CRITERION 510

ELECTRICAL MOTORS

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CRITERION 510

ELECTRICAL MOTORS

1.0 PURPOSE

The purpose of this Criterion is to establish the minimum requirements and best practices for operation and maintenance of Electrical Motors at LANL. This document addresses the requirements of LIR 230-05-01, "Operations and Maintenance Manual." (Reference 10.1)

The implementation of these requirements satisfies DOE Order 430.1A, "Life Cycle Asset Management," Attachment 2 "Contractor Requirements Document," Paragraph 2, Sections A through C, which in part require UC to "…maintain physical assets in a condition suitable for their intended purpose" and employ "preventive, predictive, and corrective maintenance to ensure physical asset availability for planned use and/or proper disposition." Compliance with DOE Order 430.1A is required by Appendix G of the UC Contract. (Reference 2)

2.0 SCOPE

The scope of this Criterion includes the routine inspection, testing and maintenance of Electrical Motors at all nuclear and non-nuclear LANL facilities.

2.1 Electrical Motors

Low voltage – 600 Volts and less, Alternating Current (AC) or Direct Current (DC), excluding motors with sleeve type bearings and fractional horsepower motors with factory sealed bearings. A typical selection criteria is motors that are 3 phase, 10 to 600 horsepower, and motors with ball-type bearings.

3.0 ACRONYMS AND DEFINITIONS

3.1 Acronyms

AR	Administrative Requirements
CFR	Code of Federal Regulations
CMMS	Computerized Maintenance Management System
IR	Insulation Resistance Test
LIR	Laboratory Implementation Requirement
NEC	National Electrical Code

NEMA	National Electrical Manufactures Association
NFPA	National Fire Protection Association
O&M	Operations and Maintenance
PI	Polarization Index Test
PP&PE	Personal Property and Programmatic Equipment
PPE	Personal Protective Equipment
RP&IE	Real Property and Installed Equipment
SEM	Systems, Engineering and Maintenance
SSC	Structures, Systems, and Components
UC	University of California
VOM	Voltage/Ohmeter

3.2 Definitions

3.2.1 Continuous Duty

A requirement of motor service that demands operation at an essentially constant load for an indefinitely long time. This is the most common duty classification and accounts for approximately 90% of motor applications. (GE Motor Selection and Application Guide) (Reference 10.22)

3.2.2 Insulation Resistance Test (meggering)

A test for measuring the electrical resistance between two conductors separated by an insulating material. (McGraw-Hill Dictionary of Scientific and Technical Terms 5th Edition) (Reference 10.23)

3.2.3 Intermittent Duty

A requirement of motor service that demands operation for alternate intervals of load and no-load, load and rest, or no-load and rest. (GE Motor Selection and Application Guide) (Reference 10.22)

3.2.4 Polarization Index

The polarization index is a specialized application of the insulation resistance test. The index is the ratio of insulation resistance at two different times after voltage application, usually the insulation resistance at 10 minutes to the insulation resistance at 1 minute. (NFPA 70B 18-9.2.3) (Reference 10.4)

4.0 RESPONSIBILITIES

4.1 Facility Manager

4.1.1 Responsible for operations and maintenance of institutional, or Real Property and Installed Equipment (RP&IE), in accordance with the requirements of this document.

4.1.2 Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that may be assigned to the FM in accordance with the FMU-specific Facility/Tenant Agreement.

4.1.3 Responsible for system performance analysis and subsequent replacement or refurbishment of RP&IE and assigned PP&PE based on sound Life Cycle Analysis techniques and system-specific performance requirements.

4.2 FWO-Systems Engineering and Maintenance (SEM)

4.2.1 Responsible for the technical content of this Criterion and assessing the proper implementation across the Laboratory. FWO-SEM should also provide technical assistance in support for implementation of this Criterion.

4.3 Group Leader

4.3.1 Responsible for implementing operational and maintenance surveillance programs including the preparation and maintenance of required procedures and documentation for PP&PE under their jurisdiction that is covered by this Criterion.

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Precautions

This section is not intended to identify all applicable precautions necessary for implementation of this Criterion (e.g., lockout/tagout, confined space entry, PPE, etc.). It is intended only to assist the user in the identification of hazards/precautions that may not be immediately obvious.

5.1.1 Personnel must be aware of a potential for electric motors with an automatic reset protector that has the potential of automatically restarting the motor. This could endanger personnel or equipment. These auto-start features can be located on the starter itself, through programmable logic controllers or variable frequency drives. Such applications should use a manual reset protector or an identification placard to caution personnel. **Note:** Lockout/Tagout procedures must always be utilized when working on or around electric motors.

5.1.2 While re-lubricating motor bearings with grease and the drain plug is removed, under no circumstances should a mechanical probe be used while the motor is in operation. **Note:** Lockout/Tagout procedures must always be utilized when working on or around electric motors.

5.1.3 Assure electric motor units are electrically grounded and electrical installation wiring and controls are used consistent with NEC and NFPA electrical code requirements. (NEC Article 430 and 250)

5.1.4 When approaching rotating electro-mechanical parts, such as couplings, pulleys, shafts, external fans, and unused shaft extensions, personnel should guard against accidental contact with hands, tools, or clothing. This is particularly important where the parts have surface irregularities such as keys, keyways, or setscrews.

5.1.5 Do not lift a motor and its driven load by the motor lifting hardware. Motor lifting hardware is adequate for lifting of the motor only.

5.2 Limitations

The intent of this Criterion is to identify the minimum generic requirements and recommendations for SSC operation and maintenance across the Laboratory. Each user is responsible for the identification and implementation of additional facility-specific requirements and recommendations.

Nuclear facilities and moderate to high-hazard non-nuclear facilities will typically have additional facility-specific requirements beyond those presented in this Criterion which are contained in their Technical Safety Requirements, Facility Safety Plans, Configuration Management Process, and the Unreviewed Safety Question Determination (USQD) process as applicable. Nuclear facilities must implement the requirements of DOE Order 4330.4B (or 10 CFR 830.340, Maintenance Management, when issued) as the minimum programmatic requirements for a maintenance program. Additional requirements and recommendations for SSC operation and maintenance may be necessary to fully comply with the current DOE Order or CFR identified above. (Reference 10.5)

6.0 REQUIREMENTS

Minimum requirements that Criterion users must follow are specified in this section. Requested variances to these requirements must be prepared and submitted to FWO-SEM in accordance with LIR 301-00-02, “Variances and Exceptions to Laboratory Operations Requirements” (Reference 10.6) for review and approval. The implementation of these requirements will ensure that the subject SSC is maintained in a condition suitable and available for its intended use. The Criterion users are responsible for analysis of operational performance and SSC replacement or refurbishment based on this analysis. The requirements contained in this section are driven by LIRs, ARs and contractually agreed to codes, orders, and standards.

6.1 Operations Requirements

6.1.1 Assure machine guarding for personnel safety on motor-driven equipment remains in place while in operation.

Basis: Based upon Occupational Safety and Health Administration regulation (Reference 10.19). Compliance with this standard is required per Appendix G of the UC Contract.

6.2 Maintenance Requirements

6.2.1 None.

7.0 RECOMMENDATIONS AND GOOD PRACTICES

The information provided in this section is recommended based on acceptable industry practices and should be implemented by each user based on his/her unique application and operating history of the subject systems/equipment.

7.1 Operations Recommendations

7.1.1 Motors are designed to operate at or below any maximum surface temperature stated on the nameplate. Failure to operate the motor properly can cause this maximum motor temperature to be exceeded and cause premature failure. If applied in a hazardous area, this excessive temperature may cause ignition of hazardous materials. Operating motors at any of the following conditions may have the potential to cause nameplate temperatures to be exceeded:

- Motor load exceeding service factor value
- Ambient temperatures above nameplate value
- Voltages above or below nameplate value
- Unbalanced voltages
- Loss of proper ventilation
- Variable frequency operation
- Altitude above 3000 ft. **Note**: See 7.1.3
- Severe duty cycles – repeated starts. **Note:** See 7.1.2
- Motor stalls, motor reversing, or single phase operation

Basis: Recommendations provided by DOE Motor Challenge Program. (Reference 10.7)

7.1.2 Avoid repeated unsuccessful restarts of electric motors that can create overheating of motor or external starting equipment. Generally restarts in succession with electric motors will shorten motor life. Excessive restarts can be created both by automatic electric controls as well as manual operator actions. When additional starts are required, it is recommended that none be made until all conditions affecting operation have been thoroughly investigated and the apparatus examined for evidence of excessive heating. It should be recognized that the number of starts should be kept to a minimum.

Basis: Recommendation from National Electrical Manufactures Association - Number of Motor Starts. (Reference 10.15)

7.1.3 Los Alamos National Laboratory is located at an elevation of greater than 7000 ft. The rating of standard motors assumes operation at sea level in a 40 deg. C ambient. For purposes of standardization it is considered that there is no difference in motor operating temperature between sea level and 3300 ft. The cooling effect of ventilating air is a function of its density. The atmospheric pressure and density at higher altitudes is reduced and the air cannot remove as much motor heat, causing the motor to run hotter. As a general guide, motor temperature rise increases 1% for every 330 ft. above 3300 ft. To keep motor heating within safe limits at altitudes above 3300 ft. the LANL Facility Engineering manual and the LANL Construction Specification Section 15170 provides provisions for de-rating motors for 7500-ft. altitude in accordance with NEMA MG1-12: 1% for every 300 ft. above 3300 ft. These specifications are requirements whenever a motor is being replaced or installed for the first time and should be utilized to provide proper cooling of motors for LANL applications.

Basis: Recommendation from National Electrical Manufactures Association and Engineering requirements of LANL Facility Engineering Manual. (References 10.15 and 10.21)

7.2 Maintenance Recommendations

Careful and regular maintenance and inspections are required to detect and clear any faults as early as possible before major damage can develop. Only general inspection intervals for trouble-free operation can be recommended because of the widely differing operating conditions. The inspection intervals must therefore be matched to the prevailing circumstances (dirt, deposits, frequent starts, loading, temperature, etc.). Special information provided by motor manufactures must also be followed. The following Maintenance Frequency Matrix is provided as a general guide.

Table 7.2-1 Frequency Matrix

Frequency Matrix			
Chart Legend I = Inspect, T = Test, M = Monitor, P = Perform			
	Qtr (3mo	6 mo	1yr
COMPONENT - MOTOR			
Lubrication / Cleaning / Inspections			
Air Filters inspection		I	
Bearing Lubrication - See Note 1 below			P
Motor Cleaning			P
Mountings, Couplings			I
Monitor of Operating Conditions			
RPM (revolutions per minute)			T
Voltage			T
Current			T
Power			T
Power Factor			T
Monitor Thermal, Vibration, Acoustics			
Thermography/Temperature Assessments			M
Vibration Monitoring			M
Acoustics			M
Electrical Tests			
Insulation Resistance			T
Polarization Index			T
Storage			
Lubrication			P
Start/Run (when available)	P		
Shaft Rotations - See Note 2 below	P		
Space Heater Inspection	I		
Note 1 : Refer to Lubrication Tables - 7-2 & 7-3			
Note 2 : Shaft rotations to be done in a manner that shaft is left in a 90 deg. rotation from as-found position			

Basis: Engineering judgement of standard industry practice and DOE Motor Challenge Program (Reference 10.7)

7.2.1 Cleaning

7.2.1.1 Maintain external and internal cleanliness of motors when deemed cost effective (based on size and cost of motor). Frequency will be based upon the conditions and atmosphere in which the motors operate.

Basis: Engineering judgement and Todd Litman, "Efficient Electric Motor Systems," The Fairmont Press, Inc., 1995, Lilburn, GA (Reference 10.8)

7.2.2 Lubrication

7.2.2.1 Lubricate motors based initially upon manufacture's recommendations. Typical lubrication intervals vary from less than 3 months for large motors subject to vibration, severe bearing loads, or high temperature continuous duty to ten years for smaller motors with intermittent duty. Motors used seasonally should be lubricated before the season of use. Small or fractional horsepower motors have sealed bearings that do not require re-lubrication. All larger motors require some form of lubrication. Refer to Appendix A for an in-depth explanation on lubrication. It is important to note that the correct quantity of lubricant is vital to the proper operation of motor bearings. Insufficient or excessive lubrication will result in failure. Reference the following lubrication frequency guide.

Table 7.2-2 Lubrication Frequency Guide

LUBRICATION GUIDE	Motor Horsepower			
Type of Service	Up to 7.5	10 to 40	50 to 150	Over 150
Easy: infrequent operation (1 hr per day), valves, door operners, portable floor sanders	10 yr.	7 yr.	4 yr.	1 yr.
Standard: 1- or 2-shift operation, machine tools, air-conditioning apparatus, conveyors, garage compressors, refrigeration apparatus, lauddry machinery, textile machinery, wood-working machines, water pumping	7 yr.	4 yr.	1.5 yr.	6 mo.
Severe: motors, fans, pumps, motor generator sets, running 24 hr per day, 365 days per year; coal and mining machinery; motors subject to severe vibration; steel-mill servic.	4 yr.	1.5 yr.	9 mo.	3 mo.
Very Severe: dirty, vibrating applications, where end of shaft is hot (pumps and fans), high ambient	9 mo.	4 mo.	3 mo.	2 mo.

Basis: Data from vendor operation and maintenance manuals and "Incompatibility of Greases," NSK Techtalk Vol. 01, No. 02, April 1992; Technical Tip-Sheet of the NSK Corporation and "How to Get the Most From Your Electric Motors," Electric Apparatus Service Association, St. Louis, MO.; and NFPA 70B Table 19-3.7.3. (References 10.4,10.9, 10.10)

7.2.3 Mountings and Couplings

7.2.3.1 Assure motor and load is firmly mounted to common structure or floor and motor-to-load couplings are firmly connected during maintenance performance.

Basis: Operational experience and recommendations provided by Richard L. Nailen, "Managing Motors," Barks Publications Inc., 1991, Chicago, IL. (Reference 10.11)

7.2.4 Monitoring Operating Conditions

7.2.4.1 Test and monitor operating conditions at annual intervals as a minimum. Items to monitor are RPM, voltage, phase imbalance, current, power, and power factor. Maintain historical records of this monitoring. As per Section 9.1 of this document.

Basis: Standard commercial operations field experience and DOE Motor Challenge Program. (Reference 10.7)

7.2.5 Thermal, Vibration, and Acoustic Monitoring

7.2.5.1 Test electrical motors with high safety and risk levels on a routine basis for running temperature utilizing a contact thermometer at the middle of the motor housing and at the inboard and outboard bearing housings after the motor has come up to operating temperature and record (Thermography scans are acceptable as well). Test the same electrical motors for excessive vibration and acoustical noise that may alert experienced personnel to problems. Reference the following guide for guidance in motor vibration.

Table 7.2-3 Vibration Limits – Solo Run Test

Resiliently Mounted Machines

RPM @ 60 Hz	Velocity in/s peak	Velocity mm/s peak
3600	0.15	3.6
1800	0.15	3.6
1200	0.15	3.6
900	0.12	3
720	0.09	2.3
600	0.08	2
Note: For machines with rigid mounting, multiply the limiting values by 0.8.		
(Ref. 10.15)		

Basis: Operations and maintenance field experience show monitoring of critical motors closely on a routine basis has proven to be an excellent tool to prevent unsafe and/or critical conditions.

7.2.6 Electrical Tests

7.2.6.1 Regular periodic electrical tests should be performed on motors and motor circuits. These tests are usually performed on an annual basis to detect insulation problems. The following insulation deterioration testing techniques are predictive maintenance so that appropriate measures can be taken on a planned, and not a crash-action basis.

- Insulation resistance testing, commonly called meggering or IR, is an important predictive electrical test that is useful when the data is properly recorded and trended.
- Polarization Index (PI) is a basic IR test that goes a step further with more definitive results. The test is maintained for 10 minutes. The ten-minute reading is divided into the 1-minute reading to yield a polarization index. The PI should be above 1 and remain relatively consistent over time; a PI of 2 is very good. A pronounced drop in PI is a potential indication of a loss of insulation integrity.

Basis: Recommendations by IEEE 43-1991 and International Electrical Testing Association. (Reference 10.12, 10.13, and 10.14)

7.2.6.2 Analyze testing results of predictive/preventative maintenance records after each scheduled maintenance. Utilize NFPA 70B for acceptance criteria of data recorded.

Basis: Recommendation of DOE Motor Challenge Program and NFPA-70B 14-1.2 1998 (Reference 10.4 and 10.7).

7.2.7 Storage and Transport

7.2.7.1 Care and maintenance of spare motors is necessary to prevent premature damage leading to early failures. Lubricants can drain away or bleed, exposure to humidity can cause rust pits in bearing races and damage winding insulation, and exposures to vibration areas in a static condition will damage bearings. Several things are necessary to reduce the stress of storage. If the motors are connected, they should be started and run up to operating temperatures at a minimum quarterly basis. Motors in storage should have their shafts rotated manually on a quarterly basis to reposition the bearings and redistribute the lubricant. The shaft rotation must be done in such a way that from quarter period to quarter period, the shaft does not get rotated to it's previous position but placed 90 degrees from previous as-found position. Utilizing a marking tape on the shaft and dating the time it was rotated is a good method. Some motors equipped with internal space heaters should be connected and energized to maintain a dry atmosphere within the motor.

Basis: DOE Motor Challenge Program. (Reference 10.7)

8.0 GUIDANCE

8.1 Operations Guidance

8.1.1 Appropriate selection and maintenance frequency criteria for motors should be based upon two main categories in the following priority:

8.1.1.1 *The graded approach category*, that is a selective assignment of resources to the maintenance of motors based on their level of risk, mission impact, or criticality, and cost of replacement or repairs. Motors are assigned to one of four categories based on the potential impact of a worst case failure on public safety, worker safety, the environment, safeguards and security, and the programmatic function. The categories are identified as ML1, ML2, ML3, and ML4, with ML1 representing the highest level of importance and the most rigorous level of maintenance and ML4 representing the lowest level of importance and requiring less frequent maintenance activities. (Reference 10.3).

8.1.1.2 *The maintain or replace approach category*, that is a selective decision for each individual motor as to whether motor maintenance will be performed regularly or whether the motor will be allowed to operate until failure. The following factors to consider when making these selective decisions to maintain or replace are:

- Importance of having the motor back in service immediately
- Type and size of the motor (e.g., horsepower, efficiency rating)
- Application (speed/torque requirements), electrical operating costs and hours operated annually
- Simple payback analysis
- Cost and availability of repair service versus the cost of a new motor
- Age and repair history of the motor
- Maintenance and capital budgets

Basis: Based upon data provided by Electrical Apparatus Service Association (EASA) Chuck Yung, Technical Support Specialist, St. Louis Missouri. (Reference 10.9)

8.2 Maintenance Guidance

8.2.1 Clean motors run cooler. Dirt and contaminants build up on fan-cooled motor inlet openings and fan blades reducing flow of air and increasing motor operating temperature. Surface dirt can be removed by various means. The most common means are compressed air (max. 30 psi), vacuum cleaning, and direct wipe down with rags and brushes. Internal contamination is more difficult to remove. The most effective method is to prevent internal contamination. Larger motors can have filters placed at air intake areas to reduce contamination. (Reference 10.7)

8.2.2 With further analyses and well-kept records, different types of lubricant, and/or optimized lubricant intervals improve a lubrication program. Improper greasing techniques shorten bearing and motor life. The thorough cleaning of grease relief ports, grease fittings, and grease gun nozzles prior to lubrication is necessary to allow for proper lubrication flow and for preventing introduction of contaminants. Maintaining cleanliness of lubricant and preventing introduction of contaminants into the lubricant is a very common problem. Utilizing cartridges rather than bulk lubricant can prevent some contamination problems. The free flow of grease is important to prevent damage to motor bearings. Grease guns are capable of producing high pressures that can literally drive seals and shields out of the bearing. Mixing of incompatible greases will cause bearing failures. Refer to Table 8.2-1. Adding too much grease or adding grease too frequently can force grease past bearing shields into the motor windings.

Table 8.2-1 Grease Compatibility Chart

Grease Compatability Chart

	Aluminum Complex	Barium	Calcium	Calcium 12-hydroxy	Calcium Complex	Clay	Lithium	Lithium 12-hydroxy	Lithium Complex	Polyurea
Aluminum Complex		I	I	C	I	I	I	I	C	I
Barium	I		I	C	I	I	I	I	I	I
Calcium	I	I		C	I	C	C	B	C	I
Calcium 12-hydroxy	C	C	C		B	C	C	C	C	I
Calcium Complex	I	I	I	B		I	I	I	C	C
Clay	I	I	C	C	I		I	I	I	I
Lithium	I	I	C	C	I	I		C	C	I
Lithium 12-hydroxy	I	I	B	C	I	I	C		C	I
Lithium Complex	C	I	C	C	C	I	C	C		I
Polyurea	I	I	I	I	C	I	I	I	I	

I=Incompatible C=Compatible B=Borderline

Note: It is necessary to remove old lubricants from bearings that are not compatible with introduction of new type grease. (Reference 10.10)

8.2.3 Motor and load must be rigidly bound to a common structure or floor. Failure to maintain solid mountings will lead to vibration problems that may lead to bearing failure. Coupling alignment is important to coupling and bearing life. (Reference 10.13)

8.2.4 Testing of operating speed should be performed utilizing a non-contact type tachometer for safety reasons. For belt-drive applications, it is important to measure the RPM of both the driver and the load to detect changes in slippage over time. Voltage and current checks may be performed utilizing the standard clamp-on ammeter and VOM. It is important to note phase balance because unbalance can dramatically reduce motor efficiency and life. Check both voltage and current balance. A current imbalance over 2% is cause for immediate action. Significant changes in voltage are not likely to be caused by the motor, but affect the way a motor performs. Figure 8.2-1 shows how various load performance parameters tend to change with a departure from nameplate voltage. Power and power factor may be determined utilizing power factor meter or power meter. A maintenance procedure similar to JCNNM MOI 41-50-002, "Motor Circuit Evaluation" is acceptable provided it has been reviewed and approved by FWO-SEM. (Reference 10.9 and 10.18)

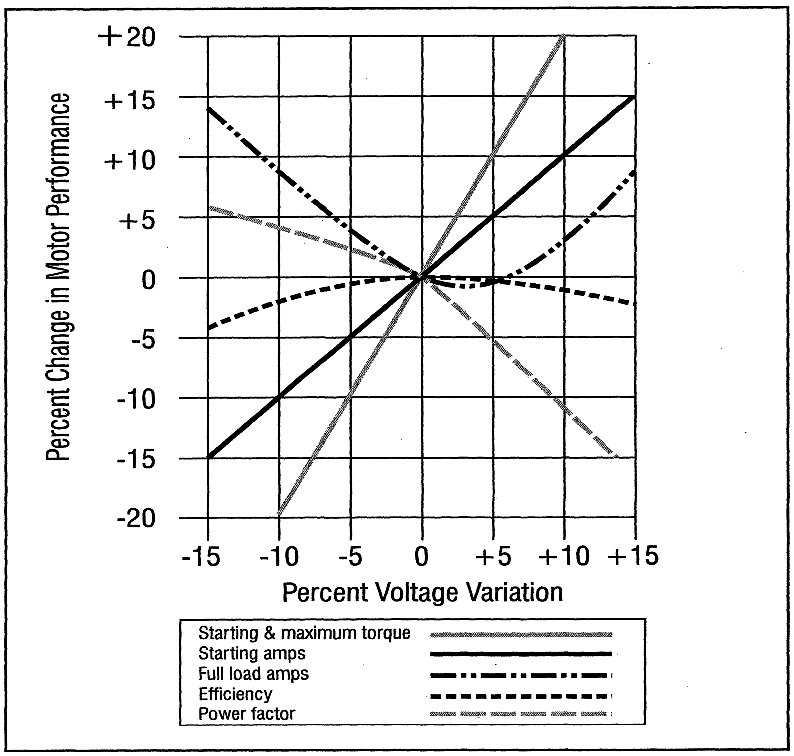


Figure 8.2-1 Effects of Voltage Variation on Induction Motor Performance Characteristics.

"Energy Management for Motor Driven Systems," US Department of Energy, Motor Challenge Program, June 1997, Rev. 1 (Reference 10.7)

8.2.5 Non Electrical Tests

8.2.5.1 Alignment

8.2.5.1.1 All rotating equipment should be properly aligned when installed. The “eyeball” and straight edge, feeler gauges, and bubble gauges do not provide the precision required. Rim and face and reverse dial methodology, or both, should be used. For high-speed equipment and precision work, laser-alignment technology is available. Laser alignment can provide the advantages of accuracy, speed and minimum chance for operator error. If the operating temperature of equipment changes significantly, thermal expansion should be considered.

8.2.5.2 Thermal Testing

8.2.5.2.1 Thermal testing is a good problem indicator. Thermography can also be utilized for thermal testing. It is not possible to measure surface temperature of a motor only once and infer its efficiency or general health. However, over time, increases in temperature that cannot be explained by other observed factors often signal problems. A temperature increase away from the bearing housings is usually associated with something external to the motor that can harm the motor. Check for

- Increases in loading,
- Obstructions to cooling air flow,
- Under-voltage,
- Development of a voltage unbalance condition,
- Line harmonics, and
- Recent multiples starts, or frequent jogging.

In variable speed drive motors, low speed without a dramatic torque reduction can cause overheating. Check with the drive and motor manufacturer regarding minimum safe speed for the torque loading. Some larger motors have temperature sensors built into the stator slots. This allows for effective monitoring, trending, and alarming of motor temperature limits. A maintenance procedure similar to JCNNM MOI 41-50-0010, “Infrared Thermography” is acceptable provided it has been reviewed and approved by FWO-SEM. (Reference 10.7 and 10.16)

8.2.5.3 Vibration

8.2.5.3.1 Vibration characteristics in motors can be used to indicate mechanical and electrical problems. Characteristics from the vibration summary spectrum (frequency vs. amplitude) and time waveform (time vs. amplitude) are used to identify motor problems such as: mass unbalance, bent shaft, coupling misalignment, broken/cracked rotor bars, stator eccentricity, loose electrical connections, rotor rub, mechanical looseness and bearing deterioration. Analysis and trending of these motor defects are performed in order to forecast equipment degradation so that "as-needed planned maintenance can be performed prior to equipment failure. A maintenance procedure similar to JCNNM MOI 41-40-002, "Equipment Vibration Data Collection / Analysis" is acceptable provided it has been reviewed and approved by FWO-SEM. (Reference 10.7 and 10.17)

8.2.5.4 Acoustics

8.2.5.4.1 Acoustic monitoring can often alert experienced personnel to problems as well. The most common of these are bearing problems. Ultrasonic listening devices can sometimes detect pitting or arcing in bearings or the occurrence of arcing within windings. (Reference 10.7)

8.2.6 Establishing motor maintenance frequency is an iterative process. It is often necessary to prescribe somewhat frequent intervals at first (manufacture recommendations), then experiment with lengthening the intervals (refer to Section 7.2). Some activities can actually be harmful if performed too frequently (e.g. high voltage insulation testing and bearing greasing). If certain test results progress uniformly, you can establish a definite and often longer interval. Revise, but do not abandon the schedule. (Reference 10.7)

9.0 DOCUMENTATION

9.1 History

Data from inspection, testing, and maintenance should be recorded and controlled in equipment history files, e.g., CMMS. Computerizing the techniques proves to be the most efficient. The recorded equipment history information should be suitable to support maintenance activities, upgrade maintenance programs, optimize equipment performance, and improve equipment reliability. Utilize historical testing data to allow for trending analyses to be performed and identify needs for less or greater frequencies and weaknesses and strengths within the schedules chosen to be maintained.

9.2 Data

Spreadsheets and database tools are useful for storing, manipulating, and analyzing data. Statistical software is often the best choice. DOE's Motor Challenge Program offers a special cost-free software package that is tailored specifically for motor performance and maintenance analyses (http://www.motor.doe.gov/). (Reference 10.7)

10.0 REFERENCES

The following references, and associated revisions, were used in the development of this document. Facility specific O&M procedures written to the requirements of this criterion should use the latest, LANL approved, revision of these documents.

10.1 LIR 230-05-01.0, Operation and Maintenance Manual.

10.2 DOE O 430.1A, Life Cycle Asset Management, Attachment 2, "Contractor Requirements Document," Paragraph 2, Sections A through C.

10.3 LIR 230-14-01.0, Laboratory Maintenance Management Program.

10.4 NFPA 70B-1998, Recommended Practice for Electrical Equipment Maintenance.

10.5 DOE O 4330.4B, Maintenance Management Program, Section 3.4.9.

10.6 LIR 301-00-02.3, Variances and Exceptions to Laboratory Operation Requirements.

10.7 "Energy Management for Motor Driven Systems," US Department of Energy, Motor Challenge Program, June 1997, Rev. 1.

10.8 "Efficient Electrical Motor Systems," Todd Litman, Fairmont Press, Inc. 1995.

10.9 "How to Get the Most From Your Electric Motors," Electrical Apparatus Service Association (EASA).

10.10 "NSK Tech Talk," Volume 1, No. 2, April 1992, Technical Tip Sheets of NSK Corporation.

10.11 "Managing Motors," Richard L. Nailen, Barks Publications, Inc. 1991.

10.12 NETA MTS-1997 International Electrical Testing Association, "Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems."

10.13 NETA ATS-1999 International Electrical Testing Association, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems."

10.14 IEEE Std 43-1991 The Institute of Electrical and Electronic Engineers, Inc. "Recommended Practice for Testing Insulation Resistance of Rotating Machinery."

10.15 NEMA MG1 – 1998 National Electrical Manufacturers Association "Motors and Generators" Sections 12.55, 12.13, and 7.8.1, Table 7-1.

10.16 JCNNM MOI 41-50-0010, "Infrared Thermography."

10.17 JCNNM MOI 41-40-0020, "Equipment Vibration Data Collection / Analysis."

10.18 JCNNM MOI 41-50-002, "Motor Circuit Evaluation."

10.19 OSHA 1910.212, Occupational Safety & Health Administration "General Requirements for all Machines," subpart title "Machinery and Machine Guarding."

10.20 Reliance Electric Motor Information Center, http://www.reliance.com/prodserv/motgen/b5021.htm, "Reliance Proper Motor Lubrication White Paper – B-5021."

10.21 LANL Engineering Facility Manual, Chapter 7, Section 200, 248.5.5

10.22 GE Motor Selection and Application Guide

10.23 McGraw Hill Dictionary of Scientific and Technical Terms 5th Edition

11.0 APPENDIX

Appendix A: Reliance Proper Motor Lubrication White Paper – B-5021.

APPENDIX A

RELIANCE PROPER MOTOR LUBRICATION WHITE PAPER – B-5021

White Paper:

AC Motors

Proper Motor Lubrication

|Open Bearing | Sealed Bearing | Shielded Bearing | Lubrication Techniques | Over-greasing |

The service life of most motors is dependent on a little bit of good grease at the right times. This report discusses the pros and cons of different types of bearings, under-or-over-lubrication problems, and proper lubrication techniques.

Most motor failures are related to bearing failures. However, most bearing failures are not the result of bearing fatigue but improper lubrication. Bearing fatigue life calculations are commonly referred to as L-10 life (previously B-10). These calculations, expressed in thousands of hours of bearing life, give a good indication if a specific bearing can handle a specific load; but they can not and should not be used to predict bearing life. Why? Because it all comes back to taking care of that bearing with good lubrication practice.

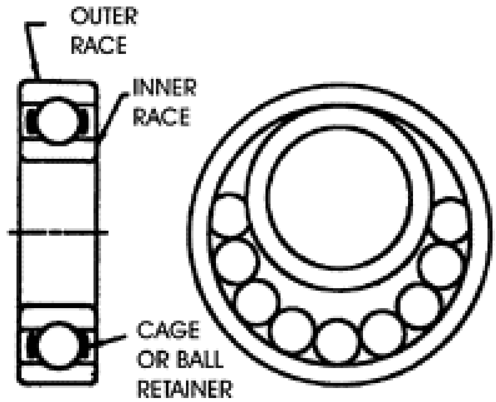
Before we can discuss good lubrication practices we need to understand the basic types of bearings that motor manufacturers generally use, along with their advantages and disadvantages.

Open Bearing

Single Row, Deep Groove Ball Bearing: This is sometimes called a Conrad bearing and is listed by AFBMA (Anti-Friction Bearing Manufacturers Association) as Type BC (single row radial contact without filling slot).

The Conrad open bearing is assembled by eccentrically offsetting the thinner and outer races to allow the insertion of balls (see figure below). The Conrad type bearing therefore has uninterrupted raceways (no filling slot) which permits excellent bearing performance under light to moderate radial loads, relatively moderate thrust loads, or combined radial and thrust loads.

This bearing is also somewhat self-aligning and typically allows for a minor misalignment of °ƒ without affecting the bearing operation and life.



Open Bearing

Advantages:

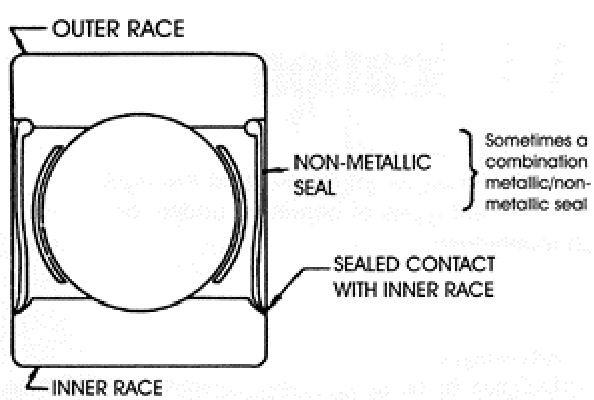
1. Open bearings (non-shielded) minimize friction allowing cooler bearing operation.
2. Not as susceptible to over-greasing because they have no shields to collapse.
3. Allows for complete and unrestricted grease relubrication.

Disadvantages:

1. The bearing system must be designed to protect the open bearing from contamination.
2. Grease must be restricted from migrating out of the bearing cavity.

Sealed Bearing

A "sealed" cartridge width bearing is a variation of the standard deep groove Conrad bearing. The construction of the raceway, cage, and ball assembly is the same; however, between the inner and outer rings are mechanical non-metallic seals. A "sealed" bearing cannot be relubricated.



Sealed Bearing

Advantages:

1. Entry of contamination is greatly restricted.

2. No regular relubrication is necessary.

Disadvantages:

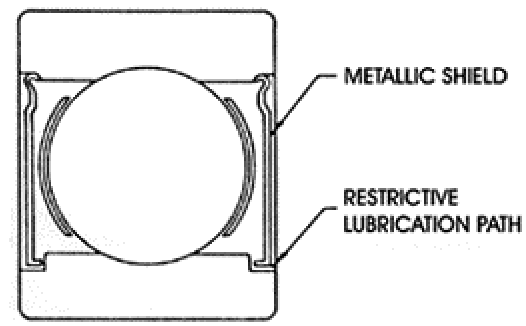
1. The bearing life is limited by the amount of lubrication packed between the seals of the bearing and the lubricant life.

2. The practicality of using sealed bearings is restricted due to the excessive heating on larger sizes.

3. Maintenance requires replacement of the bearing.

Shielded Bearing

A shielded bearing also is a variation of the Conrad bearing and is similar to the sealed-type bearing except that the shielded bearing has a metallic rather than a non-metallic shield. The metal member is secured to the outer race with a close running clearance to the inner race. With care a shielded bearing can be relubricated. (A shielded bearing may be shielded on one side or both sides.)



Shielded Bearing

Advantages:

1. Retains the lubricant at the rolling elements regardless of the chamber fill.

2. Provides relubrication to the balls by the slinger feeding of inner race.

3. Restricts contamination from getting into the rolling elements at installation and during operation.

Disadvantage:

1. Excessive pressure with no relief provided can force the shield against the cage or balls, eliminating regreasability or causing immediate failure.

Lubrication Techniques

If most motor failures are due to lubrication problems-how do they fail? First, it could be lack of lubrication for whatever reason. Second, it could be contamination of the bearing system. Third, believe it or not-too much grease.

We all know that if you don't grease a motor, sooner or later it's going to fail. Or if for some reason (such as heavy wash-down usage) you lose grease in the bearing, a failure is imminent. High motor and bearing temperatures also will tend to dry up the grease over time.

Contamination due to dirt and other foreign matter also should cause concern. Dirt and other hard particles such as metal and chips from abrasive wheels can get into the bearing raceways and be squeezed between the balls and raceway. This will cause roughness of the race and ball and will eventually cause failure. If the particles are a consistency of a very fine dust, they will act like a lapping compound and cause accelerated wear of the races and ball.

So like it or not, we are faced with regreasing most motors. It is important, when we do regrease, that the grease is clean and fresh; that the grease entry is also free of dirt and contamination; and most important, that the new grease is compatible with the existing grease.

Over-greasing

In many cases over-greasing can be just as damaging as under-greasing. Heat is the biggest enemy a bearing has, and over-greasing causes the bearings to run at higher temperatures. When you combine over-greasing with other factors such as high bearing loading, you get excessive bearing heating and premature failure.

The other concern of over-greasing is that if the bearing is the shielded type, excessive pressure with no relief provided can force the shield against the cage or balls, thereby, eliminating regreasability or causing an immediate failure.

How much is enough?

An easy question without an easy answer. The best advice is to consult the manufacturer instruction manual. Remember this rule of thumb: It is better to use a little grease more often than a lot of grease less often.

Re-lubrication frequency depends on environmental conditions. Under extreme conditions such as heavy shock, vibration, or dust, relubrication every one to three months is not uncommon. Under normal conditions relubrication every year or longer may be acceptable. Here again the manufacturer's recommendation and experience are the best guidelines. But nobody, including the motor manufacturer, knows the application and lubrication needs better than the people that work with the equipment every day.

Another tip is to regrease the motor while it's still warm. This will allow the existing dirty grease to flow freely and it will provide better relubrication. Also, remember to unplug grease drains (if provided) during regreasing. For safety reasons, always disconnect power before relubricating.

A little bit of common sense, a little bit of grease, and a good lubrication schedule will keep the industrial motors of today running a long, long time.

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Note: This material is not intended to provide operational instructions.

Appropriate Reliance Electric Industrial Company instruction manuals and precautions should be studied prior to installation, operation, or maintenance of equipment.

(Reference 10.20)

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