Oil Degradation

CJC™ Fine Filters, CJC™ Filter Separators
and CJC™ Varnish Removal Unit, VRU
not only remove particles and water from oils
- they also remove oil degradation products

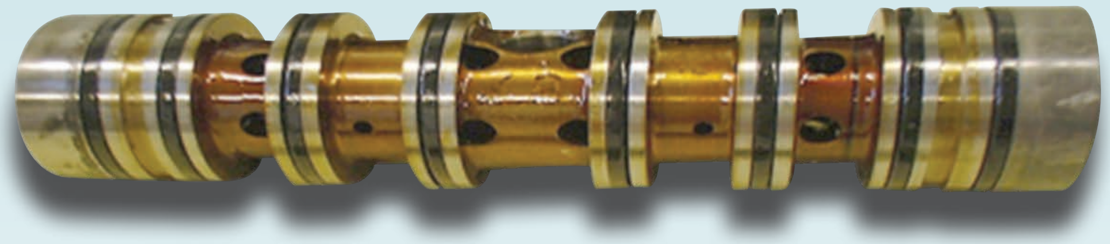
Oil degradation products
are the precursors of varnish
deposits on metal surfaces of
machines and components

Definition
oil degradation products

Varnish / oxidation / sludge

"A thin, insoluble, nonwipeable film deposit occurring on interior parts, resulting from the degradation and polymerization of oil"

(source: Noria)



Any lubricant in service or in storage will degrade over time, depending on the type of oil, the operation conditions and the environment.
When the oil ages, it will change its composition and functional properties. During the degradation process, a number of unwanted products are formed, all of which will result in costly consequences for the machineries, such as corrosion, sticking valves, varnish, etc.

The importance of removing oil degradation products from oil

Why remove oil degradation products from the oil ?

Oil degrading is a common problem in both lubrication and hydraulic systems in applications like plastic molding machines, gas turbines etc.

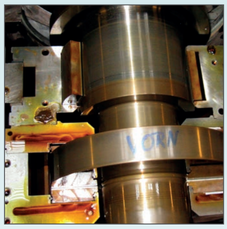
In this brochure you can read about the consequences of oil deteriorating, as well as finding solutions on how to remove and monitor oil degradation products.

Examples of varnish

Oil reservoir on plastic moulding machine

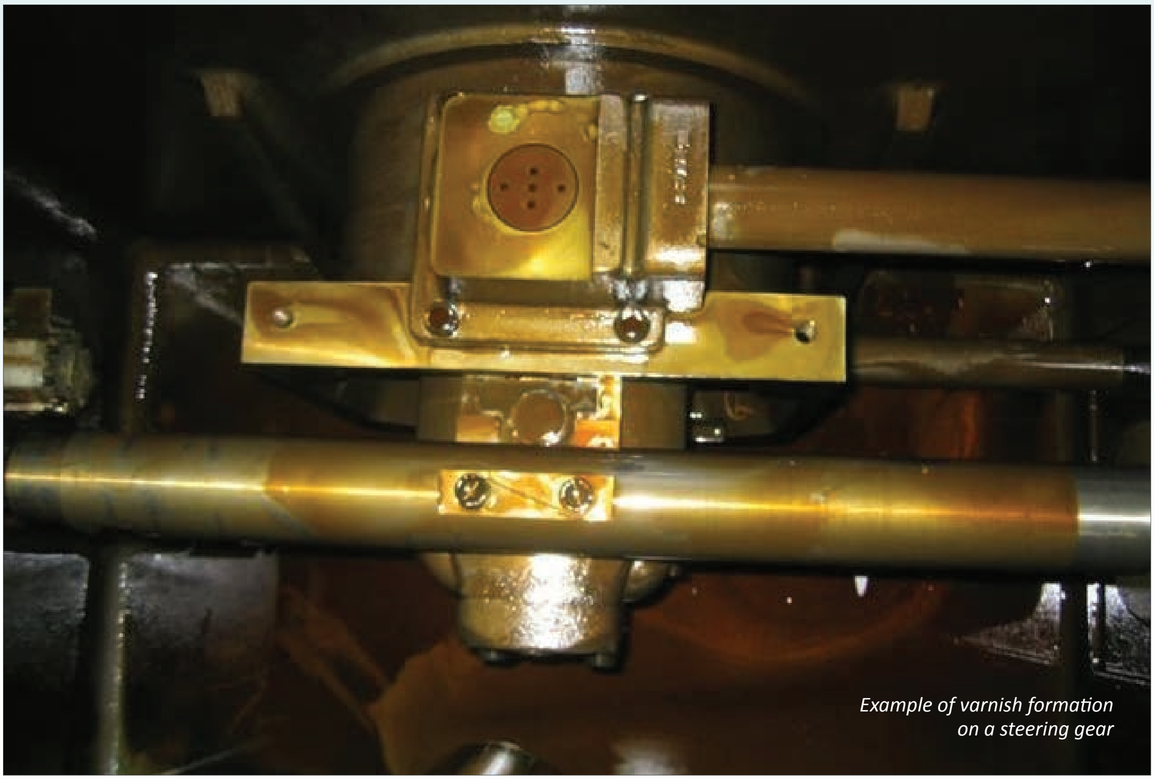
Machine components

Steering gear



Gas turbine

Bolts



Example of varnish formation on a steering gear

Catalysts to oil degradation

- oxidation, hydrolysis, thermal degradation

Catalysts

Oil degrading is a common problem both in lubrication and hydraulic systems. The main causes of this are typically oxidation (oxygen), hydrolysis (water) and thermal degradation (high temperature). In many cases it is a combination of all three.

Process	Oxidation	Hydrolysis	Thermal degradation
Reagent	Oxygen	Water	Heat
Process catalysed by:	Temperature/Water	Oxygen/Temperature	Water/Oxygen
	• Transition metals (wear particles, Cu, Fe, Al) • Contaminants (contamination in general, oxidation products) • Pressure		

Oxidation

Oxidation is the breakdown of the oil with oxygen as reagent. The oxidation process involves a series of reactions forming acidic compounds and polymerized compounds. Oxidation leads to insoluble products (sludge) that may precipitate out as a thin film, forming lacquers or varnish deposits on hot or cold metal surfaces.

Hydrolysis

Hydrolysis is the breakdown of the oil with water as reagent. Like oxidation, hydrolysis can result in acidic compounds and varnish. Oxidation products such as: hydroperoxides, carboxylic acidity, ketones, aldehydes and others, usually possess increased solubility in water and therefore often accelerate the hydrolysis process.

Thermal degradation

Thermal degradation is the breakdown of the oil activated by heat (high temperature). Typically thermal degradation occurs in the hot spots of the system. It can also result in polymers and insoluble compounds, which lead to varnish formation as occurs in the oxidation process.

Oxygen

Water

High temperature

Wear particles


Contaminants

Oil degradation & consequences

80% of oil related machinery repair and maintenance costs
are caused by contaminated oil

Oil degradation will result in

Formation of acidic compounds

Increased acidity results in short oil lifetime. Furthermore, acidity promotes corrosion, for example pitting. This leads to increased wear in the internal surfaces of the machine.

Increase in oil viscosity

The oil´s resistance to flow will increase, which will result in friction, wear and loss in efficiency of equipment.

Decreased additive performance

Additives (antioxidants and detergents) also react with the degrading products. The result is that the additives lose their effect - and instead accelerate the deterioration process.

Varnish formation

Varnish deposits are “sticky” and will trap hard contaminants, creating a“sandpaper surface”. This “sandpaper” causes accelerated wear of components. In addition, varnish can result in filters and valves blocking, and orifices clogging. Furthermore varnish acts as an insulator, reducing the effect of the heat exchangers. Once the varnish deposits have formed on the metal surfaces, it is very difficult to remove.

Consequences of the oil degrading

Shorter oil life

- An increase in acidity level and oil degradation
- Degradation products act as a catalyst
- A reduction of additive performance

Reduced oil performance

- Loss of lubricity
- Valve failure
- Restricted oil flow

Reduced productivity

- Monday morning problems: slow start-ups
- Increased downtime
- Reduced machine performance

Higher energy consumption

- Friction and wear

Increased maintenance costs

- Increased filter change frequency
- Increased wear of components
- Short oil life in service
- Component failures
- Cleaning of the varnish deposits

Environmental pollution consequences

- Greater disposal costs of oil and filter insert changes
- Leakages

The CJC™ Technology

The adsorption equilibrium behaviour
Absorption and **Ad**sorption by CJC™ Filter Inserts

Oil degradation products cannot be removed with conventional mechanical filters because they are submicron particles and a fluid in a fluid, like when sugar is dissolved in coffee.

These degradation products can be removed by CJC™ Fine Filters, CJC™ Filter Separators and CJC™ VRU through a combination of **ad**sorption and **ab**sorption processes.

Adsorption is the physical or chemical binding of molecules to a surface (like getting a cake thrown into your face). In contrast with **ab**sorption, in which molecules are absorbed into the media. See illustrations.

CJC™ Filter Inserts, made of cellulose fibres, have a high surface area and are effective as **ad**sorbents and **ab**sorbents. In addition, due to their chemical nature, they are highly suited to pick-up oxygenated organic molecules, such as oil degrading products.

Absorption - **Ad**sorption

Absorption

Absorption can be illustrated by this drawing: The chemical substances (the cake) is absorbed by the media (the man)

Adsorption

Adsorption can be illustrated by this drawing: The chemical substances (the cake) is binding to a surface (the man)

The CJC™ dirt holding capacity

CJC™ Filter Insert consisting of cellulose fibres treating the oil

This illustration shows the contaminated oil approaching the cellulose fibres in an almost new Filter Insert

Feed

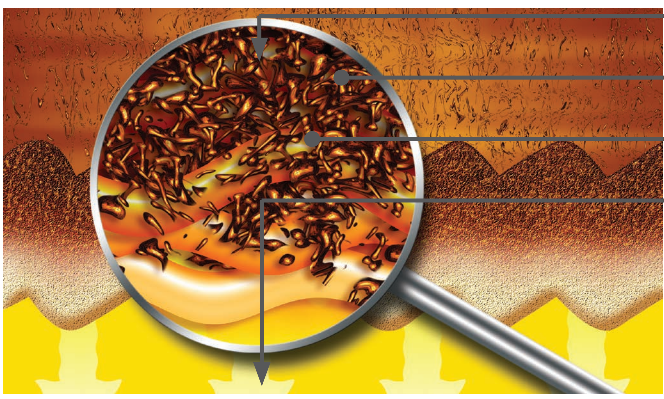
Small amount of oil degradation products are retained by the cellulose fibres

Fibres

Purified oil

CJC™ Filter Insert near saturation

This illustration shows that the Filter Insert is still delivering clean oil even though the cellulose fibres are nearly saturated



Feed

Even high amount of oil degradation products are retained by the cellulose fibres

Fibres

Purified oil

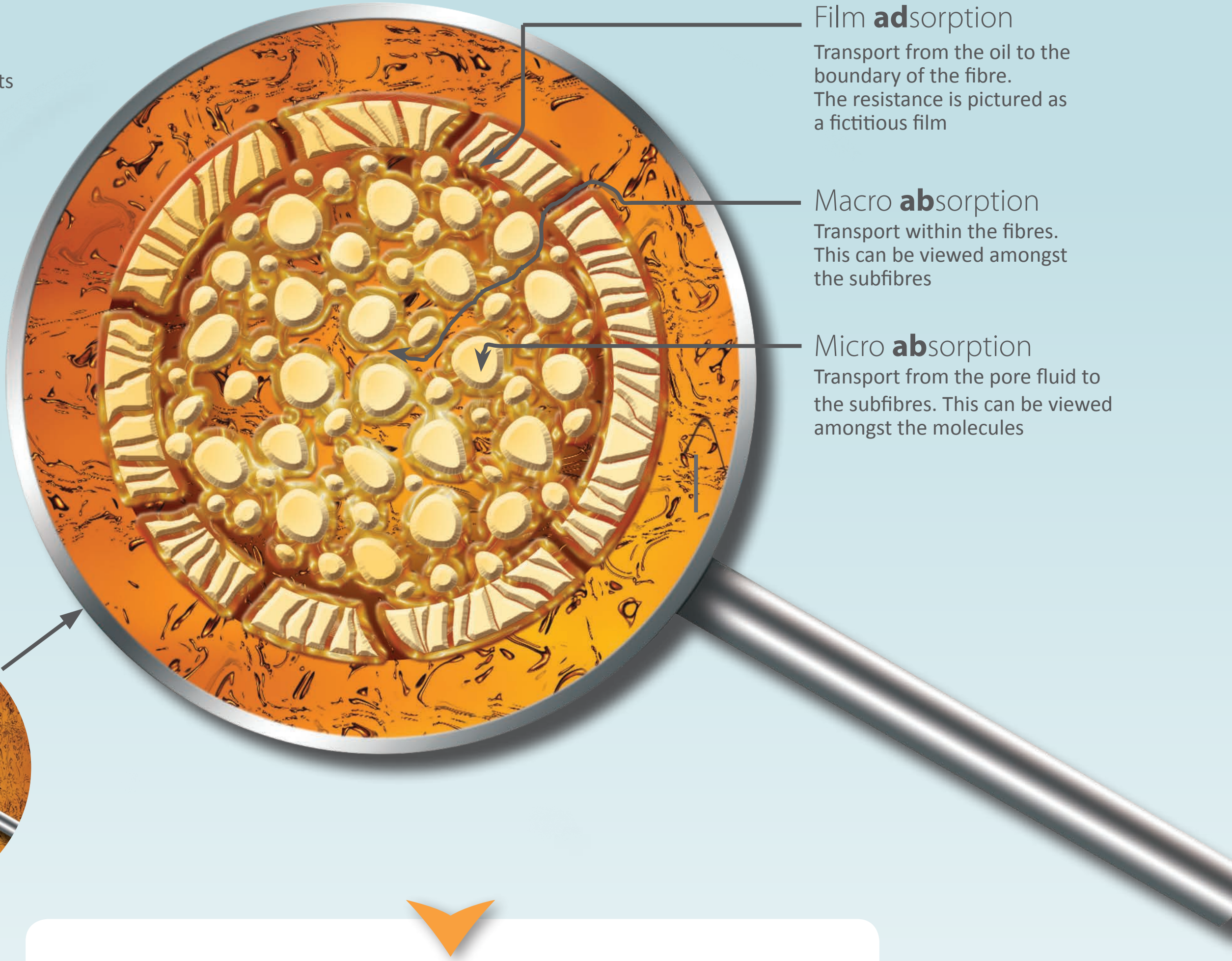
Cellulose fibre technology

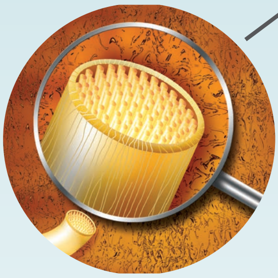
The filtration technology

Cross-section of a cellulose fibre

Each cellulose fibre consists of millions of cellulose molecules.
Each strand of cellulose molecules has a diameter of 10 - 30 micron.

Degradation products are **ab**sorbed and **ad**sorbed into the cellulose material





Film **ad**sorption

Transport from the oil to the boundary of the fibre.
The resistance is pictured as a fictitious film

Macro **ab**sorption

Transport within the fibres. This can be viewed amongst the subfibres

Micro **ab**sorption

Transport from the pore fluid to the subfibres. This can be viewed amongst the molecules

CJC™ Filter Inserts remove contaminants of any kind and size

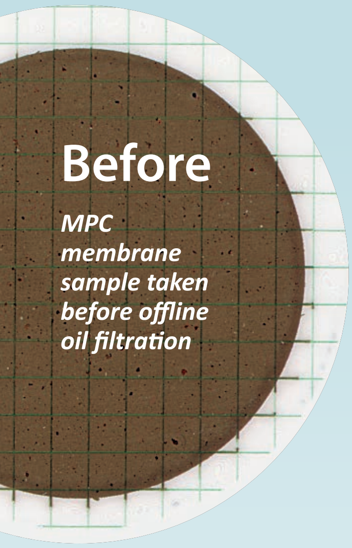
- Hard contaminants
  Wear particles, debris, dirt
- Soft contaminants
  Varnish / oxidation products
- Water

New and clean CJC™ Filter Insert, ***before use***

Used and dirty CJC™ Filter Insert now saturated with contaminants, ***after use***

Your natural solution

CJC™ Oil Filtration will maintain both oil and system cleanliness



CJC™ Oil Filtration systems

Fine Filter

Filter Separator

Varnish Removal unit, VRU

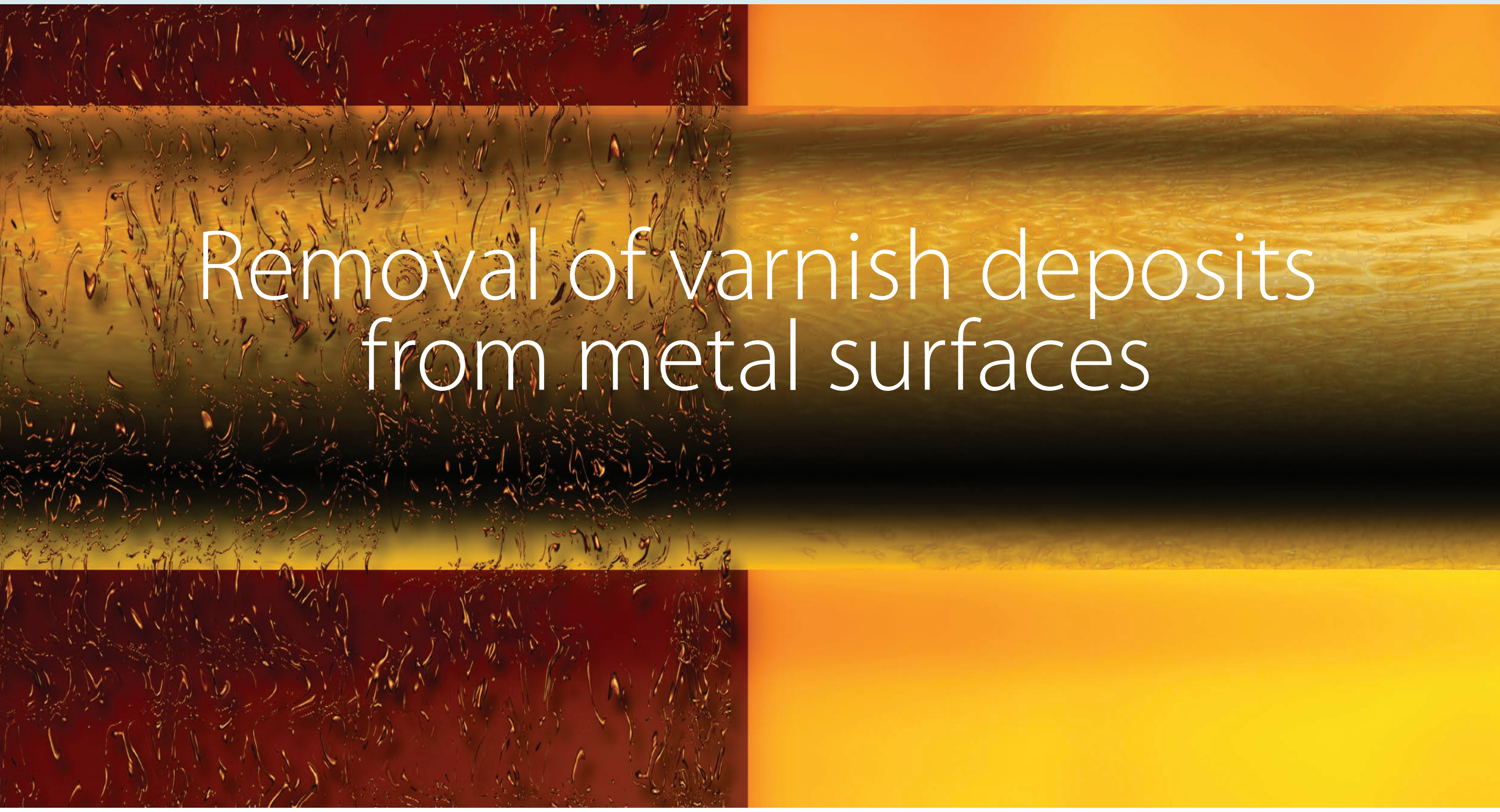
Filter Inserts

Produced of 100% natural cellulose fibres from sustainable resources - no metal, no plastic, no chemicals

By installing CJC™ Oil Filters, the amount of varnish deposits on metal surfaces will be reduced. It is explained by the adsorption equilibrium behaviour.

There is an equilibrium between the two phases, i.e. the fluid (oil) and varnish on the surfaces. When the oil becomes cleaner, the deposits from the system become unstable because the concentration of oil degradation products in the oil has decreased. This will result in a removal of the amount of adsorbed varnish on the compounds.

In other words, this means that the oil degradation products on the metal surfaces are released. The oil functions as a system cleaner.



Problem

The oil is contaminated by hard particles, water and soft contaminants, which lead to varnish deposits.

Solution

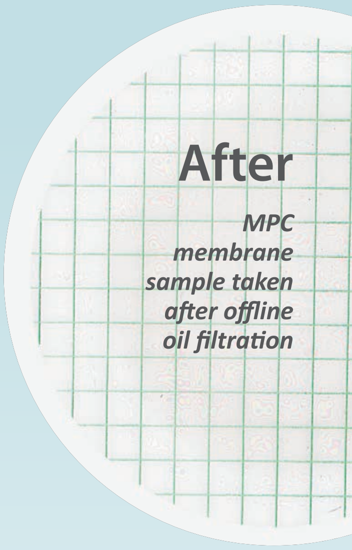
Removal of the contaminants by CJC™ Oil Filters before they will form sludge and varnish deposits. Varnish already deposited, will be removed from the metal surfaces.

Your benefits

Removal of degradation products before they have time to react further and form insoluble sludge and varnish deposits

An oil system free from varnish deposits

- Longer oil life
- Increased oil performance and lower energy consumption
- Increased productivity and up-time
- Less maintenance and breakdown
- Maintain additive performance
- Maintain oil viscosity and acidity
- Environmentally friendly



Result

Lower levels of contamination, which will prevent deposit formation. Furthermore, the deposits - once formed - will be reduced continuously by installing CJC™ Oil Filtration systems.

Maintenance

By CJC™ Oil Filtration you will maintain both oil and system clean.

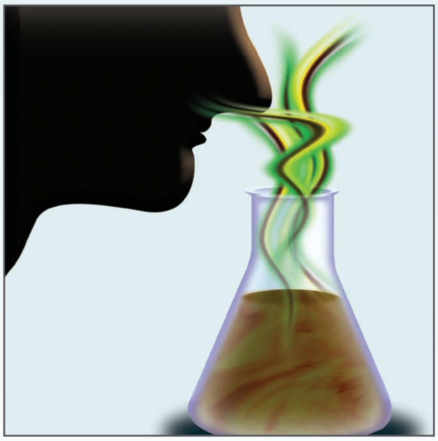
How to observe oil degradation?

Oil degradation products are compounds of molecular sizes, which cannot be measured by conventional particle counting methods

The following are indications of oil degradation / aging:

- Dark colour (amber - brown - black)
- Sour and putrid odour
- Increase in oil viscosity

The dark colour indicates contaminated oil



Sour and putrid odour indicates oil degradation

Increase in oil viscosity

Methods to monitor oil degradation

How to measure the amount of certain degradation products from oil or the amount of additives in the oil.

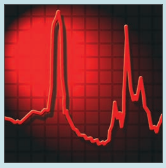
Methods that measure different aspects of the deteriorating oil

Ultracentrifuge test

This test uses the gravitatory forces to extract and settle the contaminants of the oil. The sediments are compared with a sedimentation rating system to determine the degradation of the oil.

Infrared spectroscopy

(FTIR Analysis - Fourier Transformation Infrared Spectroscopy)
This analysis is based on the principles of molecular spectroscopy. It can verify the level of oil degradation by the identification of the functional groups (e.g. ketones, carboxylic acidity) in molecules.

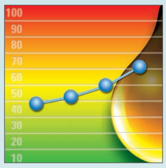


Membrane Patch Colorimetry MPC

This analysis is an indication that the oil contains degradation products.
The varnish is captured in the white MPC membrane (0.45 micron cellulose membrane), and shows as a yellow, brownish or dark colour depending on the amount of varnish present in the oil. A microscopic magnification shows if the colour comes from varnish or hard particles.

QSA test

This method identifies the varnish potential rating, and is based on colorimetric analysis. By comparing the result to a large database of QSA tests, a 1 to 100 severity rating scale indicates the propensity of the lubricant to form sludge and varnish

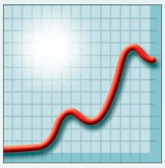


Gravimetric analysis

This analysis can determine the level of oil degradation by measuring the weight of residual components.

Viscosity test

This test measures the oil resistance to flow. It can be used as an indicator of oil degradation.



RULER test

Indicates the amount of anti-oxidants (oil additives). When the additives get depleted due to incipient degradation of the oil the RULER number decreases. This effect is evident before varnish starts precipitating, which makes the test proactive.

TAN (Total Acid Number)

This analysis measures the level of acidic compounds. It can also be used as an indicator of oil degradation, since acidity is a product of degradation.

Methods to monitor the consumption of additives

- **FTIR analysis**
  (Fourier Transformation Infrared Spectroscopy)
  Monitor the additive depletion
- **RULER test**
  (Remaining Useful Life Evaluation Routine)
  Measures the remaining antioxidants by voltammetric analysis
- **RPVOT test**
  (Rotating Pressure Vessel Oxidation Test)
  Measures the oil's resistance to oxidation under prescribed conditions

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