THE IMPACT OF CONTAMINATION ON ROLLING ELEMENT BEARING LIFE
What Causes Machines to Fail?

70% of loss of machine life is due to loss of surface material

Loss of Usefulness

Ref: MIT, E. Rabinowicz
What Causes Surface Degradation?

Surface Degradation

- Corrosive Wear: 20%
- Mechanical Wear: 50%

Ref: MIT, E. Rabinowicz
What Causes Machines to Wear?

82% of mechanical wear is caused by particle contamination

* Most common lubrication related failure modes for rolling element bearings

Ref: NRCC, STLE
Contact Fatigue

**Where it occurs:** Particle-induced fatigue pitting can occur anytime clearance sized particle exist between surfaces in rolling contact (EHD films).

**How to stop it:** Particle-induced fatigue wear can be reduced or eliminated by removing clearance-sized particles from the oil or increasing the oil’s film thickness beyond the size of the particles.
Three-body Abrasion

**Where it occurs:** Three-body abrasion occurs any time clearance-sized particles are present in the oil between two surfaces in sliding contact.

**How to stop it:** Three body abrasion can be reduced or eliminated by removing clearance-sized particles from the oil or increasing the oil’s film thickness beyond the size of the particles.
What Causes Bearings to Fail?

- Specific to rolling element bearings, it has been estimated that over 50% of bearing failure are induced by contamination.

- According to SKF “bearings can theoretically have an infinite life, provided particles the same size as the lubricant film are removed.”
How Big is a Micron? How Big is the Oil Film?

In most rolling element bearings the dynamic clearance between the rollers and raceways under load/speed is the same size as pollen, soot or red blood cells.

Dynamic clearance = 0.1-10 microns
Oil and Water do Mix

States of Coexistence

**Dissolved Water**

Can effect oil life by increasing oxidation rates and degrading additives.

**Emulsified Water**

Causes machine wear via corrosion, cavitation and loss of film strength. Shortens oil life by increasing oxidation, additive degradation and water washing.

**Free Water**

Serves to indicate that the oil has reached saturation for dissolved and emulsified water.

Factors that affect demulsibility

- Viscosity
- Contaminants
- Loss of additives
- Oil type
- Oxidation
- Temperature
## Effects of Contamination on Bearing Life

<table>
<thead>
<tr>
<th>Damage Caused by Contaminant Type</th>
<th>Direct Machine Wear</th>
<th>Damage to Lubricant</th>
<th>Indirect Damage</th>
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<tbody>
<tr>
<td><strong>Particle Contamination</strong></td>
<td>• Abrasion</td>
<td>• Oxidation</td>
<td>• Varnish / Deposits</td>
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<tr>
<td></td>
<td>• Fatigue</td>
<td>• Particle Scrubbing</td>
<td>• Corrosive attack</td>
</tr>
<tr>
<td><strong>Moisture Contamination</strong></td>
<td>• Corrosion (rust, fretting corrosion etc.)</td>
<td>• Oxidation</td>
<td>• Varnish / Deposits</td>
</tr>
<tr>
<td></td>
<td>• Cavitation erosion (journal bearings)</td>
<td>• Hydrolysis</td>
<td>• Corrosive attack</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Water Washing</td>
<td>• Increase Aeration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Viscosity Increase</td>
<td>• Exacerbates all wear mechanisms due to loss of film strength</td>
</tr>
</tbody>
</table>
Effects of Particle Contamination on Bearing Life

3x Life Extension!
Effects of Water Contamination on Bearing Life

Oil appears "hazy"

Oil appears clear
Beware of Cycling Temperatures

When a machine shuts down and the oil cools, the relative humidity within the oil rapidly increase until the oil hits the dew point, resulting in free and emulsified water.
Sources of Moisture & Particle Ingression

- breather/vent during normal aspiration
- Through the dipstick port or other open vent
- Through the shaft seal due to wash down or normal ambient humidity
Headspace Management – the Key to Contamination Control

"At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid."

*Henry’s Law 1803*

**Strategies for headspace management**

- Desiccant breathers
- Hybrid breather
- Nitrogen purge
- Conditioned air purge
- Expansion chambers
OEM Vent Port vs Desiccant Breathers

Upgrading basic vents or OEM fill ports to desiccant breathers helps control contamination.
Controlling Headspace Cleanliness and Humidity

inhale

exhale
Desiccant Breathers Help to Maintain a Low Headspace Humidity
Additional Strategies for Controlling Contaminants

• Top off oil • Check oil level • Take oil sample
• Drain/fill oil • Kidney loop oil
Summary

- Over than 50% of bearing failures are due to water or particle ingestion
- Particles the same size as a red blood cell (3 microns) can reduce bearing life by as much as 66%
- The best way to control oil cleanliness and dryness is to control the headspace cleanliness and humidity
- All lubrication tasks including oil changes and top-offs, sampling, levels etc. should be done without exposing the oil to the ambient environment
THANK YOU FOR YOUR PARTICIPATION