Improve Equipment Reliability and Reduce Costs with Clean Oil

Presented by: Caren Caffrey
C.C.JENSEN Inc.
Topics

- Oil Contamination 101
- Mobile Mining Equipment conundrum
- CJC™ Mobile Flushing Unit concept
- Case Studies
- Questions
Primary Causes of Oil Related Problems

- Moisture/water creating micro-pitting and cavitation
- Oxidation products: Varnish and sludge resulting in sticky valves, dirty tanks etc.
- Catalysts for oil degradation
- Particles creating abrasive wear and machine breakdown

Essential for best practice lubrication: Cool, clean and dry oil
Abrasivewear

Fatigue Wear

1. Particle trapped
2. Cracking initiated
3. Load and stress, cracks spread
4. Surface failure, creating particles, spall
Oil Contamination by Particles

Dispersion of particles by size

- In medium loaded oil systems, the dispersion of particles will be as follows:
  - Only approximately 10% of the particles are \( \geq 10 \, \mu m \)
  - Approximately 70-80% of the particles are between 1-5 micrometre

MacPherson graphic

The importance of particles

The graph is based on a test with roller bearings. The lubricant was contaminated by wear of a gearbox.
Dynamic Oil Film

Journal, slide and sleeve bearings:
Hydraulic cylinders:
Engines, ring/cylinder:
Rolling element bearings / ball bearings:
Servo and proportional valves:
Gear pumps:
Piston pumps:
Gears:
Dynamic seals:

**Oil film thickness:**
- 0.5 – 100 microns
- 5 – 50 microns
- 0.3 – 7 microns
- 0.1 – 3 microns
- 1 – 3 microns
- 0.5 – 5 microns
- 0.5 – 5 microns
- 0.1 – 1 micron
- 0.05 – 0.5 micron

Source: Noria Corporation

- 3 µm - bacteria
- 1 µm - tobacco smoke
- 5 µm - flour
The ISO 4406/1999 classification of particle contents was introduced to facilitate comparison in particle counting, using automatic particle counters.

ISO 4407/1999 is describing particle counting using a microscope (particle sizes 2 / 5 / 15 µm).

Sudden break-down in an oil system is often caused by large particles (≥ 14 µm) in the oil while slower, progressive faults, e.g. wear and tear, are caused by the smaller particles (2-6 µm).

This is one of the explanations why the particle reference sizes were set to 4 µm, 6 µm and 14 µm in ISO 4406.

A typical sample from a new oil contains in every 100 ml:

- 450,000 particles ≥ 4 micron
- 120,000 particles ≥ 6 micron
- 14,000 particles ≥ 14 micron

Introduced in the ISO classification table (on the right), this oil sample has a contamination class of 19/17/14.

<table>
<thead>
<tr>
<th>More than</th>
<th>Till</th>
<th>Class</th>
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<td>2,000,000</td>
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<tr>
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<td>64</td>
<td>130</td>
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<td>32</td>
<td>64</td>
<td>6</td>
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</table>

Max. number of particles per 100 ml fluid after their size ranges.

Typically given per millilitre in the US and Canada
Examples of ISO Codes

Test membranes and microscopic photographs of various contamination levels

ISO 14/12/10

ISO 16/14/11

ISO 17/15/12

ISO 19/17/14

ISO 22/20/17

New oil is typically around ISO 19/17/14
## LET – Cleanliness Level
### ISO Codes, Complete

<table>
<thead>
<tr>
<th>Current Machine Cleanliness (ISO Code)</th>
<th>Expected Cleanliness level (ISO Code)</th>
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<tr>
<td></td>
<td>21/19/16</td>
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<tr>
<td>24/22/19</td>
<td>21/19/16</td>
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<tr>
<td>23/21/18</td>
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<td>1.3</td>
</tr>
<tr>
<td>15/13/10</td>
<td>1.3</td>
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</table>

**Source:** Noria Corp.

H&L 2013 Improve Equipment Reliability & Reduce Costs with Clean Oil
Mobile Mining Equipment Conundrum

Operation vs. Maintenance
The Cost of Wear

Repairing the wheel motor on a mining haul truck

- Lost production: $190,000 + per day
- Oil Change: $3,500 - $4,000 + labor
- Minor repair (seals replacement): $90,000 - $130,000
- Major repair (seals, bearings, sleeves): $230,000 - $260,000
- Replacement of wheel motor:
  - Cost: $650,000 - $780,000
  - Lead Time: 1 – 21 Days

Repair cost easily exceeding 250,000 USD
What should you do?

- Ensure Clean Oil by flushing out dirt, wear particles and sludge from the oil systems (hydraulic/gear motor/differential etc.).

- Clean Oil improves oil and additive life.

- Clean Oil reduces component wear and significantly increases reliability & life expectancy.

The solution:

CJC™ Mobile Flushing Unit, MFU
CJC\textsuperscript{TM} Mobile Flushing Unit

- Optimized for high viscosity lubricants
- Measure particulate contamination with in-line CJC\textsuperscript{TM} Oil Contamination Monitor
- Automatic flow regulation based on viscosity
- Heated oil reservoir
- Preheaters maintain optimal oil temperature
- 3 um cellulose depth filter inserts
- Large dirt holding capacity (~50-60 Lbs)
- Cam-Lock couplings for easy mounting
- Removable tool box
The CJC™ Mobile Flushing Unit

Effective in cold climates & with high viscosity oils

Flexible installation options

During PM in the workshop area
Case 1: Komatsu 930E Haul Truck

Objective: Exceed OEM oil cleanliness specs

- Mobil SHC 680 gear oil
- Severe weather conditions (minus 4°C)
- Oil cleanliness before flushing: ISO 25/25/23
- In 10 min, contamination reduced 98%

- Oil Cleanliness after 90 Min: ISO 16/15/11

Life Expectancy Extension: ~3.5X
Goal: Filter new hydraulic oil to OEM
USL ISO 19/17/14

New shovel being assembled on-site
• Main reservoir: 3,785 L ISO 32 hydraulic oil
• Bulk oil initial cleanliness: ISO 23/19/14

Problem: Oil is added to the shovel in 200 L batches. Each batch must be below the required ISO target before the machine will transfer to main reservoir. The on-board filter was not capable of cleaning the oil to the desired level.

Solution:
Each batch was pre-cleaned with CJC™ MFU. ISO 14/13/11 was achieved after 30 minutes of processing.
Case 3: Caterpillar 793C/D Haul Truck

Goal: Reduce costs by flushing differential/planetary gear oil

- 1,022 L of SAE 60 Final Drive Axle Oil (FDAO)
- Target: ISO 19/17/14

- Planetaries & differential share oil sump
- CJC™ MFU draws oil from differential, return is split and flushed in through each wheel
- Flushing is performed every 500 hours during 8 hour ‘Mini-PM’

Oil cleanliness after 8 hours: ISO 17/15/12
Case 3: Caterpillar 793C/D Haul Truck

Financial Results

Initial Benchmarks:
- Wheel Assembly Rebuild: 18,000 hours
- Oil: ~$3,600
- Average Cleanliness: ISO 22/20/17

New Benchmarks After CJC™ MFU:
- Wheel Assembly Rebuild: 25,000 hours
- Oil: ~$3,600
- Average Cleanliness: ISO 17/15/13

Average Fleet Operating Hours / year: 290,000

Wheel Assembly Rebuilds:
- Initial: 16 per year
- New: 12 per year
- Cost: ~$95,000 each
- Savings: ~$380,000

Additional Savings: ~$100,000
- Reduced oil consumption, labor, downtime

Estimated Annual Savings: ~$480,000 - 500,000
Case 4: Caterpillar 797B Haul Truck

Goal: Reduce oil change costs for 100+ truck fleet

**Planetary / Differential Gear system:**
SAE 60 Final Drive Axle Oil (FDAO)
Oil Volume:
- 700 L in Differential
- 1,480 L total

Oil changed every 2,000 hours or less
$15,000 + per truck
4 x per year

Potential Oil Consumption Savings: $1.5 – 3.0 M

<table>
<thead>
<tr>
<th>ISO Code Particle Size</th>
<th>4 µm</th>
<th>6 µm</th>
<th>15 µm</th>
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<tbody>
<tr>
<td><strong>Start up</strong></td>
<td>22</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td><strong>5 hour flush</strong></td>
<td>16</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td>98.0%</td>
<td>96.5%</td>
<td>93.0%</td>
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</table>

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<table>
<thead>
<tr>
<th>Region</th>
<th>Industry</th>
<th>Equipment Type</th>
<th>Equipment Model</th>
<th>Oil Type</th>
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<tbody>
<tr>
<td>Alberta</td>
<td>Oil Sands</td>
<td>Mine Truck</td>
<td>Caterpillar 797B</td>
<td>SAE 60 Gear Oil, FDAO</td>
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<tr>
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<td>Oil Sands</td>
<td>Mine Truck</td>
<td>Komatsu 930E</td>
<td>ISO 680 Gear Oil</td>
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<td>Caterpillar 7495</td>
<td>ISO 46 Hydraulic Oil</td>
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<tr>
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<td>Mine Shovel</td>
<td>Caterpillar 797B</td>
<td>SAE 60 Gear Oil, FDAO</td>
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<tr>
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<td>Copper</td>
<td>Mine Truck</td>
<td>Caterpillar 793</td>
<td>SAE 60 Gear Oil, FDAO 5W30 Hydraulic Oil</td>
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<tr>
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<td>Copper &amp; Gold</td>
<td>Mine Shovel</td>
<td>Caterpillar 7495</td>
<td>Hydraulic Oil</td>
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<td>Mine Shovels &amp; Trucks</td>
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<td>Hydraulic Oil</td>
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<tr>
<td></td>
<td></td>
<td></td>
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<td>SAE 60 Gear Oil, FDAO</td>
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Thank You!

C.C.JENSEN Inc. & C.C.JENSEN A/S

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