Oil Condition Monitoring Case Study

BUREAU VERITAS
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SILVER LINING IN PLANTS OIL ANALYSIS PROGRAM PREVENTS CATASTROPHIC GENERATOR FAILURE

SYNOPSIS

This case study illustrates how oil condition monitoring (oil analysis) effectively identified serious bearing surface wear in a nuclear power station's emergency diesel generator engine, allowing plant maintenance personnel to take corrective actions to prevent a costly failure.

BACKGROUND

Every nuclear power plant has emergency power supplies, which are often diesel-driven. These generators provide power, only when needed, to special safety electrical distribution panels. These panels in turn supply power to those emergency pumps, valves, fans, etc. that may be required to operate in the event of the postulated catastrophic event - a simultaneous total loss of outside power and a major break in the reactor coolant system.

Emergency equipment is redundant with totally separate emergency electrical power supplies. The premise in nuclear power is that emergency equipment must be single failure-proof. This should guarantee that at least one channel (or "train") of emergency equipment will function. In a few cases, a plant may have 3 redundant trains of equipment for some emergency systems.

In 2002 the Nuclear Regulatory Commission (NRC) issued an information notice to inform stations of the discovery of degraded bearing surfaces on the piston bearings in a General Motors/Electromotive Division (GM/EMD) emergency diesel generator (EDG) engines. The piston wristpin bearing inserts in GM/EMD diesel engines have a silver substrate beneath a lead-tin overlay. An increasing concentration of silver in the lube oil is an indicator of excessive wear of the bearing surfaces.

Bureau Veritas has over 55 years of experience in providing Oil Condition Monitoring (OCM) programs to industrial operations including the power generation sector. Bureau Veritas' labs are all ISO 17025 accredited and the audited quality program is held in accordance with nuclear federal standard 10CFR, Appendix B.

CASE STUDY **OVERVIEW**

Industry: Power Generation - Nuclear

Est. Annual OCM Spend:
Fuel Analysis – $75,000
Lube Oil Analysis – $18,000

Est. Cost Savings: $160,000

CASE STUDY

The nuclear power station has an established PdM program in place for plant equipment which includes an Oil Condition Monitoring (OCM) program for two General Motors EMD engines. Oil samples are taken from the engines approximately every 45 days and sent offsite to Bureau Veritas for testing and evaluation.

The following tests are performed on each sample:

- Metals Analysis by ICP
- Viscosity
- Water
- Fuel Dilution
- Glycol
- Base Number
- Direct Read Ferrography (wear particle concentration)
- ISO particle count

Silver (Ag) typically trends at <0.1 ppm in these engines. Hitting or exceeding this limit triggers several inspections, including feeling the side of piston pins for signs of distress and measuring the piston-to-head clearance for the high-correct condition.

KEY FINDINGS

In January of 2015, the silver content from EMD #1 increased from 0.1 ppm to 0.2 ppm. A laboratory data analyst contacted plant personnel to report the increase and discuss the situation. It was decided to halve the sampling frequency for this unit. Subsequent samples showed a steady increase in the reported silver, peaking at 0.6 ppm.

Operating experience was reviewed at the plant and two sister plants that had experienced similar circumstances. An inspection was performed, and silver coated bearing material was identified in the EMD engine crankcase sump below the affected powerpack.

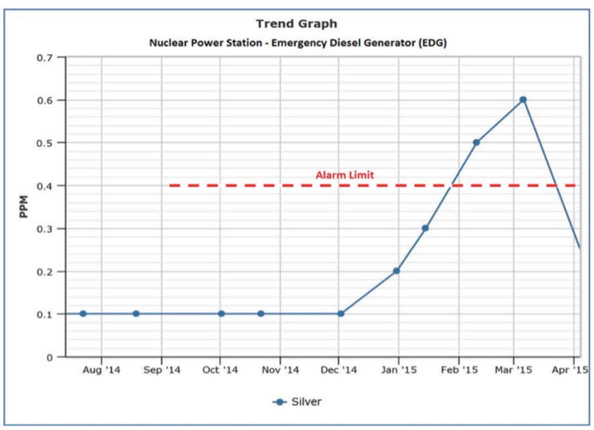

Figure 1: Trend Graph of Silver Concentration in Oil Samples

Figure 2: Silver-coated bearing material identified in the engine crankcase.

Following plant procedures, a shutdown of the engine was initiated. Further examination revealed component damage. The silver had been displaced from the wristpin bearing surfaces to the carrier bearing surfaces blocking one of the lubricating oil channels.

The partially blocked oil channel prevented normal oil flow at the bearing-to-wristpin interface. There also would have been base metal-to-base metal contact which would have led to catastrophic bearing failure and critical engine damage **(See Figures 3 & 4)**.

The plant conducted a root cause analysis in coordination with the equipment manufacturer. The findings indicated the wear was initiated by repeated engine starts under marginal lubrication conditions. The silver and lead bearing material is displaced into the oil channels of the wristpin bearing, limiting or preventing lubricant flow across the full surface of the bearing. When the channels are substantially or completely blocked, the bearing material wears away until the steel wristpin contacts the steel bearing shell and the bearing fails.

Initially, the damage occurs only while the engine is starting and until the lubricating system supplies oil to the bearing. However, after the oil channels are substantially blocked, the bearing is lubrication deprived and damage can continue and potentially accelerate while the engine in operation.

Figure 3: Silver wrist pin bearing was damaged.

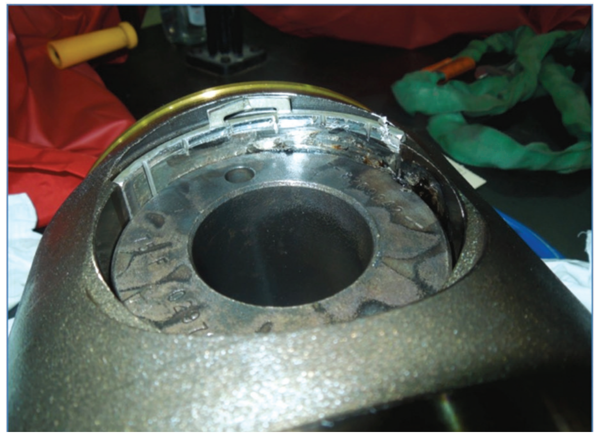

Figure 4: Silver wrist pin bearing was damaged.

CONCLUSION

While the plant utilizes several predictive maintenance technologies, oil condition monitoring was the only tool to identify the problem. By matching the proper testing to the application, plant engineers had the right monitoring in place to identify such an occurrence before it escalated into a catastrophic failure. Working closely with Bureau Veritas on establishing proper alarm limits ensured appropriate notification from the laboratory to the plant once the sample exceeded the established thresholds.

If Bureau Veritas' testing had not identified the onset of the wear and if the plant personnel had not reacted appropriately, the unit would have failed. Because the accelerated wear was identified and acted upon early, only minor repairs were required at a cost of $12,000.

The typical repair cost for a single powerpack is approximately $160,000. The overall costs of a catastrophic failure of the engine are estimated to exceed $950,000 when expenses and lost revenue are accounted for.

Note: Homeland Security regulations that govern nuclear power plant operations prevent Bureau Veritas from identifying the name and location of the plant which provided material for this case study.