Metalworking Fluids & Lubrication Principles

2025

Castrol

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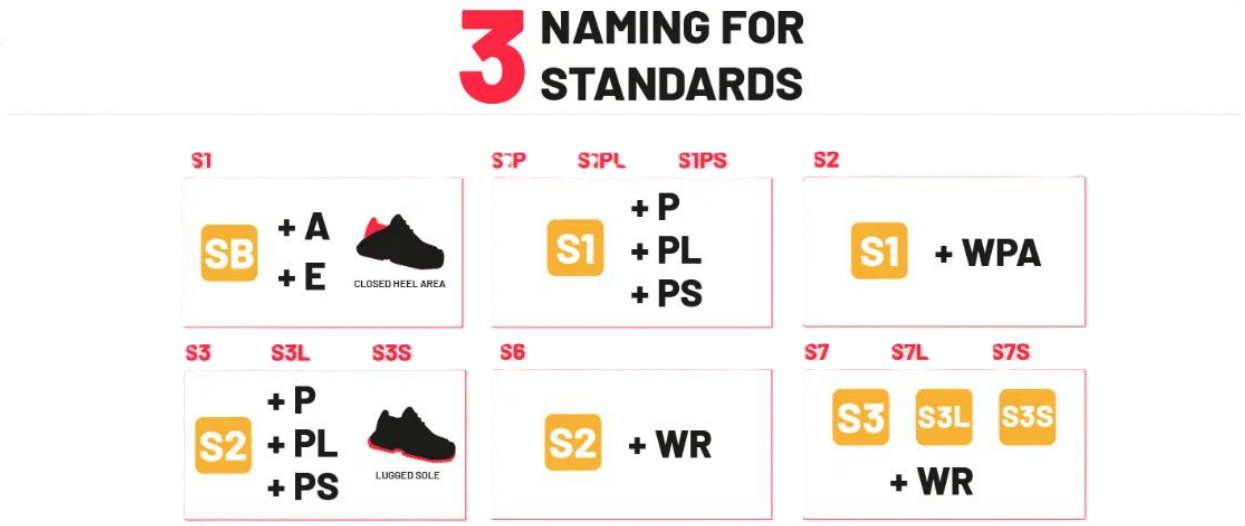
Agenda

Safety Equipment

Q: Where can you find the ratings for safety shoes?

A: On the tongue of the shoe!



Principles of Metalworking

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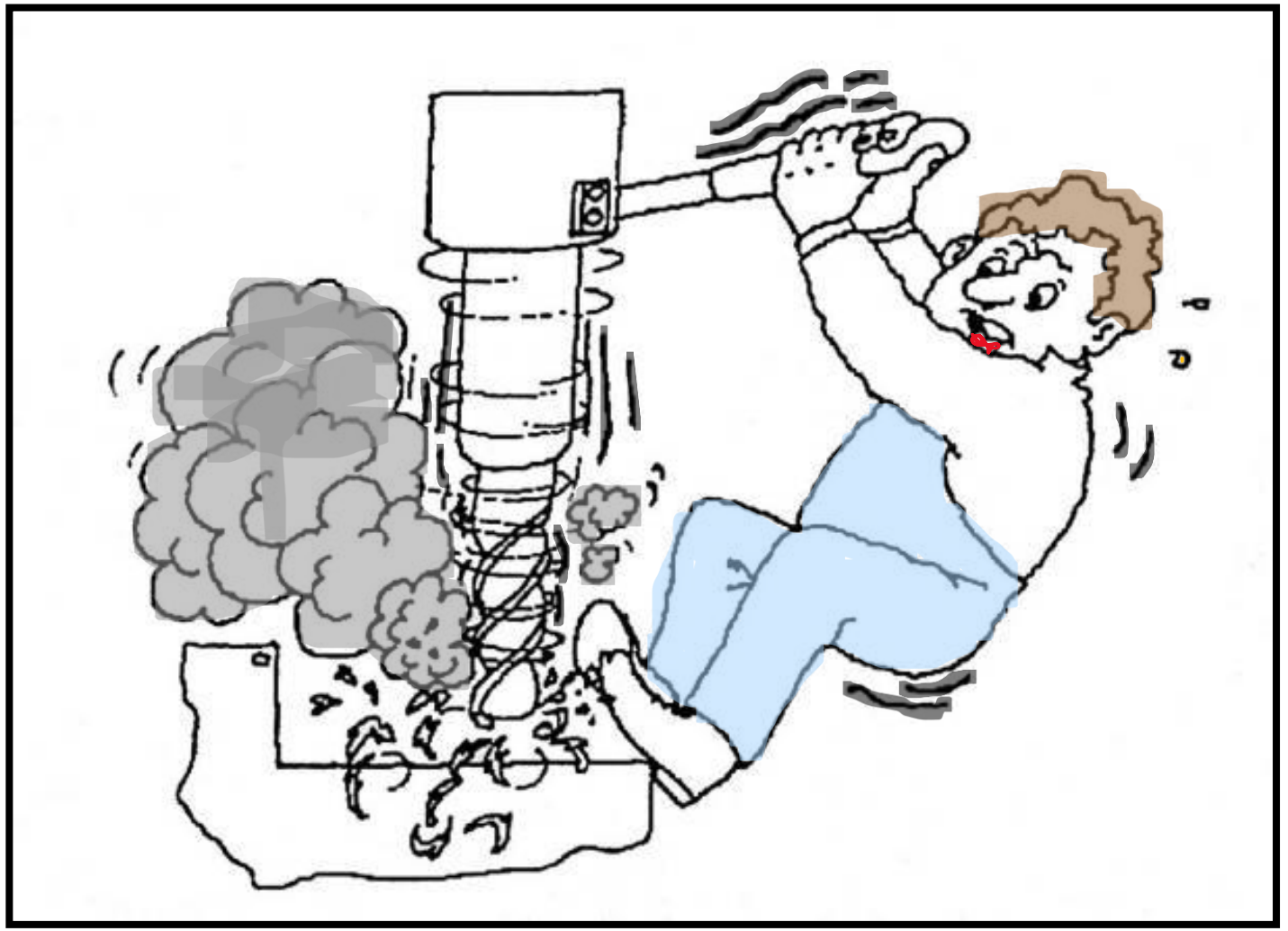
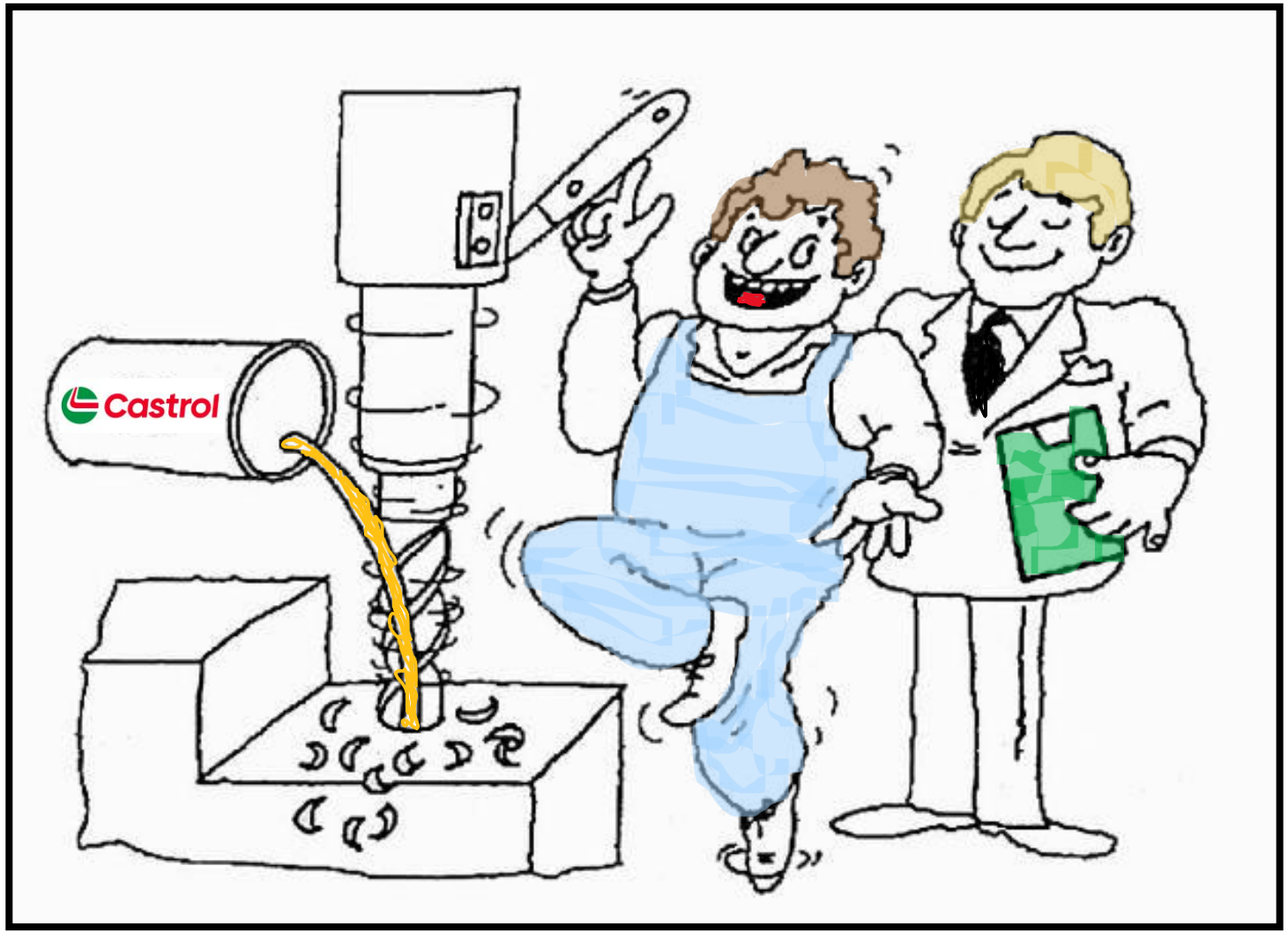
Why do we need cutting fluids?



To Make the Process More Efficient!



The Benefits of Cutting Fluids

- Increased productivity
- Improved surface finish
- Cleaner working condition
- Longer tool life
- Reduced energy requirements
- Eliminate metal dusting (can be dangerous)

What Happens When We Don't Use Cutting Fluids…???

We create friction which causes "Heat".

The results of "Heat" are:

- Expansion of work piece
- Reduced surface finish
- Rapid tool wear

Basic Role of C&G Fluids

1. Cooling
2. Lubrication
3. Tool life performance assistance
4. Wash action and chip removal from the work area
5. Corrosion protection for both machine tools and work
6. Cleanliness on machine surfaces
7. Filtration properties
8. Improve Surface Finish
9. Increase Production
10. Reduce machine energy requirements

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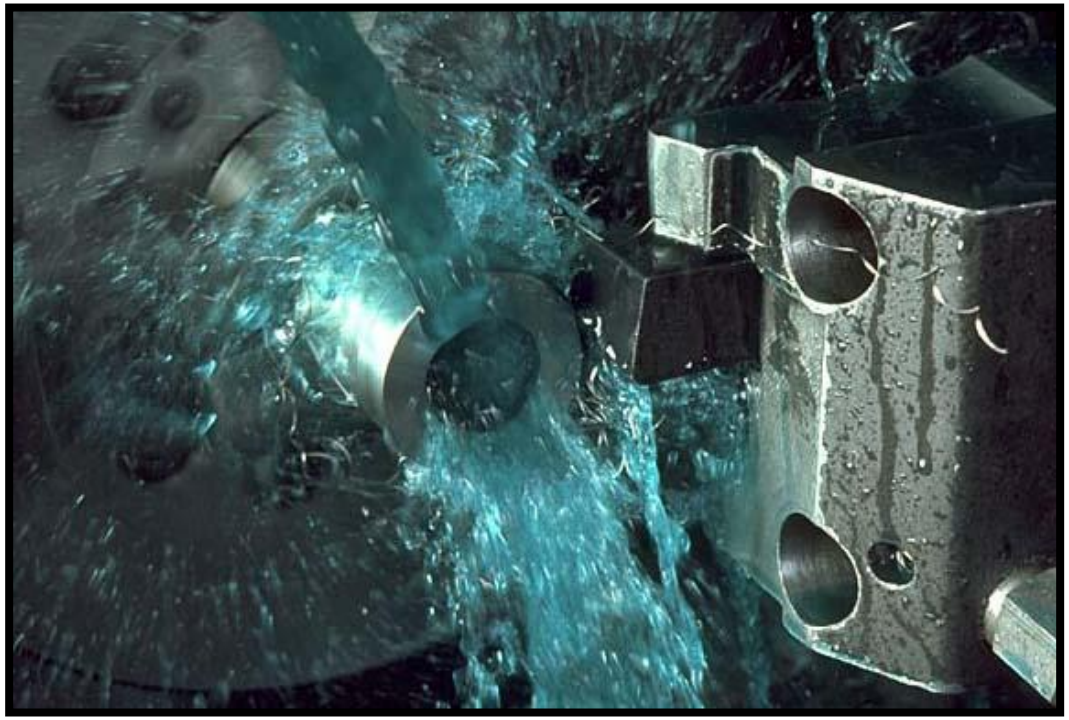
Functions at the Point of Cut

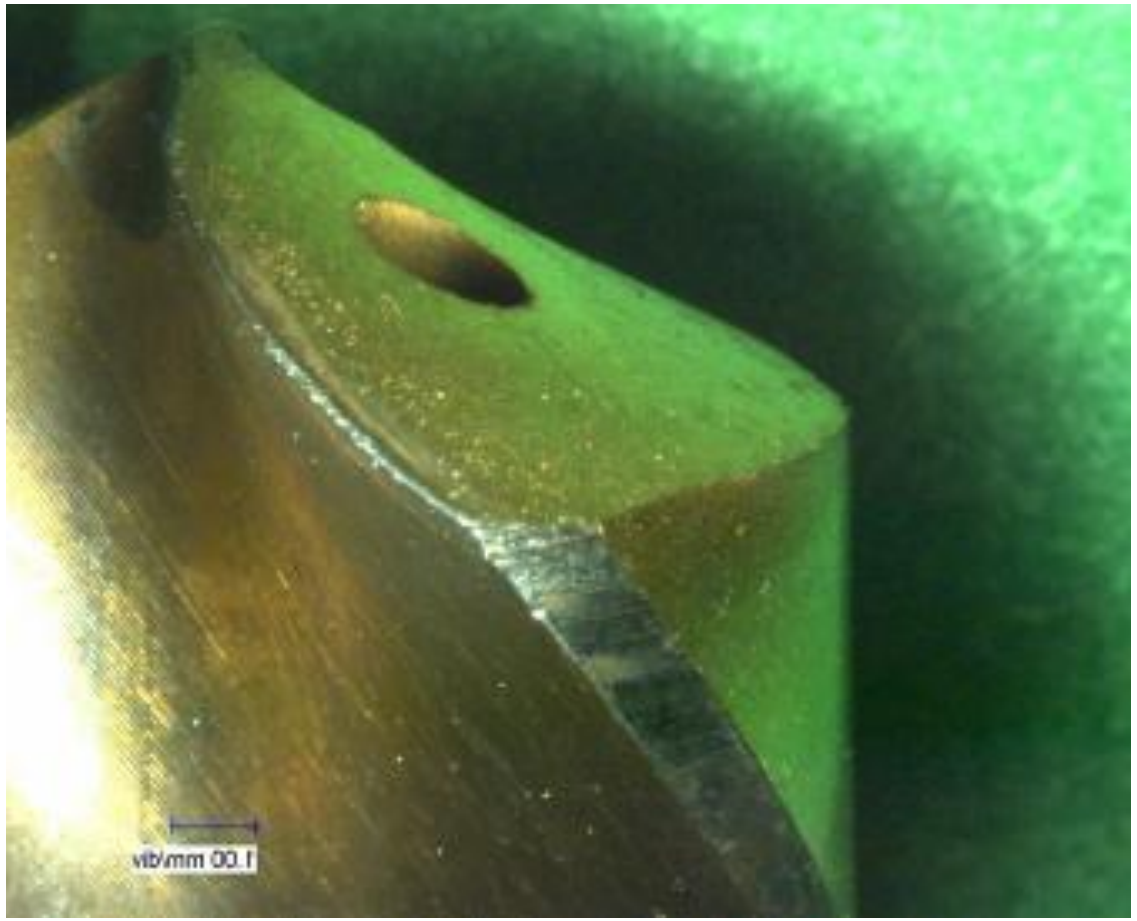
- ✓ Cooling
- ✓ Lubrication
- ✓ Flush chips and swarf from cut zone

Q: Why Would Synthetics be Featured in Cooling Discussion?



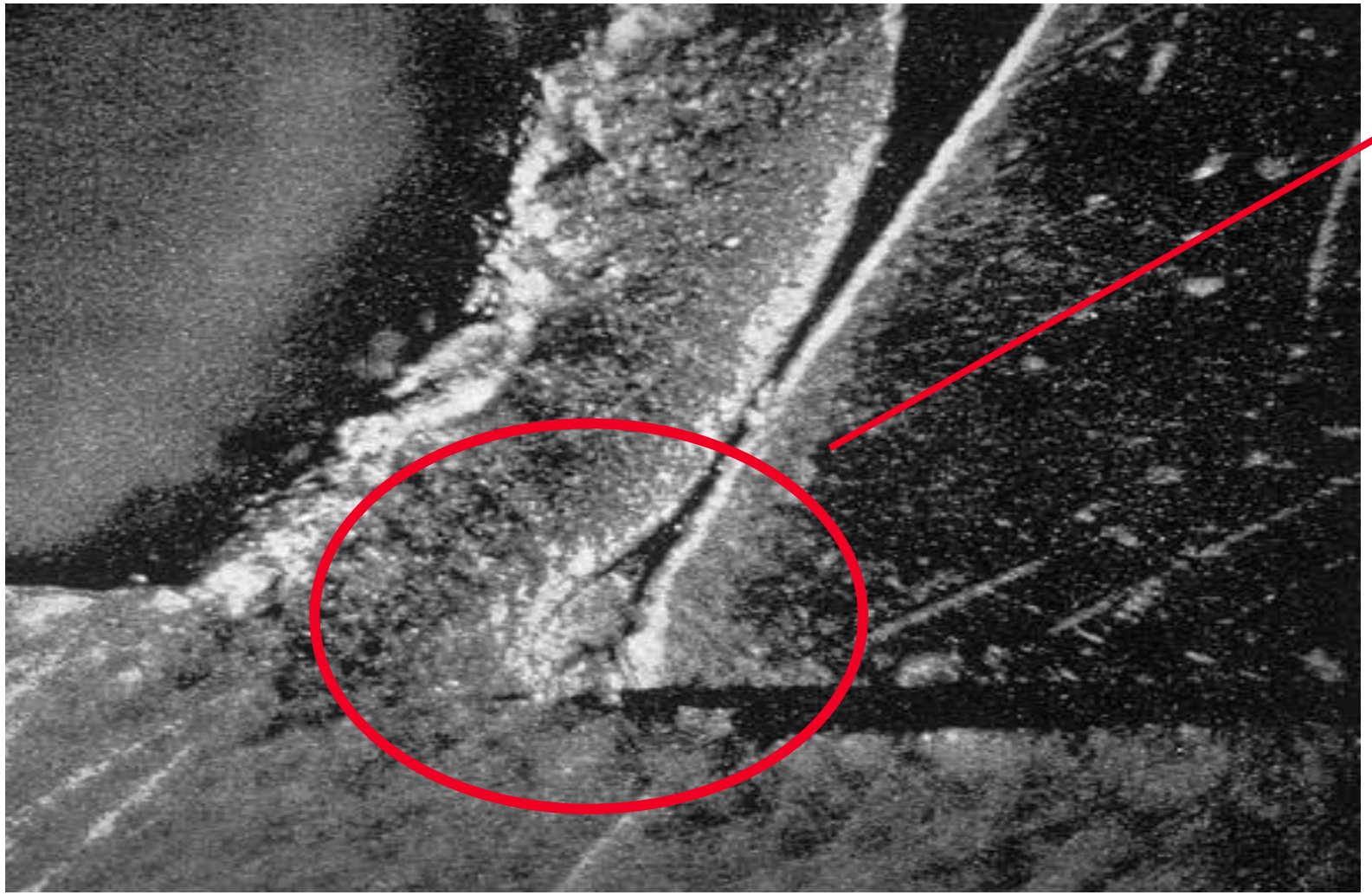
A: Because synthetic coolants offer the highest cooling capability as compared to other product categories!

Lack of Sufficient Lubrication



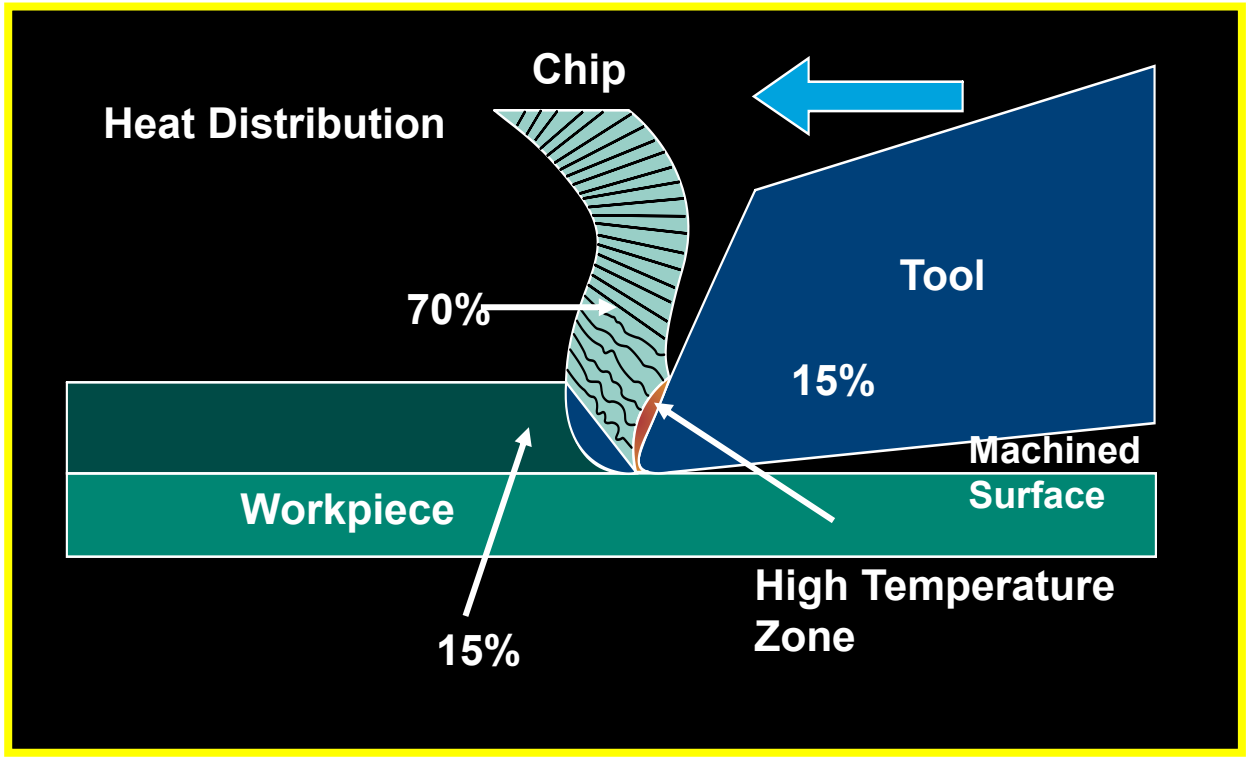
Premature tool wear can produce out of spec parts resulting in downtime to change or sharpen tools back to original geometries!

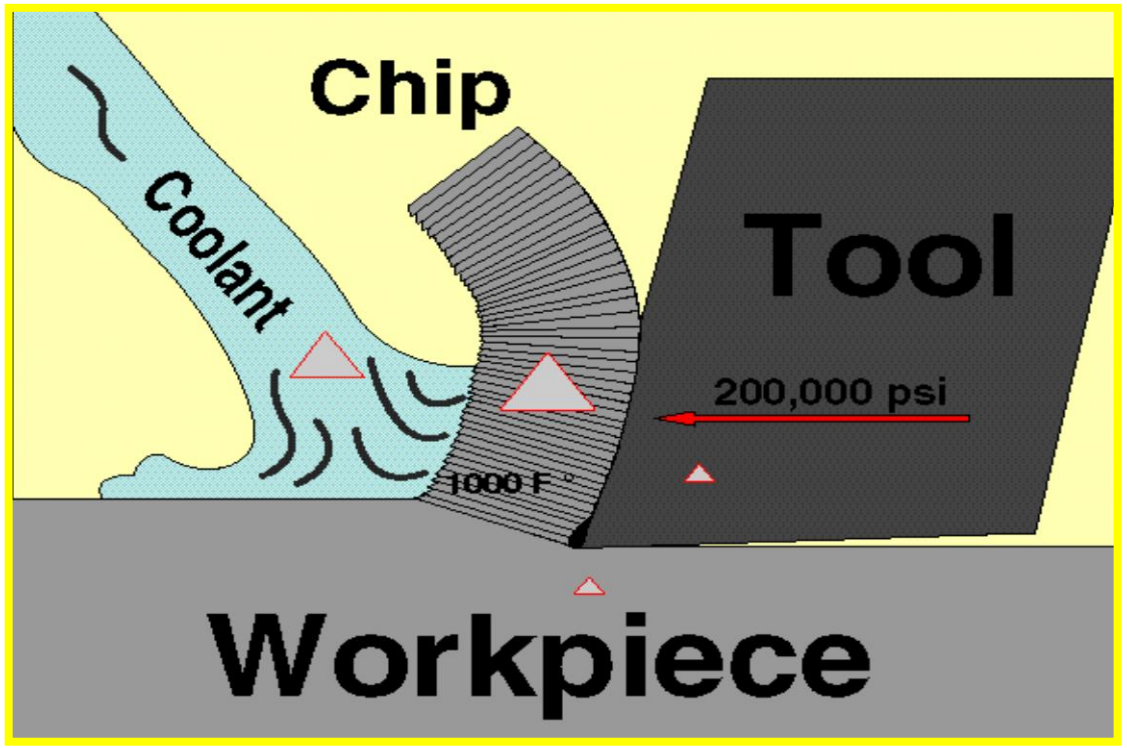
Lack of Sufficient Lubrication



BUE (Built up Edge) – a factor of force, heat, & pressure that is exerted on a cutting tool that, without sufficient lubrication, can create an environment whereby metal from a cutting face is transferred from the workpiece to the tool.

Chip Formation





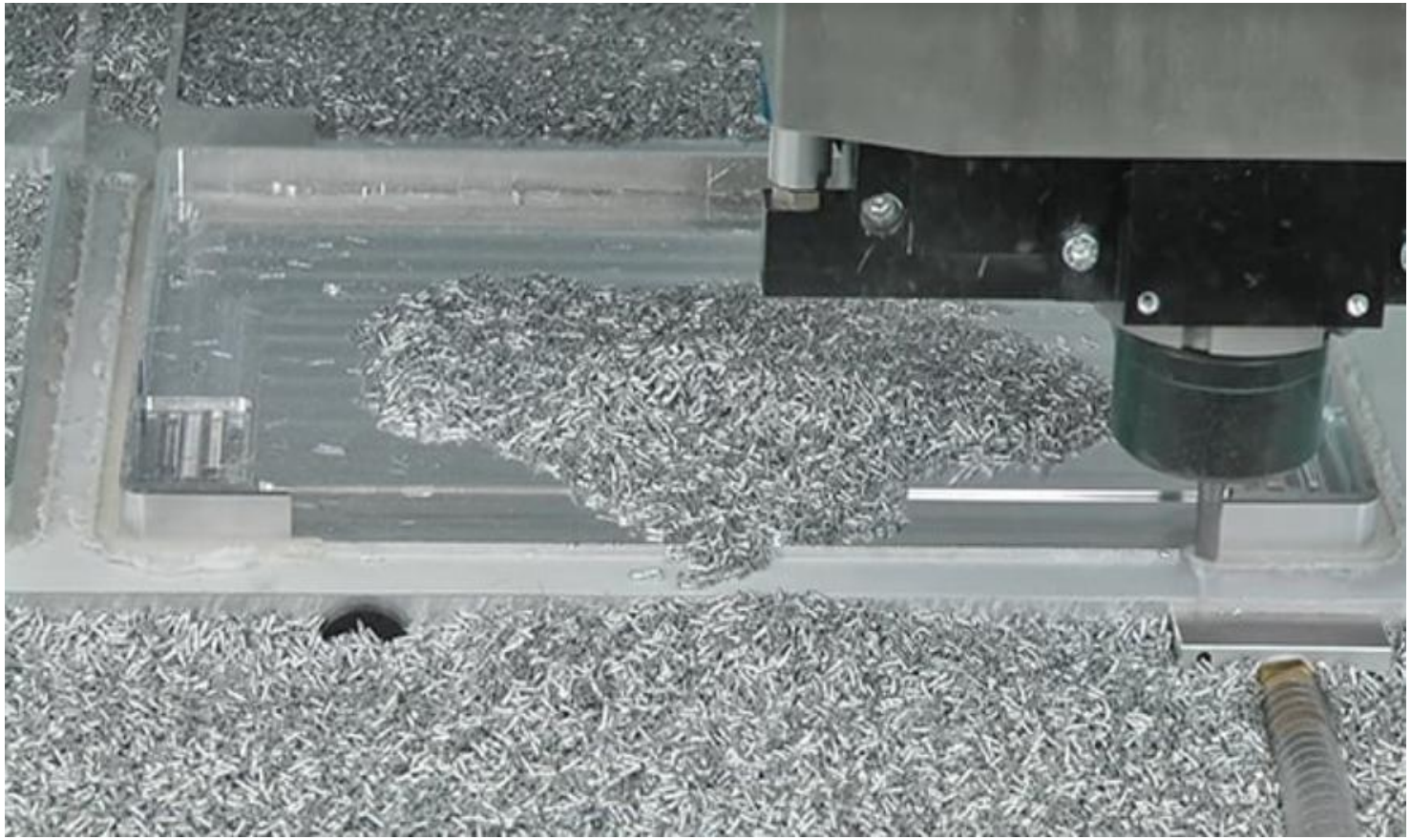
Bing Videos

There are some materials that will indicate if the majority of the heat is dissipating into the chip.

Q: What characteristic will could tell us that heat is being pulled out in the chips?

A: Color - chips will be blue in appearance

Issues related to Chip Accumulation



Q: What concerns could arise from excess chips on a machining surface?

A: Scarring of machined surfaces, impeding movement of slideways, and skin abrasions to workers who require close proximity to part movement

Effect of Lubrication on Chip Formation

- ‘’Birds nests’ in spindles can reduce efficiencies
- Clumping of chips in bins can hold on to residual coolant increasing waste

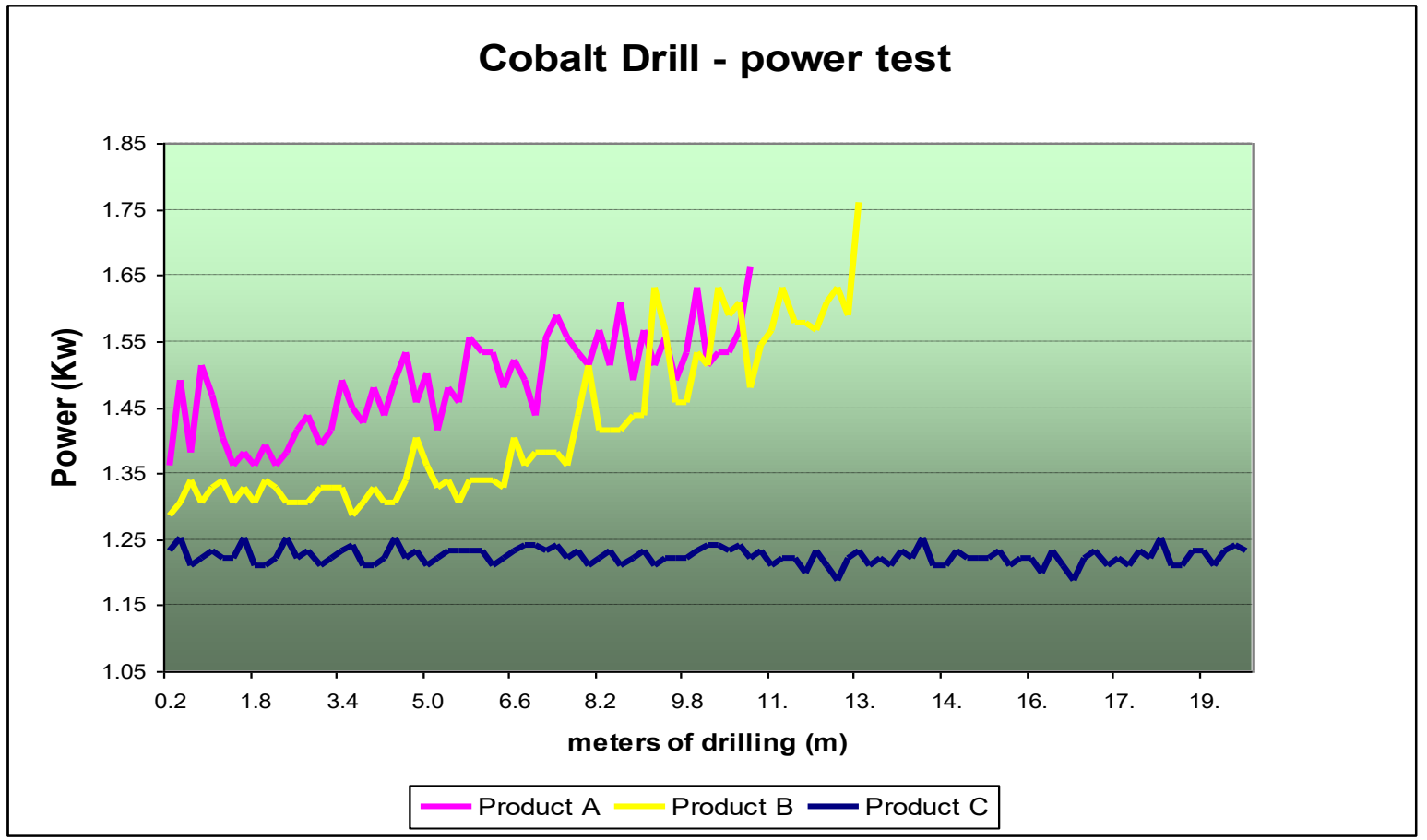
The Flushing Action Provides

- Cleanliness on machine surfaces and work piece
- Improve surface finish
- Reduce pre-mature tool wear

External

Internal

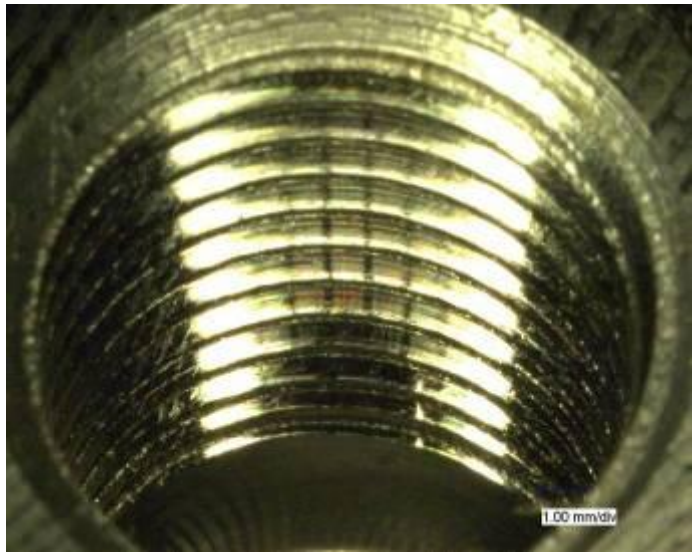
Stainless Steel Drill Test – Power Draw



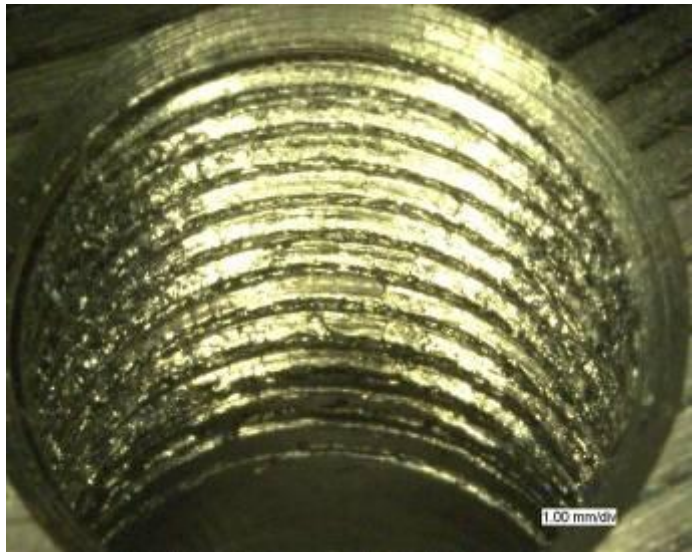
- Compare power consumption between different products performing a similar operation

Reduced power = Saved $$$

Thread Forming Test
Thread Quality



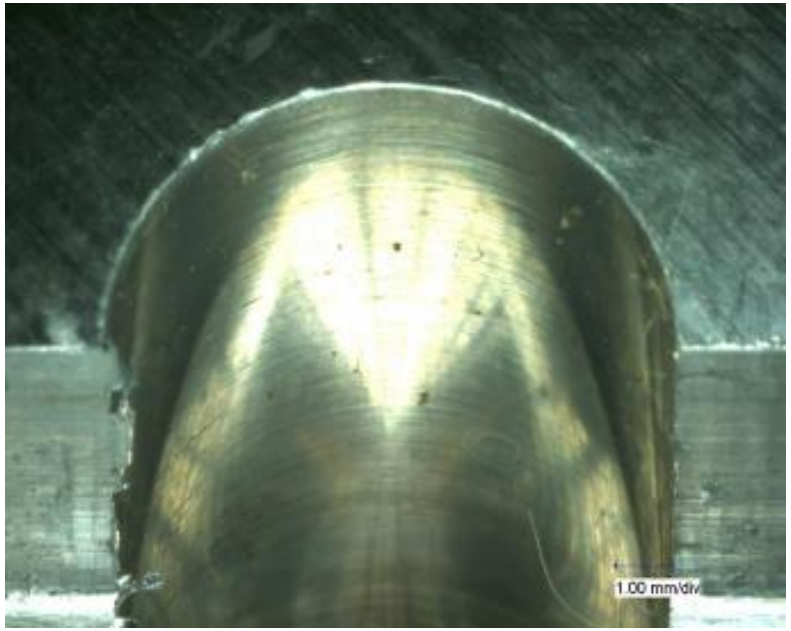
Product A

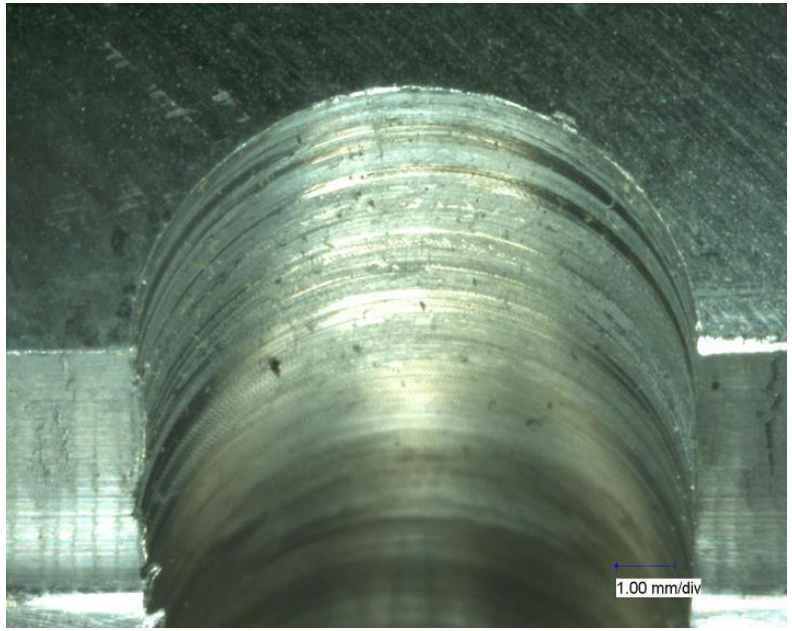


Product B

From DGP050016

Cast Aluminum Drill Test
Hole Finish





From DGP000089

Fluid Types

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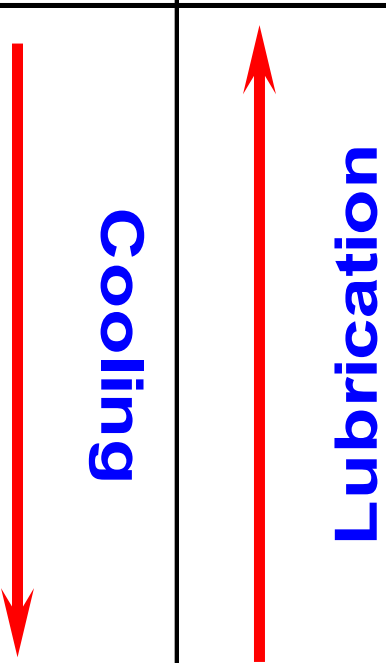
Types of Cutting and Grinding Fluids

- Straight oils – mineral
- Soluble-Oil coolants
- Semi-synthetic coolants
- Synthetic coolants
- “Green” products – Vegetable based

Cooling to Lubrication Ratio

Classification	Oil Content		
Straight Oils	100%		
Soluble Oils	40% - 80%		
Semi-Synthetics	10% - 40%		
Synthetics	0%		

Which product type would you suspect is most favored?

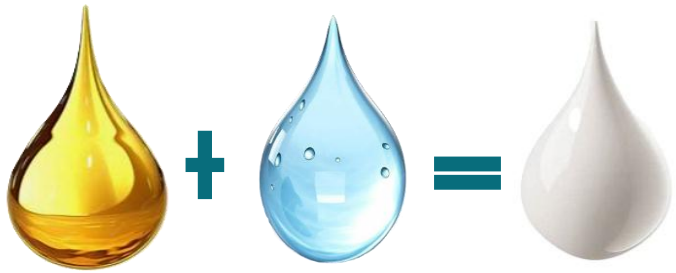
	Straight Oil	Soluble Oil	Semi-Synthetic	Synthetic
Price/gal	Very Good to Excellent	Very Good to Excellent	Good to Very Good	Fair to Good
Total Cost	Poor (run at 100%)	Fair to Good	Good to Very Good	Excellent
Usage Rate	Poor (high carry out)	Fair to Good	Good to Very Good	Excellent
Sump Life	Excellent	Poor to Good	Good to Very Good	Excellent
Maintenance	Excellent	Poor to Good	Good to Very Good	Excellent
Biostability	Excellent	Poor to Good	Good to Very Good	Excellent
Cleanliness	Good	Poor to Good	Good to Very Good	Excellent
Foam Control	Excellent	Poor to Good	Good to Very Good	Excellent
Rust Protection	Excellent	Good to Very Good	Good to Very Good	Poor to Good
Dermal Irritation	Poor to Good	Good to Very Good	Good to Very Good	Poor to Good
Seal, Paint, Plastic Compatibility	Excellent	Good to Very Good	Good to Very Good	Poor to Good
Hard Water Stability	n/a	Poor to Good	Good to Very Good	Excellent

Straight oils

- Mineral Oils
- Boundary Lubricants
  - Fats
  - Fatty Esters
- EP Lubricants
  - Chlorine
  - Sulfur
  - Phosphorus
- Anti-Mist/Anti-Foam Agents
- Odor Masking Agents

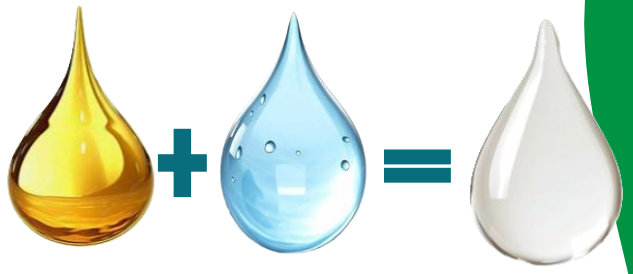
Operation	cSt @ 100°F
Honing	~17
Gun Drilling	~28
Vertical Broaching	~30
Flute Grinding	30 - 57
Swiss Automatics	~45
Screw Machines	~57
Gear Hobbing	28 - 49

Soluble Oils



- Mineral Oil
- Emulsifiers
- Coupling Agents
- Lubricant Package (EP, Boundary)
- Biocides
- Anti-foam Agents

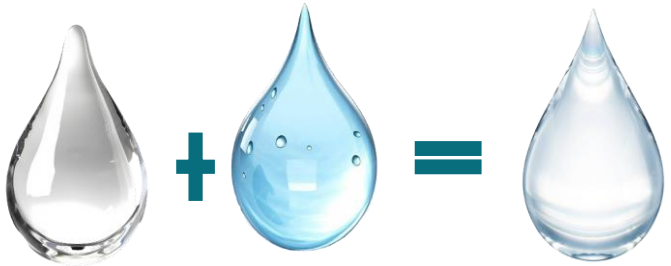
Semi-synthetics



Everything above +

- RP packages
- Buffers

Synthetics



- Coupling Agents
- Lubricant Package
- Biocides
- Anti-foam Agents
- RP packages
- Buffers

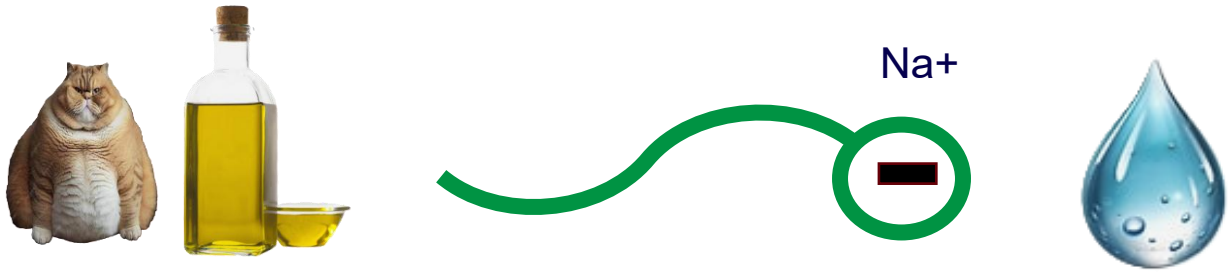
Q: What ingredient, other than mineral oil, was missing from the synthetic coolant composition that is found in both soluble oils & semi-synthetics?

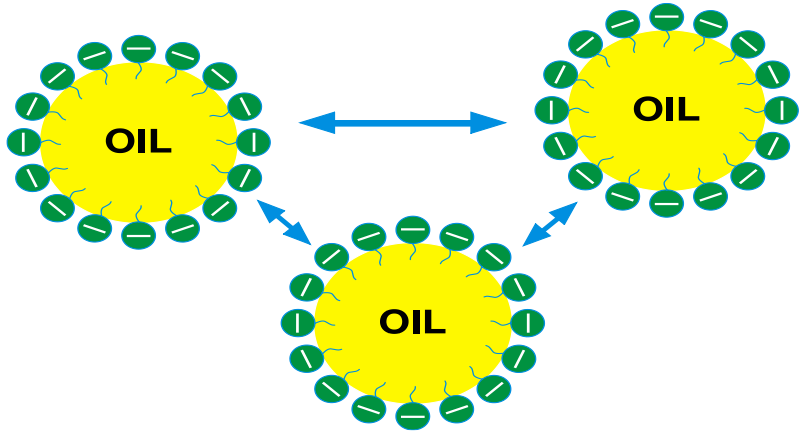
A: Emulsifiers – synthetics do not require these because there is no mineral oil present

Emulsifiers

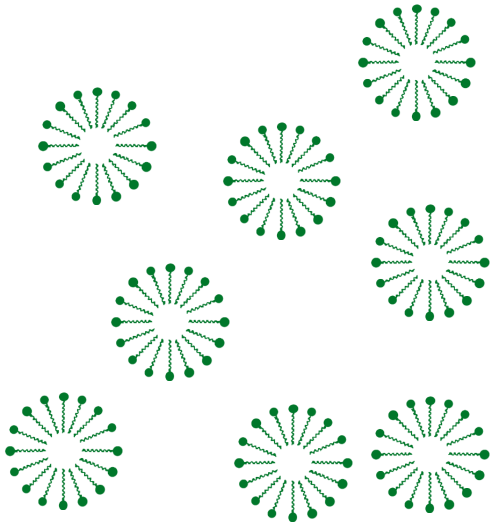
Emulsifiers are polar molecules which have a lipophilic portion and a hydrophilic portion.

The lipophilic portion attaches itself to the oil, while the hydrophilic end is in the water phase





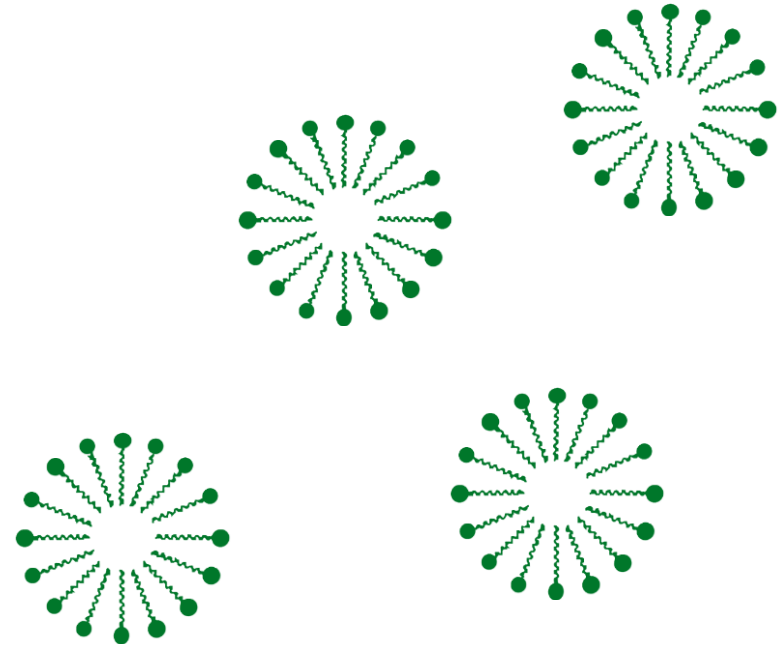
Which product is a soluble oil & which is a semi-synthetic?



Product A

Semi-synthetic : smaller oil droplet size results in a ‘tighter’ emulsion

More translucent in appearance



Product B

Soluble oil : larger oil droplet size results in a ‘looser’ emulsion

More milky in appearance

Metallurgy

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Severity of Machining

Carbon Steels
Cast & Malleable Steels
Free Machining Steels
Aluminum Alloys
Copper Alloys
Magnesium

High Machinability (Easy)

Tool Steels
Common Alloy Steels

Moderate Machinability

High Temperature Alloys
Titanium Alloys
Stainless Steels

Low Machinability (Difficult)

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Metal Types

Automotive Aluminum (300 series)

- ✓ High silicon content – more abrasion, higher tool wear
- ✓ Usually cast
- ✓ “Gumminess” – more lubrication, high speed
- ✓ Fines are light so tend to float on system – positive filtration is key
- ✓ Reaming is key operation – surface finish

Aerospace Aluminum (20XX, 60XX, 70XX)

- ✓ Staining, cracking, corrosion are key issues
- ✓ Chlorine tends to be prohibited in aerospace industry
- ✓ Corporate approvals
- ✓ Used in electronics industry applications
- ✓ Usually extruded bar stock

Metal Types

Nickel Alloys (Inconel)

- ✓ Extremely difficult to machine
- ✓ Aerospace and defense industries

Titanium

- ✓ Staining potential
- ✓ Aerospace and medical industries
- ✓ Restrictions may apply

Magnesium

- ✓ Creates Mg++; hard water soaps; splits products
- ✓ Flammability – straight oils for some customers

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Metal Types

Cast Iron

- ✓ Smut created, runs dirty
- ✓ Rust protection important
- ✓ Clinkering may occur
- ✓ Can run dry, but need fluid for dust control

Carbide

- ✓ Cobalt leaching; fluid turns purple; Inhibitor 3 needed
- ✓ Potential health issues

Plastics (Non-Metals)

- ✓ No synthetics

Metal Cutting Operations

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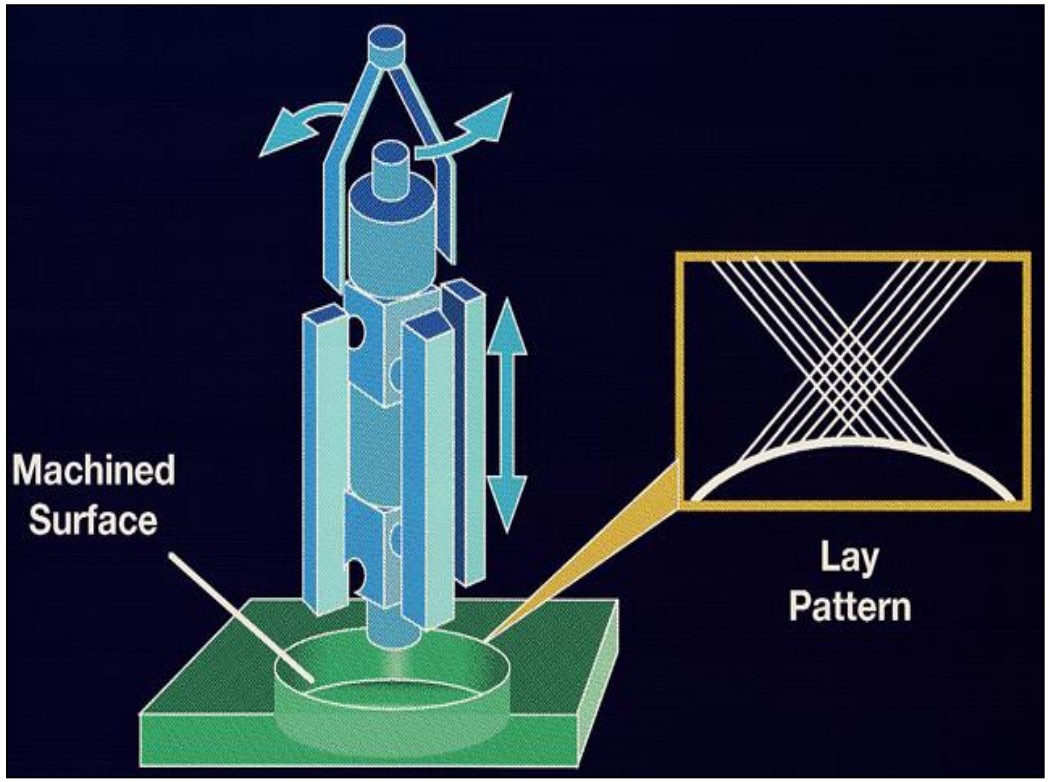
Operation vs Demand

HIGH LUBRICATION DEMAND	BROACHING	NEAT CUTTING OILS	
	TAPPING		
	GEAR HOBBING	SOLUBLE OILS	
	DRILLING		
	MILLING	SEMI-SYNTHETICS	
	TURNING		
HIGH COOLING DEMAND	SAWING	SYNTHETICS	
	HONING		
	GRINDING		

In theory, this chart is true but today almost any product type can be used in almost any application.

Honing

- Honing is a controlled, low-speed sizing and surface finishing process in which stock is removed by the shearing action to the bonded abrasive grains of a honing stone or stick.



Q: What commonly manufactured part would take advantage of the cross-hatching lay pattern?

A: Engine cylinder for a vehicle – oil adheres to the cross-hatch pattern to provide lubrication down the length of the cylinder

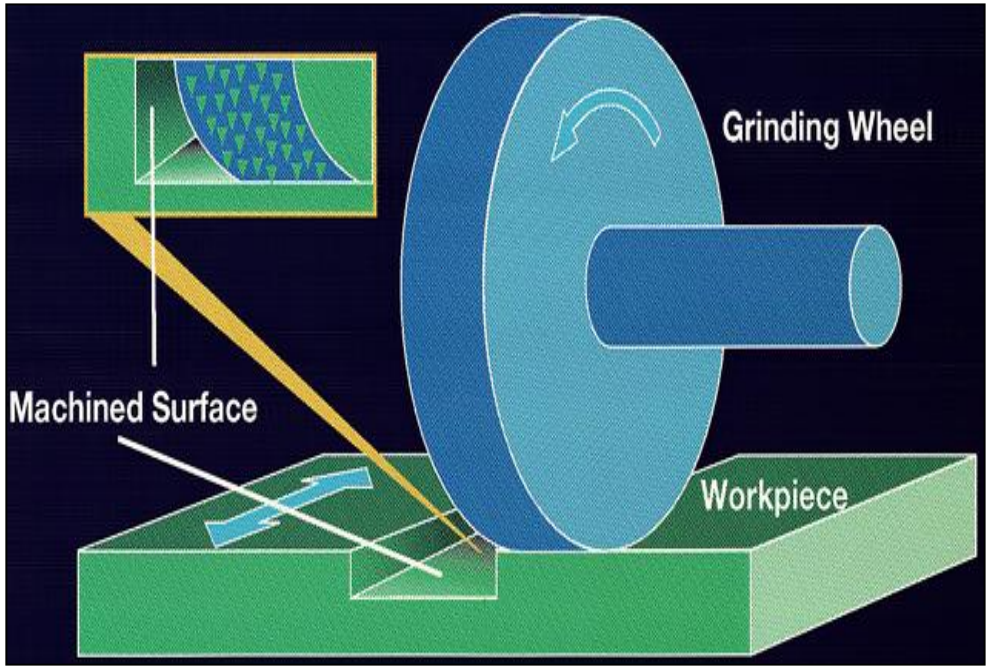
Grinding

Q: What do a sponge and grinding wheel have in common?

A: They are both porous

Q: What does it mean for a grinding wheel to be loaded?

A: The pores of the wheel are filled with metal

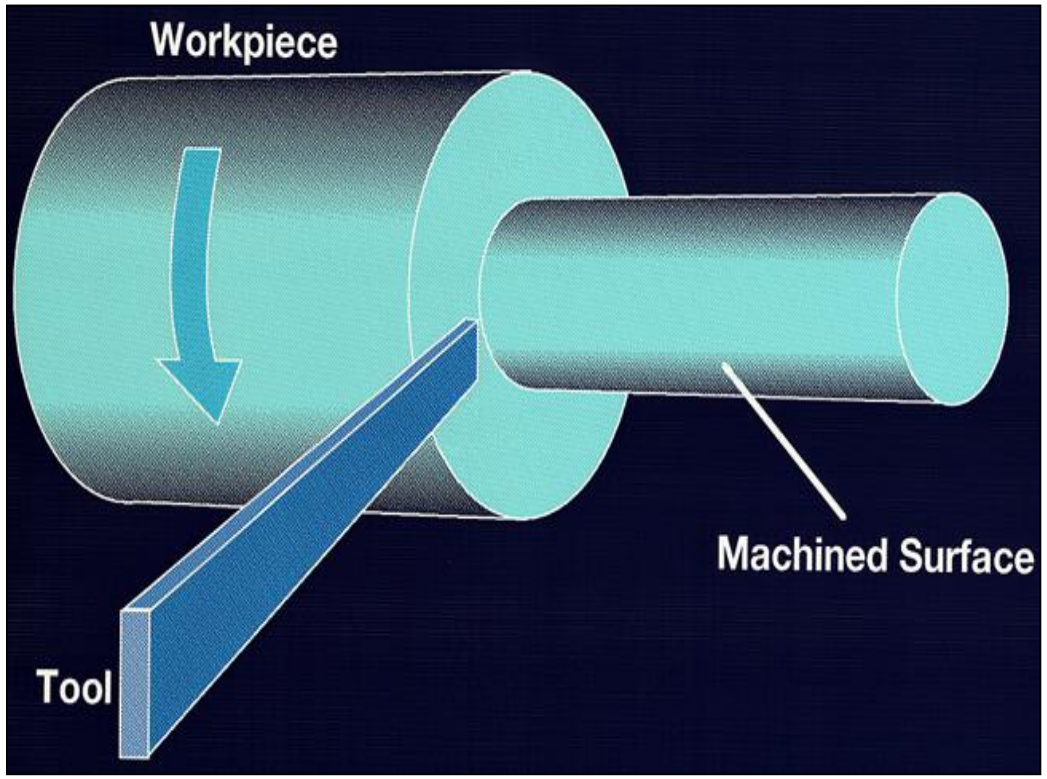


Q: What is the phrase used to clean the pores of a wheel for further machining?

A: Dressing the wheel

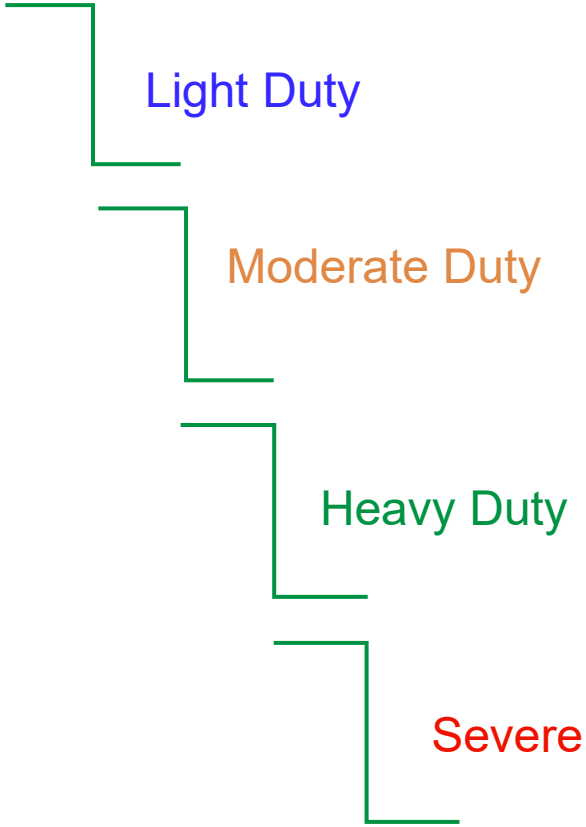
Turning

Turning is a machining process for generating external surfaces of revolution by the action of a cutting tool on a rotating workpiece, usually in a lathe.



Severity of Machining Operations

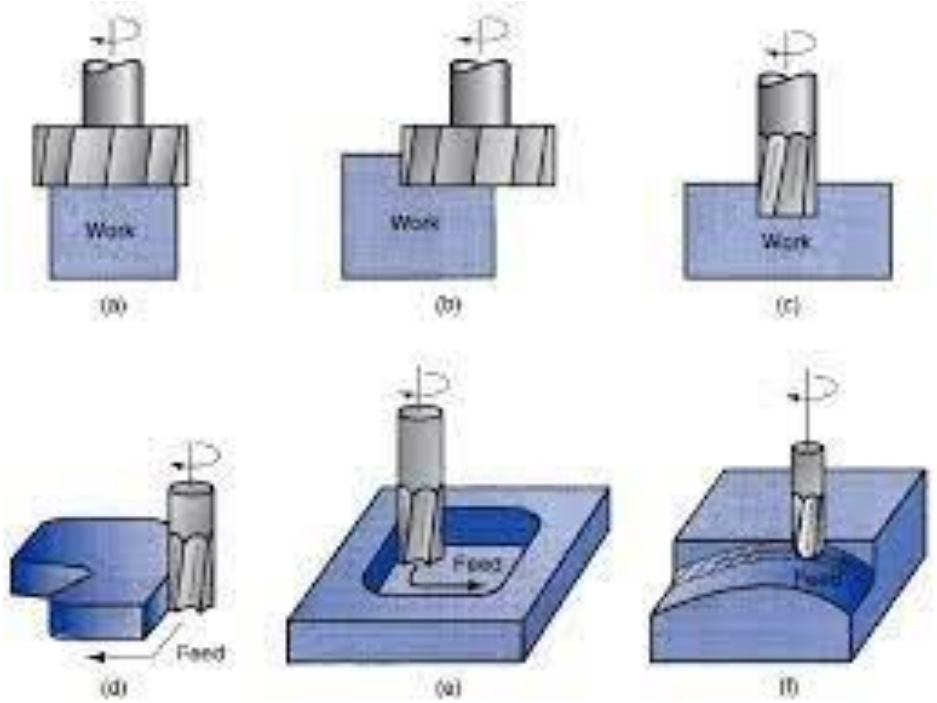
1. Grinding
2. Sawing
3. Turning, Single-point Tools
4. Planing & Shaping
5. Milling
6. Drilling
7. Reaming
8. High-speed, Light-feed Screw Machining
9. Screw Machining with Form Tools
10. Boring
11. Deep-hole Drilling
12. Gear Cutting
13. Threading
14. Tapping
15. External Broaching
16. Internal Broaching



SOURCE: Machining Data Handbook, 3rd Edition; Metcut Research Associates, Inc. 1980

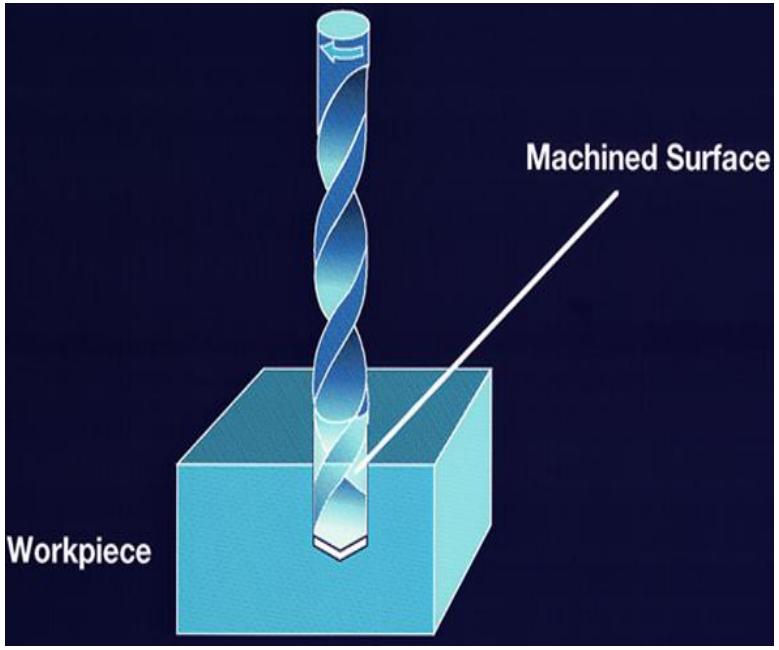
Milling

- Machining process in which metal is removed by a rotating, multiple-tooth cutter.
- Because both work piece and cutter can be moved in more than one direction at the same time, surfaces having almost any orientation can be machined
- Milling can be in a manual machine or a machining center

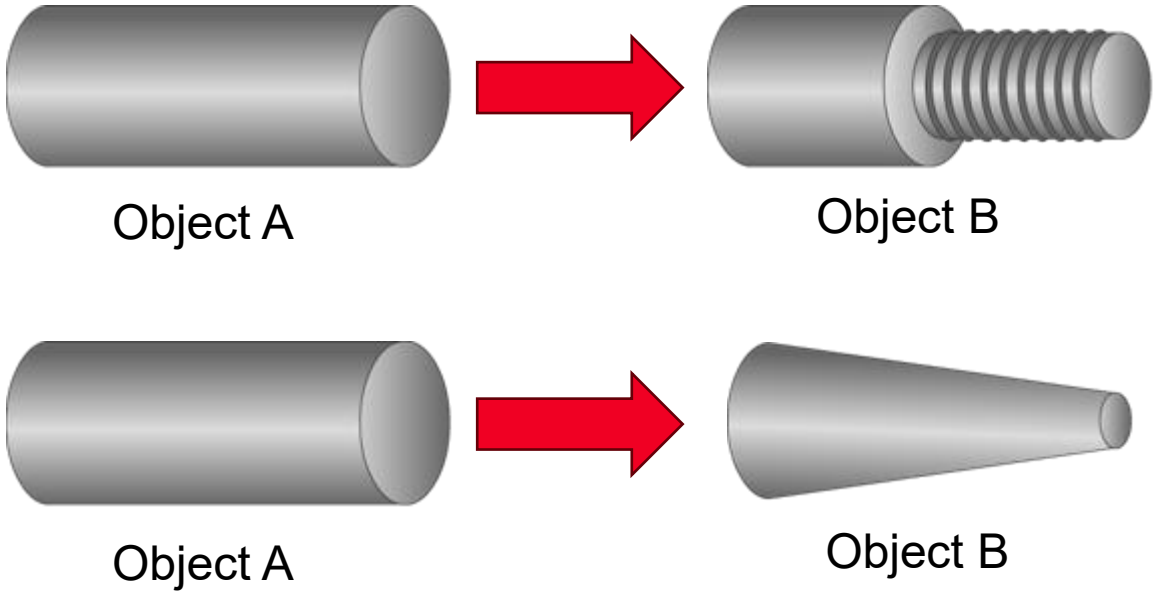


Drilling

- A drill for cutting metal is a rotary end cutting tool with one or more cutting lips and usually one or more flutes for the passage of chips and the admission of cutting fluids.
- Drilling is usually the most efficient and economical method of cutting a hole in solid metal.



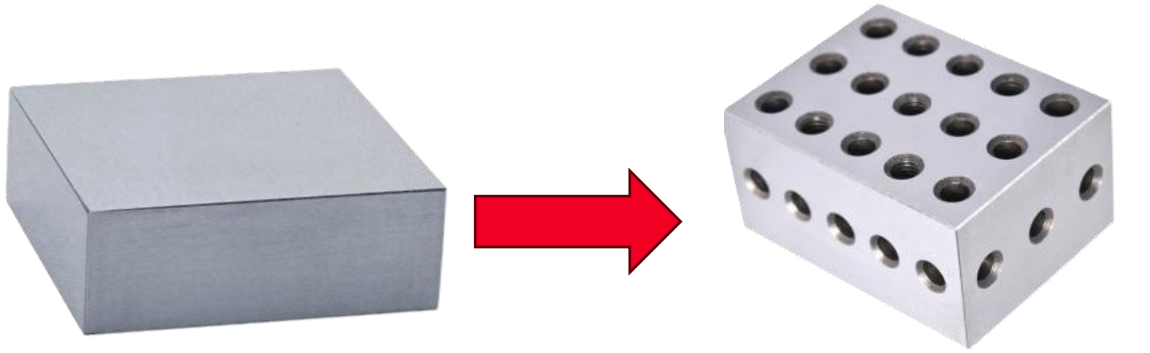
What processes are utilized?

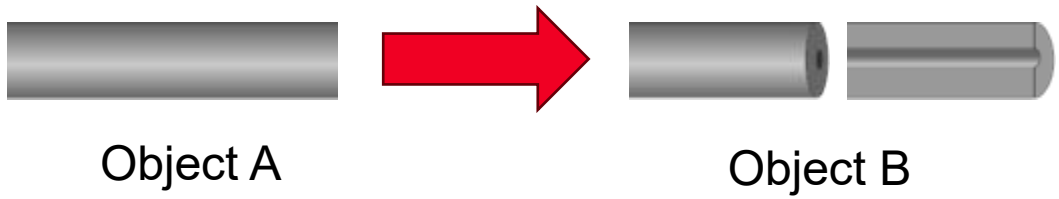


Straight turning
+
Threading

Taper turning

What processes are utilized?

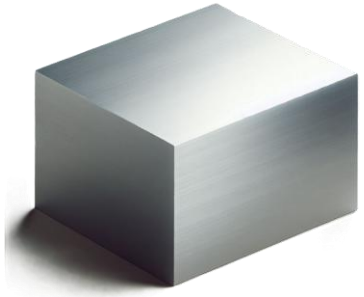




Drilling

Gundrilling

What processes are utilized?



Object A

Object B

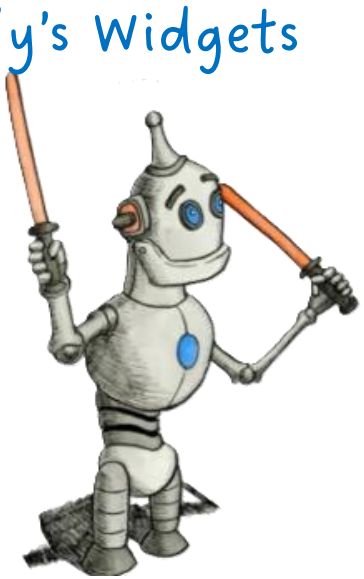
Milling

Object A

Object B

Gundrilling

Sales Scenario 1



Wally's Widgets is a job shop that manufacturers a variety of small to medium sized parts for toy companies. They have been using Ecocool 7330, a semi-synthetic, for a few years and have had mixed results.

They utilize a variety of machining applications including milling, turning, and drilling. Their CNC systems incorporate a high pressure configuration (1000psi). The primary metals being machined are steel and aluminum.

They are located in an area that has hard water (10 grain hardness).

Recently the operation manager has been commenting on unusually high corrosion both in machining centers as well as on some parts. They've also seen high levels of foam across all cells.

What considerations would you take into account when choosing what type of product category & ultimately replacement product?

1. Current product chemistry – it may make sense to stay in the same category
2. Machining operations – typically recommend to the most difficult operation
3. Metals being machined – product needs to be compatible with those metals
4. Water hardness – can contribute to product stability, foam, corrosion
5. Other issues – address corrosion with robust RP package

Hysol MB 50-semi

-Familiar product type

-very good corrosion protection

-multi-metal

-low foam in hard water

Sales Scenario 2

Allison's Air Supply is a supplier of aerospace parts to a variety of companies for the assembly of small private planes. They primarily source Titanium and Aerospace grade aluminum

Parts are machined by milling, turning, and drilling. The facility has been using Microsol 590XT, a semi-synthetic, for a few months but now are noticing a strange smell permeating through the plant. They are seeing sporadic staining on finished parts which requires additional machining.

The CNC machines operate with a moderate pressure system (500psi) and they are using local water that has very low water hardness (4 grain hardness).

What considerations would you take into account when choosing what type of product category & ultimately replacement product?

1. Current product chemistry – it may make sense to stay in the same category
2. Machining operations – typically recommend to the most difficult operation
3. Metals being machined – product needs to be compatible with those metals
4. Water hardness – low hardness can affect foam
5. Biological – choose a product that has high biostability to address growth & odors
6. Other issues – investigate whether the product requires aerospace approvals

Hysol SL 45 XBB-semi

-Familiar product type

-strong biostability

-aerospace metal compatible

Fluid Maintenance

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Q: What is Coolant Management 101?

A: Good “Housekeeping”!

2 KEYS TO SUCCESS

1. Daily Concentration Control

2. Daily Tramp oil Skimming
   #1 cause of bacterial attack

How do we do it?

- Start with a high quality, ‘forgiving’ metalworking fluid
- Good Sump Cleanouts using machine cleaner
- **Daily Refractometer Checks**
- Routine addition of make-up coolant with a pre-mix at **½ Target**
  - **Mixing Method: O-I-L = Oil In Last**
  - **Always add concentrate to water for best mixing results**
- Elimination of contaminants such as oil leaks, tapping fluids, cleaners, food, tobacco and human waste.
- **Skimming Tramp oil**

How to Mix Metalworking Fluids | Castrol USA - YouTube

Good Housekeeping: Proper make up

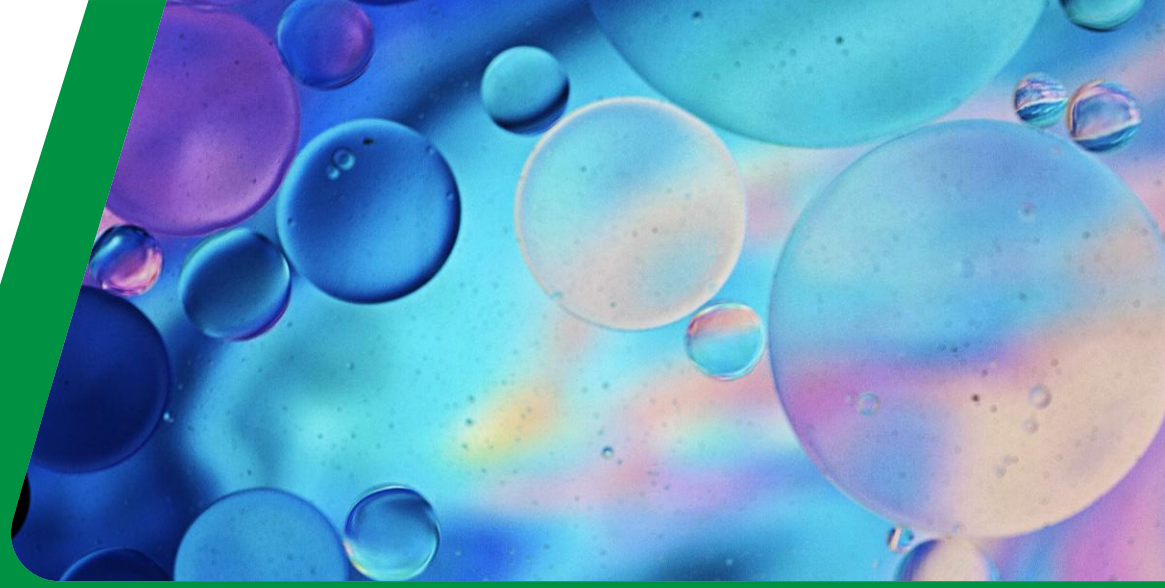
- ✓ Best way to keep sumps in line is with routine use of proportioning device
- ✓ Regular make up of **3-5 %** (or half of your target) keeps sumps in control

Wall Mount/Dual Mix

Drum Top Type

How to Mix Metalworking Fluids | Castrol USA

Good Housekeeping - Tramp Oil



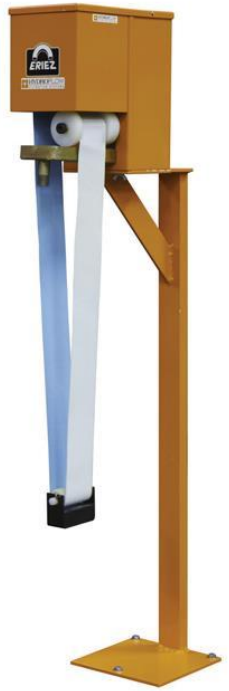
What is Tramp Oil?

Hydraulic oil, spindle oil, grease, way oil, leaks, carryover.

Excess Tramp Oil leads to:

- Poor tool life
- Bacteria
- Misting and Foaming
- Increase product usage
- Chip sticking

Tramp Oil Skimmers - Belt Type



Tramp Oil Skimmers - Disc & Rope Type

Concentration Control

- **Refractometers** are used to measure concentration by measuring the refraction of light of the fluid through a prism

- Contaminants can skew the reading or make the reading difficult, so the refractometer test will not be 100% accurate in aged or contaminated systems

How to Measure Coolant Concentration with a Refractometer | Castrol USA

Effects of Concentration Levels on Performance

Low Concentration

- ❑ Machining Issues
- ❑ Bacterial Growth
- ❑ Corrosion
- ❑ Short fluid life
- ❑ Low tool life

High Concentration

- ❑ Wastes coolant
- ❑ Staining (nonferrous materials)
- ❑ Skin irritation
- ❑ Residue buildup
- ❑ Reduces cooling
- ❑ Foam

Impact of Water on Systems

Common Water Types

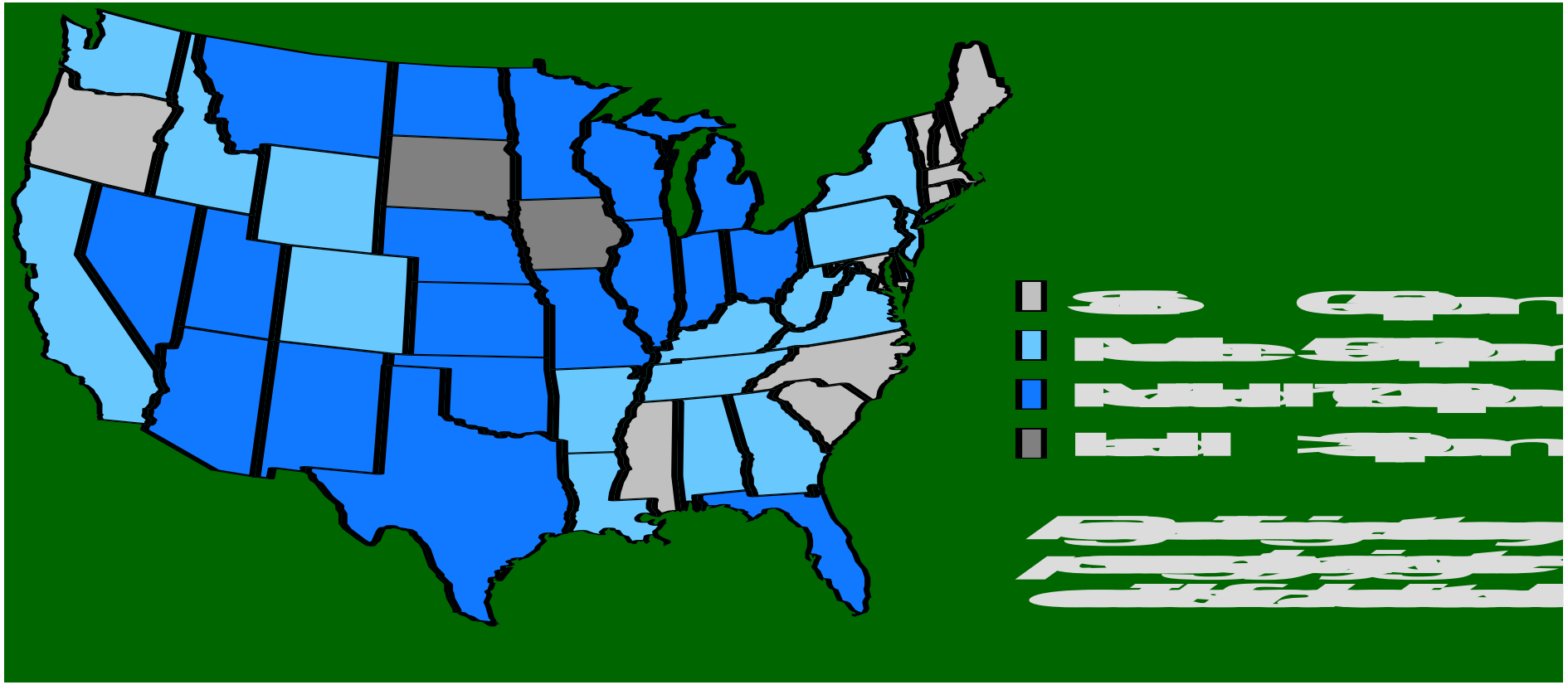
- RO Water
- DI Water
- Softened Water
- Tap Water
- Well Water

Q: Which water type would you expect to be the most likely to cause corrosion in a system? Why?

A: Softened water - salt (NaCl) is used to transfer ions leaving behind the sodium and chloride to build in the system as water evaporates

Water Quality

Water makes up 90+% of most systems, so its quality is very important!



Effect of Water Hardness

Low Hardness (0 to 5 gpg)

- More tendency to foam and mist
- Low tendency for residues
- Good for emulsion stability

DI Water

Moderate Hardness (5 to 20 gpg)

Tap Water

- Desired range to avoid foam, mist, residues and emulsion stability

High Hardness (>20 gpg)

Well Water

- High tendency to form residues
- High tendency to split emulsions
- Low tendency for foam and mist
- Other dissolved ions
- Chlorides and sulfates – known corrosion causing ions
- Keep chlorides below 250 ppm

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Housekeeping - Contamination

Contamination Types:

- Cleaners
- Solvents
- Other Coolants or coatings on raw materials
- Floor sweepings / Airborne particulate
- Dirt or oxidation on raw materials
- Food, human waste

Metalworking Fluid Dump, Clean & Recharge | Castrol USA

Housekeeping - Contamination

ALL OF THOSE MAY LEAD TO:

- Bacteria Growth
- Foam
- Odor
- Shorten Fluid Life

Machine down time and maintenance costs

Personal Hygiene

1. Minimize contact with any chemicals

2. Wash Hands regularly

3. Change clothes daily

4. Should not eat or drink while working

5. Follow proper PPE

6. Notify your EHS staff with any concerns

Fundamentals of Lubrication

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Tribology

Tribology is a term to describe the study of interacting moving surfaces (i.e, . Friction, lubrication, and wear); it encompasses aspects of physics, chemistry, metallurgy, material science, mechanical engineering, chemical engineering and applied mechanics.

Tribology – 3 Focus Areas

The science and technology of:

Friction

Lubrication

Wear

Tribology- Friction

What is friction? Resistance to Motion

Higher Resistance = More Friction

Less Resistance = Less Friction

Tribology - Friction

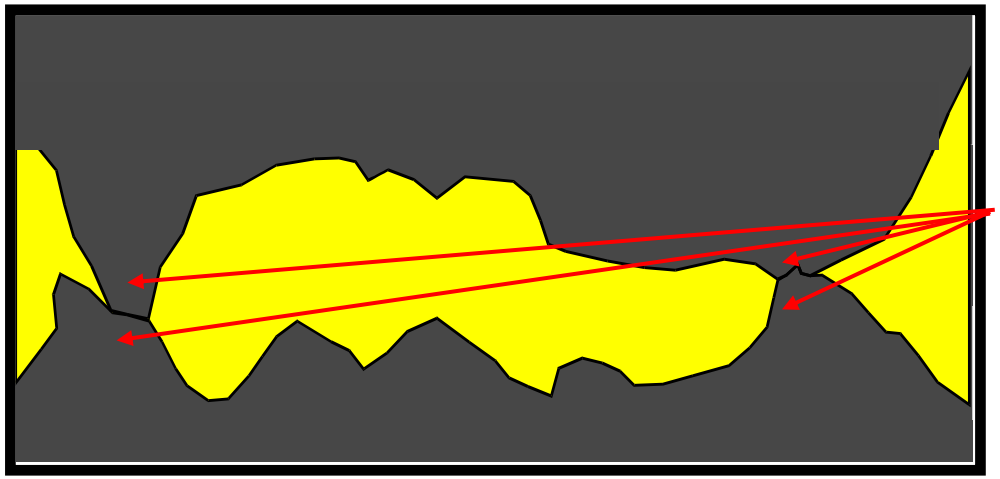
What are the 2 primary forms of friction?

Dry Friction

Fluid Friction

Tribology-Dry Friction

The resistance to relative motion between two (solid) bodies in contact

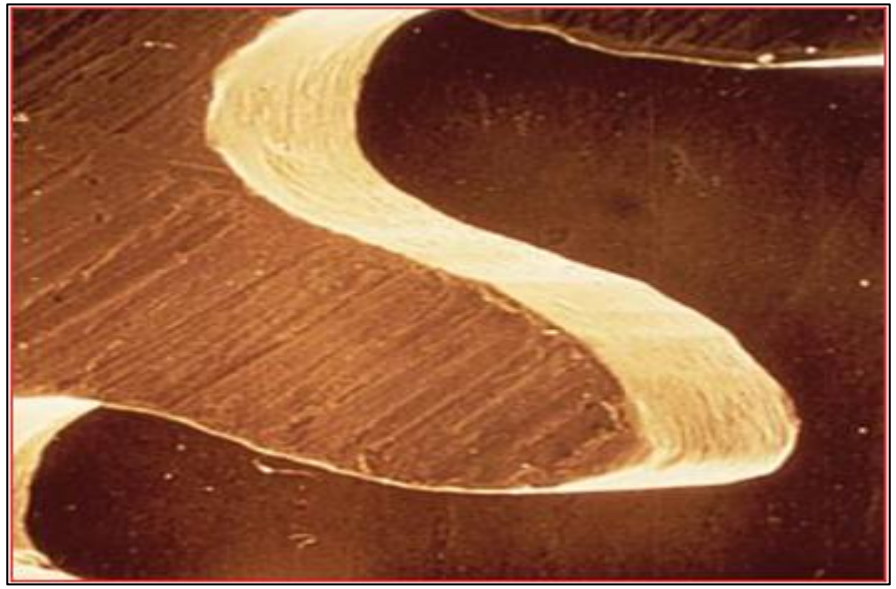


Surfaces are rough and have peaks called **asperities** which pass and "bump" into each other

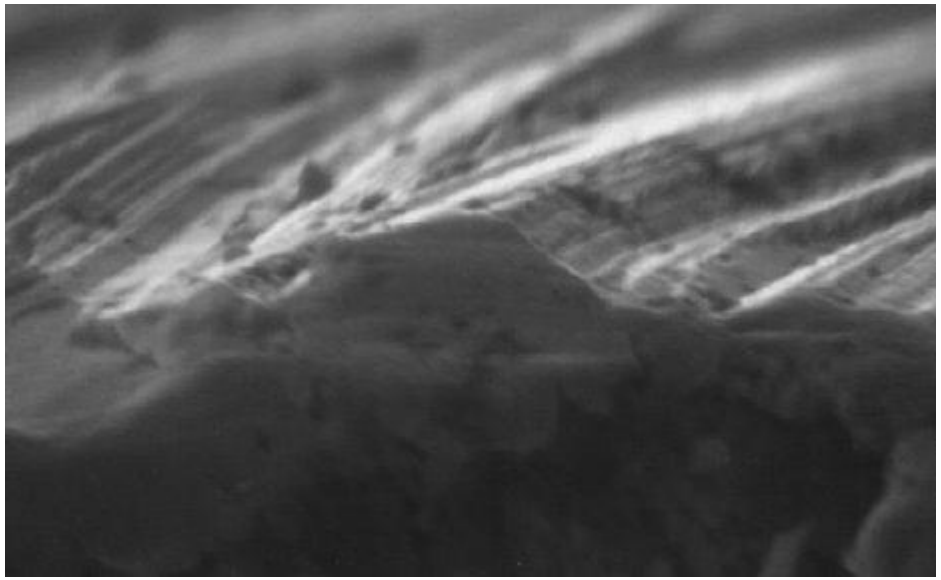
As surfaces move over each other, they will block movement and a force is required to move the asperities over or through one another.

This force is called the frictional force.

Tribology- Dry Friction (Under a Microscope)



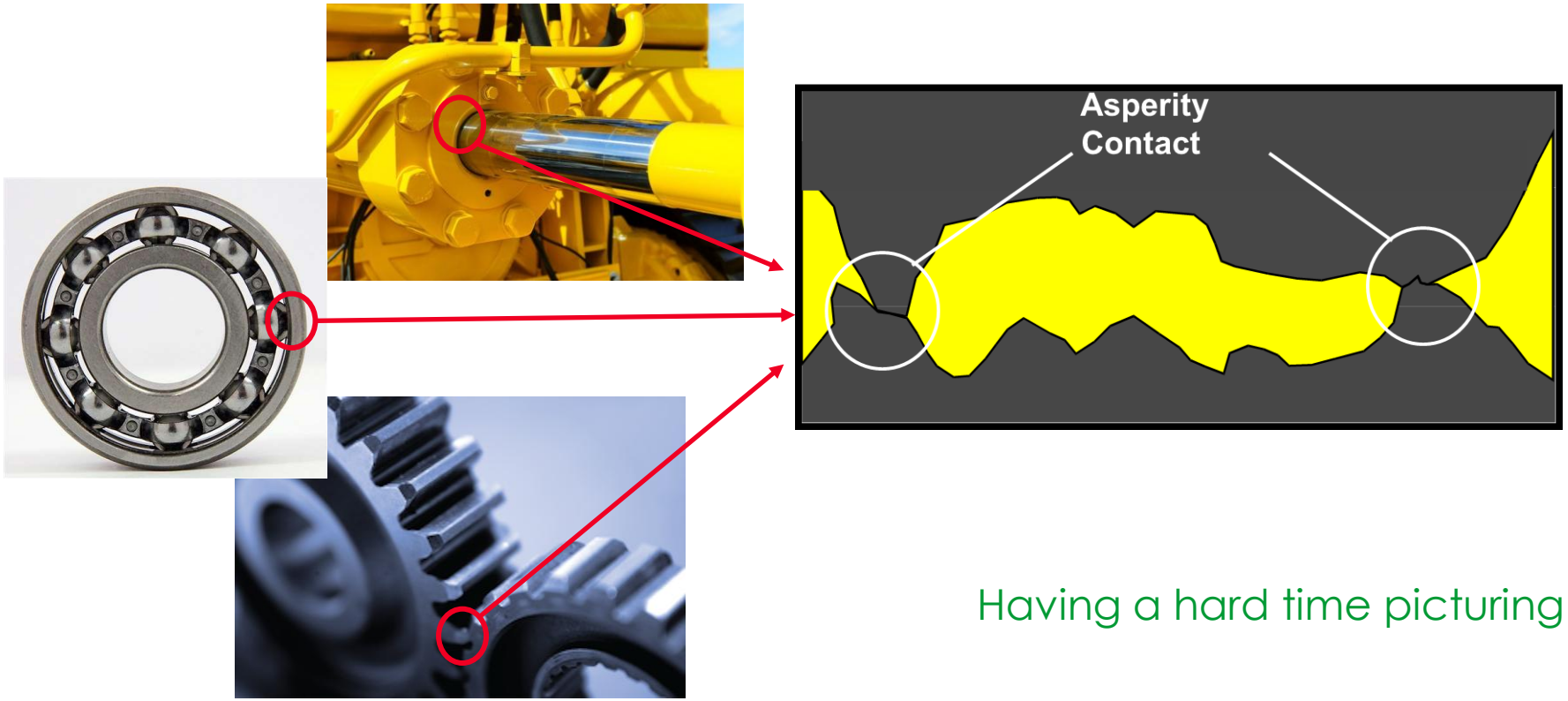
Precision Gear From a Watch under magnification



2000 times magnification of a highly machined surface

Tribology- Dry Friction

Where does dry friction occur?



Having a hard time picturing this?

Tribology- Dry Friction (A Better Picture)

From a distance, the surface of the earth appears smoother than that of a bowling ball

When you look closer, you can see the roughness of the terrain

Tribology - Dry Friction

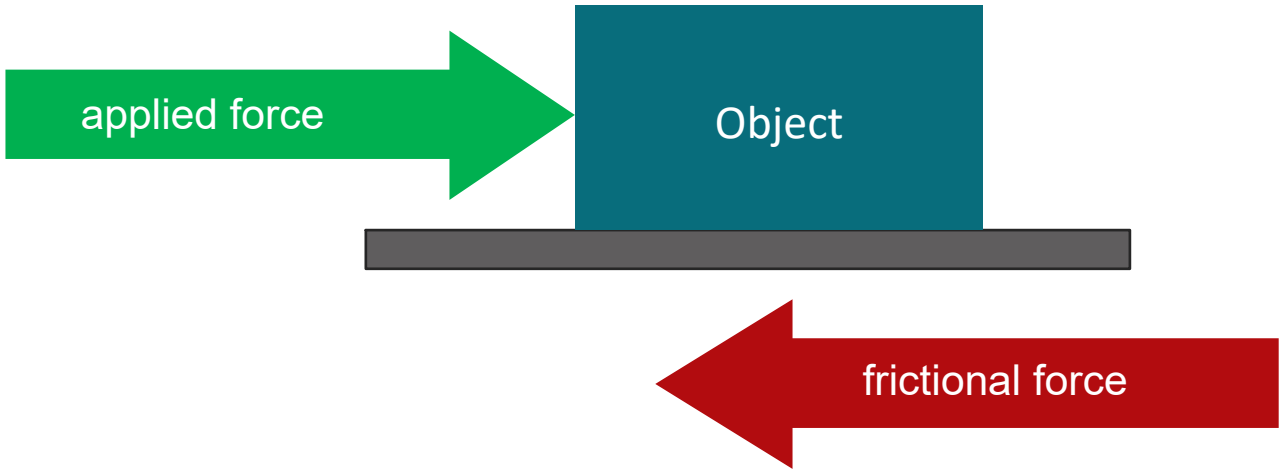
What are the two modes (i.e. different *forms*) of friction?

Sliding (or rubbing)

Rolling

Tribology - Dry Friction

Sliding Friction is the force that resists sliding motion



Applied force must be GREATER than frictional force for motion to occur!

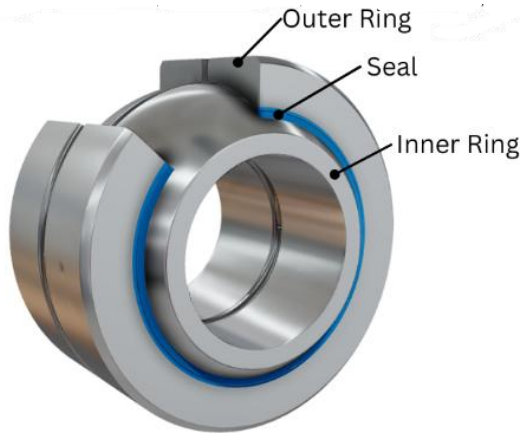
Tribology - Dry Friction

Applications with sliding friction

Slideways

Screw threads

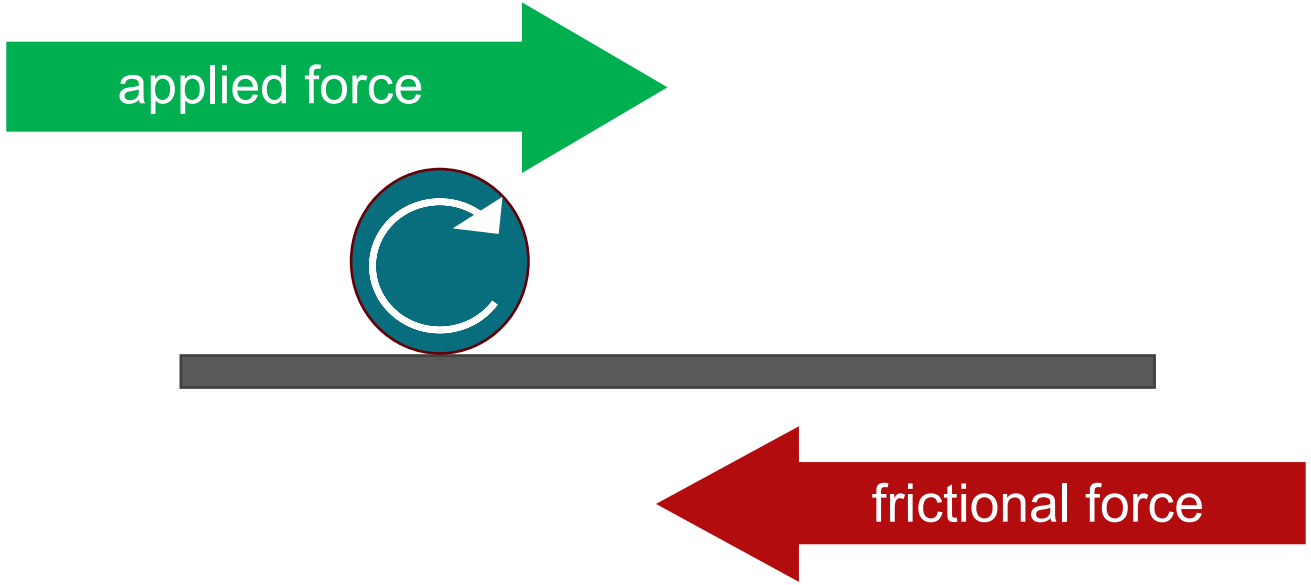
Worm gears



Plain journal bearings

Tribology - Dry Friction

Rolling Friction is the force that resists rolling motion



Applied Force must be GREATER than Frictional Force for motion to occur!

Tribology - Dry Friction

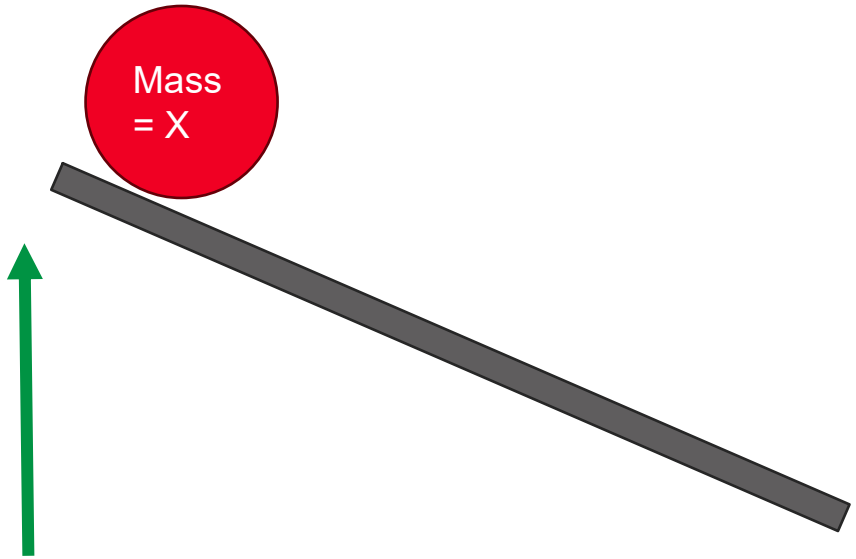
Applications with rolling friction

Roller / Ball Bearings

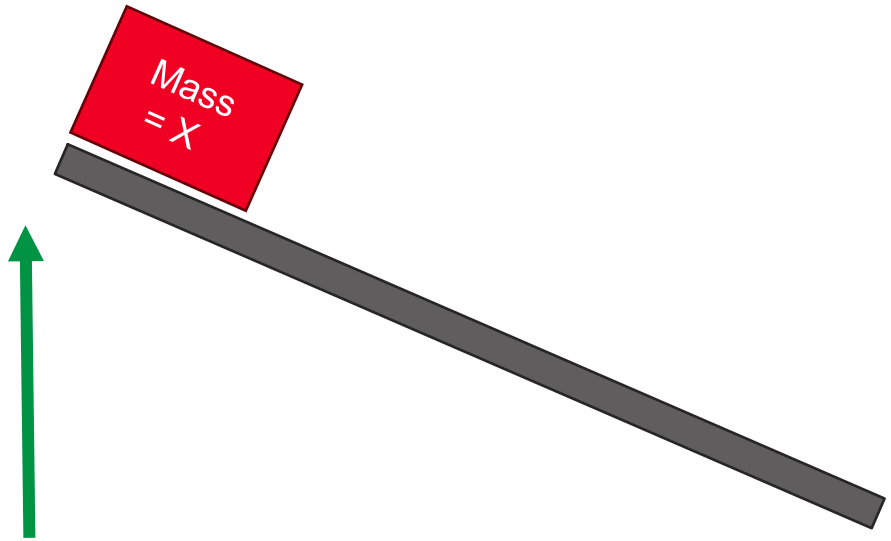
Gears – slide & roll

Tribology - Friction

Which object moves FIRST as the platforms are raised and why?



Object A



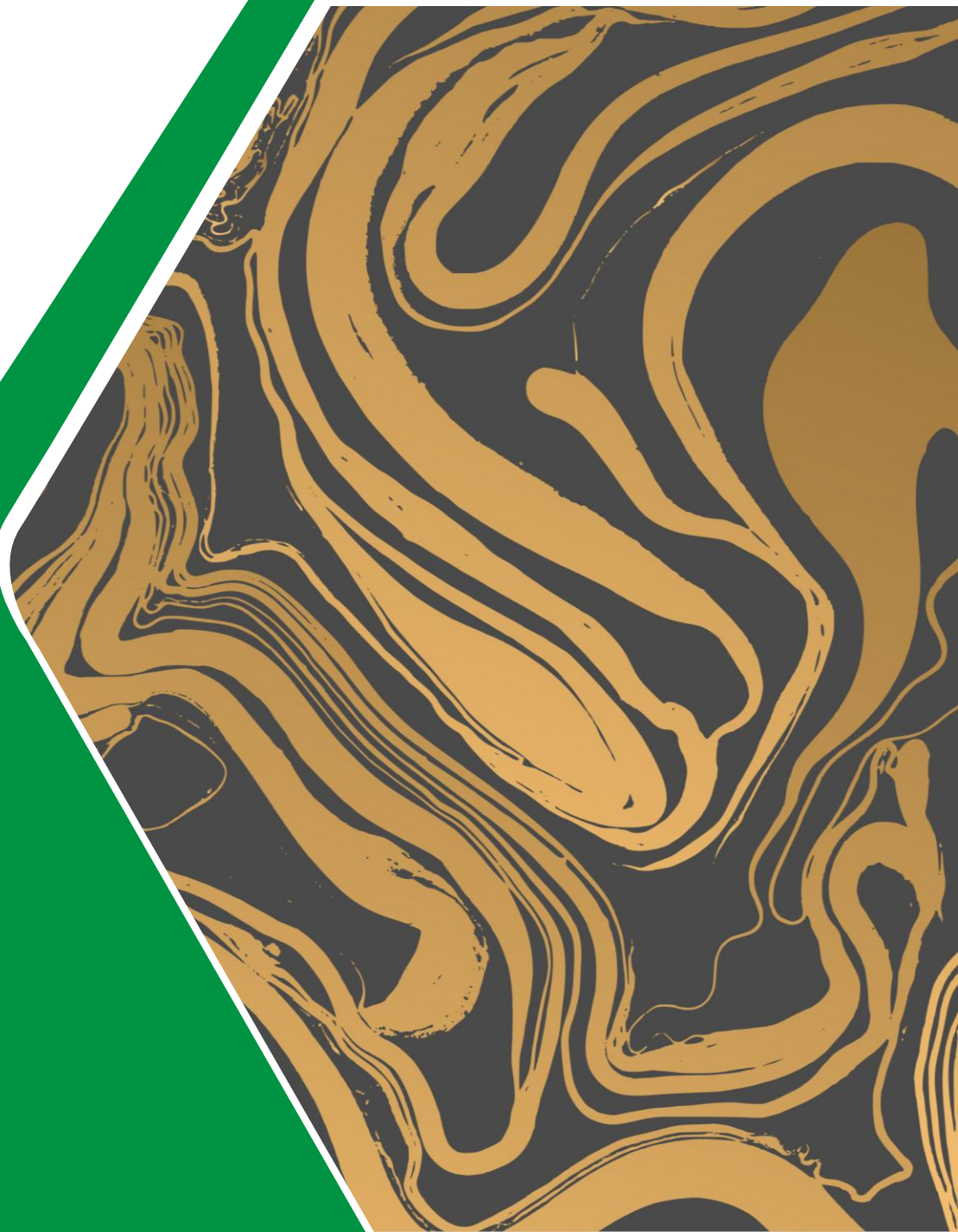
Object B

Tribology - Friction

What are the 2 primary forms of friction?

Dry Friction

Fluid Friction



Tribology - Fluid Friction

Fluid Friction - Resistance created within the fluid film when the molecules collide

GROUP QUESTION:
What could happen if you over-lubricate a bearing with grease or oil?

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Question – Place letters in order from lowest friction to highest friction.

A

B

C

What is a Lubricant?

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Tribology: What is a Lubricant?

Merriam-Webster definition:

a substance capable of reducing

- Friction
- Heat
- Wear

when introduced as a film between solid surfaces

Tribology: Lubricant History - Past

17th Century BC – Egyptians used olive oil to move stones and other objects

14th Century BC – Tallow being used to lubricate wheels/chariots

Early 1900's – mineral oil-based lubricants start being used in industry

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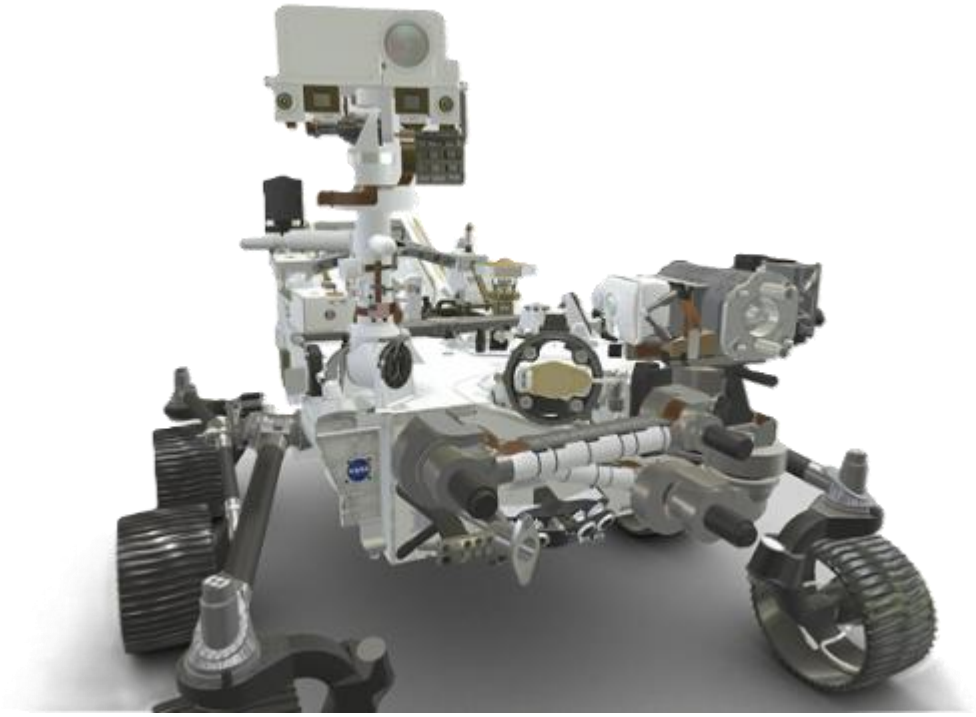
Tribology: Lubricant History - Present

Lubricants are now used in many facets of our lives:

- Sporting equipment (skateboards, etc.)
- Bikes
- Cars
- Construction equipment
- Airplanes
- Robots
- Elevators
- SPACE



Tribology: Examples of Lubricants

What are some unique lubricants?

Unique lubricants

Graphite to lubricate guitar pickups

Air as a cushion to allow puck to move freely

Tribology: Lubrication

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Tribology: Lubricant vs Lubrication

Lubricant → A substance that controls friction and wear

Lubrication → The science & art of controlling friction and wear

Lubrication Rule

The Right Amount
of
The Right Lubricant
in
The Right Place
at
The Right Time

The correct lubricant is only **ONE** piece of the lubrication puzzle!

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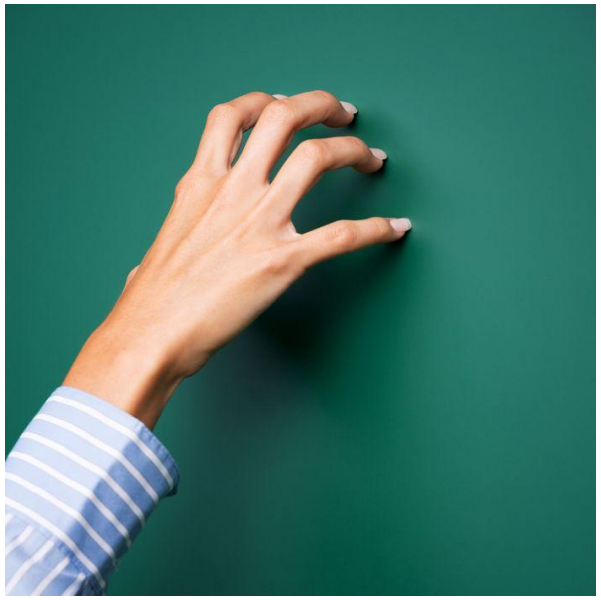
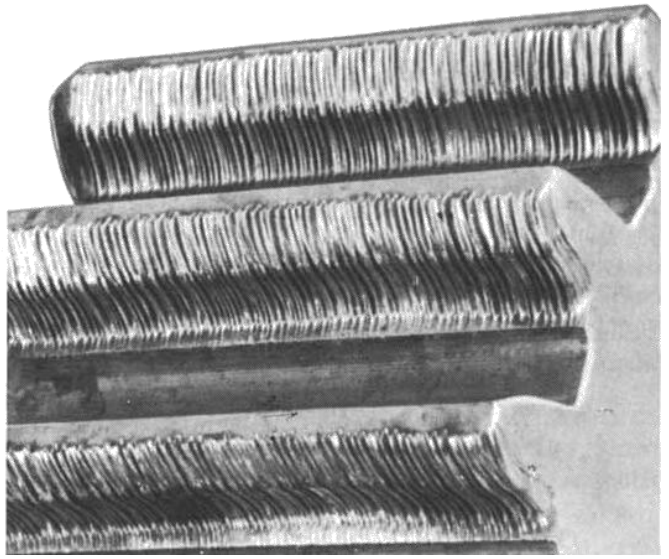
What are 3 things that friction cause?



NOISE

HEAT



WEAR

What do lubricants do? (besides the obvious)

What else do lubricants do?

Tribology: Lubrication

What we will cover in the next slides:

1. Reduce friction
2. Control wear
3. Prevent corrosion
4. Cool rubbing surfaces
5. Seal out/carry away contaminants
6. Dampen shock

Tribology: Lubrication

Reduce friction

(Energy losses are Proportional to Friction)

By reducing friction, you reduce energy required to perform work.

Studies have shown that overcoming frictional forces accounts for **30%** of all energy consumed

Tribology: Lubrication

Control Wear

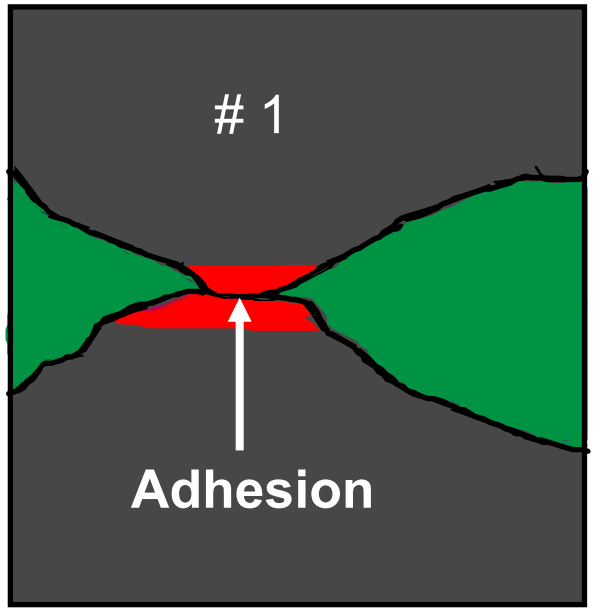
WEAR = the removal or transfer of material.

By reducing wear, equipment life is extended and the quality of production maintained longer

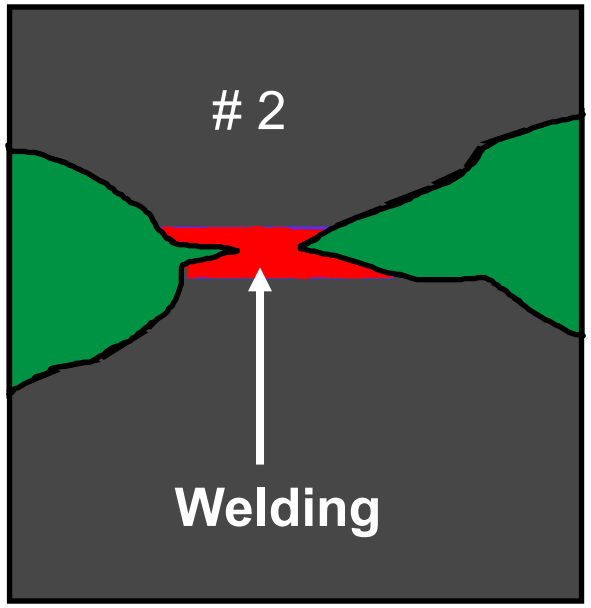
Tribology: Lubrication

Types of Wear: Adhesive

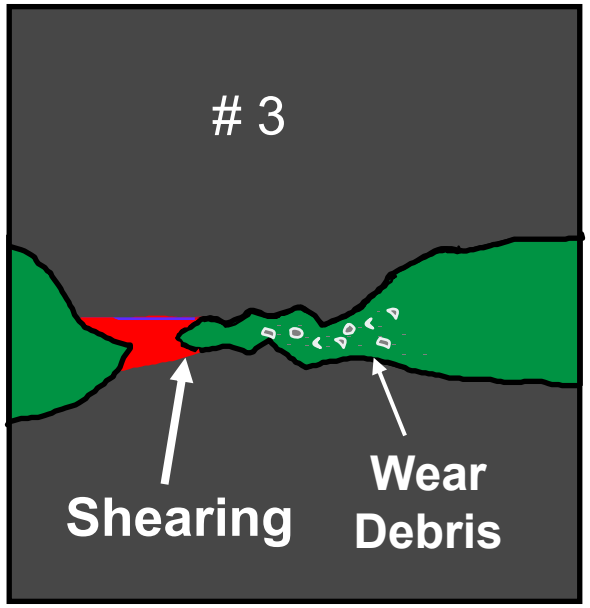
Adherence and welding causing material loss and transfer



"Like attracts Like"



High pressure = cold welding



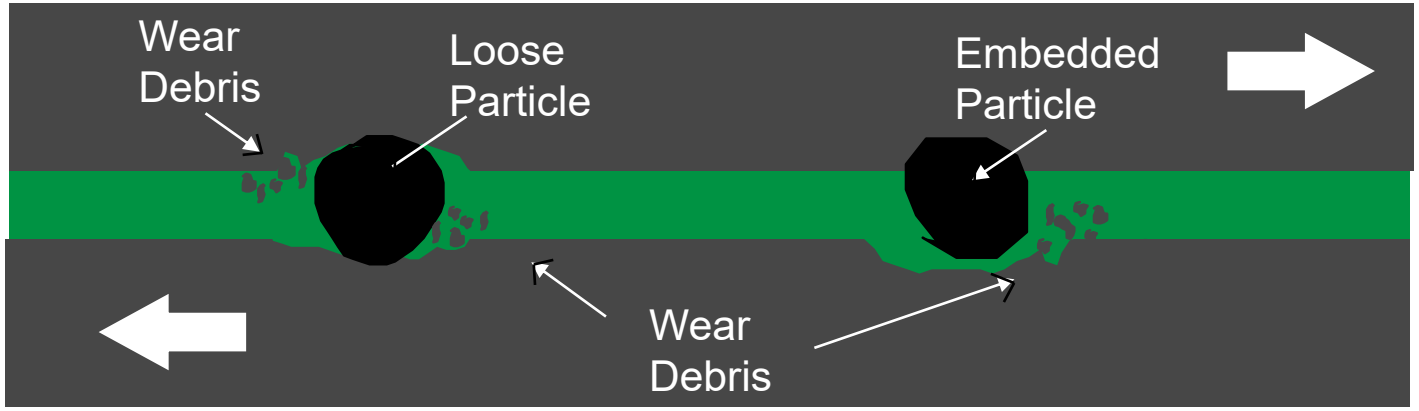
Movement creates shearing & debris to adhere further

Types of Wear: Abrasive

Abrasive medium causing physical damage

Abrasive material may be:

- Wear debris & Atmospheric contamination
- Solid by-product of oxidation
- Contamination due to handling



Types of Wear: “Running In”

Is all WEAR bad?

NO!

Running In

The process usually performed on newly installed parts to increase real contact area of the metal surface.

Running In

•Removes high spots
•Increases real contact area
•Low loads and speeds
•Work hardens surfaces

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Lubricant Categories

Gear Oil

Base Oils:

- Mineral, PAO, PAG

Additives:

- EP
- AW
- R&O
- Friction Modifiers
- Demulsifier
- Solids

Common Viscosity Grades: ISO 68-680

Hydraulic Oils

Base Oils:

- Mineral
- PAO
- POE
- Water Glycol

Additives:

- AW & EP
- R&O
- Anti-foam
- Demulsifier

Common Viscosity Grades: ISO 32-100

Common Hydraulic fluid terms

Term	What Does it Mean?
➢ Viscosity index	Fluid's ability to resist viscosity change with temperature
➢ Total Acid Number (TAN)	Measures the acid number as precursor to oxidation
➢ ISO cleanliness	Indicates how clean the oil is based on dirt particle size
➢ Particle counts	The size and quantity of the dirt particles in µm (micrometer)
➢ Carbon and varnish	Build up in the system from oil oxidation.
➢ Group base oils	The higher the group, the more refined the oil is
➢ Oxidation	Causes viscosity to rise, varnish, & possibly TAN increase
➢ Dual purpose (ie Magna SW D-32 combined hydraulic/way oil fluid)	An oil that can be used in hydraulic & way oil applications

Common Additive Types

Examples

AW = Anti-wear → Zinc

EP = Extreme Pressure → Chlorine, Sulfur, Phosphorus

R&O = Rust & Oxidation → Various additives

Lubricant Characteristics

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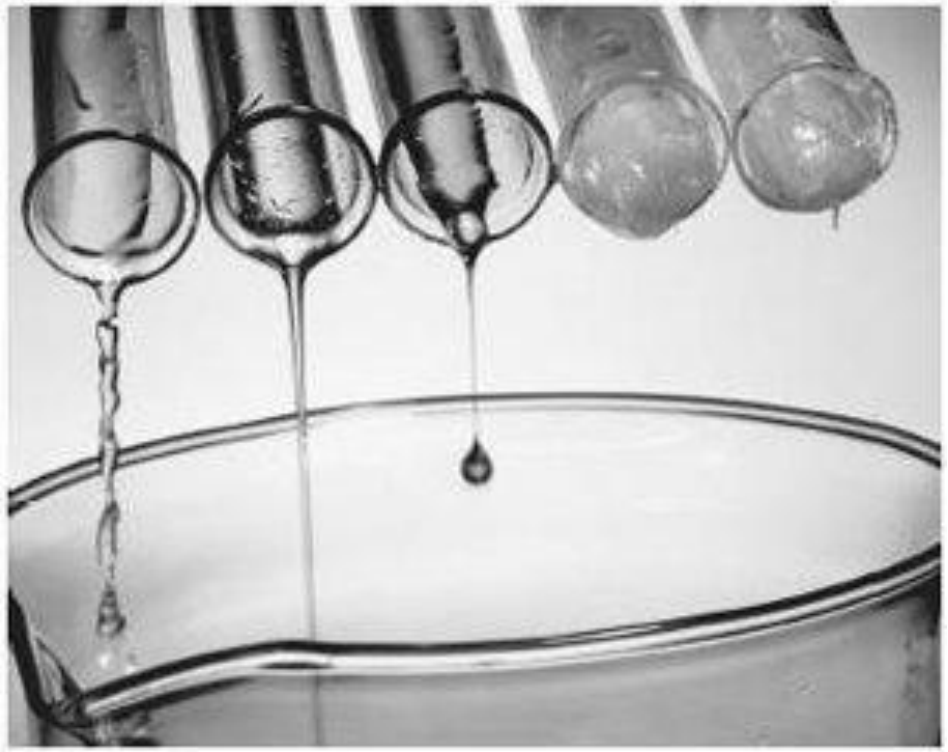
Lubricant Characteristics

What is the most important characteristic of an oil?

Viscosity!



What is Viscosity?

Property of a fluid that resists flow, measure of “flow ability” of an oil at specific temp

Importance of Viscosity

Viscosity is a measure of a fluid's resistance to flow "thickness" of the oil. Most important property of any oil.

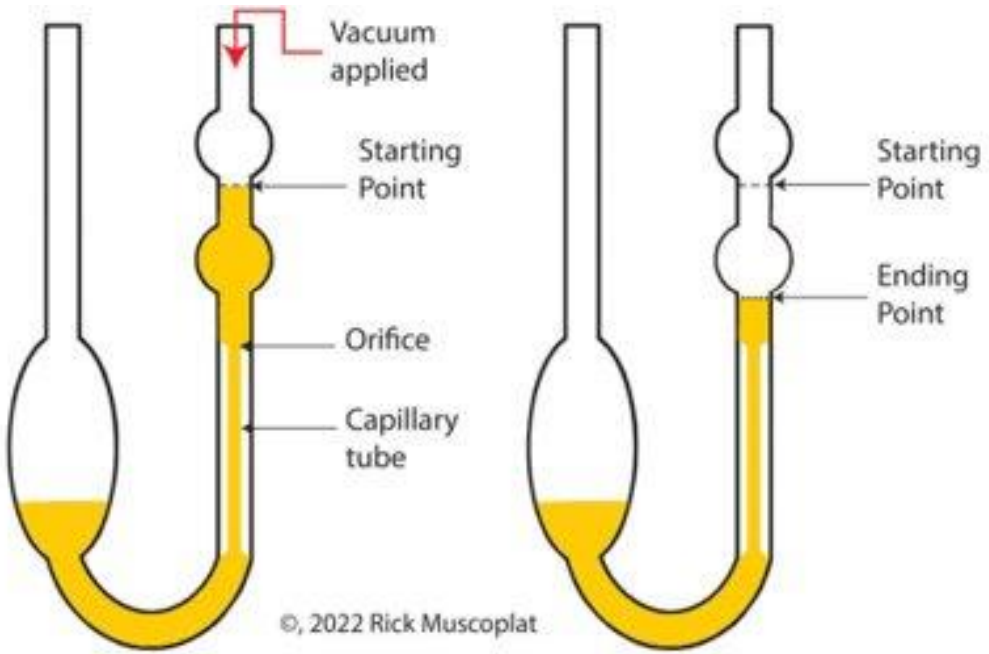
Low viscosity oils are used for applications with higher speeds, lighter loads and lower temps.

High viscosity oils are used with lower speeds, higher loads, and higher temps.

Pour Point of an oil is the depressed temperature at which it no longer flows.

Flash Point: the temp at which the oil vapor will ignite but not continue to burn for more than five seconds.

Lubricant Characteristics: Viscosity



Capillary Tubes

Kinematic viscosity (ASTM D445, done in temp. controlled water bath)

Lubricant Characteristics: Viscosity

ISO (International Standards Organization):

- Centistokes (cS at 40°C
- ex: ISO 32 Hydraulic Oil

Agma (0-15):

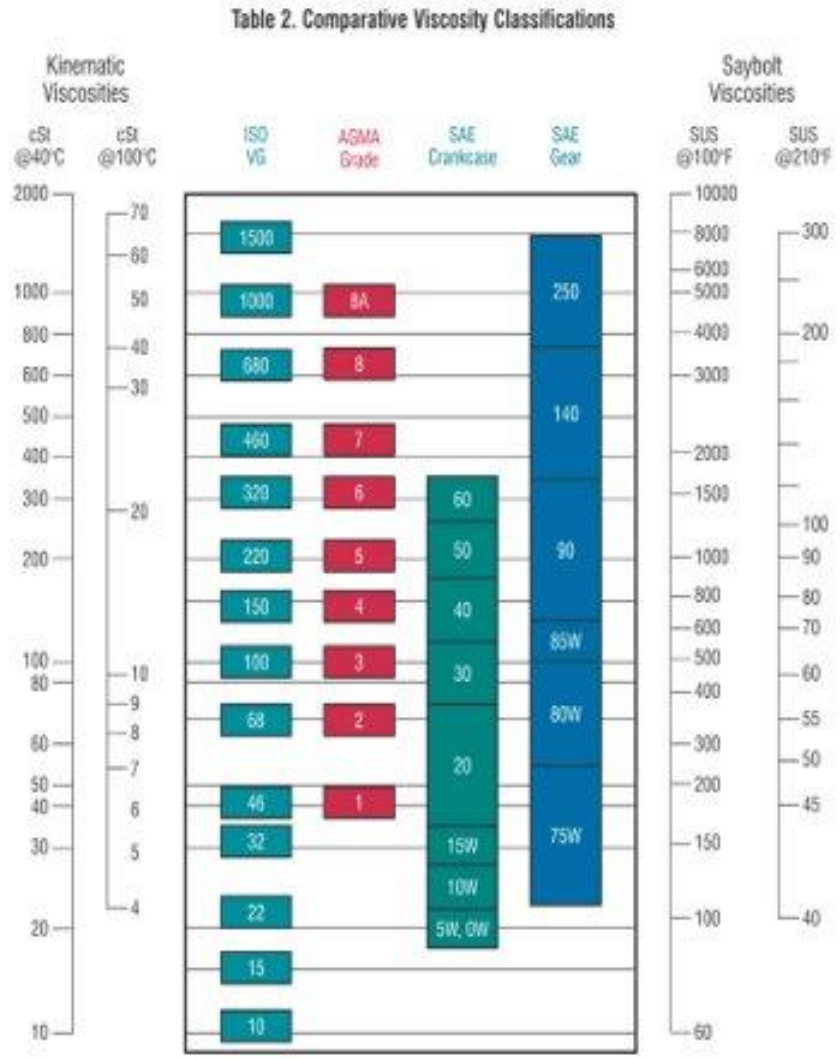
- ex: AGMA 6 Gear Oil

Agma (0-15):

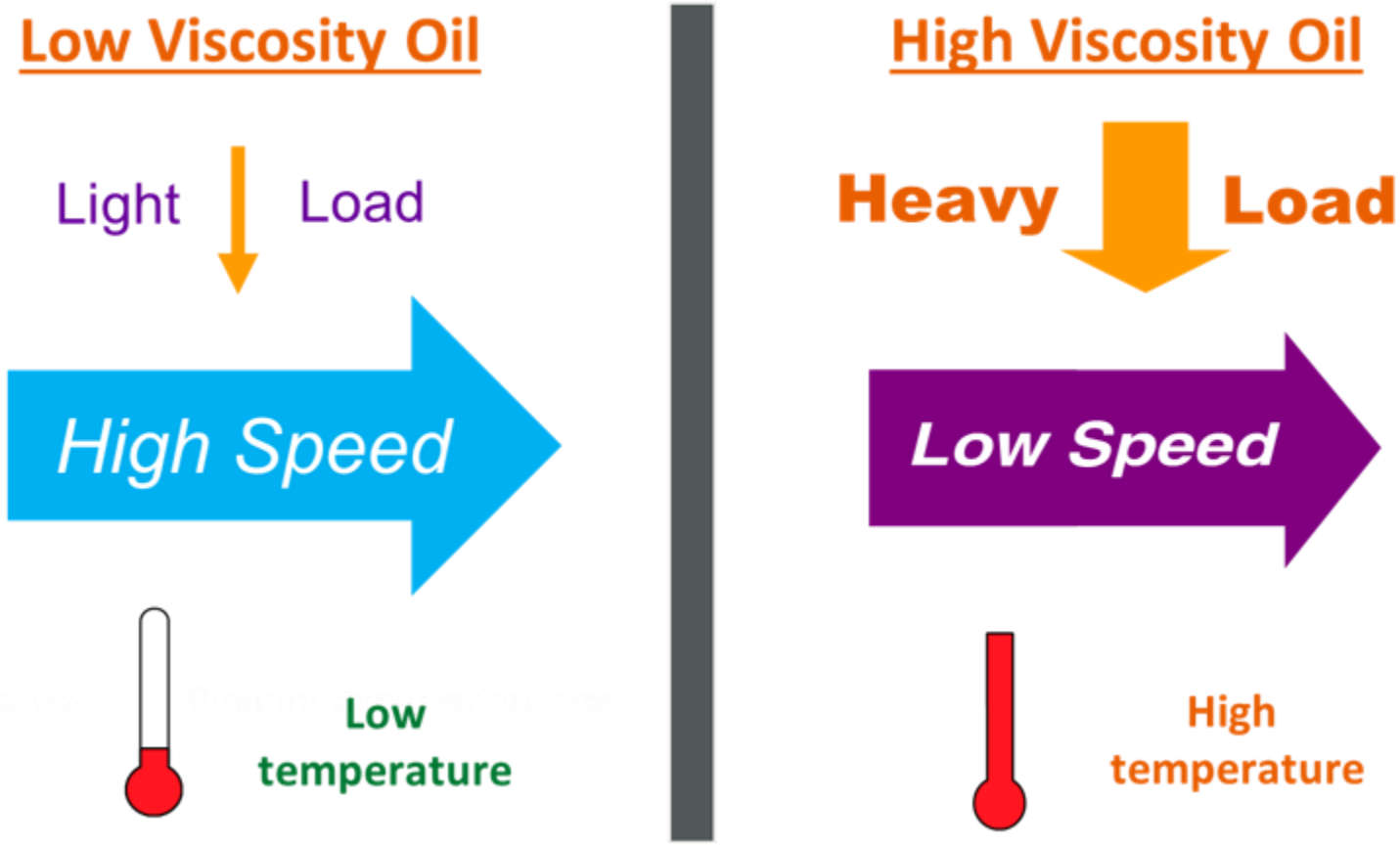
- Single grades/multifgrades
- ex: SAE 10W-30 Motor Oil

SUS or SSU:

- Ex: 500 SUS oil



Lubricant Characteristics: Viscosity



Lubricant Characteristics: VI

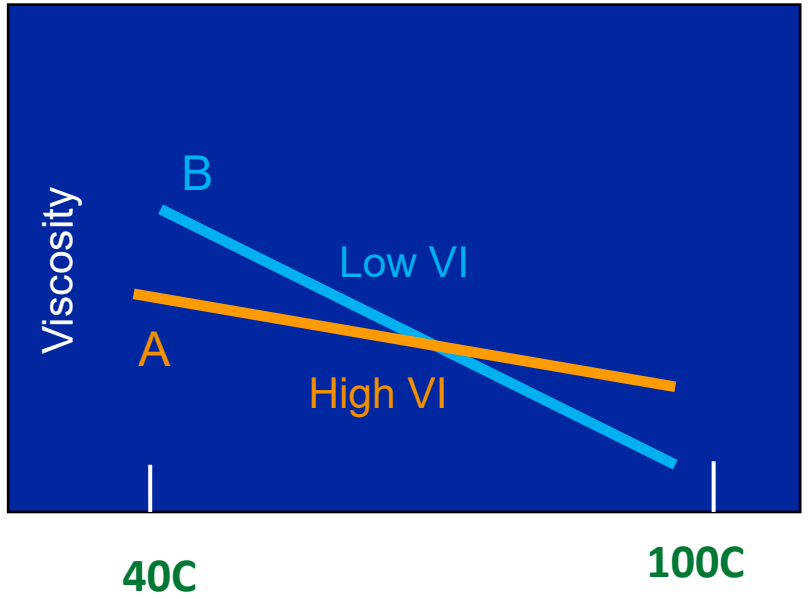
Viscosity Index (VI)

The relationship of a fluid lubricant's viscosity to temperature

A high Viscosity Index will all an oil to retain it's intended viscosity in the presence of increasing temperatures!

Why is this important?

It allows the oil to lubricate as intended rather than thin out and circulate out of the system.



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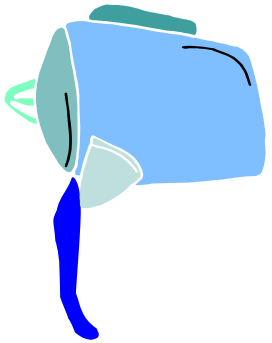
Lubricant Characteristics: Pour Point

The depressed temperature at which a fluid no longer flows

100 F

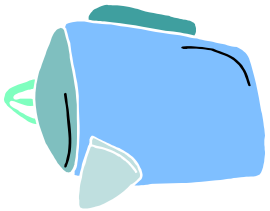


Fluid Flow

20 F

Slow Flow

-10 F



No Flow
(Pour Point)

Rule of Thumb The lowest useful temperature of a fluid lubricant is a minimum 15 F to 20 F above its pour point, at system startup.

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Lubricant Characteristics: Flash and Fire Points

Flash Point

The temperature at which a fluid lubricant will ignite but not continue to burn for more than five seconds.

Fire Point

The temperature at which a fluid lubricant ignites and continues to burn for more than five seconds.

Fluid Compatibility

✓ = Compatible

✗ = Incompatible (detailed flush needed)

	Mineral Oil	PAO	Water Glycol	Polyol/ Diester	Phos Ester	Veg Oil	Poly Glycol
Mineral Oil	-	✓	✗	✓	✓	✓	✗
PAO	✓	-	✗	✓	✗	✓	✗
Water Glycol	✗	✗	-	✗	✗	✗	✗
Polyol & Diester	✓	✓	✗	-	✓	✓	✗
Phosphate Ester	✓	✗	✗	✓	-	✓	✗
Vegetable Oils	✓	✓	✗	✓	✓	-	✗
Polyglycol (PAG)	✗	✗	✗	✗	✗	✗	-

These are only guidelines! Lab compatibility testing is recommended!

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Synthetic Lubricants

BENEFITS

- Greater oxidative stability (long life) in most cases
- Wider operating temp range
- Lower pour point
- Higher flash & fire points
- Reduced deposit formation
- Improved film strength
- Lower volatility

DRAWBACKS

- Higher purchase cost
- Potential incompatibility with seals
- Potential incompatibility with other products
- Potential misuse or product mixing
- Possible storage & handling problems
- Possible higher disposal cost of used lubricant

Greases

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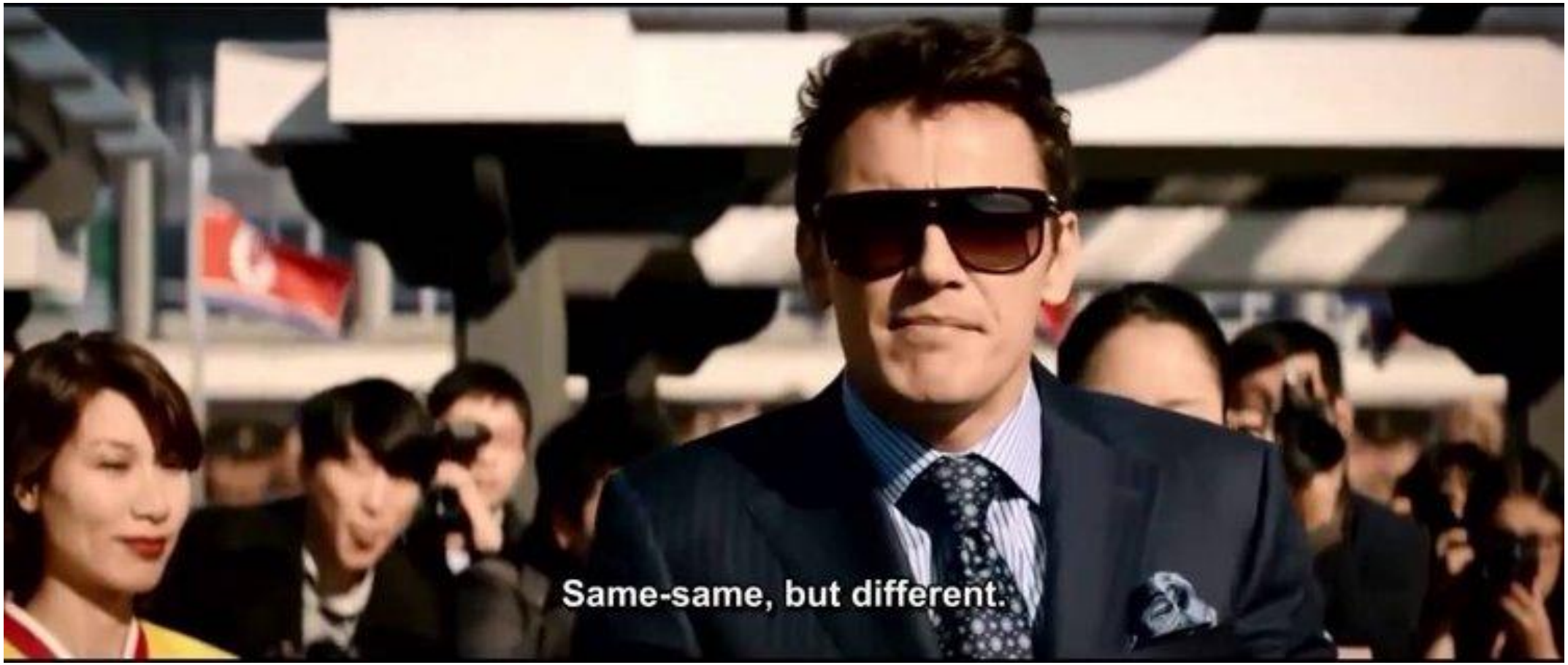
Lubricants Characteristics: Greases



Lubricants Characteristics: Greases

Everything applicable to oils also apply to greases, PLUS MORE!

Lubricant Characteristics
What is in a grease?

Base Oil

- Mineral
- Synthetic

Thickener

- Soap
- Non-soap

Additive

- EP
- AW
- R&O
- Solids

Lubricants Characteristics

Why Use Grease?

- To Seal out Contaminants
- To Reduce Lubricant Consumption & Waste
- An Oil will not work Effectively
- Simplifies Bearing Housing Design

Grease

Greases - Where?

- Where Oils Drip or Run Out
- High Loads Squeeze Oil Out
- Centrifugal Force Throws Oil Out
- Water Washes Oil Out
- In Hard to Reach Areas

Greases

Characteristics Unique to Greases:

- Thickener type
- Consistency - NLGI no.
- Dropping Point
- Water wash out
- “Worked” / Shear stability

Grease

What is a grease thickener?

+

Grease Thickeners

Metallic Soaps

- ✓ Lithium 12/Lithium Complex
- ✓ Calcium/Ca Complex (Sulfonate)
- ✓ Sodium
- ✓ Aluminum/Al Complex

Economical - Good Lubricity

Note: Complex version of a soap has 100-150 F higher useful temperature range.

Non-Soaps

- ✓ Polyurea - Long lasting
- ✓ Bentone (clay) (Microgel) - Do not melt
- ✓ Fumed Silica - Used in gear compounds
- ✓ Carbon Black - 400-1000F temp range

Generally, more costly than soaps but they have certain characteristics that make them beneficial

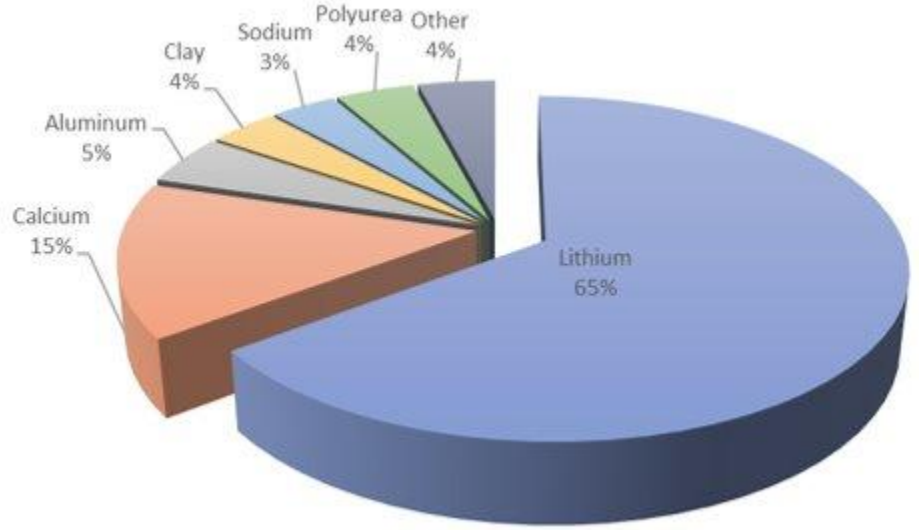
Grease Thickeners

Metallic Soaps (90% of all greases)

- Lithium and Lithium Complex greases being the most popular

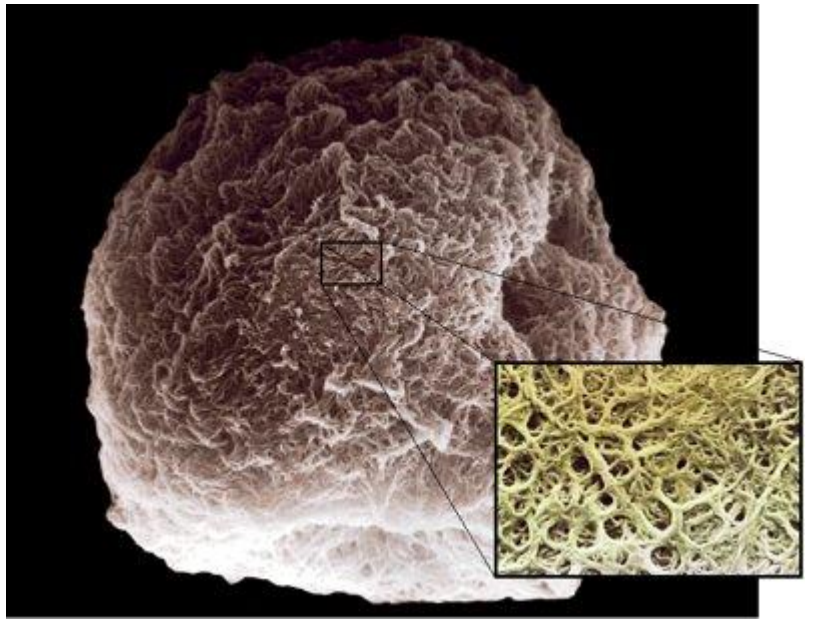
Non Soaps (10%)

- Niche applications



Grease

Characteristics of Thickeners



Q: When the base oil separates from the thickener, is the grease ok to use?

A: Yes, the grease is still acceptable to use but should be remixed before being applied.

Grease Compatibility

B/L=Borderline (Sample) C=Compatible I=Incompatible	Aluminum Complex	Barium	Calcium	Calcium 12 Hydroxy	Calcium Complex	Clay	Lithium	Lithium 12 Hydroxy	Lithium Complex	Polyurea
Aluminum Complex	X	I	I	C	I	I	I	I	C	I
Barium	I	X	I	C	I	I	I	I	I	I
Calcium	I	I	X	C	I	C	C	B/L	C	I
Calcium 12 Hydroxy	C	C	C	X	B/L	C	C	C	C	I
Calcium Complex	I	I	I	B/L	X	I	I	I	C	C
Clay	I	I	C	C	I	X	I	I	I	I
Lithium	I	I	C	C	I	I	X	C	C	I
Lithium 12 Hydroxy	I	I	B/L	C	I	I	C	X	C	I
Lithium Complex	C	I	I	C	C	I	C	C	X	I
Polyurea	I	I	I	I	C	I	I	I	I	X

Grease Compatibility

Special Considerations :

1. The chart is only a guideline; lab testing can be done to test actual compatibility

2. When incompatible, hardening or softening will occur or the high temp properties affected

3. Newer generation Polyureas are compatible with most other grease types

4. This chart only covers grease thickeners and not compatibility of the base oils and additives

Grease Compatibility

Important Rules to Follow:

1: Don’t mix incompatible lubricants.

2: When in doubt, assume that two lubricants, when mixed, will be incompatible and will exhibit adverse side effects.

Grease Consistency

NLGI – National Lubricating Grease Institute

Serves all key stakeholders in the grease industry

Image courtesy of JAX Inc

Q: Which grease is softer?

A: The one on the far right – Grade 00

Q: Which grease has higher penetration?

A: The one on the far right – Grade 00

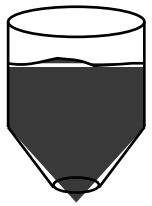
Penetration: Is the consistency or hardness of a grease.

Penetration is to a grease what viscosity is to an oil.

Grease Characteristics: Dropping Point

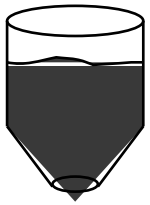
Dropping point is the temperature at which grease passes from semi-solid to a fluid state.

300 F



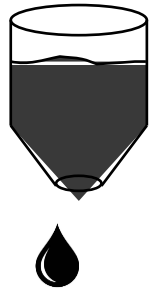
No Drip

400 F



No Drip

500 F



First Drop
(Dropping Pt)

Rule of Thumb: The highest useful temperature of a grease is **100 F to 125 F below** its dropping point

Grease - Shear Stability

Is the measure of a grease's ability to withstand repeated working (shearing) with minimum change in its structure and consistency.

Determined by working the grease repeatedly and checking its consistency.

Grease - Water Washout and Pumpability

Water Washout

Determines how well a grease will stay in place in a wet environment

Determined as a percentage of grease washed off

Includes 2 tests:

Water Wash -- Flow of water over surface

Water Spray-Off -- Direct spray onto surface

Grease Pumpability

Is the ability of a grease to be pumped through lubricating system especially centralized automatic system.

Q: What is the best water to use in a Water Washout test?

Grease – Water Contamination

Modes of Water Presence:

- Dissolved / Dispersed
- Suspended: Free or Emulsified
- Free Standing / Separated

Methods of Detection:

- Hotplate (crackle)
- Infrared (quantitative)
- Karl Fischer Titration (ppm)

Q: Which of these test methods is the most “elementary”/basic?

Methods of Detection:

- Hotplate (crackle)
- Infrared (quantitative)
- Karl Fischer Titration (ppm)