



Leading The Clean Oil Revolution

Turbine Lubricant Maintenance and Analysis

©Copyright 2005-2012, EPT

Frame 6B Users Group
June 20, 2013

Richard Trent
Hypro Filtration

Peter Dufresne
EPT





- Located in Calgary, Canada
- Specialists in
 - Turbine Varnish prevention
 - EHC fluid maintenance
 - Onsite lubricant flushing
 - Oil Testing Services
- Operating in 20 countries
 - Installed on largest plants in Asia, Europe, Middle East and North America
- Partnered with Hypro Filtration



Hypro Filtration, Fishers Indiana





© 2003 TransCanada PipeLines Limited

“The acid level in our hydraulic fluid
was reduced from 3.3 to 0.07.

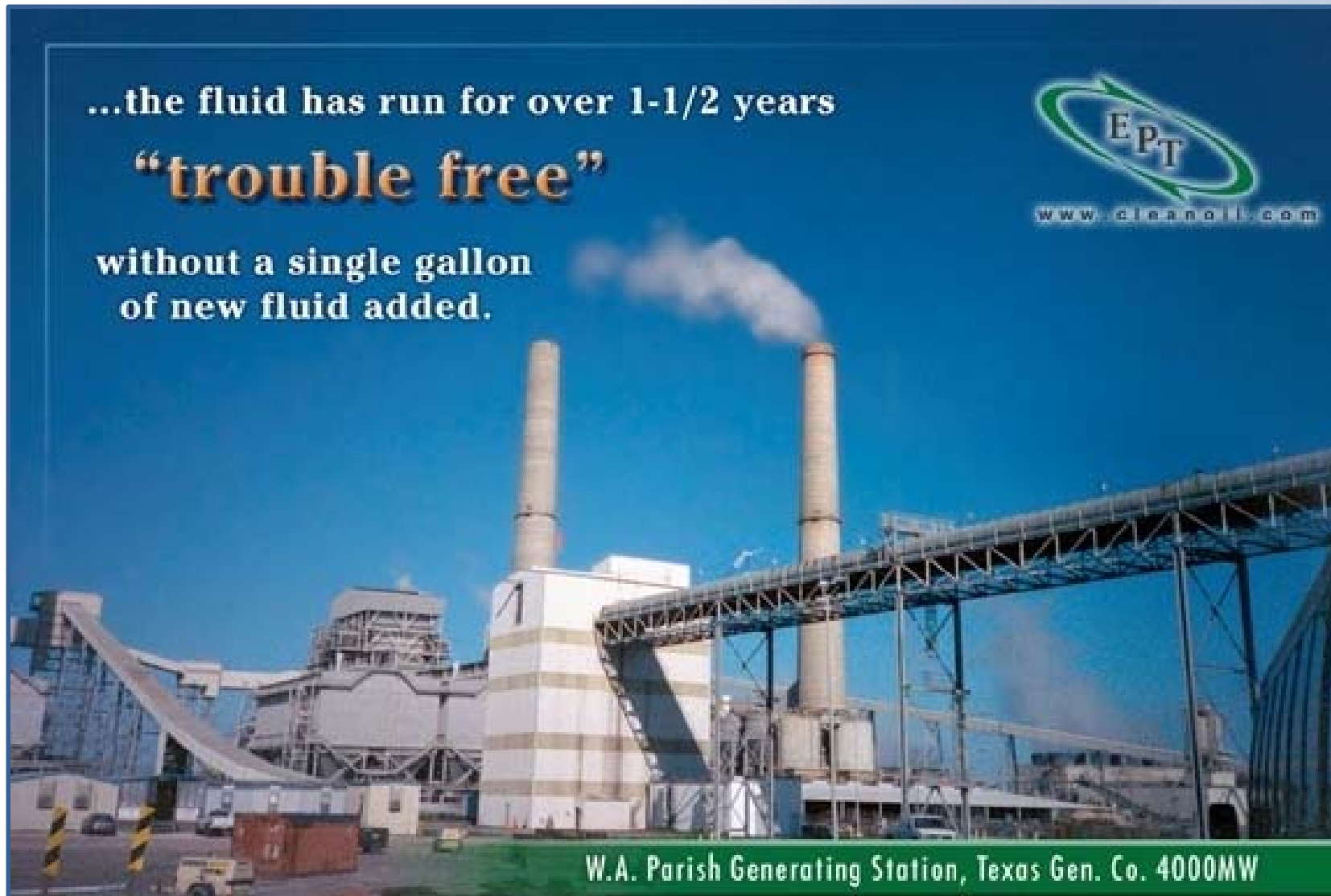
The **results** were
nothing less than
outstanding!”

USS Carl Vinson, CVN 70 Nimitz Class

...the fluid has run for over 1-1/2 years

“trouble free”

without a single gallon
of new fluid added.



W.A. Parish Generating Station, Texas Gen. Co. 4000MW



4972

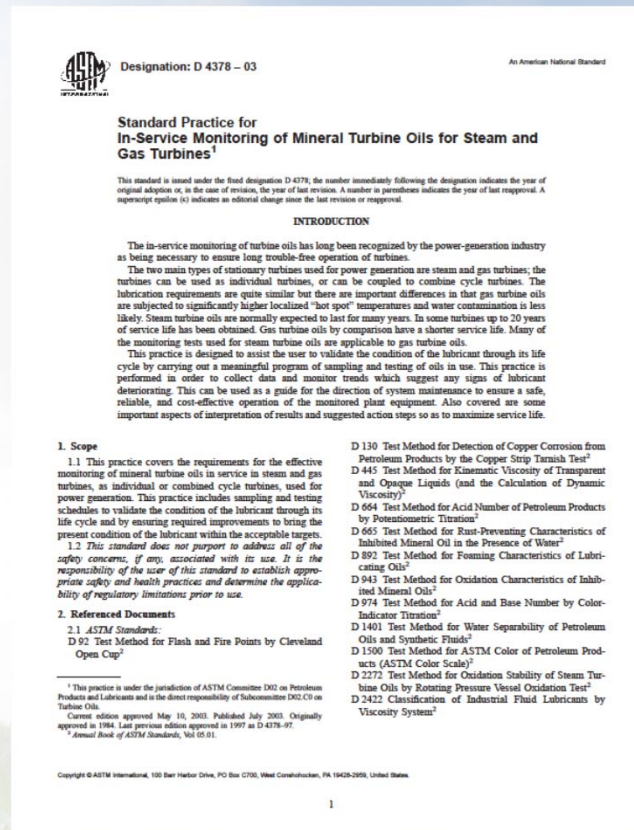
MW



TURBINE OIL CONDITION MONITORING

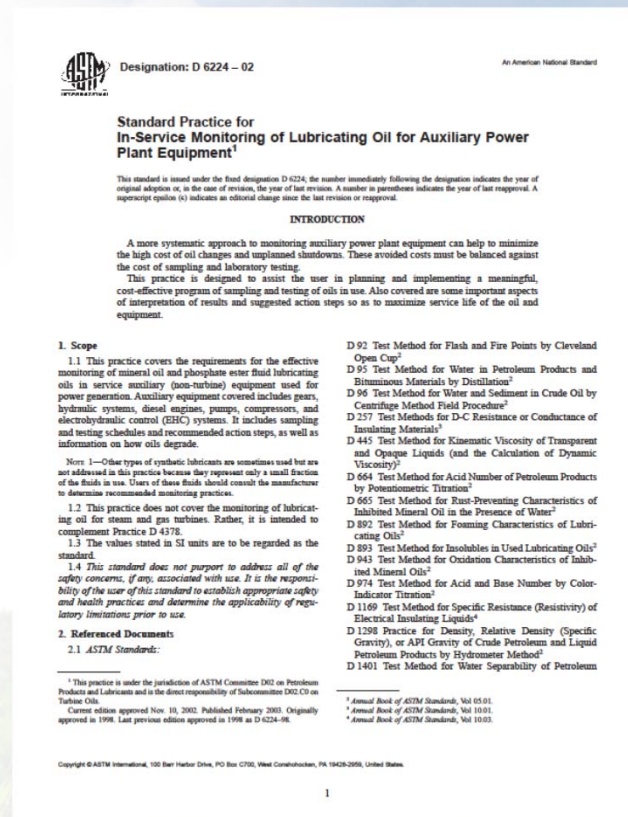
Establishing or updating an Oil Analysis Program

- Turbine oil testing guidelines are established and published in ASTM 4378-03



Establishing or updating an Oil Analysis Program

- Oil testing guidelines for auxiliary power plant equipment are established and published in ASTM D 6224-02



Turbine Oil Analyses

Suggested Frequency:

Regular Analyses	Periodic Analyses	As Required Analyses
Every 1 – 3 months	Every 3 – 12 months	Problem investigation

Testing frequency depends on:

- Unit criticality: critical systems should be tested more often.
- Unit age: new units should be tested more frequently during break-in (first 6 months).
- Fluid age: fluids should be tested more frequently when they begin to approach the end of their lifetime (RPVOT < 50% new oil value).

Testing should also be completed 24 hours after any oil change.



Turbine Oil Analyses

Analyses Recommended for Gas and Steam Turbine Users:

Regular Analyses	Periodic Analyses	As Required Analyses
Appearance (Clean and Bright)	RULER (ASTM D6971)	FT-IR (ASTM E2412)
Viscosity at 40°C (ASTM D445)	RPVOT (ASTM D2272)	Rust Test – for GT (ASTM D664)
Total Acid Number (ASTM D664)	Rust Test – for ST (ASTM D664)	Foaming (ASTM D892)
ISO Particle Count (ISO 4406)		Air Release (ASTM D3427)
MPC (ASTM D7843)		Demulsibility (ASTM D1401)
Moisture (ASTM D6304 / D7546)		Insolubles (ASTM D2273)
Metals (ASTM D5185)		Flash Point (ASTM D92)

Regular Turbine Oil Analyses

Appearance:

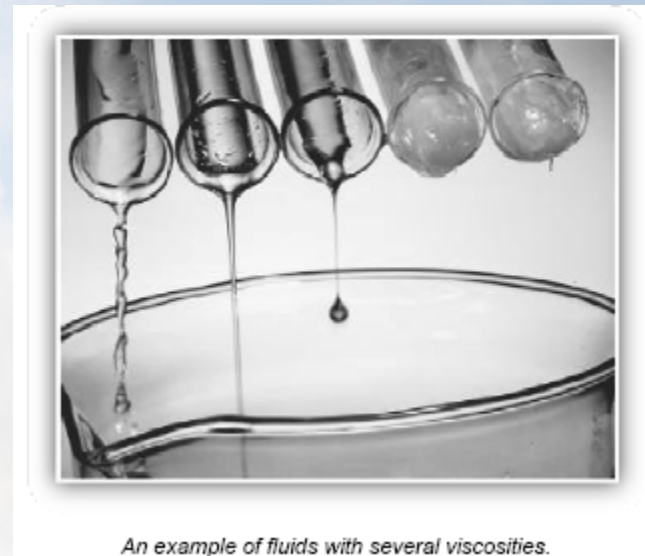
- User visual check – quick and efficient.
- Frequency: at least weekly.
- Appearance should be “clean and bright”.
 - Haziness indicates > 100 ppm water.
 - Turbine oils often darken slowly over years of service, however, rapid changes in color may be due to contamination or accelerated degradation and should be investigated.



Regular Turbine Oil Analyses

Viscosity at 40C (100F):

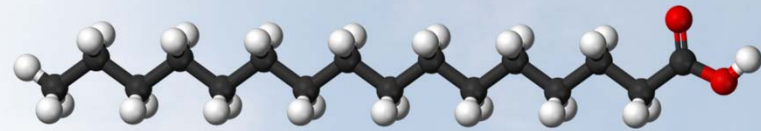
- ASTM D445
- Frequency: Every 1 – 3 months.
- Warning limit: $\pm 10\%$ new oil.
- Most important characteristic: dictates thickness of lubricating film.
 - Very sensitive to contamination or severe oil degradation.
 - Increase: incorrect oil or formation of a water emulsion.
 - Decrease: incorrect oil or contamination with solvent.



Regular Turbine Oil Analyses

Total Acid Number (TAN):

- ASTM D664
- Frequency: Every 1 – 3 months.
- Warning limit: 0.1 – 0.2 mg KOH/g above new oil.
- Severe oxidative degradation causes increases in TAN.
 - Increase may indicate depletion of anti-oxidants. Compare with results of RULER or RPVOT to evaluate anti-oxidant levels.
 - Hot spots/elevated operating temperatures accelerate degradation.
 - Elevated acid levels cause corrosion.



Regular Turbine Oil Analyses

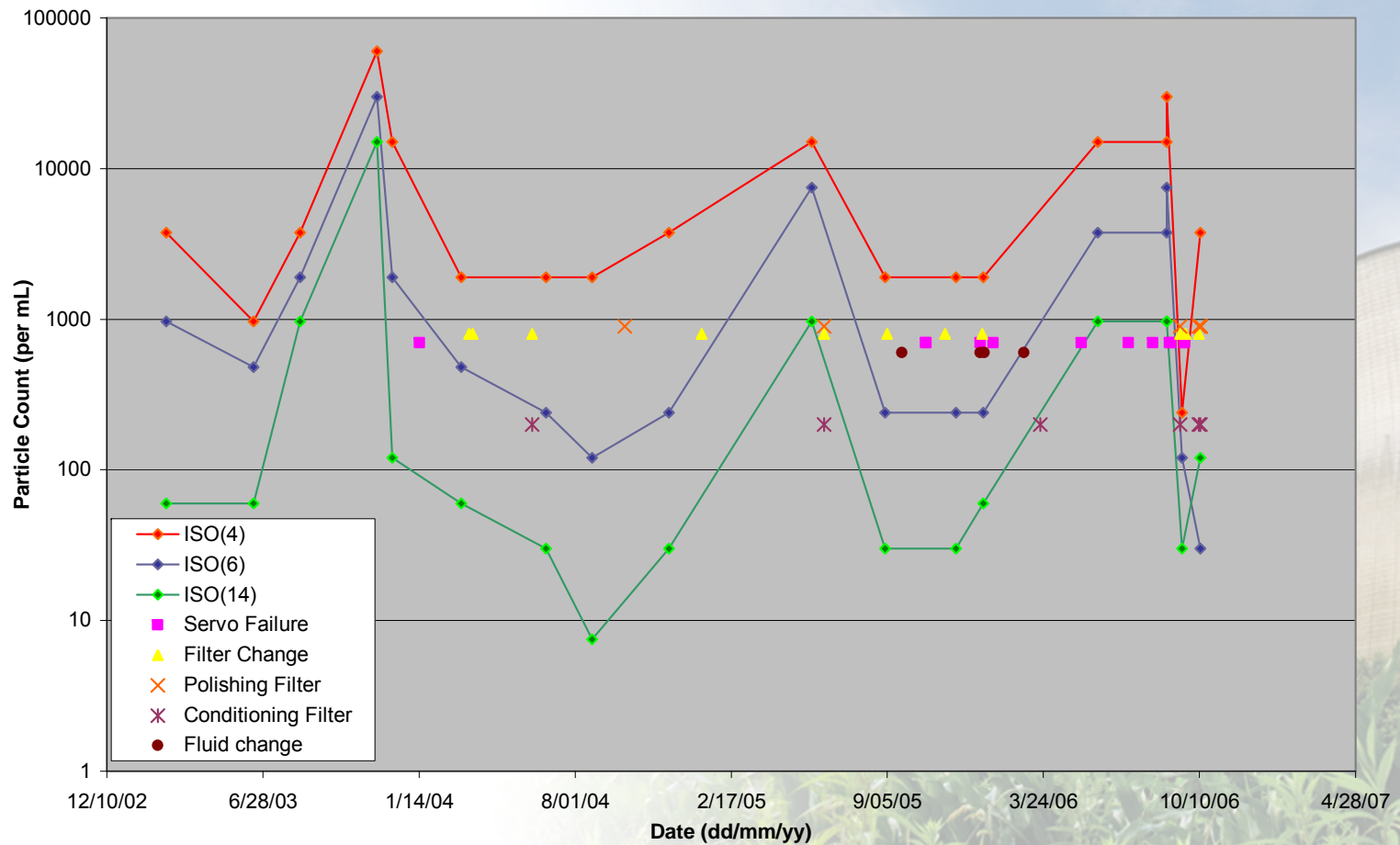
ISO Particle Count:

- ISO 11500 and 4406
- Frequency: Every 1 – 3 months.
- Warning limit: > 18/16/13.
- Quantifies particles produced by wear or contamination.
 - Once present, particles contribute to accelerated wear.
 - A sudden increase of ≥ 2 codes is cause for concern.
 - Strong correlation between lower ISO code and increased equipment reliability and lifetime.

ISO 4406 - Number of particles per ml		
More than	Up to & Including	ISO Number
2,500,000	-	>28
1,300,000	2,500,000	28
640,000	1,300,000	27
320,000	640,000	26
160,000	320,000	25
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0.00	0.01	0

Servo Failure Vs ISO Code

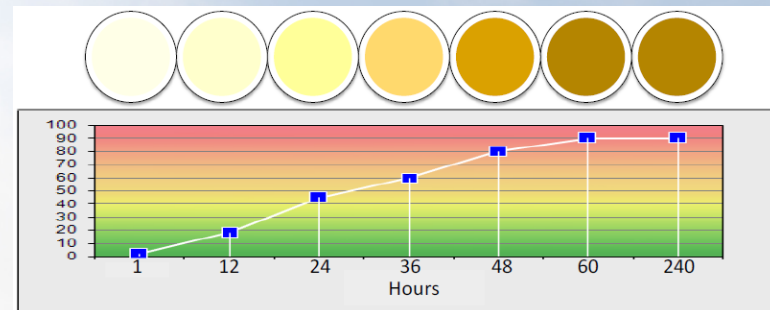
Figure 3: ISO particle count vs. System Changes time Line



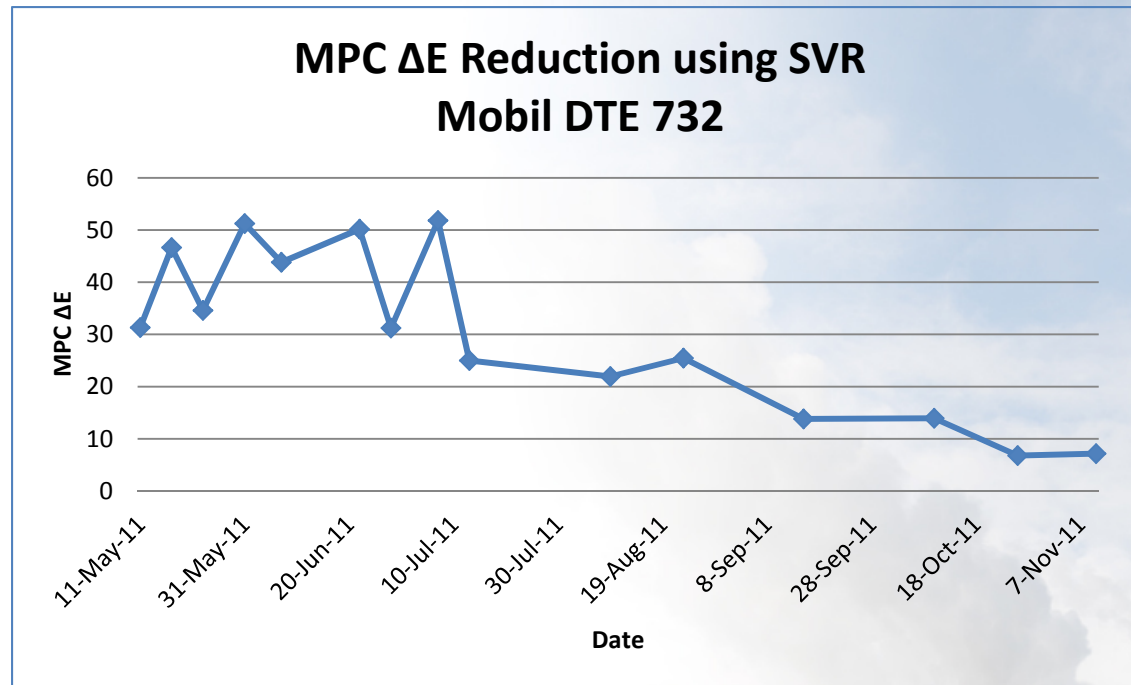
Regular Turbine Oil Analyses

Varnish Potential (MPC):

- ASTM D7843
- Frequency: Every 1 – 3 months.
- Warning limit: 30 – 40.
- Fluid degradation leads to the formation of compounds that are precursors to insoluble varnishes.
 - Fluid's potential to form varnishes quantified on a scale of 0 – 100.
 - 0 – 15: low varnish potential.
 - 16 – 30: possible varnishing.
 - 31 – 40: probable varnishing.
 - > 41: current level of fluid degradation will lead to varnish. Unit trips likely.



Graphing Varnish Potential Numbers



Regular Turbine Oil Analyses

Moisture

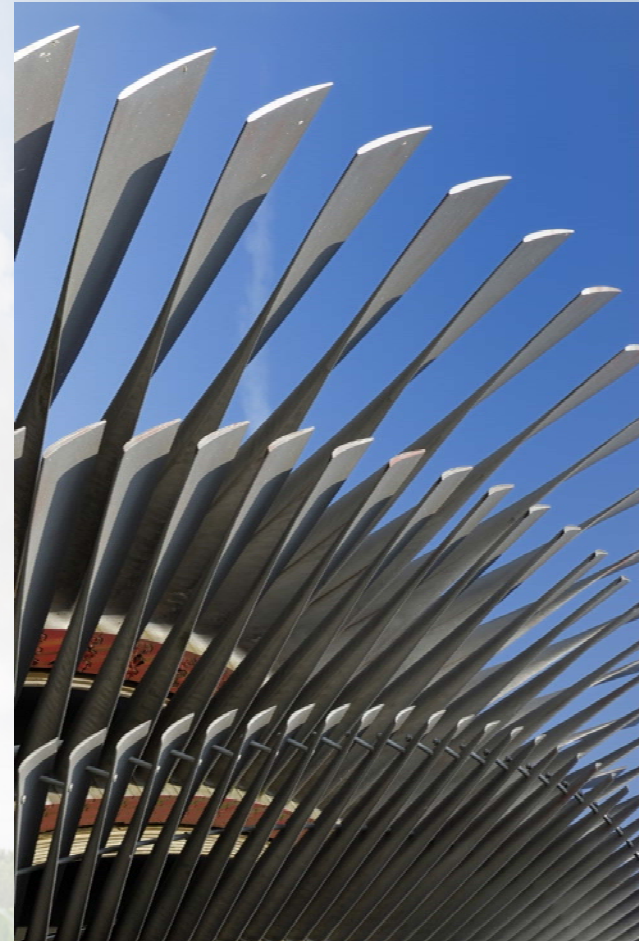
- ASTM D6304/D7546
- Frequency: Every 1 – 3 months.
- Warning limit (ppm): GT = 100, ST = 200
- Water hinders lubricating ability of fluid while promoting accelerated fluid degradation and equipment corrosion.
 - Quick check of fluid appearance is a useful screening test.
 - Moisture sources: leaking seals (ST), leaking heat exchangers and/or atmospheric condensation.



Regular Turbine Oil Analyses

Metals

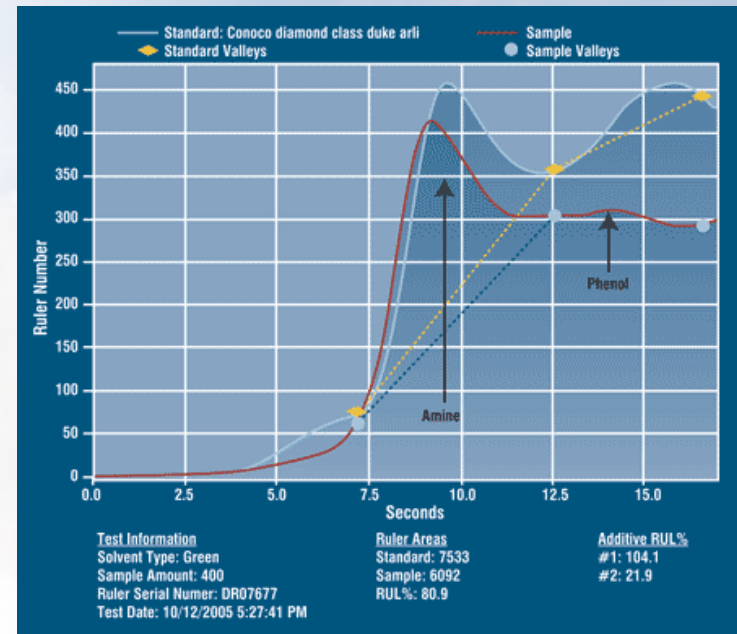
- ASTM D5185
- Frequency: Every 1 – 3 months.
- Warning limit (ppm): statistically determined.
- The presence of metals may indicate equipment wear or fluid contamination. Additive levels may also be monitored.
 - Metal identity used to identify wear/contamination source.
 - Only sees metals < 8 μm . A sudden decrease may indicate that the problem has worsened and larger wear particles are being produced.



Periodic Turbine Oil Analyses

RULER

- ASTM D6971
- Frequency: Every 3 – 6 months.
- Warning limit: 50% of new oil amines.
- Determines levels of antioxidants (generally phenols and amines) remaining in the oil.
 - Oxidation is the primary degradation route for turbine oils. Antioxidants control the rate of oxidative degradation.
 - When antioxidants are depleted, rapid degradation can occur.



Periodic Turbine Oil Analyses

RPVOT

- ASTM D2272
- Frequency: Every 6 – 12 months.
- Warning limit: 50% of new oil.
- Determines oxidative resistance.
 - Test more frequently once RPVOT value falls below 50% of new oil.
 - Replace oil once RPVOT value falls below 25% of new oil.



Periodic Turbine Oil Analyses

Rust Test (Corrosion Inhibition)

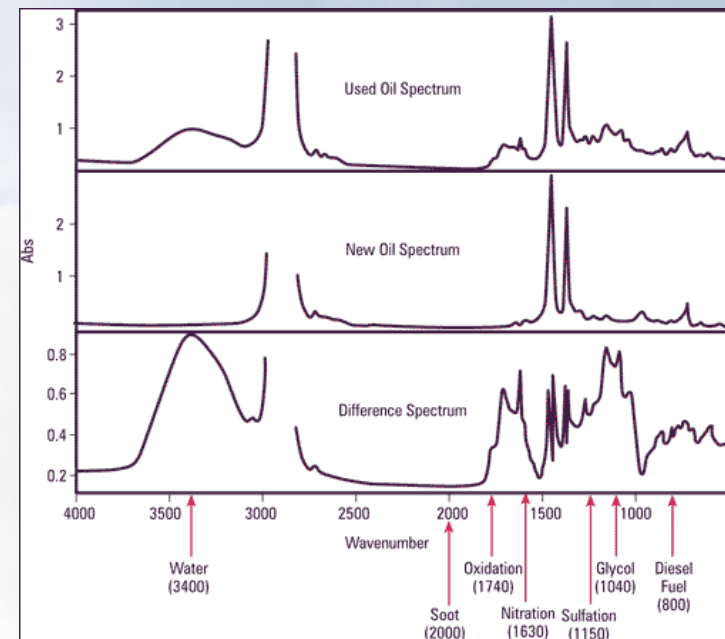
- ASTM D665
- Frequency: Every year for ST, as required for GT.
- Warning limit: failed test (rust formed).
- Turbine oils contain rust inhibitors designed to protect metal surfaces.
 - Test oil if corrosion issues are suspected or when severe contamination (water etc.) may have depleted rust inhibitors.
 - Steam turbines are more susceptible to rusting and it may be beneficial to test them on an annual basis.



As Needed Turbine Oil Analyses

Condition Monitoring by FT-IR

- ASTM E2412
- Frequency: As needed.
- Warning limit: statistically determined.
- Used to monitor oxidative degradation of oils by spectral subtraction or direct trending methods.
 - Spectral subtraction method offers simplified interpretation but requires a valid new oil sample.
- Data provided is complimentary to that obtained from:
 - Acid number, MPC and RULER tests.

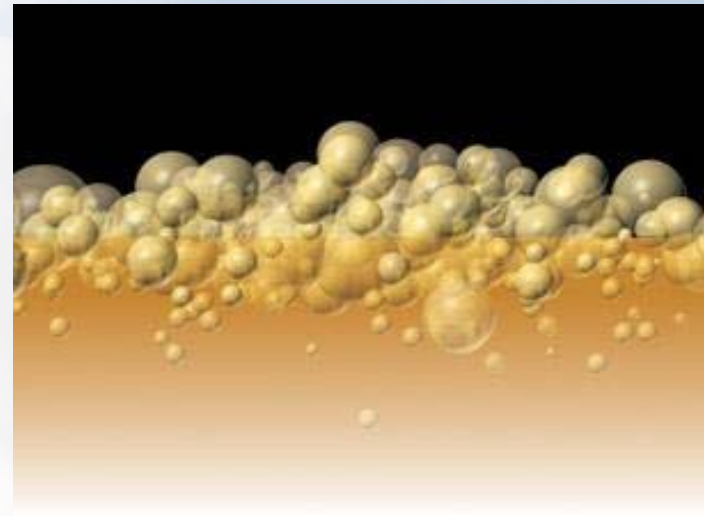


Source: Noria.

As Needed Turbine Oil Analyses

Foam Test

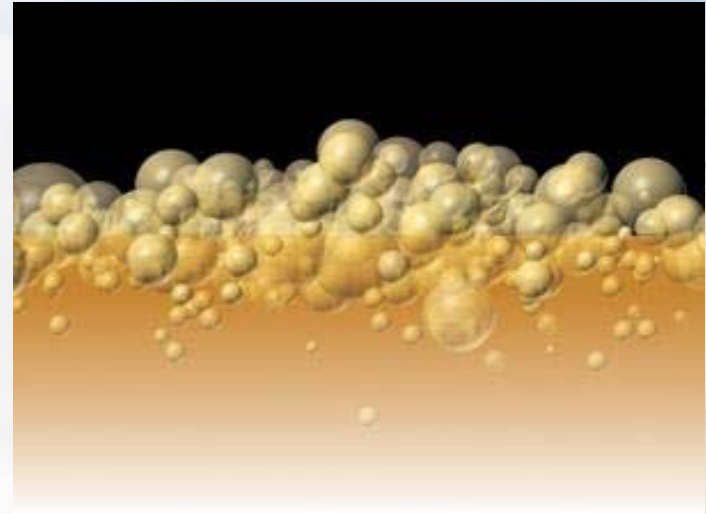
- ASTM D892
- Frequency: As needed.
- Warning limit: 450 mL tendency, 10 mL stability.
- Foaming is often mechanical in origin, however, it can also be caused by anti-foaming additive depletion or oil degradation.
 - Some foaming is normal.
 - Test if foaming is excessive.
 - Excessive foaming can lead to rapid fluid degradation by micro-dieseling.



As Needed Turbine Oil Analyses

Air Release

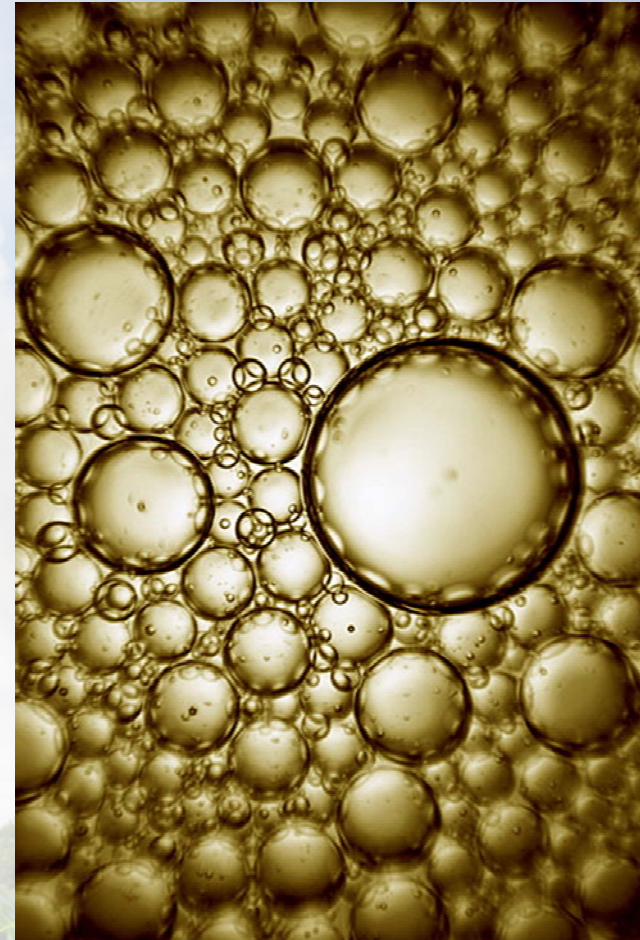
- ASTM D3427.
- Frequency: As needed.
- Warning limit: air release < reservoir residence time.
- The following issues can arise if oil is not given sufficient residence time in the reservoir to release entrained air:
 - Poor lubrication.
 - Poor hydraulic performance.
 - Inability to maintain oil pressure.
 - Degradation due to micro-dieseling.
 - Wear due to cavitation.



As Needed Turbine Oil Analyses

Demulsibility/Water Seperability

- ASTM D1401
- Frequency: As needed.
- Warning limit: 15 mL emulsion after 30 minutes.
- In GTs, heat drives off free water while in STs, free water can be drained off.
 - If the fluid has poor Demulsibility, water can form stable emulsions.
 - Emulsions hinder the lubricating ability of the fluid and expose both equipment and fluid to the damaging effects of water.



As Needed Turbine Oil Analyses

Insolubles by Ultra-Centrifuge

- ASTM D2273
- Frequency: As needed.
- Warning limit: UC rating of 4 – 6.
- Used to detect finely-suspended insolubles for poorly soluble sludge precursors.
 - Complimentary to ISO particle count and MPC.



As Needed Turbine Oil Analyses

Flash Point

- ASTM D92
- Frequency: As needed.
- Warning limit: 17 C (30 F) decrease from new oil.
- Degradation has little effect upon flash point, however, contamination by lower-boiling solvents lowers flash point.
 - Such contamination may also lead to a decrease in oil viscosity which can impede lubricating ability.





Turbine Oil Analyses

Summary:

Perform every 1 – 3 months:	Perform every 3 – 6 months:	Perform every 6 – 12 months:	Perform as needed:
Viscosity at 40°C (ASTM D445)	RULER (ASTM D6971)	RPVOT (ASTM D2272)	Rust Test – for GT (ASTM D664)
Total Acid Number (ASTM D664)		Rust Test – for ST (ASTM D664)	Foaming (ASTM D892)
ISO Particle Count (ISO 4406)			Air Release (ASTM D3427)
MPC (ASTM D7843)			Demulsibility (ASTM D1401)
Moisture (ASTM D6304 / D7546)			Insolubles (ASTM D2273)
Metals (ASTM D5185)			Flash Point (ASTM D92)
Note: Check appearance of the turbine oil for color and haziness frequently (at least weekly).			

FLEET ASSESSMENT –

***TRENDING RATES OF RPVOT AND ADDITIVE LOSS
TO DETERMINE NORMAL AND TO IDENTIFY
PROBLEM UNITS, AND TO ESTIMATE LUBRICANT
CHANGE-OUT INTERVAL***

Age of Oil Months	RPVOT	Amine	Phenol	MPC	Loss Rate RPVOT	Loss Rate Amine	Loss Rate Phenol	Increase Rate MPC
84	1180	60	0	13	3	5.7	>10	1.8
84	1005	62	0	10	4.4	5.5	>10	1.4
84	1346	62	0	9	1.0	5.4	>10	1.2
76	1094	68	0	13	3.9	5.1	>13	2.0
36	1374	76	10	9	1.7	8	21	3.0
36	1017	70	0	12	10	10	>23	3.8
111	889	57	0	18	4.2	4.7	>10	1.9
111	963	64	0	14	3.6	3.9	>10	1.5
111	1305	56	.2	16	1.1	4.7	>10	1.7
16	1005	50	n/a	9	28	37.5	n/a	6.5
24	1860	73	n/a	16	14	13.7	n/a	7.
15	1216	83	70	15	Nil	13.4	24.4	12.2
32	1352	87	24	8	Nil	5	28.6	2.8
AVG	1196	67	26	12	5.7	9.4	17.7	3.7

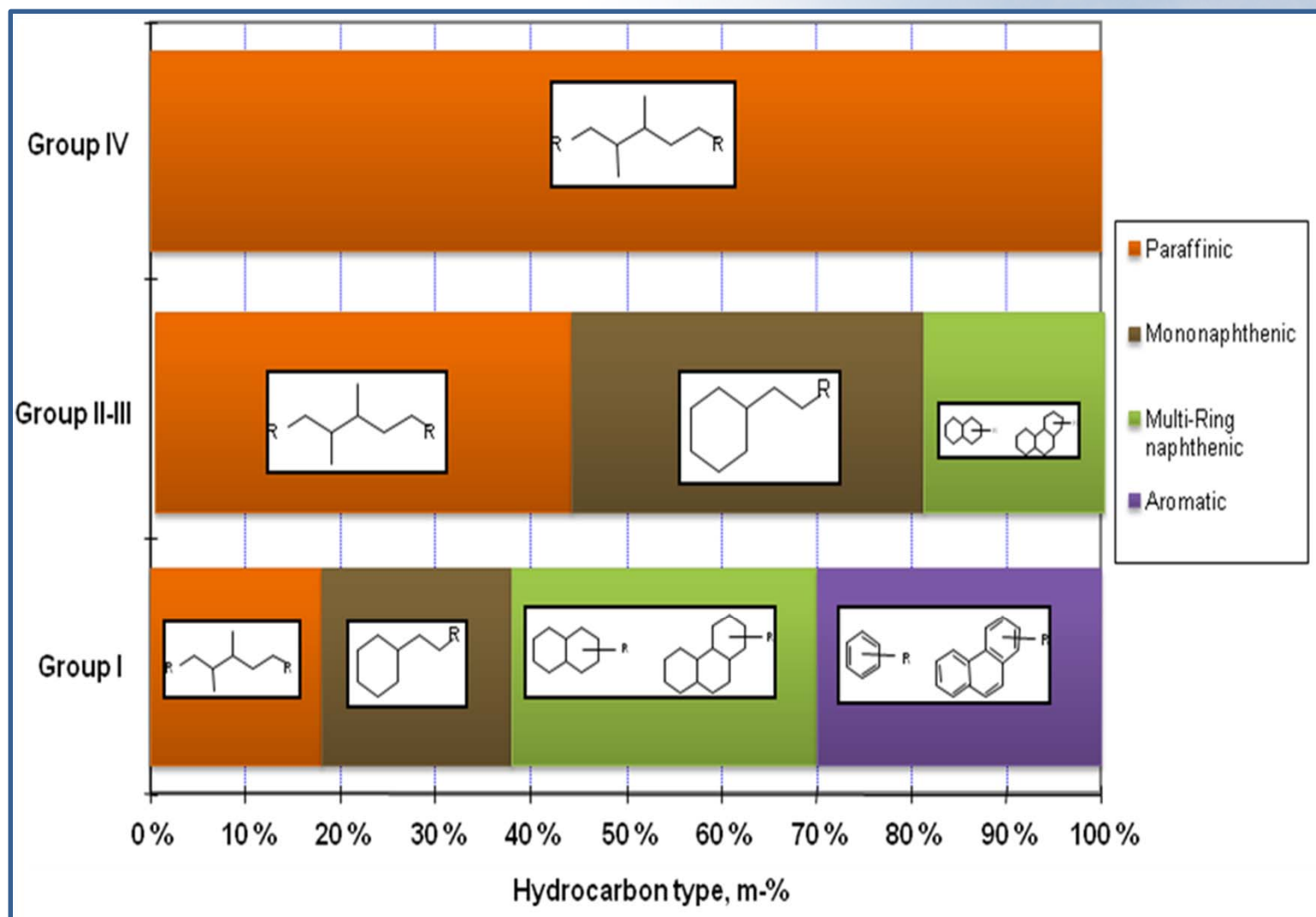
Calculating Loss Rates

- Common question. Will my oil last until the next change out interval in 18 months?

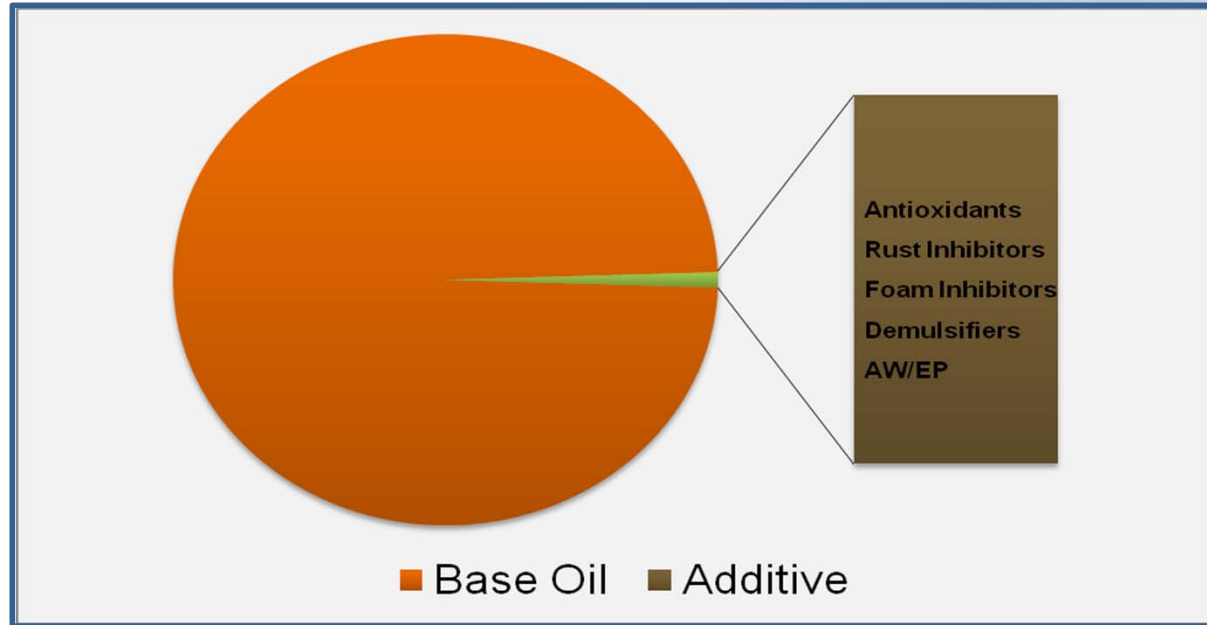
Age of Oil Months	RPVOT	Amine	Phenol	MPC	Loss Rate RPVOT	Loss Rate Amine	Loss Rate Phenol	Increase Rate MPC
76	1094	68	0	13	3.9	5.1	>13	2.0
36	1374	76	10	9	1.7	8	21	3.0
36	1017	70	0	12	10	10	>23	3.8
111	889	57	0	18	4.2	4.7	>10	1.9
111	963	64	0	14	3.6	3.9	>10	1.5
111	1305	56	.2	16	1.1	4.7	>10	1.7
16	1005	50	n/a	9	28	37.5	n/a	6.5

KNOWLEDGE REVIEW - LUBRICANT COMPOSITION AND FORMULATION

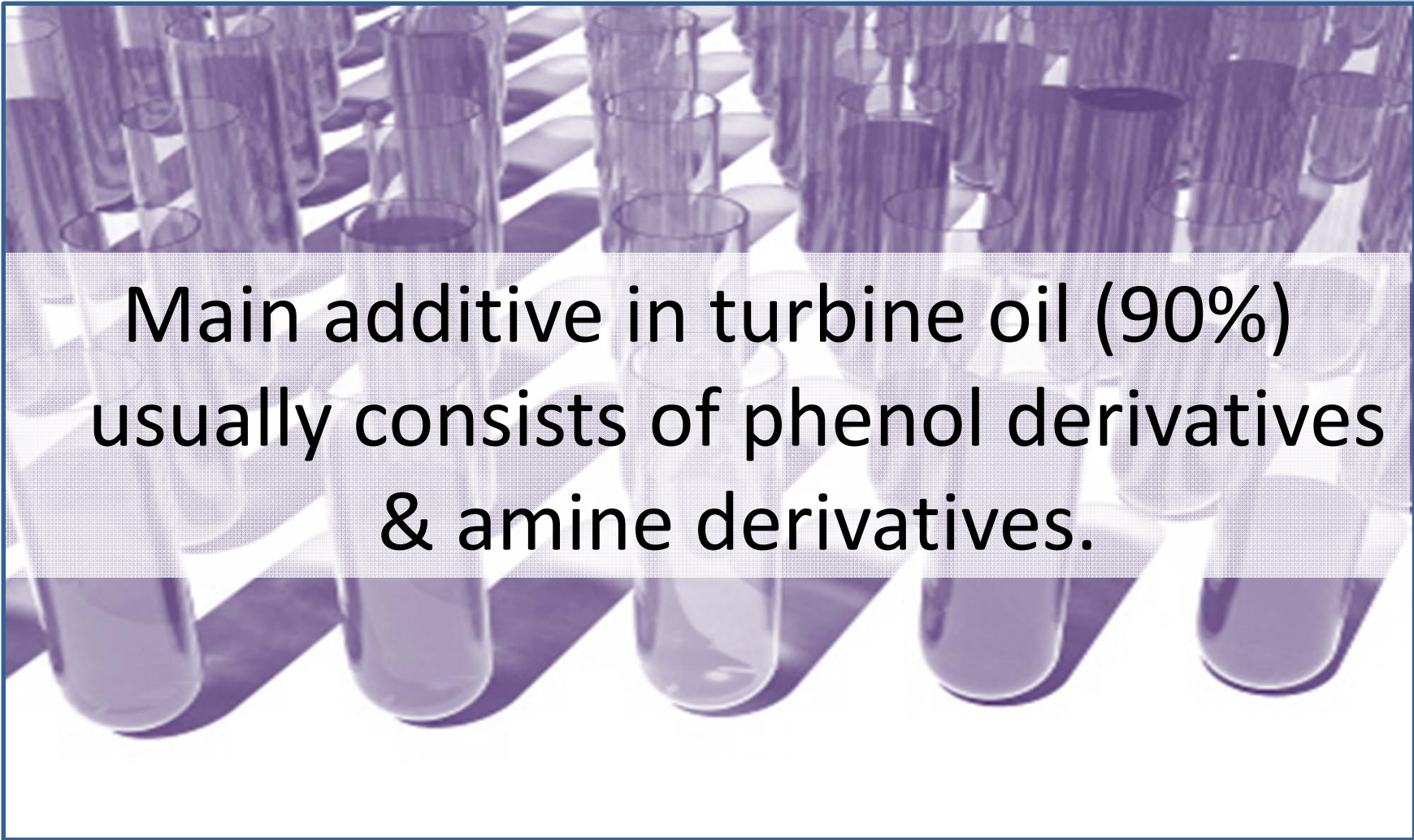
Composition of Lubricant Base stock



Turbine Lubricant Composition

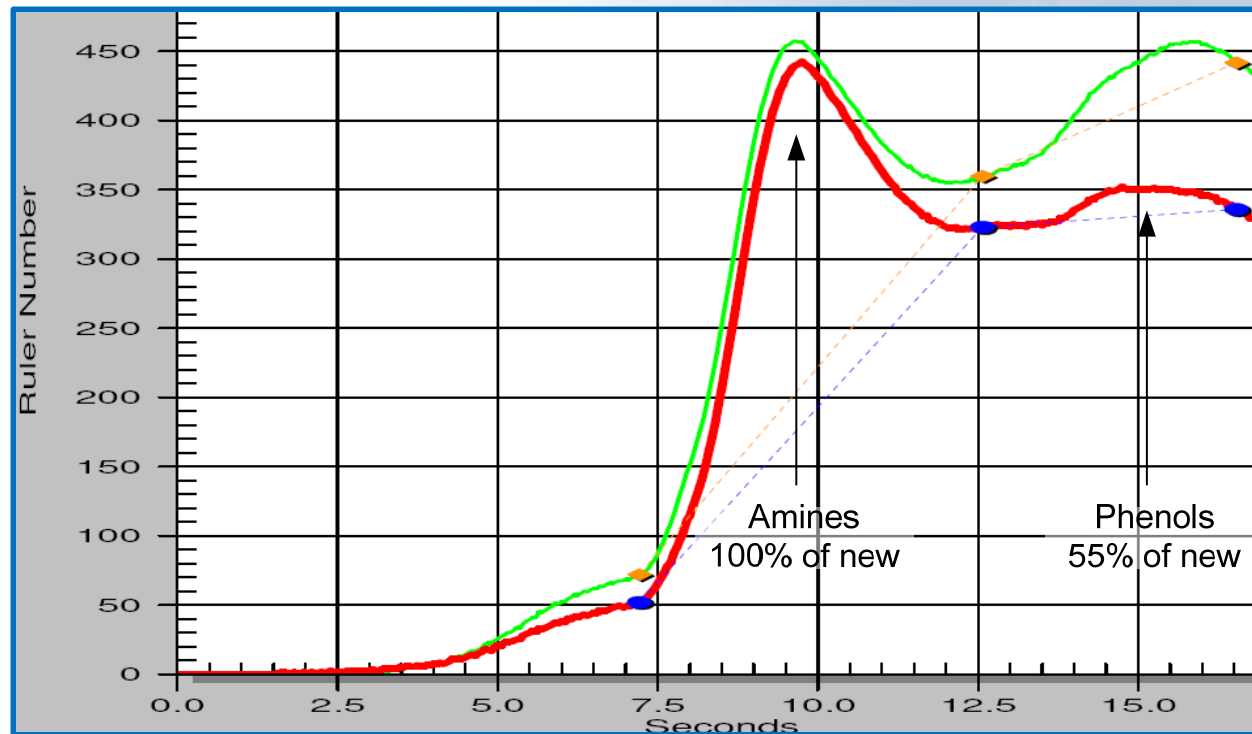


- The majority of turbine fluid is base oil (approximately 99%) blended with about one percent additive.
- These additives may consist of antioxidants, rust inhibitors, foam inhibitors, demulsifiers, anti-wear and/or extreme pressure compounds.



Main additive in turbine oil (90%) usually consists of phenol derivatives & amine derivatives.

No Performance Problems with sufficient levels of phenols.



- Applied voltage increased over time and the corresponding current is measured. All molecules respond to different voltages

- developed a test to study sludge formation in turbine oils, Modified TOST test (D 943)
 - Run at 120C, without water
- Tested 20 commercially available turbine oils
- Passing limit: <100mg/kg @ 25% residual RPVOT

Tribology Transactions, 47: 111-122, 2004
Copyright © Society of Tribologists and Lubrication Engineers
ISSN 1068-8137 print
DOI: 10.1080/089599204000278085



Study on Sludge Formation during the Oxidation Process of Turbine Oils

AKIHIKO YANO, SHINTARO WATANABE and YASUNORI MIYAZAKI
Nagasaki Research and Development Center

Mitsubishi Heavy Industries, Ltd.
Nagasaki, Japan 851-0392
MITSUYOSHI TSUCHIYA
Nagasaki Shipyard and Machinery Works
Mitsubishi Heavy Industries, Ltd.
Nagasaki, Japan 851-0392

and
YUJI YAMAMOTO
Kyushu University
Graduate School of Engineering
Fukuoka, Japan 812-8581

Against the backdrop of increased needs for longer operating life of turbine oils, there is a tendency to use amine-type antioxidants for steam turbine oils as well as gas turbine oils. Amine-type antioxidants are known to form sludge during the oxidation process, and the sludge formation from turbine oils involves the high risk for a power plant of bearing temperature rise caused by sludge deposition onto the bearing surface. But currently, there is no global specification to evaluate the sludge formation from turbine oils that have high rotating bomb oxidation test (RBOT) life. In this study, we examined 18 kinds of commercially produced turbine oils and two kinds of originally prepared oils with amine additives on sludge formation under 120°C dry turbine oil oxidation stability test (TOST) accelerated degradation test. Consequently, we found a criterion to check the quality of sludge resistance of turbine oils based on the relationship between the RBOT residual ratio and weight of filter residues (1 µm pore filter).

KEY WORDS

Antioxidant; Degradation; Gel Permeation Chromatography (GPC); Oxidation; Gas Turbine Oil; Steam Turbine Oil; Power Generation

INTRODUCTION

Thermal loads on turbine oils have been rising as turbines for power generation have become larger and more efficient (Ohgaki,

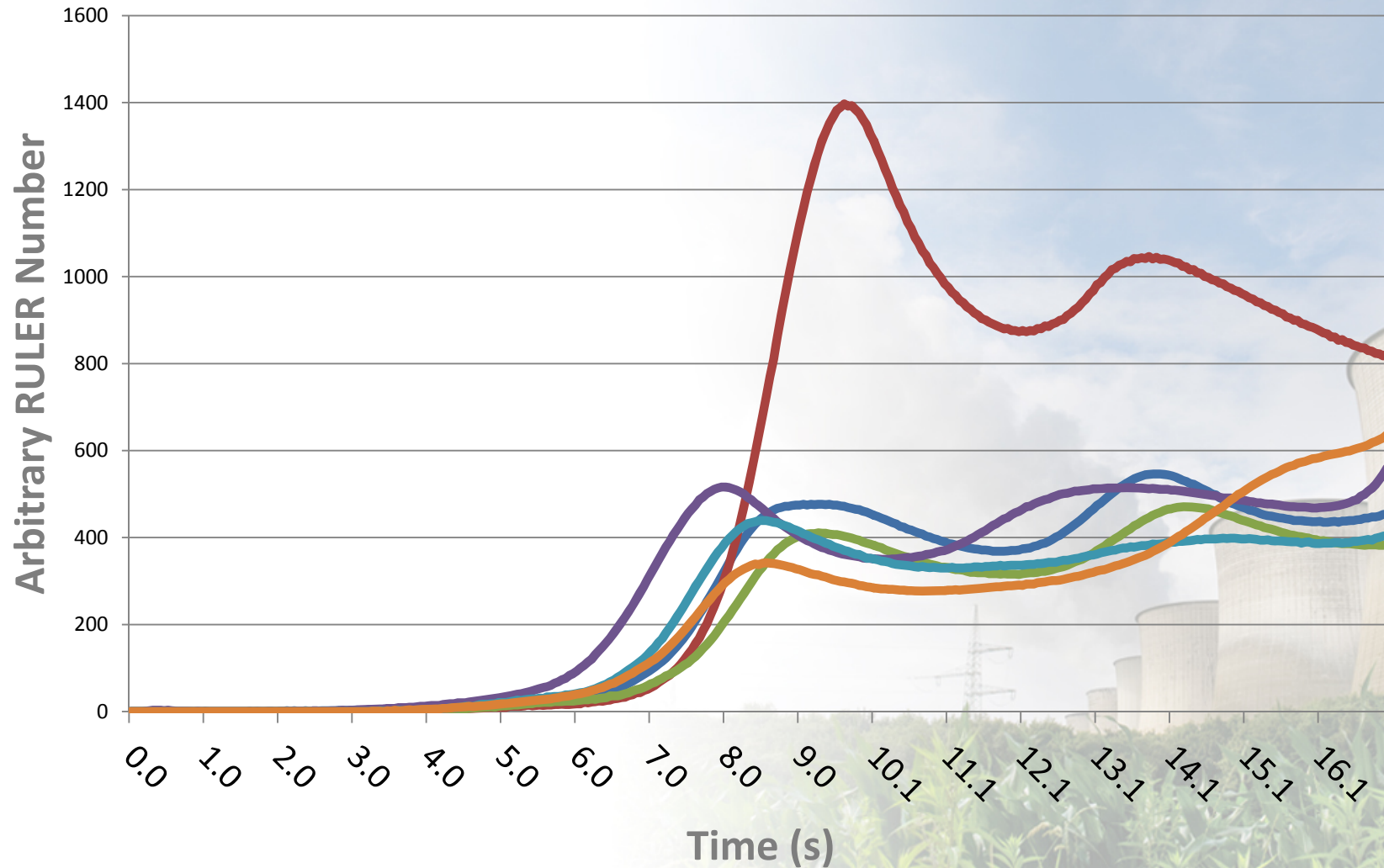
et al. (1)). At the same time, turbine oils are increasingly required to have longer life. In order to satisfy both of these demands, turbine oils need to possess superior oxidation stability. In the case of general use mineral oil-based turbine oils, oxidation stability is related to the degree of refinement of the base oil, as well as the type of antioxidant and the amount added.

Table 1 presents the API (American Petroleum Institute) classifications (American Petroleum Institute (2)) for the degree of refinement of base oils. Comparing the mineral oil types among Groups I to III, those in Groups II and III (obtained by hydrocracking) are reported to be superior to those in Group I (obtained by solvent refining) in terms of oxidation stability (Kramer, et al. (3), Swift, et al. (4), Irvine (5), Schwager, et al. (6) Okazaki and Millante (7)). Also, with respect to the influence of basic oil composition, Yoshida and Watanabe (8) observe that single-ring aromatics and resins (polar compounds such as sulfides and multi-ring aromatics in general) tend to reduce oxidation stability. API classification, which are distinguished according to factors such as saturates and sulfur content, are consistent with these findings and are considered to be an appropriate index for oxidation stability. At present, the base oils of commercially available turbine oils are shifting away from Group I toward Groups II and III.

Turning to antioxidants, amine-type antioxidants are superior to metallic and phenol-type substances in terms of raising oxidation stability (Hashimoto (9)). Mixtures of phenols and amines are common, and these are known as complex-type antioxidants. The first time that an amine-based antioxidant was used in turbine oil was when General Electric established the GEK-32564A turbine oil standard. In that standard, the rotating bomb oxidation test (RBOT) life for new oil is at least 450 minutes, in addition to antioxidant volatility as indicated by an RBOT residual ratio of at least 80% after bubbling nitrogen gas through 121°C oil for 48 hours. DBPC (2,6-di-tert-butyl-p-cresol), a representative

Presented at the STLE/ASME Tribology Conference
in Ponte Vedra Beach, Florida
October 27-30, 2003
Final manuscript approved August 20, 2003
Review led by Lois Gschwendner

Formulation Comparison 6 Different Turbine Lubes



Oil Formulation Trends

- Formulation chemistry plays a significant role in the varnish tendencies of the lubricant
- Oils with a mixed antioxidant system appear to perform better than oils with an amine or Phenol only systems.
- Phenyl-alpha-naphthylamine (PANA) is a commonly used antioxidant. Upon depletion, PANA can cause significant deposits.

Lube Oil Varnish

What is Varnish? A thin, hard, lustrous, oil-insoluble deposit, composed primarily of organic residue, & most readily definable by color intensity. It is not easily removed by wiping with a clean, dry, soft, lint-free wiping material and is resistant to saturated [light hydrocarbon] solvents. Its color may vary, but it usually appears in gray, brown or amber hues.

ASTM.D02C.01 definition



Varnish can be soft and gooey (*Sludge*)



Varnish can be hard and brittle (*Lacquer*)



Varnish on reservoir ceiling (*Stalactites*)



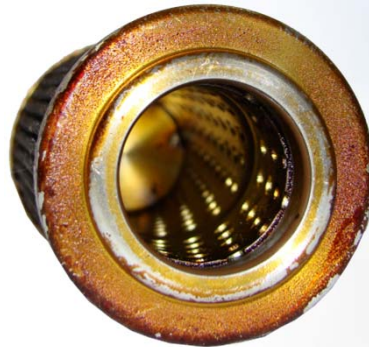
Varnish deposits on reservoir floor (*Plated*)

Lube Oil Varnish

When gas turbines fall casualty to unit trip or fail-to-start conditions, lube oil varnish is the usual suspect!



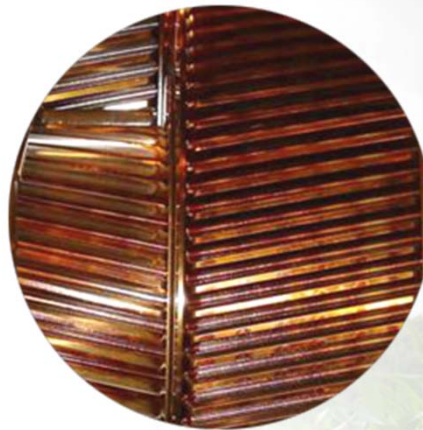
Filter element cross section (lacquer)



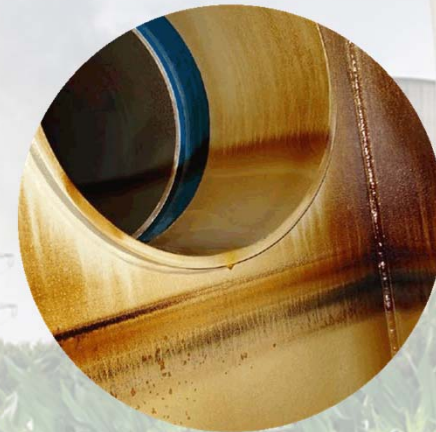
Varnish deposits on element (GE F6B)



Servo valve deposits (stiction)

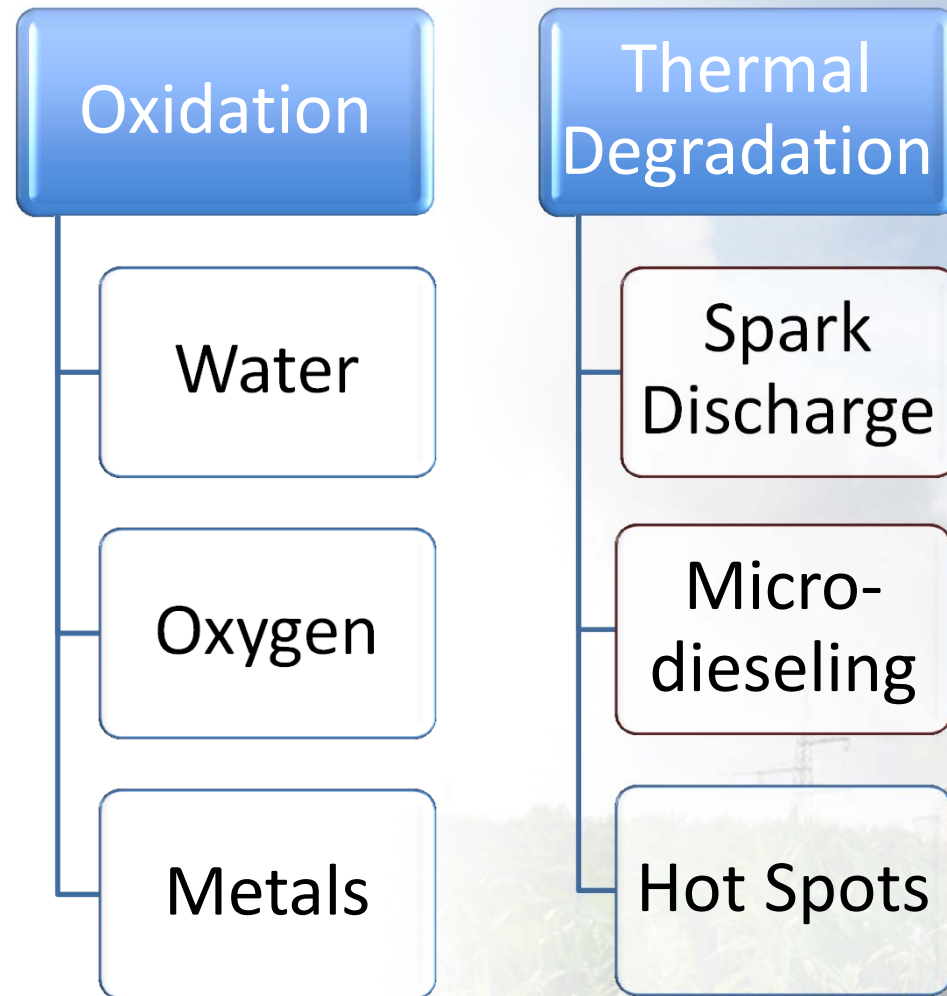


Varnish on load gear (GE F6)



Reservoir deposits

Lubricant Oxidation Mechanisms



Rethink.

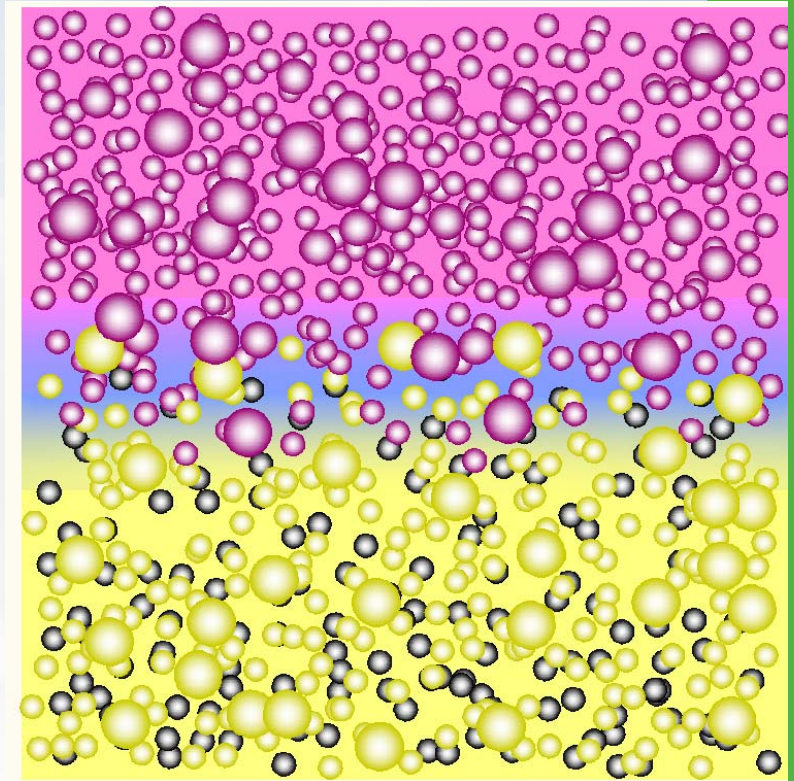
Sparks on the return line in a steam turbine.



A video of spark events from the return line in a steam turbine tube system.

• Varnish Formation Step 1: Lubricant Upset

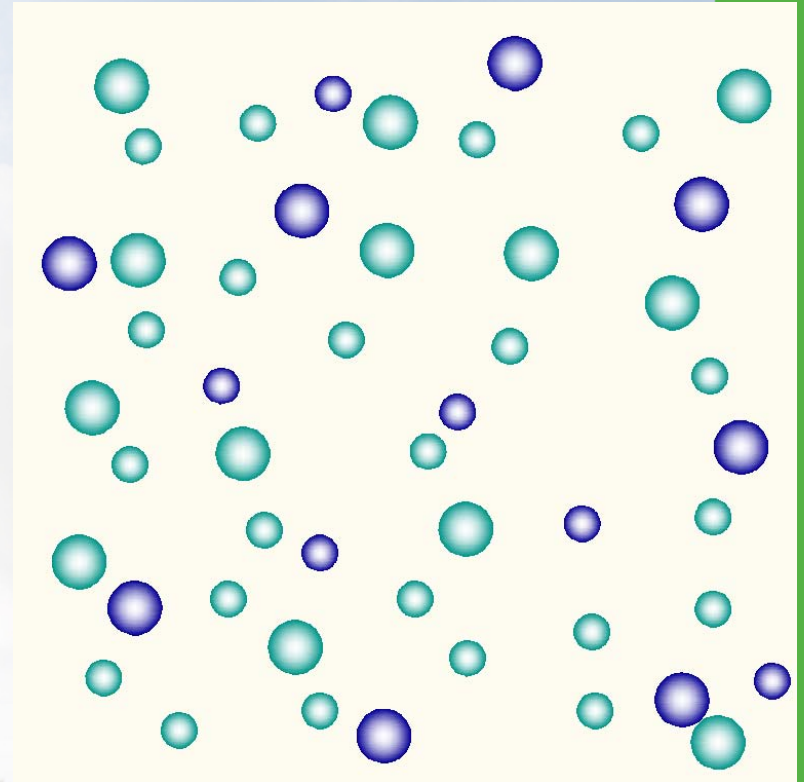
- Oxidation
 - #1 cause of fluid breakdown by water, entrained air, and heat.
- Oxidation
 - loss of electron = polar free radical
- Oxidation byproducts (free radical)
 - Acids
 - Alcohols
 - Lactones
 - Esters
- Oxidation byproducts
 - attack hydrocarbons
- Anti-oxidant additives
 - Oxidation inhibitor = arrest free radicals
 - Sacrificial (depletes)



- Varnish Formation Step 2: Soluble Impurities

Soluble oxidation byproducts

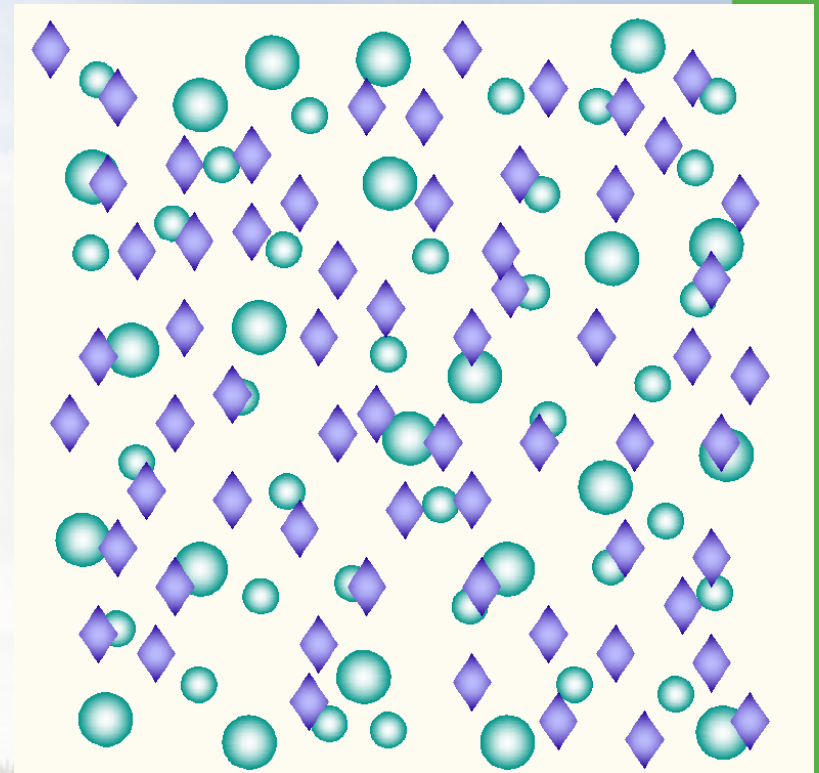
- Absorbed in oil as byproduct is created
- Polar
- Oil darkens as soluble level increases
- Foul or Burnt odor may develop
- Acid Number (AN) may begin to increase



- Varnish Formation Step 3: Insoluble Suspensions

Insoluble oxidation byproducts

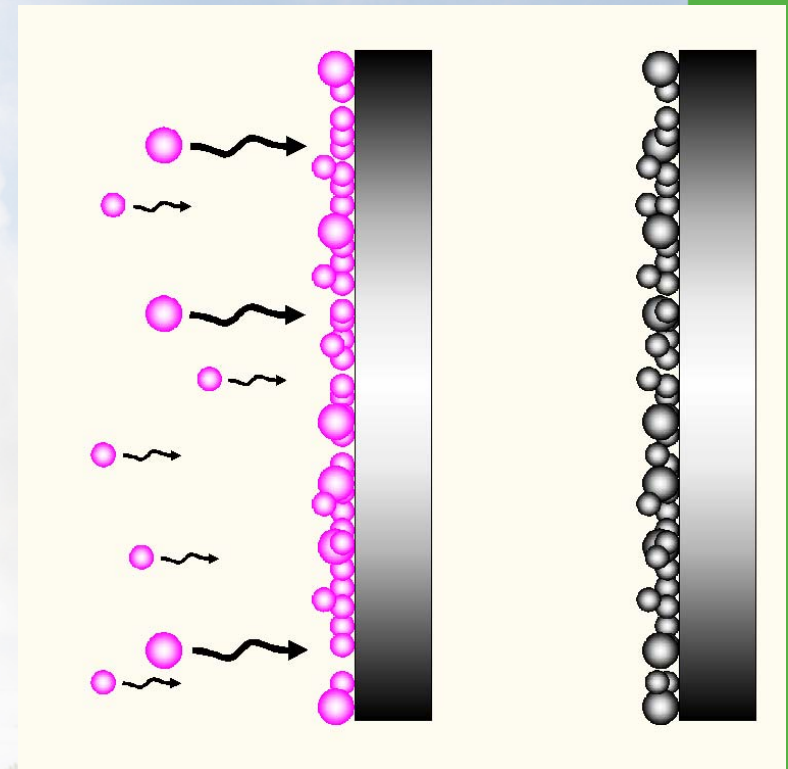
- Oil saturation point is reached
- Oxidation byproducts
 - no longer absorbed in oil
- Insoluble oxidation byproduct created
 - Polar oxides (attracted to metal surfaces)
 - Agglomerate into larger soft particles



• Varnish Formation Step 4: Varnish Deposits Form

Insoluble oxidation byproducts

- Affects on metal surfaces
 - Layers of dark, soft gel build up on metal surfaces
 - Cure to form lacquer
 - Reduces tolerance in critical components
- Affects on oil
 - Additive package depletes rapidly
 - AN increases
 - Viscosity increases
 - Sludge & sediment build-up



Lube Oil Varnish

Varnish Formation

- The first surfaces that collect Varnish
 - Cooler zones
 - Low clearance areas
 - Low flow areas
- Because that is where
 - Solubility / Saturation Point drops as temperature drops
 - Precipitation can start
 - Agglomeration is allowed to be un-disturbed

Video- Varnish formation as a function of temperature



Turbine Lube Oil Varnish

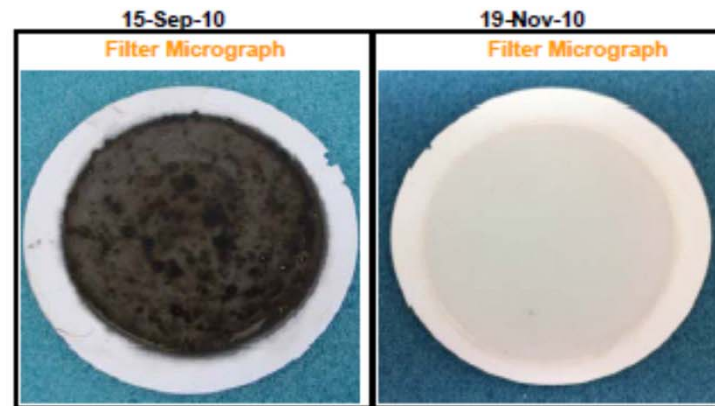
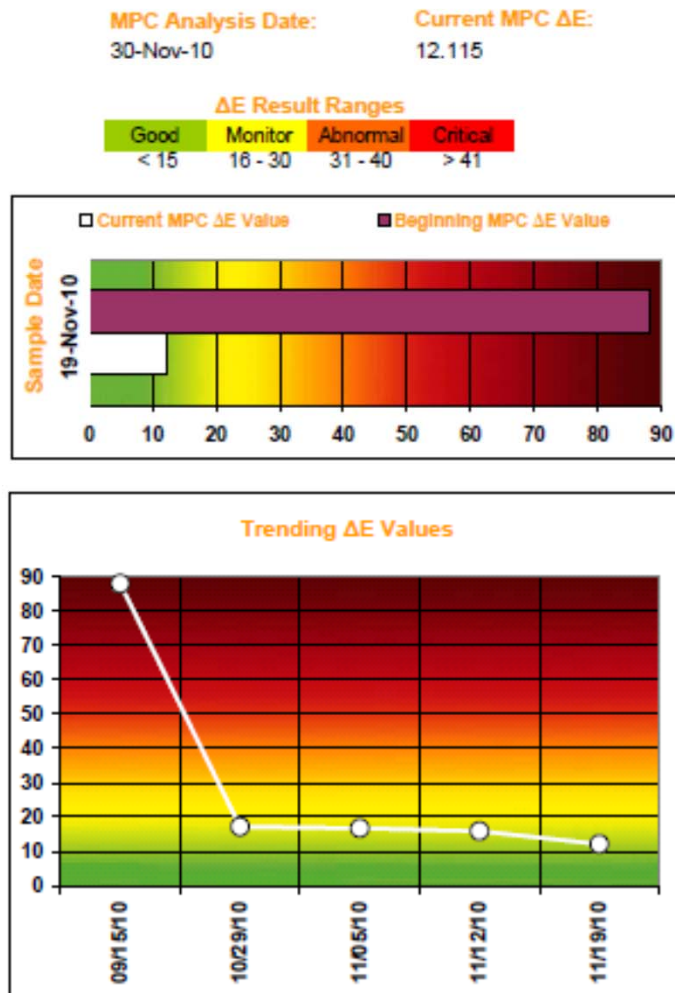
- Condition Monitoring - Measuring Varnish Potential

- Varnish potential increases as soluble & insoluble contamination increase
- Varnish Potential Rating (VPR) can be measured before varnish forms
- Soluble & Insoluble oxidation by-products are sub-micron and cannot be measured by traditional oil analysis (ISO laser particle counts)
- Patch test & analysis determine the potential of a fluid to form varnish
 - QSA – Quantitative Spectro Analysis (Analysts, Inc.)
 - MPC – Membrane Patch Colorimetric (ASTM standard, Insight Services)
 - Others – Some independent labs have their own patch method
- Darker the patch = more soluble, insoluble oxidation byproducts in fluid
- Value increase = Potential increase for varnish to form

GE Frame 6B

ISO 32 R & O

- Only 30ml of baseline through patch before blocked



The sample taken November 19, 2010 was analyzed by membrane patch colourimetry on November 30, 2010 following the recommended method outlined in ASTM D02.C0.01 - WK 13070.

The MPC ΔE is at the monitor range. This means the production of varnish within the system could be approaching soon and the oil condition should be watched.

MPC ΔE on 9/15/10: 88.000
MPC ΔE on 10/29/10: 17.197
MPC ΔE on 11/05/10: 18.735
MPC ΔE on 11/12/10: 15.903
MPC ΔE on 11/19/10: 12.115

Lube Oil Varnish

RULER Test Measure Anti-Oxidant Levels

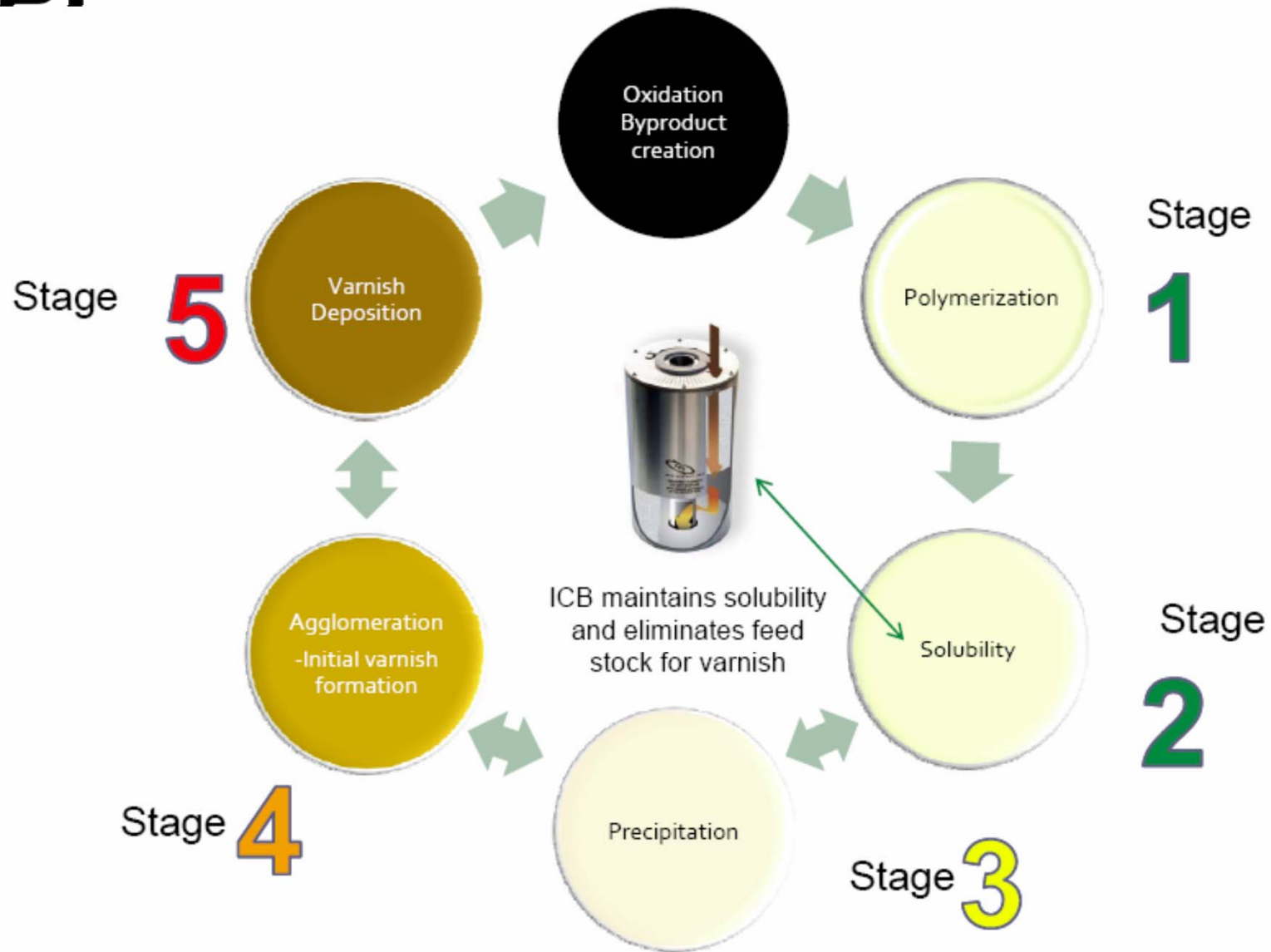
- RULER – Remaining Useful Life Evaluation Routine
- Measures Antioxidants relative to a new sample (%).
- Gets around the limitations with RPVOT in which failure point of lubricant can be difficult to measure with modern GT lube formulations.
- Shows relative consumption of additives at the time of sample
- Depletion of AO additives is one reason oil is condemned.

Oil Formulations & Additives

Oil production capacity is moved from Group I to Group II oils

- Group II oils are hydro-cracked versus traditional refining
- Group II oils have lower solvency than Group I
- Group II ability to hold oxidation by-products in suspension is lower than Group I
- Group II oils do not have the conductivity of Group I (charge dissipation)
- Group II oils have higher thermal and oxidation stability
- Role of anti-oxidant additives (Amines & Phenols)
 - Amines react with free radicals / polar oxides (sacrificial)
 - Prevent varnish and deposit formation
 - Phenols recharge the amines so show low RULER levels first
 - Once levels < 20% of new oil condemned Oxidation Rate INCREASES
- Re-additization of oil - Replenishing Phenol Additives
 - New additive might not be compatible with changed oil chemistry
 - New additive typically not soluble in the in-service oil (short life)

Varnish Formation “Clock”





Soluble Varnish Removal

Reversing the chemical reaction of varnish deposit formation



1. Off-line SVR connects to main lube reservoir up to 8000 gal/30,000 liters
2. Oil is circulated through ICB vessel & post filter
3. Soluble oxidation byproducts removed by ICB cartridge
4. Oxidation byproduct level in oil drops below saturation point
5. Oil regains solubility
6. Insoluble oxidation byproducts are dissolved back into oil and removed by ICB cartridge
7. Oil regains solubility (oxides removed as created)
8. Varnish is dissolved back into oil and removed by ICB cartridge



Soluble Varnish Removal

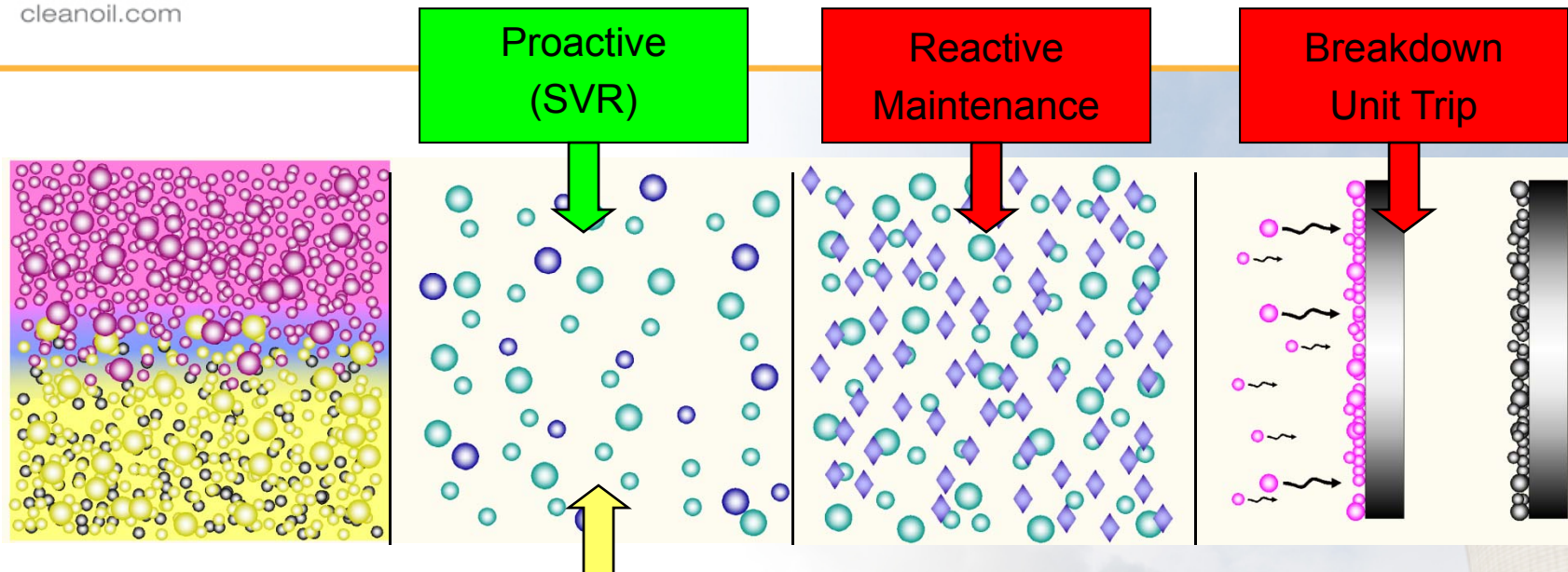
VTM Insoluble
Filter Element



ICB Soluble
Varnish Element



Lube Oil Varnish



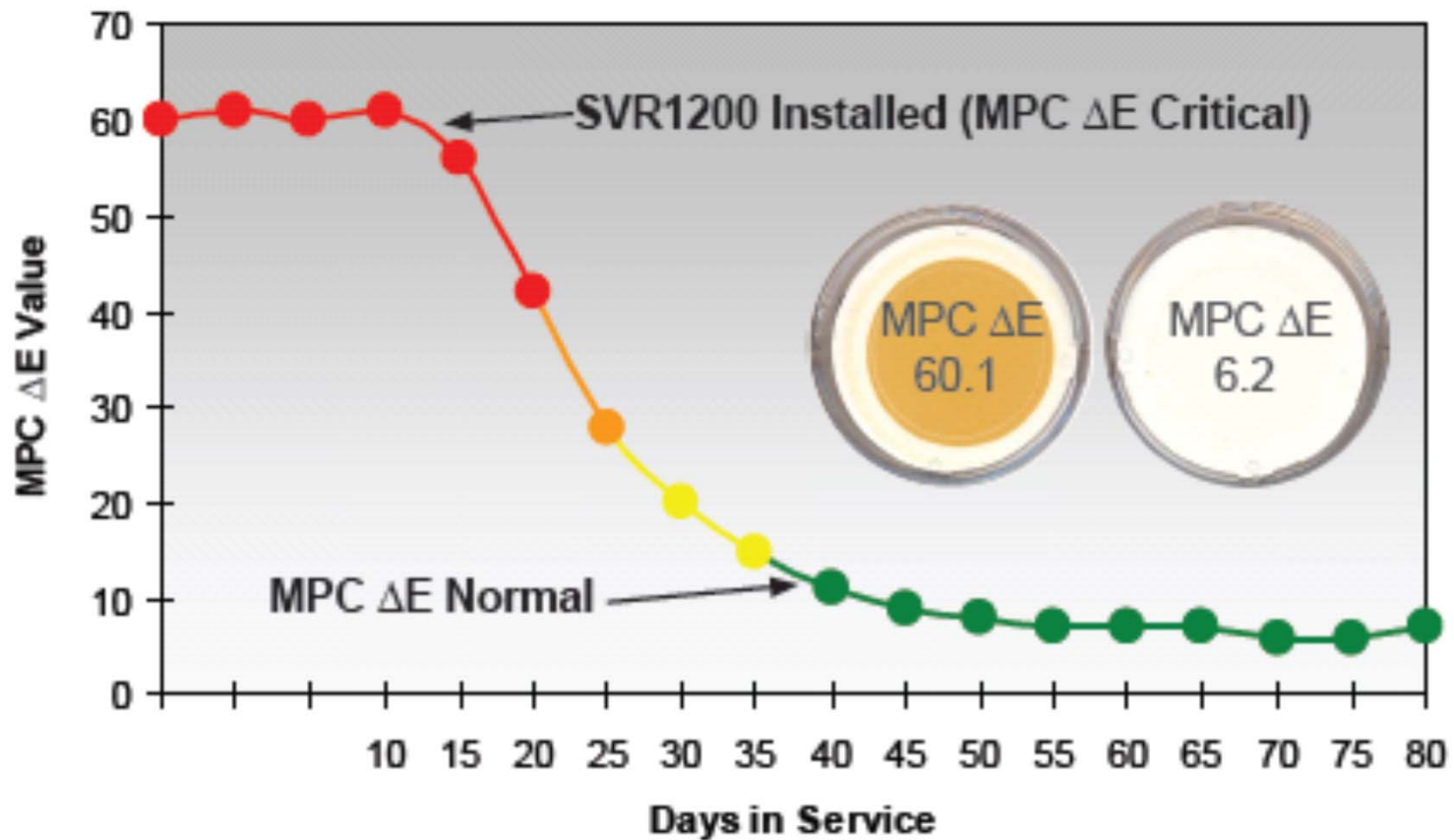
Ion Charge Bonding (ICB) is the only technology that can remove the soluble impurities

1. Eliminates varnish forming insoluble oxidation byproducts
2. Restores oil solubility (health), allowing the oil to clean the system
3. Varnish deposits dissolved back into the oil and removed by ICB element

Lube Oil Varnish

1

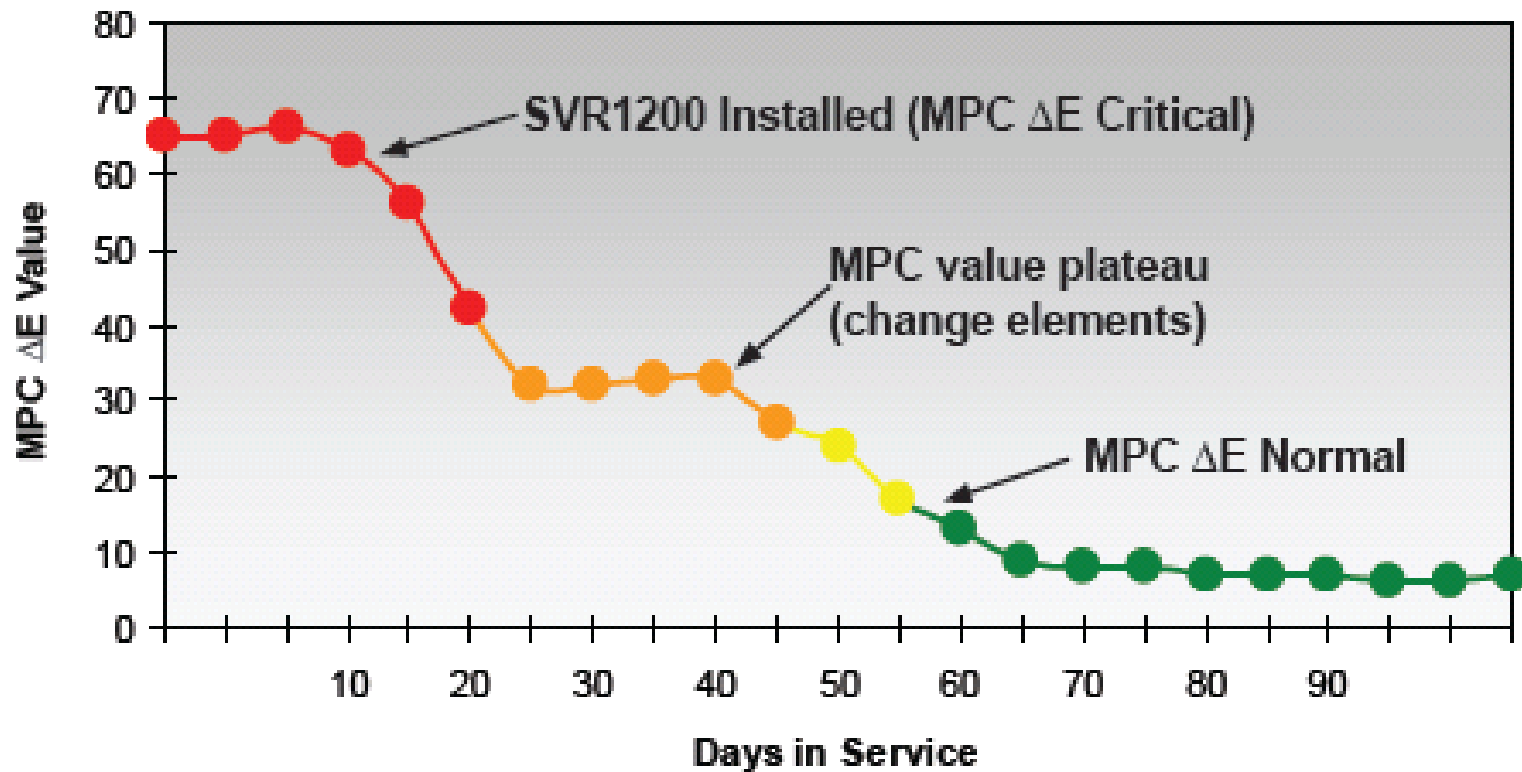
Varnish Potential (MPC) Trend After SVR Installation



Lube Oil Varnish

2

Varnish Potential (MPC) Trend After SVR Installation



Hy-Pro / EPT Fluid Investigation Report Analysis and Result Interpretation



Customer:
Calpine - Zion

Unit:
CT2

Sample Date:
14-Apr-11

TAN (mgKOH/g):
N/A

MPC Analysis Date:
21-Apr-11

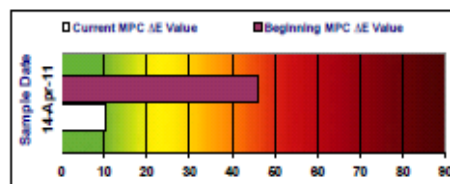
Current MPC ΔE :
10.5

Insoluble Content by Weight:
N/A

Current ISO code:
N/A

ΔE Result Ranges

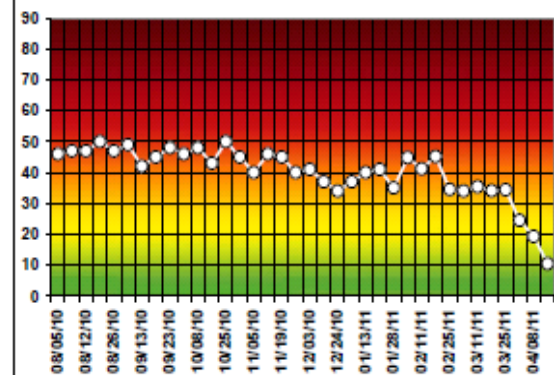
Good	Monitor	Abnormal	Critical
< 15	16 - 30	31 - 40	> 41



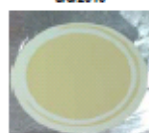
The sample taken April 14, 2011 was analyzed by membrane patch colorimetry on April 21, 2011 following the recommended method outlined in ASTM D62.C0.01 - WK 13070.

The MPC ΔE is at the good range. This indicates that there are low levels of the precursors that lead to soft contaminants (varnish).

Trending ΔE Values



Baseline sample
8/5/2010



MPC ΔE = 48

3/18/2011



MPC ΔE = 46.2

3/25/2011



MPC ΔE = 34.4

MPC value 8/05/10 = 46
MPC value 8/09/10 = 47
MPC value 8/12/10 = 47
MPC value 8/19/10 = 50
MPC value 8/26/10 = 47
MPC value 9/03/10 = 49
MPC value 9/13/10 = 42
MPC value 9/17/10 = 45
MPC value 9/23/10 = 48
MPC value 9/29/10 = 46
MPC value 10/08/10 = 48
MPC value 10/14/10 = 43
MPC value 10/25/10 = 50
MPC value 10/29/10 = 45
MPC value 11/05/10 = 40
MPC value 11/12/10 = 46
MPC value 11/19/10 = 45
MPC value 11/26/10 = 40
MPC value 12/03/10 = 41
MPC value 12/17/10 = 37

MPC value 12/24/10 = 34
MPC value 1/07/11 = 37
MPC value 1/13/11 = 40
MPC value 1/22/11 = 41
MPC value 1/28/11 = 35
MPC value 2/04/11 = 44.8
MPC value 2/11/11 = 41.2
MPC value 2/18/11 = 45.2
MPC value 2/25/11 = 34.5
MPC value 3/04/11 = 34.0
MPC value 3/11/11 = 35.4
MPC value 3/18/11 = 34.1
MPC value 3/25/11 = 34.4
MPC value 4/01/11 = 34.5
MPC value 4/08/11 = 19.3
MPC value 4/14/11 = 10.5



MPC ΔE = 24.6

4/8/2011



MPC ΔE = 19.3

4/14/2011



MPC ΔE = 10.6

Solvent used = pentane

Leading The Clean Oil Revolution



Curt Martin, Engineering, Phone: 317-849-3535, E-mail: curt.martin@hyprofiltration.com

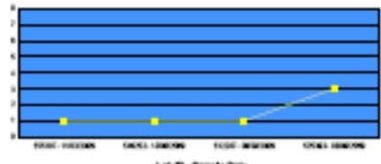




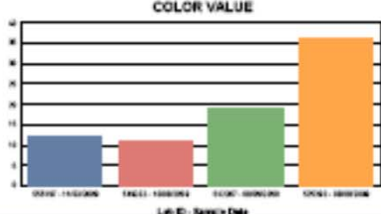




SVR installation GE Frame 7FA

VARNISH STATUS

Normal

VARNISHING POTENTIAL ANALYSIS

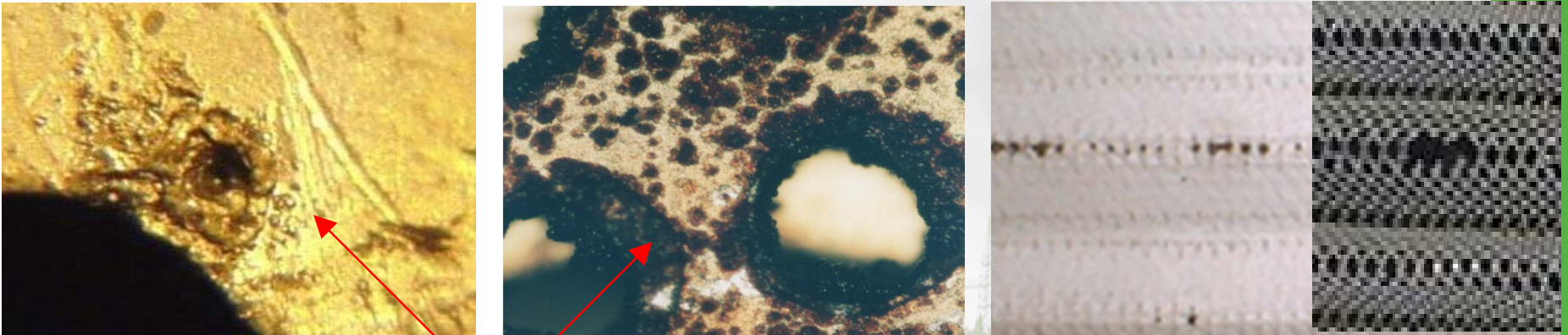
Lube Type:	MOBIL DTE 832	Received:	11/04/2009	PB CT LUB VARNISH
Machine MFG:	GENERAL ELECTRIC	Report:	11/11/2009 2:41:00PM	
Machine MOD:	7FA	Sample No:	1328-45-2004	
Machine Type:	Industrial Turbine			

<p>UC VALUE</p>  <p>Lab ID - Sample Date</p>				
<p>COLOR VALUE</p>  <p>Lab ID - Sample Date</p>				
SAMPLE DATE	11/03/2009	10/08/2009	09/09/2009	08/09/2009
LABID	555197	549202	542267	535393
ULTRA CENTRIFUGE TEST				
UC VALUE	1	1	1	3
MEMBRANE PATCH COLORIMETRY				
COLOR VALUE	12	11	19	36
PHYSICAL PROPERTIES				
ACID NUMBER mg KOH/g	0.110	0.090	0.070	0.110
KARL FISCHER WATER ppm	50	40	40	10
RULER TEST				
RULER %	78	80	94	101
AMINE	59	64	71	82
PHENOLIC	59	70	65	80
ZDDP	N/A	N/A	N/A	N/A

Filter Element Sparking

• Friction through filter media creates static charge on elements

- Group II oils not conductive & some elements use non-conductive materials
- Charge arcs through filter media to nearby metal surfaces (core, housing)
- Excessively high heat results in thermal degradation (pyrolysis)
- Spark Damages filters (reduced efficiency) and oil (creates acids & fines)
- Sparking can be heard as popping / clicking (lube or hydraulic elements)



Evidence of sparking

Filter Element Sparking

Leading The Clean Oil Revolution

Plastic Mesh Element - Electrical Arcing Damage

Non-conductive filter materials can't shed static charge





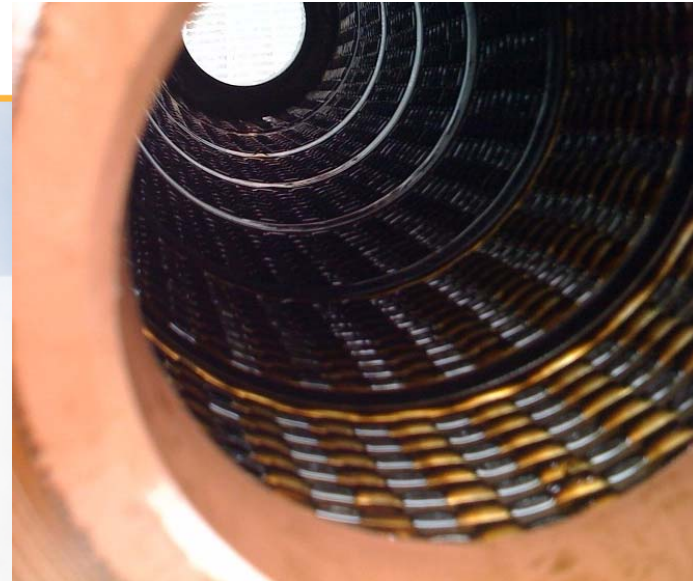
Hy-Pro Non-Spark Discharge (NSD) Elements

Leading The Clean Oil Revolution



- Reduced resistance to prevent churning / friction
- NSD uses all conductive filter element materials
- Available in all Hy-Pro series (lube & Hydraulic)
- Primary apps main lube duplex and EHC elements
- P/N HP102L18-12MV = HP102L18-12**EV-NSD**
- Some report lower MPC after NSD elements (40 to 30)
- Minimizes thermal degradation
- Prevents one of the causes of varnish

Hy-Pro Non-Spark Discharge (NSD) Elements



Varnish deposits on NSD lube element

- Does varnish deposits on elements = sparking?
- No, Hy-Pro NSD elements will collect varnish on ferrous metal surfaces
- This is an indicator that varnish could soon form in the lube system



Varnish Test Equipment - MPC

MPC patch test kits (VFTK field kit, VLTK lab kit)

- Photospectrometer reports results as $\Delta E > 0$ (included in kit)
- Kit available w/out Photospectrometer & P-meter available individually
- Includes detailed reference and results interpretation manual





SVR - The case for prevention

Many users don't react until QSA / MPC is critical

- Installing SVR without high QSA / MPC extends oil life
- Phenol is the low temp AO additive that fights varnish & deposit formation
- GE Frame 7 without SVR was consuming 20% of phenols annually
- Oil was replaced and SVR installed
- After 16 months of operation (+ SVR) phenol levels were unchanged
- SVR is extending oil life by removing soluble oxidation byproducts
- Phenol anti-oxidant additives aren't consumed as quickly, with SVR
- Lube oil with < 20% remaining phenols is typically replaced
- In this case SVR performs role of sacrificial phenol anti-oxidant
- Turbine can continue to run with no risk of varnish on the same oil

Lube Oil Varnish

RULER Test Measure Anti-Oxidant Levels

RULER TEST (EXAMPLE)						
Date		7/22/2009	4/15/2009	1/6/2009	8/29/2008	6/1/2008
Lab No	Reference					
RUL %	>25%	92.3	86.7	91.2	96.7	91.3
Amines		94.7	100	98.2	98.0	
Phenols		99.1	97	94.7	93.6	

- Gas turbine was losing 20% of AO additives annually
- After changing oil installed SVR on the lube reservoir
- After 20 months AO levels are still near new levels with < 5% depletion
- Life of the oil has been extended with SVR by slowing AO depletion
- Oil typically condemned once AO are 20% of new values

Lube Oil Varnish Prevention

The Solution - Summary

Leading the Clean Oil Revolution

- Determine oil condition & oil type (Shell CC 32)
 - OA reports for QSA or MPC (varnish potential)
 - OA reports RULER for additive levels
- SVR (soluble varnish removal) skid
 - Removes soluble oxidation by-products
 - Restores oil health
 - Healthy oil removes varnish deposits
 - Installation requirements
- Non-Spark filter elements
 - Lube duplex
 - Pump discharge filters (combined L&H reservoir)
 - Pilot valve filters (combined L&H reservoir)
 - Off-line filters, sparking typically not a problem





- Mobil 732 on GE 7FA
- IGV filter elements before SVR installed with varnish deposits
- Support tube coated with varnish
- Valve failures and heavy deposits



- New resin implemented for 732 / 832
- MPC dropped from high 30's to < 10
- No more deposits on IGV filter elements
- No more valve deposits
- New resin will be future standard



Leading The Clean Oil Revolution

Thank you. If we can be of any support please contact us.

[Richard Trent](#)

Richard.Trent@hyprofiltration.com

www.hyprofiltration.com

+205-492-6666

[Peter Dufresne](#)

pdufresne@cleanoil.com

www.cleanoil.com

403-450-1755

Copyright © EPT 2002. All Rights Reserved
403-389-4104 Cell

