Turbine Oil Varnish:
Formation, Detection & Proactive Solutions

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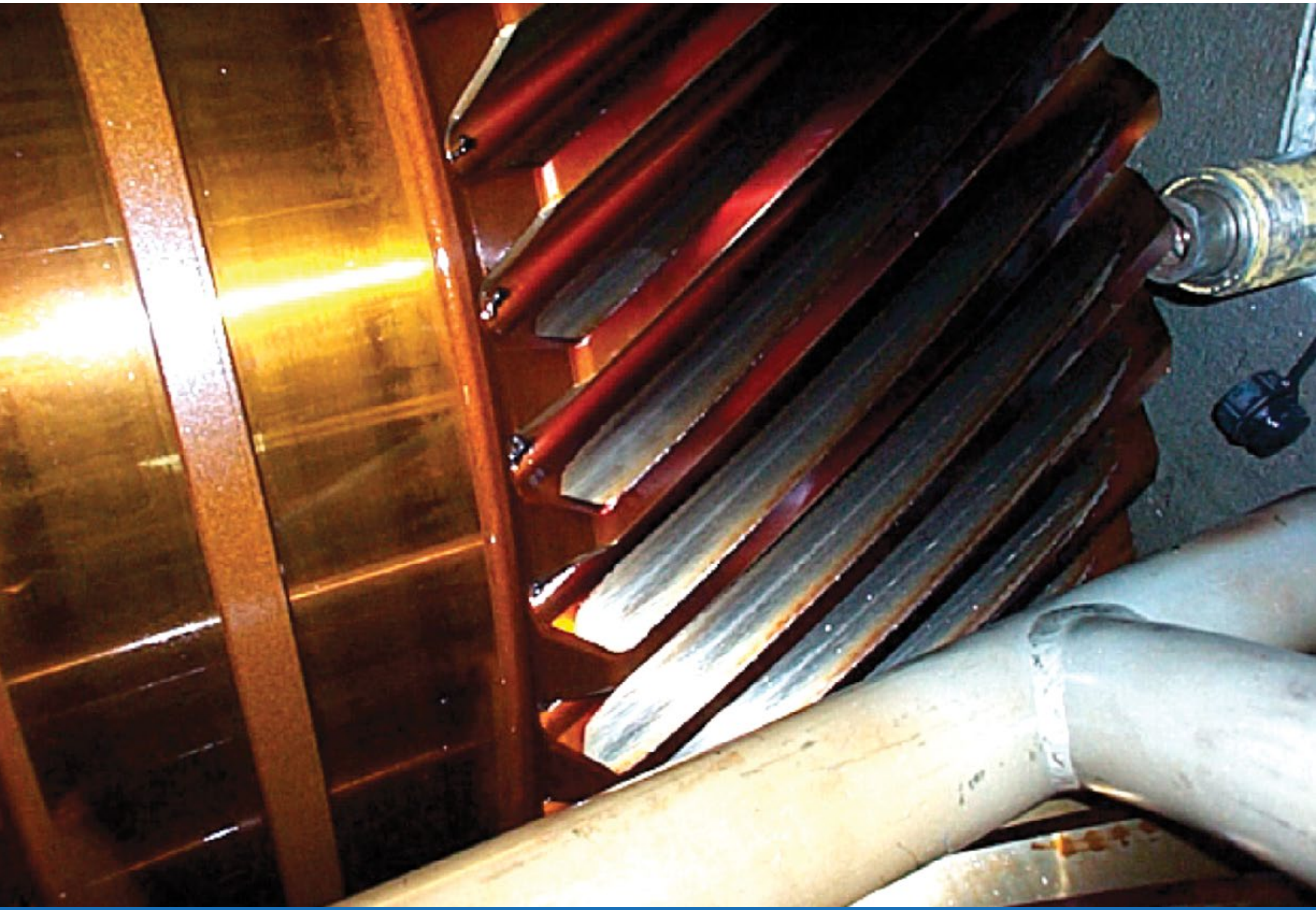

Turbine oils are designed and formulated for specific purposes and are fabricated to resist runaway oxidation or excessive varnish formation. But when contamination and other factors impact the health of these oils, they may lose performance characteristics, experience additive depletion and cause a dangerous buildup of varnish or sludge. Unplanned downtime and expensive drain, flush and fill procedures may result if varnish problems are not detected and mitigated quickly enough. As always, it pays to be proactive when it comes to lubrication.

Just as we take care in selecting turbine oils for specific applications and purposes based on their properties, it takes a similar amount of focus and attention to ensure that these important lubricants are kept clean and protected both before they are put into service and throughout their service life. This includes the shipment, reception and storage of "new" turbine oil as well as oil that is in service or nearing the end of its service life.

In this paper, we will examine important attributes of turbine oils and their additives before moving on to cover varnish formation, detection, and removal methods. Finally, we will discuss practical tips and advice for keeping varnish and other contamination-related problems under control through efficient preventive and proactive maintenance actions.

Attributes of Turbine Oil

The majority of turbine systems are oil lubricated, and many components of the turbine are lubricated. The bearings are the primary component where lubricant builds a hydrodynamic film, separating the shaft from the bearing surface — problems arise when this film is disrupted.

Several things can disrupt the film, principally contamination (water, dirt, etc.). Contamination poses a threat because bearings in applications like those discussed tend to be made of very soft material (Babbitt material: lead, tin, etc.) and thus easily wear out. So, not only must you concern yourself with the parameters of the turbine oil, but also the oil's cleanliness, temperature and dryness.

Base Oils

When selecting a turbine oil, one of the first components to look at is the base oil. A quality base oil provides protection and life-extending benefits to both the machines and the other lubrication oils. Almost every lubricant used in plants today starts off as just a base oil. The American Petroleum Institute (API) has categorized the potential base oil options into five categories:

Group I base oils typically range from amber to golden brown in color due to their sulfur, nitrogen and ring structures remaining in the oil. They are traditionally older base oils created by solvent-refining technology used to remove weaker chemical structures from the crude oil.

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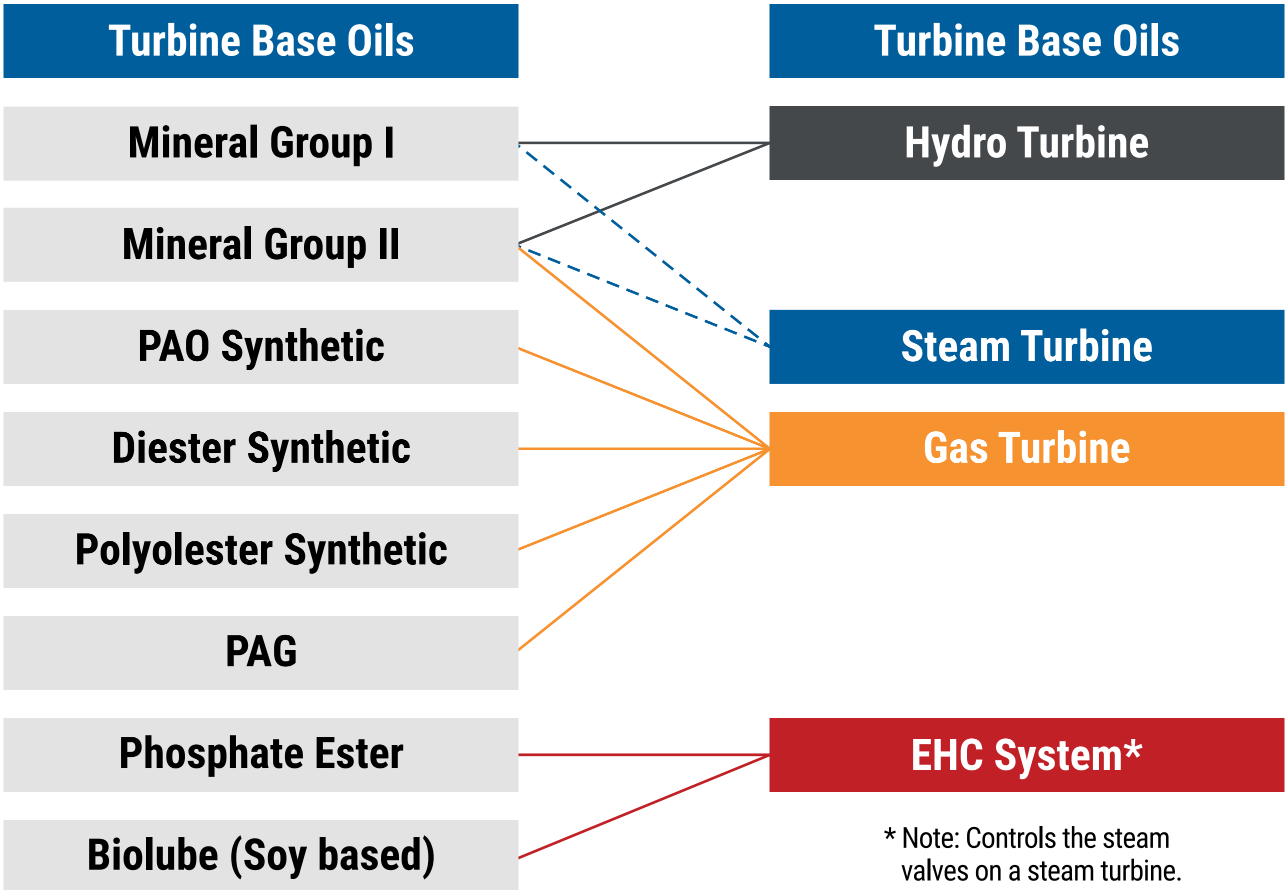
Group II base oils are clear and colorless with very little sulfur or nitrogen, and the undesirable components are typically removed or converted using hydrocracking — essentially cracking larger undesirable molecules in the presence of hydrogen to create hydrogen-saturated desirable hydrocarbon molecules. This group of base oil is still considered mineral oil, and it is the most commonly used base oil across all applications, from automotive engine oil to hydraulic and turbine oil.

Group III base oils also use hydrocracking to remove and convert unwanted components, but this group's process is more severe and is operated at higher temperatures and pressures than Group II. In some markets, such as diesel engine oil, this type of base oil is considered fully synthetic, but in other industries, such as power generation, there is some conflict about whether this base oil should be considered a mineral or synthetic base oil. While the base oil is derived directly from the refining of crude oil, as is standard for mineral oils, it is also believed to have a new chemical structure that was created due to the harsher hydrocracking process, helping to categorize it also as synthetic.

Group IV base oils are polyalphaolefin (PAO) synthetic base oils that are made by polymerizing an olefin gas in a chemical plant, as opposed to being created through the refinement of crude oil. This group has a viscosity index of greater than 120 and is significantly more expensive than other base oil groups due to the high degree of processing that is required. Its core hydrocarbon structure is very similar to groups I, II and III oils.

Group V base oils are made up of all of the other types of base oils that cannot be included in groups I-IV. Base oils that fall into this category include naphthenic base oils, various synthetic esters, polyalkylene glycols, silicones, phosphate esters and other exotic chemicals. These are very different chemical structures than group I-IV oils.

The base oil chosen for a specific turbine application may vary based on the type of turbine and its operating parameters.



Base oils and associated turbine types.

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Additive Packages

Turbine oil additives are organic or inorganic compounds that are either dissolved or suspended in the oil. These additives have three basic roles:

- Enhance the existing base oil's properties with antioxidants, corrosion inhibitors, antifoam agents and demulsifying agents.
- Modify other base oil properties with pour-point depressants and viscosity index improvers.
- Impart new properties to base oils using extreme pressure additives, detergents, metal deactivators and solvency enhancers.

Depending on the performance level desired, turbine oils are formulated with different additives to enhance performance. Along with proper base oil, these additives will offer good resistance to oxidation, inhibit sludge formation and protect against corrosion.

The factors that affect oil service life vary, but the performance properties of new turbine oils are expected to degrade over the life of the product. Thorough and routine testing of the turbine oil will determine when the properties have changed significantly to warrant corrective actions.

Water in Oil

One of the largest stressors to be aware of is the presence of water. While there is no established standard governing the allowable level of water in turbine oils, ASTM D4378-08 mentions that 0.1 percent or 1,000 parts per million (ppm) of water is considered a significant volume and should be condemned. Indeed, 0.1 percent or 1,000 ppm is a large amount of water for a turbine system. In fact, most turbine manufacturers would say this number is unacceptable. In practice, lower moisture is better, with a realistic maximum of 200 ppm or often lower. Turbines may continue to run at elevated moisture levels, but damage to the lubricant and machine will occur.

In oil, water exists in three forms: dissolved, free and emulsified. The dissolved state occurs naturally and is not noticeable to the naked eye. Once the oil reaches its saturation point (the point at which it can hold no more water), the dissolved state of the water will become free or emulsified. Some free water will fall to the bottom of the sump due to gravity, while other water will be introduced to internal components. Emulsified water will appear cloudy or white and will impair film strength.

Machine criticality will need to be evaluated and monitored to help determine the appropriate water levels for your facility. When reviewing criticality, consider the safety risks upon failure, the cost and length of downtime, the material and labor costs to repair and the early warning systems. The higher the liability, the lower the target dryness should be set. A better approach to selecting moisture limits based on machine criticality would be to employ the tactic of "as low as reasonably achievable" (ALARA). This takes the logic of measuring the moisture content a step further to exclude, remove or monitor water contamination.

Selecting a Turbine Oil

There are some properties that every high-quality turbine oil should possess, regardless of the environment in which the oil will be used. Many of the problems associated with turbine oil degradation can be traced to oxidation, which will be discussed in detail later on. Oxidative stability, then, is one of the primary properties to look for in a turbine oil.

It is also essential for turbine oil to have excellent property retention. A good additive package and a quality base oil mean nothing if the oil fails prematurely. A high-quality turbine oil will retain its properties throughout its operational life.

The viscosity of the oil is also of equal importance, especially when it comes to determining the oil film thickness. Changes in turbine oil viscosity can have serious consequences and can lead to unwanted rotor movement, which can impact the success of power-generating operations. Excluding circumstances where

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contamination or oxidation is present, the viscosity of an in-service oil should remain constant for years. If there is a five percent or greater change in the oil's viscosity, this should be taken as an early warning sign and should be remediated as soon as possible.

There are many different organizations that define the qualities and abilities an oil must possess to obtain the classification of turbine oil, such as the British Standards Institute, the German Institute for Standardization, and ASTM International. Sometimes, equipment manufacturers will set standards based on their specific equipment, outlining which oils are compatible. Regardless of who sets the standards, the following categories are usually considered:

- Viscosity
- Viscosity Index
- Flash Point
- Pour Point
- Copper Corrosion
- Acid Number
- Foam Characteristics
- Oxidation Characteristics
- Rust Prevention
- Cleanliness
- Water Separability

Reclamation and Refortification

One of the most proactive steps a facility manager can take to develop a deeper relationship with their equipment is to understand that the lifecycle of an oil can be extended beyond what was once thought possible through the process of reclamation and refortification.

Reclamation refers to the cleaning and reconditioning of a lubricant, thereby rendering it suitable for continued use in the same application for which it was originally formulated. Refortification refers to the act of adding a predetermined amount of additive to a clean, dry, used lubricant to replenish some of the depleted additives. In most cases, refortification and reclamation are used in combination to have a stronger impact on the state of the oil.

Reclamation is a fairly straightforward concept, and it can be easily accomplished by facility maintenance managers. Reclamation is the process by which water and particulate contamination are removed from the oil. Water can be removed from turbine oils via reservoir settling/bowsers, coalescing filters, centrifugation, vacuum dehydration and membrane separation technologies. Methods to reduce particle counts include reservoir settling, mechanical filtration and electrostatic filtration. These methods are effective in removing contaminants, and they do not significantly reduce the additive content of the reclaimed turbine oil.

However, some surface-active additives, such as antifoamants and demulsifiers, can be selectively removed from oil formulations. These materials are not filtered out but tend to accumulate or plate-out on filter media surfaces. The removal rate is relatively slow, so over the life of the lubricant, these additives can gradually be depleted from the formulation. Therefore, properties such as foaming characteristics and water separation should be monitored over the life of the lubricant.

Some varnish filtration technologies target the removal of polar dissolved species in the oil, which includes dissolved varnish but can also deplete polar additives such as rust inhibitors and some extreme pressure (EP) additives. Close monitoring to balance good and bad effects is important.

Refortification, or the addition of additives to the turbine oil, is a much more difficult process and requires knowledge of the formulation. The need for this knowledge should not be underestimated. Turbine oils are balanced formulations designed to provide optimum performance. The addition of different additives to the used turbine oil may result in an imbalance in the formulation that could adversely affect performance. Trying to refortify another supplier's product is risky business because the original formulation may contain additives that are not compatible with the additives that are used to refortify the turbine oil formulation.

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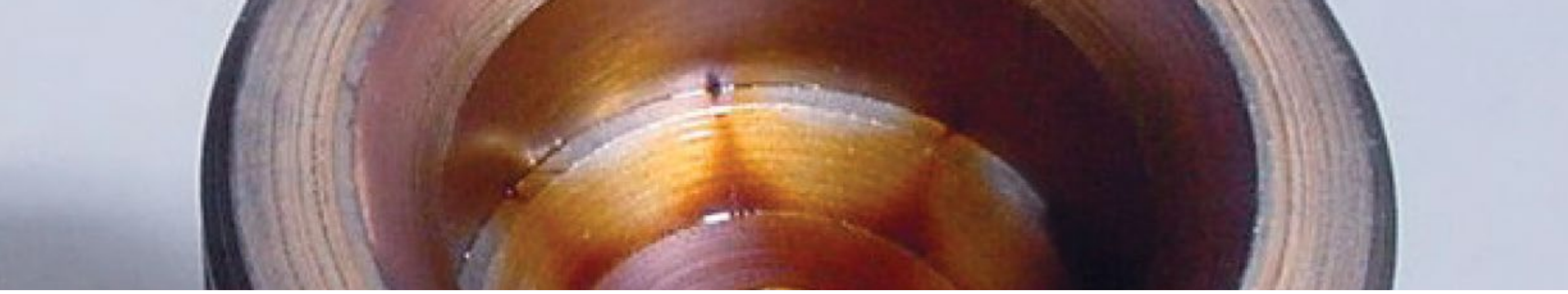


Varnish

What is Varnish?

Turbine oils must endure a host of different challenges due to heat from the process itself, compressive heating, aeration and internal and external contamination, including water and particles. Perhaps the most misunderstood failure modes are those induced by the turbine oil itself.

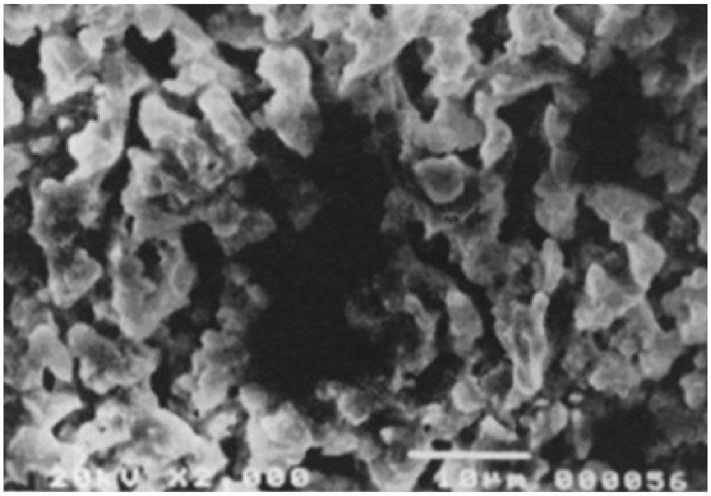
While turbine oils are naturally pure, well-formulated oils, the long-term stress caused by adverse operating conditions can result in both thermal and oxidative degradation of the oil, which can cause problems with the reliability and operability of turbine systems. Even in the most controlled systems, turbine oils are subjected to a number of stressful factors that can lead to premature degradation of the fluid. These include heat, aeration, water and metal catalysts from the machine itself. While the chemical processes are complex, they each end with the same result: the formation of oxidation by-products such as varnish.

Varnish, which is a result of oxidation, is also part of a larger problem: oil degradation. When first forming, natural by-products of degradation are present in the oil in a dissolved state. The oil can only hold a certain amount of dissolved materials at any given point. Once the oil reaches its saturation point, or the maximum holding capacity, the excess dissolved by-products agglomerate and turn into insoluble, sub-micron, soft, suspended particles referred to as varnish precursors.

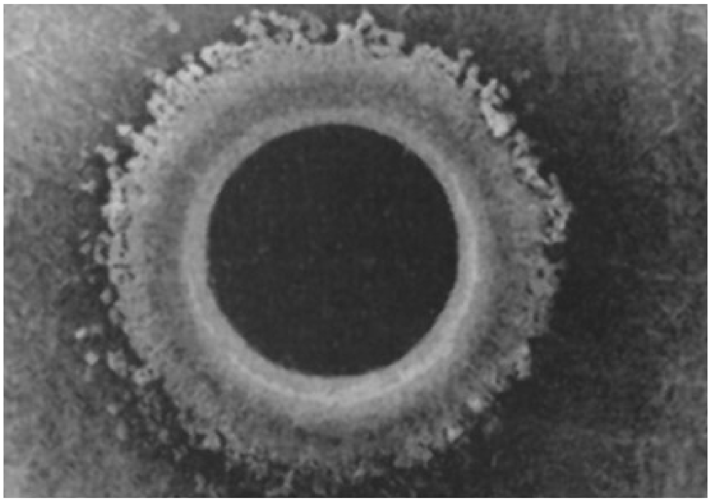
These insoluble varnish precursors are polar and are attracted to polar surfaces such as metals, so they begin to build up on machine surfaces, both in the origin location and in other areas of the machine, as the by-products are carried off by the lubricants. These buildups become a severe issue when they begin to form on sensitive or critical machine surfaces. When this happens, mechanical movement, heat transfer and oil flow are all restricted, which can lead to critical machine failure.

Varnish formation is a sequential process. Initially, heat — in combination with aeration — causes base oil molecules to react with oxygen chemically. This process forms soluble by-products, including ketones, hydroperoxides and organic acids. Over time, these by-products can combine either physically through agglomeration or chemically due to further reactions.

Eventually, these combined by-products drop out of solution and suspension in the oil, forming solid or semisolid deposits on oil-wetted machine surfaces, which is varnish.

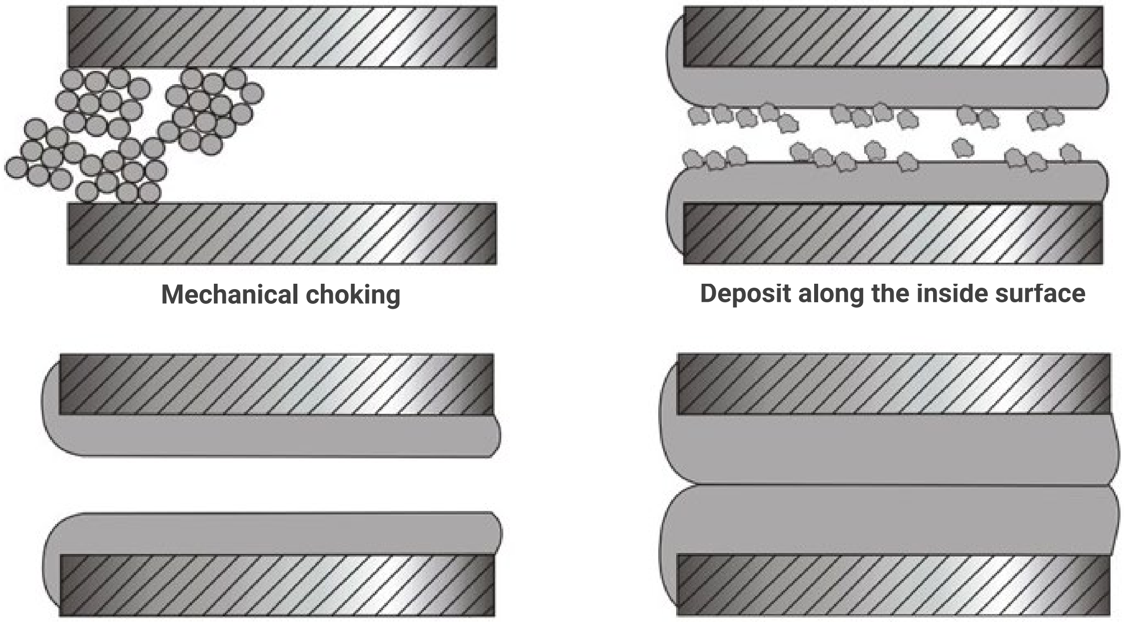


Surface deposits under magnification.



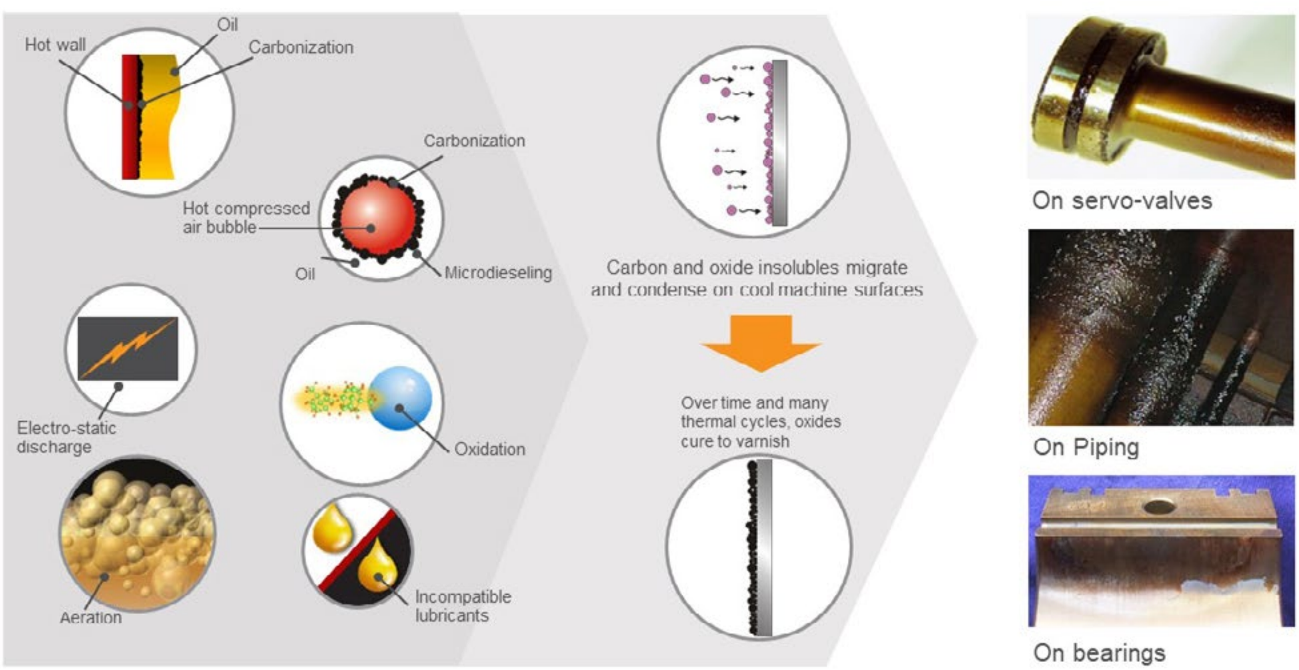
Inlet port deposits under magnification.

Compounding their effect, by-products of oil degradation are often sticky or resinous in nature. This can cause a host of problems, including servo valve stiction, buildup on spool metering edges, restriction of oil flow, reduced spool-to-bore clearances, thermal insulation of the valve, combination with other particles and the loss of stick-slip control called hysterisis.



Impaired oil flow and part movement can result from the buildup of varnish, sludge and other associated deposits on components.

How Varnish Forms



The process of varnish formation can involve many contributing factors, but heat and contamination are two of the biggest culprits.

Oxidation

Research findings point to many contributing causes in the oxidation to varnish process, such as:

- Highly localized overheating of the lubricant due to flow restriction or pooling.
- Microdieseling, which occurs when tiny air bubbles undergo pressure-induced, high-temperature implosions that break down oils.
- Static electricity generated by some filter media, leading to spark discharges that may subject the oil to localized temperatures above 10,000 C.
- Chemical degradation resulting from chemical reactions within a previously used oil which has not been adequately drained/flushed from the system (liquid catalyst).
- Chemical degradation from catalyst properties of solid or semisolid varnish or varnish precursors (varnish or precursor sludge catalysts).
- Additive chemistries and base oil types used in lubricant formulations that greatly affect the propensity of a finished lubricant to generate varnish.

Common locations where varnish likes to form in turbine oil systems are at temperature extremes; hot places where oil degrades, such as mechanical seals, oil filters and sump heaters, as well as cooler, more stagnant places where varnish precursors agglomerate, such as servovalves, oil coolers, reservoirs and piping.

Aeration

There are five serious problems associated with aerated oil, which occurs when air or foam becomes entrained. The five problems often associated with this are:

- Oxidative oil degradation
- Thermal degradation
- Impaired heat transfer
- Impaired oil supply
- Cavitation

MICRODEISLING

One possible cause of varnish, microdiesling occurs when microscopic air bubbles in the oil move from areas of low pressure where they expand to areas of high pressure where they collapse, pressurizing the bubbles.

As this pressure rise occurs, the temperature inside the bubble increases rapidly, enough to ignite the tiny oil/air mixture in the bubble (micro diesel combustion), shooting temperatures even higher, essentially cooking the oil that surrounds the bubble.

When the bubble pops, combustion carbon and oxide insolubles are released, floating freely in the oil until they condense on cool machine surfaces.

Over time and through the course of many thermal cycles, these condensed materials cure to form varnish. This extreme pressure change is uncommon in circulating oil systems but can occur in turbine hydraulic systems and lift oil systems where pressures are higher.

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Oxidative Oil Degradation

Aeration exposes the oil to oxygen. The bubbles produce a high surface area interface between the air and the oil. This interface serves as a reaction site for oil oxidation to initiate, particularly when the oil is hot and moist.

Thermal Degradation

Aerated oil generates heat by the following mechanisms:

- Adiabatic compression of air bubbles (localized heat generation)
- Aeration-induced oil flow resistance in piping and components (energy is converted to heat)
- Loss of bulk modulus (air makes oil compressible, which generates heat)

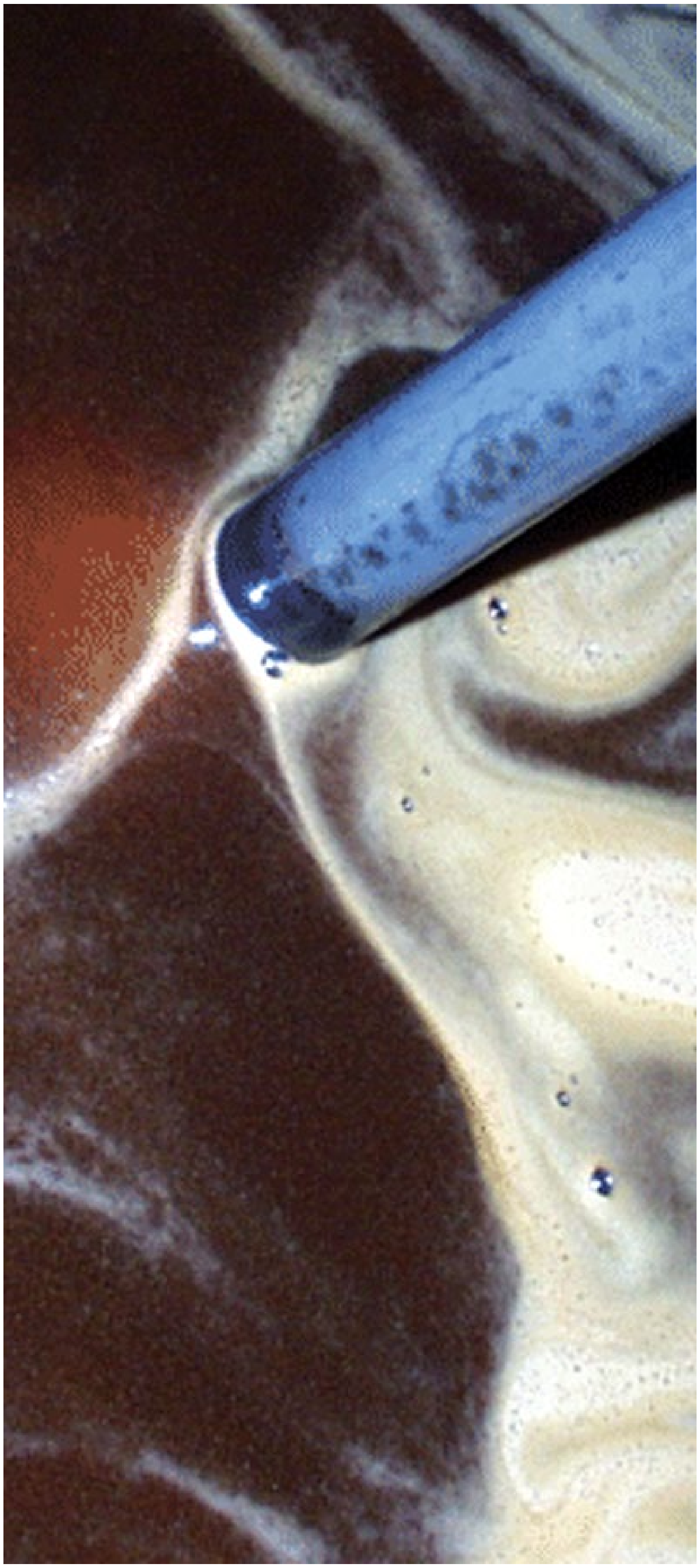
The heating problem is compounded by impaired cooling, as described below in impaired heat transfer. The building heat leads not only to oil oxidation but also to thermal degradation (such as from microdieseling), forming varnish and carbon insolubles. Additives such as zinc dialkyldithiophosphate (ZDDP) will also deplete prematurely due to the heat.

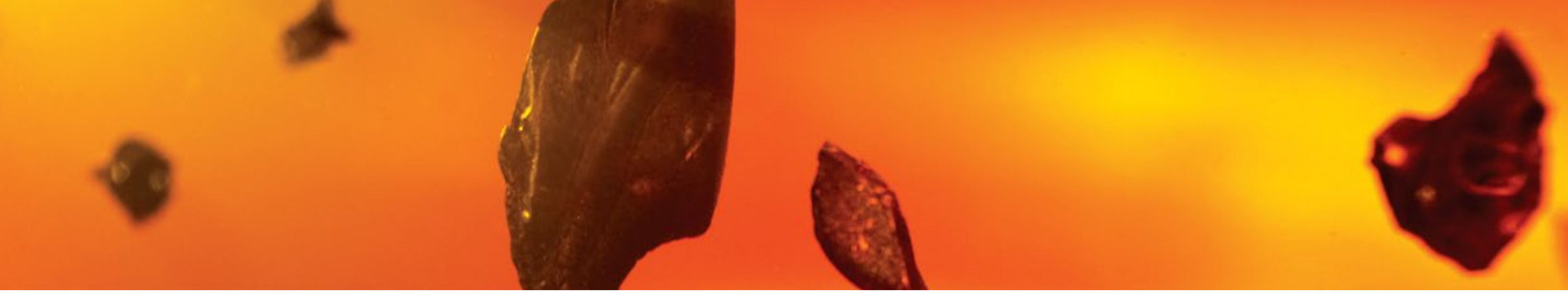
Impaired Heat Transfer

Aeration degrades the heat transfer properties due to several reasons, including:

- The aerated oil is not a good thermal conductor.
- There is restricted oil flow from aeration that impedes convection (movement of the heat from movement of the fluid).

While foam slows the oil's ability to release heat in the reservoir, entrained air also interferes with heat transfer (and movement) in coolers and through machine casing, piping and other thermally conductive surfaces. When the oil runs hot, viscosity runs thin, which degrades film strength in frictional zones and can result in friction heat and wear.





Slowed Oil Supply

Many factors contribute to oil supply problems associated with air. Some of these factors include:

- **Oil Compressibility —** Aerated oil is hard to pump. It's like trying to pump against a sponge. The actual delivered oil volume (oil flow rate) may be only a fraction of what the pump normally supplies without the aeration condition.
- **Dampening —** Foam causes the dampening of important headspace oil movement in machines that depend on oil lifting (throwing) mechanisms, including splash lubrication, paddle gears, flingers and slingers. The foam impedes the oil travel (toss) through the air, resulting in it failing to reach critical zones of the machine, including bearings and gears.
- **Reduced Oil Density —** Many machines depend on oil flowing efficiently by gravitational forces. A bubbly oil has a very low density and gravitational pull. For instance, a ring oiler may lift some foamy oil to the upper port of the journal bearing; however, its low density (and increased apparent viscosity) impairs its ability to penetrate down into the bearing's channels and grooves for lubrication. The same is true in gravity oil drains and headers from bearings and gears in circulating oil systems.
- **Airlock —** Foamy, low-density oil can cause airlock resulting in a complete cessation of oil flow (restricted oil drains, loss of pump prime, redirected oil flow, etc.). An aerated oil has an apparent viscosity sharply greater than that of the oil alone, which compounds the problem.
- **Reduced Oil Level —** Foam robs liquid-phase oil from the reservoir or sump, which means the working oil level falls. This often brings the oil level below what is needed to adequately prime pumps (head), supply oil to lifting devices (ring, collars, paddles, flingers, slingers, etc.) and supply oil to bath/splash-lubricated gears and bearings. Low oil level is a circular problem causing more aeration, more heat and less air-release residence time.

Cavitation

When vapor bubbles become rapidly pressurized, such as in a pump or journal bearing, destructive microjets of oil can collide with machine surfaces at extremely high velocities. Some have estimated that the velocities may approach the speed of sound. The result is a progressive localized erosion of these surfaces. Note that vapor bubbles cause most erosive damage from cavitation, not air bubbles. Vapor bubbles form from the oil itself (light oil fractions) as well as from water contamination (water vapor).

Electrostatic Discharge

In oil-circulating systems, electrostatic charges generally can occur if there is friction in the flow between the oil and the surfaces surrounding it and even friction within and between molecules when passing through small orifices. The strength of the static charge depends on many different and partly interconnected factors. Oil can be especially electrostatically charged if certain situations occur, such as if the oil is being fed into pipes that are too small, when high flow, small micron filters are used and if it contains high proportions of undissolved air, or if the oil level has dropped too low.

If the level of electric charge in the system becomes too great, an electrostatic discharge (ESD) will occur. In such cases, microsparks or sparking results. Typically, a crackling or clicking sound will be heard near the filter or in the tank. If the charge is high enough, the discharge could be repeated several times in quick succession.

Discharges primarily take place in areas with vastly different material combinations. Modern filters with a high proportion of plastic are often affected. The microsparks caused by a static charge can lead to temperatures approaching 1,000 C. This can be extremely dangerous if the fluids are even slightly flammable.

In addition, if hydrocarbon vapors have formed in the tank ventilation area, the system could spontaneously combust. However, when discharge sparks occur within a turbine or hydraulic oil-circulation system,

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they are normally smothered very quickly by the oil. Nevertheless, these mini-explosions can burn holes in filters or even seriously damage the oil due to increased sludge buildup.

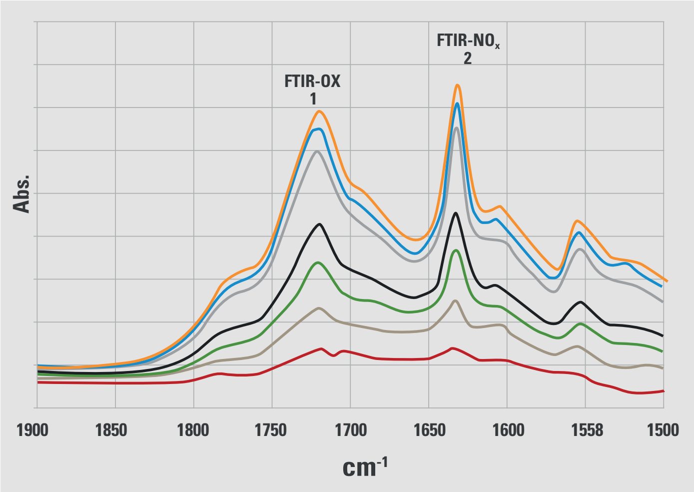
Analysis Techniques for Monitoring Sludge and Varnish

Membrane Patch Colorimetry (MPC) — Varnish Potential (ASTM D7843-21)

As oxidation occurs, degradation materials are generated and accumulate in the oil. MPC varnish potential testing is an adapted patch test using non-polar solvent and a spectrophotometer to quantify the insoluble color bodies that are captured on the patch. Because the MPC result will be higher the longer the sample sits in the sample container, the ASTM procedure requires a reset period whereby the sample is heated to 140 F (60 C) for 24 hours and aged for 68-74 hours. In this manner, all laboratories can test MPC at the same moment in time. The resulting patch's varnish potential is expressed as ΔE. The recommended in-service guideline is to maintain MPC ΔE <20.

Fourier Transform Infrared Spectroscopy

As oxidation increases, common reaction by-products are carbon-oxygen double bonds, also called the carbonyl group. Carbonyl peaks on FTIR spectra in the 1,740 cm-1 region, easily identifying oxidation. As oxidation increases, the absorbance peaks will increase in this region. Additionally, phenol inhibitors used as antioxidants in the oil show peaks around 3,650. Changes in this peak are also noteworthy.



FTIR Spectrum Showing Oxidation Peak around 1,740 cm-1 Range.

Because thermal degradation can occur without significant amounts of oxygen, different degradation by-products are often observed. Therefore, the 1,740 cm-1 peak is less likely to be significant. Instead, the by-products of thermal base oil degradation show up in the 1,600 to 1,640 cm-1 region — also known as the nitration peak due to the nitrogenous by-products, which is more pronounced using a thick-cell (500 μm path length) spectrometer.

Acid Number (ASTM D974 or D664)

Acid Number (AN), previously referred to as Total Acid Number (TAN), increases over time due to the oxidation process. In large turbine systems, AN change should be very gradual, with increases as low as 0.3 to 0.4 above the new oil baseline often sufficient to condemn an oil.

Rotating Pressure Vessel Oxidation Test (ASTM D2272)

RPVOT measures an oil's resistance to oxidation. This information indicates the oil's remaining oxidative useful life (RUL) and is calculated by dividing the in-service sample result, expressed in minutes, by the new oil result. RPVOT values are influenced by the type and quantity of antioxidants present in the oil and the oxidative robustness of the base oil. Cautionary and critical limits for turbine oils are usually at 60 percent and 40 percent RUL, respectively.

FREE MPC Plus oil sampling kit and analysis

Do you know what type of varnish you have?
This three-step testing system can offer valuable insights into the type of varnish that is in your system.

Click here to get your FREE MPC Plus oil sampling kit

Linear Sweep Voltammetry (ASTM D6971)

Measures the aromatic amine and hindered phenol antioxidants in new or in-service type turbine oils. Values are expressed as a percent of new oil baselines. Warning levels are expressed at <50% of the primary antioxidant, which is normally the amine, but in some oil brands, it can also be the phenol. The critical value is <25% of the primary antioxidant.

Viscosity (ASTM D445)

During oxidation, cleaved oil molecules recombine to form higher molecular weight species. An increase in absolute viscosity can indicate when oxidation becomes advanced. In some cases, oil can be thermally cracked during degradation, where the oil molecules are severed into smaller molecules. As a result, a decrease in viscosity can be detected.

Flash Point (ASTM D92)

Flash point may be used to identify thermal degradation if oil molecules have been thermally cracked. As the percentage of lower molecular-weight oil fractions increases due to thermal cracking, the flash point will drop accordingly.

In order to differentiate between the failure mechanisms and assess varnish potential severity, turbine owners should consider an ensemble of tests to monitor the oxidative or chemical degradation of turbine oils.

Varnish Removal

Soft contaminants are often in the equilibrium state of being both insoluble and dissolved within the oil. They can be difficult to extract due to the high operating temperature of many in-service lubricants, which can cause them to change into a soluble state. In addition, soft particles are generally submicron in size. However, their concentration and effect on the system still need to be monitored and controlled.

Several filtration and separation technologies are currently on the market that can intervene with the formation of varnish. By continuous removal of harmful degradation by-products, the concentration of these varnish precursors is reduced, thus providing cleaner working oil. Two means of removing varnish insolubles are available: one employs the use of various filtration media to adsorb or filter the undesired particles in the oil, while the other makes use of the charged or polar nature of target contaminants and electrostatically separates them from the oil.

Balance Charge Agglomeration

The balance charge agglomeration (BCA) technology works by dividing the fluid into two streams and then charging the contaminant particles with opposite charges (positive [+] and negative [-]). These charged particulates are then recombined and mixed under turbulent flow to form neutral and larger particles that can now be removed through traditional mechanical filtration devices.

Electrostatic Particle Removal System

The electrostatic particle removal (EPR) system operates on the basic principle of physics, stating that opposite charges attract. With the use of a constant electric field, a particle with a positive charge is drawn toward a negative electrode within the system, while particles with an inherent negative charge are drawn toward a grounded plate. Polar contaminants (molecules having nonuniformed charge distribution, which is usually the main component of varnish) are drawn to the area of greatest field strength on the collector media. Note that the EPR does not charge the particles but merely enables the already-charged contaminants in the oil to separate onto collectors.

Adsorption Method

Adsorption is the physical and/or chemical binding of atoms, molecules or particles to a surface. Many materials can be used as adsorbents, including compressed cellulose, cotton linters, rice hulls and even newsprint. Adsorption is divided into two types: physisorption and chemisorption.

Because of its chemical structure, varnish molecules are believed to be attracted to the adsorbent through weak molecular forces such as Van der Waals (or dispersion) and hydrogen bonding.

Sometimes chemical resins are used to increase the attraction of polar compounds in the adsorption process.

Preventive and Proactive Solutions for Varnish Problems

The removal methods described above can help to solve varnish problems once they occur, but the most efficient solution is to detect and prevent them by taking action even earlier in the degradation process. By taking a proactive approach to keeping lubricants clean, cool and dry, it is possible to cut down on the root causes of varnish formation and avoid many of the associated costs.

Consistent Oil Analysis

Even with the condition monitoring and analytical methods described above, varnish can be very difficult to detect. The best method for detecting varnish is via precision oil analysis with uninterrupted intervals of consistent and representative samples taken with the appropriate test slate described above.

Early detection through consistent sampling and inspections is the most efficient way to stop varnish problems before they cause a major failure.

Preventive & Proactive System Cleaning

Once varnish is found in the system, there are two strategies that can be used to combat it. Varnish filtration cleaning can be used as described above, but when an oil is nearing the end of its service life, and an oil drain is warranted, it is likely time for a more rapid and thorough chemical cleaning, pulling deposited varnish back into the oil before the oil is drained.

During chemical cleaning, chemicals are introduced into the system, softening surface deposits and stabilizing them in the oil. This process can take several hours or up to several days, depending on the amount of varnish. This process can often be done during normal machine operation or off-line while only the lube oil system is still operating. Shorter cleaning time is another benefit of being proactive about varnish removal rather than waiting for a varnish problem to get out of control.

With the varnish deposits cleaned from components, the old degraded oil with its re-absorbed deposits is thoroughly drained from the entire system. Often the system must then be flushed again until all contaminants are removed so the new oil will not be contaminated.

VARTECH® Industrial System Cleaner (ISC)

Developed to excel where conventional competitive cleaners fall short, VARTECH™ ISC is added near the end of the in-service oil's life to clean existing varnish. It provides drain schedule flexibility and prepares the system for fresh oil — all while the operation remains online.

- Cuts through hard varnish to remove it as micro-sized particles
- Captures and stabilizes varnish particles in a protective barrier to enable removal
- Provides compatibility with in-service oil for optimum operational flexibility and performance

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Demanding Cleanliness

Keeping turbine oil clean is cheaper and simpler when you start with clean oil. It is much easier to stop or exclude a gram of dirt from entering a lubricant system than it is to remove that same gram of dirt once it has made its way into your lubricant.

How lubricants are stored, transported, received and protected are all opportunities for contamination in the lubricant's lifecycle, yet it is quite common for facilities around the world not to check the cleanliness of new lubricant shipments when they first arrive on site. There are numerous reasons why new lubricants are dirty or off-specification. Contaminated drums or containers, cross-contamination of bulk loads and container mislabeling are just a few.

Humans are imperfect and make mistakes. Some suppliers are working diligently to improve their internal processes and minimize these issues, while others may not have tight controls in place.

If you are purchasing lubricants based primarily on price without checking cleanliness on arrival, it is very likely that costs from additional filtration equipment, replacement filter media, increased testing, labor expended cleaning oil, increased downtime and reduced reliability are all being avoided to lower cost while raising the risk to machine health.

In nearly every case, it pays to work with a supplier who provides clean oil consistently. Be sure to question your supplier's cleanliness standards and verify cleanliness upon receipt, especially when it comes to high-volume, critical fluids like turbine oils.

Filtration, Headspace Control, Storage and Handling

If you are certain that your oil is arriving with an appropriate level of cleanliness, there are three key areas to focus your contamination control efforts to keep it that way.

Filter New Oil

Even if your oil arrives at the agreed-upon level of cleanliness, in some cases, it may not be clean enough to enter your machines or storage tanks, depending on the cleanliness targets you have set. Have a good filter in place to catch contaminants that reside in the oil when it first arrives, whether in drums, pails or bulk deliveries. A mobile filter system or "filter cart" should be used when the oil first enters its storage container and at each lubricant transfer thereafter. The oil may pick up particulates within the reservoir too, so it is common practice to use the same filter cart to kidney loop filter the oil in the reservoir even after pump circulation to ensure clean oil in the machine.

Headspace Control

If oil is circulating in a reservoir or churning around the inside of the housing, or otherwise changing volume over time, air is being "inhaled" into the headspace of the oil reservoir. Even lubricants in storage can be contaminated in this way as temperature changes cause changes in stored oil volume.

When air flows into the reservoir or container, it brings with it fine particulates and moisture from the surrounding environment. Replacing OEM vent caps with desiccant breathers is a cost-effective way to exclude contaminants before they have a chance to

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enter lubricants. This not only slows the degradation that leads to oxidation and ultimately varnish formation, but it also cuts down on the amount of filtration needed later in the lubricant's lifecycle.

Many turbines have a vapor extractor on the reservoir to remove flammable gas buildup. This puts a slight vacuum on the reservoir, which can pull dirt past any leaking seals, such as manways and explosion doors. Checking and regularly replacing these seals can prevent dirt contamination.

Lubricant Handling and Transfers

Quick-connects should be installed on transfer hoses to prevent contamination of the transfer hose from the immediate environment and to provide leak-free connections to tanks or reservoirs. Quick-connects also provide a means for off-line filtration should a contaminant level rise above the target set for the machine.

For smaller volume top-ups, color-coded and sealed transfer containers should be used to avoid accidental lubricant mixing or contamination during transfers from storage to service.

Conclusion

No matter what detection methods and tests you use in your fight against varnish, taking a proactive approach to cleanliness and varnish removal is the key to achieving total cost savings and improving equipment reliability. Work closely with your lubricant suppliers, equipment vendors and service providers to ensure you have the right tools to help you both detect and mitigate varnish problems in your critical turbine systems.

GST Advantage™ with VARTECH®

Technology Formulated with advanced chemistry to limit varnish precursors, GST Advantage™ with VARTECH™ Technology turbine oils help maintain peak performance, reliability and productivity by preventing varnish formation before it starts.

- Outstanding oxidation stability
- Rust and corrosion protection
- Limits varnish precursors to prevent varnish from forming