VITALPOINT
ADVANCED FLUID ASSESSMENT

Turbine Lube Analysis Programs

Monitoring and Optimizing Turbine Oil Life

ANALYSTS, INC.

Introduction

The economic and social vitality of a technological society depends upon energy. Global energy demands have never been increasing at such a rapid rate. The uninterrupted and reliable performance of turbines in energy production is fundamental to our way of life. Modern turbines are sophisticated machines, which rotate in excess of 7,500 rpm and weigh over 100 tons.

Monitoring turbine fluids is recognized by the power generation industry as a necessity to ensure long, trouble-free operation. The practice assists users in evaluating the stages of oil degradation and in carrying out meaningful programs to protect their systems.

Turbines in power generation generally rely on reservoirs with capacities that can exceed 10,000 gallons, containing oil that can remain in the lubrication system for up to 20 years. Consequently, monitoring the condition of turbine oils is critical for a number of reasons:

- Expense of repair and lost production when an undetected, wear-related condition leads to failure.
- Damage caused to the equipment as a result of oil deterioration in service.
- Expense of unnecessarily replacing multi-thousand gallons of oil and disposing of the changed oil.
- Lead time required to plan, prepare for, and change oil.

The proper functioning of a turbine is critically dependent on the performance of the turbine oil in use. If the lubricant does not provide the required performance, turbine owners risk the loss of hundreds of thousands of dollars a day. All turbine manufacturers carefully specify the characteristics of the lubricants suitable for their turbines, defined by requirements specified in a broad set of performance and laboratory bench tests.

Significant changes have occurred in turbine technologies over the last couple of decades. In particular, strides have been made to combine efficient gas turbines and steam turbines, called the Combined Cycle System, which is now considered to be the most effective method for converting fuel into electrical energy. By-products of these efficiency improvements however are increased compression ratios and higher temperatures. For example, the center bearing temperature on a GE MS7001 gas turbine may exceed 500°F.

Such high expectations and stresses on the turbine lubricant mandates a sophisticated fluid formulation, and a monitoring program to match.

VitalPoint® represents the most advanced condition monitoring tools currently available for turbine oil users. This comprehensive program was developed to help today's turbine lube-oil systems function at optimal levels—maximizing their ability to cool bearings, flush contaminants, actuate valves, and protect critical lube systems from failure.

Turbine Lubricant Formulations

Turbine lube-oil systems have many missions. Among the most important: cooling bearings, flushing contaminants away from rotating parts, providing hydrostatic lift for shafts, actuating valves in the hydraulic circuit, and coating and lubricating the system internals.

Formulating lubricants capable of performing all these tasks well is a difficult job, one that must consider the impacts of large temperature fluctuations and ingress of contaminants such as dirt and water, as well as other physical and chemical challenges. Turbine oils have undergone several advancements as turbine oil specifications have been amended. Turbine oils must now simultaneously meet the requirements of both steam and gas turbines. Improvements in base oil refining technologies provide more thermally stable and oxidatively robust products. Coupled with improvements in additive chemistries, modern turbine oils represent a delicate blend of lubrication science.

Almost 99% of turbine oils are base oil with additives making up the remaining percent. There are several different additives in turbine oils such as antioxidants, rust inhibitors, metal deactivators, antifoam agents, demulsifier, pour depressants and antiwear additives. The most abundant additives are antioxidants, which have the strongest influence on the life of turbine oil. Current antioxidants can be categorized as either primary (radical scavengers) or secondary (peroxide decomposers). Primary antioxidants consist of aromatic amines--which perform well under high temperature oxidative conditions (>120^{o}C)--and hindered phenols, which are designed for lower temperatures (<120^{o}C). The table below outlines some of the formula changes that turbine lubricants and electro-hydraulic control fluids have undergone over the last two decades.

	"R&O"	Conventional Turbine Oils	Current Generation Turbine Oils	Current Generation Control Fluids[1]
Basestock	Group I	Group I / II	Group II / II+ III	Trixylenyl phosphate ester, butylated phenol phosphate ester, isopropyl phenol phosphate ester, blend of trixylenyl phosphate ester and butylated phosphate ester
Primary Antioxidants	Phenolic	Phenolic, Diphenylamine	Phenolic, Diphenylamine, PAN, APAN & others[2]	None or aryl amine
Secondary Antioxidants	-	Sulfur containing compounds, phosphites	Sulfur containing compounds, phosphites	None
Metal Deactivators	-	Surface pacifiers (eg. Benzotriazole) or chelators	Surface pacifiers (eg. Benzotriazole) or chelators	None or Benzotriazole
Rust Inhibitors	Succinic acid/ester	Succinimide, succinic acid/ester	Succinimide, succinic acid/ester	None or Organic acids,esters or amides
Antifoam	Silicone	Acrylate, Silicone	Acrylate	None or Acrylate
Other	Pour depressant, antiwear	Pour depressant, antiwear, demulsifier	Pour depressant, antiwear, demulsifier	None

[1] Many commercial phosphate ester lubricants may contain no performance-enhancing additives.
[2] PAN – phenyl-α- naphthylamine; APAN - alkylated phenyl-α- naphthylamine

Turbine Oil Degradation

Oil degrades due to mechanical and thermal energy, which produces heat. When a turbine oil degrades the integrity of the hydrocarbon base-stock becomes compromised and the sacrificial additive chemistries deplete, causing irreversible molecular changes.

The two primary degradation mechanisms in turbine applications are:

- Oxidation – A chemical process where oxygen converts hydrocarbon molecules into different products, such as carboxylic acids. The rate of oxidation doubles for every 10°C rise in temperature above 100°C. In addition, catalysts will speed up the rate of oxidation such as air, water and certain metals.
- Thermal Degradation – This process occurs in the absence of oxygen at temperatures above 300°C. The hydrocarbon bonds are broken ("cracked") often creating insoluble carbonaceous by- products. The primary causes of thermal degradation are:
  - Micro-dieseling (Adiabatic Compression) – When air bubbles transition from low pressure zones (reservoir) to high pressure zones (pump), the bubbles can collapse creating a temperature over 1,000°C.
  - Electrostatic Spark Discharge (ESD) – The result of an accumulation of internal molecular friction developed as oil passes through very tight clearances at high flow rates. ESD is common in full-flow, small micron mechanical filters and may produce temperatures in excess of 10,000°C.
  - Hot Spots – Very hot spots in a turbine system will also cause in thermal degradation. Figure 1 demonstrates the wide ranging affects of Lubricant Degradation in a turbine system and useful analytical tools to detect degradation.

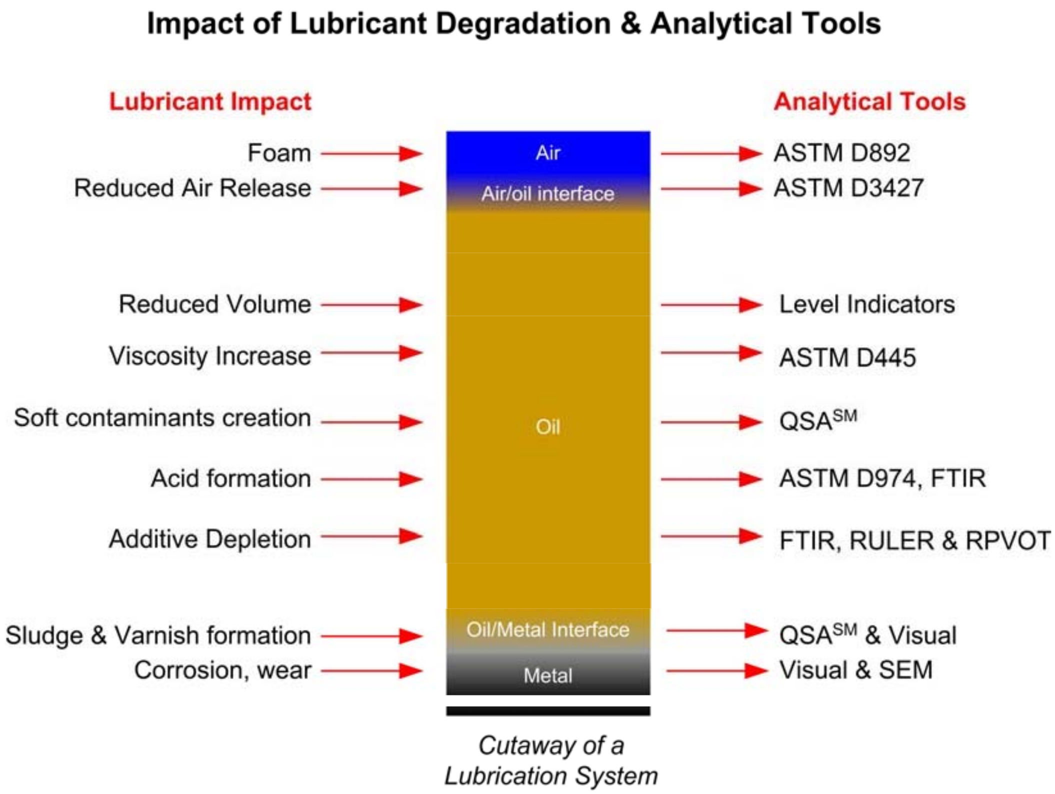


Figure 1: Testing for Lubricant Degradation in a Turbine Oil System

Turbine Oil Varnish

One result of turbine oil degradation is the creation of insoluble byproducts called soft contaminants. Soft contaminants are typically under 1-micron in size and cannot normally be removed through standard mechanical filtration. Soft contaminants may be either soluble or insoluble in the oil. Insoluble soft contaminants are polar in nature and are unstable in a non-polar oil environment. Soft contaminants combine and adsorb onto dipolar metallic surfaces. Varnish forms when these soft contaminants agglomerate and harden into a lacquer-like coating on valve spools and sleeves, bearing surfaces, gears and other internal surfaces of the lubricant system.

This micro layer of contamination is capable of shutting down a turbine or causing a unit trip. The sticky nature of varnish captures hard contaminants as they flow within the system, forming an abrasive, sandpaper-like finish on the metal surface that accelerates component wear. Varnish is an efficient insulator, too. Bearing surfaces with varnish coatings typically run at much higher temperatures than those without deposits. Heat exchangers coated with varnish have lower efficiencies than those with clean tubes or plates. Figures 2-4 are varnished components from a modern large frame gas turbine.

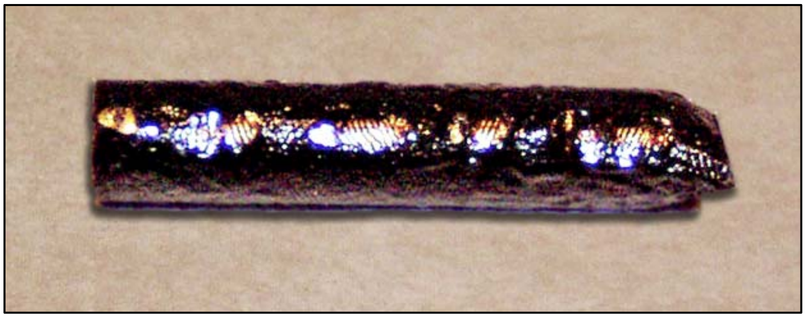


Figure 2: Heavily Varnished Pencil Strainer Inside a Fuel Oil Bypass Control Valve

Figure 3: Varnish Found on Fuel Oil Stop Valve Pilot Spool

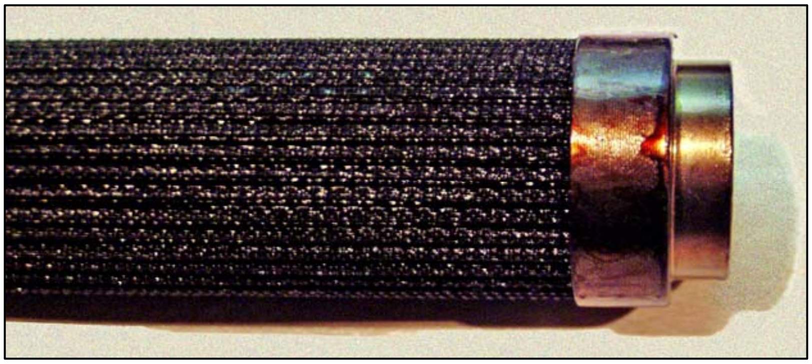


Figure 4: Varnish coating on a Last Chance Filter upstream of a Servo Valve

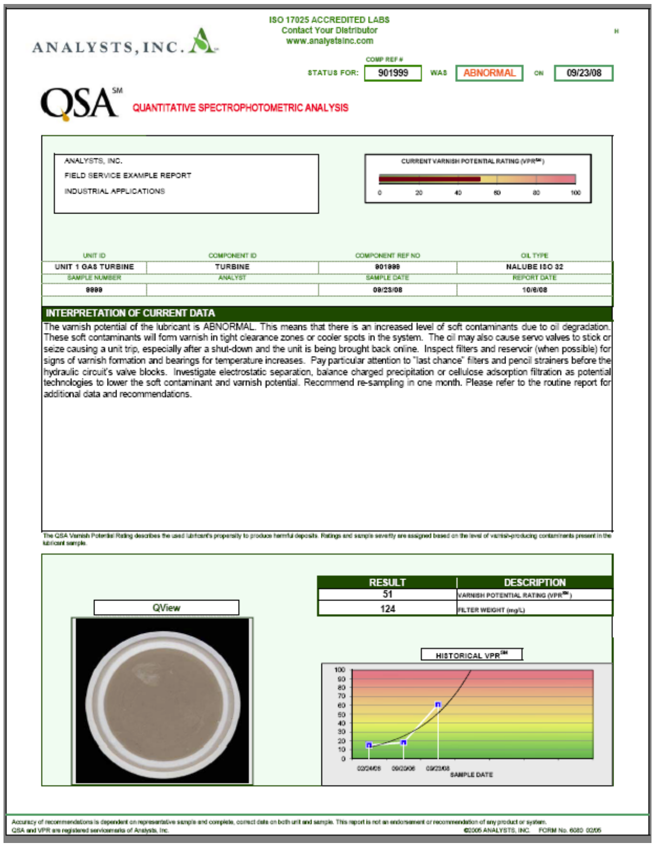
Lube Monitoring

Quantitative Spectrophotometric Analysis – A Method to Measure Oil Varnish Potential

Due to the potentially high costs associated with varnish, it is important for maintenance and reliability personnel to have a predictive tool to measure the circulating lubricant's varnish potential. Determining the varnish potential of a fluid enables the user to investigate the root cause and implement corrective action before a catastrophic failure occurs. However, routine oil analysis cannot successfully identify varnish potential. Analysts, Inc. has developed a predictive test called Quantitative Spectrophotometric Analysis (QSA^{SM}), designed to alert turbine oil users to alarming varnish potentials.

QSA^{SM} is a technique of deliberately isolating and measuring the specific lubricant degradation by-products responsible for varnish formation. The process begins by treating the lubricant sample with a specific chemical mixture designed to isolate insoluble by-product material. Next, a separation process collects the varnish-forming insoluble degradation by-products, including the sub-micron species. The process concludes with Quantitative Spectrophotometric Analysis on the isolated degradation by-product. The color of the isolated degradation by-products can directly correlate to the varnish potential of the fluid. By comparing the results to a large database of field-correlated QSA^{SM} tests, a 1 to 100 severity rating scale indicates the propensity of the lubricant to form sludge and varnish.

QSA^{SM} has correctly diagnosed hundreds of varnish problem samples in turbine applications. It is the most advanced single testing technology available for monitoring varnish problems and should be a part of any turbine oil user's predictive maintenance program.



ANALYSTS, INC.

ISO 17025 ACCREDITED LABS
Contact Your Distributor
www.analystsinc.com

STATUS FOR: COMP REF # 901999 WAS ABNORMAL ON 09/23/08

QSA^{SM} QUANTITATIVE SPECTROPHOTOMETRIC ANALYSIS

ANALYSTS, INC.
FIELD SERVICE EXAMPLE REPORT
INDUSTRIAL APPLICATIONS

CURRENT VARNISH POTENTIAL RATING (VPR^{SM})

UNIT ID	COMPONENT ID	COMPONENT REF NO	OIL TYPE
UNIT 1 GAS TURBINE	TURBINE	901999	NALUBE ISO 32
SAMPLE NUMBER	ANALYST	SAMPLE DATE	REPORT DATE
9999		09/23/08	10/6/08

INTERPRETATION OF CURRENT DATA

The varnish potential of the lubricant is ABNORMAL. This means that there is an increased level of soft contaminants due to oil degradation. These soft contaminants will form varnish in tight clearance zones or cooler spots in the system. The oil may also cause servo valves to stick or seize causing a unit trip, especially after a shut-down and the unit is being brought back online. Inspect filters and reservoir (when possible) for signs of varnish formation and bearings for temperature increases. Pay particular attention to "last chance" filters and pencil strainers before the hydraulic circuit's valve blocks. Investigate electrostatic separation, balance charged precipitation or cellulose adsorption filtration as potential technologies to lower the soft contaminant and varnish potential. Recommend re-sampling in one month. Please refer to the routine report for additional data and recommendations.

The QSA Varnish Potential Rating describes the used lubricant's propensity to produce harmful deposits. Ratings and sample severity are assigned based on the level of varnish-producing contaminants present in the lubricant sample.

RESULT	DESCRIPTION
51	VARNISH POTENTIAL RATING (VPR^{SM})
124	FILTER WEIGHT (mg/L)

QView

HISTORICAL VPR^{SM}

SAMPLE DATE

Accuracy of recommendations is dependent on representative sample and complete, correct data on both unit and sample. This report is not an endorsement or recommendation of any product or system.
QSA and VPR are registered servicemarks of Analysts, Inc. ©2005 ANALYSTS, INC. FORM No. 6080 02/05

Fig. 5: Example of a QSA^{SM} Report

Oil Condition Monitoring

Turbine oils may last only a few hundred hours in jet engines to several decades in hydro-electric systems. In recent years, condition monitoring has become an essential focus in maximizing the performance and life of turbine oils. Careful assessment of the actual state of lubricants in use allows system maintenance and oil change frequencies to be optimized. Premature replacement of the lubricants leads to high running costs. The same is true if unplanned oil changes are required because of inadequate assessment of the lubricant condition.

ASTM D4378, the "Standard Practice for In-Service Monitoring of Mineral Turbine Oils for Steam and Gas Turbines" is the recognized standard for determining the condition of turbine oils. This standard states "The in-service monitoring of turbine oils has long been recognized by the power-generation industry as being necessary to ensure long trouble-free operation of turbines. This practice is designed to assist the user to understand how oils deteriorate and to carry out a meaningful program of sampling and testing of oils in use. Also covered are some important aspects of interpretation of results and suggested actions to maximize service life.

Maximizing the life of turbine oils has influences beyond establishing an effective condition monitoring program. Other factors include:

- Selecting and using the correct lubricant
- Sampling point determination and sampling techniques (Fig. 6)
- Contamination control
- Proper handing & storage
- Performing maintenance activities at required intervals
- Program management (establishing goals, metrics, procedures & continuous improvement)
- Training of key personnel & management

Analysts, Inc. provides a wide range of services to assist customers in all areas of fluid management.

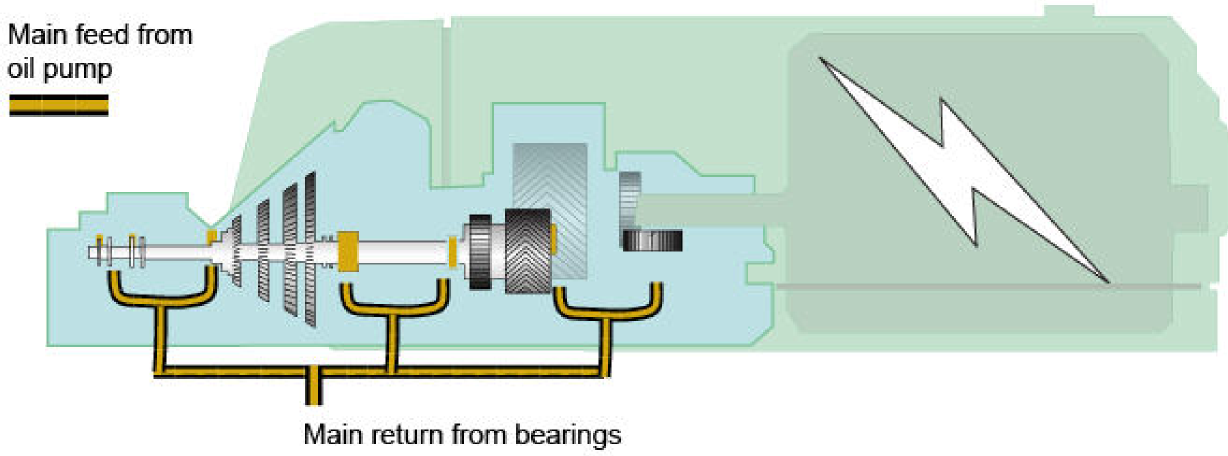


Figure 6: Establishing Primary Sampling points Is An Essential part of a Turbine Lube Condition Monitoring Program

VITALPOINT ADVANCED FLUID ASSESSMENT

VitalPoint^{SM}

Analysts' new VitalPoint program includes four comprehensive analytical packages; bringing industry-leading protection to the business-critical turbines that drive today's power industry.

Five Paths to Assurance

These packages represent the most advanced condition monitoring tools currently available for turbine oil users. Each package contains a battery of ASTM and Analysts' laboratory procedures:

They are broken into the following categories:

TOM^{SM}

Turbine Oil Monitoring

Modeled from the test recommendations in ASTM D4378 for monthly to quarterly sampling.

TOQ^{SM}

Turbine Oil Quality

Modeled from the test recommendations in ASTM D4378 for semi-annual to annual sampling.

QSA^{SM}

QSA^{SM} Complete - QSA^{SM} Advanced

Testing packages designed to assess the varnish potential of a turbine oil in addition to several other important oil quality parameters. The QSA^{SM} Advanced package supplements QSA^{SM} with a temperature-range dependent series of measurements to assess the varnishing tendency over a wide thermal regime.

TLA^{SM}

Turbine Lubricant Assessment

The most comprehensive test package available for turbine oils. It covers the majority of the testing outlined in the TOQ, in addition to determining the varnish potential, additive levels and degradation mechanisms. Each report includes customized, detailed interpretations and recommended actions.

CFA^{SM}

Control Fluid Assessment

The most comprehensive test package available for control fluids (fire-resistant fluids). Fire-resistant fluids can remain in service for many years with the proper maintenance. The CFA package is based on testing recommended by ASTM D4293, major OEM's and Analysts' years of experience to optimize fluid life and avoid costly fluid replacement and down time. As with the TLA, each CFA includes customized, detailed interpretations and recommended actions.

VitalPoint® Testing Packages Test Slate

Analysis	Procedure/volume	TOM	TOQ	QSA[SM] Complete	TLA[SM]	CFA[SM]
Spectrochemical	**ASTM D6595**, 10ml	Yes	Yes	Yes	Yes	Yes
Viscosity @ 40º C	**D445**, 20ml	Yes	Yes	Yes	Yes	Yes
Acid Number	**D974**, 50ml	Yes	Yes	Yes	Yes	Yes
Appearance	**Visual**, 100ml	Yes	Yes	-	Yes	Yes
Water Content, ppm	**D1744**, 1ml	Yes	Yes	Yes	Yes	Yes
Color	**D2500**, 50ml	Yes	Yes	-	Yes	Yes
Rust Test	**D665**, 300ml	-	Yes	-	Yes	Yes
ISO Particle Count	**ISO 4406-99**, 100ml	Yes	Yes	Yes	Yes	Yes
RPVOT (RBOT)	**D2272**, 50 gm	Yes	Yes	-	Yes	-
Copper Corrosion	**D130**, 50ml	-	Yes	-	Yes	Yes
Water Separability	**D1401**, 100ml	-	Yes	-	Yes	-
Foaming	**D892**, 600ml	-	Yes	-	Yes	Yes
QSA[SM]	**Analysts, Inc**, 100ml	-	-	Yes	Yes	Yes
RULER	**D6810**, 10ml	-	-	-	Yes	-
FT-IR (Custom)	**Analysts, Inc**, 10ml	-	-	-	Yes	Yes
Mineral Oil Content	**GEK46357E**, 10ml	-	-	-	-	Yes
Chlorine	**D4929**, 1ml	-	-	-	-	Yes
Resistivity	**D1169**,	-	-	-	-	Yes
Specific Gravity	**D1298**, 100ml			-		Yes
Flash Point	**D92**, 75ml	-	-	-	-	Yes
Fire Point	**D92**, 75ml	-	-	-	-	Yes
Air Release	**D3427**, 200ml	-	-	-	-	Yes
Gravimetric Solids	**D4898**, 100ml	-	-	-	-	Yes
Custom Report	**Analysts, Inc**.	-	-	-	Yes	Yes
Sample Package Volume	-	300ml	1100ml	850ml	2L	2L

*D6810 is under revision to cover multiple additive types

Recommended Packages & Sampling Frequency

Length of Service	Turbine Lubricant	Control Fluids
	Recommended Package	
New Oil (Prior to installation)	TOQ	CFA^{SM}
New Oil Charge (Prior to installation)	TOQ	CFA^{SM}
During first 6 months (every 500 hrs.)	TOQ	CFA^{SM}
In-service (every 500 hrs.)	TOM / QSA^{SM}	-
In-service (every 1500-2000 hrs.)	TOQ / TLA^{SM}	CFA^{SM}
During first twelve months operation (monthly)	TOM / QSA^{SM}	-
During first twelve months operation (quarterly)	TOQ / QSA^{SM}	-
In-service (quarterly)	TOM / QSA^{SM}	-
In-service (annually)	TOQ/TLA^{SM}	CFA^{SM}
Observed Condition Monitoring	**Recommended Package**	
Evidence of Varnish	QSA^{SM} / TLA^{SM}	QSA^{SM} EHC
Valve Sticking	QSA^{SM} / TLA^{SM}	QSA^{SM} EHC
Poor Heat Exchanger Performance	QSA^{SM} / TLA^{SM}	-
Poor Water Separability	TOQ / TLA^{SM}	-
Inefficient Performance of Water Coalescers	TOQ / TLA^{SM}	-
Introduction of New Contamination Control Technology	QSA^{SM} / TLA^{SM}	-
Measurement of Varnish Removal	QSA^{SM} / TLA^{SM}	QSA^{SM} EHC
Rapid Color or Odor Change	TLA^{SM}	-

Qualifications of Analysts, Inc.

- Independently owned and operated with 49 years experience.
- Quality First: ISO 17025 accredited, certified compliant to 10CFR50 Appendix B.
- Five laboratories in the USA and international service in Monterrey, Mexico and Tokyo, Japan.
- Chemists, STLE Certified Lubrication Specialists (CLS), and Oil Monitoring Analysts (OMA) at all locations.
- Participation in ASTM and other leading industry groups that develop and establish standards and practices for the power generation industry.
- A lead researcher and publisher in the subject of turbine oil degradation, in addition to other tribological areas.
- Innovator in specialized condition monitoring for turbine lubricants and turbine control system fluids

Laboratory Services

- Rush analysis available (contact lab for specific details when needed).
- Fax transmission and/or emailed reports upon request.
- Interpretation with recommendations provided on each report.
- Sample container, processing form, and pre-addressed mailer available.
- D.O.T. approved shipping materials available.
- Wide range of sampling supplies available
- Refrigerant, coolant/antifreeze, and grease analysis programs available.

SOVICE

- A subsidiary of Analysts Inc. designed to enhance special analytical services and bring additional value
- Root Cause Analysis & Consulting
- Recognized expertise in power generation

Fig. 7: Steam Turbine at a Nuclear Facility

Fig. 8: Hydro-electric Turbines

Definitions and Significance Of Turbine Oil Testing Terms

Acid Number – ASTM D974: A measure of the acidic constituents present within the lubricant. Most rust inhibitors used in turbine oils are acidic and contribute to the acid number of the new oil. Increases from the new oil level are monitored, and for the most part, increases reflect the presence of acidic oxidation products. Though less likely, increases in acid number could be attributed to contaminants, mixtures of products, and/or chemical transformations.

Appearance: Visual assessment for sample clarity, cloudiness, separations, visible debris or free water, etc.

Color - ASTM D1500: New turbine oils are typically light in color. Darkening will occur with age and service. Periodic comparisons of the sample color are useful in spotting significant and/or rapid changes due to contamination or fluid degradation.

Copper Corrosion – ASTM D130: The copper strip test measures the potential corrosive nature of a lubricant and the possible difficulties with yellow metals, such copper and brass or bronze components, within a system.

Foaming Characteristics – ASTM D892: Measurement of the oil's tendency to foam and the stability of the foam after it is generated. Some foaming is a typical occurrence and antifoaming agents are blended into the oil to assist with the rapid release of entrained air bubbles. These additives will deplete with time and must be monitored. Excessive foaming is indicative of mechanical or lubricant problems requiring investigation and correction.

FTIR – ASTM E1252: Fourier Transform Infrared: Infrared Spectroscopy is applied to measure organic molecular components. FTIR can be applied to monitor for additive depletions (antioxidants), organic degradation products (oxidation), and the presence of various contaminants.

Particle Count – ISO 11171: A count of the number of particles present greater than given micron sizes per unit volume of fluid. The results reflect the solid contaminants present and are applied to assess fluid cleanliness and filtration efficiency. Cleanliness levels are also represented by the ISO 4406 classification system to classify the particles larger than 4-µm, 6- µm, and 14-µm per milliliter of fluid (for example: 18/16/14).

QSA – Quantitative Spectrophotometric Analysis: An analysis technique for purposely isolating and measuring the specific lubrication degradation by-products responsible for varnish formations. This is not a measure of varnish already formed; it is a determination of the lubricants propensity to form varnish and can be applied to preventing varnish formations and build-up within the system. Results are represented as the Varnish Potential Rating (VPR) with a scale of 1 to 100 severity rating.

RPVOT – ASTM D2272: Rotating Pressure Vessel Oxidation Test (Previously RBOT). One of the most important properties of turbine oil is its oxidation stability or resistance. RPVOT test is a controlled, artificially accelerated oxidation of a lubricant to determine the level of remaining antioxidant additives. Results are evaluated and compared to new oil levels.

Rust Test – ASTM D665: Antirust protection provided by the lubricant is of significant importance for turbine systems. Antirust inhibitors will deplete during lubricant service and can also be affected by water contamination, adsorption onto wear and debris particles, and/or chemical reactions with contaminants.

Spectrochemical Analysis – ASTM D6595: Specific trace metals are measured and monitored for wear and corrosion levels, airborne or internally generated contaminants, oil additives, and water treatment additives. Particles detected are typically 8-µm and less and results are reported in parts per million (ppm) by weight.

Water Content – ASTM D6304: Water contamination within turbines adversely affects the lubricants by acting as a catalyst for oxidation and rapidly depleting water sensitive additives. Water also promotes rusting, corrosion, and filter plugging. Results are reported in parts per million (ppm) by weight.

Water Separability – ASTM D1401: This test measures the ability of a lubricant to separate from water. New turbine oils are designed to have good water separability characteristics. Polar contaminants influence turbine oil's ability to separate from water. This is particularly crucial to steam turbine applications where water contamination is most prevalent and separation in the reservoir is essential. Contamination control technologies such as oil/water coalescers also depend on turbine oil's water separability characteristics to function properly.

Viscosity – ASTM D445: Viscosity is the most important characteristic of turbine oil and can be readily affected by more types of influences than any other property. Maintaining the proper viscosity is crucial to retaining oil film thickness under hydrodynamic lubrication conditions.

NOTES

FIVE LABORATORIES TO SERVE YOU:

ANALYSTS, INC.
WESTERN LABORATORY
3401 Jack Northrop Avenue
Hawthorne, California 90250
(800) 424-0099

ANALYSTS MAINTENANCE LABS
MIDWESTERN LABORATORY
2450 HASSELL ROAD
HOFFMAN ESTATES, IL 60195
(800) 222-0071
FAX (708) 884-8098

ANALYSTS MAINTENANCE LABS
SOUTHWESTERN LABORATORY
12715 ROYAL DRIVE
STAFFORD, TX 77477
(800) 248-7778
FAX (713) 240-4481

ANALYSTS MAINTENANCE LABS.
SOUTHEASTERN LABORATORY
3075 CORNERS NORTH COURT, N.W.
NORCROSS, GA 30071
(800) 241-6315
FAX (404) 448-5918

ANALYSTS MAINTENANCE LABS
MID-CONTINENT LABORATORY
1803 Watterson Trail
Louisville, KY 40299
(888) 491-6063
FAX (502) 671-5370

CORPORATE OFFICE

ANALYSTS, INC.
3401 Jack Northrop Avenue
Hawthorne, California 90250
(800) 336-3637

VISIT OUR WEBSITE AT:
www.AnalystsInc.com

VITALPOINT
ADVANCED FLUID ASSESSMENT

 FORM 4060 1208

A service of ANALYSTS, INC.