HY-PRO Filtration Introduction

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by

Patrick A.J.M. Kreutzer

Topic of the presentation

- Introduction / Opening
- HyPro Filtration Introduction
- Contamination
- ISO CODE
- Product Range Overview HyPro Filtration
  - Dynamic Filter Efficiency
  - Water Ingression
  - Acid Scavenging system

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Company Overview

Hy-Pro Filtration Anderson, Indiana

- *H.Q. Indianapolis, USA*
- *Production Facility Vancouver WA*

Corporate headquarters + laboratory + training facility

Filter elements + filter assemblies manufacture

Primary element stocking warehouse Off-line contamination solutions (portable + dedicated) manufacture

Focused Activity

Filtration & Conditioning

Lube & Hydraulic Systems Diesel Oil and Fuel

Company Overview, Capabilities Anderson, IN

- Corporate headquarters
- Filter element production
- Filter assemblies
- Small contamination solutions equipment
- Hy-Pro laboratory
- UL approved control panels
- Hy-Pro Training facilities

Certificate of Quality Management System Registration

HY-PRO CORPORATION
P.O. BOX 386
12955 FORD DRIVE
FISHERS, IN 46038

DESIGN AND MANUFACTURE OF FLUID FILTRATION COMPONENTS AND SYSTEMS

Rethink. Remove Restore.

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Filter Element Production Anderson, IN

Rethink. Remove Restore.

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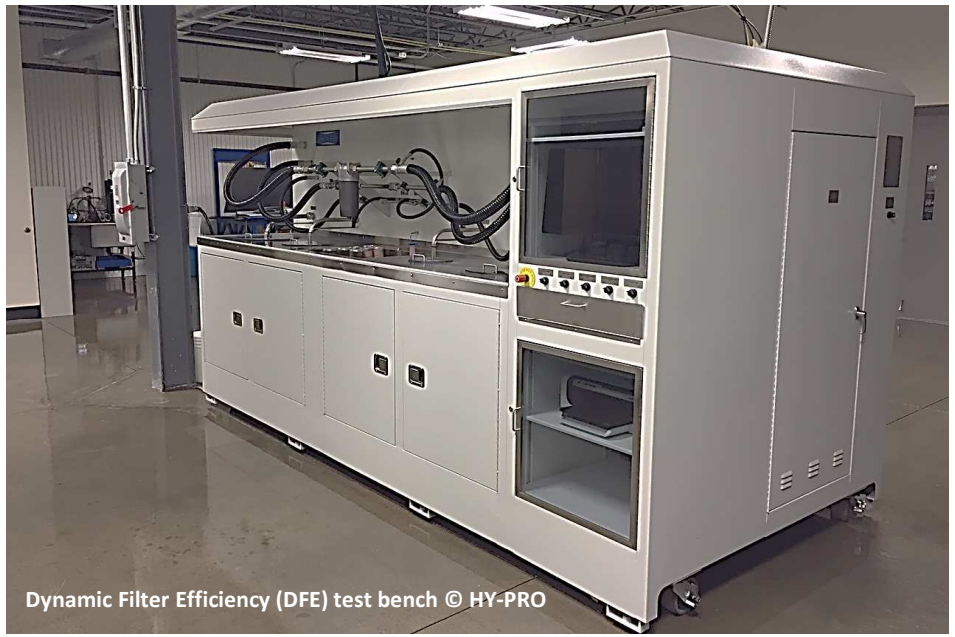
Off-line Systems Production Anderson, IN

Rethink. Remove Restore.

Metal Fabrication Anderson, IN

Hy-Pro Laboratory Anderson, IN

- Element integrity (bubble point)
- ISO Code
- KF (H_2O)
- Microscope / Patch
- MPC Varnish
- Element forensic
- Contaminant analysis
- Partner labs


Dynamic Filter Efficiency (DFE) test bench © HY-PRO

Rethink. Remove Restore.

Capabilities Hy-Pro West Vancouver, WA

- Vacuum dehydration purifiers
- High flow coalesce
- Diesel conditioning systems
- Large custom contamination solutions
- West coast stocking location
- Equipment rental fleet & service
- Contamination solutions support
- Electrical panels (UL, CUL, CE, ATEX, IEC)

Rethink. Remove Restore.

Capabilities Hy-Pro West Vancouver, WA

Capabilities Hy-Pro West Vancouver, WA

Rethink. Remove Restore.

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Thanks

End of this part of the presentation

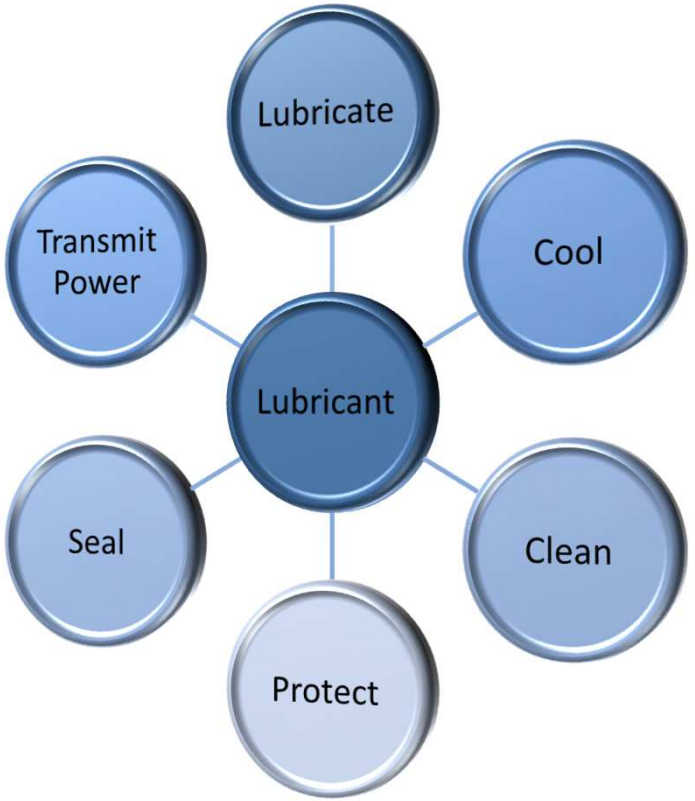
Next Presentation:

Contamination

Rethink. Remove Restore.

Lubrication Functions

1. Reduce friction and wear
2. Carry away heat
3. Seal against contaminants
4. Prevent rust and corrosion
5. Remove contaminants
   Hard,Soft,Water,Gas
6. Transmit Power (hydraulics)
7. Act as a dielectric fluid (transformers)
8. Dampen shock (shock absorbers)



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Lubrication Development

- Continuous development of equipment within the industry (OEM) made it necessary to develop also modern lubricants (Turbine Oils)
- Turbine oils have changed continuously to meet the operational requirements of new generation turbine technology
- Requirements for modern oils increased, driven by stringent specifications like:
  - Change of Operational conditions of the installation
  - Increasing bearing temperature
  - Higher bearing load
  - Smaller lubrication oil reservoir set

Changing OEM requirements → New turbine oil products
(different base oils / synergistic mixtures + different additives)

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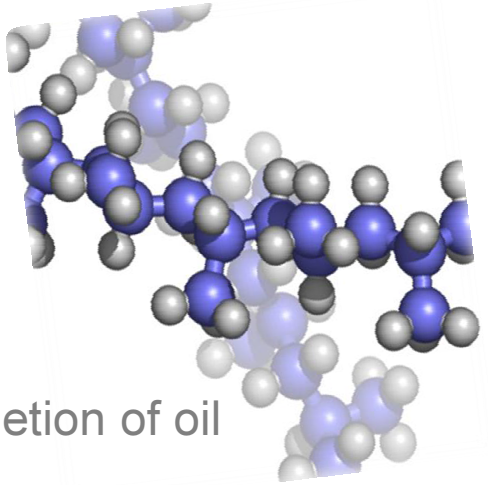
Lubrication Groups



- Group I :
  - Original group, base oil (base stock)
- Group II, III, IV, V :
  - created by further development of oil (hydro-cracked)
  - Development required by equipment OEM
  - Lubricant = base stock + **additive package (AO**)
  - Additive (**A**nti**O**xidants) is protection package for depletion of oil

- Mineral Oil
  - HydroCarbon chains cleaner, more structured depending on Group Level
  - The higher the group level the better the prevention towards oil degradation
  - Mineral Oil : Group I,II,III
    - Basis : Napthenic, Parafinic, Aromatic
- Synthetic Oil: Group IV,V
  - Basis : Synthetic Hydrocarbons (SHC) build out of Poly Alpha Olifins Monomers (PAO)

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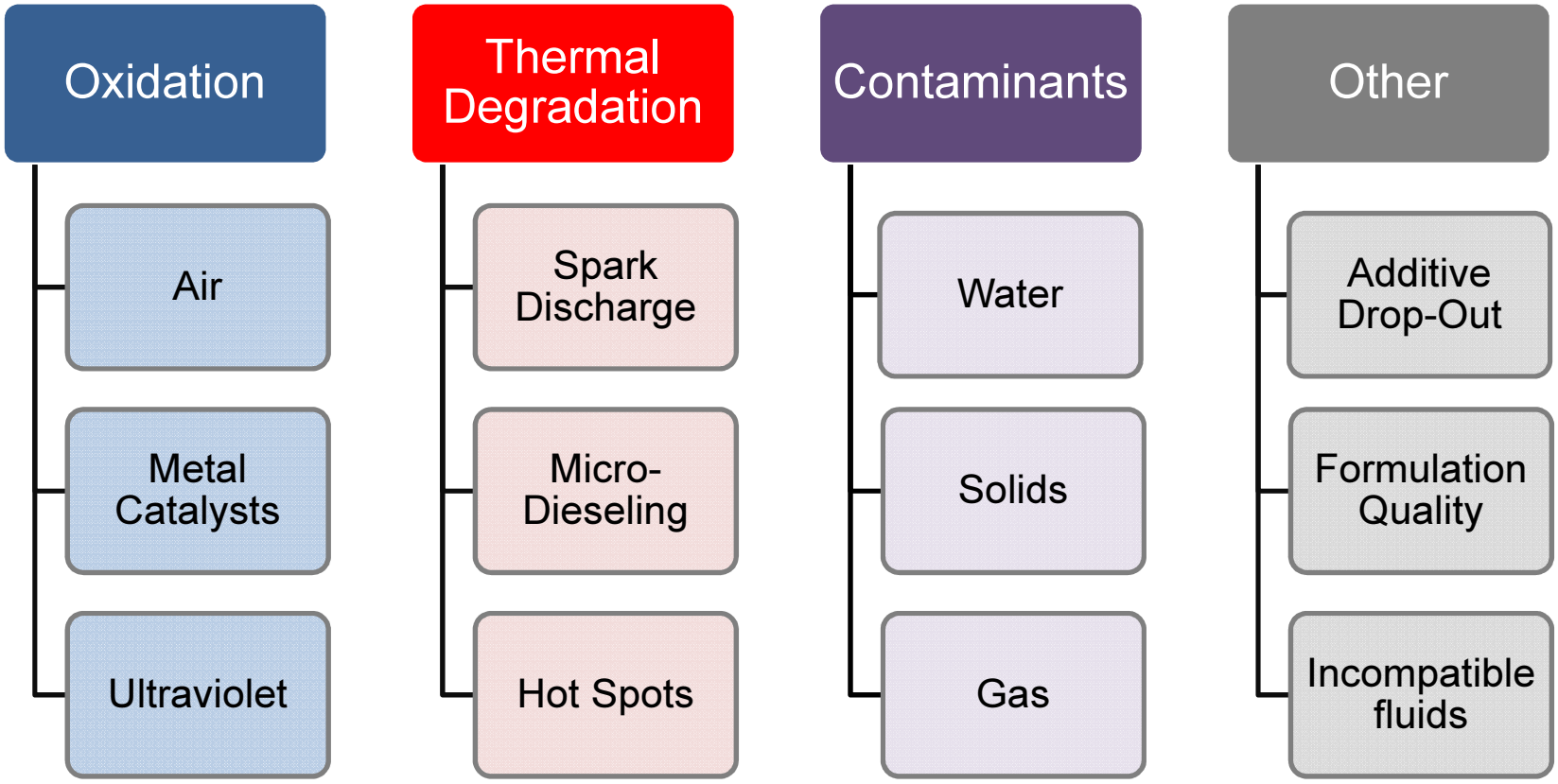
Lubrication Depletion Mechanism



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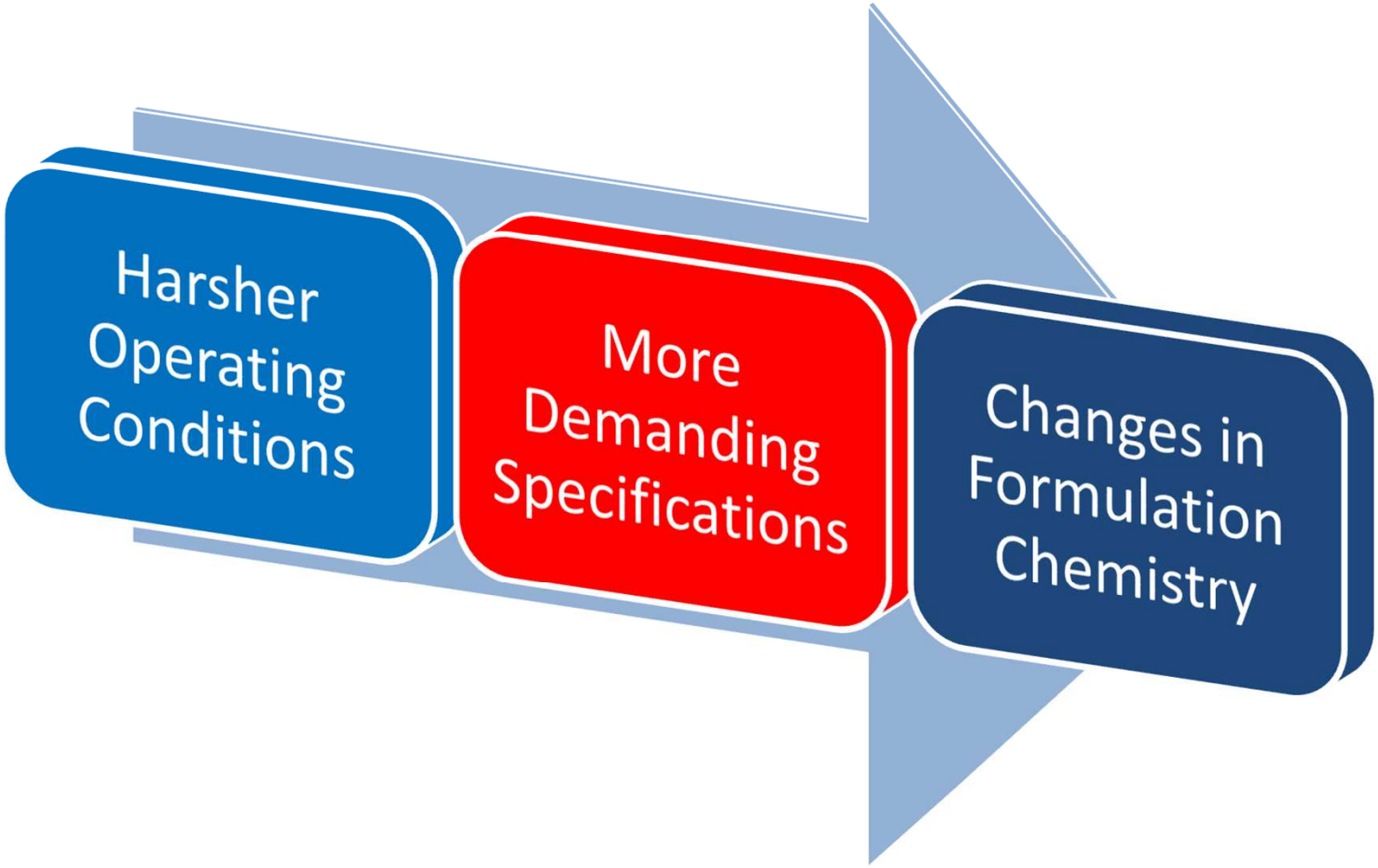
Environment



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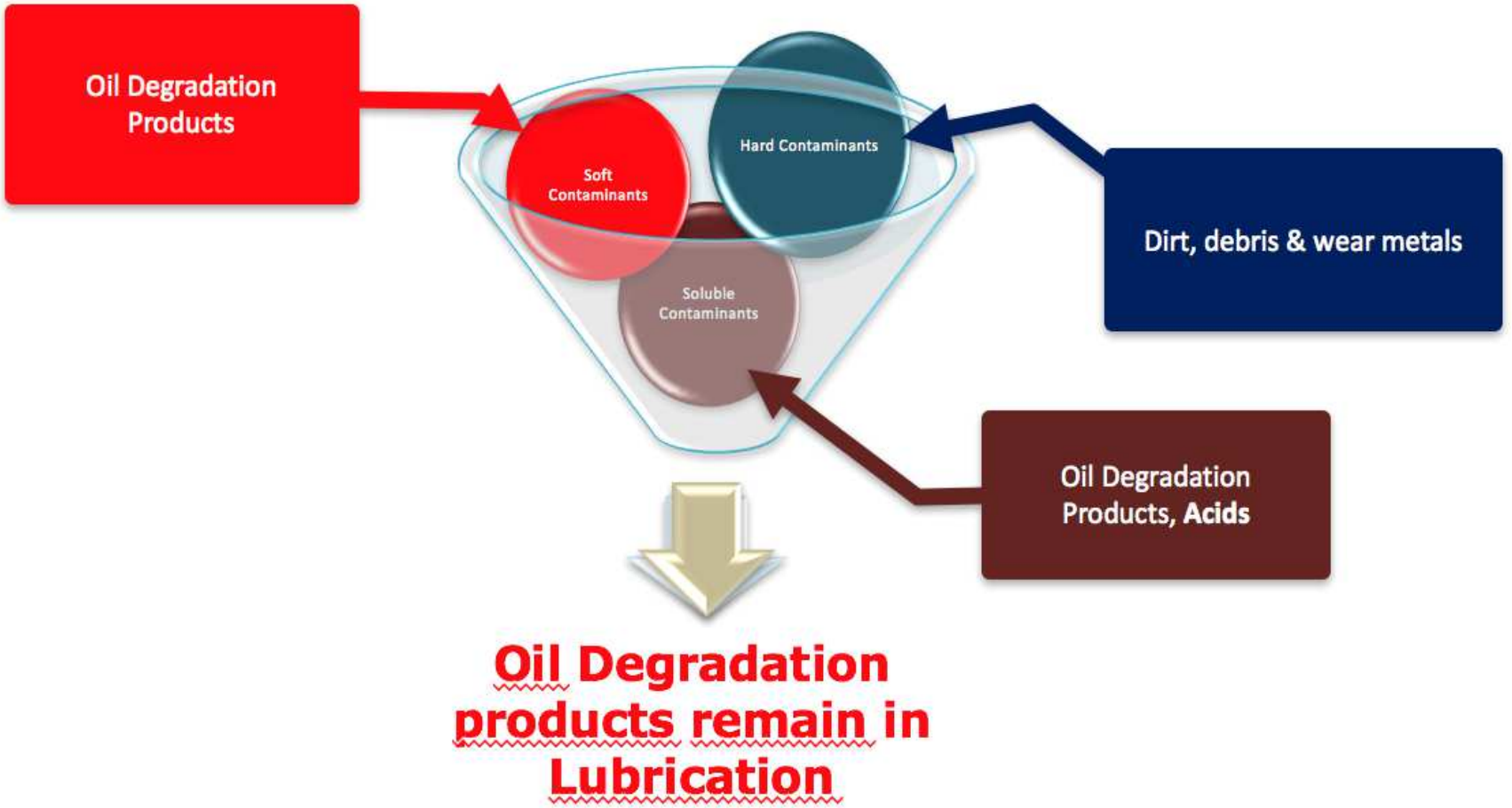
Contamination classification



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Contamination classification

- **Soft Contaminants**
  - Fluid degradation by-products comprised of degraded base oil and depleted additives. Can be caused by many factors including oxidation, thermal degradation, additive depletion, additive/base-stock incompatibilities.
    - Characteristic size < 1 micron
- **Hard Contaminants**
  - Dirt, Debris, Wear Particles,
  - Characteristic size > 2 micron. But can be much smaller as in the case of micro-dieseling. Smaller than 0.45 micron
- **Liquid Contaminants**
  - Water, Incompatible Lubricants or other Fluids from Ingression or Process
- **Gaseous Contaminants**
  - - Ingression or Process

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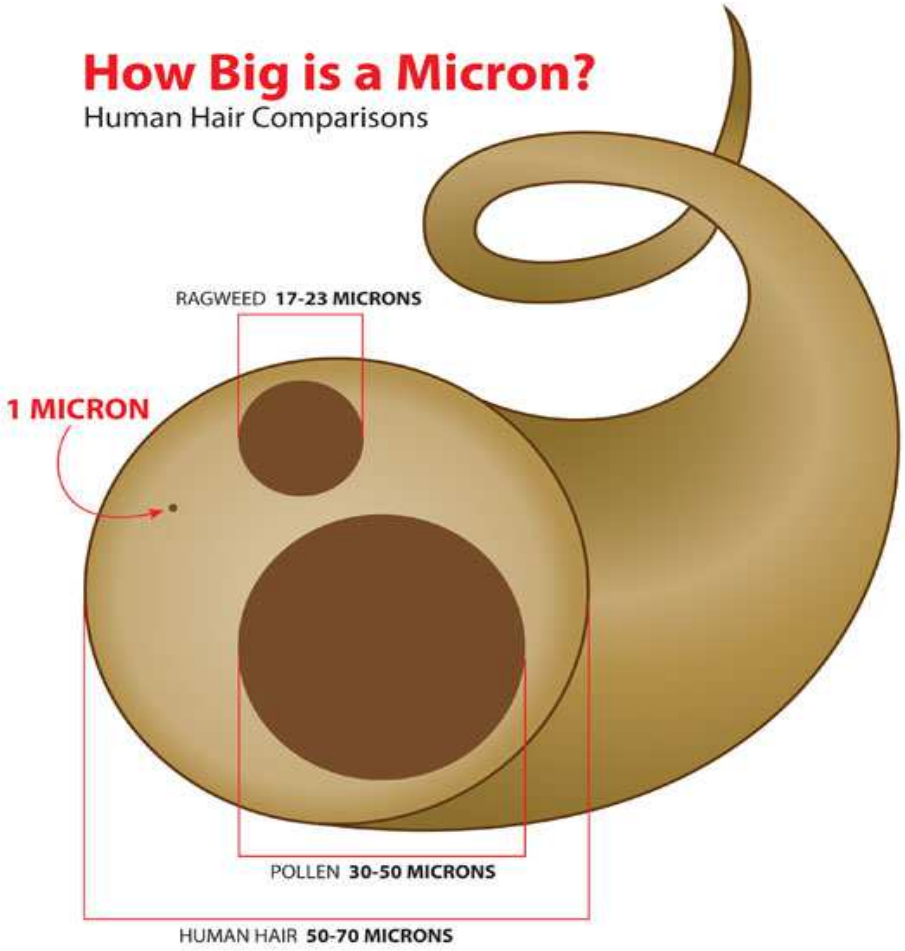

- Grain of salt 100 Microns
- Limit of visibility 40 Microns
- White blood cells 25 Microns
- Red blood cells 8 Microns
- Bacteria 2 Microns

- 1 micron = 0.000039” = 1 micrometer
- 1 micron = 0,000001 meter = 0,001 mm

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Thanks

End of this part of the presentation

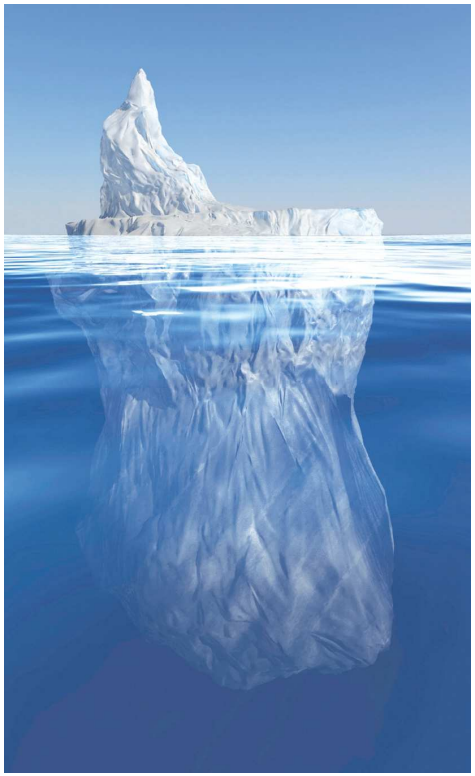
Next Presentation:

ISO Codes

Rethink. Remove Restore.

ISO Codes / Contamination / Maintenance

- Filtration: cost is < 3% of total contamination cost.
- Hidden costs, below the surface
  - Increase
    - Downtime
    - Component repair, replacement
    - Safety issues
    - Maintenance labor
    - Environmental impact
  - Decrease
    - Reliability Fluid life
    - Production
    - Useful fluid life



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Cleanliness saves contamination cost

- Increase
  - Component life
  - Hydraulic performance
  - Safety
  - Fluid Life
- Decrease
  - Downtime
  - Labor
  - Filter usage
  - Failures
  - Ingression

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ISO Code - Cleanliness

ISO 4406:1999 Code Chart		
Range Code	Particles per Milliliter	
	More than	Up to & including
24	80000	160000
23	40000	80000
22	20000	40000
21	10000	20000
20	5000	10000
19	2500	5000
18	1300	2500
17	640	1300
16	320	640
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	5	10
9	2.5	5
8	1.3	2.5
7	0.64	1.3
6	0.32	0.64

Particle Size	Particles per mL	ISO 4406 Code range	ISO Code
$4\mu_{[c]}$	**151773**	**80000~160000**	**24**
$4.6\mu_{[c]}$	87210		
$6\mu_{[c]}$	**38363**	**20000~40000**	**22**
$10\mu_{[c]}$	8229		
$14\mu_{[c]}$	**3339**	**2500~5000**	**19**
$21\mu_{[c]}$	1048		
$38\mu_{[c]}$	112		
$68\mu_{[c]}$	2		

Understanding ISO Codes

The ISO cleanliness code (per ISO4406-1999) is used to quantify particulate contamination levels per milliliter of fluid at 3 sizes $4\mu_{[c]}$ / $6\mu_{[c]}$ / $14\mu_{[c]}$. The ISO code is expressed in 3 numbers (example: 24/22/19). Each number represents a contaminant level code for the correlating particle size. The code includes all particles of the specified size and larger.

It is important to note that each time a code increases the quantity range of particles is doubling and inversely as a code decreases by one code the level of contaminant is cut in half.

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Thanks

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Next Presentation:

Product Range Overview

Partnership EPT

- Calgary based knowledge guided company with over 25 years of experience in advance science of lubrication maintenance and reliability for critical applications.

- Strategy Partnership between EPT and HY-PRO:
  - Design,
  - Engineering,
  - Oil Analysis
  - Sales
  - Dedicated Customer Solutions

- EPT patented technologies:
  - Ion Charged Bonding (ICB™),
  - Soluble Varnish Removal (SVR™)
  - Electrostatic Contamination Removal (ECR™), and
  - Total Moisture Removal (TMR™)

- EPT Technologies have tens of millions of hours of proven performance on super-critical applications such as airports, aircraft carriers, gas turbines, and EHC systems at some of the largest power plants in the world. Markets : e.g. Power Generation, Manufacturing, Heavy Industries ect.

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Dynamic Filter Efficiency

- All Hydraulic and Lubrication systems have a critical contamination tolerance level that is often defined by, but not limited to, the most sensitive system components, such as Servo Valves or high speed Journal Bearings.
- Component manufactures specify fluid cleanliness level as per ISO 4406:1999 for optimum performance and predictable life.
- AN OPERATING SYSTEM IS AT RISK WHENEVER THE CRITICAL CONTAMINATION LEVEL IS EXCEEDED.
- Contamination levels determine the individual component wear rate (hence useful life), and its ability to perform as intended. Filters are expected to maintain contamination below the critical tolerance levels.
- System design, filter performance and maintenance practices largely determine the contamination levels in a system.

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Dynamic Filter Efficiency

- Filter performance in a dynamic operating system is variable and based upon flow rate and flow density, changes in flow rate, viscosity, fluid and structure born vibration, contamination levels, ingression rate, and several other conditions.

- All filters are subject to a form of system dynamics:
  - Hydraulic Filters
    - frequent and rapid changes in flow rate accompanied by operational frequency changes
  - Lubrication Filters
    - Dynamic conditions during start up and shut down

- Key characteristics of filter performance
  - Capture efficiency
    - how effective a filter captures the particles
  - Retention efficiency
    - how effectively a filter retains the particles it has collected

- IF NOT PROPERLY DESIGNED AND APPLIED A FILTER CAN BECOME ONE OF THE MOST DAMAGING SOURCES OF CONTAMINATION IN A SYSTEM

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Dynamic Filter Efficiency

In response to contamination issues with customer hydraulic and lubrication systems Hy-Pro Filtration along with SSI, Inc., developed a test method that provides information on the varying contamination levels in operating systems.

This is based upon bridging the gap between the **Laboratory** and the **Real World** in Filtration Performance and ISO Codes

An alternative approach to multi-pass filter performance testing and development of the industry standard ISO16889.

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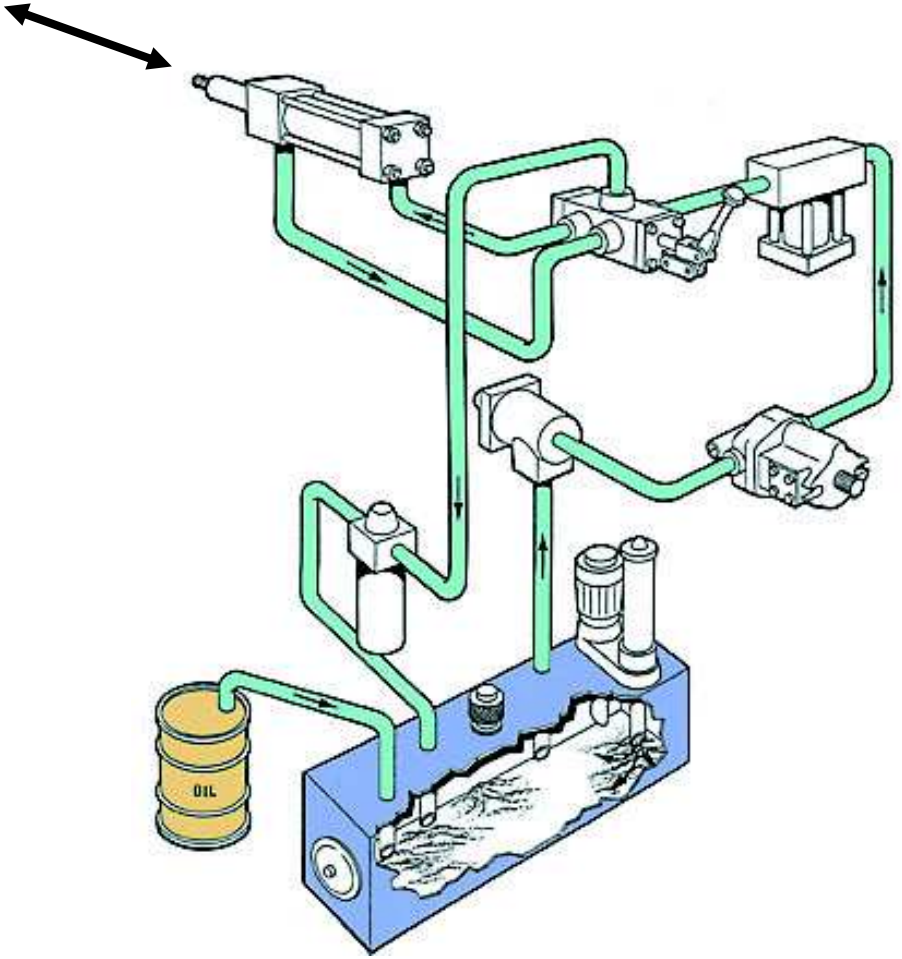
Efficiency – Actual systems operation

- Movement = Work
- Work Needs Pressure
- Work Needs Flow

- Constant Flow?
- Constant Pressure
- NO STATIC
- DYNAMIC



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Dynamic Filter Efficiency

Manufacturers of filter assemblies and filter elements use the industry standard protocol ISO 16889 multi pass method, to rate the efficiency and dirt holding capacity of filter elements under ideal laboratory conditions.

This ISO 16889 multi pass test was updated in 1999 from ISO 4572.

The standard provides a good repeatable test method where identical filters should produce like results when tested on a variety of Test Rigs.

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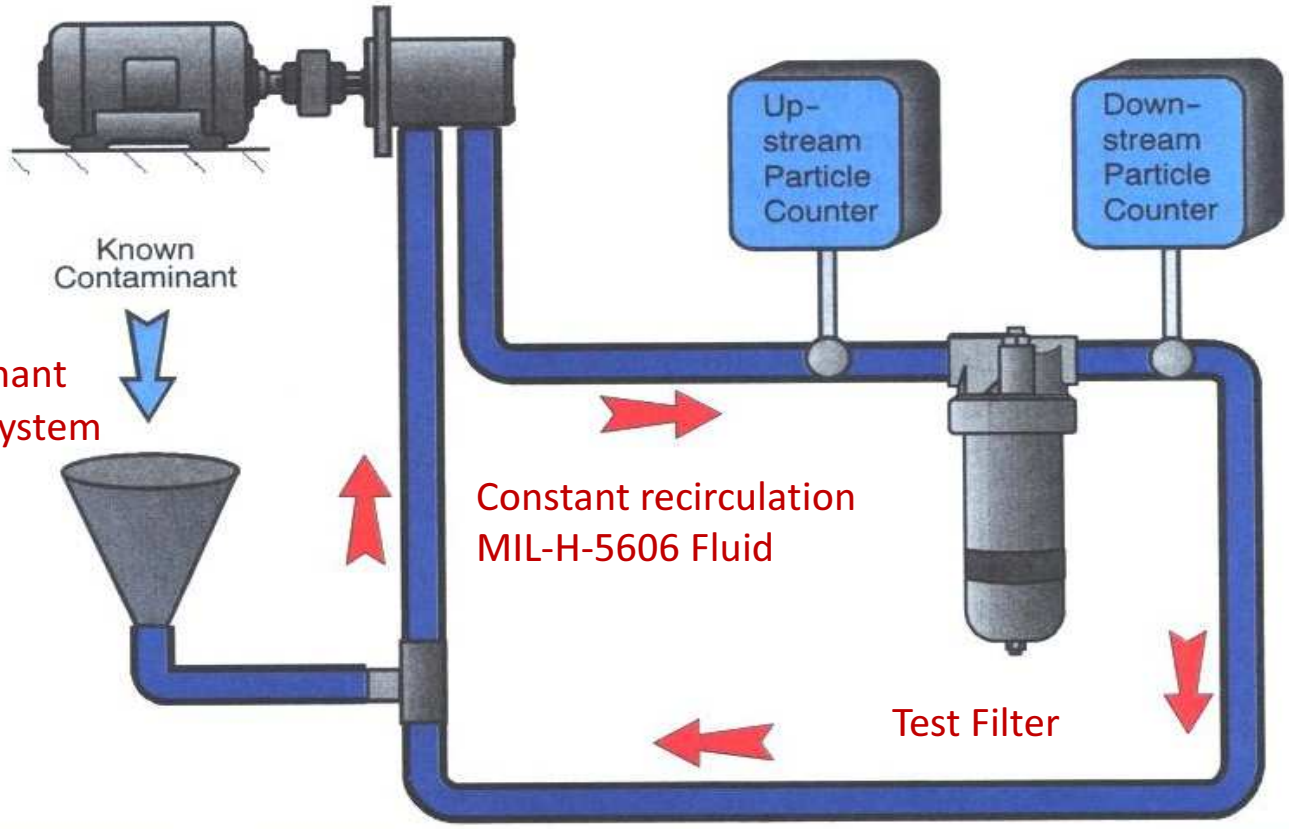
ISO 16889 Multi Pass Filter Test

Small amounts of fluid are removed before and after the filter for particle counting to calculate efficiency – expressed as the Filtration ration (Beta)

Fixed flow rate



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Dynamic Filter Efficiency : Beta Ratio (β)

Filtration Terms

$$\beta_x = \frac{\text{quantity of particles} \geq x\mu\text{©} \text{ upstream of filter}}{\text{quantity of particle} \geq x\mu\text{©} \text{ downstream of filter}}$$

10 micron = Particle size used in the calculation

Upstream Particles = 400

Downstream Particles = 2

$\beta_{10} = 400 \div 2$

$\beta_{10} = 200$

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Dynamic Filter Efficiency : Efficiency

Filtration Terms

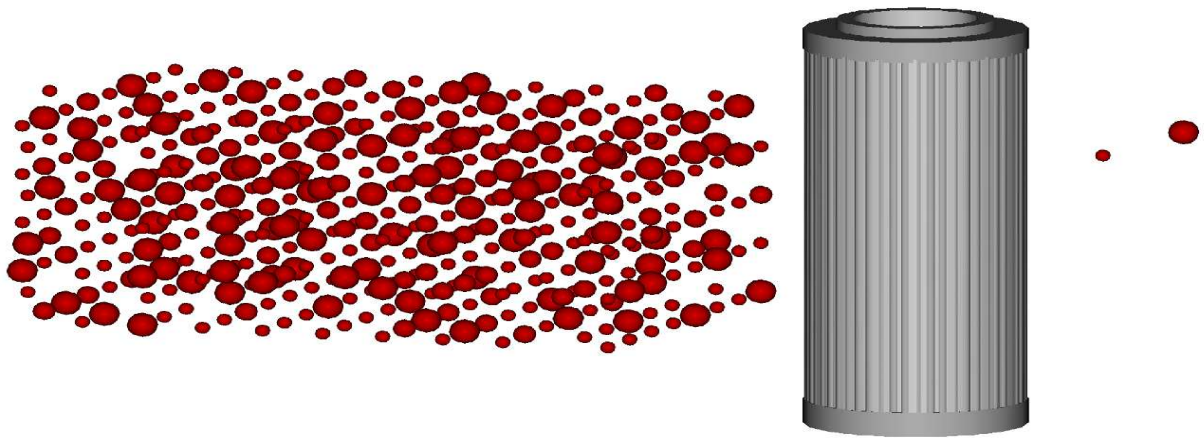
% Efficiency (ε)

- $\varepsilon = \{(\beta_x - 1) / \beta_x\} \times 100$
  - $\beta 10 = 200$
- $\varepsilon = \{(\beta 10 - 1) / \beta 10\} \times 100$
- $\varepsilon = \{(200 - 1) / 200\} \times 100$
  - $\varepsilon = 99.50\ \%$

% Efficiency (ε)

- $\varepsilon = 1 - \beta_x^{-1}$
  - $\beta_{10} = 200$
- $\varepsilon = 1 - 200^{-1}$
- $\varepsilon = 99.50\ \%$

% Efficiency (ε)



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Beta Ratio vs. Filter Efficiency

Filtration Terms

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Absolute

Nominal

	β Ratio	Efficiency	# upstream	# downstream
β_x	10000	99.99%	100,000	10
β_x	5000	99.98%	100,000	20
β_x	**1000**	**99.90%**	100,000	100
β_x	500	99.80%	100,000	200
β_x	300	99.67%	100,000	333
β_x	200	99.50%	100,000	500
β_x	150	99.33%	100,000	667
β_x	100	99.00%	100,000	1,000
β_x	75	98.67%	100,000	1,333
β_x	60	98.33%	100,000	1,667
β_x	40	97.50%	100,000	2,500
β_x	20	95.00%	100,000	5,000
β_x	10	90.00%	100,000	10,000
β_x	4	75.00%	100,000	25,000
β_x	**2**	**50.00%**	100,000	50,000

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Dynamic Filter Efficiency

- The DFE test goes further than the current industry standard, by inducing dynamic duty cycles and measuring real time performance, before during and after the cycles.
- DFE multi pass testing quantifies both capture and retention efficiency in real time so that a prediction can be made of the “worst case” fluid cleanliness with average cleanliness.
- The DFE test utilizes upstream and downstream particle counters, test filter and injection point much like ISO 16889.
- The DFE flow rate is hydrostatically controlled to make flow changes quickly, while maintaining full system flow through the test filter.
- Particle counter sensor flows remain constant during all particle counts, which ensures that the fluid counted is representative of the system contamination level.
- Counts are taken before, during and after each flow change. The total number is determined by the duty cycle of the specific test.
- The efficiency results are reported as Filtration Ration (Beta), efficiency percent and actual particle levels per milliliter.
- The rapid particle counting and timing of DFE allows the user to analyse and understand both capture and retention efficiency of each filter tested.

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ISO 16889 vs. DFE

Multi-pass Test:

- ISO 16889 SS Testing
- Pump flow is fixed by tester
- 4 samples minimum required

Dynamic Filter Efficiency Test:

- Modified ISO 16889 Testing
- Pump flow varies (50% - 100%)
  - Transition 50% Flow to 100% Flow
  - 100% Flow
  - Transition to 50% Flow
  - Repeat
- Sampling is real time throughout test (100+ samples drawn)

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DFE Rated Filter Elements

Achieving a Higher Standard !!!

- Products designed to a higher standard
  - High efficiency capture & retention
  - Media optimized for Low ISO CODES not beta
- Reliable system operation
- Improve plant efficiency & profitability
- You can't fix a problem that you don't realize exists

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DFE Rated Filter Elements

Filter Elements & Media:

- DFE Dynamic Filter Efficiency
- Cellulose to Glass Upgrades
- Lube Design Filter Elements
- Dynafuzz Stainless Steel Fiber Media
- NSD Non-Spark Discharge Filter Elements
- Water Removal Filter Elements
- Turbo-TOC Filter Element Upgrade

- Upgrades (Not Replacements) For All Major Filter OEM **Hydraulic** and **Lubrication** Filter Elements
- Modifief ISO 16889 testing principle -> DFE $\beta_{[x]} > 1000$
- Over **480.000** Interchange Upgrade Elements & critical interchanges
- Flexible manufacturing
- Hot Order Response; Delivery in hours/days **not** in weeks
- Extensive element stock levels

Pall
Hydac
Parker
Schroeder
Donaldson
Stauff
Mahle
Taisei Kogyo
Internormen
Indufil
Moog
Kaydon
Hilco
Eppensteiner
Fleetguard
Fairey Arlon
Caterpillar
Nugent
Porous Media
PTI
Western
Vickers
Many more

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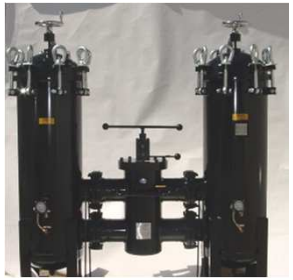
Filter Assemblies & Accessories

In-Tank



Duplex Filter

Spin-On

Hy-Dry

Reservoir Accessories

- In-Tank Assemblies
- Low Pressure Assemblies
- Medium Pressure Assemblies
- High Pressure Assemblies
- Duplex Filter Assemblies
- Reservoir Accessories
- Test Kits & Equipment

Low Pressure

Medium Pressure

High Pressure

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Off-Line Filter Systems:

- CFU Compact Filter Unit
- FPL Filter Panel
- FC Filter Carts
- FSL High Viscosity Filter Systems
- FSLD Duplex High Viscosity Filter Skids
- FSW Wall Mounted High Viscosity Filter System
- FCL High Viscosity Filter Carts
- HS Heater Skid

CFU

FC

FPL

FSL

FSDL

FSW

FCL

HS

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Water Contamination; the basics

- Water is one of most common and damaging contaminants found in lube and hydraulic oils

- Continuous or periodic high water results in damage such as:
  - Metal etching (corrosion)
  - Wear in hydraulic components
  - Dielectric strength loss
  - Fluid breakdown
  - Additive depletion
  - Oil oxidation
  - Reduction of lubricating properties

- Oil is like a sponge, it will accept water until it can't accept any more.

- The process of water contamination will then continue with free water.

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Water Contamination; the basics

- When water/oil solution cools down, depending on temperature, you may see some free water separation
- Effect of moisture/water in your oil system can reduce on-stream plant availability
- Bearing life and critical component life are also reduced by moisture levels above and within saturation point
- Degree of contamination and type of water contamination is determining the best method of removal:
  - Dissolved water
  - Emulsified water
  - Free water

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Water Contamination; the basics

- **Dissolved water**

- Dissolved water is the state at which individual water molecules (not visible to the naked eye) are dispersed throughout a fluid.
- Dissolved water accrues below the fluid's saturation point.
- Fluid with only dissolved water in it will have a bright, clear appearance.

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Water Contamination; the basics

- **Emulsified water**

- Once the dissolved water's concentration has exceeded the saturation point of the fluid, microscopic water droplets will start to form an emulsion which is suspended within the fluid.
- Fluid samples containing emulsified water will have a cloudy, hazy appearance (mayonnaise)

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Water Contamination; the basics

- **Free water**

- Free water is formed once the emulsified water has reached a concentration at which it starts a separation phase and large water droplets begin to fall out of solution.
- Fluid samples containing free water will have a cloudy, hazy appearance.
- As the sample settles, the free water will fall out to form a separated layer on the bottom of the sample.

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Water Contamination; the basics

- Free and dissolved water in hydraulic and lub systems leads to:
  - Bearing fatigue
  - Accelerated abrasive wear (friction)
  - Corrosion of metal surface
  - Increased metal conductivity
  - Variance in viscosity
  - Lost of lubrication capacity
  - Additive package breakdown

- Sources could be:
  - Reservoir leakage
  - Worn actuator seals
  - Heat exchanger leakage
  - New oil

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Water Contamination; the basics

DISSOLVED Water

Oil appears bright and clear; Difficult to separat

EMULSIFIED Water

Very small droplets dispersed in oil. Oil viscosity may go UP (like mayonnaise). Tiny amounts of detergent engine oil can contaminate industrial oils.

FREE Water

Large drops that readily settle out.

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Water Contamination; the basics

- Water Contamination Removal Methods:
  - **Water Absorbing Filter Elements**
    - Only for Free water
    - Usable for all lubricants
    - Needs replacement within a certain period.
  - **Head Space Dryer**
    - Usable for all dissolved, emulsified and free water
    - Usable for all lubricants
    - Control water ingression via reservoir
  - **Coalesce Systems**
    - Only Free Water and a small portion of emulsified water
    - Usable for Turbine oils, Compressor oils and Diesel oils
    - Limited to oils not having aggressive additive package like AW and/or EP additive
  - **Vacuum Dehydration Systems** → **VUD20**
    - Usable for all lubricants, including phosphate esters
    - Usable for dissolved, free and emulsified water

Old tech. is Centrifuge. Only free water removal, sensitive to maintenance and very costly

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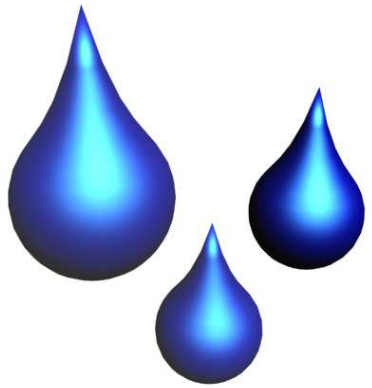
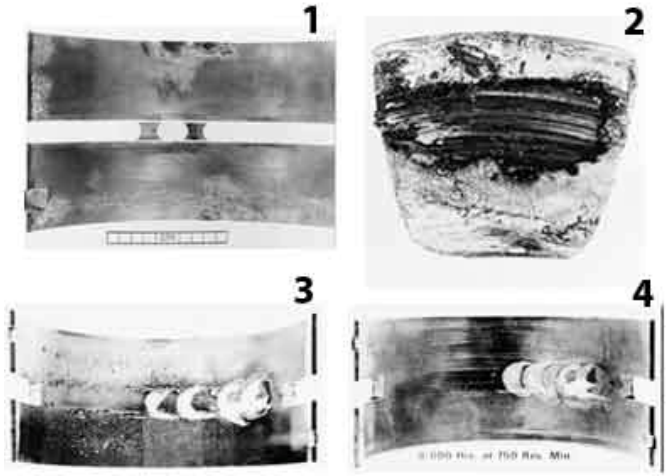
Water Contamination; the problem



- Downtime
- Accelerated wear
- Premature Bearing & Component Failure
- Viscosity fluctuation
- Oxidation
- Additive Depletion
- Acid production
- Premature fluid replacement



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Water Contamination; the problem

- Base oil effects:

Water-related Problem	What's Happening
Hydrolysis and Oxidation	Water promotes chemical and physical changes in the base oil. • Acid formation • Oil thickening • Varnish • Sludge
Aeration	Water encourages aeration problems. • Foaming • Air entrainment
Viscosity Effects	Water leads to stable emulsions, higher viscosity and non-Newtonian properties.
Dielectric Effects	Water reduces electric insulating properties of oil.

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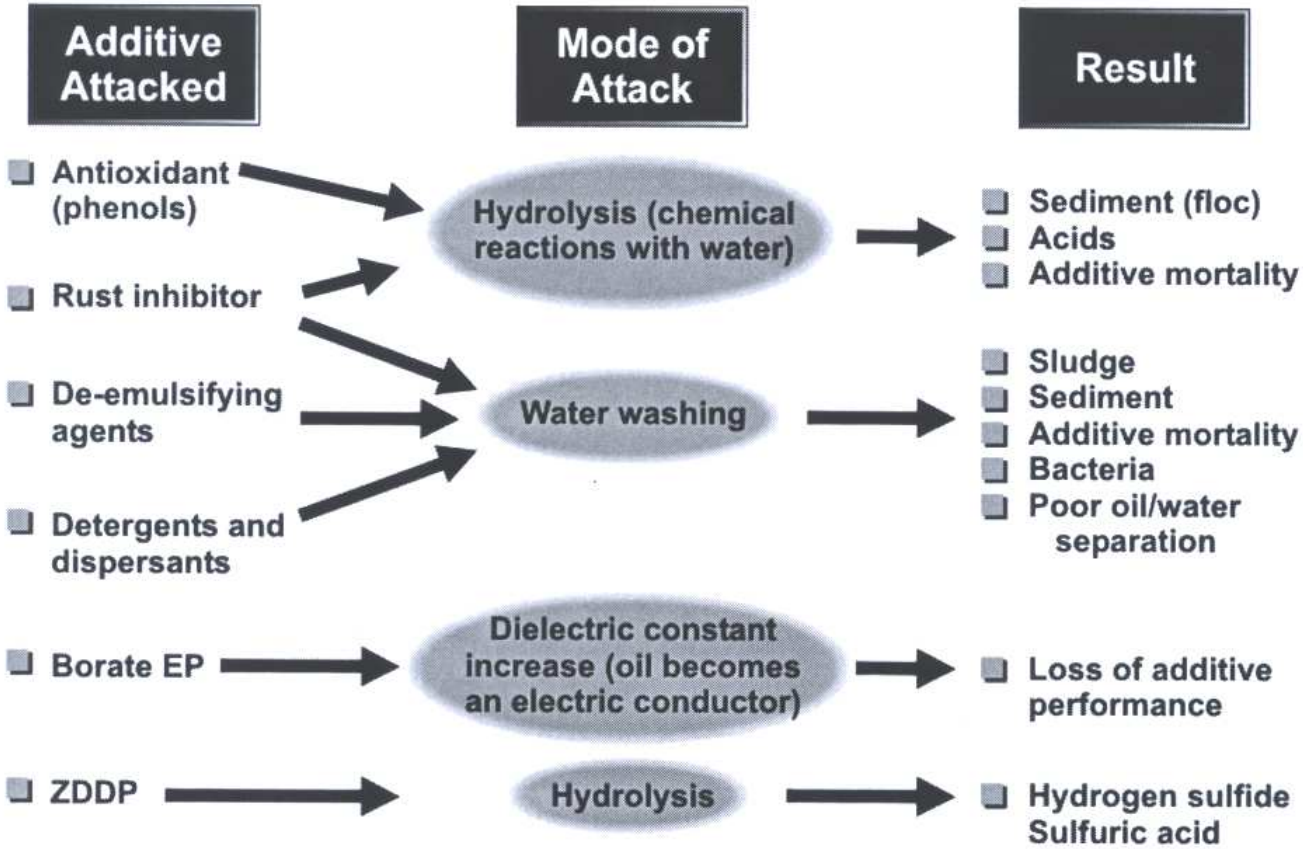
Water Contamination; the problem

- Additive effects:



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Water Contamination; the problem

- Machine effects:

Water-related Problem		What's Happening
Corrosion	⇨	Water in oil gives acid greatest destructive potential. Water is the central promotor of rust.
Film Strength Loss	⇨	Water in elastohydrodynamic contacts (rolling element bearings) cause film strength failure and hydrogen embrittlement. Water flash-vaporization in hydrodynamic contacts causes bearing failure.
Cavitation	⇨	Water is the leading cause of hydraulic pump cavitation (vaporous cavitation).
Silting and Filter Plugging	⇨	Water causes poor filterability and valve stiction.

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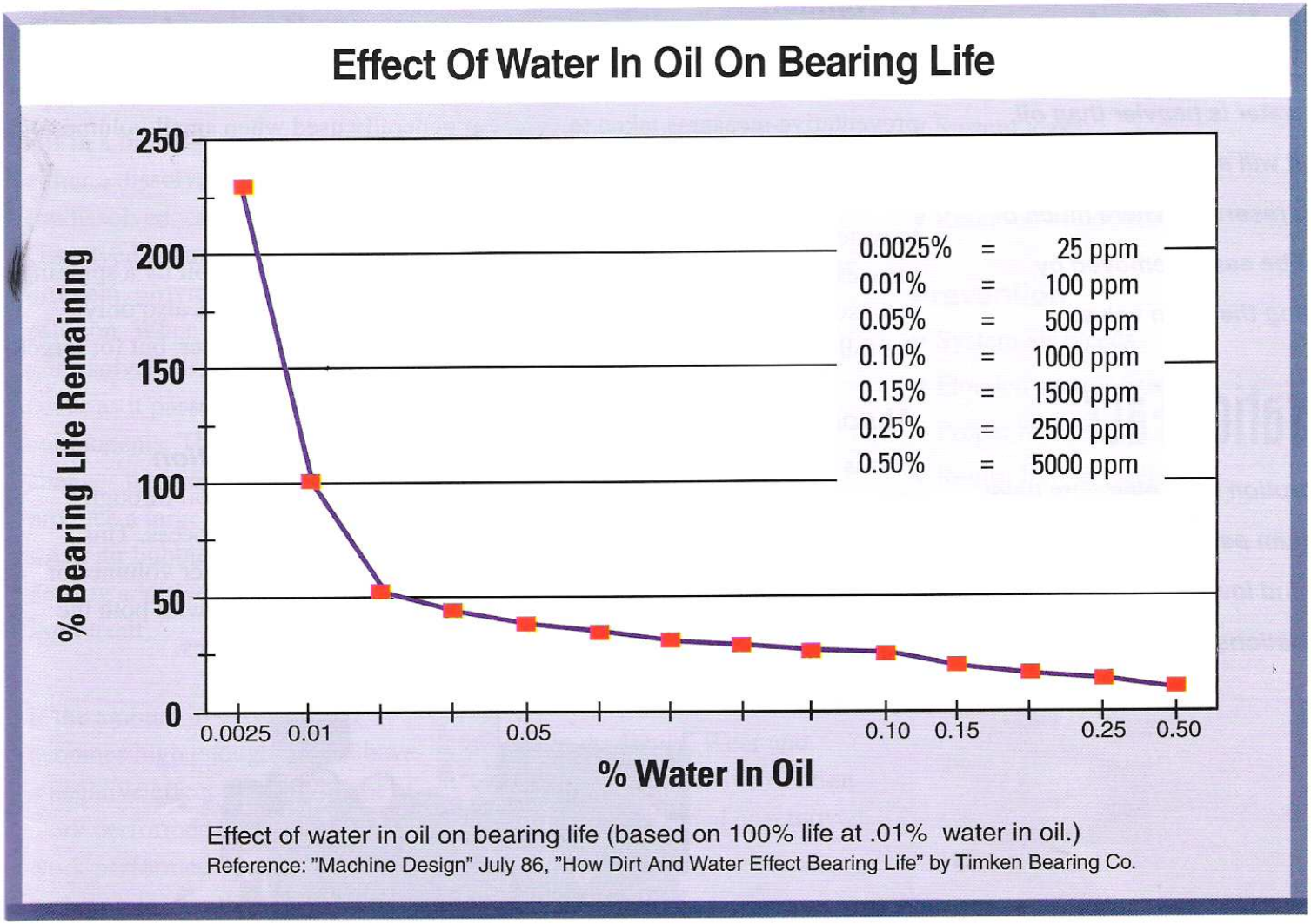
Water Contamination; the problem



Effect of water in oil on bearing life (based on 100% life at .01% water in oil.)

Reference: "Machine Design" July 86, "How Dirt And Water Effect Bearing Life" by Timken Bearing Co.

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Water Contamination; the problem

500 ppm | 1000 ppm | 2500 ppm | 5000 ppm | 10,000 ppm

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Water Contamination; the problem

New Moisture Level (ppm)

Current Moisture Level (ppm)	10,000		5,000		2,500		1,000		500		250		100		50	
	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal
50,000	2.3	1.6	3.3	1.9	4.8	2.3	7.8	2.9	11.2	3.5	16.2	4.3	26.2	5.5	37.8	6.7
25,000	1.6	1.3	2.3	1.6	3.3	1.9	5.4	2.4	7.8	2.9	11.2	3.5	18.2	4.6	26.2	5.5
10,000			1.4	1.2	2.0	1.5	3.3	1.9	4.8	2.3	6.9	2.8	11.2	3.5	16.2	4.3
5,000					1.4	1.2	2.3	1.6	3.3	1.9	4.8	2.3	7.8	2.9	11.2	3.5
2,500							1.6	1.3	2.3	1.6	3.3	1.9	5.4	2.4	7.8	2.9
1,000									1.4	1.2	2.0	1.5	3.3	1.9	4.8	2.3
500											1.4	1.2	2.3	1.6	3.3	1.9
250													1.5	1.3	2.3	1.6
100															1.4	1.2

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Water Contamination; the problem

- Fyrquel EHC N & Fyrquel EHC are both phosphate esters
  - Former is trixylenyl phospate (TXP); the latter is a mixture of butylatedphenyl phospates and TXP.
- Moisture level will depend on the application
- Typical moisture levels recommended for both would be **200 – 500** ppm.
- > 500 ppm:
  - Fluid prone to acid-producing break-down via hydrolysis
    - Once acids are present, they promote accelerated breakdown of the fluid and the situation can get out of hand rapidly
- < 200 ppm:
  - Fluids are so dry that they collapse
  - They loose their working / effectiveness
  - Low water levels could promote also small scale high temperature events (micro dieseling/sparking)
  - We noted that water levels below 200 PPM also tend to produce higher patch weights and MPC values

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Water Contamination; technologies

- Water Removal Filter Elements

HY-PRO FILTRATION

Water Removal

Water Removal

Available for all spin-on and cartridge filter elements.

Media code "A" specifies G8 Dualglass media co-pleated with water removal scrim to produce a filter that can remove water while maintaining $\beta x_{[c]} = 1000$ efficiency down to $1\mu / 2.5\mu_{[c]}$.

Water Contamination

Free and dissolved water in hydraulic and lube systems leads to bearing fatigue, accelerated abrasive wear, corrosion of metal surfaces, increased electrical conductivity, viscosity variance, loss of lubricity, and fluid additive breakdown. Sources include condensation, reservoir leakage, worn actuator seals, heat exchanger leakage, new oil and more.

Filter elements with water removal media can bring high water counts down. Most water removal elements utilize low efficiency (nominally rated) media. We combine the best of both worlds by removing the water while maintaining our $\beta x_{[c]} = 1000$ particulate removal efficiency and ensuring that none of the gel particles are released back into the system. Water removal is available with any of our glass media selections from 1µ to 40µ. There is a price adder to the glass element price so please consult the price list or call Hy-Pro before quoting.

Capacity by Common Series

Hy-Pro Element	Capacity H_2O	
	Liters	Ounces
HP75L8-*AB	0.7	23
HP101L18-*AB	2.5	84
HP101L36-*AB	5.1	172
HP102L18-*AB	1.9	65
HP102L36-*AB	3.3	112
HP107L18-*AB	2.8	93
HP107L36-*AB	5.8	197
HP83L16-*AB	1.7	57
HP83L39-*AB	3.6	123
HP8314L39-*AB	5.9	200
HP8310L39-*AB	6.2	207
HPKL9-*AB	0.6	21
HP60L8-*AB	0.4	12
HP25L9-*AB	0.4	12

Water Removal Application - Bulk Oil Conditioning

Fluid volume: 250 gallons, 1000 liters
Initial ppm H_2O: 12000 ppm, Final ppm H_2O: < 50 ppm

A power plant planned to use a vacuum dehydrator to remove the water from 1000 liters of hydraulic oil. Dehydrator rental was expensive and required one month minimum. As an alternative Hy-Pro element HP8314L39-6AB (A media code = G8 Dualglass + water removal) was applied. Hy-Pro estimated that 2 elements would bring the ppm levels below the target. After the second element was removed the ppm level was below 50 ppm H_2O. A third element was installed but did not reach terminal Δp before the fluid was determined to be free of water and ready for use.

Water PPM ~ Ounce conversion:
Moisture (PPM) X Fluid volume (Gallons) X .0001279 = Ounces of Water

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FE-WATER-092415

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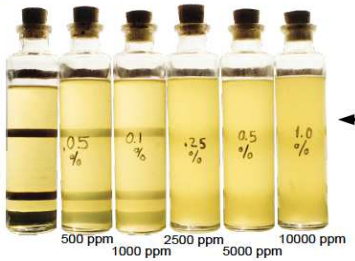
Appearance of Water in Oil

Dissolved Water- Oil appears bright and clear. Water can only be removed by vacuum dehydration.



Emulsified Water- Very small droplets dispersed in oil. Oil viscosity may go up and appear cloudy and milky. Tiny amounts of detergent engine oil can contaminate industrial oils.

Free Water- Large drops that readily settle out.

Harmful Effects of Water in Oil

Contamination Related Failure

Water is one of the most common and most damaging contaminants found in a lube or hydraulic system. Continuous or periodic high water levels can result in damage such as:

- Metal Etching (Corrosion)
- Abrasive Wear in Hydraulic Components
- Dielectric Strength Loss
- Fluid Breakdown
- Additive Precipitation and Oil Oxidation
- Reduction in Lubricating Properties

Component Life Extension by Removing Water

New Moisture Level PPM (%)

Current Moisture Level PPM	1000 (0.1%)		500 (0.05%)		250 (0.025%)		100 (0.01%)		50 (0.005%)	
	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing
5000	2.3	1.6	3.3	1.9	4.8	2.3	7.8	2.9	11.2	3.5
2500	1.6	1.3	2.3	1.6	3.3	1.9	5.4	2.4	7.8	2.9
1000			1.4	1.2	2	1.5	3.3	1.9	4.8	2.3
500					1.4	1.2	2.3	1.6	3.3	1.9
250							1.5	1.3	2.3	1.6
100									1.4	1.2

Component Life Extension by Removing Water*

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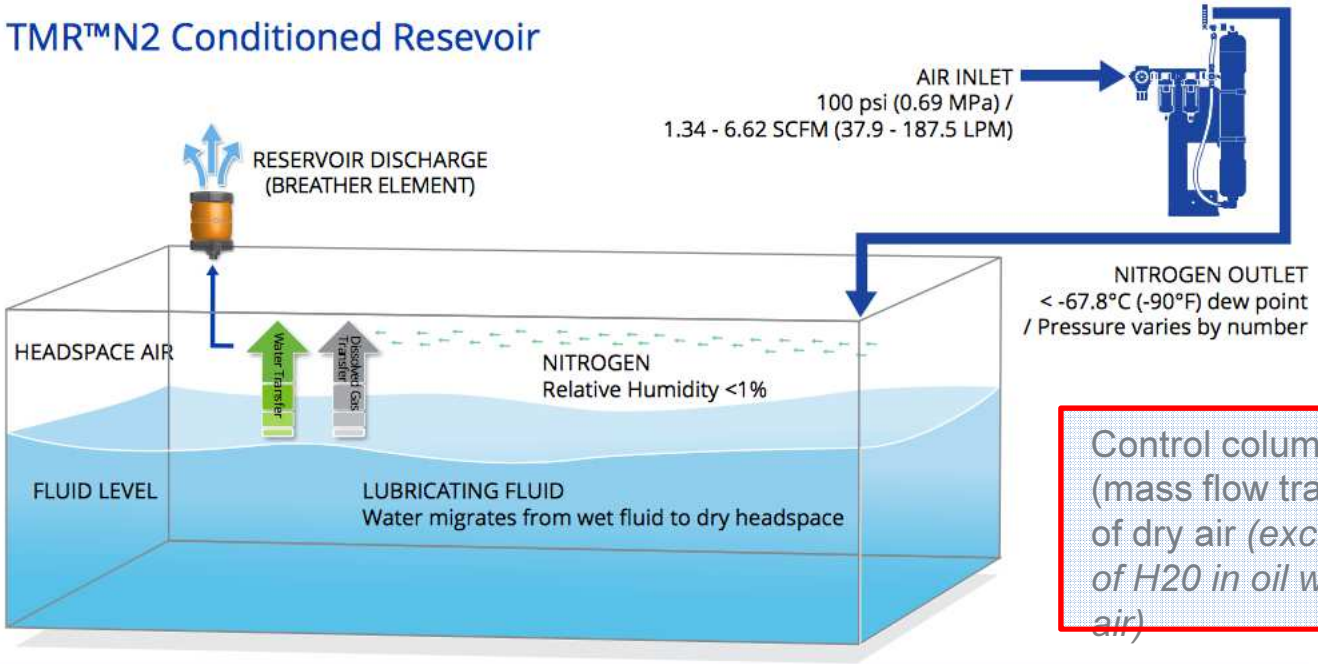
Water Contamination; technologies

- Head Space Dryer

- TMR (control dry air) or TMRN2 - Nitrogen generator
- Active headspace dryer + Nitrogen generator
- Removes dissolved water + prevent air water ingress
- Removes combustible gasses



Control columbarium (mass flow transfer) of dry air *(exchange of H20 in oil with dry air)*

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- # Coalesce System

Free Water and a small portion of emulsified water

- Waterforms on coalesce media
- Coalesce into larger droplets
- Droplet then drain down element to bottom
- Separatorscreen acts as water barrier where more droplets form
- Separator is also post-filter
- Water collects in bottom of vessel
- Water level sensor activates valve to drain water
- There will always be water in the bottom of the vessel (water leg)

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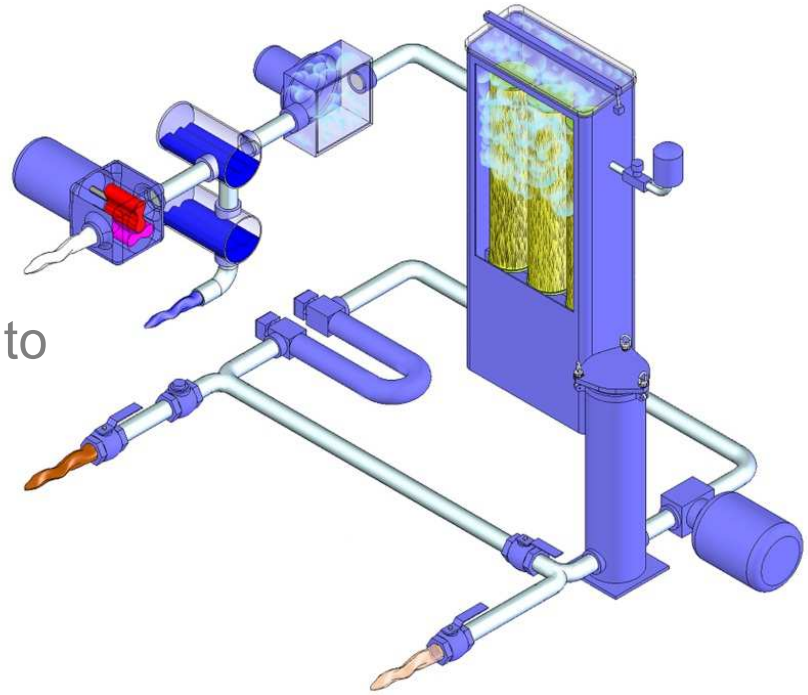
- Vacuum Dehydrator

4 Key principles:

1. Present Oil @ Optimum Heat
2. Present Large Surface of Oil/ Thin Film to Vacuum
3. Present Oil to Optimum Vacuum
4. Air Movement moving water vapour



Focus is on the specific Application / Needs
Design Flexibility to deliver the required result

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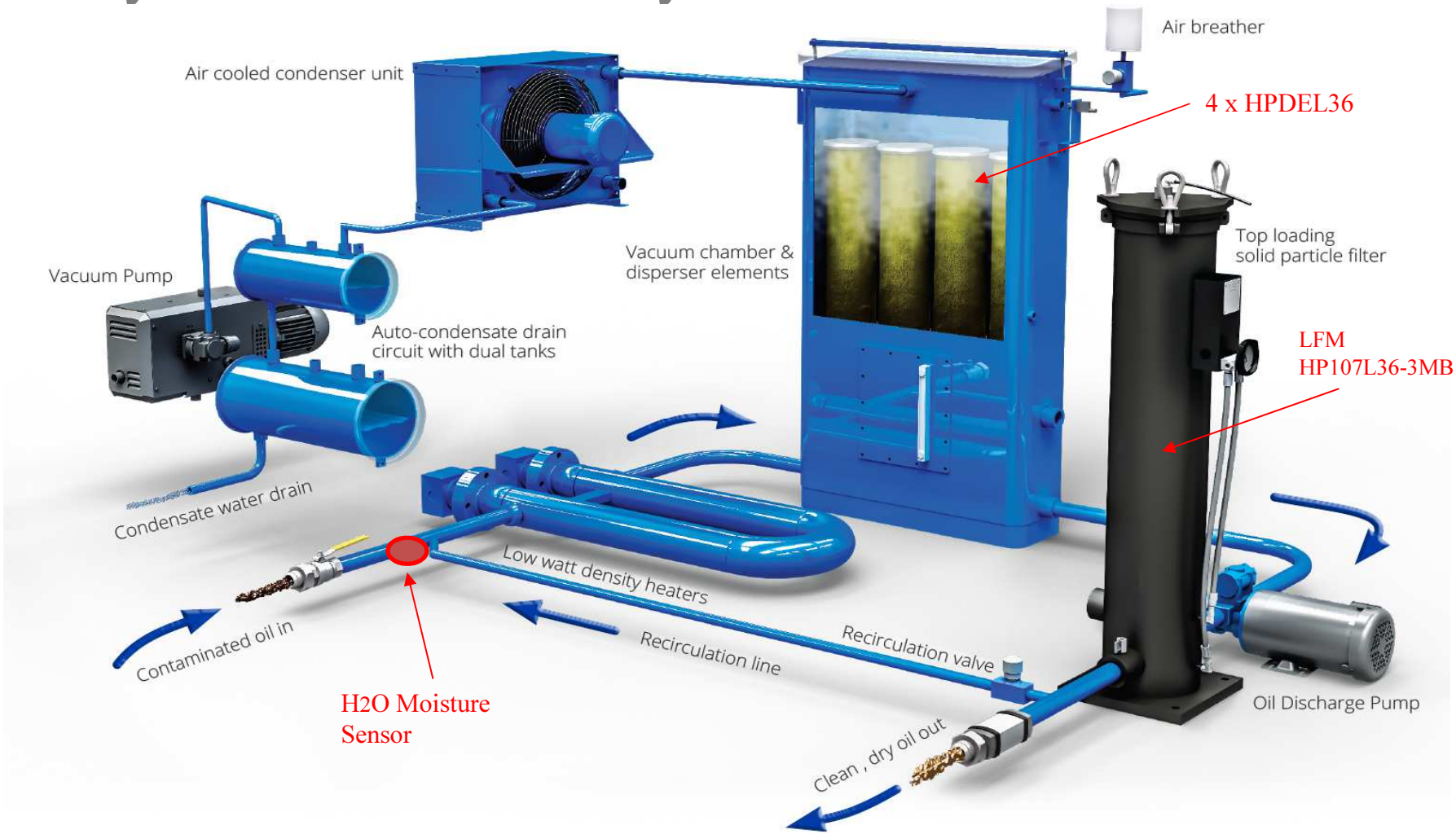
Water Contamination; technologies

- HyPro's Vacuum Dehydrator



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Diesel Filter Housing & Systems:

- COD Diesel Conditioning Filter Systems
- FSLCOD Diesel Conditioning Filter Systems
- FCLCOD Diesel Conditioning Filter Carts
- CSD Diesel Coalesce Filter Housing

COD

CSD

FCLCOD

FSLCOD

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Water Removal Equipment :

VUD

V1

- VUD Vac-U-Dry Vacuum Dehydration Systems
- V1 Compact VUD Vacuum Dehydration Systems
- COT Turbine Oil Conditioning Systems
- FCLCOT Turbine Oil Conditioning Filter Carts
- TMR-N2 Headspace Dehydrator + Nitrogen Generators
- TMR-Air Headspace Dehydrators

COT

FCLCOT

TMR-N2

TMR-Air

Soft Contaminants - Varnish

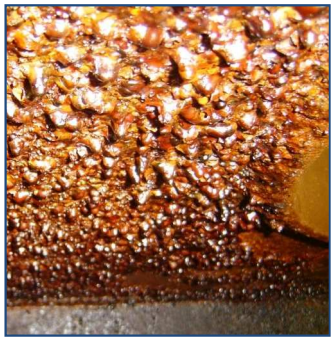
What is Varnish?

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.D

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)

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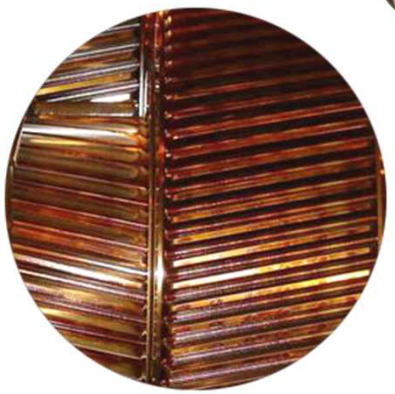
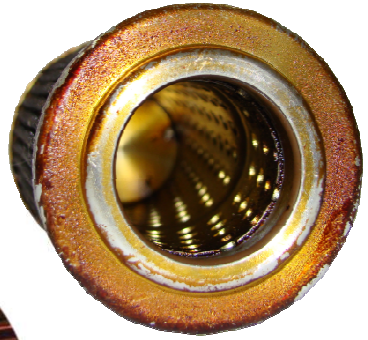
Soft Contaminants - Varnish

- Non – Aggressive additized oil is mineral based tubine lub and compressor oil.
- When gas turbines fall casualty to unit trip or fail-to-start conditions, lube oil varnish is the usual suspect!

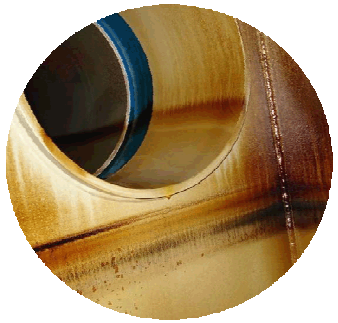
Filter element cross section (lacquer)



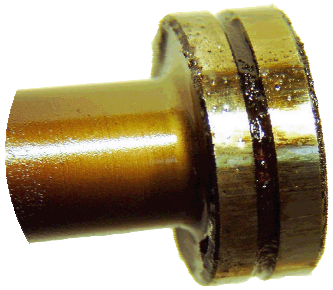
Varnish on load gear (GE F6)



Varnish deposits on element (GE F6B)



Reservoir deposits



Servo valve deposits (stiction)

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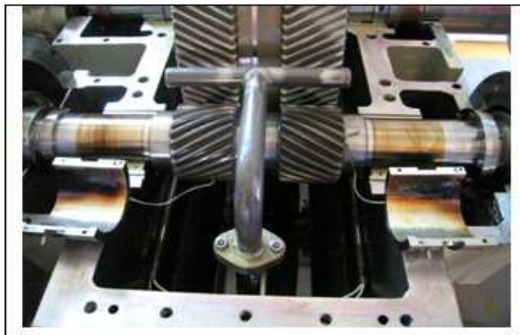
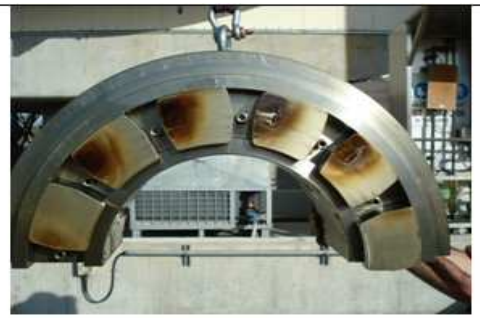
Soft Contaminants - Varnish

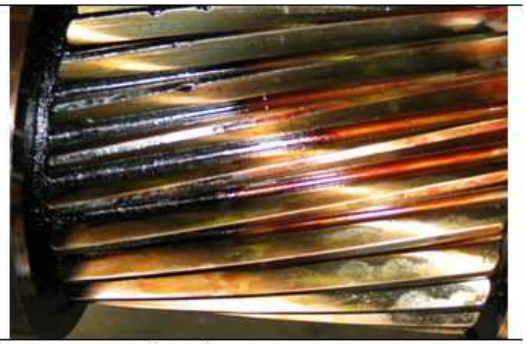
- What is Varnish ?
  - Not simply the oxidation or degradation products.
  - Varnish is:
    - Deposit from depleted AntiOxidant (AO) additive and degraded base oil
    - Soft contaminants
    - These soft contaminants are responsible for settling out of the turbine oil and forming deposits in the system, especially on white metal surfaces and at gear teeth



Deposits turbo set gear box



Deposits thrust bearing



Deposits gear compressor

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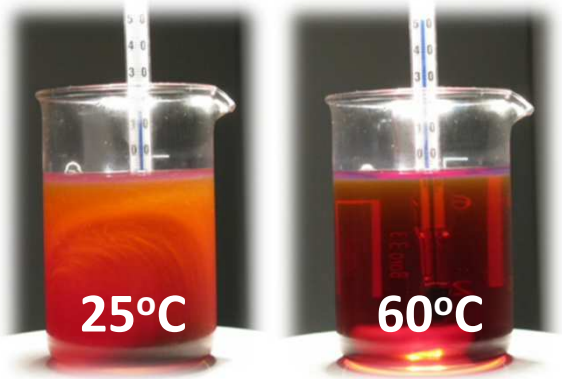
Soft Contaminants - Varnish

- **Temperature effect on Varnish**:
  - The solubility of varnish is such that they can change from soluble to suspended phase depending upon the temperature of the fluid

    Varnish contaminants become soluble > 55˚C
  - Conversely, the varnish products will fall out of solution over the course of many hours or days when the temperature of the fluid drops below 40˚C (for example during outage/shutdown)

- **Pressure Effect on Varnish:**
  - Elevated pressure will drive deposits out of solution and increase varnish potential



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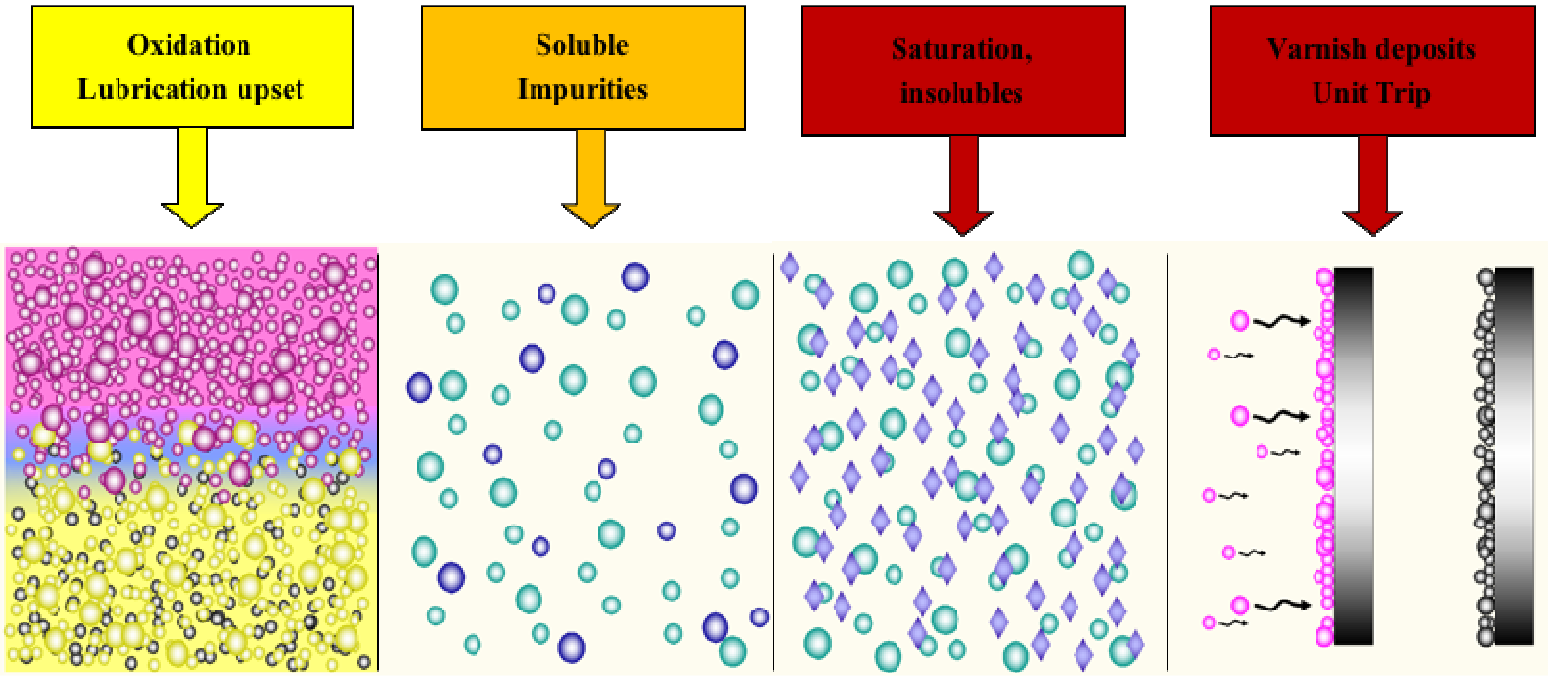
Soft Contaminants - Varnish

- Temperature and Pressure depending
- Critical Temperature -> 40^0C – 50^0C
- Soluble / Insoluble
- Organic P^+
- White Metal Surfaces



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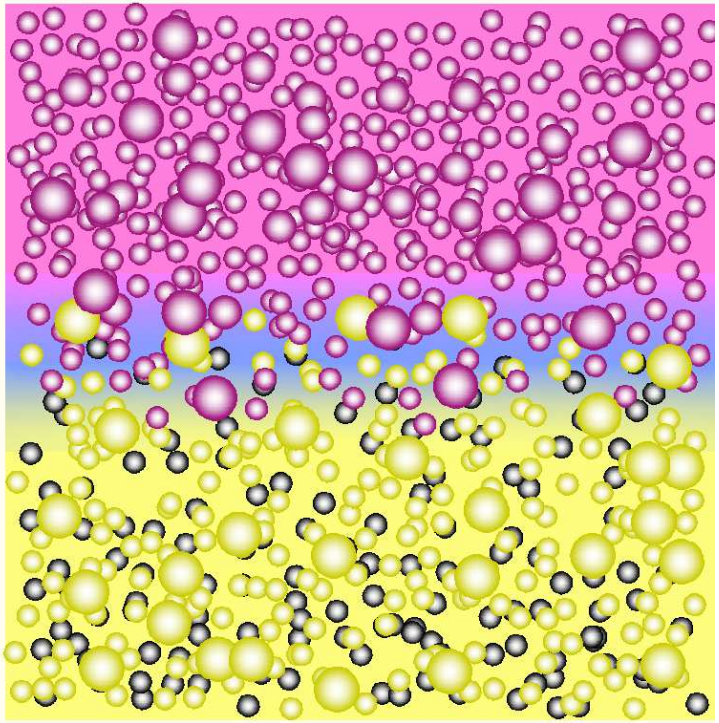
Soft Contaminants - Varnish

Step 1: Lubricant Upset

- Oxidation
- Fluid Breakdown
- Acids + Free radicals



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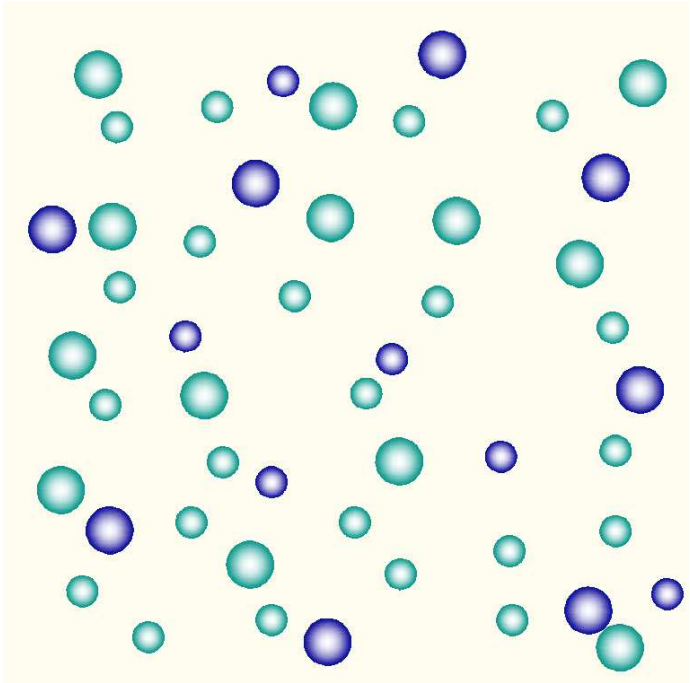
Soft Contaminants - Varnish

Step 2: Soluble Impurities

- Oxidation byproducts build
- Oil darkens
- Foul odor
- Acid Number (AN) increases



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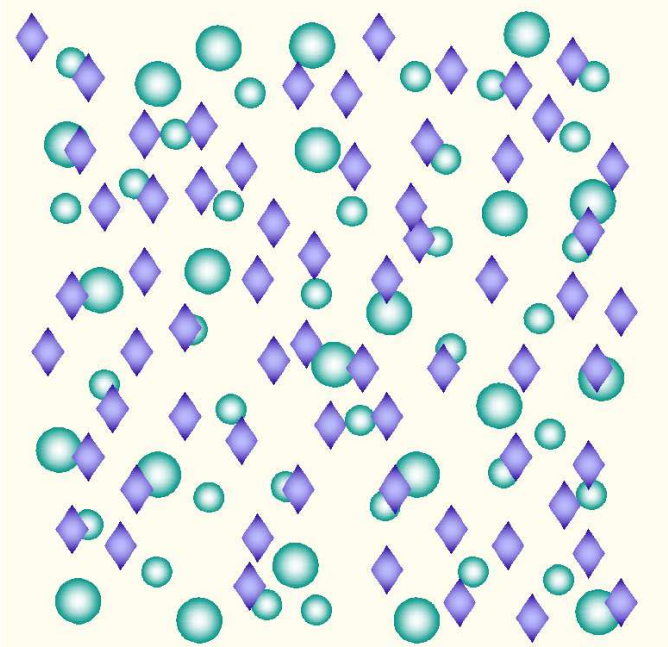
Soft Contaminants - Varnish

Step 3: Insoluble Suspensions

- Saturation point
- Sugar out of the coffee (soluble to insoluble)
- Varnish molecules form
- Looking for partners



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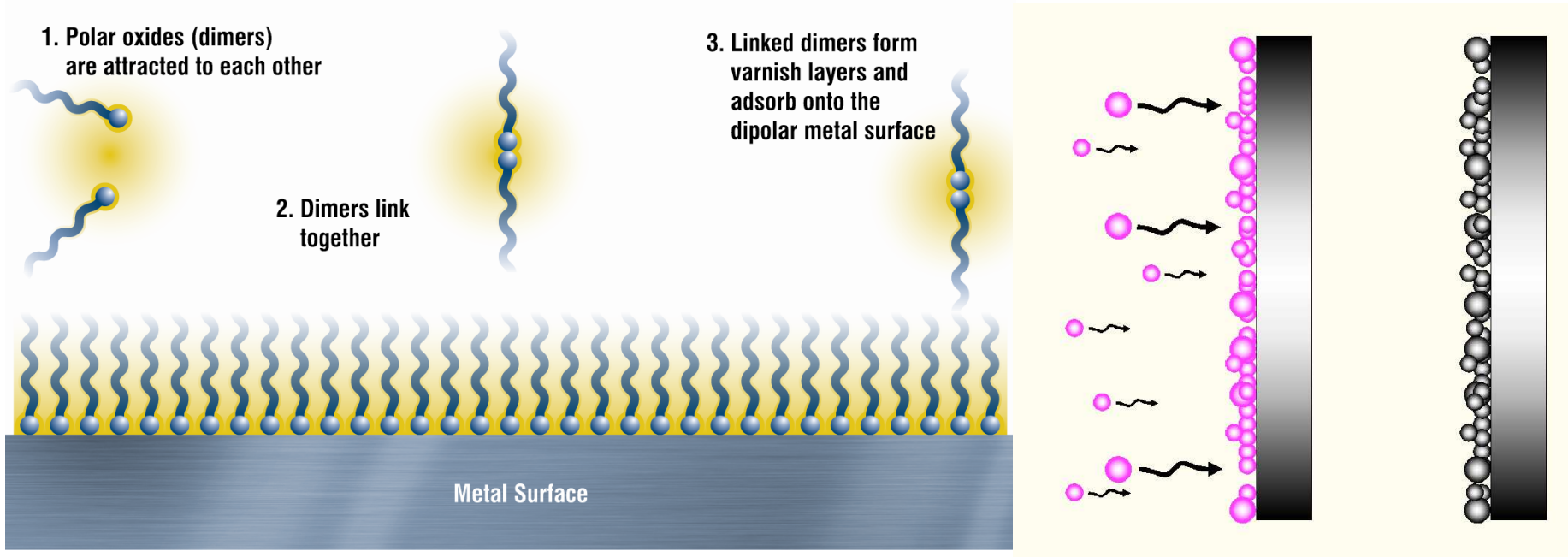
Soft Contaminants - Varnish

Step 4: Varnish Deposits Form



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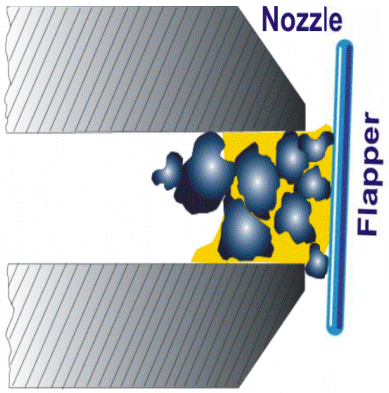
Varnish in compressor lube oil causes problems

- Deposits in heat exchanger
- High operating temperature
- Bearing failures
- Unplanned maintenance & downtime
- Premature oil disposal
- Sticky valves
- Fail Starts
- Unit Trips



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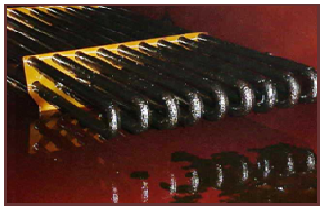
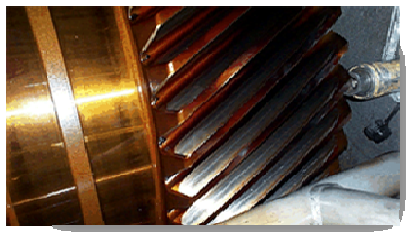
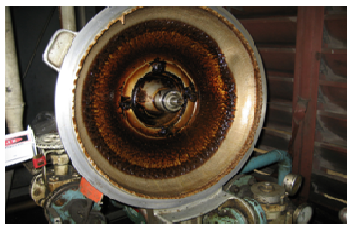
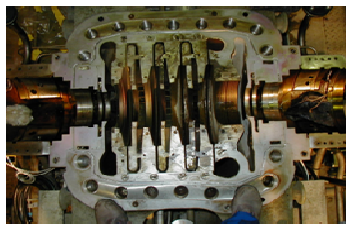
More soft contaminants related problems

- Deposits cause a lot of problems:
  - Sticking valves
  - Plugged lubricant orifices
  - Plugging filters
  - Inefficient heat exchanger operatic
  - Bearing Lubrication
  - Loss of Seals









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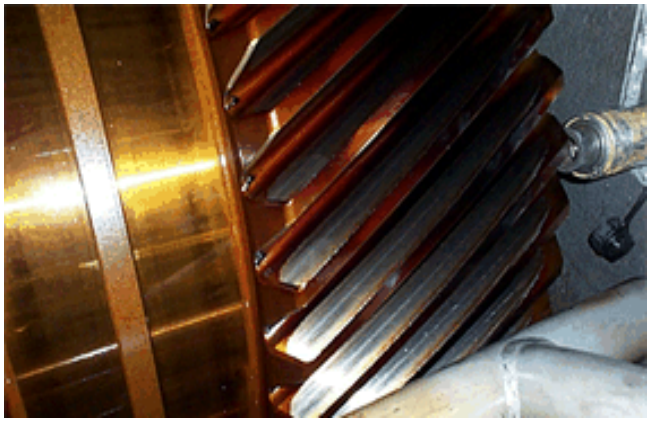
More soft contaminants related problems



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SVR

ICB

Varnish & Acid Scavenging Systems :

- SVR Soluble Varnish Removal Filter Systems
- FSTO Turbine Oil Varnish Removal Systems
- FSA Phosphate Ester Varnish Removal Systems
- FSJL Jet Lube Varnish Removal Systems
- ECR Electrostatic Contamination Removal Systems
- ICB Ionic Charged Bonding Filter Elements

FSTO

ECR

FSA

FSJL

LCS

Fluid Handling, Storage & Customer made:

- LCS Liquid Conditioning Station
- Custom Equipment

Custom Equipment: FSAPE

Custom Equipment: V10-ATEX

Custom Equipment:
V5 – Explosion Proof Class 1 Div 1

Custom Equipment:
Heater & HighSpeed Flushing unit

Thanks

End of this part of the presentation

Next Presentation:

Market Approach / Markets