Improve Equipment Reliability and Reduce Costs with Clean Oil

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

Topics

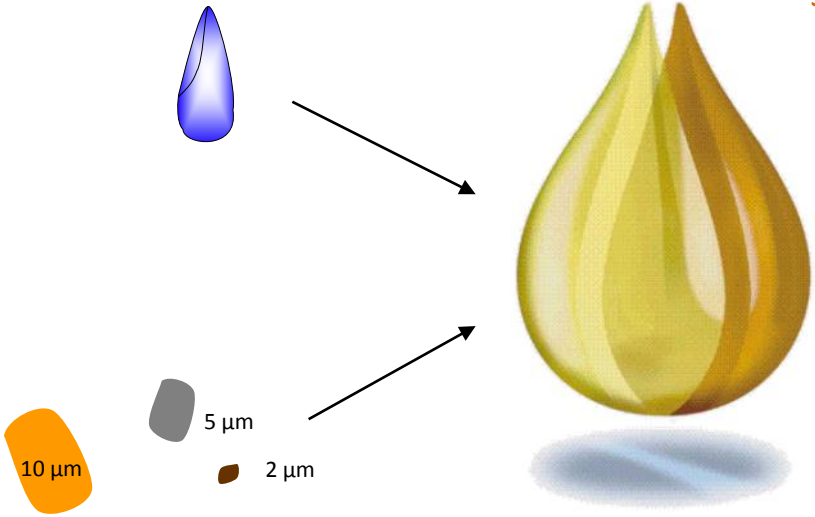
- Oil Contamination 101
- Mobile Mining Equipment conundrum
- CJC™ Mobile Flushing Unit concept
- Case Studies
- Questions

Primary Causes of Oil Related Problems

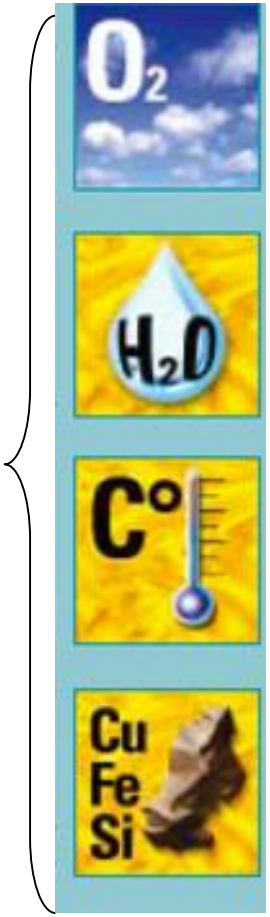
Moisture/water creating micro-pitting and cavitation

Oxidation products:

Varnish and sludge resulting in sticky valves, dirty tanks etc.



Catalysts for oil degradation

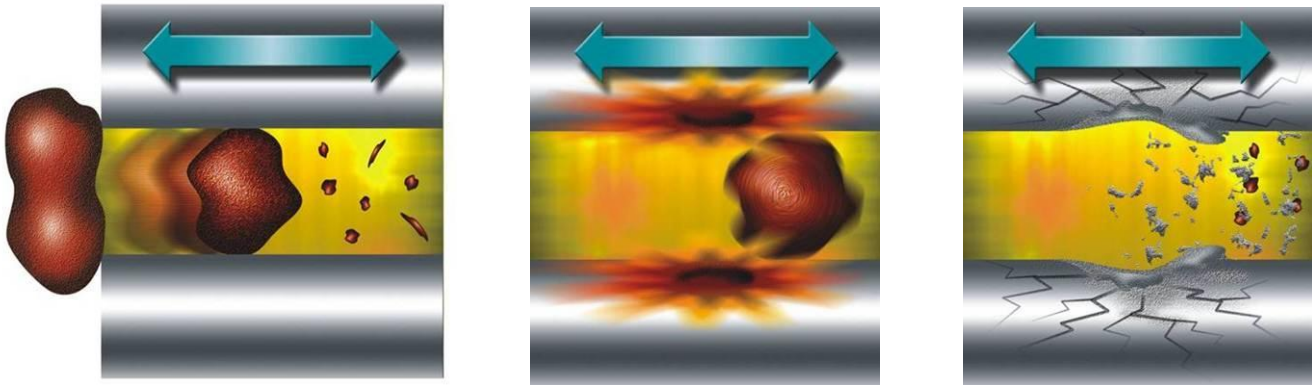


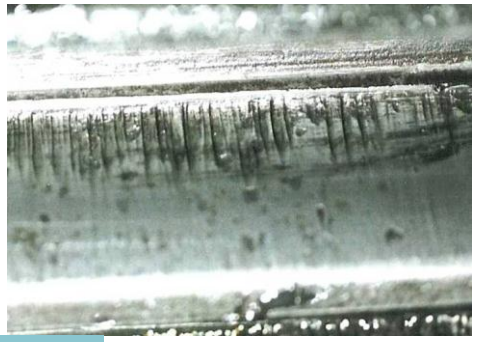
Particles creating abrasive wear and machine breakdown

Essential for best practice lubrication:

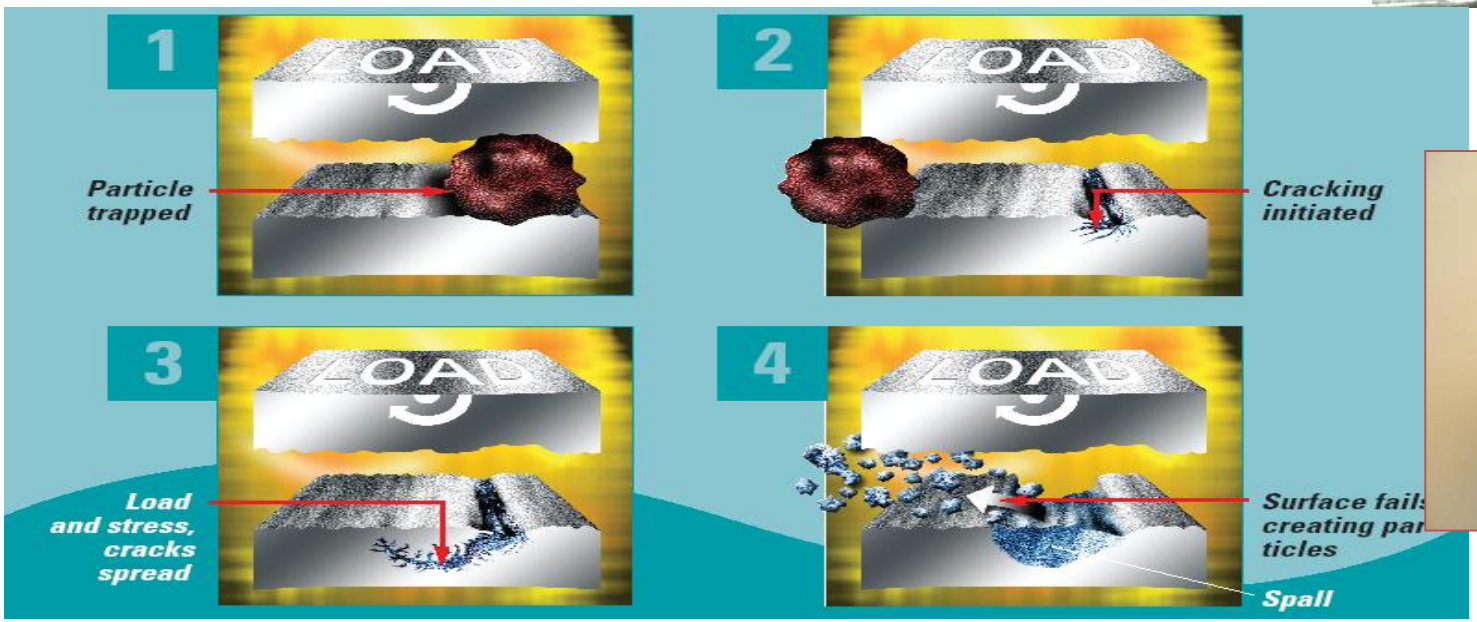
Cool, clean and dry oil

Abrasive Wear



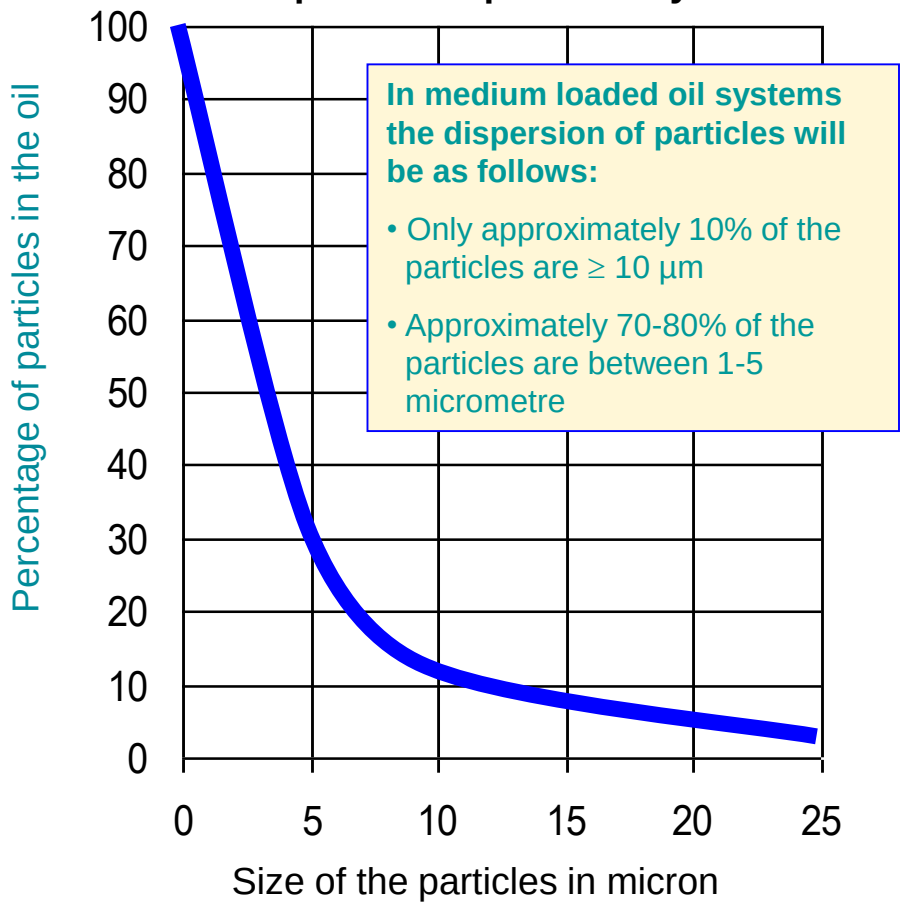


Fatigue Wear



Oil Contamination by Particles

Dispersion of particles by size

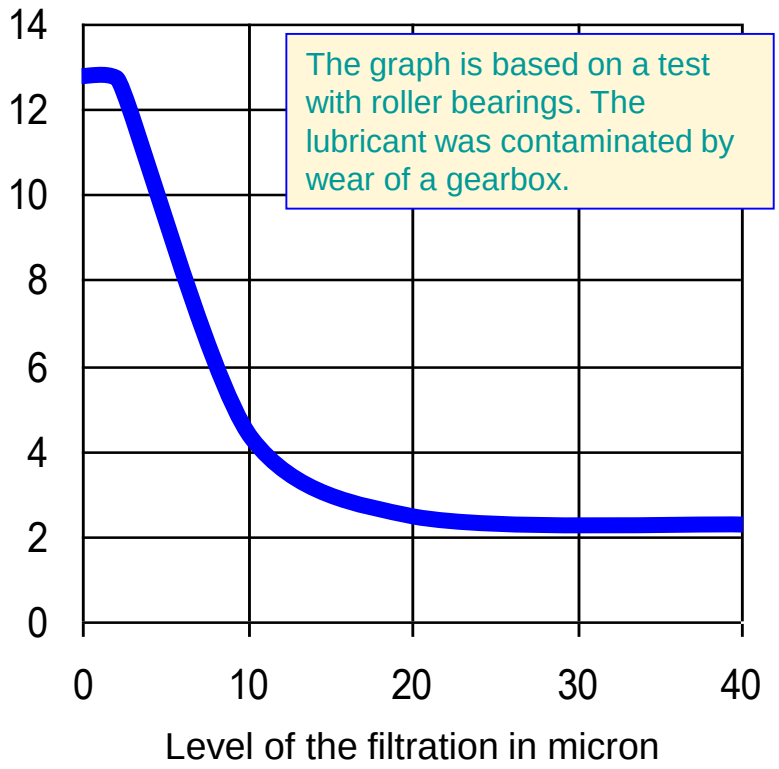


In medium loaded oil systems the dispersion of particles will be as follows:

- Only approximately 10% of the particles are ≥ 10 µm
- Approximately 70-80% of the particles are between 1-5 micrometre

MacPherson graphic

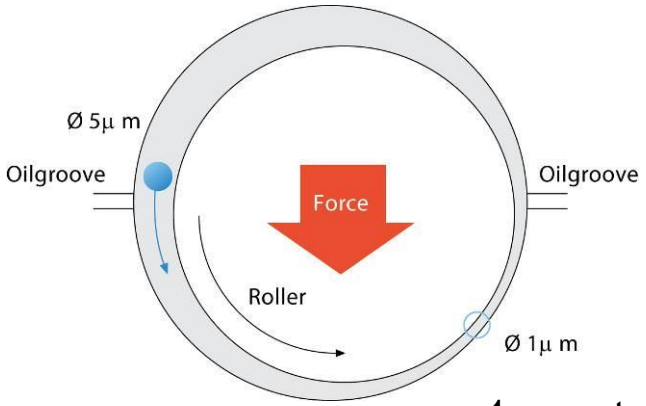
The importance of particles



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

Dynamic Oil Film

	Oil film thickness:
Journal, slide and sleeve bearings:	0.5 – 100 microns
Hydraulic cylinders:	5 – 50 microns
Engines, ring/cylinder:	0.3 – 7 microns
Rolling element bearings / ball bearings:	0.1 – 3 microns
Servo and proportional valves:	1 – 3 microns
Gear pumps:	0.5 – 5 microns
Piston pumps:	0.5 – 5 microns
Gears:	0.1 – 1 micron
Dynamic seals:	0.05 – 0.5 micron



Source: Noria Corporation

3 µm - bacteria

1 µm - tobacco smoke

5 µm - flour

ISO Standards - 4406/1999

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

Typically given per millilitre in the US and Canada

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

Contamination Classes according to the new ISO 4406/1999 Standard:

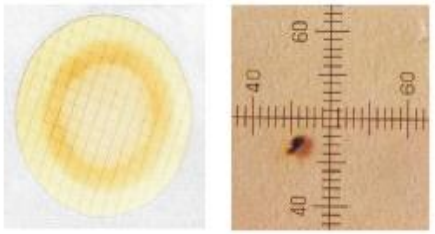
More than	Till	Class
8,000,000	16,000,000	24
4,000,000	8,000,000	23
2,000,000	4,000,000	22
1,000,000	2,000,000	21
500,000	1,000,000	20
250,000	**500,000**	**19**
130,000	250,000	18
64,000	**130,000**	**17**
32,000	64,000	16
16,000	32,000	15
8,000	**16,000**	**14**
4,000	8,000	13
2,000	4,000	12
1,000	2,000	11
500	1,000	10
250	500	9
130	250	8
64	130	7
32	64	6

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

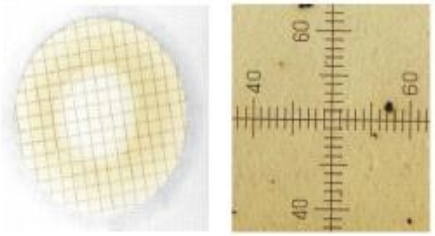
Examples of ISO Codes

Test membranes and microscopic photographs of various contamination levels

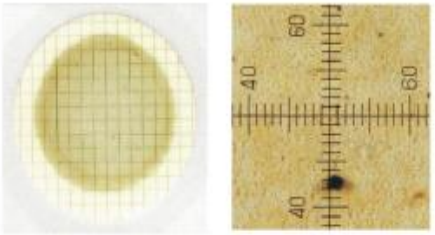
ISO 14/12/10



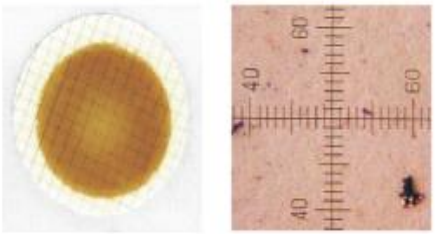
ISO 16/14/11



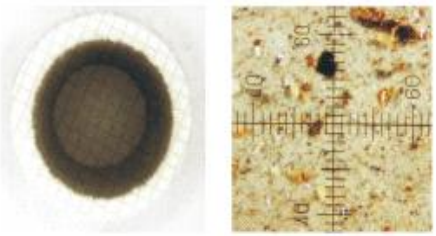
ISO 17/15/12



ISO 19/17/14



ISO 22/20/17



New oil is typically around ISO 19/17/14

LET – Cleanliness Level
ISO Codes, Complete

Current Machine Cleanliness (ISO Code)	Expected Cleanliness level (ISO Code)									
	21/19/16	20/18/15	19/17/14	18/16/13	17/15/12	16/14/11	15/13/10	14/12/9	13/11/8	12/10/7
24/22/19	2 1.6 1.8 1.3	3 2 2.3 1.7	4 2.5 3 2	6 3 3.5 2.5	7 3.5 4.5 3	8 4 5.5 3.5	>10 5 7 4	>10 6 8 5	>10 7 10 5.5	>10 >10 >10 8.5
23/21/18	1.5 1.5 1.5 1.3	2 1.7 1.8 1.4	3 2 2.2 1.6	4 2.5 3 2	5 3 3.5 2.5	7 3.5 4.5 3	9 4 5 3.5	>10 5 7 4	>10 7 9 5.5	>10 10 10 8
22/20/17	1.3 1.2 1.2 1.05	1.6 1.5 1.5 1.3	2 1.7 1.8 1.4	3 2 2.3 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4 5 3	9 5 6 4	>10 7 8 5.5	>10 9 10 7
21/19/16		1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.2 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4 5 3.5	9 6 7 4.5	>10 8 9 6
20/18/15			1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.3 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4.6 5.5 3.7	>10 6 8 5
19/17/14				1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.3 1.7	4 2.5 3 2	6 3 4 2.5	8 5 6 3.5
18/16/13					1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.3 1.8	4 3.5 3.7 3	6 4 4.5 3.5
17/15/12						1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.4	2 1.7 1.8 1.5	3 2 2.3 1.8	4 2.5 3 2.2
16/14/11							1.3 1.3 1.3 1.2	1.6 1.6 1.6 1.4	2 1.8 1.9 1.5	3 2 2.3 1.8
15/13/10								1.4 1.2 1.2 1.1	1.8 1.5 1.6 1.3	2.5 1.8 2 1.6

Hydraulics and Diesel Engines	Rolling Element Bearings
Journal Bearings and Turbo Machinery	Gear Boxes and others

Source: Noria Corp.

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

Avoid Expensive Downtime

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™ Mobile Flushing Unit

- Optimized for high viscosity lubricants
- Measure particulate contamination with in-line CJC™ 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

Flexible installation options

Effective in cold climates & with high viscosity oils

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

Case 2: Caterpillar 7495 Shovel

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.

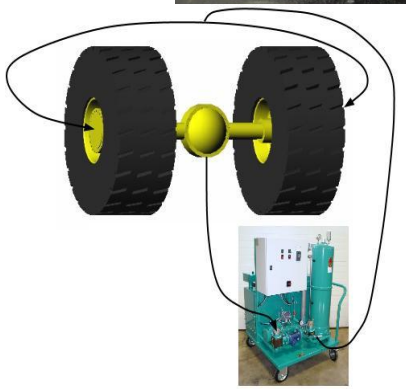
Oil cleanliness after 30 min: ISO 14/13/11

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

	ISO Code Particle Size		
	4 µm	6 µm	15 µm
Start up	22	20	15
5 hour flush	16	15	12
Reduction	98.0%	96.5%	93.0%

Potential Oil Consumption Savings: $1.5 – 3.0 M

Mine Equipment Reference List

Region	Industry	Equipment Type	Equipment Model	Oil Type
Alberta	Oil Sands	Mine Truck	Caterpillar 797B	SAE 60 Gear Oil, FDAO
Alberta	Oil Sands	Mine Truck	Komatsu 930E	ISO 680 Gear Oil
Alberta	Oil Sands	Mine Shovel	Caterpillar 7495	ISO 46 Hydraulic Oil
Alberta	Oil Sands	Mine Shovel	Caterpillar 797B	SAE 60 Gear Oil, FDAO
BC	Copper	Mine Truck	Caterpillar 793	SAE 60 Gear Oil, FDAO 5W30 Hydraulic Oil
BC	Copper & Gold	Mine Shovel	Caterpillar 7495	Hydraulic Oil
BC	Gold	Mine Scoops	Caterpillar R1600	HD 50 Gear Oil
Ontario	Gold	Mine Shovels & Trucks	Caterpillar 7495 Caterpillar 795	Hydraulic Oil SAE 60 Gear Oil, FDAO

Thank You!

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

Klassen Specialty Hydraulics Inc.

Harvey Klassen, Rick Klassen, Paul Berger

HAULAGE & LOADING