

MONITORING TURBINE OIL CONDITION

COMPREHENSIVE TURBINE
OIL ASSESSMENT



ARE YOU MONITORING THE CONDITION OF YOUR TURBINE OIL?

Gas-fired and steam-driven turbines are highly critical assets and their availability and performance has an immense impact on plant reliability. Turbine performance and up-time is greatly dependent on its lubrication system as it must meet the critical demands of many years of operation in challenging environments. Gas turbine oil is formulated to last from five to ten years, while steam turbine oil will remain in service from ten to thirty years.

Fluid Life provides a comprehensive turbine oil assessment that is designed to monitor continued oil serviceability and overall turbomachinery health. Our eight-page report includes an overall summary of results and recommendations, as well as detailed explanations for each category of tests being monitored. The comprehensive turbine oil assessment is widely recommended by turbine manufacturers on an annual basis, or more frequently for troubleshooting oil-related issues.

TURBINE
PERFORMANCE IS
GREATLY
DEPENDENT ON
ITS LUBRICATION
SYSTEM



MONITORING
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SIGNIFICANCE OF TURBINE OIL DEGRADATION

A well-rounded turbine oil analysis program should include routine testing on a monthly or quarterly basis, as well as a comprehensive turbine oil assessment annually. This level of detailed testing provides much greater insight into oil degradation.

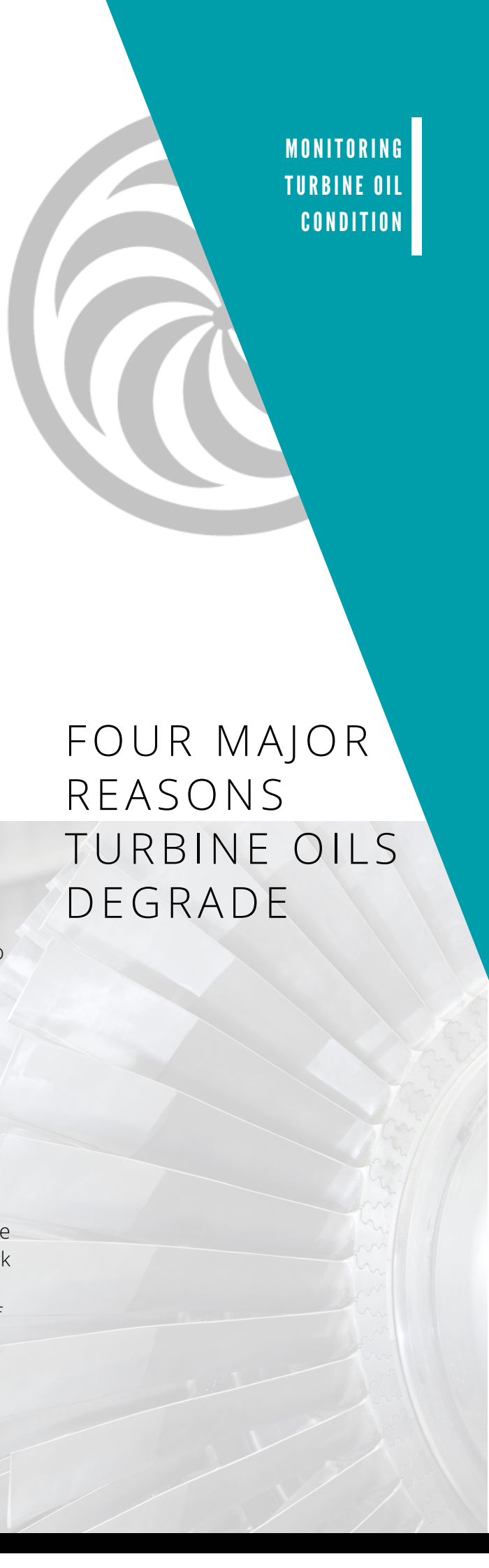
There are four major reasons that turbine oils degrade in service:

- Oxidation
- Thermal Degradation
- Contamination
- Additive Depletion

OXIDATION

Oxidation is a process where oxygen reacts with oil molecules that lead to the formation of chemical compounds. The rate at which oxidation occurs depends on a number of factors. Temperature is perhaps the most critical one, since the rate of oxidation doubles for every rise of 10°C. With increasing temperatures and flow rates found in turbines and shorter reservoir residence times, oxygen and oil have more opportunities to interact.

The resulting compounds are insoluble or marginally soluble in the oil and eventually produce deposits that can plug filters. Oxidation is also often responsible for increases in viscosity and acidity, additive depletion, base oil breakdown, loss in foam properties and the formation of varnish, sludge, sediment, rust and corrosion.

A large, stylized graphic of a turbine or compressor section, rendered in shades of gray and teal, occupies the right side of the page. It features concentric circular patterns and curved blades, suggesting a complex mechanical structure.

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FOUR MAJOR REASONS TURBINE OILS DEGRADE

THERMAL DEGRADATION

Thermal degradation ensues when oil is exposed to very high temperatures over prolonged periods of time, leading to chemical changes in base oil and additive molecules. This condition results in the formation of unstable compounds, which are not readily soluble in the oil. These compounds are easily oxidized, often causing the buildup of deposits within the oil system, which occasionally leads to preeminent machinery failures.

Often, thermal degradation occurs as a result of the processes of micro-dieseling and electrostatic spark discharge. Micro-dieseling is the combustion of imploding air bubbles creating compressive heat of 1000°C. Electrostatic spark discharge results from internal molecular friction generating high-voltage electric charges whereby oil passes through very tight clearances at high flow rates, producing temperatures over 10,000°C.

CONTAMINATION

Common contaminants present in turbomachinery oil include solid particles, water, air, heat and varnish that readily contributes to its degradation. Solid particles may be ingressed from external sources or introduced internally by machine operation or maintenance activities. These particles often create wear mechanisms such as abrasion or fatigue on internal surfaces. Tiny particles, several microns in size, cause components with tight tolerances to stick, as in the case of servo valves.

Water contamination originates from many sources including condensation. Water is incredibly harmful in turbine applications. Such hazards include the displacement of oil film, increased adhesive wear and the creation of cavitation, rust and corrosion.

Air contamination initiates from air leakage, anti-foam additive depletion or high oil turbulence that leads to air entrainment. The perils caused by air contamination include cavitation, oil film displacement and elevated oxidation and acidity.

Heat may be produced by the machine's operation, the external environment or insufficient maintenance practices. High temperature leads to several problematic conditions such as oxidation, sludge and varnish production and shortened oil and component life.

Varnish is the generation of insoluble microscopic compounds that plate out on internal turbine component surfaces. The greater the lubricant's solvency properties, the more the compounds will remain dissolved without becoming varnish. Lower temperature oils and machine surfaces are more prone to varnish issues. Factors that lead to higher varnish generation include micro dieseling, oil spark discharging, lubricant oxidation, thermal failure, entrained air and contamination with other lubricants.

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ADDITIVE DEPLETION

Additive depletion is a gradual developing process that takes place over a period of time that is often considered normal and anticipated. Anti-oxidant additives are expended as they perform their function. Demulsifiers help the oil shed water, but if exposed to extraordinary amounts of moisture, they too are quickly consumed. Antifoam additives can be removed by ultra-fine filtration or can agglomerate when the oil is not circulated for extended periods of time.

Changes in the oil's molecular structure due to additive depletion and the development of insoluble particulates (namely, sludge and varnish) are among the first oil degradation conditions that affect turbo-generator performance



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TEST ELEMENTS OF A COMPREHENSIVE TURBINE OIL ASSESSMENT

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Applications

- Steam Turbine Lube Oils
- Gas Turbine Lube Oils

The following tests are included in Fluid Life's Comprehensive Turbine Oil Assessment:

- Contamination
- Wear Indicator
- Oil Condition
- Phase Handling
- Oxidation Potential

CONTAMINATION

ISO Particle Count

The ISO Particle Count test utilizes an automatic particle counter with a light obscuration sensor consisting of a laser diode and a photodiode. It measures the number of particles present in the oil (per ml) in different size ranges (> 4, >6, >14 microns). Particle counting is used to trend and monitor the number and size distribution of particles in fluid samples. Particle count data is used to monitor contamination, ensure fluid cleanliness is within manufacturer's specifications and monitor filtration systems.

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% Water – Karl Fischer Water Titration

The Karl Fischer Water test quantifies the amount of water in an oil sample. It can detect both high moisture and trace moisture contents. The oil is reacted with Karl Fischer reagent (containing Iodine) and current is passed between platinum plates. The sample reacts until all water is gone.

WEAR INDICATOR

ICP Spectrometry

The ICP Spectrometry test provides the concentrations of various elements that are present in the oil. Element sources include generated wear debris, as well as oil additives, contaminants, or generated wear debris.

OIL CONDITION

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Viscosity @ 40°C/100°C

Viscosity is the resistance to flow of an oil at any given temperature, and is the most important property of a lubricant. The viscosity of an oil is determined by the measurement of its resistance to flow and shear under gravity at both 40°C and 100°C. Viscosity determines the film thickness of the oil, which is required to reduce friction between two moving parts. Proper operation of a turbine, in part, depends upon the appropriate viscosity of the lubricant. Turbine oils should have a proper viscosity to provide adequate lubrication for bearings and gears. Low viscosity leads to shearing and high wear.

Viscosity Index

The viscosity index is a measurement of how an oil's viscosity changes with temperature variations. Oils with higher viscosity index (VI) maintain their viscosity better over wider temperature ranges.

Acid Number

Acid Number is used as an indicator of the quality of oil and measurement of acidic by-products. Increases in acidity are often attributed to oil degradation or oxidation by-products, so the Acid Number provides an indication of when the oil should be changed.

Oxidation by Fourier Transform Infra-Red (FTIR)

Infrared analysis of a turbine oil provides information on the state of the oil itself. It measures the oxidation values and provides an assessment of oil degradation due to chemical changes. Different chemicals absorb different wavelengths of infrared light.

Rust Test

The Rust Test indicates how well the turbine oil is performing in terms of preventing rust. This test utilizes a hot bath, mechanical stirring apparatus and a steel test rod to evaluate the rust-preventing characteristics of the oil.

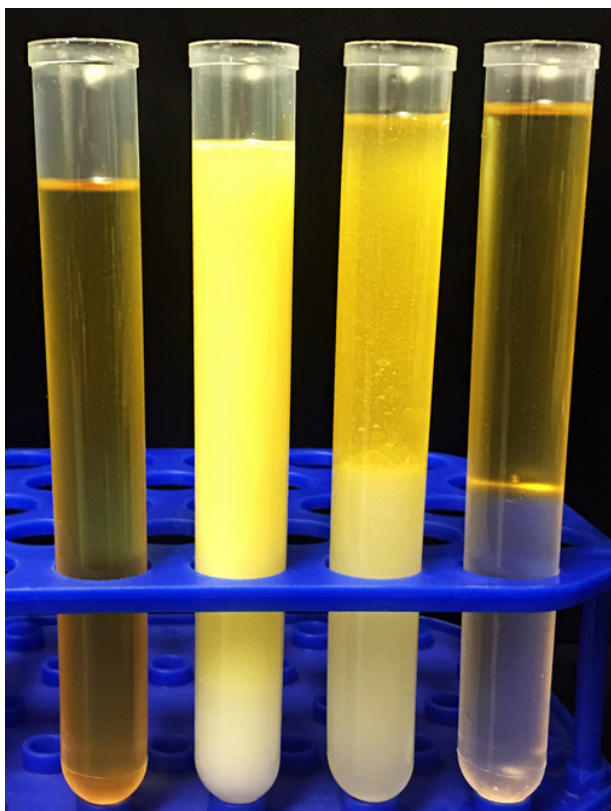
PHASE HANDLING

Foam Test (Sequence 1)

The Foam Test is used to determine a turbine oil's ability to resist foam formation (i.e. foam tendency) and dissipate the foam quickly (i.e. foam stability) under specific laboratory conditions. Sequence 1 foam testing is performed by blowing air into the oil at different temperatures and allowing it to settle for a certain amount of time, then recording the volume of foam remaining at each temperature.

Air Release Test

The Air Release Test measures the ability of turbine oil to separate entrained air. Compressed air is blown through turbine oil that has been heated. When the airflow stops, the time it takes for the entrained air content to fall to a certain percentage is measured.



Demulsibility

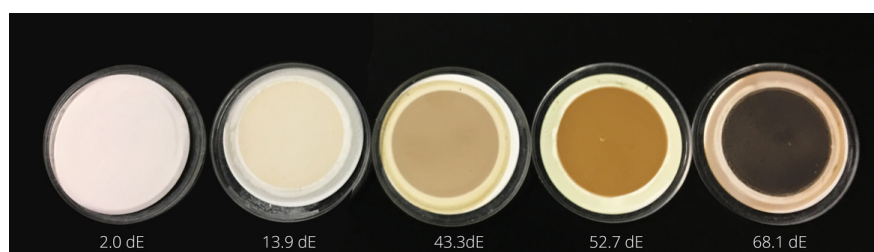
This test determines the turbine's oil ability to shed itself of ingressed water. This test, which is conducted in an oil bath, will time the separation of water from the oil after equal parts of water and oil are vigorously mixed together. After being mixed, the water and oil will separate. Because oil and water have different densities, they will form an oil layer, an emulsion layer, and a water layer. The volumes of these layers are reporting in intervals during the process of separation.

OXIDATION POTENTIAL

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Varnish Potential/Membrane Patch Colorimetry (MPC)

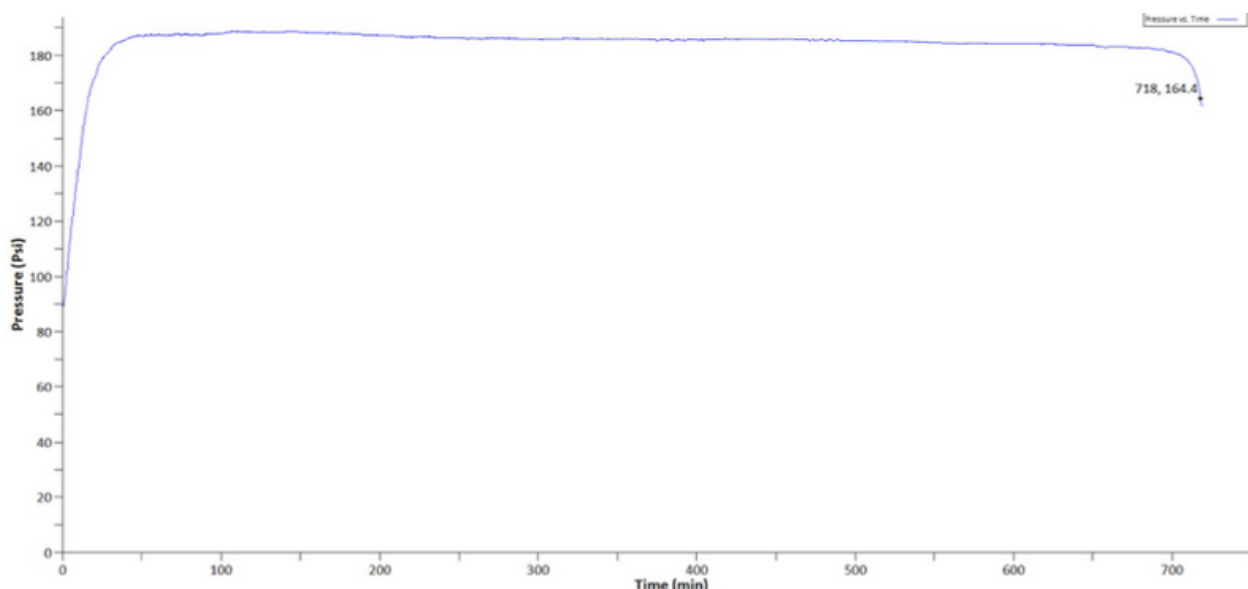
The Varnish Potential MPC test measures the propensity of the oil to form varnish deposits. It extracts insoluble deposits from an in-service turbine oil and filters it through a patch. The color of the patch is then analyzed and reported as the change of energy between a clean reference patch and the oil sample patch.



RPVOT Oxidation Stability

The Rotating Pressure Vessel Oxidation Test (RPVOT) determines the oxidation stability of a turbine oil. The RPVOT is a stress test on the in-service oil to determine if the anti-oxidant additives are still working and resisting oxidation. Water and a copper catalyst coil is added to the oil and placed in an oxygen-pressured vessel. In the vessel, it is charged with oxygen, pressure, heat, and rotated axially.

As oxygen is consumed, the pressure goes down. The depletion time of the anti-oxidants are recorded when it reaches a certain pressure drop from the maximum pressure.



Remaining Useful Life Evaluation Routine (RULER)

The RULER test measures the concentrations of anti-oxidant additives to provide an overall indication of 'remaining useful life' of the oil. The oil is dispensed into an electrolyte test solution containing a layer of sand. The antioxidant compounds are extracted into the test solution and quantified by voltammetric analysis. This causes the antioxidants to electrochemically oxidize which produces an anodic rise in the current and is recorded in a current-potential curve.

The RULER instrument displays a graph of time versus current in RULER units. Area under the peaks is calculated and the peak areas for used oils are compared to a new oil reference to determine the percent remaining useful life of the lubricant. The RULER test requires a comparison of the used oil against a new oil reference.

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ALWAYS RELIABLE. ALL WAYS.

We're a company that's All Ways Reliable. As a leading provider of lubrication analysis and asset management solutions, Fluid Life uses its best-in-class software, training, tools and programs to help keep your equipment running at peak performance. From analysis and evaluation to planning and strategy, Fluid Life has the expertise to help you achieve a higher level of reliability.

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