



# All About Grease

## 2014 Toronto STLE Education Course

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# Lesson plan

- What is a grease
- Characterization and performance
- Oil and additives
- Thickener types and their attributes
- Compatibility between products
- Finding a suitable grease
  - Formulation and application requirements
  - Selecting the base oil viscosity
  - Re-lubrication intervals
  - Steel Mill and Wheel bearing requirements
- Summary
  
- Appendix of additional information

*What is a grease?*



# Definition of Grease

- This is a lubricant which has been thickened so that it remains in contact with moving surfaces and will not leak out under gravity or centrifugal action or be squeezed out under pressure.
- It is generally shear and temperature resistant.
- Must be capable of being pumped by either grease gun or automatic lubricator.
- Must not add significantly, of itself, to the power required to operate the machine, particularly at the start.

# Grease

## Composition

**Thickener** (3 – 35%)

+

**Oil** (65 – 95%)

+

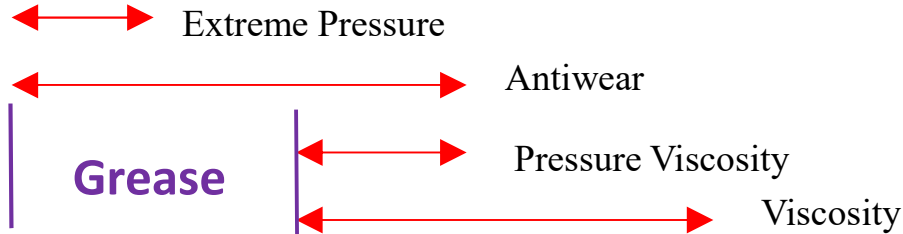
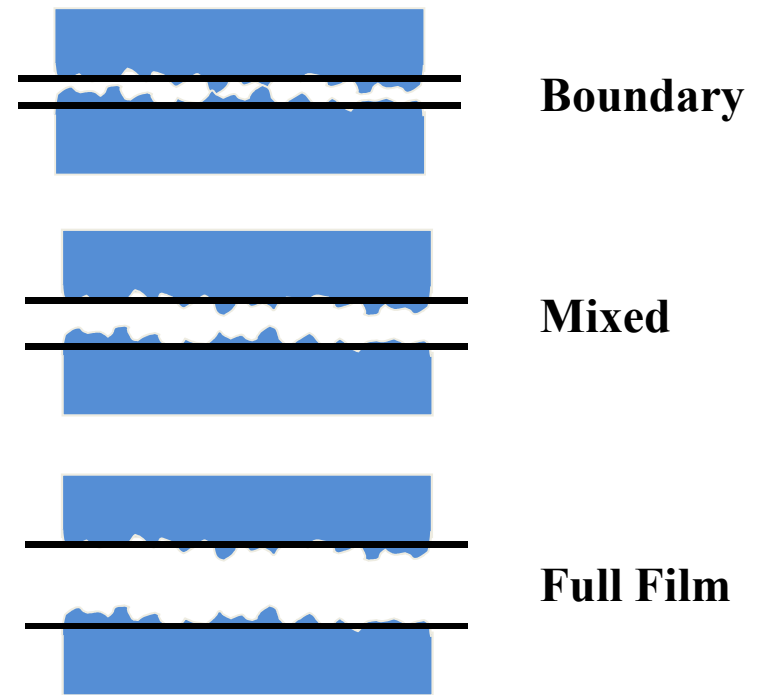
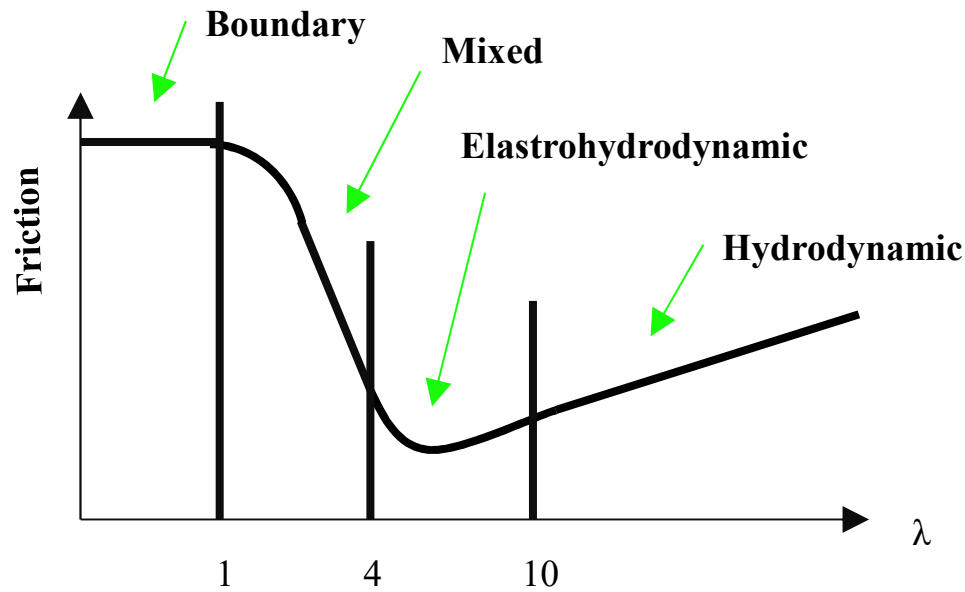
**Additives** (1 – 15%)

## Some Ways to Classify

- Thickener type
- Base Oil Type
- Base Oil Viscosity
- Consistency
- Load Carrying (EP/Non-EP)
- Application
  
- Colour



# The Stribeck Curve and Lubrication Regimes



# Grease versus Oil

## Advantages

- Seal out contaminants
- Decrease dripping
- Decrease misting
- Suspend solid additives
- Intermittent operation
- Extreme operating conditions
  - shock loading
  - high temperature
  - high pressure
  - water contamination

## Disadvantages

- Pumpability
- Replenishment
- Ability to clean lubricant in situ
- Ability to boost properties
- Frictional Drag
- Low temperature performance
- Oxidation of thickener
- Degradation of thickener
- Not recyclable

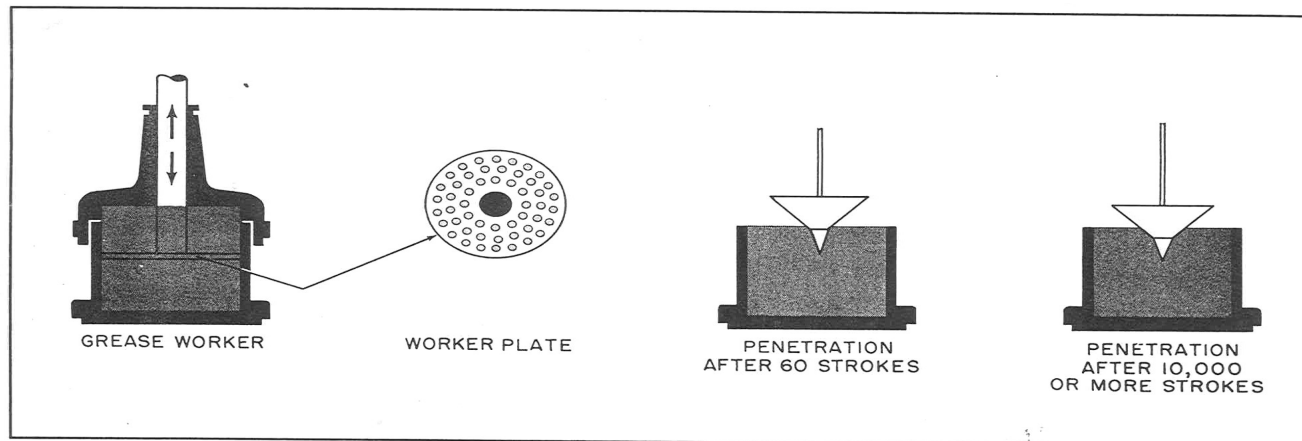
# *Characterization of Grease*





# ASTM D217

- 60 to 10,000 to 100,000 double strokes
- Change in consistency from 60 strokes indication of stability.
- Can add water to the test as well




## Worked Penetration Equipment

The container of the grease worker is the cup of the ASTM penetrometer. A counter automatically records the number of strokes that the worker has operated. An automatic shut-off device turns the machine off when the desired number of strokes has been completed. The drawings indicate that the sample is worked 60 double strokes and the penetration measured, then worked for 10,000 or more strokes and the penetration measured again. The standard worker plate shown has fifty-one  $\frac{1}{4}$ -in-diameter holes. Plates with a larger number of smaller holes may be used.

# NLGI Consistency Classification

## ASTM D217 Consistency

<u>Grade</u>	<u>Penetration (1/10 mm)</u>	
000	445 - 475	 Fluid
00	400 - 430	
0	355 - 385	
1	310 - 340	
2	265 - 295	
3	220 - 250	
4	175 - 205	(Peanut Butter)
5	130 - 160	
6	85 - 115	Solid Block

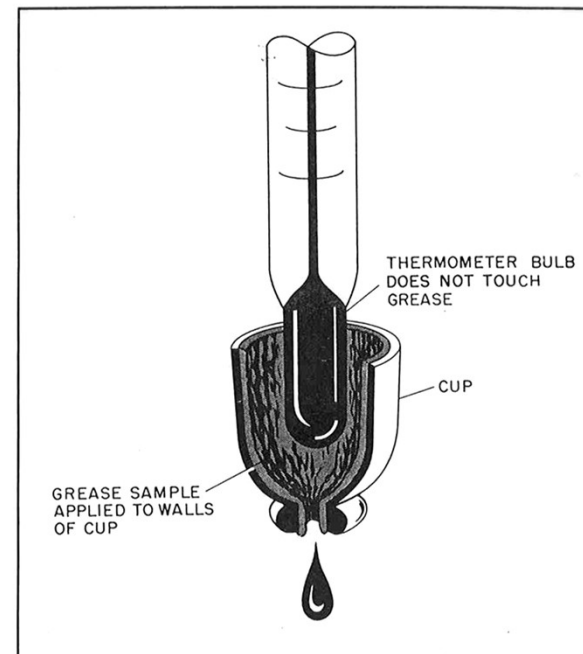
Most common →



# ASTM D2265

## Dropping Point

- Temperature at which the thickener matrix can no longer hold oil
- It is not the melting point
- Performed on small sample - thin smear.
- Higher the temperature the better - 605°F max. recordable temperature via ASTM method



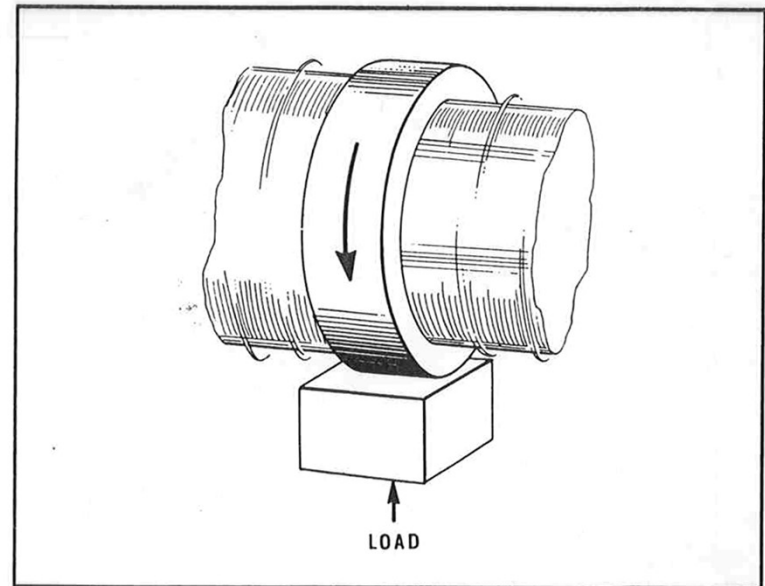
Dropping Point Test

An enlarged view of cup and thermometer applying to both ASTM D 566 and D 2265.

# ASTM D2509

## Timken Test

- This is a ring-on-block configuration with load supplied by a cantilever arm which pushes the block against the ring.
- Run at 800 rpm, 25 C, for 10 minutes at a given load.
- Successively higher loads run until scar on block becomes excessively scored.
- Poor reproducibility - +/- 60%.



Timken OK Load Test

# A multitude of possible tests

- **Wear / EP**
  - ASTM D2266 4-Ball Wear
  - ASTM D4170 Fretting Wear
  - ASTM D2596 4-Ball EP
- **Oxidation**
  - ASTM D5483 PDSC for Grease
  - ASTM D3527 Wheel Bearing Life
  - ASTM D3336 Bearing Life (High Speed)
  - FAG FE9 Test
  - Oven Panel Test
  - ASTM D942 Bomb Oxidation
- **Bleed / Leakage**
  - ASTM D6184 Oil Bleed (Cone Method)
  - ASTM D1742 Oil Bleed
  - ASTM D4290, D1263 Wheel Bearing Leakage
- **Mobility / Torque**
  - ASTM D1478, D4693 Low Temperature Torque
  - ASTM D1092 Apparent Viscosity
  - US Steel Mobility
  - Lincoln Ventmeter
- **Corrosion**
  - ASTM D4048 Cu Corrosion
  - ASTM D1743 Bearing Corrosion
  - ASTM D 6138 Emcor Corrosion
- **Mechanical Stability**
  - ASTM D1831 Roll Stability
  - ASTM D217 Consistency
- **Water Resistance**
  - ASTM D4049 Water Spray Resistance
  - ASTM D1264 Water Washout

Plus many, many others....

# *Oils and Additives used in Grease*



# Oils used in grease

- Types
  - Petroleum (Grp1 & 2)
    - paraffinic
    - naphthenic
  - Synthetics (Grp 3, 4, 5)
    - Esters – Nat/syn
    - PAO
    - PAG
    - Silicones
    - Fluorocarbon
    - Phosphate esters
    - Alkylated Naphthalene
- Important properties
  - viscosity
  - viscosity index
  - Polarity
  - Solvency / solubility
  - oxidation resistance
  - Thermal stability
  - Shear stability
  - Biodegradability
  - pour point
  - cost

# Additives used in Grease

- Antioxidants
- Anticorrosion Agents
- Rust Inhibitors
- Metal deactivators
- EP / Antiwear Agents
- VI improvers
- Polymers
  - water resistance
  - tackifier
- Pour point depressants (?)
- Dyes / Pigments



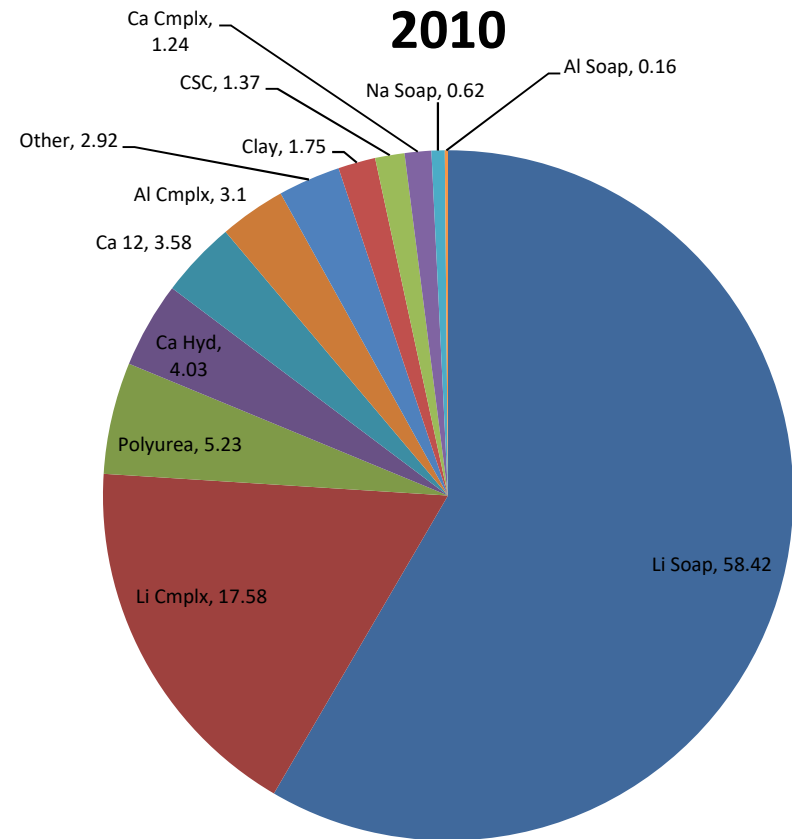
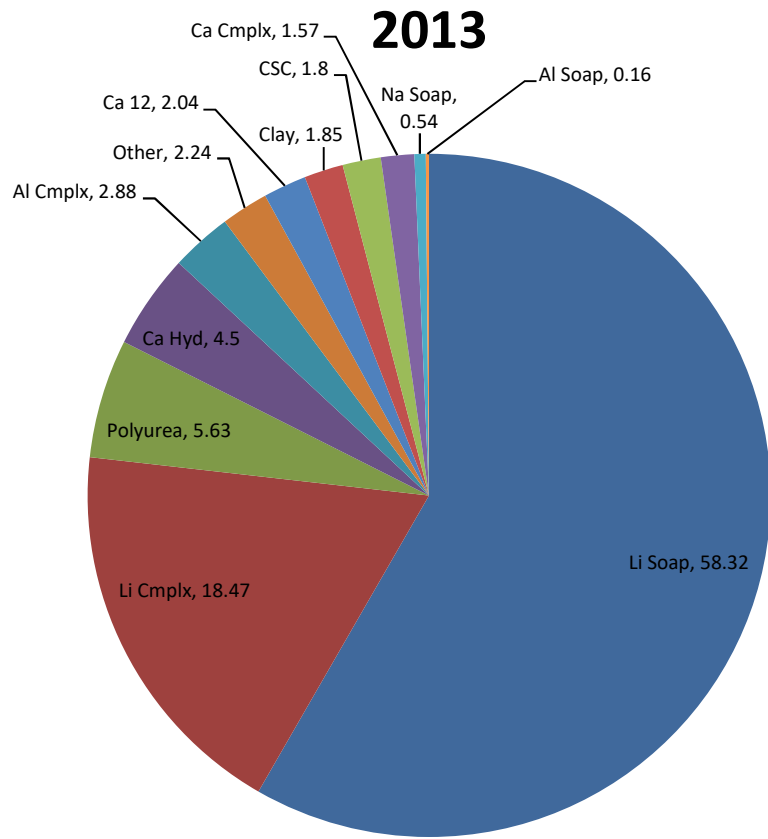
# *Thickener Types and Their Attributes*



# Thickener Types

- Simple Soap Grease
  - Aluminum
  - Barium
  - Calcium
    - Hydrated
    - Anhydrous
  - Lithium
  - Sodium
  - Mixed Soap
- Complex Grease
  - Aluminum Complex
  - Calcium Complex
  - Lithium Complex
  - Calcium Sulfonate Complex
- Non-Soap Grease
  - Organo - Clay
  - Polyurea

# Global Grease Production by Thickener Type



1,175,309 MT

<1% CAGR

1,147,172 MT



# Calcium Soap Grease

Property	Result
Thickener	$\text{Ca(OH)}_2 + (\text{un})/\text{saturated natural fatty acids (C}_{14} - \text{C}_{22})$
Appearance	Smooth and buttery
Maximum Usable Temperature	80°C
Dropping Point	90 – 105°C
Adhesion	Good
Water Resistance	Good to excellent
Mechanical Stability	Fair to Good
Corrosion Protection	Poor to Excellent
Oxidation Resistance	Poor to Excellent
EP / AW	Poor to excellent
Thickener Specific Properties	The original modern grease. Water is present in thickener, cannot exceed 80°C due to dehydration, thickener is biodegradable, very low cost grease
Applications	Chassis, water pumps, underwater, hydrant grease

# Calcium 12-Hydroxystearate Grease

Property	Result
Thickener	Ca(OH) <sub>2</sub> + 12-Hydroxystearic Acid or hydrogenated castor oil
Appearance	Smooth and Buttery
Maximum Usable Temperature	110°C
Dropping Point	135 – 143°C
Adhesion	Good
Water Resistance	Excellent
Mechanical Stability	Good to Excellent
Corrosion Protection	Poor to Excellent
Oxidation Resistance	Fair to Excellent
EP / AW	Poor to excellent
Thickener Specific Properties	Thickener is biodegradable
Applications	Food grade grease

# Sodium Soap Grease

Property	Result
Thickener	NaOH + (un)/saturated natural fatty acids ( $C_{14} - C_{22}$ )
Appearance	Smooth to Fibrous
Maximum Usable Temperature	120°C
Dropping Point	160 – 180°C
Adhesion	Excellent
Water Resistance	Poor
Mechanical Stability	Fair
Corrosion Protection	Good to Excellent
Oxidation Resistance	Poor to Good
EP / AW	Poor to excellent
Thickener Specific Properties	Water soluble, very cohesive
Applications	Gear grease, wheel bearings

# Lithium 12-Hydroxystearate Grease

Property	Result
Thickener	LiOH + 12-Hydroxystearic Acid or hydrogenated castor oil
Appearance	Smooth and Buttery
Maximum Usable Temperature	150°C
Dropping Point	177 – 204 °C
Adhesion	Good
Water Resistance	Good
Mechanical Stability	Good to Excellent
Corrosion Protection	Poor to Excellent
Oxidation Resistance	Fair to Excellent
EP / AW	Poor to excellent
Thickener Specific Properties	Highest simple soap thickener costs
Applications	Multipurpose, Market predominant grease type

# Calcium Complex Grease

Property	Result
Thickener	Ca(OH) <sub>2</sub> + inorganic acids or short chain mono-/dicarboxylic + (un)/saturated fatty acids
Appearance	Smooth and Buttery
Typical Upper Operating Temperature	177°C
Dropping Point	> 260°C
Adhesion	Very Good
Water Resistance	Fair to Excellent
Mechanical Stability	Poor to Good
Corrosion Protection	Fair to Excellent
Oxidation Resistance	Poor to Good
EP / AW	Excellent
Thickener Specific Properties	Thickener has EP properties, thickener noted for age hardening
Applications	Multi-purpose



# Lithium Complex Grease

Property	Result
Thickener	LiOH + inorganic acids or short chain mono-/dicarboxylic + (un)/saturated fatty acids
Appearance	Smooth and Buttery
Typical Upper Operating Temperature	177°C
Dropping Point	> 260°C
Adhesion	Good
Water Resistance	Good to Excellent
Mechanical Stability	Good to Excellent
Corrosion Protection	Fair to Excellent
Oxidation Resistance	Fair to Excellent
EP / AW	Poor to Excellent
Thickener Specific Properties	Excellent additive response
Applications	Multi-purpose, universal, elevated temperatures, loads, and speeds, automotive and industrial

# Calcium Sulfonate Complex Grease

Property	Result
Thickener	OB Ca Sulfonate + Ca Salts of Detergent Sulfonate + Fatty acids + Ca Salts of inorganic acids (Boric or Phosphoric)
Appearance	Smooth
Typical Upper Operating Temperature	177°C
Dropping Point	> 300°C
Adhesion	Excellent
Water Resistance	Good to Excellent
Mechanical Stability	Excellent
Corrosion Protection	Excellent
Oxidation Resistance	Good to Excellent
EP / AW	Excellent
Thickener Specific Properties	Thickener has inherent EP, AW, Corrosion Resistant properties
Applications	Multi-purpose, elevated temperatures, loads, heat, water, automotive and industrial. Food Grade versions available

# Aluminum Complex Grease

Property	Result
Thickener	Cyclic aluminum isopropylate + stearic acid + benzol acid
Appearance	Smooth and Buttery
Typical Upper Operating Temperature	177°C
Dropping Point	> 260°C
Adhesion	Good
Water Resistance	Good to Excellent
Mechanical Stability	Very Good
Corrosion Protection	Good
Oxidation Resistance	Fair to Excellent
EP / AW	Poor to Excellent
Thickener Specific Properties	Thickener has water resistance properties, thickener oxidizes easily
Applications	Multi-purpose, universal, elevated temperatures, loads, and speeds

# Organo-Clay (Bentone)

Property	Result
Thickener	Dispersion of the thickener into the oil and additive mixture. Clay itself is typically treated for stability.
Appearance	Smooth and Buttery
Typical Upper Operating Temperature	177°C
Dropping Point	> 260°C
Adhesion	Fair
Water Resistance	Fair to excellent
Mechanical Stability	Fair to good
Corrosion Protection	Poor to excellent
Oxidation Resistance	Good
EP / AW	Poor to good
Thickener Specific Properties	Structure is sensitive to polar oils and additives
Applications	High temperatures with frequent re-lube, low speeds.

# Polyurea

Property	Result
Thickener	Reaction of methylenediphenyl diisocyanate (MDI) or Toluene diisocyanate (TDI) with diamines and/or fatty amines.
Appearance	Smooth and buttery
Typical Upper Operating Temperature	177°C
Dropping Point	> 260°C
Adhesion	Fair
Water Resistance	Good to Excellent
Mechanical Stability	Poor to Good
Corrosion Protection	Fair to Excellent
Oxidation Resistance	Excellent
EP / AW	Poor to Good
Thickener Specific Properties	Thickener has no metal, inherent antioxidant
Applications	Long life bearings, low noise

# *Compatibility between Thickeners*



# Compatibility between different thickeners

- If incompatible they generally get softer
- Depends on several factors
  - Relative concentrations
  - Temperature
  - Severity of mixing
  - Duration of Mixing
- Incompatibility may also involve base oil and additives used



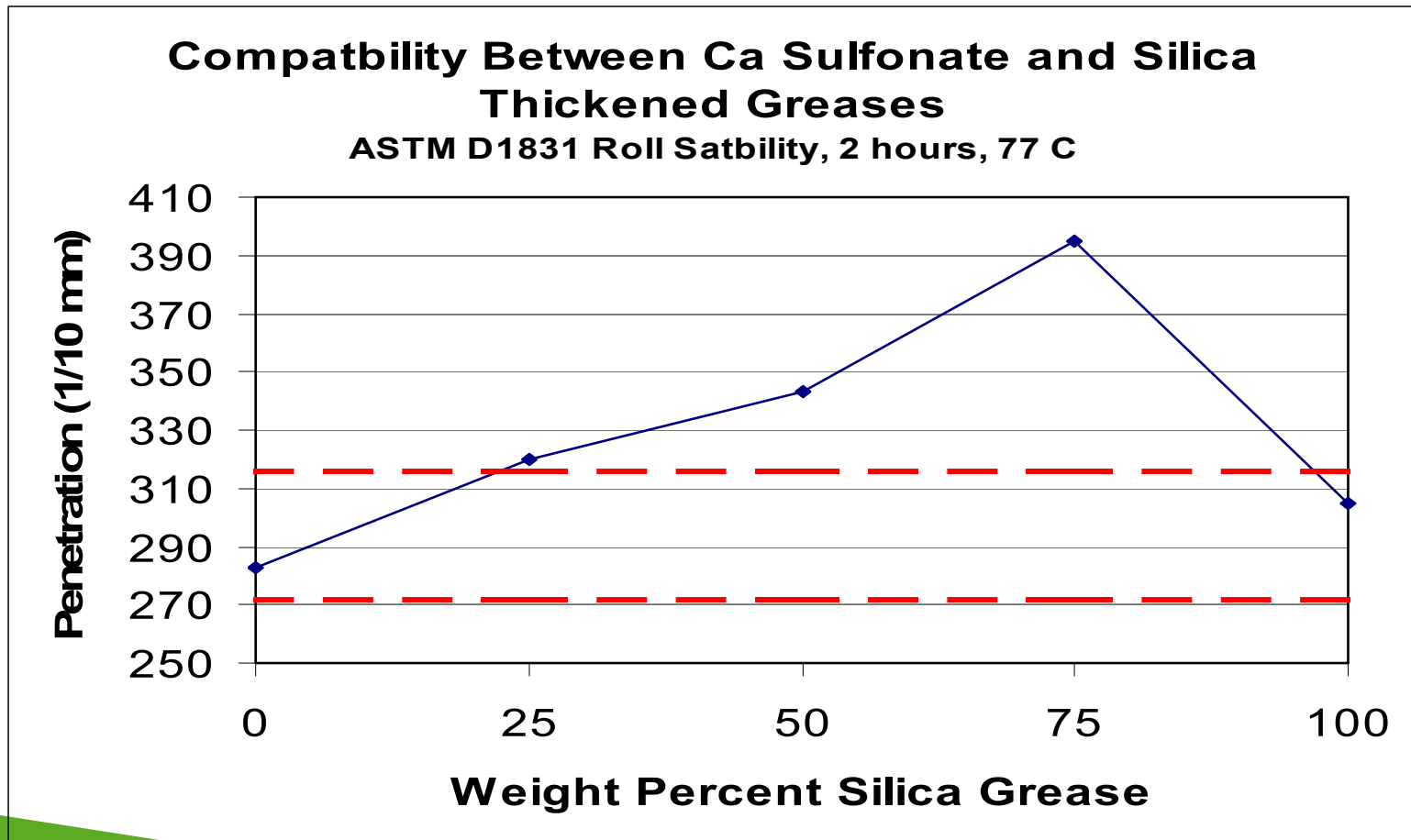
# ASTM D6185 Compatibility in Binary Grease Mixtures

- Can use any critical test, but usually mechanical stability and/or dropping point
- Start with 50-50, if compatible in mechanical stability, move onto 90:10 and 10:90
- Look at property for each grease individually, then compare to property of mixture





# Compatibility Between Ca Sulfonate and Silica Greases



# Grease Compatibility

	Thickener	1	2	3	4	5	6	7	8	9	10	11
1	Ca Sulfonate Complex		NC	NC	FC	FC	NC	FC	FC	NC	NC	NC
2	Aluminum Complex	NC		NC	FC	NC	NC	NC	NC	NC	FC	NC
3	Barium	NC	NC		FC	NC	NC	NC	NC	NC	FC	NC
4	Anhydrous Calcium	FC	FC	FC		SC	FC	FC	FC	NC	?	NC
5	Calcium Complex	FC	NC	NC	SC		NC	NC	FC	FC	NC	NC
6	Clay	NC	NC	NC	FC	NC		NC	NC	NC	FC	NC
7	Lithium	FC	NC	NC	FC	NC	NC		FC	NC	?	SC
8	Lithium Complex	FC	NC	NC	FC	FC	NC	FC		NC	FC	SC
9	Polyurea	NC	NC	NC	NC	FC	NC	NC	NC		?	NC
10	Silica Gel	NC	FC	FC	?	NC	FC	?	FC	?		FC
11	Sodium	NC	NC	NC	NC	NC	NC	SC	SC	NC	FC	

LEGEND

FC Fully compatible

SC Somewhat compatible - mixtures soften, but, remains grease like

NC Not compatible - mixtures soften severely and do not remain grease like

# How to deal with incompatibility

- Attempt to maximize % of new grease
  - change over when new equipment is installed
  - pump fresh grease into system until little old grease is observed to be coming out
- Monitor the application closely
  - incompatibility is generally observed as a softening
  - this causes more of the grease to come out
  - pump in fresh grease



*Formulation and Application  
Requirements Based on  
Service*



# Grease Selection

Criteria for Grease Selection	Needed Grease Properties
High Speeds	Light viscosity, Grade 2 to 3, low thickener content
High Temperatures	Thickener with good oxidation properties High dropping point Oxidation inhibitors Thickener with low/no metal Synthetic fluids High viscosity oils
Low noise	Filtered Grease Grease with low thickener Grease with no metal Higher base oil viscosity
Low friction	Softer grease, synthetic base oils, low viscosity, friction modifiers
Low surrounding pressure	Base oil with low evaporation losses, inorganic thickeners

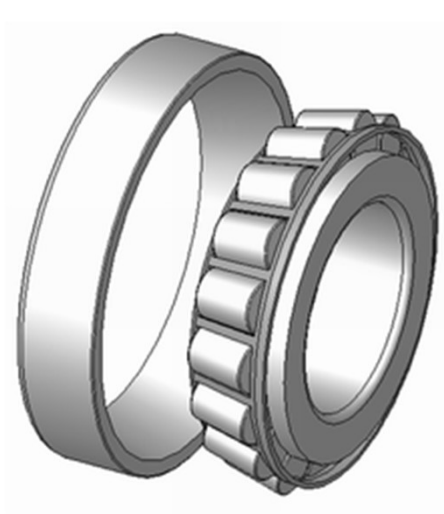
# Grease Selection

Criteria for Grease Selection	Needed Grease Properties
Low temperatures	Low thickener content Softer consistency (1 or softer) Low viscosity oil Synthetic base oil
Dirty surroundings	Stiff grease – grade 2 to 3
Exposure to water	Corrosion resistance, water wash resistance, hydrophobic oil, use of polymers, stiffer consistency
Radiation	Radiation resistance of thickener, radiation resistance of base oils and additives
Sealed for life	Excellent mechanical stability, excellent oxidation resistance, inherent oxidation resistance, low noise depending on application

# Grease Selection

Criteria for Grease Selection	Needed Grease Properties
Long pumping distances	Reduced thickener content, lower viscosity base oils, thickeners with good pumpability, softer consistency, heat tracing, good slumpability
High loads	Thickener with EP properties, use of EP agents, high viscosity base oil, solid additives
Multipurpose	High temperature thickener, mid-viscosity oil, good oxidation resistance, good corrosion resistance, good water resistance, EP, AW
Aggressive environments	Anticorrosion agent, corrosion resistant grease, PAO, PFPE.
Aerospace	Excellent low temperature performance (-73C and lower), excellent volatility
Environmentally friendly	Biodegradable fluids, biobased fluids, no mineral oil, preformed thickeners (low reactivity with esters), proper additive selection

# *Additional Selection Criteria for Bearings*



Tapered Roller Bearing



Ball Bearing



Needle Bearing



Plain Bearing, Pin  
Bushing, Sleeve Bearing



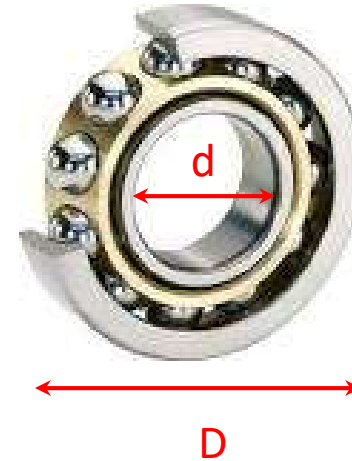
# Viscosity of the base oil

- Use the same calculation as for oil lubrication
  - calculation based on the pitch diameter, speed of the bearing, and temperature of operation

$$\text{Pitch diameter (mm)} = (d+D)/2$$

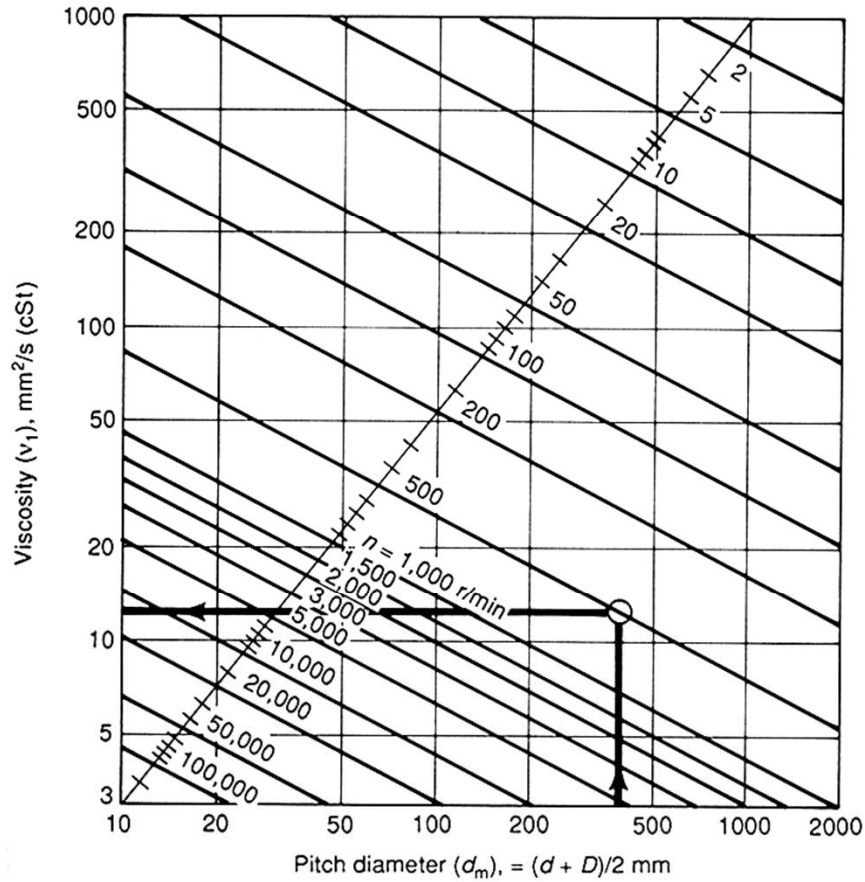
where  $d$  = bore diameter (mm)

$D$  = outside diameter (mm)



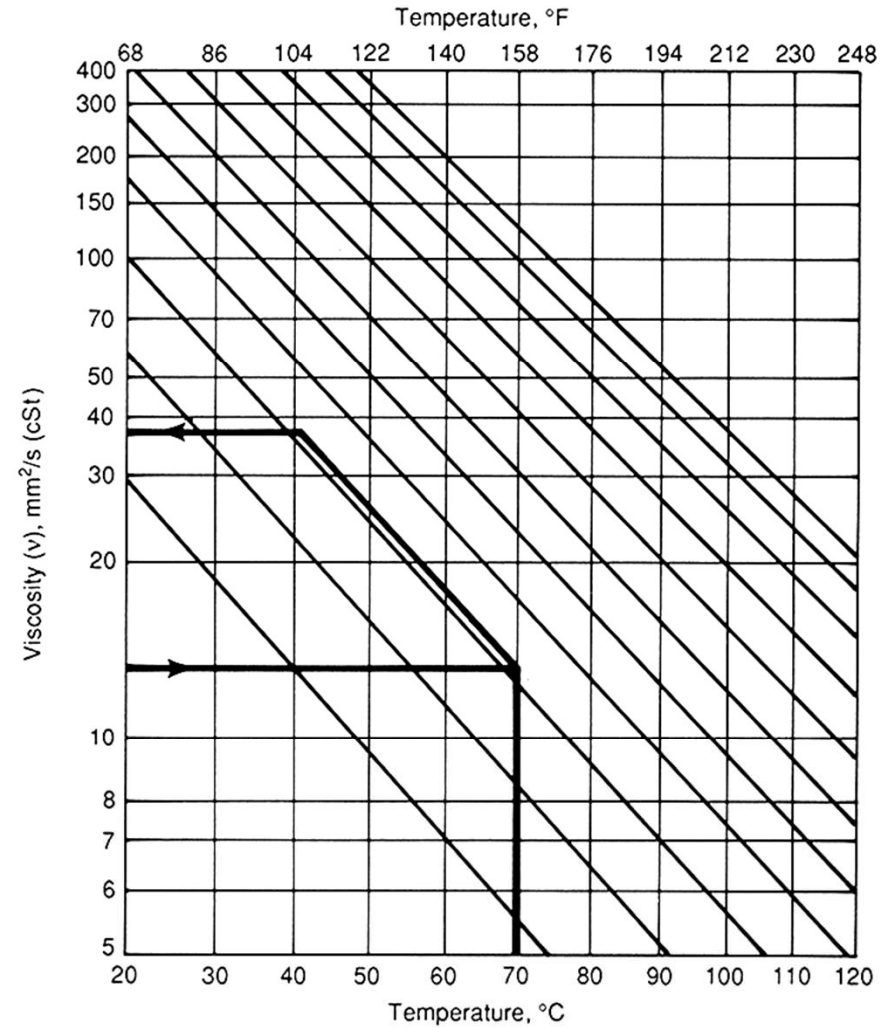
- See Figures A and B
- **Figure A** is used to calculate the minimum required viscosity
- **Figure B** is used to calculate the 40°C viscosity if the bearing is operating at a temperature other than 40°C
  - it is based on a VI of 85

# Viscosity of the base oil



Calculation of minimum required viscosity

**Figure A**



Viscosity-temperature relation for mineral oil base lubricants with a VI of 85

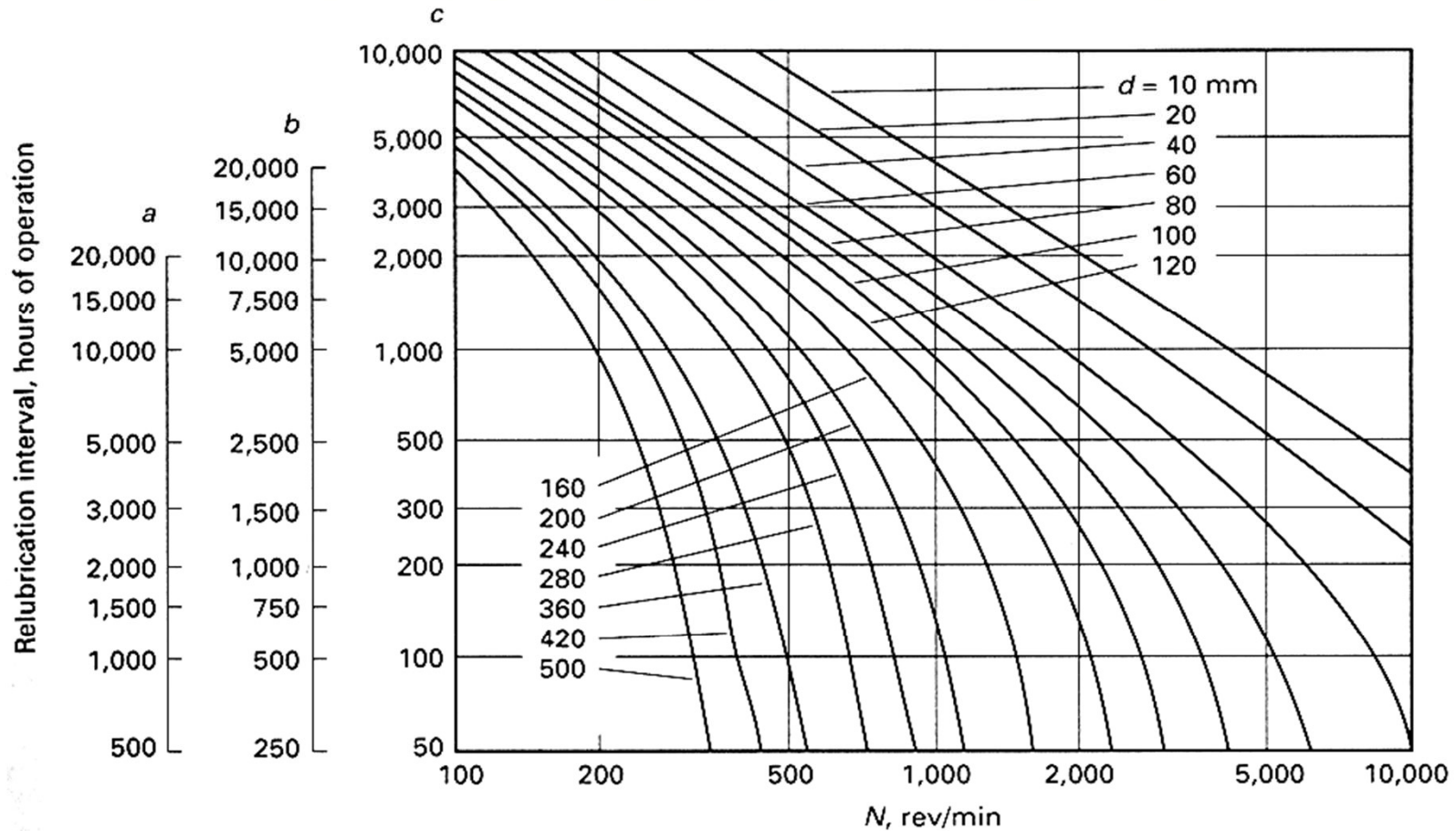
**Figure B**

# Re-lubrication Interval

- Depends upon bearing type, size, speed, operating temperature, and grease used
- **Figure C** valid for stationary bearings where loading is normal
- acceptable for temperatures up to 70°C
  - interval should be halved for every 15°C increase over 70°C
  - where contamination is a risk reduce the interval
  - where contact with water occurs, reduce the interval



# Re-lubrication Interval



Grease relubrication intervals. *a*, radial ball bearings; *b*, cylindrical or needle roller bearings; *c*, spherical or taper roller bearings and thrust ball bearings; *d*, bearing bore diameter. Courtesy of SKF-USA, Inc.

Figure

C

# Over greasing / Under greasing

- Over greasing is the most typical cause for bearing failure
  - runs at higher temperatures due to churning
    - bearing should be 1/4 to 1/3 full
    - consult bearing manufacturer for the amount of grease to lubricate a specific bearing
- Under greasing is rarely a problem
  - insufficient lubricant film leads to overheating



# *Recommendations for a Steel Mill Grease*



**GENERAL CHARACTERISTICS**  
 Pumpable  
 Water Resistant  
 Extreme Pressure  
 High Temperature

**ROLLING MILL**  
 Typical application of extreme pressure grease in steel mill operation

**CENTRALIZED GREASE SYSTEM PUMP STATION**

**TYPICAL APPLICATIONS**

**PLAIN BEARINGS**  
 JOURNAL TYPE      THRUST TYPE

**ANTIFRICTION BEARINGS**

**1.**

**2.**

E. P. GREASE CONTAINS ADJUSTERS WHICH REDUCE CALCIUM AND ZINC IN HEAVILY LOADED BEARINGS. THIS GREASE IS SUITABLE FOR USE AT HIGH TEMPERATURES OF 200° F. BUT NOT EXCEEDING 250° F.

## Extra Duty EP Grease

REQUIREMENT NUMBER 352

### LUBRICANT PERFORMANCE REQUIREMENT

#### General Requirements

#### Compounding

Base Oil Viscosity D-88

Penetration D-217

Dropping Point D-566 or D-2265

Motormatic 10,000 Strokes—D-217A

Roll Stability Test—2 Hours—D-1831

Wheel Bearing Test—D-1263  
 6 Hours @ 235 F

Water Washout Test D-1264  
 @ 100 F  
 @ 175 F

Timken EP Test—D-2509

Four Ball EP Test D-2596

Four Ball Wear D-2266  
 (20 kg, 1800 rpm, 130 F, one hour)

Grease Mobility

Field Test

High temperature, water resistant, and extreme pressure. Centralized pressure systems.

Suitable for producing extreme pressure characteristics required for heavy duty ball, roller, and plain bearing lubrication described under the application.

Not less than 75 SUS and up to 150 SUS at 210 F preferred where pumpability is not critical.

NLGI grade 0, 1, or 2 as specified.

Not less than 300 F.

Not more than 10 percent change.

Not more than 25 percent change.

Not more than 10 Percent loss.

Not more than 5 percent loss.  
 Not more than 15 percent loss.

Not less than 40 lb.

Load Wear Index—Not less than 30.0.  
 Weld Point—Not less than 200 kg.

Not more than 0.60 mm scar.

Not less than 0.01 gram or 0.1 if pumpability is critical.

Satisfactory for the application intended.

#### Application:

Extra duty EP grease is used for higher operating temperatures of 200 F and not to exceed 250 F on backup-roll, work-roll, and table bearings. These conditions are found on both ball, roller, and plain bearings, and general purpose lubrication in the presence of large quantities of water. This application also requires dispensing through centralized lubricating systems under a wide range of temperatures.

These performance requirements are benchmarks and not a specification. Therefore, meeting these limits that are used for descriptive purposes, does not relieve the supplier of the responsibility associated with brand name products.

# Steel Mill Grease

- Typical Products
  - Al Complex
  - Li Complex
  - Calcium Sulfonate Complex
  - Polyurea
  
  - Mineral Oil Based
  - Typically 220 to 460 cSt @40 C

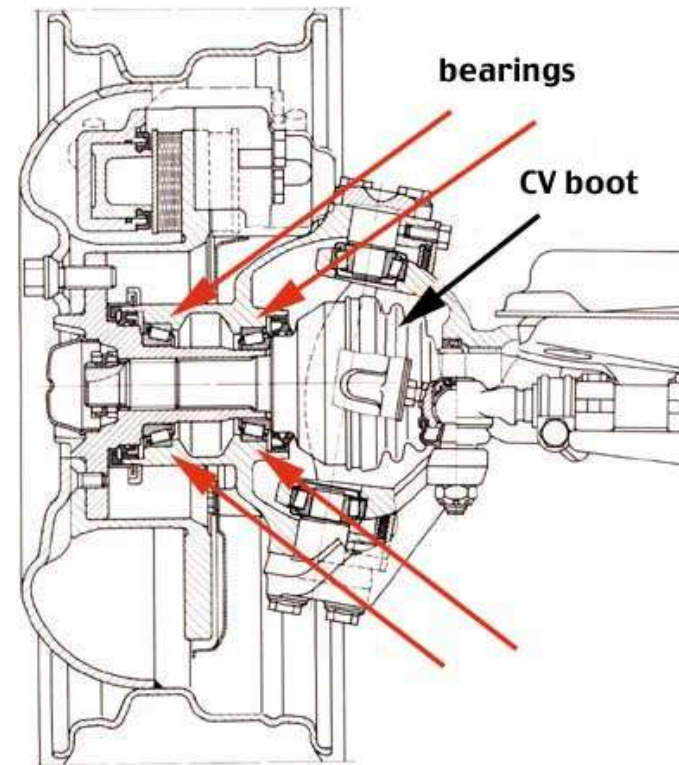
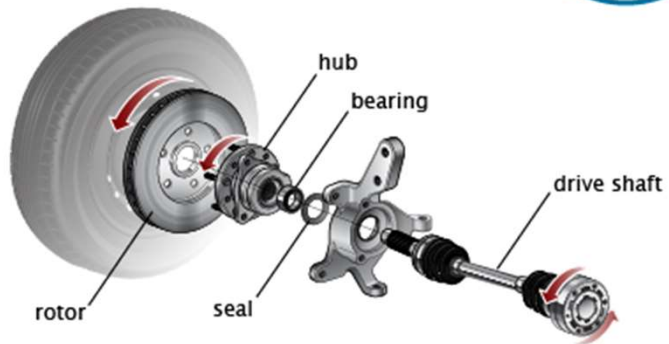
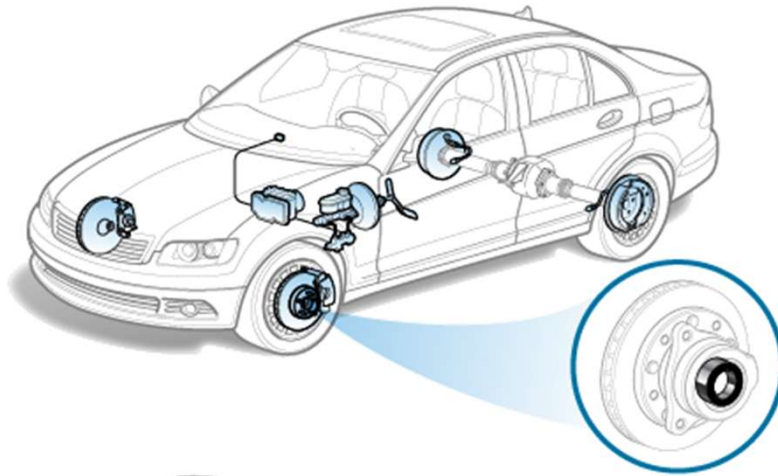




# *Requirements for Automotive Wheel Bearings*



# Automotive Wheel Bearings



# Key properties

- NLGI GC/LB is the industry standard
  - ASTM D4950
  - GC – Wheel Bearing, higher standard than GA or GB
  - LB – Chassis lubrication, higher standard than LA



- SAEJ310 is similar, and has not been updated in several years
- Other internal manufacturer specs may be present



# Wheel Bearing Grease

- Typical Products
  - Li 12HSA
  - Li Complex
  - Ca Sulfonate Complex
  - Na Soap
  
  - Mineral Oil
  - Synthetic Oil
  - 50 – 220 cSt @ 40C

# Summary

- What is a grease
- Characterization and performance
- Oil and additives
- Thickener types and their attributes
- Compatibility between products
- Finding a suitable grease
  - Formulation and application requirements
  - Selecting the base oil viscosity
  - Re-lubrication intervals
  - Steel Mill and Wheel bearing requirements
- Summary

Thank You

Questions ?



# *Appendix*





# Aluminum Soap Grease

Property	Result
Thickener	$\text{Al(OH)}_3$ + (un)saturated natural fatty acids ( $\text{C}_{14} - \text{C}_{22}$ )
Appearance	Smooth and Clear
Maximum Usable Temperature	80°C
Dropping Point	110°C
Adhesion	Very Good
Water Resistance	Good to Excellent
Mechanical Stability	Poor
Corrosion Protection	Good to Excellent
Oxidation Resistance	Excellent
EP / AW	Poor to excellent
Thickener Specific Properties	
Applications	Thread lubricants

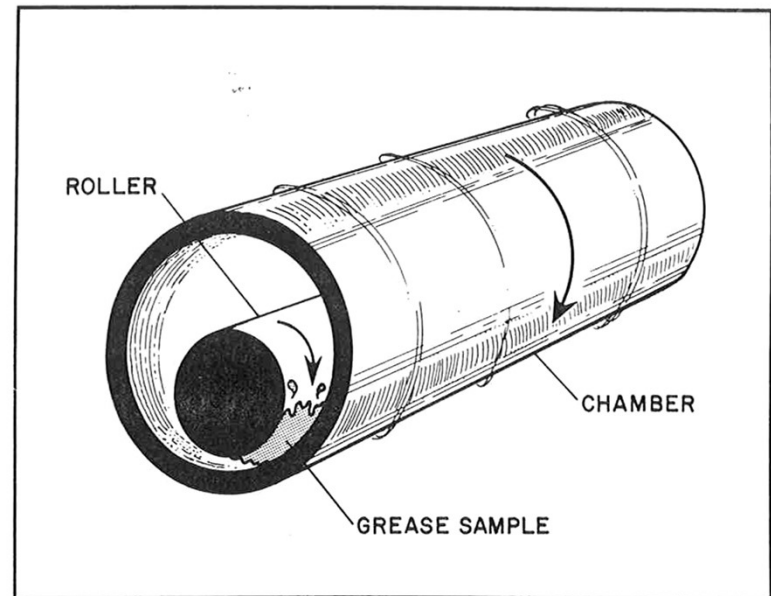
# Lithium Soap Grease

Property	Result
Thickener	LiOH + (un)saturated natural fatty acids (C <sub>14</sub> – C <sub>22</sub> )
Maximum Usable Temperature	120°C
Dropping Point	180 – 200 °C
Adhesion	Good
Water Resistance	Good
Mechanical Stability	Good
Corrosion Protection	Good
Thickener Specific Properties	
Applications	Very rarely used, Li12HSA grease preferred

# ASTM D1831

## Roll Stability

- Heavy solid steel cylinder inside a sealed hollow cylinder containing grease - simulates one roller of a large roller bearing.
- Rolling action works the grease - look for change in consistency.
- Can include heat and/or water.



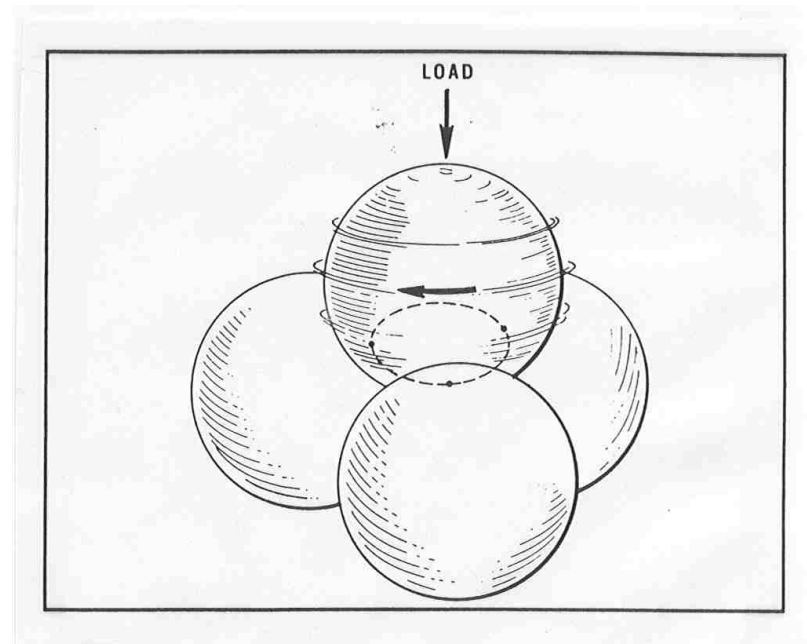
### Roll Stability Test

The heavy cylindrical roller rolls freely inside the tubular chamber which is driven by a motor and gear train. The machine can run two rollers simultaneously.

# ASTM D2266

## Four Ball Wear

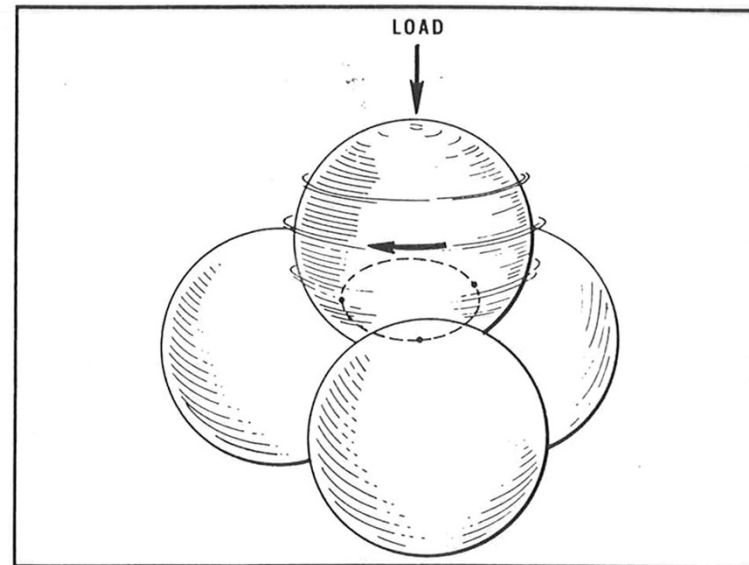
- One ball is rotated under load against three stationary balls. These are held tight in a metal cup filled with the test grease.
- Run at 40 kg, 1200 rpm, 75 C for 60 minutes.
- The diameters of the circular scars formed on the 3 lower balls are measured in mm and averaged.
- The smaller the diameter the better protection afforded.



# ASTM D2596

## Four Ball EP Test

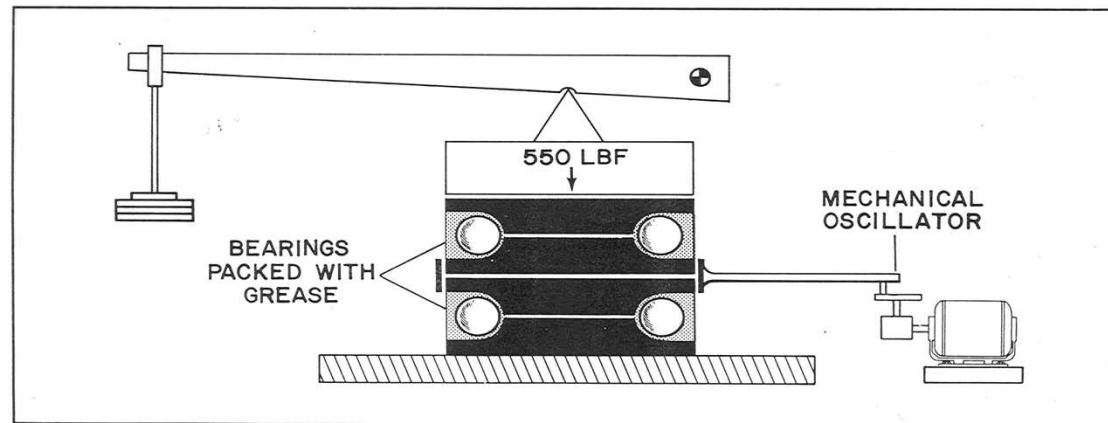
- Same configuration as above.
- Run at 1770 rpm, 25 C, 10 seconds, successive loads from 80 kg to 800 kg. or until welding occurs.
- Weld point is reported.
- Load Wear Index is a measure of the greases ability to resist welding. The higher the number the better.



# ASTM D4170

## Fretting Wear

- Ball bearings packed with grease are subjected to oscillatory motion.
- Increase in loss of bearing weight indicative of poor performance.

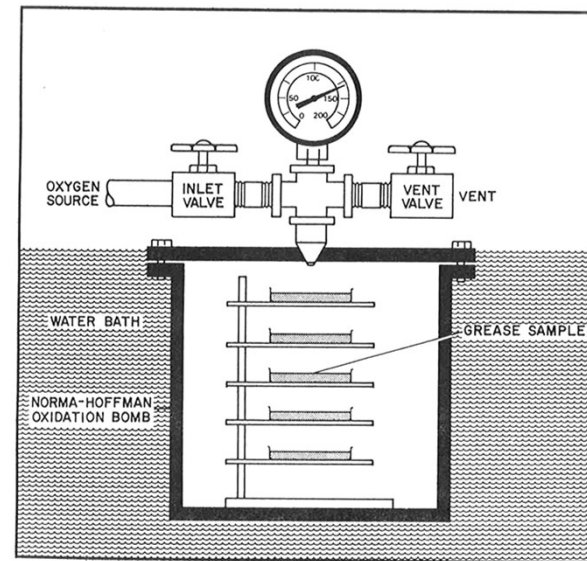


Fafnir Friction Oxidation Tester

# ASTM D942

## Oxidation Stability

- 25 g of grease spread evenly in 5 small petri dishes.
- Placed inside a sealed bomb and pressurized to 760 kPa with pure oxygen.
- Held at 99 C for various times - 100, 500, 1000 hours.
- Drop in pressure indicates oxidation.
- Static test.



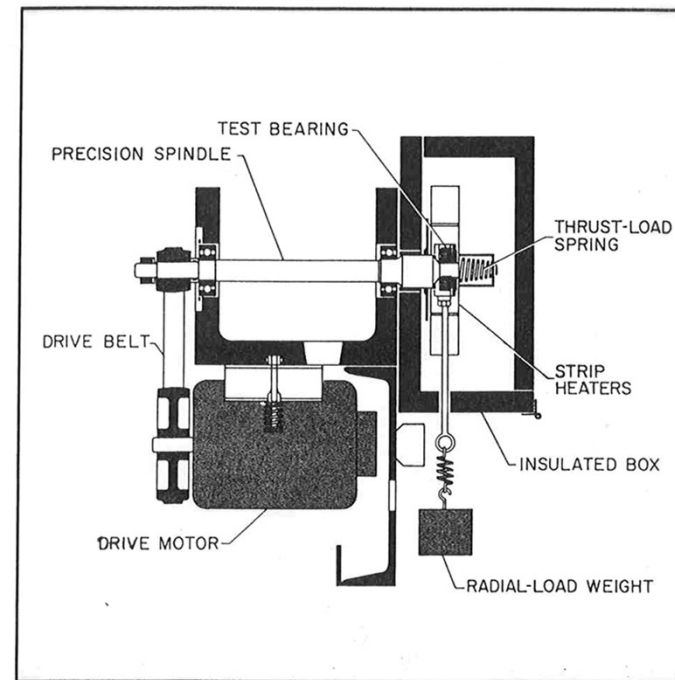
**Oxidation Stability by Oxygen Bomb Test**

The glass dishes are placed on the shelves of the rack and the whole assembly is placed in the bomb casing. The cover is bolted in place and oxygen is admitted through the valve below the gauge.

# ASTM D3336

## Bearing Life Test

- Run on ball bearings at 10,000 rpm, 177 C and 22 N thrust load.
- Cyclic pattern - 20 hours on, 4 hours off.
- Torque increase, temp increase or seizure stop the test.
- Requires several tests for determination - Weibull statistics.  
100 - 2000 hours to failure.



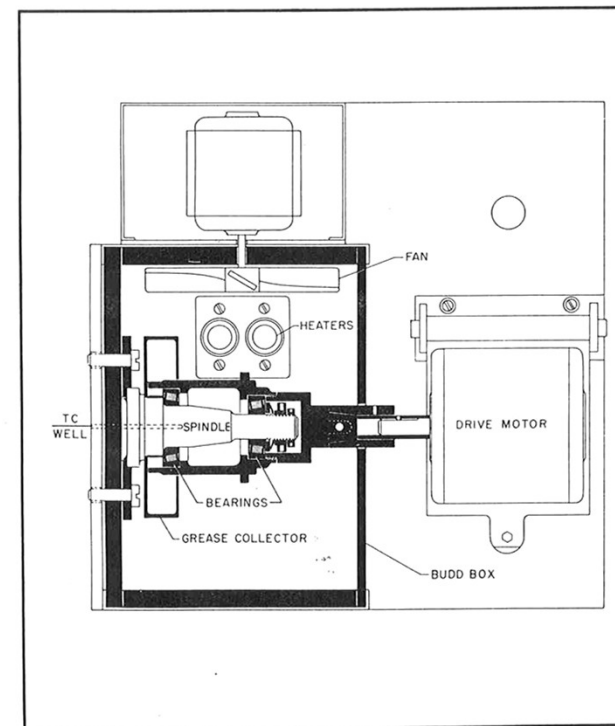
High-Temperature Bearing Test Rig



# ASTM D3527

## Wheel Bearing Life

- Run on tapered roller bearings at 1,000 rpm, 160 C, 111 N thrust load.
- Cyclic pattern - 20 hours on, 4 off.
- Run until torque exceeds preset level.
- 60 - 300 hours to failure.

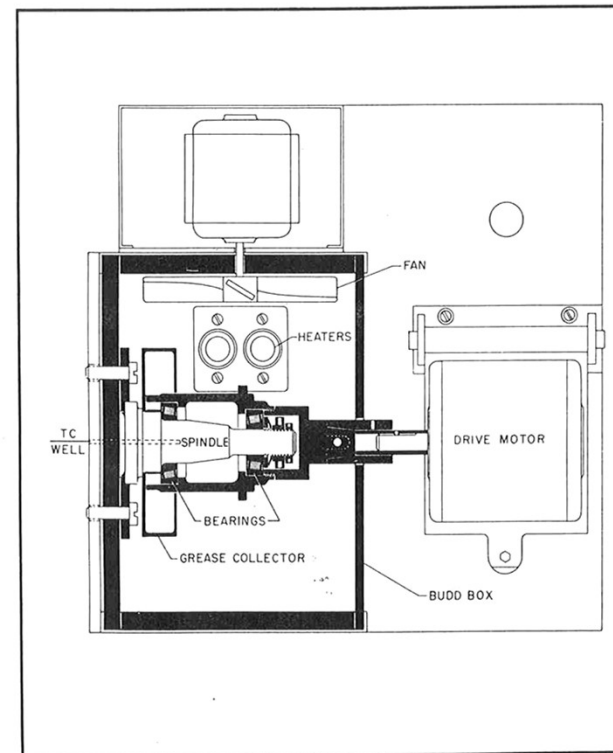


Wheel-Bearing Lubricant Tester

# ASTM D4290

## Accelerated Wheel Bearing Leakage

- Bearings and hub are packed with 60 g of grease.
- Uses same tester as D3527. Only one 20 hour cycle is run.
- Collected grease is reported as leakage in grams.



Wheel-Bearing Lubricant Tester

# ASTM D1263

## Wheel Bearing Leakage

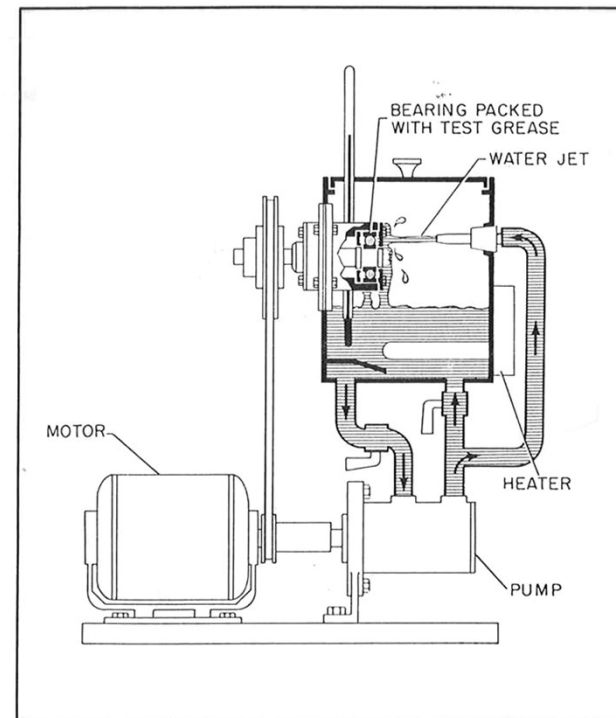
- Bearings and metal hub are packed with 90 g of grease.
- Run at 104.4 C for 6 hours at 660 rpm.
- No thrust load applied.
- Grease collected outside of bearings in grams is the leakage.



# ASTM D1264

## Water Wash Out

- Bearing packed with grease has water spray impinging on it.
- Run at 600 rpm, 38 C, and 5 cm<sup>3</sup>/s flow rate.
- Weight loss after one hour is determined.

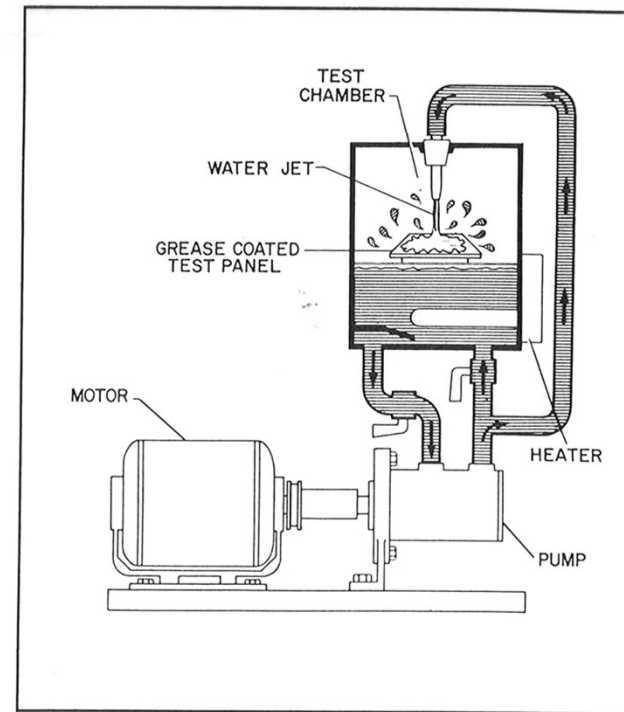


Water Washout Test

# ASTM D4049

## Water Spray-Off

- Metal panels are coated with 30 mil coating of grease.
- Water is sprayed on horizontal panel at 38 C, 275 kPa from 12" above.
- After 5 minutes, the panels are dried and weight loss is used to determine the percent spray-off.
- The less removed the better.



# ASTM D1743

## Bearing Corrosion Resistance

- Tapered roller bearings are packed with grease and spun under light load to create thin coating found in service.
- Placed in jars along with 5 ml distilled H<sub>2</sub>O, sealed and heated at 52 C for 24 hours. Salt water can also be used.
- Failure is corrosion spot larger than 1 mm in longest direction.



# ASTM B117

## Salt Spray Corrosion Resistance

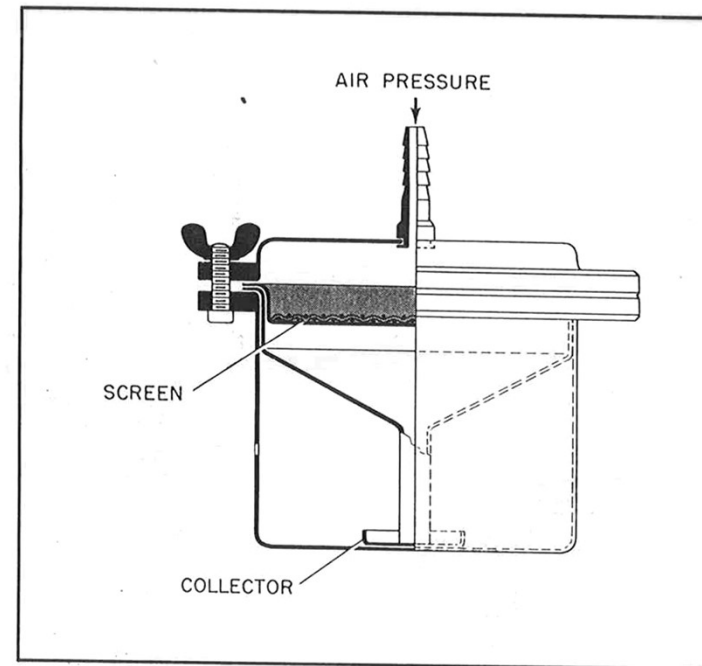
- Metal panels are coated at either 1 or 3 mil thickness and placed in salt spray cabinet.
- Time in hours until 1 spot larger than 1 mm is recorded.



# ASTM D1742

## Oil Separation in Storage

- Indication of separation tendencies of grease stored in sealed drums.
- Grease covers a 200 mesh screen at 25 C and 1.72 kPa for 24 hours.
- Any separated oil is collected and weighed.
- Percent by weight separated is reported.



Pressure Oil Separation Test



# ASTM D6184 / FTM321 Wire Cone Oil Bleed Test

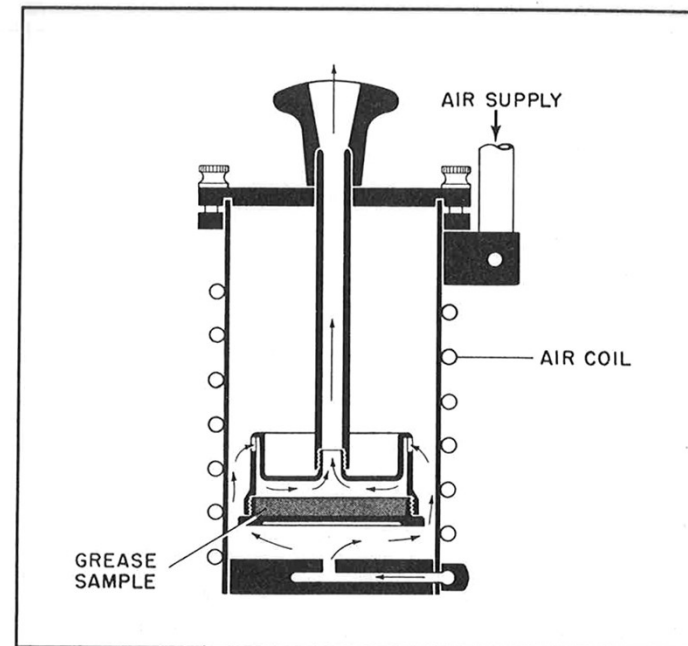
- 60 mesh screen cone filled with 10 g of grease.
- Hung inside a covered beaker at 100 C for 24 hours - oil drips into beaker.
- Reported as percent by weight separated.



# ASTM D972

## Evaporation Loss

- Characteristic of the oil used - loss of oil can lead to hardening.
- Sample and air heated to specific temperature - 99 to 149 C.
- After 22 hours, weight percent loss of grease is reported.



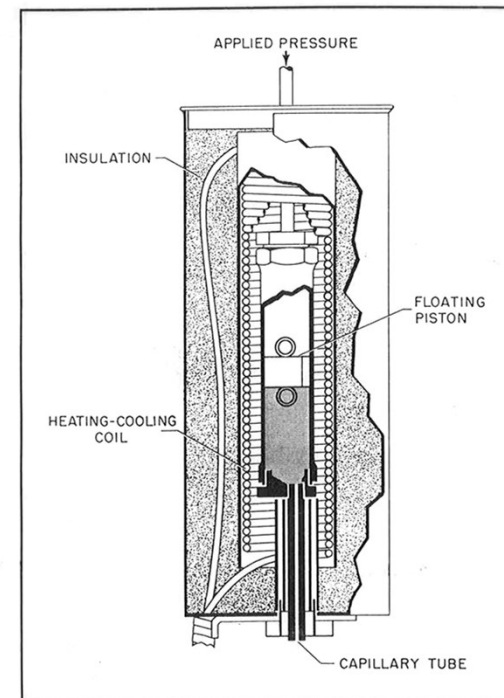
### Evaporation Loss

The cell is submerged in an oil bath or aluminum block heater. Incoming air passes through the coil and is heated to the test temperature before passing over the sample.

# ASTM D1092

## Apparent Viscosity

- Grease is pushed through various diameters of tubing to give a wide range of shear rates.
- Can be run at various temperatures.
- Plot of shear rate versus apparent viscosity.
- Good for pipe flow calculations.

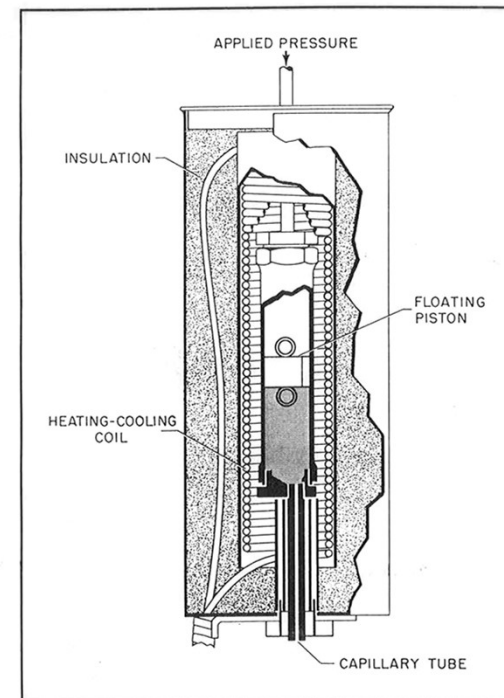


Apparent Viscosity of Greases

The ASTM test cylinder is surrounded by a close fitting, heating-cooling coil and insulated canister. The piston is driven by hydraulic pressure.

# U.S. Steel Mobility

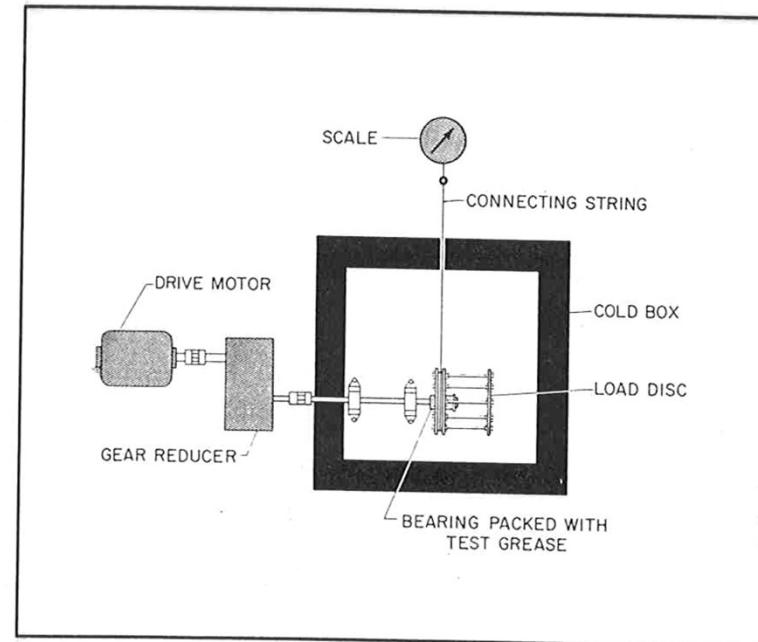
- Amount of grease pushed through one cylinder above using constant air pressure.
- Can measure amount pumped in g/sec.
- Typically run at 0 F but this can be varied.



# ASTM D4693

## Low Temp. Torque of Wheel Bearings

- Uses roller bearing with 400 N thrust load applied.
- Typically run at  $-40^{\circ}\text{C}$ , 1rpm, for 3 minutes.
- Torque after 60 s is recorded along with the maximum torque achieved.

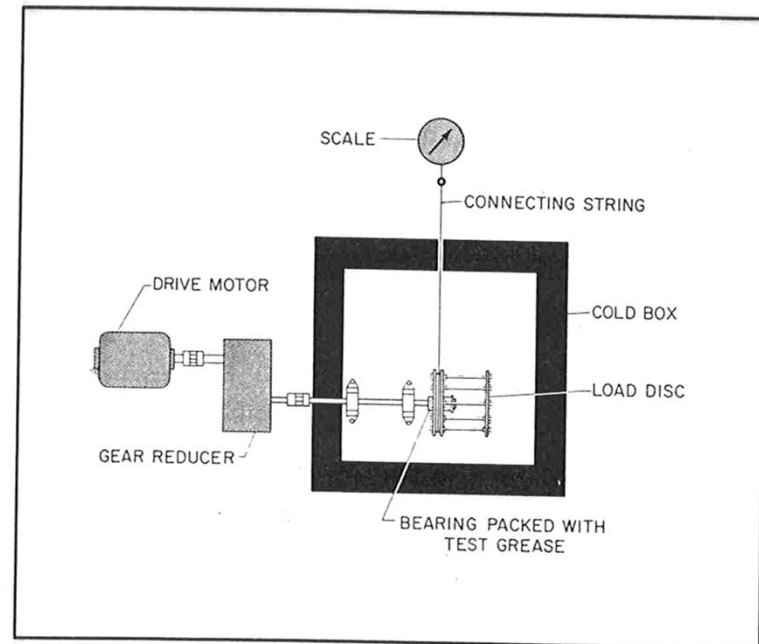


Low-Temperature Torque Test

# ASTM D1478

## Low Temp. Torque of Ball Bearings

- Bearing packed with test grease and cooled to desired temperature
- Rotated at 1 rpm - torque at start and torque after 60 minutes recorded
- Torque reported in g.cm



Low-Temperature Torque Test

# Other Tests

- Elastomer Compatibility
- Copper Corrosion
- Emcor Bearing Corrosion
- Oven panel testing
- Compatibility between greases
- Specialized wear and EP tests
- Specialized dispensing tests
- Field trials