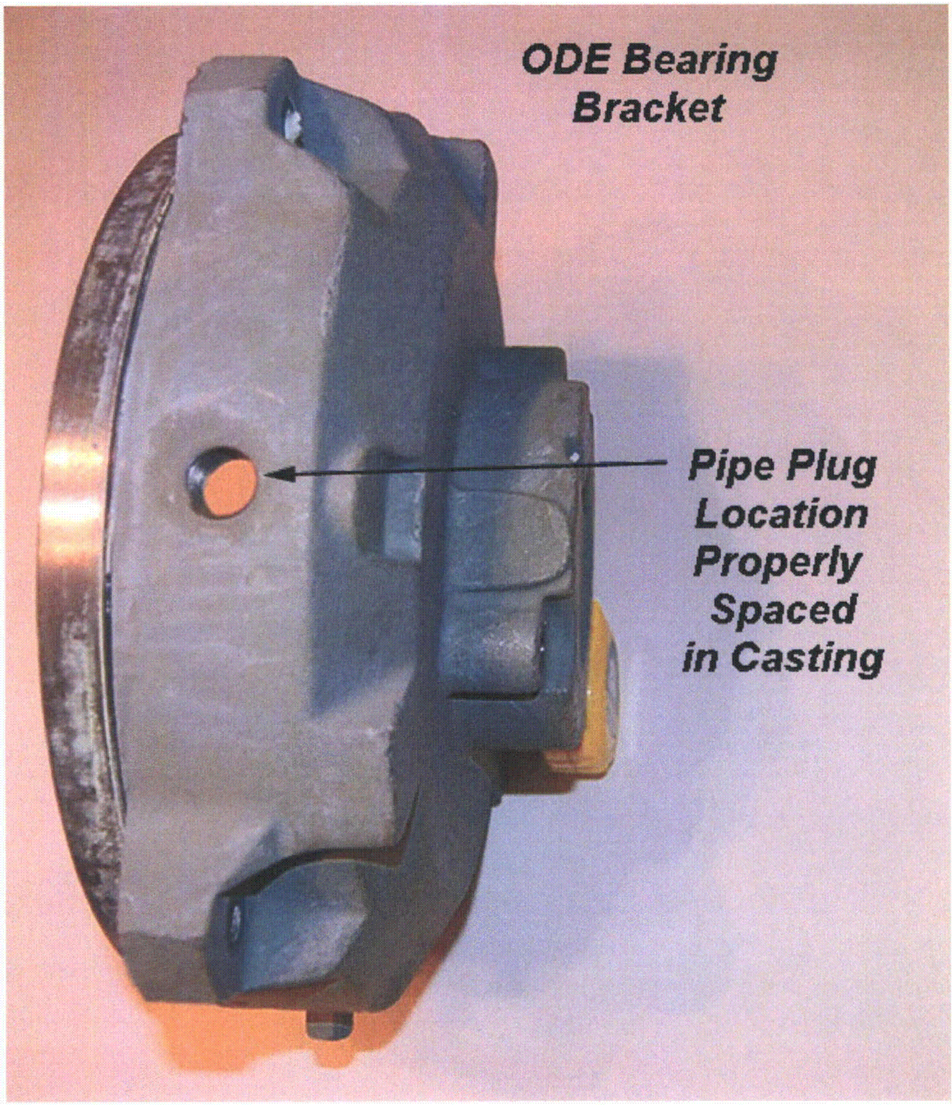


4.2.2 Opposite Drive End Bearing Bracket

The ODE bearing bracket will have no more than (4) holes drilled at 90 degree intervals. These holes should be located between the bearing bracket-to-stator frame hole locations. Once the hole location is determined, mark location with a center punch.



ODE Bearing Bracket. Pipe plug locations equally spaced between bearing bracket-to-stator frame bolting locations.



Locate the hole for the pipe plug in the proper location radially and axially in the bearing bracket casting. Consideration must be taken when determining drilling location for both the inside and outside of the casting.

4.3 Drill and Tap the Pipe Plug Holes

4.3.1 Mount the bearing bracket in a suitable clamping device so it can be held at the drill press. Ensure the bearing bracket is securely mounted to the drill press to prevent movement during the drill process.

4.3.2 Using a 37/64" drill bit, drill through the bearing bracket at the marked location.

4.3.3 Before unclamping the bearing bracket from the clamping device, tap the drilled hole all the way through the opening using thread cutting oil while tapping. If the material is too deep to tap completely through the drilled hole, the hole must be tapped to a minimum depth of 0.600". The nominal length of engagement of the plug in the hole must be 0.410" to ensure a tight joint.

4.3.4 Unclamp the bearing bracket and set up for next hole until all holes are drilled and tapped.

4.4 Clean the bearing bracket of all metal chips/filings ensuring there is no foreign material left in the bracket or bearing housing.

4.5 Install pipe plugs in new holes snug tight.

4.6 Reinstall heaters on DE bearing bracket, if previously installed.

4.7 Reassemble and test the motor per instructions above.

Appendix 3

Motor Inspection Failure and Degradation Criteria Tables

The motor inspection failure and degradation criteria tables are presented in Microsoft Word format below for ease of use for plant personnel to cut and paste into station procedures.

These tables should be used in conjunction with sections 6.0 and 8.0 of the document. Specifically the different acceptance criteria for Group A vs. Group B motors must be observed when inspecting and dispositioning motors that have any type of failure or degradation per the tables below.

Motor Inspection Failure Criteria

Item	Identified	
	Yes	No
Any observed gap or separation between the rotor end lamination and the magnesium end ring with evidence of corrosion at or near the gap interface.		
Any outward spreading or radial misalignment of any cooling fin. This would normally be found in conjunction with the item above.		
Black corrosion product build-up between the rotor end lamination and the magnesium end ring.		
Black corrosion product build-up at outside diameter of rotor at magnesium end ring.		
Indication of thermally induced stress. Obvious darkening or discoloration of the magnesium end ring adjacent to the rotor end lamination.		
Balance nubs or outside edges of the cooling fins are corroded away. This should not be confused with the factory removal of balance nubs or grinding of the cooling fins during the rotor balance process.		
The magnesium end ring is broken or has missing sections. Pieces of the magnesium end ring or cooling fins are found detached within the motor housing.		
Globular or molten metallic deposits appear anywhere on the surface of the magnesium end ring and/or cooling fins.		
Any cracking in the magnesium end ring or the cooling fins, particularly where the cooling fins join the magnesium end ring.		
Any evidence of contact between the rotor cooling fins and the stator windings.		
Excessive corrosion or bubbling of the magnesium end ring or cooling fins.		

Motor Inspection Degradation Criteria

Item	Identified	
	Yes	No
Slight blistering of the protective coating of the magnesium end ring or the cooling fins.		
Minor pockets of corrosion on the magnesium end ring and/or the cooling fins.		
Minor galvanic corrosion at the interface of the magnesium end ring and end lamination.		

ENCLOSURE 3

AFFIDAVIT REQUESTING WITHOLDING OF ENCLOSURE 1

BWR Owners' Group

AFFIDAVIT

I, Douglas W. Coleman, state as follows:

(1) I, Chairman of the BWR Owners' Group (BWROG), have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in BWR Owners' Group (BWROG) Report, BWROG-TP-09-005, *Inspection of Motor Operated Valve Limitorque AC Motors with Magnesium Rotors,* March 5, 2009. The proprietary information in BWROG Report, BWROG-TP-09-005, *Inspection of Motor Operated Valve Limitorque AC Motors with Magnesium Rotors,* March 5, 2009, is identified by [[dotted underline inside double square brackets{3}]]. Figures and other large objects are identified with double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, BWROG relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information, which fit into the definition of proprietary information, are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by BWROG's competitors without license from BWROG constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information, which reveals aspects of past, present, or future BWROG customer-funded development plans and programs, resulting in potential products to BWROG;

d. Information, which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. above.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being transmitted to NRC in confidence. The information is of a sort customarily held in confidence by BWROG, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by BWROG, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to BWROG. Access to such documents within BWROG is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside BWROG are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed results of analytical models, methods and processes, including computer codes, which BWROG has developed, and applied to perform licensing and design evaluations for the BWR.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major BWROG asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to BWROG's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of BWROG's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by BWROG.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

BWROG's competitive advantage will be lost if its competitors are able to use the results of the BWROG experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to BWROG would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive BWROG of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 14th day of May 2009.

Douglas W. Coleman

Douglas W. Coleman
Chairman
BWR Owners' Group