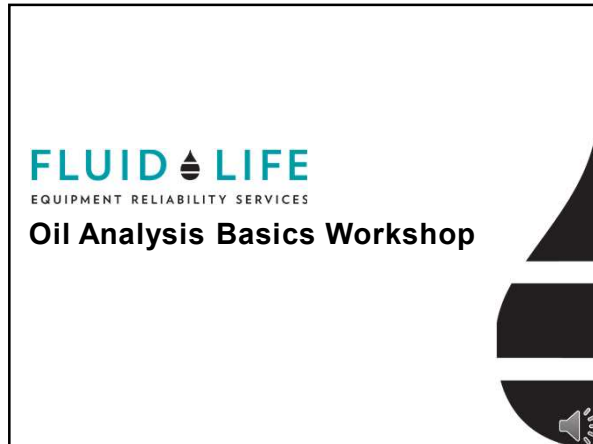
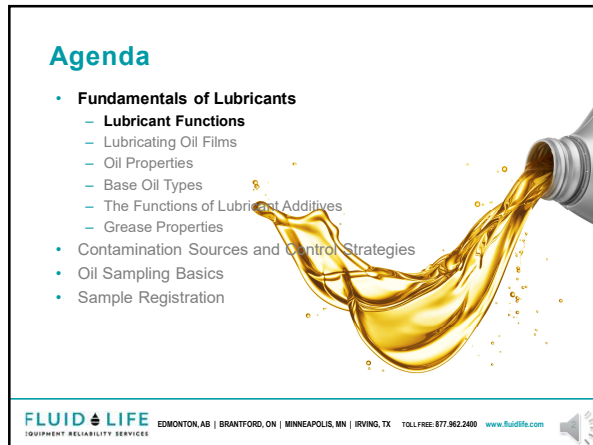
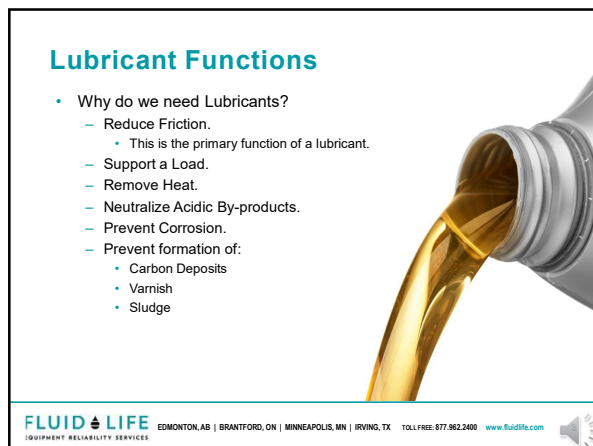




1



2



3

Agenda

- **Fundamentals of Lubricants**
 - Lubricant Functions
 - **Lubricating Oil Films**
 - Oil Properties
 - Base Oil Types
 - The Functions of Lubricant Additives
 - Grease Properties
- Contamination Sources and Control Strategies
- Oil Sampling Basics
- Sample Registration



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4

Lubricating Oil Film



- Hydrodynamic Lubrication
- Mixed Lubrication
- Boundary Lubrication
- Elastohydrodynamic (EHD)
- Hydrostatic Films

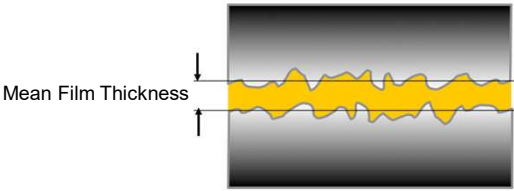
Image courtesy Imperial Oil

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Lubricating Film

- The interacting surfaces are separated by a lubricant with an oil film of varying thickness.



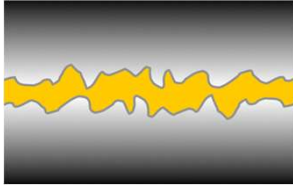
Mean Film Thickness

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Hydrodynamic Lubrication

- Complete oil film with no surface contact.
- Film thickness depends on viscosity, speed, pressure or load.

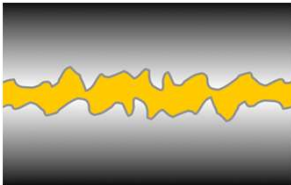


$$\lambda > 4$$

7

Mixed Lubrication

- Since the specific film thickness equation uses mean values, some asperities may still contact each other when the λ is equal to or greater than 1.

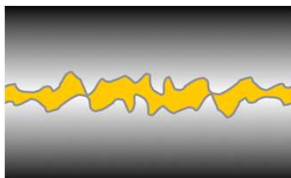


$$1 < \lambda < 4$$

8

Boundary Lubrication

- Significant asperity contact, further protection required from anti-wear or extreme pressure additives.



$$\lambda < 1$$

9

Elasto-Hydrodynamic (EHD)

- Extremely high contact pressures produce a solid film that causes elastic deformation of the surfaces.
- Occurs in both anti-friction bearings and gears.

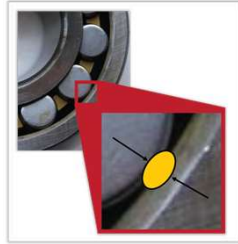


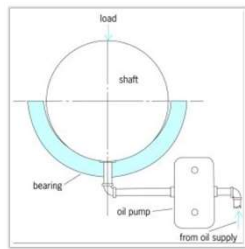
Image courtesy Imperial Oil

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Hydrostatic Films

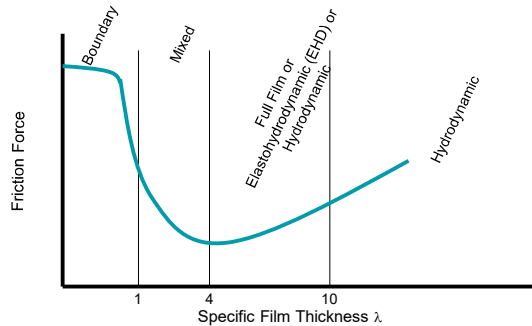
- Oil pressure supplied from an external source lifts and supports the load.
- No relative motion is required to produce an adequate oil film.



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Stribeck Curve



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Agenda

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Lubricating Oil Properties

- Viscosity
- Viscosity Index
- Density / Specific Gravity
- Flash Point / Fire Point
- Pour Point
- Cloud Point



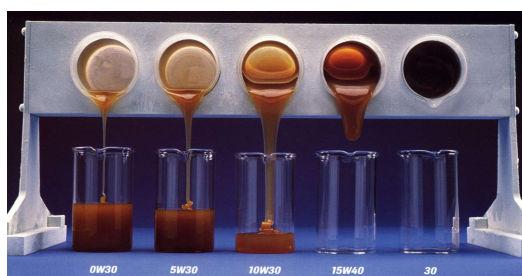
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Viscosity

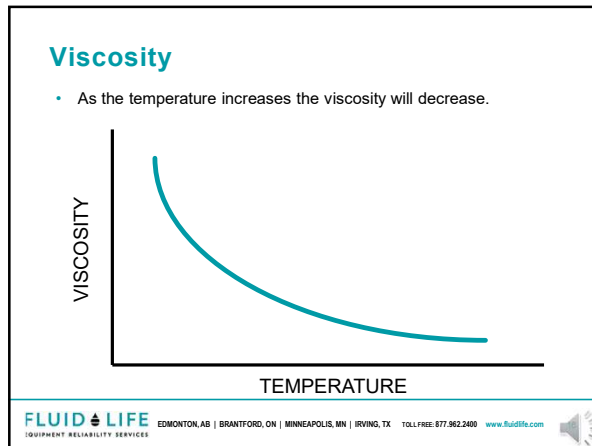
- Measurement of the oil's internal resistance to motion.



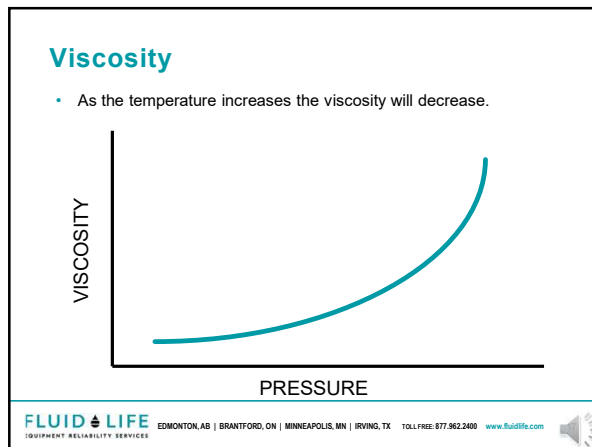
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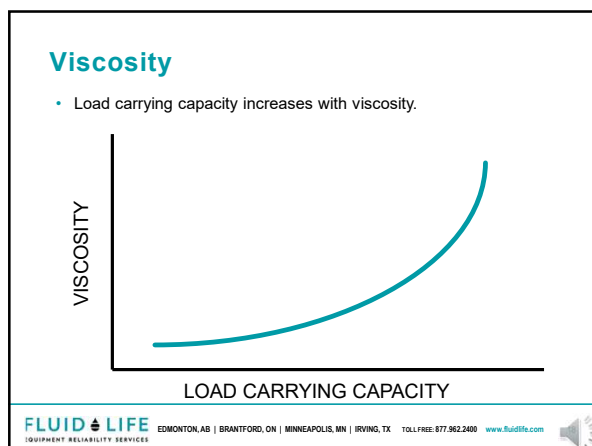
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17



18

Viscosity



- How is viscosity affected by the shear rate over time?

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Viscosity

- Viscosity will not change with increasing shear rate in Newtonian fluids.

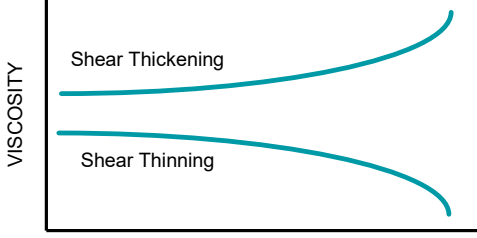


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Viscosity

- Viscosity will decrease with increasing shear rate in non-Newtonian fluids.



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Viscosity

- Kinematic:
 - Measure of fluid's resistance to flow under gravity.
 - Derived from the time taken for a lubricant to travel through a capillary tube.
 - Unit of measure - Stoke (St):
 - = 1 cm² / second
 - Typically reported as centistoke - (cSt): = 1 mm² / second.
- Absolute:
 - Measure of a fluid's resistance to flow under an applied force.
 - Derived from the force required to turn a spindle submerged in a lubricant.
 - Unit of measure - Poise (P):
 - = dyne • s/cm² = 10μN • s/cm²
 - Typically reported as centipoise (cP): Absolute Viscosity = Kinematic Viscosity x Density

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ISO Viscosity System

ISO VISCOSITY GRADE	MID POINT @40°C (cSt)	MINIMUM (cSt)	MAXIMUM (cSt)
2	2.2	1.98	2.42
3	3.2	2.88	3.52
5	4.6	4.14	5.06
7	6.8	6.12	7.48
10	10	9.0	11.0
15	15	13.5	16.5
22	22	19.8	24.2
32	32	28.8	35.2
46	46	41.4	50.6
68	68	61.2	74.8
100	100	90	110
150	150	135	165
220	220	198	242
320	320	288	352
460	460	414	506
680	680	612	748
1000	1000	900	1100
1500	1500	1350	1650

ISO SYSTEM
+/- 10%

EXAMPLE
ISO VG 32
Range 28.8 to
35.2 cSt @
40°C

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SAE J300 (2013) Viscosity Classification

SAE VISCOSITY GRADE	LOW TEMPERATURE CRANKING VISCOSITY, MAX (cP @ °C)	LOW TEMPERATURE PUMPING VISCOSITY, MAX (cP @ °C)	KINEMATIC VISCOSITY @ 100°C, MIN (cSt)	KINEMATIC VISCOSITY @ 100°C, MAX (cSt)	HIGH SHEAR RATE ABSOLUTE VISCOSITY @ 150°C, MAX (cP)
0W	6200 at -35	60 000 at -40	3.8	-	-
5W	6600 at -30	60 000 at -35	3.8	-	-
10W	7000 at -25	60 000 at -30	4.1	-	-
15W	7000 at -20	60 000 at -25	5.6	-	-
20W	9500 at -15	60 000 at -20	5.6	-	-
25W	13000 at -10	60 000 at -15	9.3	-	-
16	-	-	6.9	<8.2	2.3
20	-	-	6.9	<9.3	2.6
30	-	-	9.3	<12.5	2.9
40 ¹	-	-	12.5	<16.3	2.9
40 ²	-	-	12.5	<16.3	3.7
50	-	-	16.3	<21.9	3.7
60	-	-	21.9	<26.1	3.7

¹ with 0W-40, 5W-40 and 10W-40 grades ² with 15W-40, 20W-40 and 25W-40 grades

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Why Consider 0W-30?

SAE VISCOSITY GRADE	VISCOSITY AT 40°C (cSt)	VISCOSITY AT 100 °C (cSt)
10W-30	79	12.0
5W-30	65	11.0
0W-30	69	12.2

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SAE J306 (2005) Gear Oil Classification

SAE VISCOSITY GRADE	MAXIMUM TEMPERATURE FOR VISCOSITY OF 150,000 cP (°C)	MINIMUM VISCOSITY (cSt @ 100°C)	MAXIMUM VISCOSITY (cSt @ 100°C)
70W	-55	4.1	-
75W	-40	4.1	-
80W	-26	7.0	-
85W	-12	11.0	-
80	-	7.0	<11.0
85	-	11.0	<13.5
90	-	13.5	<18.5
110	-	18.5	<24.0
140	-	24.0	<32.5
190	-	32.5	<41.0
250	-	41.0	-

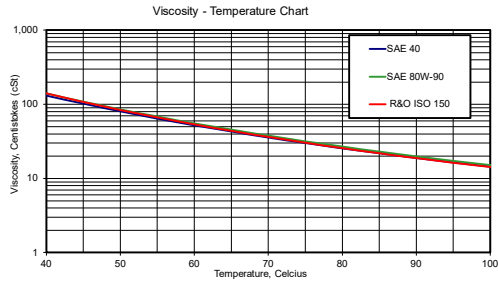
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Multi-grade oil chart



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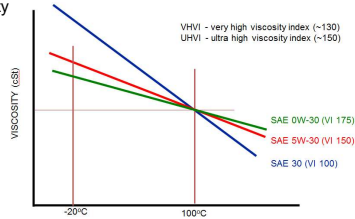
What product has the right viscosity?



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Viscosity Index

- VI is a unit less number indicating the effect of temperature on the viscosity of an oil.
- The higher the VI the less effect temperature has on the viscosity



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Consequences of Incorrect Viscosity

- Too High:
 - Poor oil flow and lubrication to bearings.
 - Increased energy consumption.
 - High temperature causes - build up of products of oxidation.
 - Inadequate defoaming / demulsifying properties.
 - Cavitation.
 - Reduced pumpability during cold starts.
- Too Low:
 - Shearing (loss of oil film) leads to high wear.
 - Insufficient lubrication at high temperatures, low speed, and / or high load.
 - Loss of energy due to friction.
 - Internal or external leakage.

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Density / Specific Gravity

- Typical specific gravity of a lube oil is in the range of 0.85-0.90, where water = 1.
- Density would be expressed as 850 kg/m^3 or 0.85 kg/l .



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Flash and Fire Point

- The flash point is the temperature at which the air vapor mixture above the surface of the oil will flash in the presence of a flame.
- The fire point is the temperature at which there is sufficient vapor to sustain combustion for 5 seconds.



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Pour Point / Cloud Point

- Pour Point
 - The temperature at which there is no movement in the oil, when tipped at 90° , for 5 seconds.
 - Influenced by wax crystallization.
- Cloud Point
 - The point, as the temperature is lowered, at which the lubricant begins to become cloudy due to the onset of wax crystallizations.



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Agenda

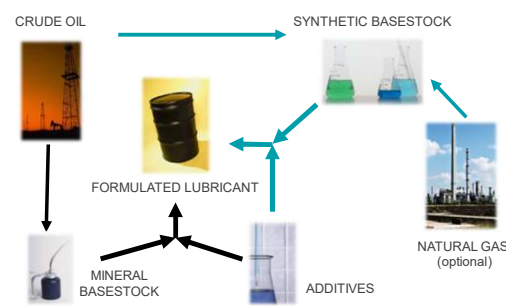
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Base Oil Types



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Lube Base Oils - API Classification

BASE OIL CHARACTERISTICS					
API GROUP	sulfur %	WT %	SATURATES WT %	VISCOSITY INDEX	MANUFACTURING METHOD
I	> 0.03	and/or	< 90	80-119	Solvent Refined
II	< 0.03	or	> 90	80-119	Hydroprocessed
III	< 0.03	or	> 90	120 +	Severely Hydroprocessed
IV	Polyalphaolefins (PAO)		125-200+		Oligomerization
V	All other base oils not included above				Various

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Hydrotreated Oils

- Pros:
 - May use poor quality crude.
 - Lower operating costs.
 - Typically have higher VI's.
 - Improved oxidation resistance.
 - Improved high temperature stability.
- Cons:
 - Higher capital costs.
 - Requires hydrogen supply.
 - High pressure units.
 - Skilled technicians.
 - Different additive package.



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Synthetic Oils

SYNTHETIC	COMMON APPLICATIONS
Polyalphaolefins (PAO)	Most Mobile & Industrial Lubricants
Alkylbenzenes	Refrigeration Compressor
Diesters	Compressors, co-synthetic with PAO
Polyolesters (POE)	Jet Engines, Refrigeration Compressors
Polyalkylene Glycols (PAG)	Natural Gas & Refrigeration Compressors
Phosphate Esters	Fire Retardant Hydraulic Fluids
Silicones	Heat Transfer Oils

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Polyalphaolefins (PAO)

- Pros:
 - Low pour point.
 - Long oxidation life.
 - Lower volatility.
 - High Viscosity Index.
 - More energy efficient.
- Cons:
 - Limited biodegradability.
 - Cost not conducive for:
 - Once-through systems.
 - Leaking systems.



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Diesters



- Pros:
 - Long oxidation life.
 - Lower volatility.
 - High Viscosity Index.
 - Good biodegradability.
 - Examples:
 - Anderol 500 & 750
- Cons:
 - Bad hydrolytic stability.
 - Limited compatibility with seal materials and paints.

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Polyglycols

- Pros:
 - High temperature, low coking tendency.
- Examples:
 - Sullube 32
 - Ingersoll-Rand SSR
 - Summit Supra 32
- Cons:
 - Water soluble.
 - Hydrocarbon soluble.



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Phosphate Esters

- Pros:
 - Excellent thermal stability, fire resistance.
 - Good for high pressures.
 - Excellent anti-wear.
 - Examples:
 - Reolube
 - Houghton 900

- Cons:
 - Very high price.
 - Low viscosity index.
 - Limited seal material compatibility.
 - Not miscible with mineral oils.
 - May attack some metal surfaces, paints.

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Polyolesters

- Pros:
 - High temperature stability.
 - Low volatility.
 - Examples:
 - BP Turbo Oil 2380
 - Mobil Jet II
- Cons:
 - Limited compatibility with seals and paints.
 - Poor hydrolytic stability.



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Silicones

- Pros:
 - High viscosity index.
 - Low pour points, good low temperature fluidity.
 - Fire resistant.
 - Water repellent.
 - Low volatility.
 - Great oxidation stability.
 - Example:
 - Dow Corning 200
- Cons:
 - Extremely high cost.
 - Worst mixed film lubrication properties.
 - Not miscible with mineral oil and additives.
 - Forms formaldehyde gas when overheated.

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Esters

- Synthetics at risk for water-induced degradation (hydrolysis):
 - Phosphate ester
 - Polyolester
 - Dibasic acid ester



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Base Oils Comparative Characteristics

	MINERAL OIL*	POLYALPH A-OLEFIN	DIESTER	POLYOL ESTER	POLY- GLYCOL	PHOSPHATE ESTER	SILICONE OIL
VISCOSITY TEMPERATURE	Fair	Good	Good	Good	Very Good	Poor	Excellent
LOW TEMPERATURE	Poor	Good	Good	Good	Good	Fair	Good
OXIDATION STABILITY	Fair	Very Good	Good	Excellent	Good	Fair	Good
COMPATIBLE WITH MINERAL OIL	Excellent	Excellent	Good	Fair	Poor	Poor	Poor
LOW VOLATILITY	Fair	Excellent	Excellent	Excellent	Good	Good	Good
ANTI-RUST	Excellent	Excellent	Fair	Fair	Good	Fair	Good
ADDITIVE SOLUBILITY	Excellent	Good	Very Good	Very Good	Fair	Good	Poor
SEAL SWELL	Excellent	Excellent	Fair	Fair	Good	Fair	Excellent

*Characteristics vary by base oil group

Ref: Various

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- 

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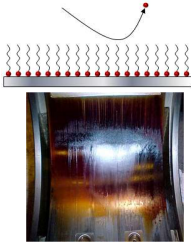
Additive Types

- **Active on Metal Surface:**
 - Anti-wear (AW)
 - Extreme Pressure (EP)
 - Friction Modifier
 - Tackifier
 - Oxidation Inhibitor
 - Rust and Oxidation Inhibitor
 - Detergent
 - **SURFACANT**
- **Active in the Oil:**
 - Viscosity Index Improver
 - Anti-Oxidant
 - Dispersant
 - Anti-foaming Agent
 - Demulsifier
 - Emulsifier
 - Pour Point / Cloud Point Depressant
 - **PENETRATING**

48

Detergents

- Role:
 - Neutralize combustion acids.
 - Inhibit deposit formation.
- How They Work:
 - Prevent deposition of sludge and varnish.
 - Neutralize strong acids due to alkali nature.
 - Form a protective film on metal surfaces.
- Common Additives:
 - Sulphonates, phenates or phosphonates of calcium and magnesium.
- Ultimate Outcome:
 - Additive is consumed.



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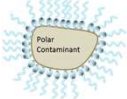
Dispersants

Polar head



Oil soluble tail

- Role:
 - Prevent agglomeration and promote suspension of polar particles:
 - Sludge, varnish, dirt, oxidation products, water
- How They Work:
 - Dispersant forms micelle around polar contaminants to hold them in solution.
- Common Additives
 - Non-metallic portion of detergent additive
 - Polyisobutylene succinimides
- Ultimate Outcome
 - Additive is consumed and can be filtered out with polar contaminant.



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Detergents versus Dispersants

DETERGENTS ATTRACTED TO METALIC SURFACES

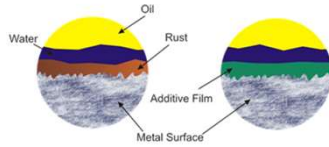
DISPERSANTS ATTRACTED TO POPLAR CONTAMINENTS

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Rust and Oxidation Inhibitor

- Role:
 - Protects iron and steel parts from attack by acidic contaminants and water.
- How They Work:
 - Forms a protective film on metal to prevent attack by oxygen, water and acids.
 - Delicate balance, can interfere with other surface active additives.
- Common Additives:
 - Calcium sulphonate
- Ultimate Outcome:
 - Additive is consumed.



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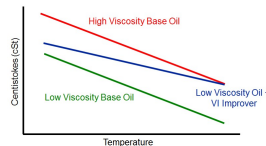
Anti-Oxidant

- Role:
 - To prevent formation of oxidative products (varnish, sludge and acids).
 - Reduce copper/lead bearing corrosion.
- How They Work:
 - React with oxidation intermediate reactive products, free radicals and hydroperoxides, to stop the oxidation reaction.
- Common Additives:
 - Zinc dialkyldithiophosphate (ZDDP)
 - Hindered phenols
 - Aromatic amines
- Ultimate Outcome:
 - Additive is consumed.

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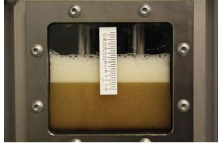
Viscosity Index Improver

- Role:
 - Reduces the rate of viscosity decreasing from increasing temperature.
 - Used to make multi-grade lubricants.
- How They Work:
 - Shrink when cold, unfurl when hot.
- Common Additives:
 - Polymethacrylates
 - Ethylene propylene copolymers
- Ultimate Outcome:
 - VI Improvers are susceptible to shear effects.
 - Permanent shear due to rupture of polymer.
 - Temporary shear thinning (aligning of polymer molecules in direction of flow).



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Anti-Foaming



- Role:
 - Prevent formation of surface foam.
- How They Work:
 - Changes surface tension of oil so that air bubbles break easily.
 - Promotes the formation of small bubbles into large ones that burst easily.
- Common Additives:
 - Dimethylsilicones (dimethylsiloxanes):
 - Very low concentrations.
- Ultimate Outcome:
 - Additive is consumed.
 - May be filtered out if bonded with polar contaminant.

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Anti-Wear (AW)

- Role:
 - Minimize metal-to-metal contact under boundary and mixed lubrication regimes:
 - For lighter loads, i.e. engines and hydraulics.
- How They Work:
 - Forms a sacrificial layer surface by **plating out** at temperatures of 65 - 100 °C.
- Common Additives:
 - Zinc dialkylthiophosphate (ZDDP)
- Ultimate Outcome:
 - Resolubilizes for reuse, consumed from role as anti-oxidant causes light chemical wear to surface.

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Extreme Pressure (EP)

- Role:
 - Minimize metal-to-metal contact under boundary and mixed lubrication regimes:
 - For heavier loads, i.e. gear boxes.
- How They Work:
 - Forms a sacrificial layer surface by reacting with metal surface at higher temperature and pressure.
- Common Additives:
 - Dark active sulfur hydrocarbon
 - Chlorinated paraffin
- Ultimate Outcome:
 - Consumed as it reacts with water to form acids.
 - Reactive EP additives cause aggressive micro-pitting of surfaces.



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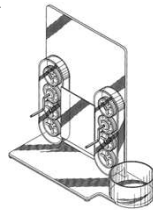
Friction Modifiers

- Role:
 - Reduce the coefficient of friction at low temperatures and mild sliding conditions.
- How They Work:
 - Polar end adsorbs to metal surface.
 - Increase oil film strength.
- Common Additives:
 - Molybdenum disulphide
 - Graphite
 - Polytetrafluoroethylene (PTFE), a.k.a. Teflon
- Ultimate Outcome:
 - Additive is consumed.

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Tackifiers

- Role:
 - Impart a tack, or stringiness, to lubricants to provide drip resistance or inhibit stray mist in pneumatic system lubricants.
- How They Work:
 - Promotes surface adhesion.
 - Increase oil film strength.
- Common Additives:
 - Polyisobutane.
 - Co-polymers of ethylene and propylene.
- Ultimate Outcome:
 - Additive is oxidized.

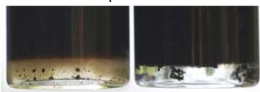


Lucas Oil demonstrator

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Demulsifier

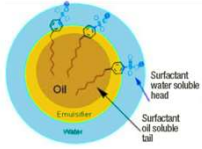
- Role:
 - Promote oil-water separation for lubricants exposed to water or steam.
- How They Work:
 - Surface-active agent (surfactant) that release moisture from the lubricant.
- Common Additives:
 - Polyisobutane
- Ultimate Outcome:
 - Exposure to water causes depletion.



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Emulsifier

- Role:
 - Promote stable mixture or emulsion.
- How They Work:
 - Polar molecule that is water-soluble at one end and oil-soluble at the other.
 - Reduce surface tension to facilitate mixing.
- Common Additives:
 - Co-polymers of ethylene and propylene.
- Ultimate Outcome:
 - Limited capacity unless water is driven off.



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Pour / Cloud Point Depressant

- Role:
 - Enhances the lower operability temperature of the oil.
- How They Work:
 - Inhibit the formation and agglomeration of wax crystals.
- Common Additives:
 - Co-polymers of polyalkyl methacrylates.
- Ultimate Outcome:
 - Additive is consumed.

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Additives

- Loss of Additives
 - Most additives physically or chemically decompose in service.
 - Additives will break down by:
 - Hydrolysis
 - Oxidation
 - Thermal Degradation
 - Shear down
- Additive Concentration
 - There is no way to replenish additives, other than to add more.
 - No mechanism to "regenerate" or "fix" additives.
 - No OEM or lubricant supplier endorses the use of aftermarket additives in fully-formulated products:
 - A fully-formulated oil, will balance the surface acting additives so that all will perform as expected.
 - The addition of a supplemental additive package may impact this balance.



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Additive Concentrations		
COMPONENT TYPE	COMMON ADDITIVES	CONCENTRATION (BY VOLUME)
Engines	Detergents, oxidation inhibitor, corrosion inhibitor, anti-wear (AW), anti-foam, viscosity index improver, alkalinity improver	10 - 30%
Gears (spiral, bevel or hypoid)	Anti-wear (AW), oxidation inhibitor, anti-foam, sometimes corrosion inhibitor, extreme pressure (EP)	1 - 10%
Hydraulics	Oxidation inhibitor, anti-wear (AW), anti-foam, corrosion inhibitor, pour-point depressant, viscosity index improver	2 - 10%
Gears (worm)	Extreme pressure (EP), oxidation inhibitor, corrosion inhibitor, friction modifier	3 - 10%
Steam turbines, Compressors	Rust inhibitor & oxidation inhibitor (R&O), demulsifier, anti-foam	0.1 - 5%

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Agenda

- **Fundamentals of Lubricants**
 - Lubricant Functions
 - Lubricating Oil Films
 - Oil Properties
 - Base Oil Types
 - The Functions of Lubricant Additives
 - **Grease Properties**
- Contamination Sources and Control Strategies
- Oil Sampling Basics
- Sample Registration



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Grease

- A solid to semi-fluid product made up of a liquid lubricant and a thickening agent.
- The nature and properties of the thickener, and the characteristics of the liquid lubricant, determine the properties of a grease.
- Two basic thickener types:
 - Soap
 - Non-soap
- Thickener Determines finished characteristics:
 - Temperature range
 - Pumpability
 - Water resistance
 - Stability - mechanical



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Grease

- Why use grease?
 - Decrease dripping, splattering and leakage.
 - Seal out contaminants.
 - Do not need circulation systems.
 - Suspend solid additives easily.
 - Suitable for intermittent operations.
 - Work under extreme operating conditions.
 - Some bearings can be pre-lubricated at factory and even sealed for life.
 - Reduce noise.
 - Greased machinery tends to need less power.
- Why not use grease?
 - May not reach all places in need of lubrication.
 - Does not have any cleaning effect.
 - Does not work as cooling agent.
 - Cannot be used at as high speeds as liquids.
 - Easy to over/under lubricate without proper procedures followed.

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Factors Affecting Grease Quality

- Additives - 1-10%:
 - Enhance base oil performance.
- Thickener - 5-20%:
 - Holds it all together and enhances properties of the oil.
- Base Oil - 70-90%:
 - Natural or Synthetic.
 - Provides the main lubrication function.



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Base Oil Viscosity for Grease

VISCOSITY	APPLICATION
ISO 100 & lower	Used for high speeds >3600 rpm, lower loads, good at low temperatures
ISO 150/220	Moderate speeds up to 3600 rpm, good load carrying, typical multi-purpose grease's oil
ISO 460	Higher loads than ISO150/220, often with improved water resistance
ISO 1500	Typical speeds <100 rpm, excellent load carrying, good water resistance

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Basic Properties

THICKENER	MAX. SERVICE TEMP °C	SHEAR STABILITY	WATER RESISTANCE	DROPPING POINT °C
Sodium Soap	93 -136	Med - Good	Poor	170-200
Calcium Soap				
Simple	121	Good	Good	80-100
Complex	149	Medium	Good	260+
Lithium				
Simple	163	Good	Medium	175-205
Complex	177	Good	Med - Good	260+
Aluminum				
Simple	79	Poor	Good	110
Complex	149	Medium	Good	260+
Clay	177	Medium	Medium	260+
Polyurea	177	Med - Good	Good	260+

Without performance enhancing additives

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GREASE COMPATIBILITY GUIDELINES

	Aluminum Complex	Barium	Calcium	Calcium 12 Hydroxyaric Acid	Calcium Complex	Clay	Lithium	Lithium 12 Hydroxyaric Acid	Lithium Complex	Polyurea	Sodium	Calcium Sulphate	Silica
Aluminum Complex	○	x	x	●	x	x	x	x	●	x	x	x	●
Barium	x	○	x	●	x	x	x	x	●	x	x	■	●
Calcium	x	x	○	●	x	x	x	■	x	x	x	N/A	N/A
Calcium 12 Hydroxyaric Acid	●	●	●	○	■	x	x	●	x	x	x	N/A	N/A
Calcium Complex	x	x	x	■	○	x	x	x	●	x	x	●	x
Clay	x	x	●	●	x	○	x	x	x	x	x	●	●
Lithium	x	x	x	x	x	○	x	●	x	x	x	●	●
Lithium 12 Hydroxyaric Acid	x	x	■	●	x	x	○	●	x	x	x	●	N/A
Lithium Complex	●	x	●	●	x	x	●	○	x	x	x	●	●
Polyurea	x	x	x	x	x	x	x	x	○	x	x	x	x
Sodium	x	x	x	x	x	x	x	x	x	○	x	x	x
Calcium Sulphate	x	■	N/A	N/A	x	x	●	●	●	x	x	○	N/A
Silica	●	●	N/A	N/A	x	●	●	N/A	●	x	x	N/A	○

○ Same Grease
● Compatible
x Not Compatible
■ Mutually Compatible

NOTE: Not all polyurea greases are mutually compatible. Contact Fluid Life for more information (info@fluidlife.com or 877-962-2400).

For more information, visit: www.fluidlife.com/resources/grease-compatibility

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Why Machines Fail

- They become obsolete.
- They degrade.
- Accidents/Incidents.

Loss of usefulness

- Due to:
 - Corrosion (water, acid due to oxidation).
 - Mechanical Wear (particles):
 - Adhesive
 - Abrasive
 - Erosive
 - Fatigue Wear

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Why Machines Fail

- Most failures are attributable to some form of particulate contamination.

```

graph TD
    A[Loss of Usefulness] --> B[Obsolescence 15%]
    A --> C[Breakage 15%]
    A --> D[Surface Deterioration 70%]
    D --> E[Wear 55%]
    D --> F[Corrosion 15%]
    E --> G[Adhesive 25%]
    E --> H[Abrasive 20%]
    E --> I[Surface Fatigue 8%]
    F --> J[Corrosive 2%]
  
```

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What is Contamination?

- Contaminate - to make unfit for use by the introduction of unwholesome or undesirable elements:
 - External contamination/Ingestion:
 - Dirt, dust, etc.
 - Water
 - Self-generated contamination:
 - Built-in/Break-in
 - Wear particles
 - Chemical contamination/Generated:
 - Mixing of lubricants
 - Additives

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New equipment is NOT clean

- A system is **considered clean when foreign matter**, such as scale, rust, metal shavings and sand, are not visible to the eye and grittiness is **not detectable to the touch**.



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New oil cleanliness is poor

- New oil can be much dirtier than what an OEM recommends.
- This is especially important in equipment that requires critical cleanliness such as:
 - Hydraulics
 - Large Turbines
 - Etc.



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How Clean Do We Need?

- The critical particle size that must be controlled is typically 1 to 5 microns to maximize component life.
 - Lubrication Engineering, February 1997
- Controlling the abrasive contaminants in the range of 2 to 22 μm in the lube oil is necessary for controlling engine wear.
 - Staley, David R. "Correlating Lube Oil Filtration Efficiencies with Engine Wear," SAE 881825

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Typical Dynamic Clearances

Component	Details	Clearances
Valves	Servo	1 - 4 µm
	Proportional	1 - 6 µm
	Directional	2 - 8 µm
Variable Volume Piston Pumps	Piston to Bore	5 - 40 µm
	Valve Plate to Cylinder block	0.5 - 5 µm
Vane Pumps	Tip to Case	0.5 - 1 µm
	Sides to Case	5 - 13 µm
Gear Pumps	Tooth Tip to Case	0.5 - 5 µm
	Tooth to Side Plate	0.5 - 5 µm
Ball Bearings	Film Thickness	0.1 - 0.7 µm
Roller Bearings	Film Thickness	0.1 - 1 µm
Journal Bearings	Film Thickness	0.5 - 100 µm
Seals	Seal and Shaft	0.05 - 0.5 µm
Gears	Mating Faces	0.1 - 1 µm

Ref. ASME (American Society of Mechanical Engineers) Wear Handbook

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Bearing Life vs. Particle Size

Improving cleanliness in this range produces HUGE life extensions.

SMALLEST PARTICLE SIZE SEEN WITH THE NAKED EYE

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The Effects of Water....

Effect Of Water In Oil On Bearing Life

0.0025% = 25 ppm
0.01% = 100 ppm
0.05% = 500 ppm
0.10% = 1000 ppm
0.15% = 1500 ppm
0.25% = 2500 ppm
0.50% = 5000 ppm

Effect of water in oil on bearing life (based on 100% life at 0.01% water in oil.)
Reference: "Machine Design", July 96, "How Dirt And Water Effect Bearing Life" by Timken Bearing Co.

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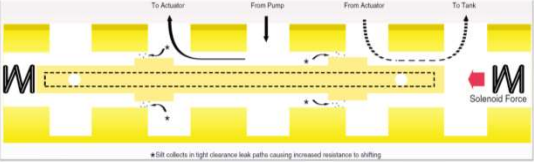
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Size, Not Quantity

- Valve Stiction or Silt Lock:
 - Contaminants can jam servo, proportional, and directional valves.
 - Sluggishness, jamming, and instability can result due to contamination from a single clearance-sized particle.



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- Sample Registration



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Contamination Sources

- Self-generated contamination.
- External contamination.
- Built-in/Break-in contamination.



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Contamination Sources

- **Self-Generated:**

- Metallic wear
- Seal abrasion
- Chemical corrosion
- Oxidation residue
- Oil-insoluble substance caused by mixing oil.

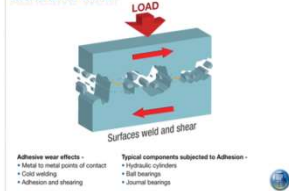


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Metallic Wear - Adhesive

Adhesive wear



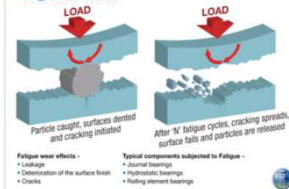
Courtesy Palf Corporation

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Metallic Wear - Fatigue

Fatigue wear



Courtesy Palf Corporation

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Metallic Wear - Abrasive

Abrasive wear

LOAD

Dynamic Fluid Film Thickness (μm)

Abrasive wear effects:

- Dimensional changes
- Leakage
- Lower efficiency
- Generated wear - more wear

Typical components subjected to Abrasion:

- Hydraulic pump (gear, vane, piston/pump)
- Hydraulic cylinders (rod seals, piston seals and bearings)
- Hydraulic motors
- Journal bearings

Courtesy Pall Corporation

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Metallic Wear - Erosive

Erosive wear

Particles impinge on the component surface or edge and remove material due to momentum effects

Erosive wear effects:

- Size response
- Spool jamming/cavitation
- Surface erosion
- Reduced burstout

Typical components subjected to Erosion:

- Servo valves
- Proportional valves
- Directional control valves

Courtesy Pall Corporation

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Seal Abrasion

WEST COAST BRONCOS

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Chemical Corrosion



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Oxidation Residue



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Mixing Oil



Courtesy: Clarus Technologies

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Mixing Grease



The image shows three white plastic cups containing a mixture of oil and grease. The first cup has a thin layer of grease on top of the oil. The second cup has a thicker layer. The third cup has a very thick, dark brown layer of grease on top. To the right of the cups is a grease gun.

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Mixing Oil or Grease?



The image shows a hand pouring oil from a can into a container. A grease gun is also visible in the background.

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Contamination Sources

- **External Contamination:**
 - Airborne contaminants
 - Contamination caused by adding oil
 - Contamination by adding grease
 - Water Ingress



The image shows a close-up of a glass containing a yellow liquid with a layer of oil on top.

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Airborne Contaminants

- Examples of air contaminants that only became visible with the camera flash.



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Airborne Contaminants



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Airborne Contaminants



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Contamination caused by adding oil

- Did the rag do its job and keep the container clean?



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Contamination caused by adding oil



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Contamination caused by adding grease



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Contamination Sources - Water

- Water will affect an oil's viscosity:
 - Free → **Increases** viscosity (visible)
 - Emulsified → **Increases** viscosity (cloudy in water)
 - Dissolved → **Decreases** viscosity (water is dissolved and invisible in oil).
- As an oil ages (oxidizes), it can hold more water.

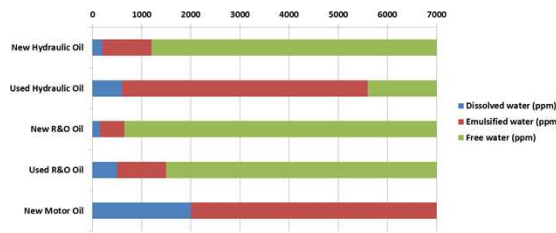


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Contamination Sources - Water

- The higher the additive package, the more water an oil will hold.



Oil Type	Dissolved water (ppm)	Emulsified water (ppm)	Free water (ppm)
New Hydraulic Oil	~100	~100	~6800
Used Hydraulic Oil	~100	~4500	~2400
New R&O Oil	~100	~100	~6800
Used R&O Oil	~100	~100	~6800
New Motor Oil	~100	~100	~6800

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Contamination Sources

- Built-in / Break-in Contamination:**
 - Foundry sand, dust.
 - Manufacturing residue:
 - Welding residue
 - Metals swarf (turnings, filings, shavings, etc...)
 - Blasting material, lacquer/paint particles
 - Preservation material
 - New parts install
 - Residue from cleaning agents (rag fibers).
 - New part installation or equipment repair/overhauls.



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Contamination Control Strategies

1. Lubricant receiving procedures.
2. Storage and inventory management.
3. Lubricant Handling.
4. Exclusion of Contaminants.
5. Health and safety assurance.

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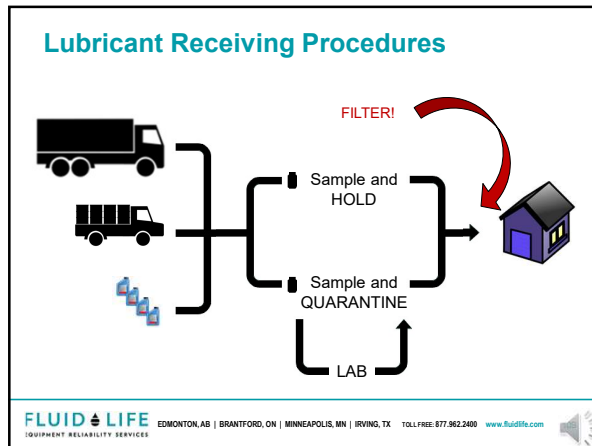
107

Lubricant Receiving Procedures

- **Step 1:**
 - Determine an acceptable and manageable cleanliness level for stored fluids.
 - Begin with understanding the cleanliness of oils being delivered on site.
 - New oils average an ISO code of 20/19/16 cleanliness or higher which is up to eight times dirtier than recommended for a majority of critical machinery.

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Lubricant Receiving Procedures

- Quality Control:
 - Sampling new oil can verify the following:
 - Quality of base stock
 - Additive quality and concentrations (+/- 25% variance ok)
 - Lubricant performance properties.
 - Grease thickener performance properties.
 - Important information to document and track:
 - Delivery date, and date of oil sample.
 - Storage container inspection details:
 - Check for damaged containers, broken or damaged seals.
 - Labels with results of oil analysis (eg. Cleanliness).
 - Periodic filtration of bulk storage and drums.

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Storage and Inventory Management

- Step 2:
 - Take measures to exclude contaminants from becoming part of the lubricant or fluid.
 - This must happen in the main stores and at the individual storage stations throughout your plant.

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Storage and Inventory Management

- Bulk Oil Storage:
 - Typically 10,000 gallon tank or 55 gallon drums.
 - Need to avoid contamination and additive settling.
 - Optimize bulk storage by:
 - Determining lubricant consumption rate.
 - Determining lubricant storage capacity.
 - Determining lubricant supplier turnaround time.
 - Identifying lubricant requirements for critical equipment.

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Storage and Inventory Management



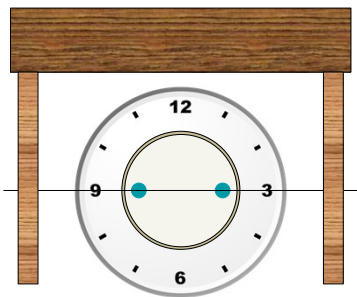
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Storage and Inventory Management



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Storage and Inventory Management

Lubricant Room Design:

- Location
- Cleanliness
- Worker Safety
- Lubricant contamination control
- Lubricant filling control
- Procedures and staging area for new lubricants.
- Ability to document actions (record keeping).
- Optimize bulk oil and grease volumes.
- Limited access door, with a record of people who enter.
- Fire proof storage for top up containers, grease guns, etc.
- Separate storage area to store bulk totes, drums, buckets, etc.



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Great Lube Rooms



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Storage of Grease and Top-up Containers

- Each should have a dedicated fire proof cabinet.
- Clean, dry, and cool.
- Grease guns should be cleaned periodically, and calibrated annually (ensure the same volume of grease is delivered per pump).
- If grease drums are used to fill grease guns, they must be resealed carefully.



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Lubricant Handling - Oil

- Step 3:
 - Preserving the integrity of the fluid while getting it from storage to usage.
 - Bear in mind that often the best ways are also the easiest and most efficient ways.



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Lubricants Handling - Oil

- Top up/small oil change out containers.



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Lubricant Handling - Oil

- Topping up from drums and bulk storage:
 - Best practice is to filter the dispensing oil (again).
 - Can use a hard plumbed filtration system with dedicated dispensing nozzles on a rack mounted system.
 - 55-gallon drums can be fitted with quick connect fittings, a hand pump, sight glass, and breather (with filter).
 - Filtered hand pumps with breathers



Courtesy Lubrication Engineers

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Storage and Inventory Management

- Containers that reduce the potential of contamination:
 - Funnels represent the "highest risk factor" for contamination ingress while adding oil into components.
- Don't be afraid to go one step better:
 - Consider retro-fitting containers with air breathers, and hand pumps with quick couplers.



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Lubricant Handling - Oil

- Establish a procedure that incorporates adding oil via a portable filtration system - for larger reservoirs, etc.
- Filter Carts are good for:
 - Oil Flushing
 - Oil Addition
 - Oil Drains
 - Kidney Loop Filtration



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Lubricant Handling - Grease

- Grease guns are handled improperly:
 - Transparent or color coded greasing tools eliminate mixing products from picking up the wrong grease based on grease color.



Courtesy Lubrication Engineers

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Exclusion of Contaminants

- **Step 4:**
 - The cost of cleaning dirty oil can be **10X higher** than keeping it clean in the first place.
 - High-quality breathers can exclude particles as small as ½ micron.
 - Desiccant breathers will also exclude moisture.



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Health and Safety Assurance

- **Step 5:**
 - Oil can be HOT and slippery.
 - Keeping your lubrication storage clean, cool, and dry will also safeguard against slips, trips, burns, and other safety incidents.
 - Machines that are properly lubricated are also less likely to fail, and therefore safer to be around.
 - If a skin condition develops after handling lubricants:
 - Consult MSDS for the product and seek medical assistance.
 - Container labels must identify hazard information. Otherwise, employers must provide the MSDS and/or appropriate training.

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Agenda

- Fundamentals of Lubricants
- **Contamination Sources and Control Strategies**
 - Overview
 - Contamination Sources
 - Contamination Control Strategies
 - **Filtration**
- Oil Sampling Basics
- Sample Registration



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Goal of Filtration

- Improve oil dryness and cleanliness.
- Help optimize the oil's usefulness.
- Improve reliability and productivity of the machine.
- Pay for itself in a short amount of time.



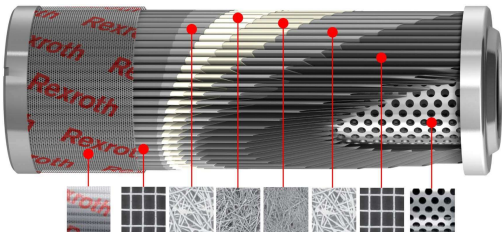
Courtesy CC Jensen

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Filter Overview



1-Perforated protective cage, 2-Media support, 3-Media protection, 4-Pre-filter, 5-Main filter, 6-Protective membrane, 7-Media support, 8-Perforated center tube

Courtesy Bosch Rexroth

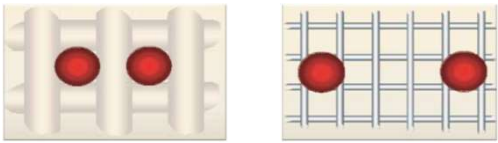
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Filter Media Type

• Cellulose (Paper): – Lower density – Larger pores – Higher restriction – Random matrix	• Glass (Synthetic): – Higher density – Smaller pores – Lower restriction – Can be tapered
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Courtesy CC Jensen

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Filter Types

Surface Filtration

Typical Surface Filter for Inline Filters

Depth Filtration

Typical Depth Filter for Offline Filters

Courtesy CC Jensen

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Filter Construction

- You can have the best media, but without the appropriate construction, particles will flow through:
 - Note the break in the pleats.
- Properly engineered construction will provide the particle-removing capability:
 - Note the media support that is resilient against pressure fluctuations.

Courtesy Pall Corporation

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Beta Ratio / Efficiency

Beta Ratio	Efficiency
1	0%
2	50%
5	80%
10	90%
20	95%
75	98.7%
100	99%
200	99.5%
1000	99.9%

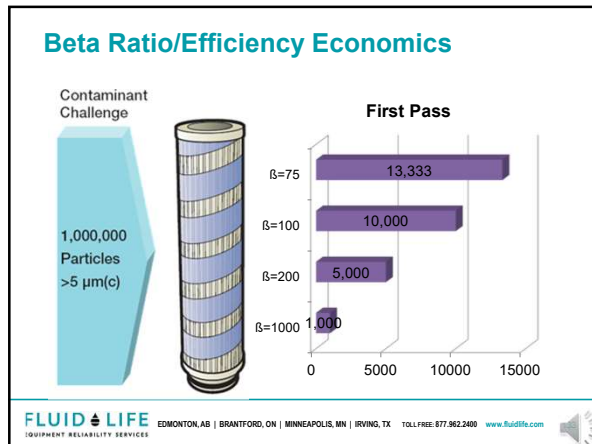
$\beta_x = 75$

Simple calculation:

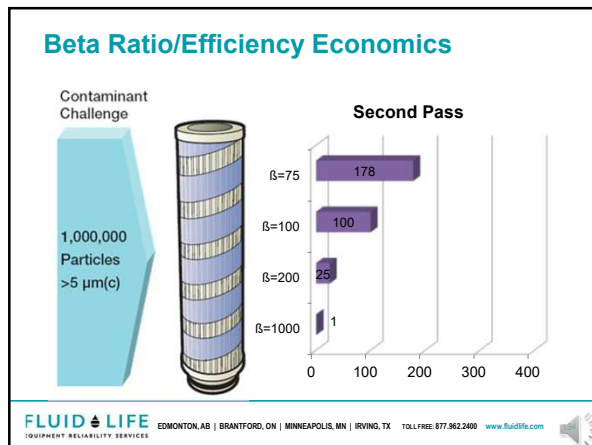
$$\frac{75-1}{75} = 98.7\%$$

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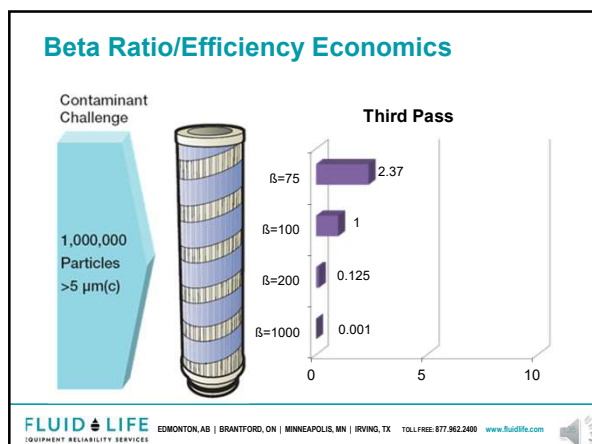
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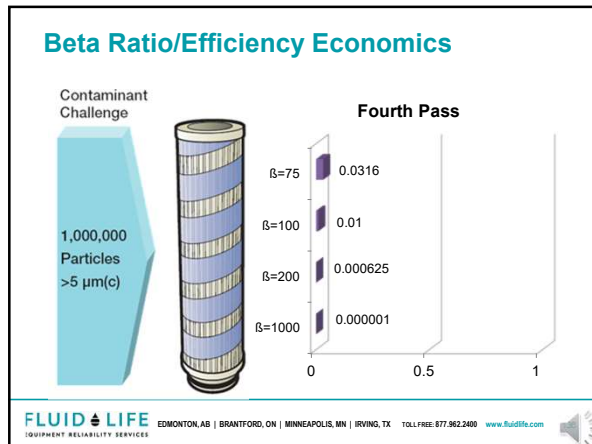
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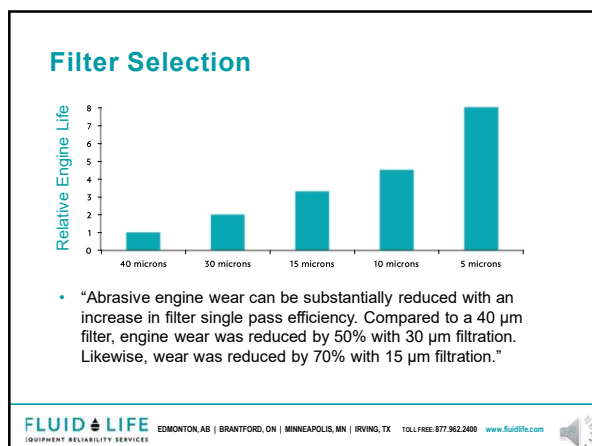
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Beta Ratio/Efficiency Economics

- Is a $\beta_5 = 1000$ worth twice as much as a $\beta_5 = 200$ filter?
- How about compared to a $\beta_5 = 100$ or $\beta_5 = 75$?
- In a single pass application, such as transferring to or from lubricant storage, the difference can be significant.
- In a multi-pass application, such as full-flow or kidney loop filtration, the difference becomes negligible quite quickly.

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Potential Filter Problems

- Excessive Back-Pressure
- Electrostatic Discharge




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Moisture Removal by Filtration

TECHNOLOGY	EFFICIENCY	TYPES OF WATER REMOVED
Centrifugal	Centrifuge spins out water and other higher density contaminants	Free water
Coalescing	Variable density media forces agglomeration of water to the point it separates and falls out of suspension	Free water, emulsified water
Desiccant	Water is absorbed by media, requiring filter changes	Free water, emulsified water
Head Space Air Dryer	Dry's air in the head space by pushing dry air into the headspace. And water is evacuated through desiccant breather.	Free water, emulsified water and dissolved water
Vacuum Dehydration	Oil is heated and put under a vacuum to reduce boiling point and drive out moisture in the form of steam	Free water, emulsified water and dissolved water

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Agenda

- Fundamentals of Lubricants
- Contamination Sources and Control Strategies
- Oil Sampling Basics**
 - Lube Oil Sampling Objectives
 - Sampling Frequency and Location
 - Proper Sampling Methods
 - Managing Interference When Sampling
- Sample Registration



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Lube Oil Sampling Objectives

- Samples are best taken when system is **live and/or hot**.
- Wipe the sample port before opening:
 - Don't place plugs or caps on dirty surfaces.
- Pre-label or label bottles immediately after filling to avoid mix-ups.
- Flush sample point and associated piping or tubing thoroughly.
- **"REPRESENTATIVE SAMPLE"**



Bad Routine Samples

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Lube Oil Sampling Objectives



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Where, When, How Often?

- Number of samples and points depends on program's goals:
 - Monitoring filtration performance.
 - Failure diagnosis.
 - Contamination ingress.
 - Oil Change intervals.



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Sampling Valve Installation Practices

- Install valves on elbows, rather than straight sections of pipe.
- More likely to "catch" particles at the elbow because of oil turbulence.
- A viscous fluid running through a straight line for a period can go laminar, and allow contaminants to drop out.



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Oil Sampling Location General Guidelines

MOBILE EQUIPMENT	GOOD	BETTER	BEST
Engine	LOCATION: Oil Dipstick TOOLS: Suction pump, Plastic Tubing, Flush Jar	LOCATION: Drain Plug TOOLS: None	LOCATION: Sample Valve (upstream of filter) TOOLS: Pushbutton Sample Valve
Engine Coolant system	LOCATION: Overflow tank TOOLS: Suction Pump, Plastic Tubing, Flush Jar	LOCATION: Radiator Cap TOOLS: Suction Pump, Plastic Tubing, Flush Jar	LOCATION: Sample Valve (upstream of filter) TOOLS: Pushbutton Sample Valve
Transmission	LOCATION: Drain Plug TOOLS: None	LOCATION: Oil Dipstick TOOLS: Suction Pump, Plastic Tubing, Flush Jar	LOCATION: Sample Valve (upstream of filter) TOOLS: Pushbutton Sample Valve
Hydraulic / Steering	LOCATION: Oil Tank (Drain) TOOLS: None	LOCATION: Oil Tank (Air Breather or Head) TOOLS: Suction Pump, Plastic Tubing, Flush Jar	LOCATION: Sample Valve (Return line on valve block) TOOLS: Minimes Sample Valve, High Pressure Port Adaptor
Differential	LOCATION: Drain Plug TOOLS: None	LOCATION: Oil Fill / Air Breather Plug TOOLS: Suction Pump, Plastic Tubing, Flush Jar	N/A
Final Drive / Wheel Hub Spindles	LOCATION: Drain Plug TOOLS: None	LOCATION: Oil Fill Plug (if equipped) TOOLS: Suction Pump, Plastic Tubing, Flush Jar	N/A

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Oil Sampling Location General Guidelines

FIXED EQUIPMENT	GOOD	BETTER	BEST
Hydraulics	LOCATION: Oil Tank (Drain) TOOLS: None	LOCATION: Oil Tank (Air Breather or Hatch) TOOLS: Suction Pump, Plastic Tubing, Flush Jar	LOCATION: Sample Valve (Return line on valve block) TOOLS: Mininess Sample Valve, High Pressure Port Adaptor
Electric Motor	LOCATION: Drain valve TOOLS: None	LOCATION: On a designated sample port TOOLS: Mininess Sample Valve, High Pressure Port Adaptor	N/A
Turbines/Compressors	LOCATION: Oil Tank (Drain) TOOLS: None	LOCATION: Oil Tank (Air Breather or Hatch) TOOLS: Suction Pump, Plastic Tubing, Flush Jar	LOCATION: Sample Valve (Return line on valve block) TOOLS: Mininess Sample Valve, High Pressure Port Adaptor
Bearings	LOCATION: Drain valve TOOLS: None	LOCATION: On a designated sample port TOOLS: Mininess Sample Valve, High Pressure Port Adaptor	N/A
Gearboxes	LOCATION: Drain Valve TOOLS: None	LOCATION: Drain port with a pilot tube above sludge line TOOLS: Mininess Sample Valve, High Pressure Port Adaptor	LOCATION: On a designated sample port TOOLS: Mininess Sample Valve, High Pressure Port Adaptor
Pumps	LOCATION: Drain Valve TOOLS: None	LOCATION: Modified Breather TOOLS: Suction Pump, Plastic Tubing, Flush Jar	N/A
Stationary Engines/Generators	LOCATION: Oil Dipstick TOOLS: Suction pump, Plastic Tubing, Flush Jar	LOCATION: Drain Plug TOOLS: None	LOCATION: Sample Valve (upstream of filter) TOOLS: Pushbutton Sample Valve

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Sample Point Identification Engines

- Samples taken from installed ports (after pump, before filters) provide best sample.
- Dipstick or mid-stream drain samples can also be used.



Plug on filter housing



Dipstick

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Sample Point Identification Differential

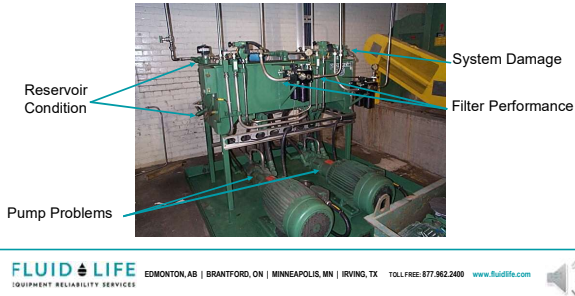
- Oil is not normally changed when sample is taken, therefore, a mid-stream drain sample is impractical for majority of samples.
- Take sample consistently from breather or top-up plug using a pitot tube if possible to take samples from consistent depth.



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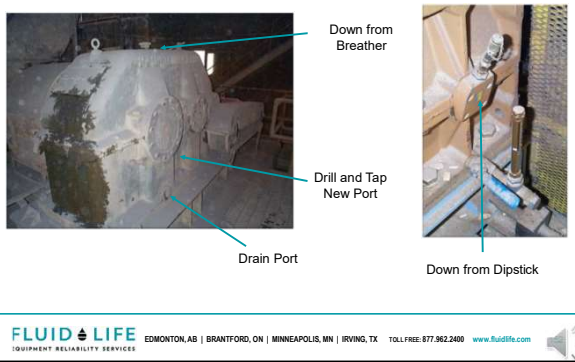
Sample Point Circulating Systems

- Samples are best taken after a pump, and before a filter.
- When trying to monitor specific components it is possible to have multiple secondary sampling points as shown below.



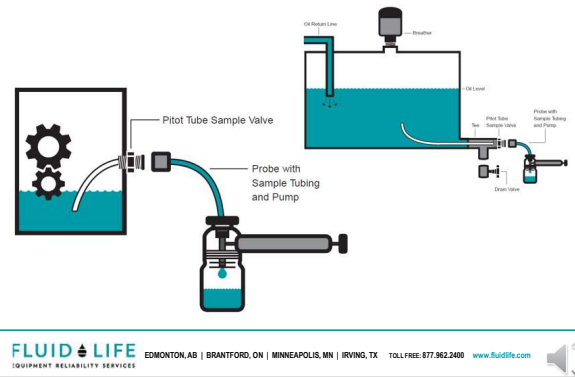
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Sample Point Identification Gearbox

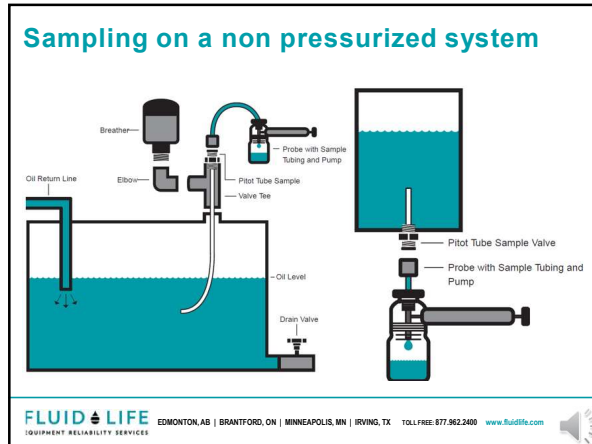


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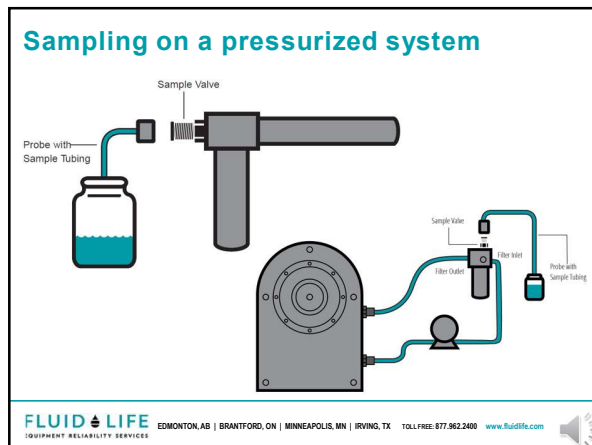
Sampling on a non pressurized system



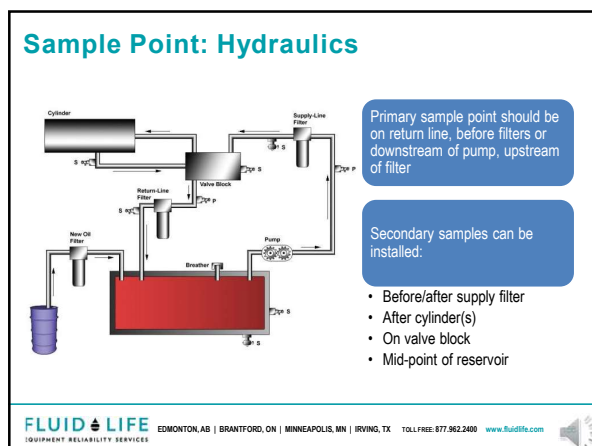
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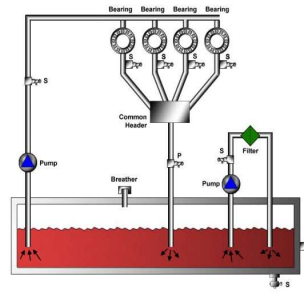


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Sample Point: Lube Systems



Primary sample point should be installed on return line header.

Secondary sample points can be installed:

- After each bearing
- After the main pump
- Before auxiliary filter
- After auxiliary filter
- Mid-point of reservoir

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Sample Frequency

- General guidelines are a starting point.
- Frequency of sample depends on several factors:
 - LETS (Load, Environment, Temperature, Speed)
 - Downtime costs
 - Repair / replacement costs
 - Safety requirement
 - Equipment tolerance
 - Contamination factor



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Sample Frequency

Component	Frequency
Diesel Engines	20,000 km / 250 Hrs. / Monthly
Gasoline Engines	10,000 km / Quarterly
Natural Gas Engines	500 Hrs. / Monthly
Standby Generators	50 Hrs. / Quarterly
Hydraulics	500 Hrs. / Monthly
Gears (Industrial)	750 Hrs. / Monthly
Air/Gas Compressors	500 Hrs. / Monthly
Refrigeration Compressors	Quarterly
Gas Turbines	500 Hrs. / Monthly
Steam Turbines	1500 Hrs. / Quarterly

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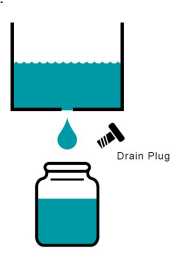
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Proper Sampling Methods

- A common method of sampling is midstream from a reservoir into a sample cup.



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Sampling Tools: Suction Pumps

- Used on low or non-pressurized systems:
 - Gearboxes, Bearings
 - Fluid reservoirs, Return lines
- Use a new section of hose every time
- Flush tubing before every sample



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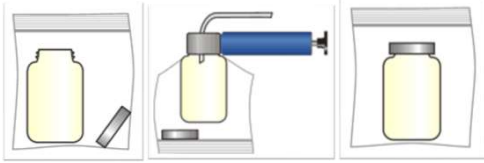
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Sampling Tools: Suction Pump

- If Sampling in an extremely dirty environment, put sample jar in a plastic baggy.
 - Seal bottles in a bag in a clean environment
 - Screw into pump, tube will pierce bag
 - Afterwards, seal bottle without opening the bag



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Sampling Valves: Pressurized Systems

- "B" Series Valve
- Push button valve



Courtesy CheckFluid

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Sampling Valves: Low Pressure

- Works with a suction pump.
- "M" Series Valve
- Pitot Tube
- Modified Breather kit



Courtesy Check Fluid, Tico

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Sampling Valves: Other Common types

- KST - Pressurized System
- Probalyzer - Pressurized System
- Cover plate - Non Pressurized System



Courtesy Checkfast, Baldwin Filters, JLM Systems

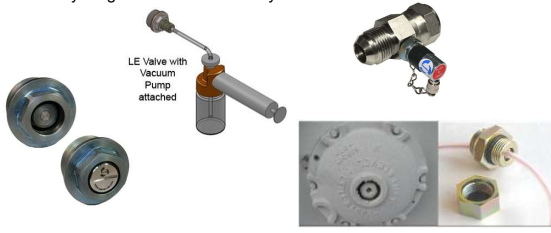
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Sampling Valves: Other Uncommon Types

- Inline T adapter - Pressurized and Non Pressurized System
- Flush mount drain - Non Pressurized system
- Dry Plug - Non Pressurized System



Courtesy Checkfast, JLM Systems

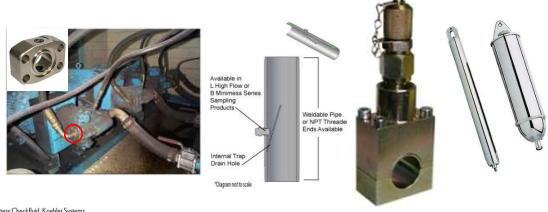
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Sampling Valves: Other Uncommon Types

- Spacer Flange - Pressurized System
- Catch Pipe - Non Pressurized System
- Valve Mount - Pressurized And Non Pressurized System
- Bacon Bomb - Non Pressurized System



Courtesy Checkfast, Koolha Systems

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Agenda

- Fundamentals of Lubricants
- Contamination Sources and Control Strategies
- Oil Sampling Basics**
 - Lube Oil Sampling Objectives
 - Sampling Frequency and Location
 - Proper Sampling Methods
 - Managing Interference When Sampling**
- Sample Registration



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Bottle Cleanliness and Management

- Re-using any container is **WRONG!**
 - Examples of actual containers sent to Fluid Life.



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Bottle Cleanliness and Management

- New sample bottle cleanliness may have an affect on the oil analysis results.
- Just like new oil - all sample bottles come in varying degrees of cleanliness (dirtiness).
- Storing samples before shipping or lab analysis:
 - Samples should be shipped to Fluid Life ASAP after being taken.
 - Fluid Life labs will follow best practices and suspend solids, water, wear metals, etc. by shaking gently (end over end rolling or on a gentle shaker table) at room temperature.



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Bottle Cleanliness May Produce Bias

- Affected:
 - ISO Particle Count
 - OPC
 - Sediment (less likely)
- Not Affected:
 - Viscosity
 - Wear Metals
 - Acid Number
 - Base Number
 - Water



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Flushing

- One Sample - One Tube:
 - Never re-use a sample tube, even for the same location.
- FLUSH at least 5 to 10 times the dead space volume:
 - New tubing volume
 - Dead-legs
 - Sampling ports, valves, and probes
 - Adapters for using vacuum pumps
 - Plastic tubing



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- Fundamentals of Lubricants
- Contamination Sources and Control Strategies
- Oil Sampling Basics
- Sample Registration**
 - Overview of Registering Samples**
 - Mobile App
 - Web Based
 - Sample Card



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Importance of Sample Registration

- An incorrectly registered sample is just as bad as an improperly taken sample:
 - Label bottles immediately after filling to avoid mix-ups or pre-print labels.
 - If not logging in samples through myLab or the mobile app:
 - Ensure to always label the unit ID consistently so that the sample results don't end up in different places by us creating double units.
 - If no unit/component is listed the samples will be held and you will be contacted to ensure it's registered correctly, resulting in delayed results.
- Ensure all sample data is accurately entered:
 - Missing data will delay processing.
 - Incorrect data will give irregularities or false positives.
 - Wrong sample entry will cause incorrect data trending.
 - Registering Samples correctly will ensure results are logged in under the same unit consistently for trending purposes.

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Importance of Sample Registration

- Having all the unit info registered to ensure correct results includes the following:
 - Unit/component type
 - Manufacturer/model
 - Correct oil type
 - Was sample taken when the oil changed (Y/N)?
- Correct data for registration is critical because different equipment will have different criteria:
 - For example the same particle count flagging limit would not apply to a hydraulic and a final drive, etc.
- How can you address incorrect sample registration?
 - Sample tags (QR Tags for equipment):
 - Your company's sampling and registration policy and procedures.
 - Ensure all units are created in myLab.

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Sample Registration: Key Points

- Samples can be registered via:
 - Mobile myLab app
 - myLab web portal
 - Manual Registration (Sample Cards)
- Samples can be registered individually or in batches through myLab by:
 - Components
 - Due samples
 - Routes
 - PM Definition

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Mobile App Sample Registration

- Fluid Life oil samples can be registered using :
 - Phone
 - Tablet
 - Other mobile device.
- The app can be downloaded at:
 - App Store (Apple/iOS devices)
 - Google Play (Android devices)
- If samples are registered in remote areas or while in airplane mode, the information will be transmitted back once in cellular range or connected to Wi-Fi.
- When the samples are received in the lab, they are scanned to pull up correct information.

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Mobile App Sample Registration

We will do a demonstration for this step:

- Equipment Tag Scan
- Manual Input




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Mobile App - Equipment Tag Scan

- Step 1:** Login
- Step 2:** Scan equipment tag
- Step 3:** Select components
- Step 4:** Scan sample bottle
- Step 5:** Verify Information
- Step 6:** Check for recently submitted samples.



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Mobile App - Manual Input

- Step 1:** Login
- Step 2:** Enter unit information
- Step 3:** Select components
- Step 4:** Scan sample bottle
- Step 5:** Verify information
- Step 6:** Check for recently submitted samples.



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Web Based Sample Registration

- Samples can be registered individually or in batches through myLab.
- Workflows can be done as:
 - Register and print first, then collect sample:
 - Can include meter hours, date, if oil change was done.
 - Collect Sample, then register and optionally print:
 - A lid sticker is good for keeping track of samples taken.
 - Register in advance:
 - Blank label workflow.
 - Labels without a date and meter reading, go back and update information.
 - Route based (fixed equipment):
 - Routes need to be set up initially (Fluid Life can help with this).
 - Print out labels and apply to bottles as you sample at component.
 - PM Definition (mobile equipment):
 - Defined once which components are taken at a specific interval.
 - Not specific an individual unit, but can be applied to any unit (i.e heavy truck).



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Web Based Sample Registration

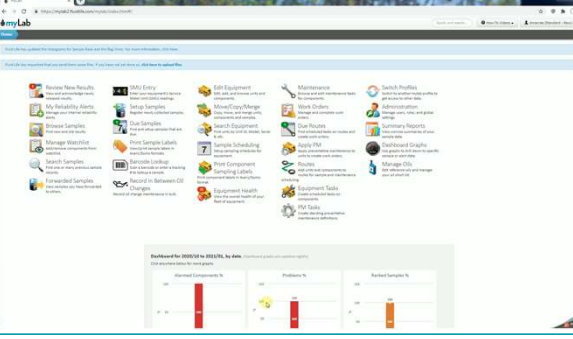
- We will do a demonstration for this step in the myLab Portal



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Web Based Registration



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Sample Card Sample Registration

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CUSTOMER: _____
UNIT # _____
COMPONENT: _____
LOCATION: _____
SAMPLE DATE: _____
ADDRESS: _____
CITY: _____
PROVINCE/STATE _____ POSTAL/ZIP: _____
PHONE: _____
FAX: _____
EMAIL: _____
CUSTOMER CARE GROUP: _____
TOLL FREE: 877.962.2400 www.fluidlife.com

TRACKING # _____

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SAMPLE DATE: _____
COMPANY: _____
CONTACT: _____
ADDRESS: _____
CITY: _____
PROVINCE/STATE _____ POSTAL/ZIP: _____
PHONE: _____
FAX: _____
EMAIL: _____
CUSTOMER CARE GROUP: _____
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TRACKING # _____

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DATE: _____
OIL TYPE: _____
OIL GRADE: _____
OIL VOLUME: _____
OIL WEIGHT: _____
OIL COLOR: _____
OIL CONDITION: _____
OIL ANALYSIS: _____
OIL TESTS: _____
OIL RESULTS: _____
OIL COMMENTS: _____
OIL TRACKING: _____
OIL LOCATION: _____
OIL COUNTRY: _____
OIL TYPE: _____
OIL GRADE: _____
OIL VOLUME: _____
OIL WEIGHT: _____
OIL COLOR: _____
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FLUID LIFE OIL ANALYSIS SAMPLE CARD

The Lab Use Only grey area held in for Fluid Life internal lab or testing notes.

The Unit # (or ID/Name) identifies the equipment. The lab should match the above existing Unit ID in the system. If it has been previously sampled, Units can have multiple components (i.e. engine, transmission). If the for each component is created under the Unit. Samples for each component are filed together for easy tracking.

Component Make & Model (e.g. with test flags)

Component & Oil Service (e.g. oil change, oil analysis, oil test results)

Oil Manufacturer, Brand and Grade (e.g. PETROL, CARL, CUBICIN 15W-40) prompts the lab to add a New Oil Reference to the card of report, some tests cannot be performed without complete information. Check "Yes" if you changed the oil after taking a sample.

The new off portion of the sample card can be retained for your records.

This section is mandatory. For example, the Company or Account field can be an individual used to distinguish where samples will be logged under in the lab system.

Fuel Type notifies the lab to check for diesel fuel for diesel fuel contamination in the oil, as well as to trigger specific testing on engine oils.

Component Type is important to the lab for applying test flags. When Reference, do not select a Component type.

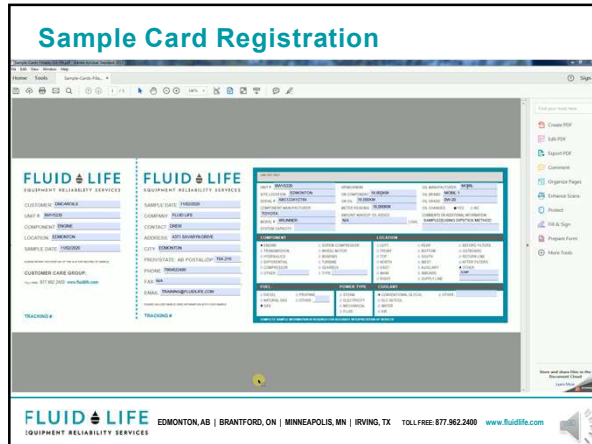
Coolant Type signals the lab to check for coolant contamination in the oil of an engine and transmission components.

If submitting a New Oil Reference, use Component field to indicate that it is a baseline sample.

Location of sample point or component on the unit (if applicable).

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Sample Card Sample Registration

- Common mistakes with sample cards:
 - Only the slip on left is filled out and the remainder of the card is left blank.
 - Oil type often left out or not filled out to match what is in use.
 - Card will be filled out with equipment ID in different forms lacking consistency.
 - The Grey box which reads "Lab Use Only" on the top right hand of the sample card:
 - Often misinterpreted to indicate the entire right half of the card isn't supposed to be filled out.
 - If using cards, ensure the entire right hand portion is completed with as much information as possible.
 - Completed information slip on left is not torn off - this portion can be kept by you as a sample record.
 - Including serial numbers on cards helps find equipment if other data is missing.

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