

RULER[®] - Technology

Remaining Useful Life Evaluation Routine

"Portable Condition Monitoring Technology for your Lubricants and Greases"

The RULER is the instrument by excellence to bring added value to your on-site oil condition monitoring programs. As a fully portable technology it will enable you to screen the condition of your lubricant by monitoring and trending its oxidative health, before excessive stress will start to degrade the lubricant and result in equipment damage and/or failure. The RULER utilizes a very small oil sample volume (50-400 µl max) to measure the remaining amount of antioxidants. The test method is a non-destructive test method which shall be part of any proactive condition based maintenance program, increasing value of modern equipment Reliability Management Programs.

This technical paper will cover different technical subjects related to the RULER technology and Fluitec is proud to offer our customers the different areas of competences as part of our core business:

- **Consulting:** on-site diagnostic and auditing to detect oil condition related problems (ex. Varnishing, water presence, accelerated oxidation, etc.)
- **Preventive Condition Monitoring:** by using our portable instrument, each field lubrication professional has the capability to monitor the level of Remaining Antioxidants in all your lubricants and greases (concept of Trending Remaining Useful Life ») enhancing quick and cost-reduction decisions at the plant level.
- **Solutions :** once the diagnostic and CM has identified the Root Cause of your equipment problems, Fluitec offers a wide range of Contamination Control technologies resulting in optimum economical lubricant life (ESD reduction filters, or ESP process for soluble varnish removal.)



Features and Benefits of an Oil Condition Based Program

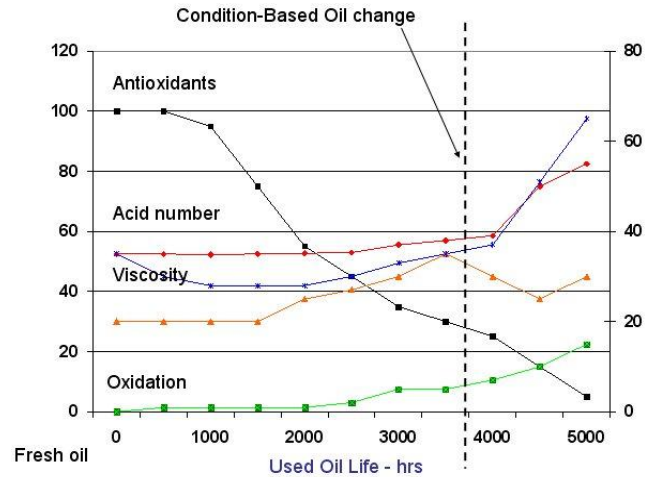
In modern maintenance strategies, OCM is vital for understanding and predicting the lubricant degradation of in-service industrial lubricants (lubricant condition-monitoring and diagnostics program).

Therefore, during the last decade maintenance programs driven by Condition Based Monitoring programs, have proven to be valuable for cost reduction and cost control programs (Reliability Based Maintenance - RBM).

This consists of monitoring, controlling and trending the vital physical and chemical parameters like viscosity, antioxidants, oxidation on-set, water, and particulate contamination, resulting in proactive information for condition based oil changes, and enhancing on-site decisions

Power Generation plant has improved through its 2-years old on-site OCM, its overall efficiency with 3%, by reducing their downtime costs, as well maintenance and spare parts costs."

Press Release, June 2005



What is the link between Maintenance and Remaining Useful Life of Lubricants (RUL)?

By monitoring the consumption of the antioxidants during their service life, directly related to the **lubricants Remaining Useful Life**, operators will manage the potential safeguard for lubricants against oxidative stresses (before the onset and propagation of oxidation, and one of the major reasons of lubricant degradation).

As the oxidation process is a chemical reaction between oxygen and the base-oil (hydrocarbon chain) this oxidation reaction results in the formation of reactive oxidative compounds, which will themselves start to attack the oil base stock and form polymers. Chemically this reaction is better known under the formation of oil insoluble sludge, varnishes and other deposits, and will directly result in a significant increase of viscosity. Fundamentally the antioxidants main function will be to react with the reactive oxidative compounds by neutralizing them. By industrial standards this is referred to as the "oxidation stability", and will extend the operating life of the oil.

So, during use of the fluid the antioxidants (AO) will be depleted until a certain critical level is reached at which the fluid start to degrade / polymerize at a higher rate. At this point the fluid reached its useful life. In order to estimate the Remaining Useful Life (RUL) of a fluid it is therefore important to know its critical antioxidant concentration (see figure 1).

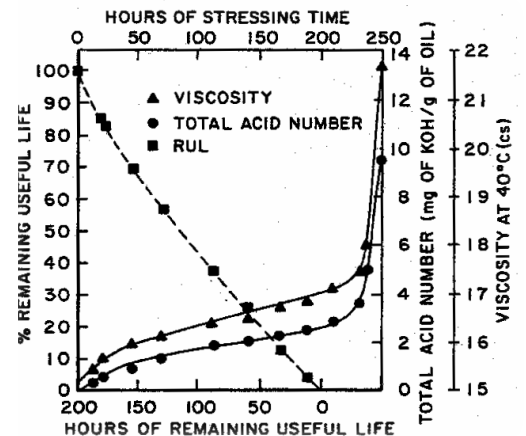
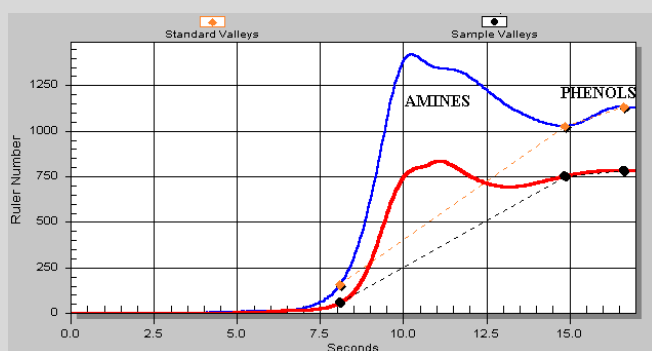


Fig 1: plots of the percent – RUL , viscosity (@40°C), and Total Acid Number vs. hours of stressing time and RUL at 175°C

How to integrate successfully the RULER into your On-Site Oil monitoring Program?

Through time-series testing, the Remaining Useful Life of a lubricant can be tracked from test to test, enabling the end-user to identify "normal" trends for a given engine or other equipment. Variations from this normal trend can be indicative of changes in operating conditions causing accelerated oxidation. Consequently, determinations can be made to predict when rapid changes in the base stock are likely to occur, and decisions can be made regarding oil changes or additive reinforcement to extend the Useful life of the lubricant. This information allows quick and highly accurate assessment of the Remaining Useful Life (RUL) of lubricants, in contradiction to classical techniques such as RPVOT and TAN. Traditional analytical tests such as RPVOT (ASTM D2272) have been shown to be ineffective at indicating when performance problems will commence and how much longer the lubricant can be safely used. This is especially true in modern lubricant formulations, where individual antioxidant monitoring is of very high value for end-users, such as gas and steam turbine lubricants. RULER™ is an essential lubricant condition monitoring tool for critical applications utilizing antioxidant chemistry. Over the last decade RULER has been approved and implemented as part of several OEM programs, such as SIEMENS, and is also part of ASTM and DIN In-Service Turbine oil specifications.

Characteristics of the RULER instrument & its RDMS software



When using the RULER® technology for oil condition monitoring purposes, it is important to realize that the test is not finished once the RULER® analysis is done. A very important step in lube oil analysis programs will be data interpretation, in order to enable operators to take corrective actions, if necessary.

To facilitate and enhance users for quick and easy data interpretation, Fluitec International has made following software available at your choice:

The RULER® CE520 software working under Windows CE.NET environment

The RULER® R-DMS version 2.0, allowing the user maintain large databases, trend time-series testing (figure below), view multiple tests, and export data to other database formats.

The **RULER®** is a fully portable instrument that measures the antioxidant levels of lubricants and greases in just a few seconds

The main features you can find into the **RULER®** instrument are listed below:

- ◆ Test capability for Antioxidant and Acid Number measurement
- ◆ Compact and completely portable (dimensions: 2.36"H x 4.08"W x 9.74"L) – 1.5 lbs
- ◆ Easy to use software powered by Windows CE.NET and Intel XScale - PXA270, 520 MHz processor
- ◆ Super flex touch screen - 320 * 240 pixels backlit, color LCD
- ◆ Data Storage for over 100 tests
- ◆ Quick and easy data-communication to personal computers via USB 2.0 port
- ◆ *Backlit Keyboard:* Highly ergonomic backlit keyboard, with separate numeric keypad.
- ◆ Fully tested for harsh and industrial environments
 - ◆ Operating Temperatures: -4°F to +122°F
 - ◆ MIL-STD-810F
 - ◆ IP67
- ◆ Long lasting rechargeable 2400 mAh Lithium-Ion Battery Pack with a battery life of 2 to 4 working

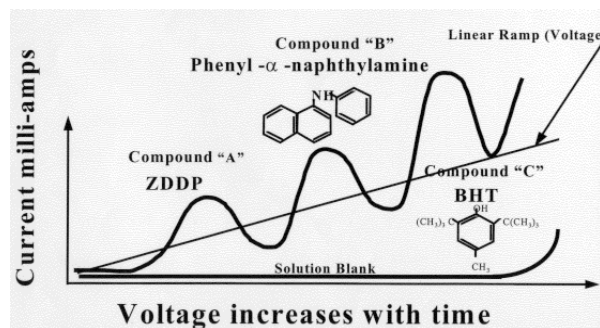
Principle of measurement behind the RULER

The **RULER®** test can be performed with any lubricant containing at least one antioxidant species. The test vial (electrolytic cell) is prepared by mixing an oil sample with a solvent and a solid substrate. The solvent separates the antioxidant from the oil, as the vial is shaken vigorously. By inserting the electrode into the test vial, a controlled voltage ramp through the electrode excites chemically the antioxidants. This causes the increasing oxidation current to reach a peak, and then decrease as voltage potential continues to increase. (see figure 2).

RULER = ASTM approved test

D 6810 – measurement of phenolic antioxidants in lubricants

D 6971 – measurement of phenolic and aminic antioxidant in lubricants



In the voltage/current relationship: The voltage potential range is related to the identification of the type of antioxidant. And the current peak height indicates the concentration of the antioxidant.

The RULER® displays a RUL number representing the concentration of the antioxidants being monitored. Each test compares the RUL number of used oils to a standard RUL number of a fresh oil sample of the same brand and formulation

Areas of application for the RULER

- ◆ The **RULER** monitors antioxidants in wide range of industrial lubricants, including gear and circulating oils, transmission fluids, compressor lubricants, phosphate esters as well greases.
- ◆ The **RULER** monitors antioxidants in combustion and engine lubrication, such as automotive and truck diesels, locomotive/railway diesels, (bio)gas engine oils, and generator diesel oils.
- ◆ The **RULER** monitors antioxidants (aromatic amines) in polyol ester based jet engine lubricants (turboprops for aerospace applications)
- ◆ The **RULER** monitors antioxidants in a wide range of industrial steam and gas turbine oils, as part of power generation equipment such as steam turbines, gas turbines, as well combined cycle power plants.

Application	Fluid	RULER solution
Industrial Steam and gas turbines for power generation	Industrial lubricating oil and R&O fluids	Green (Yellow only for phenols)
Aerospace jet engines	Lubrifiant à base d'ester	Red
Circulating and gear lubrication, compressors, hydraulics	Mineral/ Synth./ R&O/ Greases	Green (Yellow only for phenols)
Automotive and truck diesels, marine engines, railway diesels, biogas and natural gas engines, generators	Mineral & synthetics	Blue

References



During the last 10 years, the RULER has been integrated by a large amount of OEM's in the field. One example of a successful integrated program is at SIEMENS ENERGY which integrated both RULER and MPC testing in their Siemens Monitoring Recommendations as part their Power Generation Equipment maintenance programs. In addition the RULER is also part of ASTM and DIN standard methods and practices for industrial lubricating oils. .

SIEMENS

Siemens Monitoring Recommendations

Standard Analysis Program (2 analysis per year)

- Air release
- TAN
- Foaming
- Water separability
- Viscosity
- Cleanliness
- Colour
- Additive Content (Voltammetry)
- Membrane Patch Colorimetry (MPC)



All oil analysis results are evaluated and presented in a Technical Report to the customer together with recommendations (maintenance actions, next oil sampling, remaining useful life).

Seite 172009-01-21Dr. Ludger QuickCopyright © Siemens AG 2008. Alle Rechte vorbehalten.
Energy Sector

Following list of international companies have selected FLUITEC and RULER/MPC for their oil monitoring programs :

Bayer	Endesa	Duke Energy
OelCheck	Eon	Exelon
Chevron	American Electric Power	Albemarle
Atlas Copco	Exxon Mobil	Saudi Aramco
SKF	Lubrizol	Vattenfall
Alstom	Eaton Aerospace	SNCF
ENI	MTU Aero Engines	BP

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