

Field Operator Certification

Lubrication/Bearings/Gears

Lesson Objectives

1. Describe the purpose of lubrication.
2. Describe the principles of Lubrication.
3. Describe the different types of lubricants.
4. Describe the different types of lubrication systems.
5. Describe the types of equipment that require lubrication.
6. Describe the filtration process and methods.
7. Describe the best practices and inspections for Lubrication systems.
8. Describe the troubleshooting for common Lubrication problems.
9. Identify safety hazards associated with Lubrication.
10. Perform inspections on the Lubrication systems.

Objective 1 - Purpose

- The purpose of lubrication is to reduce friction, prevent wear, remove heat and prevent rust and corrosion.

Objective 2 - Principles of Lubrication



Principles of Lubrication (cont'd)

■ Lubrication Terms and Principles

◆ Friction

- A force that a body must overcome when it slides across another.
- Solid or sliding friction occurs mainly due to “asperities” (roughness) present in the two surfaces that rub together.
- Whenever friction is overcome, dislocation of the surface particles generates heat that could become destructive.

◆ Lubrication

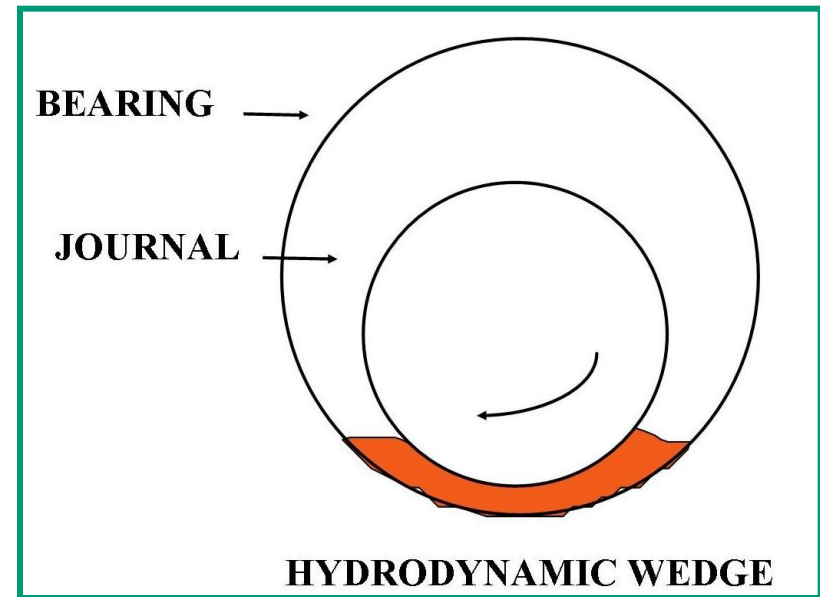
- The principle of supporting a sliding load on a friction-reduction film is known as lubrication.
- The substance of which the film is composed is a lubricant, and to apply it is to lubricate.

Principles of Lubrication (cont'd)

■ Lubrication categories

◆ Hydrodynamic lubrication

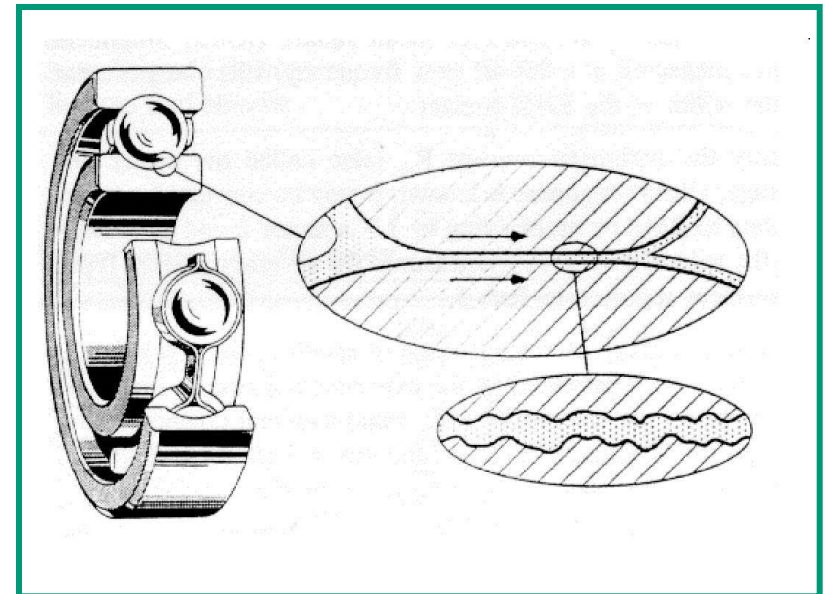
- Oil Wedge is Formed
- Surface Contact Area is Flooded



Principles of Lubrication (cont'd)

■ Lubrication categories (cont'd)

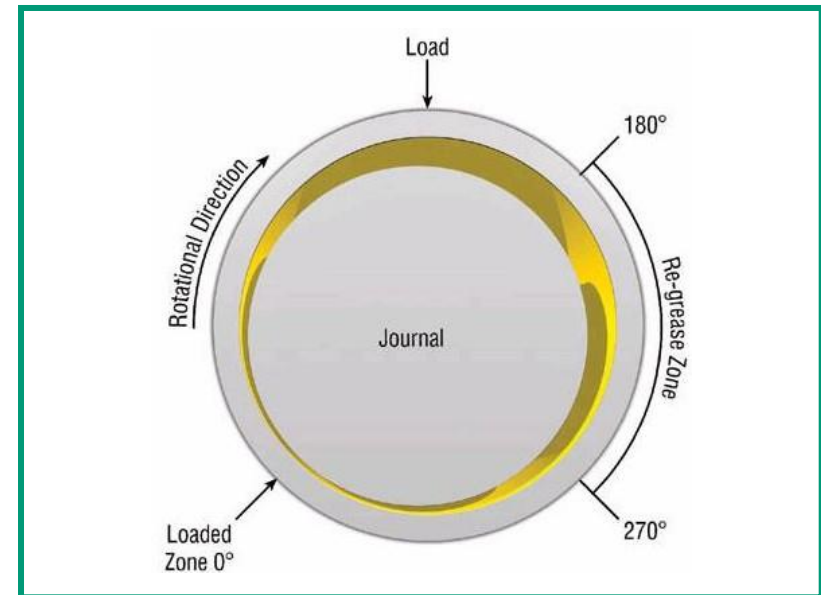
- ◆ Elastohydrodynamic lubrication (**EHL**)
 - Film Developed Between Two Heavily Loaded Surfaces in motion
 - Oil Viscosity Increases as it is Forced into Load Zone



Principles of Lubrication (cont'd)

■ Lubrication categories (cont'd)

- ◆ Boundary lubrication
 - Very Thin Film of Lubrication
 - Film Strength Additives Must be Used



Principles of Lubrication (cont'd)

■ Lubricants

- ◆ All liquids will provide lubrication to a degree, but some do it a better than others. There are two main groups of lubricants, oil (petroleum) lubricants and grease lubricants.
- ◆ For almost every situation, petroleum products have been found to excel as lubricants.

Principles of Lubrication (cont'd)

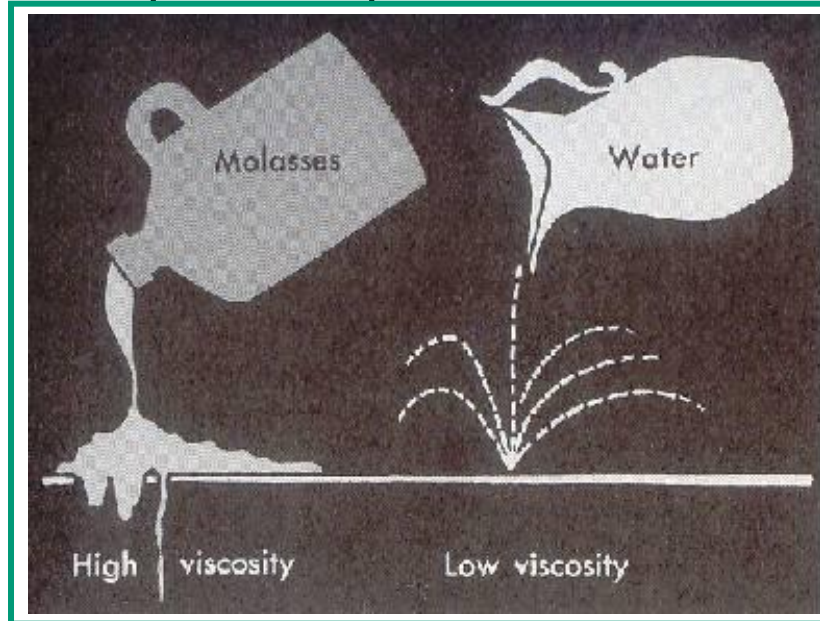
■ Lubricant Properties

- ◆ **Viscosity** is one of the main properties of any oil lubricant. It is the measure of a lubricant's resistant to flow
- ◆ Viscosity is commonly measured by petroleum industry in centistokes, which numerically equal to $\text{mm}^2 (\text{square})/\text{s}$
- ◆ Viscosity is often the first consideration in selecting lubricant oil for specific applications

Principles of Lubrication (cont'd)

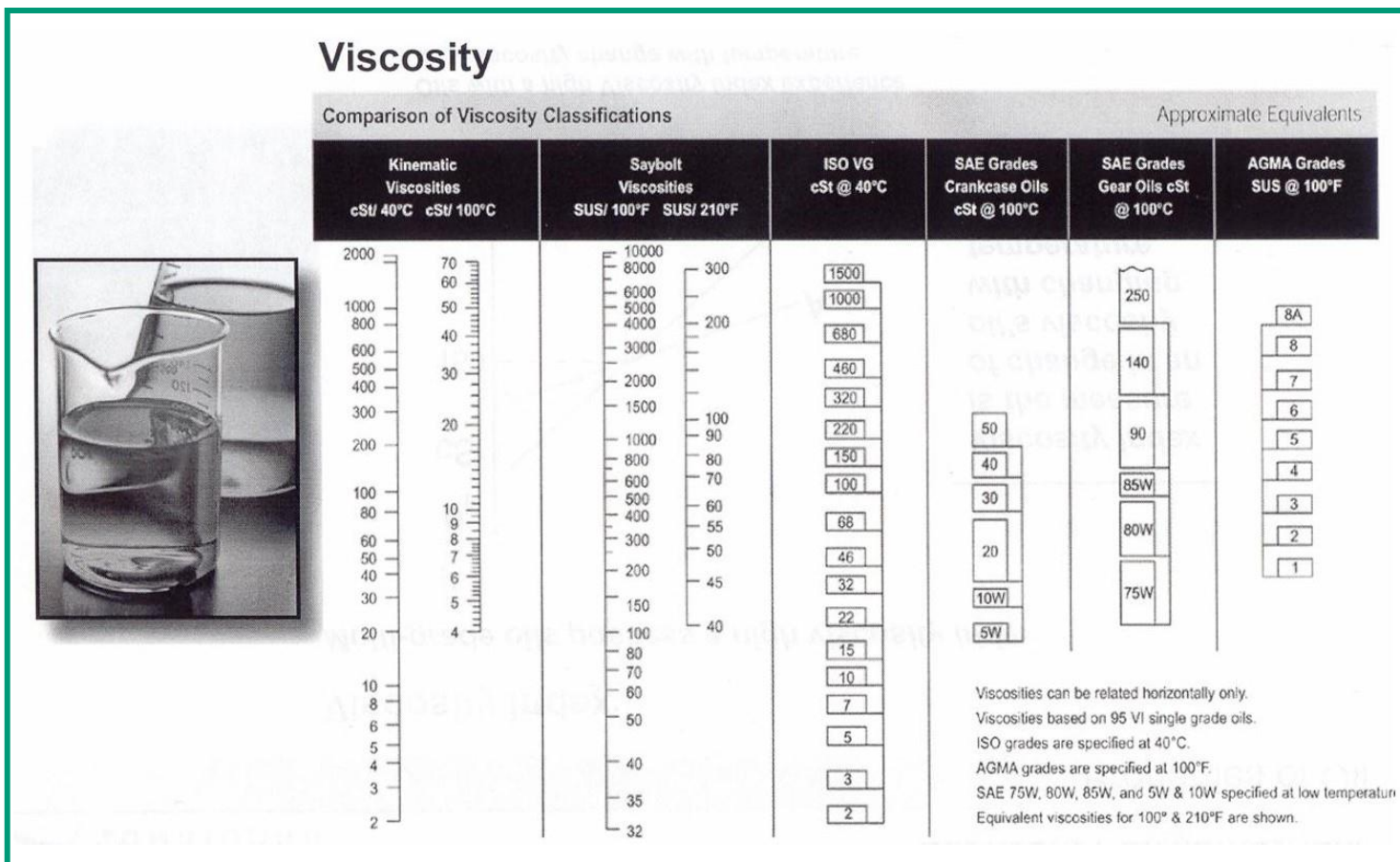
■ Lubricant Properties - Viscosity (cont'd)

- ◆ Operational condition VS viscosity needed
 - Higher load requires high viscosity
 - Higher temperature requires higher viscosity
 - Increased speed requires lower viscosity



Principles of Lubrication (cont'd)

■ Lubricant Properties - Viscosity (cont'd)



VISCOSITY CLASSIFICATIONS

Principles of Lubrication (cont'd)

■ Lubricant Properties (cont'd)

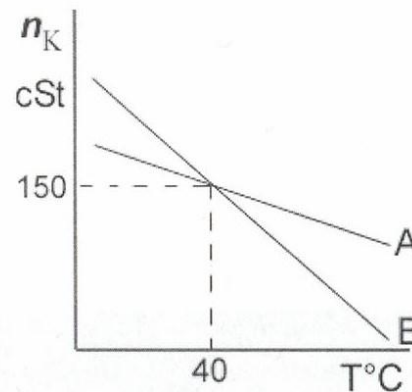
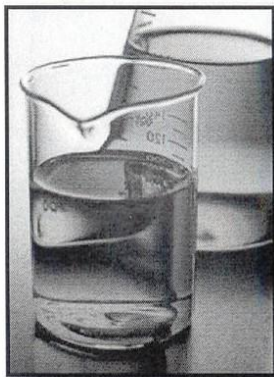
- ◆ **Viscosity index.** Lubricants tend to thin out when heated and to thicken when cooled.
- ◆ The property of resisting changes in viscosity due to changes in temperature can be expressed as the Viscosity Index (VI).
- ◆ The higher the VI number of an oil, the less the tendency for its viscosity to change with changes in temperature.

Principles of Lubrication (cont'd)

■ Lubricant Properties – Viscosity index (cont'd)

Viscosity Index

Multi-grade oils possess a high viscosity index



Viscosity Index is the measure of change in an oil's viscosity with changing temperature.

Oils with a high Viscosity Index experience less viscosity change with temperature.

In the graph above Oil 'A' has a higher VI than A represents a multi-grade oil with VII and B represents a mono-grade oil.

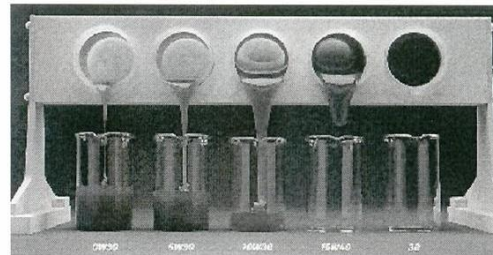
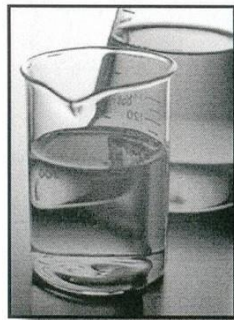
Viscosity Index Graphic For Two Lubricants

Principles of Lubrication (cont'd)

■ Lubricant Properties (cont'd)

- ◆ **Pour point.** The lowest temperature to which oil can be chilled and still poured from a container is approximated by its pour point.

Synthetic oils typically have lower pour points than mineral oils



Pour Point is a measure of the temperature at which a given oil will no longer flow.

Oils with low wax content (i.e. naphthenic oils) possess lower pour points than those with higher wax content (i.e. paraffinic oils).

The test stand depicted above shows the relative Pour points of 0W30 oils (left) to straight 30W oil (right) at -60°C.

Lubricants With Different Pour Point

Principles of Lubrication (cont'd)

■ Lubricant Properties (cont'd)

- ◆ ***Flash point.*** Minimum temperature at which sufficient liquid is vaporized to create a mixture of fuel and air that will burn if exposed to a source of spark.
- ◆ ***Consistency or penetration number (greases).*** The consistency of lubricating grease is defined as its resistibility to deformation under an applied force, in other words its relative stiffness or hardness.
- ◆ ***Dropping point.*** The temperature at which the oil separates from the thickener.
- ◆ ***Structural stability.*** The ability of the grease to resist changes in consistency during mechanical working.

Objective 3 – Types of Lubricants

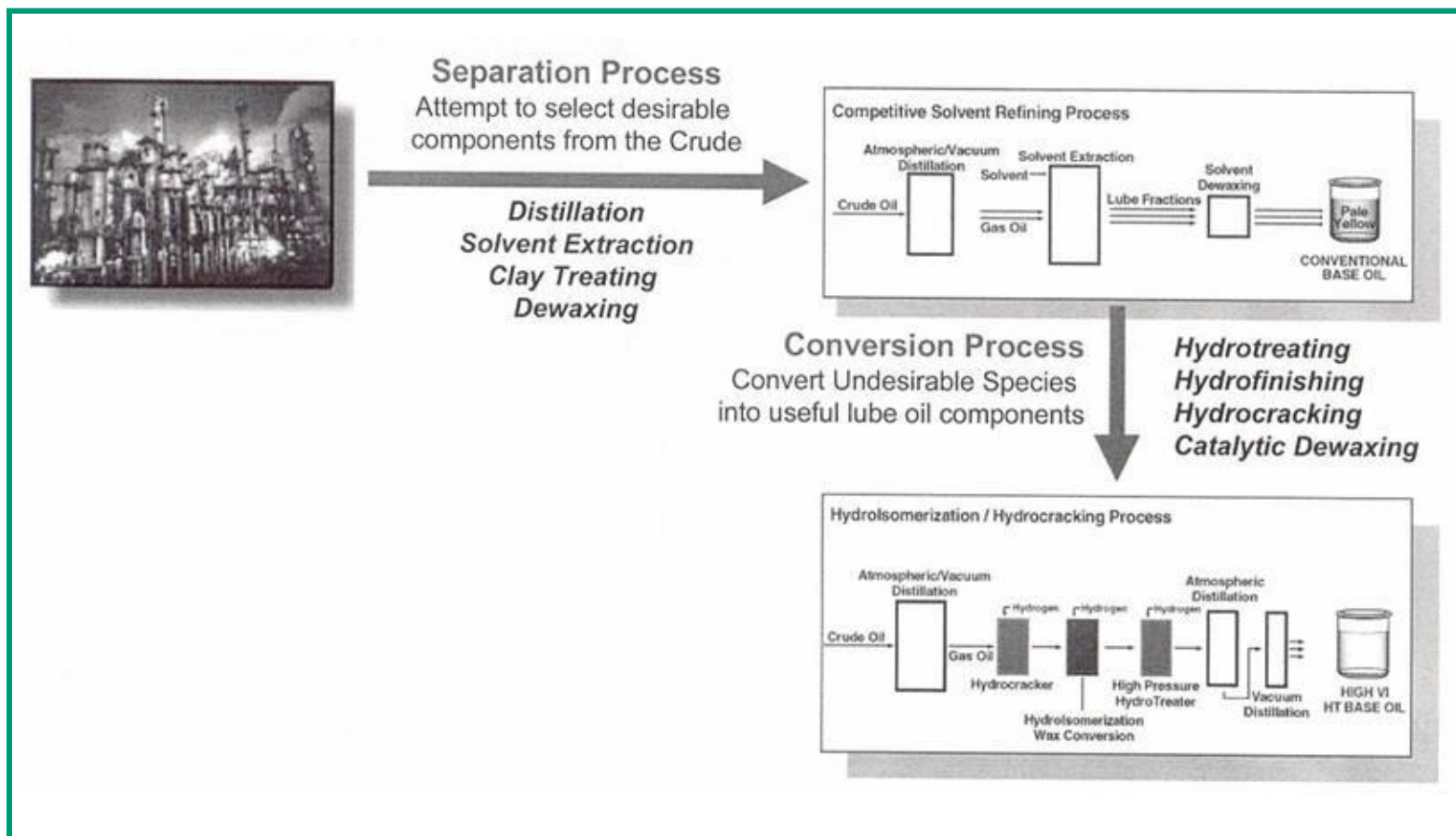
■ *Mineral Oils*

- ◆ Consist of base oil and additives which determine their performance characteristics.
- ◆ The base oil is responsible for the typical properties of oil. The additives, however, determine its actual performance by influencing the base oil's.
 - Oxidation stability
 - Anticorrosion properties
 - Wear protection
 - Wetting behaviour
 - Viscosity-temperature behaviour

95% of lubricants are derived from petroleum crude oil.

Types of Lubricants (cont'd)

■ Mineral Oils (cont'd)



Oil Lubricant Manufacturing Process

Types of Lubricants (cont'd)

■ *Synthetic Oils*

- ◆ Chemically synthesized (polymerization) and designed to have specific properties.
 - Low pour point and /or
 - High flash / fire point and/or
 - High viscosity index and /or
 - Oxidative and thermal stability and /or
 - High shear strength

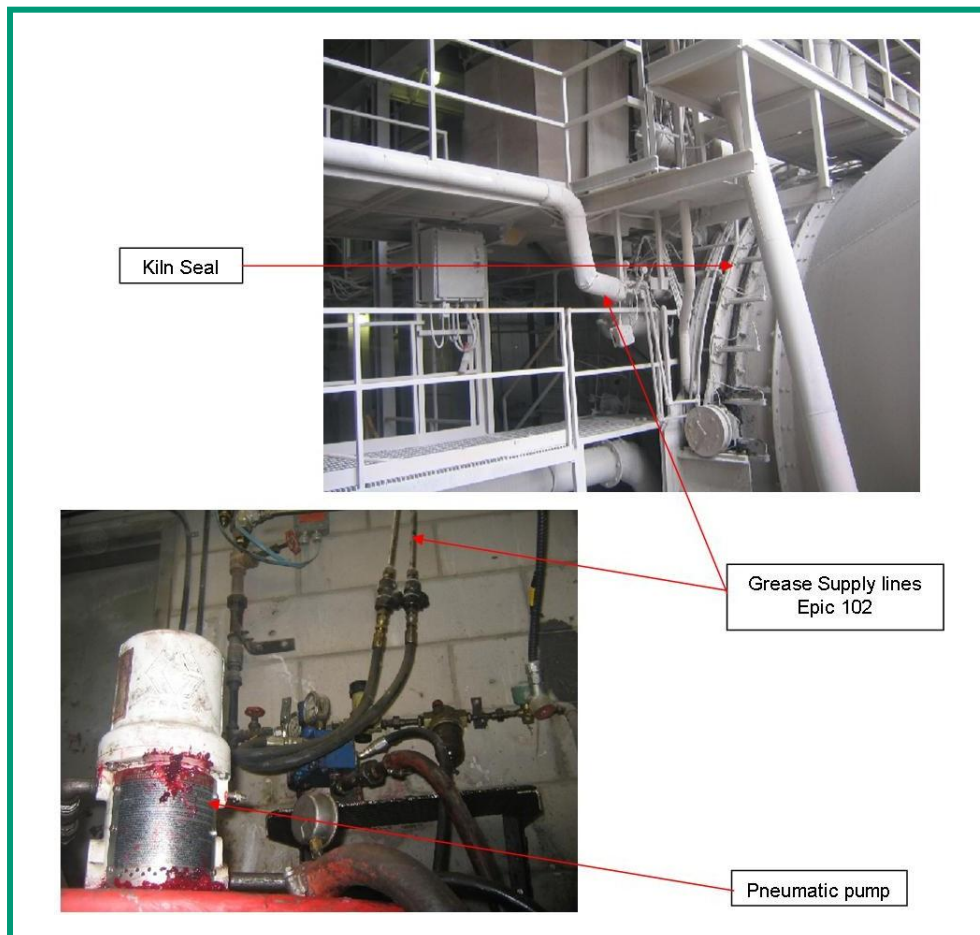
Types of Lubricants (cont'd)

■ *Industrial grease*

- ◆ Is a fine dispersion of an oil-insoluble thickening agent, usually soap, in a fluid lubricant which is generally mineral oil.
 - Adequate Lubrication
 - Prevent Corrosion
 - Seal Out Contamination
 - Resist Leakage
 - Resist Change in Consistency
 - Tolerate Some Contamination
 - Seal Compatibility
 - Suitable for Method of Application

Types of Lubricants (cont'd)

■ *Industrial grease (cont'd)*



Farval System For Kiln Fed End Seal

Types of Lubricants (cont'd)

■ Grease vs. oil

■ Oil

- ◆ Better Lubrication
- ◆ Easier to Fill / Drain
- ◆ Correct Amount More Easily Controlled
- ◆ Heat / Cleaning

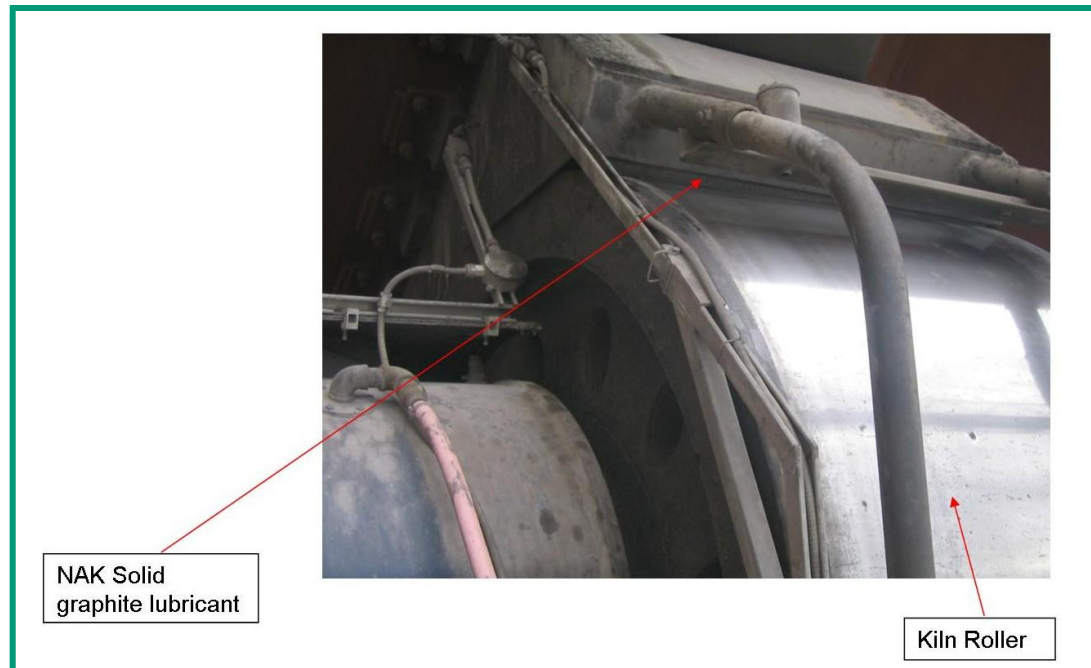
■ Grease

- ◆ Leakage Control
- ◆ Reduced Maintenance
- ◆ Acts as a Seal from Contamination

Types of Lubricants (cont'd)

■ *Solid Lubricants*

- ◆ There are many types of solid lubricant used for different applications, like synthetic, metallic or mineral powders such as PTFE (Teflon), copper, graphite, etc.



Kiln Roller Graphite Lubricated

Types of Lubricants (cont'd)

■ *Synthetic lubricants*

Pure hydrocarbon, manufactured from raw materials derived from crude oil with a controlled molecular structure with predictable properties.

◆ **Polyglycols**

- Advantages
 - Largest Single Class
 - High VI (150)
 - Good Low Temp Flow
 - Good Thermal/ Oxidation Stability
 - Low Volatility
- Disadvantages
 - Not Compatible w/ Mineral Oils
 - Not Miscible w/ Additives Common to Lubricants
 - Surface Paint and Finish Effects

Types of Lubricants (cont'd)

■ *Synthetic lubricants (cont'd)*

◆ Organic esters

- Advantages

- Oldest Type
- Diesters
- Excellent Low Temp
- High VI (140)
- Good Thermal/ Oxidation Stability

- Disadvantages

- Seal Compatibility Concerns
- Additives Not Soluble
- Surface Paint / Finish Effects
- Not Compatible w/ Mineral Oils

Types of Lubricants (cont'd)

■ *Synthetic lubricants (cont'd)*

◆ **Phosphate esters**

- **Advantages**

- Excellent Fire-Resistant Properties
- Fair High Temp Stable
- Low Pour Point

- **Disadvantages**

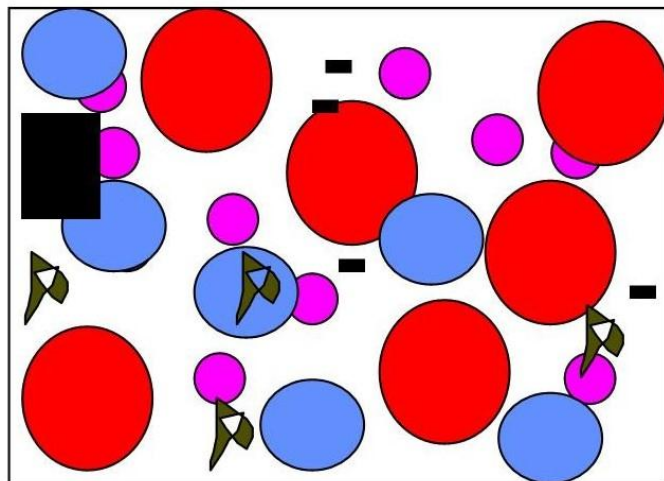
- Poor VI Characteristics
- Considerable Effect on Paints and Finishes
- Excessive Seal Swell
- Extremely High Cost
- Not Compatible w/ Mineral Oils

Types of Lubricants (cont'd)

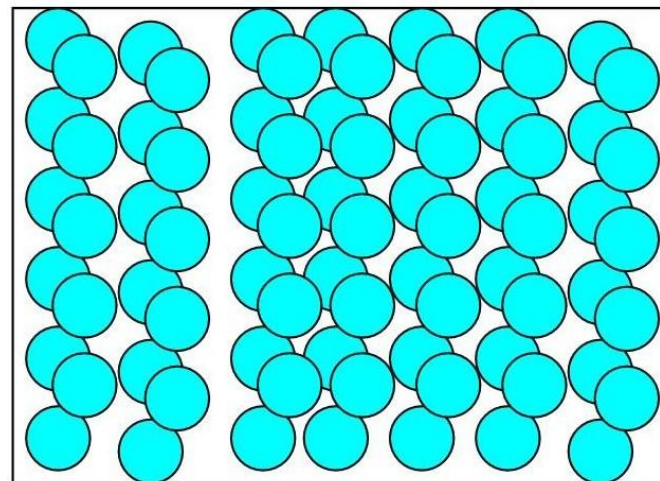
- **Advantages of synthetics vs. conventional mineral oils**
 - ◆ Longer Life
 - ◆ Fuel Savings
 - ◆ Better Cold Weather Start Up
 - ◆ Better Protection At High Temperatures
 - ◆ Longer Equipment Life
- **Disadvantages of synthetics vs. conventional mineral oil**
 - ◆ Cost
 - ◆ Leakage

Types of Lubricants (cont'd)

■ Synthetics vs. conventional mineral oils



Mineral Oil



Synthesized Hydrocarbon

Types of Lubricants (cont'd)

■ Additives

◆ Purpose:

- To improve the performance of the base oil
- Impart entirely new performance characteristics to a lubricant
- Reduce the rate at which undesirable changes take place

Types of Lubricants (cont'd)

■ Additives (cont'd)

◆ *Antiwear agent (aw)*

- Provides chemical film to reduce metal-to-metal contact when thin films of oil are created.
- Enhances the antiwear characteristics of oil to permit loadings of double or triple that of non-additized oil.
- ZDP- most popular antiwear agent.
- Can be found in hydraulic oils

◆ *Extreme pressure (ep)*

- Reacts with metal surface to provide sufficient antiwear material to carry even heavier loads than film strength additives allow
- Can be found in gear oils, greases

Types of Lubricants (cont'd)

■ Additives (cont'd)

◆ *Oxidation inhibitors*

- Peroxide decomposers: convert peroxides into harmless compounds.
- Chain stoppers: interrupt the chain reaction between oxygen and hydrocarbon radicals to prevent or slow the formation of acidic material and sludges.
- Metal deactivators: metals that may have catalytic effect on oxidation are covered by agent. (copper, lead, iron)
- Can be found in engine oil

Types of Lubricants (cont'd)

■ Additives (cont'd)

◆ *Detergent*

- Metallic soaps with neutralization and cleanliness power.
- Because of metallic nature it leaves a slight ash when oil is burned.
- Metals are usually calcium, magnesium, or sodium.
- Can be found in engine oil

Types of Lubricants (cont'd)

■ Additives (cont'd)

◆ *Dispersant*

- Helps prevent sludge, varnish and other engine deposits by keeping particles suspended in a colloidal state.
- usually non-metallic - ash less dispersant
- Can be found in engine oil

◆ *Rust inhibitor*

- Plates out on metal surfaces.
- Protective film is formed that protects the surfaces from contact with water.
- Can be found in gear oils

Types of Lubricants (cont'd)

■ Additives (cont'd)

◆ *Viscosity (VI) improver*

- Synthetic, high-molecular-weight polymers which improve the viscosity index by coiling and uncoiling in response to temperature.
- Increase the viscosity proportionally, more at higher temperatures than low.
- Can be found in engine oil

◆ *Pour point depressant*

- Improves the low-temperature fluidity of mineral oils and reduces wax formation at low temperature.
- Can be found in low pour hydraulic oil

Types of Lubricants (cont'd)

■ Additives (cont'd)

◆ *Molybdenum disulfide*

- *moly*: a black, lustrous powder that serves as a dry-film lubricant
- Can be found in grease

◆ *Defoamant*

- Silicone Polymer molecules which attach themselves to air bubbles in the foam, producing points of weakness.
- Can be found in gear oil

Types of Lubricants (cont'd)

■ Additives (cont'd)

	Gear Oil	Hyd/Circ Oil	Engine Oil
Oxidation Inhibitor	X	X	X
Antiwear /EP	X	X	X
Rust/Corrosion	X	X	X
Defoamant	X-Hi Speed	X	
VI Improver		X-Low Temp	X
Pour Depress.		X-Low Temp	
Detergent / Dispersant		X-Prem Oils	X
Demulsifier	X	X	

Additive by lubricant type

Objective 4 – Lubrication systems

■ Oil bath

- ◆ Mainly used to lubricate bearings or low speed gears. The oil is poured in a reservoir and as the part rotates they get wet by the lubricant.



Oil Bath System Used on Kiln Bearings. The bearing is submerged into the oil and a scoop picks up the oil to lube the roller trunion

Lubrication systems (cont'd)

■ Splash

- ◆ Very common lubrication method used in gearboxes. As the gear turns, it picks up oil and splashes it to the matching gear tooth and bearings.

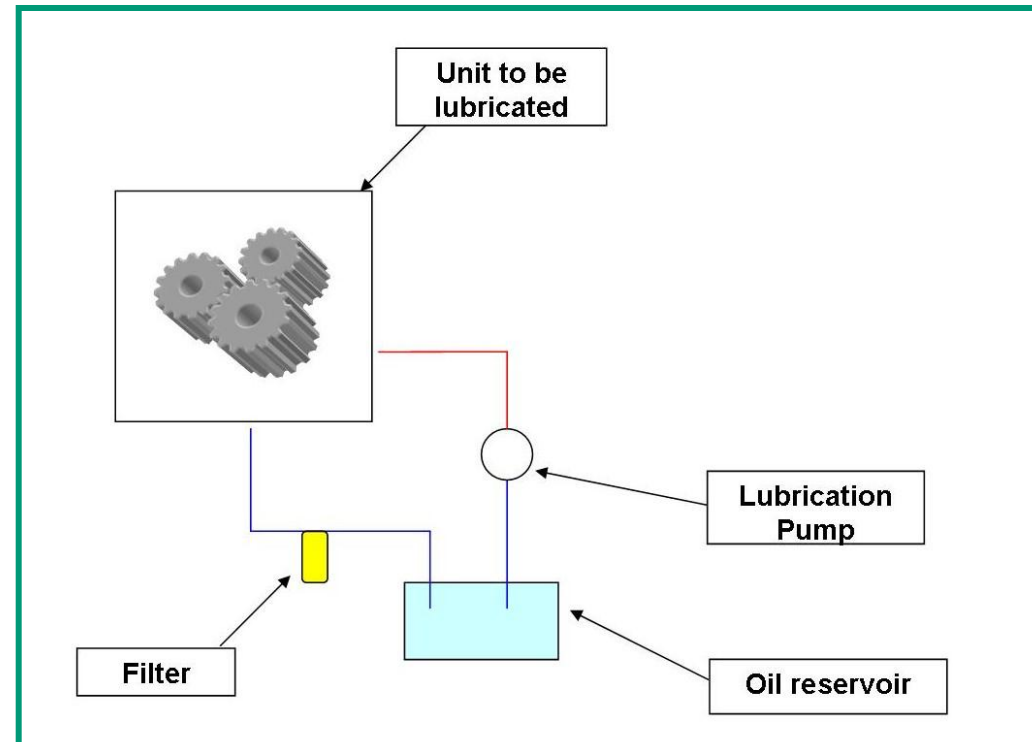


In this reducer the gears pick up the oil from the bottom of the reservoir and splash it to bearings and higher gears

Lubrication systems (cont'd)

■ Circulating system

- ◆ Specially used to control lubricant temperature or pump oil to areas where conventional methods would not work.



Lubrication systems (cont'd)

■ Circulating system (cont'd)

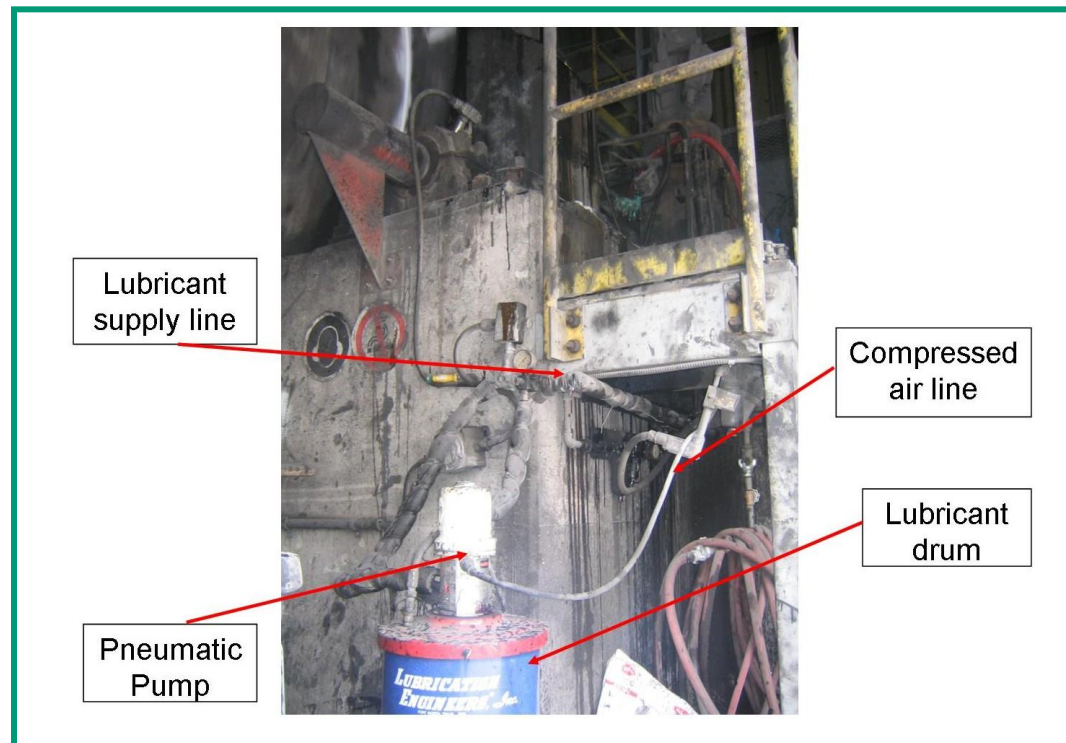


Reducer with circulating system. Oil pump located underneath of the reducer.

Lubrication systems (cont'd)

■ Spray System

- ◆ The lubricant is pumped from a drum to a set of nozzles by applying compressed air. The lubricant is sprayed to the gear periodically for a pre-determined period of time depending of gear size and speed.



Spray System for Coal mill Gear

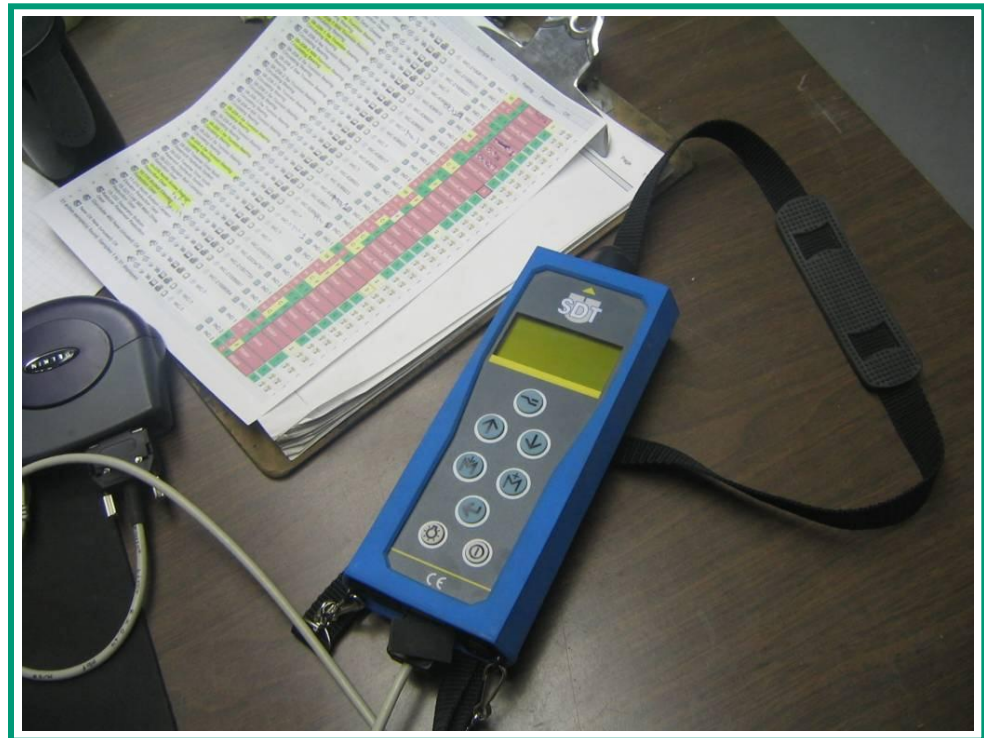
Lubrication systems (cont'd)

■ Manually

- ◆ Apply grease to bearings. Based on equipment speed and bearing size, the lubrication frequency and amount is previously determined.



Grease guns

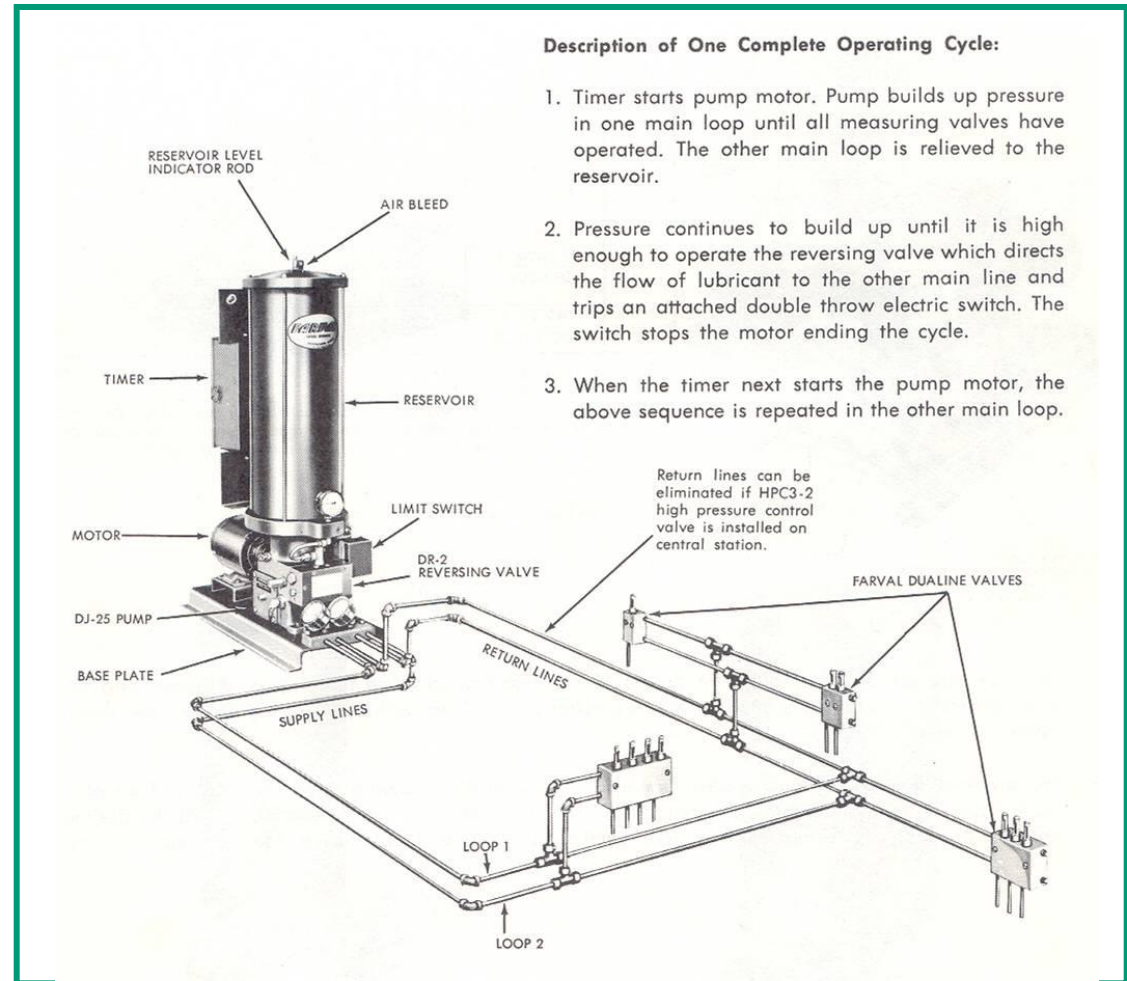


Ultra Sound Tool for bearings Lubrication

Lubrication systems (cont'd)

■ Central System (Farval)

- ◆ A complete system consists of the central station with its pump, reservoir, reversing valve, and timer; distribution lines and measuring valves



Grease Central (Farval) System used in Material stackers and reclaimers

Objective 5 - Lubricated equipment

- Three main types of equipment need lubrication:
 - ◆ **BEARINGS** - two types, plain and roller element or antifriction
 - ◆ **GEARS** – spur, helical, herringbone, spiral bevel, tapered roller, worm, plain journal, ball and hypoid
 - ◆ **CYLINDERS** - hydraulic pumps

Note: This equipment will be covered in another module.

Lubricated equipment (cont'd)

■ BEARINGS



Lubricated equipment (cont'd)

■ BEARINGS (cont'd)

◆ *Bearings main functions*

- Support the Load
- Prevent/Minimize Movement
- Minimize Friction

Lubricated equipment (cont'd)

■ BEARINGS (cont'd)

◆ *Bearing types*

- **Plain – Friction Bearings**

- Advantages: Simple in Design
- Disadvantages: Higher Starting Torque Required
- Type of plain bearing: Journal bearings



Lubricated equipment (cont'd)

■ BEARINGS - *Bearing types* (cont'd)

● Rolling Element or Anti-friction



- Advantages: Minimal Friction
- Disadvantages: Complex in Design and Maintenance
- Types of rolling element bearings:
 - » Roller Bearings: cylindrical, spherical, tapered, needle
 - » Ball Bearings: single row, double row, angular contact

Lubricated equipment (cont'd)

■ BEARINGS (cont'd)

◆ *Types of Bearings and their application*

- **Needle Bearing** – Compact design with space limitations



Lubricated equipment (cont'd)

- **BEARINGS - *Types of Bearings and their application* (cont'd)**
 - **Spherical Roller Thrust Bearings** – heavy thrust loads or combined loads that are predominantly thrust



Lubricated equipment (cont'd)

■ BEARINGS - *Types of Bearings and their application (cont'd)*

- **Taper Bearing** – Radial and axial loads acting simultaneously; carries thrust in one direction



Lubricated equipment (cont'd)

- **BEARINGS - *Types of Bearings and their application* (cont'd)**
 - **Cylindrical Bearings** – high radial load capability and high speed applications with minimal thrust loads



Lubricated equipment (cont'd)

- **BEARINGS - *Types of Bearings and their application* (cont'd)**
 - **Spherical Bearings** – inherently self-aligning. Can withstand radial loads and heavy thrust loads carried in either direction



Lubricated equipment (cont'd)

- **BEARINGS - *Types of Bearings and their application* (cont'd)**
 - **Single or Double Row Spherical Bearing** – high speed radial load with moderate thrust.
 - **Plain Bearing** – Automotive rod and main bearings.



Lubricated equipment (cont'd)

■ BEARINGS - *Types of Bearings and their application (cont'd)*

- **Angular Contact Bearings** – heavy thrust load; minimal radial load



Lubricated equipment (cont'd)

- *Lubricants used for bearings*
 - ◆ Oil
 - ◆ Grease

Lubricated equipment (cont'd)

■ ***Methods for lubricating Bearings with oil***

- ◆ **Circulation System:** oil is pumped from the reservoir, through a cooler, to the bearings and drains back to the reservoir.
- ◆ **Oil Bath System:** Oil Bath System - bearings are partially submerged in a static oil system (*pool of oil*).
- ◆ **Oil Splash System:** has a static oil reservoir. Gears rotating in the oil reservoir splash oil into adjacent bearings or catch troughs which distribute the oil through channels to outlying bearings by gravity flow.
- ◆ **Oil Mist System:** delivers very fine particles of oil in a low velocity, low pressure air stream

Lubricated equipment (cont'd)

- ***Methods for lubricating Bearings with grease***
 - ◆ **Hand Packing:** bearing usually packed by hand. Bearings should only be 1/3 filled.
 - ◆ **Gun Packing:** housing is designed such that re-lubrication can be performed via grease fitting using a pressure grease gun.
 - ◆ **Centralized System:** Centralized System - supplies grease with a hand or power operated pump which takes grease from a reservoir and forces it through supply lines to bearings.
 - ◆ **Automatic Lubricator ???? Gas activated**

Lubricated equipment (cont'd)

■ ***Advantages to using grease in a bearing***

- ◆ Better staying capability than oil; good where frequent oiling intervals are not possible (*poorly accessible locations*)
- ◆ Provides metal separation at low speeds and high loads where the oil wedge will not form.
- ◆ Good sealant for keeping out contaminants (*dirt and water*)
- ◆ Grease – rule of thumb
- ◆ The smaller and faster the bearing the more frequent the interval
- ◆ For Every 27 °F increase above 158 °F the interval should be halved
- ◆ Contamination requires more frequent lubrication to purge system

Lubricated equipment (cont'd)

- ***Disadvantages to using grease in a bearing***
 - ◆ Poor cooling ability due to the absence of flow
 - ◆ Retains contaminants due to the absence of flow
 - ◆ Grease can separate/harden over time
 - ◆ Since bearing is used in an oil lubricated gear box; the grease can contaminate the oil.

Lubricated equipment (cont'd)

■ *Causes of Bearing Failures*

- ◆ Misalignment
- ◆ Vibration
- ◆ Faulty mounting/installation
- ◆ Passage of electric current through the bearing
- ◆ Inadequate lubrication
- ◆ Improper fits

Lubricated equipment (cont'd)

■ *Failure Conditions Present in Bearings*

- ◆ **Smearing:** the repositioning of metal from one point to another on a single surface or the transfer of metal from one metal surface to its mating surface.

Causes - improper assembly, faulty parts, inadequate lubrication, excessive speed and shaft misalignment.

- ◆ **Flaking** - surface metal loss in the form of flakes or scale-like particles. Form of pitting that results from fatigue.

Causes - attributable to assembly misalignment

Lubricated equipment (cont'd)

■ *Failure Conditions Present in Bearings (cont'd)*

- ◆ **Fluting** - metal removal, a type of pitting in the form of ribs, or flutes, in a regular pattern.

Causes - combination of vibration with either passage of electric current or excessive load.

- ◆ **Electrical Pitting** - metal removal in the form of tiny pinpoint craters.

Causes - caused by current across gap between surfaces; proper grounding will correct problem.

- ◆ **Corrosion** - metal loss from chemical attack due to one or more of the following; presence of water, corrosive atmosphere, corrosive (oxidized) lubricant and fretting.

Lubricated equipment (cont'd)

■ *Failure Conditions Present in Bearings (cont'd)*

- ◆ **Cracks** - narrow openings or breaks usually without metal loss.

Causes - caused by improper fits, housing deformation, etc., that over-stress the races.

- ◆ **Brinnelling** - (indentation) surface depressions w/o material loss.

Causes - impact loading beyond static load capacity on a stationary bearing; improper mounting and the presence of abrasive particles.

- ◆ **Broken or Damaged Races and Cages**

Causes - improper mounting, lube starvation and excessive speed.

Lubricated equipment (cont'd)

■ *Failure Conditions Present in Bearings (cont'd)*

- ◆ **Grooves** - develop when a hard, abrasive metallic particle enters a bearing and gets caught in the softer cage pocket, creating grooves as it rubs against the roller.
- ◆ **Heat Checks or Thermal Cracking** - minute radial cracks resulting from frictional heat that causes sliding contact within bearing.
Causes - inadequate lubrication or improper fitting practices
- ◆ **Handling Damage** - during installation and at any time thereafter, any and all of these can happen: broken flanges, nicks and burrs, misalignment, machining errors, excessive preload, and cage damage; great care should be exercised to prevent such things; otherwise failure is sure to follow.

Lubricated equipment (cont'd)

- ***Troubleshooting Potential Bearing Problems***
 - ◆ Excessive heat
 - ◆ Excessive noise
 - ◆ Damaged seals
 - ◆ Excessive leakage
 - ◆ Oil analysis results showing high metals or contamination

Lubricated equipment (cont'd)

■ ***Reasons for Grooving/Chamfering Plain Bearings***

- ◆ Allow a mechanism for sufficient oil distribution to the proper areas.

■ ***Oil viscosity in bearings:***

- ◆ Too High an oil viscosity in a bearing causes: Overheating
- ◆ Too Low an oil Viscosity in a bearing causes: Too much metal-to-metal contact resulting in excessive wear and eventual failure.

Lubricated equipment (cont'd)

- ***Procedure for re-greasing an anti-friction bearing (roller) bearing mounted in a pillow block with a purge plug***
 - ◆ Pull the grease plug
 - ◆ Pump grease in until you no longer see old grease coming out of plug hole. (I.E. when new grease begins to come out)
 - ◆ Run bearing for a couple of minutes to allow internal pressure to escape.
 - ◆ Stop bearing
 - ◆ Put plug back in
 - ◆ Restart bearing

Lubricated equipment (cont'd)

■ GEARS



Lubricated equipment (cont'd)

■ *Purpose of Gearing*

- ◆ Gearing is used to transmit power from a prime mover to a final source with either an increase or decrease in power or torque or a change in direction or plane from that of the initial source.
- ◆ The driving gear is the pinion and the driven gear is the bull

Lubricated equipment (cont'd)

■ *Gears definitions*

- ◆ **Addendum** - Area between pitch line and tip
- ◆ **Bull** - Driven Gear
- ◆ **Burnishing** - State of gear wear which leaves shiny mirror-like finish on gear.
- ◆ **Dedendum** - Radial distance from pitch line to root
- ◆ **Face** - Surface area between pitch line to tip
- ◆ **Featheredging** - Gear wear mode resulting in metal flow towards gear tooth.
- ◆ **Flank** - Surface area between pitch line and root.
- ◆ **Galling** - Gear wear resulting from lubricant failure.
- ◆ **Interval of Approach** - Time needed for gear engagement.

Lubricated equipment (cont'd)

■ **Gears definitions (cont'd)**

- ◆ **Misalignment** - Gear wear from uneven load distribution
- ◆ **Peening** - Gear wear resulting in metal flow towards gear end tips
- ◆ **Pinion** - Driving Gear
- ◆ **Pitch Circle** - Imaginary line of contact for outermost points in gear circle.
- ◆ **Pitting** - Gear wear resulting in metal removal along pitch line
- ◆ **Root** - Innermost region of gear tooth
- ◆ **Scoring** - Lateral gear wear along face and flank
- ◆ **Scuffing** - Lateral gear wear along gear face and flank
- ◆ **Spalling** - Severe pitting
- ◆ **Tip** - Outermost region of gear tooth

Lubricated equipment (cont'd)

■ *Lubrication Factors to Consider in Gear Lube Selection*

- ◆ Gear type
- ◆ Gear speed
- ◆ Reduction ratio
- ◆ Operating Temperature
- ◆ Input power
- ◆ Surface finish
- ◆ Load characteristics
- ◆ Drive Type
- ◆ Application method
- ◆ Water Contamination
- ◆ Lubrication leakage

Lubricated equipment (cont'd)

■ *Types of Gears*

- ◆ **Spur Gear** - Gear set that generates with teeth that run parallel to their mounting shaft. Low speeds/light loads



Lubricated equipment (cont'd)

■ *Types of Gears (cont'd)*

- ◆ **Bevel Gear** - Gear set that operates in intersecting shafts. Low Speeds



Lubricated equipment (cont'd)

■ *Types of Gears (cont'd)*

- ◆ **Spiral Bevel Gear** - Gear with intersecting shafts.
Carry more loads. Quieter/Smother



Lubricated equipment (cont'd)

■ *Types of Gears (cont'd)*

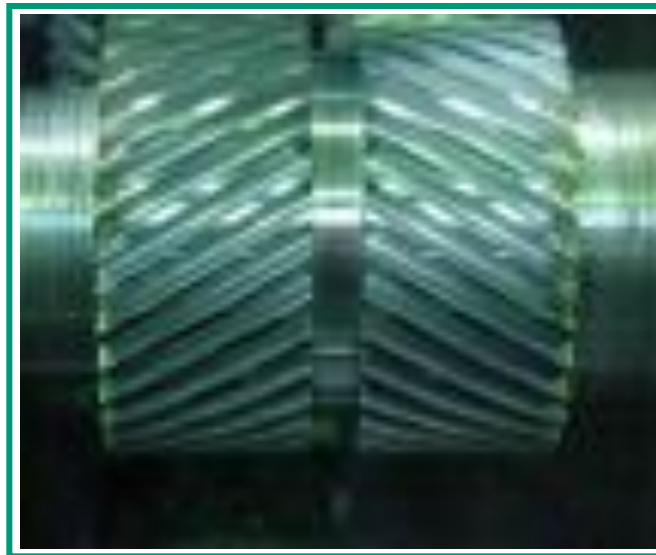
- ◆ **Helical** - Gear with short line of contact. Load distributed over more teeth at one time.



Lubricated equipment (cont'd)

■ *Types of Gears (cont'd)*

- ◆ **Herringbone Gear** - Gear that enables the opposing thrust forces to be cancelled out. Parallel shafts. Operate under shock and vibration loading.



Lubricated equipment (cont'd)

■ *Types of Gears (cont'd)*

- ◆ **Hypoid Gear** - Gear used when shafts must cross but do not intersect. High speeds and moderate loading



Lubricated equipment (cont'd)

■ *Types of Gears (cont'd)*

- ◆ **Worm Gear** - Gear set for large reduction ratios. Compact with heavy load carrying ability. Produce constant output speed and torque transfer.



Lubricated equipment (cont'd)

- ***Characteristics of a Good Gear Lubricant***
 - ◆ ***Proper Viscosity***
 - ◆ ***Good Film Strength***
 - ◆ ***Good Rust Protection***
 - ◆ ***Good Oxidation Protection***
 - ◆ ***Good Demulsibility and Foam Resistance***
 - ◆ ***Good Anti-wear Properties***

Lubricated equipment (cont'd)

- ***Gear Box Lubrication possible disruptive points***
 - ◆ Gear wear
 - ◆ Venting
 - ◆ Operating temperature
 - ◆ Leakage
 - ◆ Excessive loads
 - ◆ Contamination
 - ◆ Lubricant

Lubricated equipment (cont'd)

- ***Open Gear Lubrication possible disruptive points***
 - ◆ Temperature
 - ◆ Dirt
 - ◆ Rust
 - ◆ Water
 - ◆ Method of application
 - ◆ Disposal of waste oil

Lubricated equipment (cont'd)

- ***Reasons Why Gear Sets Fail***
 - ◆ Surface Fatigue
 - ◆ Wear & Scoring
 - ◆ Plastic Flow
 - ◆ Tooth Breakage
 - ◆ Failure Associated with processing

Objective 6 – Filtration process and methods

- Reclamation and conditioning of lubricating oils are now standard practices. Lubricant conditioning may be accomplished by settling, centrifuging, re-refining and filtering. This topic will only cover the filtration process and methods.



Filtration process and methods (cont'd)

■ *Filtering definitions*

- ◆ **Filtering** - Removing microscopic solids in the range up to 50 to 60 microns.
- ◆ **Microns** – 0.000039 in. or 0.000001 meter (linear measurement)
- ◆ **Straining** – removing solids in size generally larger than 75 to 100 microns.
- ◆ **Medium or element** – the device that actually removes and retains the solids or soluble impurities.
- ◆ **Element particle** – size rating; dimension in microns of the particle that the element will retain to some predetermined efficiency.

Filtration process and methods (cont'd)

■ *Filtering definitions (cont'd)*

- ◆ **Element efficiency** – ration of number of particles removed to number present for any particular particle-size rating.
- ◆ **Influent** – unfiltered portion of fluid.
- ◆ **Effluent or filtrate** – filtered portion of fluid.
- ◆ **Absorb** – depth filtration as contrasted to surface retention.
- ◆ **Adsorb** – filter process performed by certain media having the selective characteristic of retaining undesirable solution impurities by an adhesive phenomenon.

Filtration process and methods (cont'd)

■ ***Characteristics***

- ◆ Pressure loss versus flow
- ◆ Particle size retention
- ◆ Pore size distribution
- ◆ Efficiency
- ◆ Dirt storage capacity

■ ***Significant points***

- ◆ Susceptibility of filter media to migration
- ◆ Channelling
- ◆ Rupturing
- ◆ Bypassing
- ◆ Action of various fluids
- ◆ Resistance to extraordinary temperature

Filtration process and methods (cont'd)

■ *Filtration equipment*

- ◆ Replaceable cartridge filters
- ◆ Bulk type filters
- ◆ Inert filters
- ◆ Adsorbent or active filters
- ◆ Extended area filters
- ◆ Edge type filters
- ◆ Wire wound filters
- ◆ Magnetic filters
- ◆ Web type filters

Filtration process and methods (cont'd)

- Most mineral oil filters will be affected by water to some degree.
- Filtration efficiency is impaired and flow rates reduced thereby.
- If a filter is saturated thoroughly with oil before water reaches it, it usually will shed considerable amounts of water provided by flow rates, viscosities, and pressures are not too high and the water is not too finely divided or emulsified.

Filtration process and methods (cont'd)

- Proper system design and operating procedures leading to economical filtration can be obtained by controlling or eliminating entry of contaminants into a lubricating system.
- Every precaution should be used to minimize entrance of water, dust, diluted fuel and other foreign matter.

Filtration process and methods (cont'd)

- There are three types of filtration systems in use today:
 - ◆ individual-machine continuous systems
 - ◆ central-continuous systems
 - ◆ central-reclaiming systems

Filtration process and methods (cont'd)

■ Central-continuous systems

- ◆ In high-production plants, central-continuous systems are often used.
- ◆ In this method, used oil is pumped into a collecting line, goes to a central-continuous clarification system and is returned clean to the machines.
- ◆ Some operations require individual machine continuous filtration, while in others, oil is used for several days, taken to central-reclaiming plant, reconditioned and returned to use.

Filtration process and methods (cont'd)

■ *Hydraulically actuated machinery*

- ◆ Hydraulic oils do not become contaminated in the same sense as engine oils; nevertheless maintenance is required.
- ◆ Continuous filtration is the best way to maintain these oils in the best condition, although intermittent filtration has proved very successful.
- ◆ The proper filtration of hydraulic oils prevents excessive wear of hydraulic parts, prevents clogging and sticking of control valves and pistons and extends oil life.
- ◆ When straight mineral oils are used adsorbent filters are very satisfactory.
- ◆ Inert filters are recommended for systems employing oils containing oxidation and corrosion inhibitors and will maintain these oils essentially free of abrasives.

Filtration process and methods (cont'd)

■ *Synthetic fluids*

- ◆ Synthetic fluids are sometimes used in place of petroleum oils because of some shortcomings of petroleum oils such as their inflammability and oxidation characteristics.
- ◆ Filtration equipment for synthetic fluids varies with the liquid. Both inert and active earth filters have proved very satisfactory.

Filtration process and methods (cont'd)

■ *Conclusion*

- ◆ The trend in filtration is toward the removal of smaller and smaller particles. It is generally found that the filtration cost varies inversely with the size of the particle retained.
- ◆ Continuous filtration is the most efficient and economical way to operate. It is preferred over intermittent filtration or batch filtration because contaminants are removed from the lubricant as they are formed, thereby allowing the engine or machine to operate on clean oil at all times.

Filtration process and methods (cont'd)

■ *Conclusion (cont'd)*

- ◆ Adsorbents are widely used in the conditioning lubricating oil. The most commonly used adsorbent are fuller's earth, acid-activated bentonites, bauxite, and activated silicate.
- ◆ Centrifuges are extremely economical and simple to operate, create no loss of additive content and occupy very little space.
- ◆ The most important saving accruing from lube-oil conditioning is in the extended useful life of the engine or machine involved.

Objective 7 – Best Practices & Inspections



Grease gun

Filter Carts

Oil drums

Lubricant
dispensers

Best Practices & Inspections (cont'd)

Oil analysis/Cleanness

Sample Reports - Lotus Notes

File Edit View Create Actions Applet Help

Welcome Jorge Caicedo - Inbox FW: CAR SONIDO > 2005 Objectives and Go... [WebCheck] - Active Sam... Sample Reports notes

WEAR CHECK

INDUSTRIAL OIL ANALYSIS REPORT

CONTAMINATION NORMAL
WEAR ABNORMAL
OIL CONDITION NORMAL

06-106 MS BRG WEST - Bearing

Unit Make : N/A Date Rec'd : May 3, 2005 Sample Date : Apr 30, 2005
Unit Model : N/A Serial No. : (n/a) Time on Unit : 0 hrs
Comp Make : N/A Cust. RefNo. : (n/a) Time on Oil : 0 hrs
Comp Model : N/A Stub No. : WC- Time on Filter : 0 hrs

RECOMMENDATION Diagnostician: Barry Goslin

Consider re-sampling and monitoring equipment operating parameters and/or vibration analysis for bearing frequencies to confirm the condition of this unit. We recommend that you drain the oil from the component if this has not already been done.

CONTAMINATION

There is no indication of any contamination in the component.

Sample Date	06/08/04	08/30/04	Current	Abn
Silicon	0.5	0.2	1.4	---
Potassium	0.0	0.0	1.2	---
Water (%)	<0.1	<0.1	<0.1	---
*Dirt	NONE	NONE	NONE	---
*Debris	VLITE	NONE	NONE	---
*Silt	NONE	NONE	NONE	---
*Precipitate	NONE	NONE	NONE	---

WEAR

The lead level is abnormal. The copper level is marginal. Bearing and/or bushing wear is indicated.

Sample Date	06/08/04	08/30/04	Current	Abn
*White Metal	NONE	NONE	NONE	---
*Babbitt	NONE	NONE	NONE	---
Iron	1.9	1.1	1.2	20
Nickel	0.0	0.0	0.0	20
Chromium	0.0	0.0	0.0	20
Titanium	0.0	0.0	0.0	---
Copper	4.0	1.6	10	20
Aluminum	0.0	0.0	0.4	20
Tin	1.0	0.0	0.0	20

start Sample Report... Operators Lubr... My Pictures MAXIMO 4i Rel... Purchase Req... 2:13 PM

Oil analysis report example

Best Practices & Inspections (cont'd)

- Lubricants must be kept cool, clean and dry
- All oil dispensing containers/equipment should be kept clean
- No level of oil contamination is allowable
- All grease and oil drums, kegs and tanks should be properly identified
- Proper 'oil-house' rotation of lubricants is essential
- Lubricants have a shelf life
- Dust acts as an insulator - creates heat. Wipe dust
- Check oil reservoir ventilation and filter maintenance

Objective 8 - Troubleshooting

■ Circulating System problems:

- ◆ Low pressure
- ◆ High pressure
- ◆ Low flow
- ◆ High temperature

■ Spray System problems:

- ◆ Lubrication does not occur
- ◆ Lube fault

■ Farval System problems:

- ◆ Lubrication doesn't occur

Objective 9 - Safety

- General speaking lubricants do not represent any risk; however they should be properly handled, stored and manipulated.
- Lubrication or hydraulic systems where high temperature and pressure are present might become a safety hazard, if a line, valve or seal fails.

Safety (cont'd)

- General recommendations are:
 - ◆ Piping, houses, seal, should be installed according to operational conditions including possible extreme conditions and a per government regulations.
 - ◆ Safety switches (pressure, temperature, etc.) should be operational and not jumped out.
 - ◆ For lubricant handling and storage; using the proper rigging and storing tools will greatly eliminate the risk of accidents.

Safety (cont'd)



Hoisting beam



Drum handling cart

Safety (cont'd)

- **Cleanness:** Oil spills represent an accident hazard. Maintaining a clean and well organized area will prevent accidents and will help to detect potential problems.

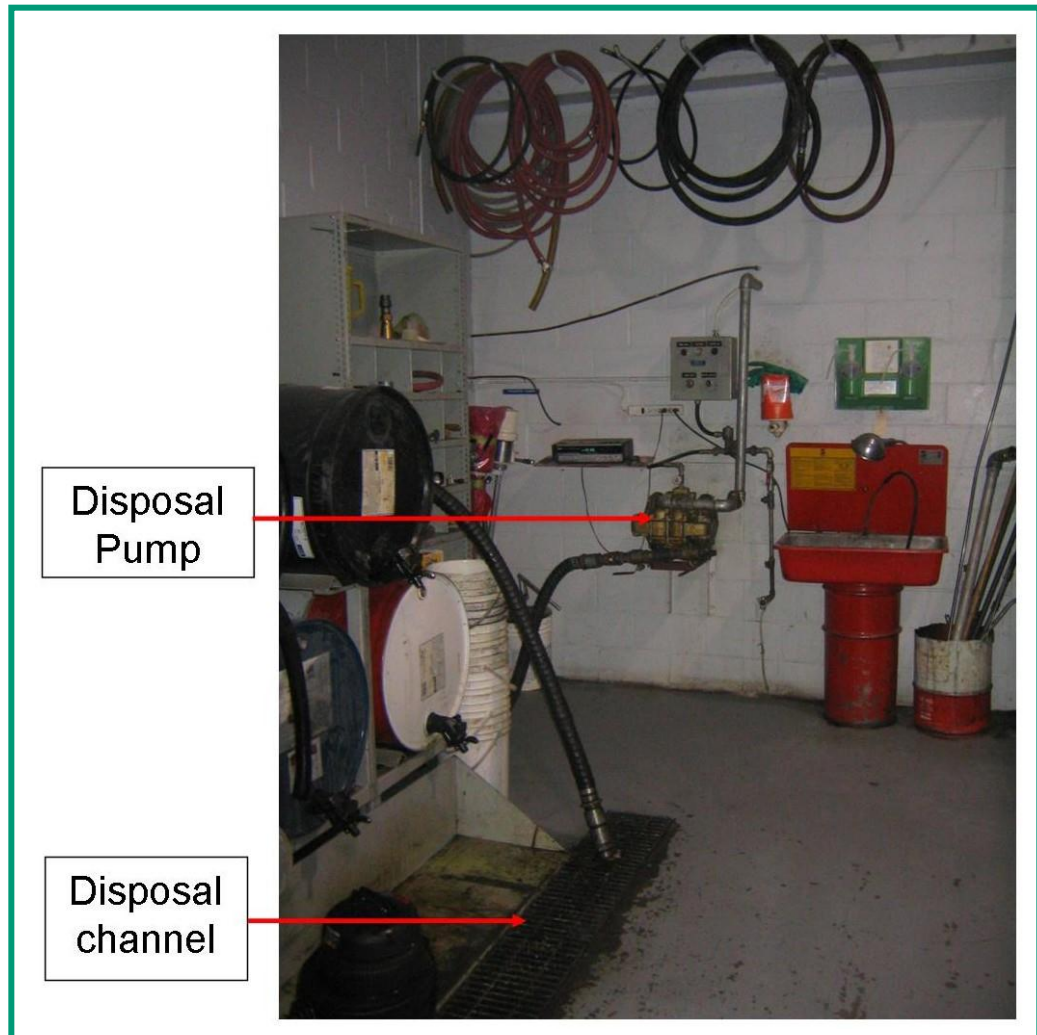


Lubricants Storing

Safety (cont'd)

- **Lubricants disposal:**
Government regulations should always be followed and the resources provided for an adequate waste management.

Disposal system



Lesson Review

- Define what friction is and how lubrication relates to friction.
- ◆ A force that a body must overcome when slides across another. Solid friction is present when two rigid bodies are in contact and fluid when liquids or gases molecules are in motion. Solid or sliding friction occurs mainly due to asperities present in two surfaces that rub together. When ever friction is overcome, moreover, dislocation of the surface particles generates heat that could become destructive. Additionally where there is solid friction, there is wear; a loss of material due to the cutting action of opposite asperities. Lubrication reduces or eliminate potential equipment failure due to the friction action and also reduces the power consumption by reducing friction between sliding each other.

Lesson Review

- Define what lubrication is and why it is important.
 - ◆ The principle of supporting a sliding load on a friction-reduction film is known as lubrication. Lubrication reduces friction, prevents wear, removes heat and prevents rust and corrosion.

Lesson Review

- Describe the 3 main types of lubricants.
 - ◆ **Oils.**
 - **Mineral:** Consist of base oil and additives which determine their performance characteristics
 - **Synthetic.** Chemically synthesized (polymerization) and designed to have specific properties.
 - ◆ **Industrial grease.** Is a fine dispersion of an oil-insoluble thickening agent, usually soap, in a fluid lubricant which is generally mineral oil
 - ◆ **Solid Lubricants.** There are may type of solid lubricant used for different applications, like synthetic, metallic or mineral powders.

Lesson Review

■ Describe the main lubricants properties.

◆ *Mineral Oils*

- Oxidation stability
- Anticorrosion properties
- Wear protection
- Wetting behaviour
- Viscosity-temperature behaviour

◆ *Synthetic oils*

- Low pour point and /or
- High flash / fire point and/or
- High viscosity index and /or
- Oxidative and thermal stability and /or
- High shear strength

◆ *Industrial grease*

- nature and amount of thickener
- characteristic of mineral oil
- whether additives are used
- the way the grease is made

◆ *Solid Lubricants*

- synthetic
- metallic
- mineral powders

Lesson Review

- What are the advantages and disadvantages of synthetic oil?
 - ◆ These properties enable the lubricant to handle tougher conditions (high temperature, temperature change, water contamination, etc.) better than its equivalent mineral oil, however due to the high cost they are used only under special conditions.

Lesson Review

- Describe three types of oil lubrication systems.
 - ◆ *Oil bath*
 - ◆ *Splash*
 - ◆ *Circulating system*
 - ◆ *Spray System*
 - ◆ *Manually*
 - ◆ *Central System (Farval)*
- ◆ Details as per lubrication systems information.

Lesson Review

- Describe what oil analysis is and its purpose.
 - ◆ In the past the oil was changed only based on time, that is, in some plants the oil was changed days or months after the last change without any consideration of the oil condition. For mobile equipment especially, the oil was changes based on miles or running time. However today it is more common to find plants implementing oil changes based on oil analysis. This procedure not only provides information about the oil condition but also about the equipment condition. Sometimes it can detect equipment problems even before a vibration analysis would pick it up. The oil analysis provides information in regards to the oil degradation, contaminants and metal particles due to wear. It also helps to reduce lubricants consumption costs and maintenance costs by preventing failures and repairing equipment based on their condition rather than on a fixed time period.

Lesson Review

- Name 3 problems related to the circulating system.
 - ◆ Low pressure
 - ◆ High pressure
 - ◆ Low flow
 - ◆ High temperature

Lesson Review

- What are the main considerations when dealing with hydraulic systems in regards to safety?
 - ◆ Piping, hoses, seal, should be installed according to operational conditions including possible extreme conditions and as per government regulations.
 - ◆ Safety switches (pressure, temperature, etc.) should be operational and not jumped out.
 - ◆ For lubricant handling and storage; using the proper rigging and storing tools will greatly eliminate the risk of accidents.
 - ◆ Cleanliness: Oil spills represent an accident hazard. Maintaining a clean and well organized area will prevent accidents and will help to detect potential problems.
 - ◆ Lubricants disposal: Government regulations should always be followed and the resources provided for an adequate waste management.

Lesson Review

- What are the two main categories of bearings?
 - ◆ Plain
 - ◆ Rolling element

Lesson Review

- What is the purpose of gearing?
 - ◆ Gearing is used to transmit power from a prime mover to a final source with either an increase or decrease in power or torque or a change in direction or plane from that of the initial source.

Lesson Review

- Name 3 oil additives.
 - ◆ Antiwear agent (aw)
 - ◆ Extreme pressure (ep)
 - ◆ Oxidation inhibitors
 - ◆ Detergent
 - ◆ Dispersant
 - ◆ Rust inhibitor
 - ◆ Viscosity (vi) improver
 - ◆ Pour point depressant
 - ◆ Molybdenum disulfide
 - ◆ Defoamant

Lesson Review

- What are the components of grease?
 - ◆ Oil
 - ◆ Thickener
 - ◆ Additives

Lesson Review

- Name the 3 lubrication categories.
 - ◆ Hydrodynamic lubrication
 - ◆ Boundary lubrication
 - ◆ Elastohydrodynamic lubrication (EHL)

Lesson Review

- What is viscosity?
 - ◆ Viscosity is defined as a measurement of a fluid's resistance to flow.

Lesson Review

- Name 3 type of oil filters.
 - ◆ Replaceable cartridge filters
 - ◆ Bulk type filters
 - ◆ Inert filters
 - ◆ Adsorbent or active filters
 - ◆ Extended area filters
 - ◆ Edge type filters
 - ◆ Wire wound filters
 - ◆ Magnetic filters
 - ◆ Web type filters

Lesson Review

- What is the most important saving obtained from oil conditioning?
 - ◆ The extended useful life of the engine or machine involved.