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Evaluation of Safety-related Motor Maintenance in Nuclear Power Plants

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1. Introduction

This paper presents results of the evaluation of a diagnostic program for large motors in nuclear power plants. Unexpected motor failures can lead to lost generation and accident mitigation, and necessitate time-consuming corrective maintenance. Therefore it is necessary to predict the sign of the failures in the early stage.

Current diagnoses and monitoring programs of the motors in plants have been compared with the requirements of the technical standards and literatures related to motor maintenance. The result of the review pointed out the items to be made up for the weak point in the current maintenance and trend management system in nuclear power plants.

2. Maintenance Evaluation

In this section some of the techniques used to monitor and diagnose motors are described. The description includes various monitoring diagnostic methods for the motors in nuclear power plants.

2.1 Motor tests and diagnoses

Electric motor performance is vital to the reliable and efficient operation of power plants. The failure of one or more critical motors could cause lost capacity and excessive repair and maintenance cost. [1]

Motors were found to be relatively long lived devices whose organic materials and wearing parts must be evaluated periodically during motor lifetime. It is expected that insulation, bearings, and lubricants will have to be refurbished or replaced during the 40 year plant life. Proper testing and maintenance can extend required replacement times.

These tests and diagnostic methods are described briefly below.

1) Internal Visual Inspection

Internal visual inspection is a primary method of determining the condition of bearing surfaces, air passages, and end windings.

2) External Visual Inspection

External visual inspection might include a check of the cooling water/oil flow, restrictions to air flow, bore scope investigations, seal and bearing conditions (leaks, looseness, etc.), and a possible alignment check.

3) Insulation Resistance (IR)

IR is very common to see insulation condition of a motor. The insulation resistance can be measured easily without damaging the motor. When 500 volts dc is applied between the insulation system and the ground, four elements of currents flow capacitance, absorption, conduction, and surface leakage.

4) Polarization Index (PI)

PI can be a useful indicator of contaminants and moisture on the exposed insulation surfaces of the winding. PI can give false indications of problems, as well as false indications that conditions are normal.

5) AC Current Tests

When ac current source applied to the insulation, I-V characteristic indicates the condition of the insulation through the relation between current and voltage upon it.

6) Dissipation Factor Test

The dissipation factor is the cotangent of the phase angle. The power factor is the cosine of the phase angle. The phase angle is the number of degrees that the electrical current leads or lags behind the applied voltage.

7) Vibration Analysis

Vibration analysis detects repetitive motion of a surface on rotating or oscillating machines. The repetitive motion can be caused by unbalance, misalignment, resonance, electrical effects, rolling element bearing faults, or many other problems. The vibration and temperature of the major motors for a continuous operation of a turbine and essential water have been monitored in main control room.

2.2 Recommended diagnoses and monitoring

The result of evaluation of the actual current test procedures and monitoring programs recommended additional tests to enhance the reliability of motors in operation in nuclear power plants.

The main purpose of the DC step voltage test is to apply a high dc voltage to the stator insulation, while at the same time reducing the risk of insulation breakdown from a major insulation defect. [2]

Current Signature Analysis [CSA] should be included in the condition monitoring program because it can detect more potential failure modes than any other type of test, giving the program more information for the money.

The partial discharge test measures the level of activity of high-frequency discharges formerly referred to as corona. The discharges can be internal to the insulation lying between the conductor and the outside of the coil, or they can be on the surface of the coil.

Surveillance testing, condition monitoring, preventive maintenance and equipment repair are all elements of an overall operational verification program organized to ensure that the equipment is still working as well as when it was installed, at least for the expected lifetime of the equipment.

The use of trending information on temperatures, loads, humidity, vibration, and contamination can help ensure acceptable motor operation.

2.3 Evaluation Results

Besides vibration and temperature monitoring in main control room, most testing and diagnoses have been performed by the off-line tests such as a visual inspection and insulation measuring. The procedures and tests performed are focusing to maintenance and repair recommended by manufacture.

In order to predict a failure in early stage, we need more enhanced monitoring and diagnostic methods like current signal analysis and partial discharge test. These on line tests focus on the detection of broken rotor bars and insulation breakdown as determined by Partial Discharge Detection.

Table 1 shows various techniques to monitor motor conditions.

Table 1: Various Monitoring Techniques

	Tests in Programs	Recommended Motor Tests
Visual inspection	x	
Insulation resistance	x	
Polarization Index	x	
DC Step Voltage		O
AC Current Tests	x	
Dissipation Factor Test	x	
Vibration Analysis	x	
Lubricant Analysis	x	
MCSA		O
Partial Discharge		O

O: Additional recommended test.

3. Conclusions

Based on the results of the testing procedures and maintenance program inspection in nuclear power plants, additional enhanced testing and monitoring methods were recommended. Current maintenance program needs data base of operating and failure experience, and a trend analysis to predict overall motor life. Individual motor life time predictions with adequate maintenance and surveillance are a function of localized environmental conditions and motor design and operating conditions.

In addition to the above suggestion, maintenance personnel are properly trained and qualified to perform the scope of work necessary to maintain a motor that is experiencing performance problems. Procedures and manufacturer's maintenance instructions have been properly applied to the motor that is experiencing performance problems.

REFERENCES

[1] J. A. Oliver, Electric Motor Predictive and Preventive Maintenance Guide, EPRI NP-7502, July 1992.
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[3] C. E. Beck, G. Hussain, and A. K. Behera, Condition Monitoring of 4kV Induction Motors Used in Nuclear Generating Stations. Nuclear Science Symposium, Page: 970-973 vol. 2, 1996.