Fluid Analysis

Fluid Property Changes due to SVR™

CONFIDENTIAL

[redacted]

[redacted]

Unit 5

Fluid types: [redacted]

Sample Date: 2-June-2014

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BACKGROUND

[redacted] Power Plant recently provided the EPT laboratory with a sample of the lubricant in-service in Unit 5. EPT completed a series of analyses upon this fluid in an effort to evaluate its current condition.

Once the condition of the lubricant was established, EPT subjected the degraded fluid to a laboratory-scale Soluble Varnish Removal (SVR™) treatment. EPT's SVR™ systems are designed to remove soluble contaminants and degradation products (including varnish and acids) from lubricants, eliminating the risks associated with lubricant varnishing and sludge formation. The properties of the degraded lubricant were compared prior to and following SVR™ treatment in an effort to assess the potential benefit of SVR™ treatment on-site at [redacted] Power Plant.

METHOD

The following analyses were performed in order to assess the condition of the lubricant in-service at [redacted] Power Plant:

- Varnish Potential (MPC): ASTM D7843.
- Acid Number (AN): ASTM D664.
- ISO particle count: ISO 4406.
- Water content: ASTM D7546.
- Dissolved metals: ASTM D5185.
- Kinematic viscosity: ASTM D445.
- RULER testing: ASTM D6971.

SVR™ treatment of the degraded sample involved running the fluid from Unit 5 through a laboratory scale SVR™ column prepared with "V" ICB™ media (approximately 1/250th the size of a commercial 600504 cartridge). The oil sample (approximately 150 mL) was heated to 40°C and then passed through the "V" media column for 24 hours at a rate of 20.00 mL/minute; this was equivalent to 192 reservoir turnovers. Following SVR™ treatment, the relevant analyses listed above were repeated and their results used to assess the effectiveness of SVR™ in this application.

RESULTS AND DISCUSSION

The properties of the lubricant sample provided from Unit 5 are summarized in Table A (below). A complete sample analysis report for this unit is appended.

The unit sampled suffers from elevated levels of particulate contamination as evidenced by the ISO particle counts of 21/19/16. The ISO particle count of lubricants used in critical equipment like turbines should not exceed 16/14/10. Each increase of 1 ISO code indicates a doubling of the number of particles present, therefore, the particulate levels in the samples provided are approximately 32 (2^5) times greater than the target level for this application irrespective of particle size (4 µm, 6 µm, 14 µm). This result suggests that the mechanical filter in-use on Unit 5 is performing poorly and may be inadequate.

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Table A: Condition of In-Service Lubricant Samples Provided by [redacted] Power Plant (Critical results in red, abnormal results in orange).

Unit	Fluid	MPC ΔE	AN (mg KOH/g)	ISO Particle Count (4µm/6µm/ 14µm)	Moisture (ppm)	Viscosity at 40°C (cSt)
Target	-	< 15.0	< 0.14	< 16/14/10	< 500	30.6
Unit 5	[redacted]	**29.2**	**0.28**	**21/19/16**	111	31.5

In addition to elevated particulate levels, the [redacted] in-service in Unit 5 also suffers from an elevated varnish potential (MPC ΔE) and acid number (AN) indicating the presence of moderate levels of soluble contaminants. The presence of degradation products like acids and varnish in lubricating fluids is correlated with poor equipment performance and reliability.

In an effort to assess the potential benefits of SVR™ use at [redacted] Power Plant, the fluid from Unit 5 was subjected to laboratory-scale SVR™ treatment. The results of this treatment are summarized in Table B below.

Table B: [redacted] Power Plant Unit 5 Lubricant Condition Prior to and Following Laboratory-Scale SVR™ Treatment (Critical results in red).

Sample	MPC ΔE	MPC Patch Photo	AN (mg KOH/g)	Antioxidant Levels (%)
Initial	**29.2**		**0.28**	100*
Following SVR™	5.5		0.03	100
Change	**- 81.2%**	-	**- 89.3%**	**- 0.0%**

*Antioxidant levels in the as received sample have been set to 100%.

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Following 24 hours (equivalent to 192 reservoir turnovers) of laboratory-scale SVR™ treatment with EPT's ICB™ "V" media, the concentration of soluble contaminants/breakdown products present in the lubricant sampled from Unit 5 fell dramatically.

The varnish potential of the fluid decreased by 81.2%, falling from an abnormal level (MPC ΔE = 29.2) to an excellent level (MPC ΔE = 5.5). At MPC ΔE levels below 15.0, the risk associated with lubricant varnishing and sludge formation is effectively mitigated.

In addition to removing varnish from the lubricant, SVR™ treatment also effectively removed other soluble contaminants including acids whose levels fell by 89.3%. Following treatment, the previously critical acid number of the fluid was reduced to a value (0.03 mg KOH/g) below that measured for the new oil sample provided (0.14 mg KOH/g).

Analysis of the sample's amine antioxidant package revealed that SVR™ treatment had no deleterious effect upon the level of antioxidants present in [redacted]. These results demonstrate that SVR™ selectively removes undesirable species (varnish, acids and other soluble contaminants) while leaving desirable species (antioxidant amines) unaffected.

CONCLUSION

The turbine oil sample provided by [redacted] Power Plant featured elevated levels of particulate contamination suggesting that the mechanical filter in use on Unit 5 is performing poorly. In addition to the presence of these insoluble contaminants, the lubricant also contained elevated levels of soluble contaminants (acids and varnish).

Laboratory-scale SVR™ treatment of the abnormally degraded Unit 5 lubricant sample revealed that SVR™ effectively removes undesirable soluble species (varnish and acids) while leaving desirable soluble species (antioxidants) unaffected. Following SVR™ treatment of the in-service lubricant, the treated fluid's condition was found to be superior to that of the new oil sample provided. At the low acid and varnish levels observed following SVR™ treatment, the risk to turbine reliability associated with lubricant varnishing is mitigated.

Laboratory-scale testing uses very small volumes of fluid relative to the amount of ICB™ media, therefore, the speed with which these results were achieved may be exaggerated when compared to field conditions.

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