Insight: Turbine Lube Oil Monitoring – Oil Quality Leads to Reliability

Proper Control of Lubrication Oil Quality is Key

Recognizing the Risk

The steam turbines and gas turbines that power our electrical grids spin at 3000 or 3600 rpm, supported in sleeve bearings with the shaft riding on wedge of oil not much thicker than a human hair. Successful operation depends on the quality of the lubrication oil being maintained. Even a minor change in the oil properties or the presence of small debris particles can be very problematic in regards unit reliability.

It is a fact that lubrication oil will degrade over time and with usage. Elements affecting the service life of turbine lubricating oils are as follows:

a) Design of system,
b) Contamination in the system on startup,
c) Quality of the oil initially,
d) System operating conditions,
e) In service contamination,
f) In service oil makeup rate, and
g) Handling and storage of the oil.

The lubrication oil used for heavy duty gas turbines and large steam turbines is quite similar, although there are some differences in oil exposure. Gas turbines operate at a much higher temperatures with the oil in these systems being exposed to extreme spot temperatures. This causes some oxidation to the additive package contained in the oil. Steam turbines see lower temperatures, but the oil is exposed to water from steam glands and seals. In contrast to gas turbines, steam turbines do not see a high rate of oil package oxidation from temperature extremes but are prone to higher moisture contamination. A properly monitored and managed steam turbine lube oil charge will last from 20 years to 30 years, compared to only 3 to 5 years for a gas turbine oil charge.

Lubrication oil degradation will accelerate with exposure to higher-than-expected temperature, and or sudden ingestion of water or dirt. These exposures will degrade the inhibitor package and the quality of the oil. As the oil degrades its viscosity increases, its acidity increases, and more particulate matter accumulates within it. Additionally, varnishing can occur, particularly in gas turbines, potentially impacting the operation of the hydraulic controls as well as the lubrication performance at the bearing.

Lubricating oil quality is therefore a useful indicator of overall turbine health. Monitoring and trending its condition is a very useful function that can help identify turbine problems before they result in major failure.

Oil Program Recommendations

Routine inspections during operation

During operation of the unit, the operator should establish a routine inspection procedure to ensure that:

1) The temperature and pressure levels of the lubrication system are within the limits specified by the service manual and the piping schematic diagrams.

2) The oil purity is maintained by checking for water leaks, by draining tank bottoms, and by adhering closely to the recommendations set forth by the equipment manufacturer and the oil vendor for sampling, purifying, and replenishing the lube oil supply or inhibitors.

Monitor the quality of lube oil

ASTM D4378 provides a guideline for lube oil monitoring. A good monitoring program should include proper sampling methods and intervals, comprehensive trending/data analysis, and have identified action steps with required follow up.

TESTING RECOMMENDATIONS

New Oil may be delivered with various contaminates rendering it unsuitable for service, particularly if delivered by bulk tanker. It must be tested once received to ensure it meets required specifications before being added to the system. Upon the installation of a new oil charge, either as an initial fill or as replacement charge, a sample should be taken after a 24hr circulation period and kept for quality control purposes. A 4 liter base sample is recommended, and this should be kept for at least 12 months, in case further testing is required.

Tests Recommended for Steam Turbines

Test	Frequency	Action Point
Viscosity	3 to 6 Months	5% change
Acid No	3 to 6 Months	0.2 mg KOH/g change
Appearance	Daily	Hazy
Water Content	3 to 6 Months	Over 0.1%
Color	Weekly	Rapid change
Rust Test	1 Year	Light fail
Wear Metals	1 Year	>10-20 ppm
Cleanliness (Particle count)	3 to 6 Months	18/16/13
FTIR Anti –oxidant trend (RULER)	1 Year	Up to 20,000hr: less than 50% total RUL; Or 25% RUL anytime
RPVOT	1 Year	<20,000hr. 50% of the new value; Or 25% of the new value anytime

In-Service Oil (Steam Turbines) – Lube oil qualities should be tested at regular intervals and the results compared to the quality control sample. The table above summarizes the key recommended sampling frequencies and tests to conduct. Longer periods can be applied if the results appear stable and well within acceptable ranges. The shorter interval should be used if test results are near to the action point criteria.

In-Service Oil (Gas Turbines) – the table below outlines the key tests and sampling frequencies. Test requirements are essentially similar to steam turbines but there are some differences in recommended sampling frequencies, due to the fact that the oil in gas turbines experiences higher spot temperatures and experience a faster degradation rate (compared to steam turbine lube oil).

The higher temperature leads to varnish forming in the oil. Varnishing occurs when the products of lube oil oxidation precipitate out of solution and form sludge on piping and control element surfaces. The sludge build up can result in control problems, reliability issues and undesired forced outages. Lube oil use in a gas turbine application may require replacement as early as 20,000 hrs., making monitoring the lube oil as it degrades an essential function.

As with steam turbines, longer sampling frequencies can be used if the oil quality proves to be stable over time. Shorter intervals should be used if test results are near to the action point criteria.

Tests Recommended for Gas Turbines

Test	Frequency	Action Point
Viscosity	3 to 6 Months	5% change
Acid No	3 to 6 Months	<20,000hr. 0.1 to 0.2 mg KOH/g change; Or 0.3 change from new
Appearance	Daily	Hazy
Color	Weekly	Rapid change
FTIR Anti –oxidant trend (RULER)	6 months	Up to 20,000hr: less than 50% total RUL; Or 25% RUL anytime
Rust Test	1 Year	Light fail
Wear Metals	1 Year	>10-20 ppm
Cleanliness (Particle count)	3 to 6 Months	18/16/13
RPVOT	1 Year	<20,000hr. 50% of the new value; Or 25% of the new value anytime

Review lube oil test results and take action

Test results from the internal or vendor lab must be reviewed against the criteria provided. If the oil is changing and nearing the action point, a plan must be developed to investigate the cause and to determine suitable rectifying actions that will address the cause and restore the oil to specification.

ASTM 4378 provides guidance on likely causes for poor testing results and suggests corrective actions. Some actions might include:

1) Replenishing the oil partially or completely
2) Purifying the oil with conditioning and/or treatment (see below)

Oil Conditioning and Treatment

Even with the best care contaminates will enter the lube oil and some oxidation of the additive packages will occur. Having an oil treatment skid on the lube oil reservoir that will filter and clean a portion of the oil on a continuous or periodic basis is recommended. These systems keep the lube oil in top condition and typically include: fine particle and coalescing filters; centrifuges and vacuum treating systems. Lube oil longevity will be increased if the oil is treated on a regular basis.

Conclusion

Paying close attention to the health and quality of lube oil is paramount to maintaining the reliability of your turbine. Monitoring, trending, and treating lube oil to maintain quality should be considered an essential part of a plant's risk mitigation strategy. This practice will promote reliability and maximize the performance and availability of your critical turbo machinery.

Resources / Standards

The references are:

ASTM 4378, Practices for In-Service Monitoring of Mineral Turbine Oils for Steam and Gas Turbines

ASTM D6439 Standard Guide for Cleaning, Flushing, and Purification of Steam, Gas, and Hydroelectric Turbine lubrication Systems.

EBNER, W, - STRATEGIES FOR THE PREVENTION OF TURBINE LUBE OIL SYSTEM FAILURES ASME 2013-983032013

For more information, contact your local AIG Property Risk Control Representative.