Lubrication Basics
Training Topics

- Introduction
- Safety Moment
- What a Lubricant is Expected to do
- What is Friction (causes)
- Lubrication Regimens
- Lubrication Intervals
- One Minute Inspections
Mike Hitchcock, CLS, OMA-1
Engineer
719-338-8436
mhitchcock@acornpetroleuminc.com

Certified Lubrication Specialist (STLE)
Certified Oil Monitoring Analyst (STLE)
Integration Engineer

• Navistar Truck and Engine (Workhorse)
• General Motors
• Spartan Motors
Who We Are
Problems are the price of progress. Don't bring me anything but trouble. Good news weakens me.

Charles Kettering
What’s a Lubricant Expected To Do?

• Reduce Friction
• Minimize Wear
• Cool Parts
• Prevent Corrosion
• Disperse Contaminants
• Act as a Sealant
• Transmit Power
3 Keys to Successful Lubrication

- Viscosity
- Additives
- Lubrication Practices
Five Rights of Lubrication

- Right Type of Lubricant
- Right Quality
- Right Amount
- Right Place
- Right Time
Causes of Friction

- Friction is caused by interactions at the surfaces of adjoining parts
  - At a microscopic level, all surfaces are “rough”
  - Surface peaks (asperities) may bond to one another or protrude into adjoining surface
Major Causes of Friction

- Movement of surfaces requires an applied force great enough to overcome microscopic surface interactions.
- Friction can lead to high wear.

Adhesion (Micro “Spot-Welding”)

A abrasive Deformation (“Plowing”)

Asperity Override (With Adhesion → “Stick-Slip”)
Ways to Reduce Friction

- Lower Adhesive
- Separate Surfaces With a Liquid (“Oil”) Film

- Design moving parts to roll over each other (minimize slide/roll ratio)

• Lower Adhesive

• Separate Surfaces With a Liquid (“Oil”) Film
Lubrication and Friction

• Coefficient of Friction Varies With Velocity

Three Positions of a Shaft (Journal) in a Bearing

A
At Rest

B
Starting Up

C
Steady Speed

Friction Coefficient

Velocity

Smooth

Rough Surfaces

Hydrodynamic Lubrication
Viscosity

Viscosity = Resistance to Flow

THE MOST IMPORTANT CHARACTERISTIC OF AN OIL!!
Viscosity

- Viscosity is a delicate balance
  - Viscosity too high
    - More heat from liquid friction
  - Viscosity too low
    - Mechanical friction
What Viscosity Does For Us
The force required to slide one object over another when the two surfaces are fully separated by a fluid is dependent on the fluid’s viscosity.

Viscosity is defined as a measurement of a fluid’s “RESISTANCE TO FLOW.”
Viscosity and Temperature

- Lubricant Viscosity Decreases Dramatically With Increasing Temperature \([\log(\log X)\) Relationship\]

- Viscosity Index (V.I.) is a Measure of an Oil’s Viscosity-Temperature Behavior

- Multigrade Oils Have Higher V.I.’s Than Single Grades, i.e., Their Viscosity Changes Less With Temperature
Viscosity Modifier Mechanism

Increasing Temperature

Increasing Viscosity Contribution

(Increasing Effective Size of Polymer)
Viscosity and Shear Rate

- High Speed Environments Cause Viscosity “Shear Down”
- Multigrade Oils Can Undergo Permanent Shear Losses With Age

Viscosity (Pa • Sec.)

- Oil Pan Flow Before Screen
- Across Screen
- New Oil
- Used Oil
- Polymer Additive
- High Shear
- Shear Deformed
- Very High Shear
- Bond Breakage
- Behind Piston Rings
- Valve Guides
- Pump Inlet
- Additive Permanent Shear Loss
- Crankshaft and Con Rod Bearings
- Piston Rings/Cylinder Liner
- Gears Cams, Tappets

Additive

Logarithmic Scale
Regimes of Lubrication
(Dependent on Speed, Viscosity, and Load)

• Hydrodynamic
  • Thick oil films

• Elastohydrodynamic (High Pressure)
  • Thin oil films

• Extreme Pressure or Boundary Lubrication
  • No oil film
BOUNDARY LUBRICATION

• Boundary Lubrication occurs in the absence of proper lubrication film. Additives can coat surfaces to prevent welding but tearing and damage can happen.
Mixed or Boundary or Extreme Pressure Lubrication

- Onset of metal/metal contact
- Need surface active anti-wear/anti-scuff (AW) and extreme pressure (EP) additive agents to prevent metal/metal adhesion and to lower shear forces (friction)
HYDRODYNAMIC LUBRICATION

- Continuous full-fluid film prevents metal to metal contact. The entire load is supported by the hydrodynamic pressure created by the fluid. The viscosity of the fluid prevents the contact.
Hydrodynamic Lubrication

• Characteristic:
  • Surfaces separated by an oil film

• Oil Film Thickness:
  • 0.003 – 0.0001 inch

• Typical Examples:
  • Plain and journal bearings such as pin and bushings, or engine main or rod bearings

• Wear (in Steady Operation):
  • Nil
ELASTOHYDRODYNAMIC LUBRICATION

- Pressure increase in the contact zone increases the viscosity
- Trapped oil in the contact zone becomes a solid
- Metal surfaces in the contact zone are “elastically” deformed
- EHD friction (traction) from viscous shearing raises the contact zone temperatures
- Examples: Rolling element bearings, gears, cams and followers, and traction devices
Viscosity Versus Pressure

- Viscosity Increases Dramatically With Pressure
- High V.I. Base Oils Exhibit Relatively Small Pressure-Viscosity Changes

![Graph showing viscosity versus pressure for different oils.](image_url)
Particle Contamination
How Big is a Micron?

MICRON
Unit of Measurement
1 Millionth of a Meter (Micrometer)
or 0.000039"
µm = Micron Symbol

PARTICLE SIZE
100 µm = Grain of Table Salt
40 µm = Lower Limit of Visibility
10 µm = Talcum Powder
  8 µm = Red Blood Cells
  2 µm = Bacteria

Particles “Suspended” in Oil: <5-10 µm in Size

Ref: Donaldson
Mixed or Boundary or Extreme Pressure Lubrication

• Characteristic:
  • Surfaces separated by films of molecular dimensions

• Film Thickness:
  • About 0.08-0.4 microinch

• Examples:
  • Heavily loaded gears, diesel engine ring on liner at TDC, valve trains

• Wear:
  • High during running in period — then becomes moderate to low depending on lubricant and additive package
Industry Standards

- Engine Oils
  - 250 Hours
- Hydraulic Oils
  - 500 - 1000 Hours
- Coolants
  - Annually
- Grease
  - Daily/Shift
Industry Standards

Operating at 250 Hours is Equivalent to 11,250 Miles.
MODERN ENGINES

• MaxxForce 7

Preventative Maintenance Intervals

• Change Engine Oil, Replace Oil Filter: 10,000 miles (16,100 km) / 350 hours / 1,000 gallons (3,800 L) / 6 months
• Replace Fuel Filter: 30,000 miles (48,280 km)
• Replace Coolant*: 300,000 miles (482,803 km) / 5 years / 12,000 hours
• Valve Lash Adjustment: Not Required
• Crankcase Breather: 60,000 (96,561 km)

*Add extender @ 150,000 miles (241,400 km) / 2.5 years / 6,000 hours
350-HOUR OIL-CHANGE INTERVALS SAVE MORE THAN $12,000 PER YEAR

Average-sized excavator relieves reliability concerns with a real-world test and careful oil analysis

By Larry Stewart, Executive Editor

February 01, 2003

Steve Fallert, Bloomsdale Excavating
Headquarters: Bloomsdale, Mo.

Specialties: Earthmoving for highways, industrial and commercial development, utility work

Equipment Value: $20 million

fleet: 120 total units, including 30 light trucks and cars
# MODERN ENGINES

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<tr>
<th>Manufacturer</th>
<th>MaxxForce DT</th>
<th>MaxxForce 9</th>
<th>MaxxForce 10</th>
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<th>ISL9</th>
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<td><strong>Oil Change Intervals</strong></td>
<td>Up to 25,000 mi. / 825 hrs. / 3,100 Gals. Fuel</td>
<td>Up to 25,000 mi. / 825 hrs. / 3,100 Gals. Fuel</td>
<td>Up to 25,000 mi. / 825 hrs. / 3,100 Gals. Fuel</td>
<td>Up To 15,000 mi. / 500 hrs. / 6 mos.</td>
<td>20,000 mi. / 500 hrs. / 6 mos.</td>
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## Modern Engines

**Cummins**

(Cummins TSB101040 – Heavy Duty Product Oil Drain Intervals - 24 Aug-2010)

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<tr>
<th>Engine Type</th>
<th>Light*</th>
<th>Normal*</th>
<th>Severe*</th>
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</table>
| EPA 2010 ISX 15**| 35,000 miles – CES 20081  
40,000 miles – CES 20078  
25,000 miles – CES 20081  
30,000 miles – CES 20078 | 25,000 miles – CES 20081  
30,000 miles – CES 20078 | 15,000 miles – CES 20081  
20,000 miles – CES 20078 |
| EPA 2010 ISX 11.9** | 35,000 miles – CES 20081  
40,000 miles – CES 20078  
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30,000 miles – CES 20078 | 25,000 miles – CES 20081  
30,000 miles – CES 20078 | 15,000 miles – CES 20081  
20,000 miles – CES 20078 |
| EPA 2010 ISL 9**  | Check with Cummins | 20,000 miles  
500 Hours | Check with Cummins |
| EPA 2010 ISC 8.3** | Check with Cummins | 20,000 miles  
500 Hours | Check with Cummins |
| EPA 2010 ISB 6.7** | Check with Cummins | 20,000 miles  
500 Hours | Check with Cummins |
| EPA 07 ISX**     | 35,000 miles – CES 20081  
40,000 miles – CES 20078  
25,000 miles – CES 20081  
30,000 miles – CES 20078 | 25,000 miles – CES 20081  
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20,000 miles – CES 20078 |
| EPA 07 ISM**     | 35,000 miles – CES 20081  
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30,000 miles – CES 20078 | 15,000 miles – CES 20081  
20,000 miles – CES 20078 |
| EPA 07 ISC**     | Check with Cummins | 15,000 miles  
500 Hours | Check with Cummins |

*Light Duty > 6.5 mpg or < 70,000 lbs gross weight; Normal Duty = 5.5 to 6.5 mpg or 80,000 lbs gross weight; Severe Duty < 5.5 mpg or > 80,000 lbs gross weight

**CES 20081 refers to an API CJ-4 approved oil like Delo 400 LE 15W-40; CES 20078 refers to an API CI-4 Plus Oil like Delo 400 Multigrade 15W-40

*** For any Cummins engine models with light or normal service duty, Cummins allows an additional 5,000 mile drains when using Cummins Premium Blue & Valvoline Premium Blue Extreme
## MODERN ENGINES

### Detroit Diesel
(Detroit Diesel Service and Maintenance Intervals Bulletin)

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<td>MBE 900***</td>
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*Severe Duty is up to 30,000 miles annually and for vehicles that average 5 mpg or less; Short Haul is between 30,001 and 60,000 miles annually and average between 5.1 and 5.9 mpg; Long Haul is over 60,001 miles annually and average greater than 6 mpg.*

** Use engine oils approved against DD 93K218 – API CJ-4 oils like Delo® 400 LE 15W-40

***Use Engine Oils approved against DD 93K214 – API CI-4 Plus Oils like Delo 400 Multigrade 15W-40
How Can We Extend Oil Drains?

• OEM’s Understand Oil Quality has Increased.
• Modern Oils Have no Aromatics (sulfur)
New Oil Technology

• Older Technology leaves impurities that aids in product deterioration

• Group II oils
Maintenance

Acronym to Remember is “FLAB”

- Fasteners
- Lubrication
- Alignment
- Balance

Drew Troyer is the originator of this Acronym
Where Do We Start

• Control Intrusion
  Reduce Silica Contamination
Where Do We Start

• Control Intrusion
  Reduce Silica Contamination
  Reduce Water Contamination
Reducing Costs

Using Analysis to Solve Problems
Reducing Costs

Using Analysis to Solve Problems

A Oil Analysis Program is at the heart of any “BEST PRACTICES” program.
### Life Extension Table

**NEW CLEANLINESS LEVEL (ISO CODE)**

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<th>19/16</th>
<th>18/15</th>
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**Legend**
- **Hydraulics and Diesel Engines**
- **Rolling Element Bearings**
- **Journal Bearings and Turbo Machinery**
- **Gear Boxes and Other**
Life Extension Table

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- Hydraulics and Diesel Engines
- Rolling Element Bearings
- Journal Bearings and Turbo Machinery
- Gear Boxes and Other
Operators are the FIRST line of defense when it comes to maintenance issues
Where Do We Go From Here?

OMI

One Minute Inspections
• Temperature
  • Touch
  • Gauges
  • Heat Guns

Doing this we discover a host of issues that can be easily solved.
• Oil Volume
  • Sight Gauges
  • Dip Sticks

• Pressure
  • Gauges or sensors at multiple locations

• Filter
  • Delta P gauges
  • Bypass indicators
• BS&W
  • Samples at bottom of reservoir
  • BS&W Bowls

• Ventilation
  • Breathers
  • Fumes
- Clear and Bright
  - Samples
  - Sight glass
- Leakage
  - Fittings and Gaskets
  - Hoses
- Fluid Surface and Headspace
  - Foam
  - Varnish
  - Sludge
- Points of Entry
  - Ingression Points
    - Breathers
    - Open covers
• Dirty Exterior
  • Dirty outside = Dirty inside
• Vibration, Spits and Sputters
  • Noise is a huge indicator of problems
• Grease Condition/Color
  • Change in color (darkens)
  • Watery discharge from bearings
  • Hardening
Where to Start

- Independent Survey
- Assess Where You Are In The Process
- Equipment Status
- Training Requirements
- Commitment
- Call.
What we Talked About

• Introduction
• Safety Moment
• What a Lubricant is Expected to do
• What is Friction (causes)
• Lubrication Regimens
• Lubrication Intervals
• One Minute Inspections
Questions

Mike Hitchcock, CLS, OMA-I
719-338-8436
mhitchcock@acorncporleuminc.com