BRIDGING THE GAP:
FILTER DEBRIS ANALYSIS

Henry Neicamp | 5.22.19
About the Speaker

HENRY NEICAMP | POLARIS LABORATORIES®

Henry Neicamp
Technical Business Consultant

Industry Experience

- B.S. General Engineering/Mining Engineering University of Illinois
- More than 35 years technical sales, engineering and management experience in the petroleum industry and lubricants marketplace
- Well Logging Engineer with Seismograph Service Corporation and Dresser Industries
- Sales Engineer and Technical Services Manager with Pennzoil-Quaker State Company
- Sales/Technical Engineer with Warren Oil Company
- Field Services Manager; Midwest Territory Sales Manager; Technical Business Consultant with POLARIS Laboratories®
- CLS/OMA certified by STLE
Detect failure at its earliest stages!
WHAT IS FILTER DEBRIS ANALYSIS (FDA)?

- FDA is a way to determine what particles (data) are being captured by the filters
- Filters by nature capture all large particles so these particles are excluded from routine oil analysis
- FDA on large particles provides valuable insight on how the machine is functioning
- Originated in the mining industry
  - Estimate equipment life expectancy, monitor wear
WHY DO FILTER DEBRIS ANALYSIS (FDA)?

• Your filter can tell you things your oil can’t!
  – Filter Debris Analysis (FDA) identifies “MISSING DATA”, such as contaminants and wear mechanisms not detected by traditional elemental analysis.
WHAT PARTICLES ARE BEING CAUGHT BY YOUR FILTER?

What data is your filter "catching"
WHAT ARE THE BENEFITS?

- Detects early stages of component failure
- Bridges gap between elemental analysis & Particle Count (PC) / Particle Quantifier (PQ)
- Determines particle size, type & wear mechanism
- Tell you what is causing filter plugging
- Facilitates root cause analysis
FIELD TESTING

• Mechanics have been cutting filters for years
• When doing this, you may observe abnormal wear particles
• Now what?
WHAT FILTERS CAN BE TESTED?

Spin-On Filter

Canister Filter

Filters that have been cut

Up to 8” in diameter and 6-21 inches long
HOW IS FDA PERFORMED?

1. Filter is received and prepared for flushing
2. Filter is installed in flushing apparatus & flushed w/solvent
3. Flushed solvent is collected and prepared for: acid digestion and microscope analysis
4. Spectral analysis is performed on prepared fluid then microscopic analysis is performed
5. Report is generated with data analyst’s observation and sent to the customer
HOW IS FDA PERFORMED?

Filter Flushing
Agitated and Separated

Sample A
Centrifuge
Micropatch
Acid Digestion -- ICP

Sample B
Micropatch
FDA TESTS PERFORMED

- Elemental Analysis by ICP, if applicable (oil from filter)
- Acid Digestion Elemental Analysis (filter flushing fluid)
- Analytical Ferrography
- Micropatch
FDA WEAR DEBRIS

ANALYTICAL FERROGRAPHY

MICROPATCH
WHAT CAN FDA IDENTIFY THAT STANDARD TESTING CANNOT?

Analytical Ferrography

- Ferrous metals
- Type of wear
- How much
- How large
- Typically for boundary lubrication
WHAT CAN FDA IDENTIFY THAT STANDARD TESTING CANNOT?

Micropatch

- Non-Ferrous metals
  - Bronze
  - Lead
- Soot agglomerations
- Metallic debris
- Dirt
- Black oxides
- Red (rust) oxides
# OIL SAMPLING VS. FDA

<table>
<thead>
<tr>
<th>Testing provides</th>
<th>Routine Oil Analysis</th>
<th>Filter Debris Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle wear up to 10 micron</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Particle wear greater than 10 micron</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Provide information on type of wear</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Maintenance recommendations</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Lubricant additive information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detailed photographs of magnified wear particles</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Detect and identify contamination outside of the</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>standard / routine 24 element spectroscopy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
INTERPRETING A REPORT
# INTERPRETING A REPORT

## Filter Debris Analysis

<table>
<thead>
<tr>
<th>Component ID</th>
<th>Secondary ID</th>
<th>Component Type</th>
<th>Manufacturer</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 FILTER</td>
<td>MILL GEARBOX</td>
<td>FILTER-GEAR SYSTEM</td>
<td>KSP400</td>
<td></td>
</tr>
<tr>
<td>Filter Manufacturer</td>
<td>Filter Number</td>
<td>Unit Time</td>
<td>Oil Time</td>
<td>Filter Time</td>
</tr>
<tr>
<td>12 Months</td>
<td>9 Months</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Account Number</th>
<th>Company Name</th>
<th>Lab Number</th>
<th>Analyst</th>
<th>Solids (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/16/2017</td>
<td>000-000-000</td>
<td></td>
<td>I-123456</td>
<td>JDT</td>
<td>9.8036</td>
</tr>
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</table>
### Evaluation and recommendations from the analyst

With the lubricant change and repair previously done, no corrective action is suggested. There is no wear debris present that suggests this unit is having a progressive failure event. Significant amount of aluminum alloy. Suspect this is residual from the contamination ingestion event mentioned on the phone causing cylinder region wear, specifically the piston. Moderate amount of ferrous rubbing wear. Rubbing wear is from normal sliding contact of surfaces. Moderate amount of sliding wear particles, which potentially indicates the components were subjected to excessive load or speed. Moderate amount of abrasives (silica/dirt and environmental contaminants). Moderate amount of soot. Soot is a normal byproduct of the combustion process.
INTERPRETING A REPORT

Evaluation

With the lubricant change and repair previously done, no corrective action is suggested. There is no wear debris present that suggests this unit is having a progressive failure event. Significant amount of aluminum alloy. Suspect this is residual from the contamination ingestion event mentioned on the phone causing cylinder region wear, specifically the piston. Moderate amount of ferrous rubbing wear. Rubbing wear is from normal sliding contact of surfaces. Moderate amount of sliding wear particles, which potentially indicates the components were subjected to excessive load or speed. Moderate amount of abrasives (silica/dirt and environmental contaminants). Moderate amount of soot. Soot is a normal byproduct of the combustion process.

<table>
<thead>
<tr>
<th>Method (ppm)</th>
<th>Iron</th>
<th>Chrome</th>
<th>Nickel</th>
<th>Titanium</th>
<th>Manganese</th>
<th>Copper</th>
<th>Lead</th>
<th>Tin</th>
<th>Aluminum</th>
<th>Silicon</th>
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</thead>
<tbody>
<tr>
<td>ICP Oil</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
<td>NES</td>
</tr>
<tr>
<td>Acid Digestion / ICP</td>
<td>213910</td>
<td>900</td>
<td>2823</td>
<td>0</td>
<td>866</td>
<td>2163</td>
<td>0</td>
<td>0</td>
<td>4210</td>
<td>0</td>
</tr>
</tbody>
</table>

### Elemental analysis of the oil from the filter if applicable

- Ferrous:
  - 2-5μm: 2
  - 5-10μm: 2
  - 11-25μm: 1
  - 25-50μm: 0
  - 51-100μm: 0
  - >100μm: 0

- Non-Ferrous:
  - 2-5μm: 2
  - 5-10μm: 3
  - 11-25μm: 3
  - 25-50μm: 1
  - 51-100μm: 0
  - >100μm: 0

### Elemental of the debris flushed from the filter after Acid Digestion
# INTERPRETING A REPORT

With the lubricant change and repair previously done, no corrective action is suggested having a progressive failure event. Significant amount of aluminum alloy. Suspected mentioned on the phone causing cylinder region wear, specifically the piston. Moderate normal sliding contact of surfaces. Moderate amount of sliding wear particles, with excessive load or speed. Moderate amount of abrasives (silica/dirt and environment) byproduct of the combustion process.

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<th>Titanium</th>
<th>Manganese</th>
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<tbody>
<tr>
<td>ICP Oil</td>
<td>N/E</td>
<td>N/E</td>
<td>N/E</td>
<td>N/E</td>
<td>N/E</td>
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<tr>
<td>Acid Digestion / ICP</td>
<td>213910</td>
<td>0</td>
<td>2823</td>
<td>0</td>
<td>866</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Particle Size (μm)</th>
<th>Ferrous</th>
<th>Non-Ferrous</th>
<th>Cutting</th>
<th>Fatigue</th>
<th>Spheres</th>
<th>Sliding</th>
<th>Red Oxides</th>
<th>Black Oxides</th>
<th>Dirt</th>
<th>Soot</th>
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<tbody>
<tr>
<td>2-5</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>2</td>
</tr>
<tr>
<td>5-10</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>11-25</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>51-100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>&gt;100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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</tbody>
</table>
DEBRIS: MICROSCOPE PHOTOS

<table>
<thead>
<tr>
<th>Analytical Ferrography</th>
<th>Analytical Ferrography</th>
<th>Analytical Ferrography (Heat Treated)</th>
<th>Micropatch</th>
</tr>
</thead>
</table>
SUCCESS STORY

• ABC Company with large expensive gearbox(s) was experiencing failures
• FDA – Detailed Analysis Impossible; AF – Clean; Micropatch – Severe Varnish
• Company is flushing gearboxes and switching to an oil with better oxidative stability
• Gearbox(s) costs $250K apiece and the company has many of these gearbox(s)
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THANK YOU!

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