

The webinar will start in less than five minutes.

Grease Basics

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- CITGO Product Specialist
- Chemical Engineer
- 37 Years Experience in Lubricants
- STLE Certified
 - Certified Lubrication Specialist
 - Oil Monitoring Analyst I
- NLGI Certified
 - Certified Lubricating Grease
 Specialist
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Agenda

- What is lubricating grease, and how it differs from oil
- Grease composition
- How grease is manufactured
- Industry organizations related to lubricating grease
- Grease tests
- Grease compatibility
- Industry standards for grease
- Grease selection
- Grease applications
- Proper grease handling and storage
- Troubleshooting problems
- How to sell grease

Lubricating Grease



What is It?	Oily semi-solid material Oil (80-98%), Additives (0-5%). Thickener (2-20%)
HOW is it Made?	Thickener created* by <u>chemical reaction</u> Special process technology required * with exceptions Batch or Continuous
Where is it used?	80% of all bearings are grease lubricated Cars, Airplanes, Industrial Plants

Lubricating Grease

- Stays in place where oil can't
- Seals components from contaminants
- Carrier for solid additives
- Extra film thickness for extra protection
- Cost effective maintenance



Grease Composition

- Grease contains three primary components:
 - Lubricating fluid
 - Additives
 - Thickener



Grease Composition – Lubricating Fluid

- Mineral oil lacksquare
 - Paraffinic or naphthenic



Vegetable oil

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Synthetic fluid

Grease Composition – Lubricating Fluid

–Naphthenic » Synthetic Ester
–Paraffinic
» Group I
» Group II
–Synthetic (PAO)

Smoother Appearance Higher Yields

Coarser Appearance Lower Yields

Grease Composition - Additives

- Antioxidants
- Rust Inhibitors
- Antiwear Additives
- Extreme Pressure (EP) Additives
- Polymers
- Solids
- Dyes

Additives Enhance Performance!

Grease Composition - Thickener

- Simple Soap Thickeners
- Lithium

Barium

Calcium

• Aluminum

Calcium

Barium

- Sodium
- Complex Soap Thickeners
- Lithium
- Aluminum
- Non-Soap Thickeners
- Polyurea
- Calcium Sulfonate
- Clay (bentonite, hectorite)



Fumed Silica

Grease Composition – Thickener Reaction

- Saponification
- <u>Acid + Base = Soap + Water</u>

Common Acids

Stearic Acid, 12-Hydroxystearic Acid,

Tallow, Azelaic Acid, Sebacic Acid

Common Bases

Lithium Hydroxide, Calcium Hydroxide, Sodium Hydroxide, Barium Hydroxide





Grease Manufacture

- For Soap Thickeners
 - Reaction (Saponification)
 - Dehydration
 - Finishing
- For Inorganic Non-Soaps
 - Dispersion

Grease Manufacture - Equipment

• Open or Pressure Kettle

• Stratco[®] Contactor[™]



Continuous Unit



Grease Industry Organizations

- NLGI (National Lubricating Grease Institute)
- ASTM International (American Society for Testing and Materials)
- Society of Tribologists and Lubrication Engineers (STLE)
- SAE International (Society of Automotive Engineers)
- American Gear Manufacturers Association (AGMA)

Grease Tests

- Grease has unique properties that require different tests from those used to test oils
- Two key grease properties:
- Dropping Point The melting point of the thickener
- Consistency Flow and handling characteristics
 How hard (solid) or soft (fluid) the grease is

ASTM D2265 Dropping Point

- Temperature at which the grease becomes fluid and drops from the test cup orifice
- Like a melting point a temperature range
- For high-temperature greases, may indicate oil separation rather than thickener melting
- Maximum Usable Temperature is less than the dropping point, and is better defined by bearing life tests



Dropping Point Ranges

	°F	°C	
Calcium	265-285	129-140	
Lithium	380-400	193-204	
Lithium Complex	4501	222.	
Aluminum Complex	430+	232+	

Consistency – Penetration Test

- ASTM D217 (Full Scale)
- ASTM D1403 (½-Scale and ¼-Scale)
- Undisturbed in the original container
- Unworked minimum of handling
- Worked after 60 double strokes of working
- Prolonged Worked after 10,000 or 100,000 double strokes of working

Grease is graded based on the worked penetration





NLGI Grease Consistency Grades

NLGI Consistency Grade	Penetration Range, mm/10	Description
000	445 - 475	Fluid
00	400 - 430	Semi-Fluid
0	355 - 385	Very Soft
1	310 - 340	Soft
2	265 - 295	Medium
3	220 – 250	Medium-Hard
4	175 - 205	Hard
5	130 - 160	Very Hard
6	85 - 115	Block



Other Grease Tests

- Mechanical (Shear) Stability
- Oxidation Resistance
- Water Resistance
- Oil Separation



- Antiwear and Extreme Pressure (EP) Properties
- Corrosion (Copper and Steel)
- Pumpability

Consistency vs. Viscosity

- Consistency is related to thickener content
 - Higher thickener content = stiffer grease
- Viscosity is a base fluid property
 - A 'soft" grease can have a high viscosity base oil
 - A "hard" grease can have a low viscosity base oil
- Apparent Viscosity is a grease property
 - Grease is thixotropic
 - It acts like a solid when still, but like a fluid when pumped (sheared)
- Consistency and base fluid viscosity are independent properties of a grease, and both are important in selecting the right grease for an application

Grease Compatibility

- ASTM D6185 Standard Practice for Evaluating Compatibility of Binary Mixtures of Lubricating Greases
- Important for satisfactory operation of grease-lubricated equipment
- Neat products and 50:50 mixture tested
- Dropping Point
- Change in 60-stroke penetration after heating
- 100,000-stroke penetration
- Additional tests as required based on application
- Severe change in properties indicates incompatibility

Grease Compatibility Chart

General Guide - Exceptions Are Likely	Aluminum Complex	Calcium Stearate	Calcium 12-Hydroxy	Calcium Complex	Clay	Lithium Stearate	Lithium 12-Hydroxy	Lithium Complex	Polyurea	Sodium Soap	Key:
Aluminum Complex	С	I	I	I	I	I	I	С	I *	I	C = Compatible
Calcium Stearate	1	С	С	I	I	С	В	С	I *	Т	B = Borderline
Calcium 12-Hydroxy	1	С	С	В	I	С	С	С	I *	I.	I = Incompatible
Calcium Complex	1	I.	В	С	I.	I.	I	С	С	I.	I* = Dependant
Clay	1	I	I	I	С	I	I	I	I	I	Upon Type
Lithium Stearate	1	С	С	I	I	С	С	С	I *	I	
Lithium 12-Hydroxy	1	В	С	I	I	С	С	С	I *	Т	
Lithium Complex	С	С	С	С	I	С	С	С	I *	I	
Polyurea	I *	I *	I *	С	I	I *	I *	I *	С	I	
Sodium Soap	I.	I	I	I	I	I	I	I	I	С	

Grease Industry Standards

- NLGI/ASTM/SAE
 - ASTM D4950 Standard Classification for Automotive Service Greases – GC, LB, GC-LB
- SAE
 - J310 Automotive Lubricating Greases
 - J2695 Heavy Duty Vehicle Lubricating Greases
 - Both based on D4950
- NATO/Military
 - Multiple standards for greases
- OEMs
 - Automotive, heavy machinery, railroad, etc.



Grease Selection

- Operating Temperature
- Rotational Speed





Bearing Type



Operating Environment



How to Select a Grease

- Base Fluid Type and Viscosity
 - Operating Temperature Range, Load, and Speed
- Thickener Type
 - Operating Temperature
 - Operating Conditions (contamination types and sources)
 - Pumpable/Slumpable
- Consistency
 - Pumpable/Slumpable
- Additive Components
 - EP, Tackifier, Severe Corrosion Protection, Solids, Dye

Correct Viscosity Selection

Viscosity	Application
ISO 100	Electric motors and high-speed bearings > 3600 rpm
ISO 150 & 220	Multipurpose grease operating at moderate speeds
ISO 460	High loads and good water resistance
ISO 680*	High-speed couplings
ISO 1500	Very low speed, high loads and good water resistance
ISO 3200*	High-speed couplings

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Thickener Types and Common Uses

Thickener Type	Application
Straight Lithium	Versatile and less expensive than the Li Complex. Should not be used over 275 F.
Lithium Complex	Most versatile thickener for wide variety of industrial and automotive applications. Used up to 350 F. Does not have H1 approval and is not used as food grade grease.
Aluminum Complex	Good high-temperature and water-resistant properties. Used in steel and paper mills. Most common food grade thickener with H1 approval. Used up to 350 F.
Polyurea	Excellent oxidative resistance because of non-metallic thickener. Grease of choice for electric motors and sealed-for-life applications. Use up to 350 F.
Organophilic clay	Non-melt resulting in good high-temperature properties along with H1 approval for food grade. Used in oven conveyers. Used up to 350 F.
Calcium Complex	Good water resistance and H1 approval. Used in steel and paper mills. Also used in food plants. Used up to 350 F.
Calcium Sulfonate	Very good inherent corrosion resistance and high EP along with H1 approval, but expensive because of high thickener content. Used in food grade, corrosive and high-load environments. Used up to 350 F.
Sodium	Inexpensive and used where good adhesion and corrosion protection required. Cannot be used in presence of water and limited to 250 F.



Load, Speed, and Oil Viscosity



Viscosity Required at Operating Temperature



Amount of Grease

- Journal Bearings: not usually grease lubricated but have a speed limitation. When re-greasing, completely displace the old grease.
- Rolling Element Bearings: require calculated lubrication amounts for an effective re-greasing program unless in a contaminated environment where total grease displacement is required. (Doesn't apply to electric motors where over greasing is a problem).
- Lubricators should have specific instructions on the exact amount of grease and when to add.



How much is enough?

How much grease is enough within the bearing itself?

"1/3" to "1/2" full

 Either too much or too little grease, and/or inappropriately high or low base oil viscosity can cause viscous drag and/or destruction of the bearing surfaces and lubricant within the bearing.



Calculate Correct Amount of Grease



 $G_{\rm q}=.114~DB \label{eq:Gq}$ The amount of grease calculated is in ounces.

- Most bearing dimensions are expressed in millimeters (mm) hence the following formula:
 - G (ounces) = 0.00018 x DB (mm)
- For example a 150 hp motor with a 313 size bearing has the following dimensions:
 - 65 mm bore, 140 mm OD, 33 mm width
- Using the above formula: G= 0.00018 x 140 x 33 = <u>0.83</u> ounces of grease required
- Calculate the number of shots of a grease gun to deliver one ounce.
- Calibrate the grease gun to know how many shots say 10 and weigh how much grease is delivered.
- Assume here for this example: 0.5 ounces in 10 shots or equates to 1 ounce in 20 shots
- We need 0.83 ounces from above: 0.83 x 20 = <u>17 shots</u>

Frequency of Re-Lubrication



$$\Gamma = K \times \left[\left(\frac{14,000,000}{n \times (d^{0.5})} \right) - 4 \times d \right]$$

Where:

- T = Time until next relubrication (hours)
- K = Product of all correction factors Ft x Fc x Fm x Fv x Fp x Fd (see table)
- n = Speed (RPM)
- d = Bore diameter (mm)

Note:

ips = inches / second 0.2 inches / second = 5 mm / sec.

Grease Interval Correction Factors

Condition Average Operating Range		Correction Factor			
Temperature Ft	Housing below 150°F 150 to 175°F 175 to 200°F Above 200°F	1.0 0.5 0.2 0.1			
Contamination Fc	Light, non-abrasive dust Heavy, nonabrasive dust Light, abrasive dust Heavy, abrasive dust	1.0 0.7 0.4 0.2			
Moisture Fm	Humidity mostly below 80% Humidity between 80 and 90% Occasional condensation Occasional water on housing	1.0 0.7 0.4 0.1			
Vibration Fv	Less than 0.2 ips velocity, peak 0.2 to 0.4 ips Above 0.4 (see note)	1.0 0.6 0.3			
Position Fp	Horizontal bore centerline 45 degree bore centerline Vertical centerline	1.0 0.5 0.3			
Bearing Design Fd	Ball bearings Cylindrical and needle roller bearings Tapered and spherical roller bearings	10 5.0 5.10			

Normal temperature is considered 160° F, for every 27° F increase requires the frequency to be cut in half.

When Changing Greases...

- What grease has been used previously?
- Was it working satisfactorily?
 - If not, why not?
- Grease formulation is based on thickener type, consistency, base fluid type and viscosity, and additives.
- Grease selection is often a compromise.

Where are Greases Used?



• Bearings





Sliding Contacts



Where are Greases Used?

• Bearings

• Gears





Sliding Contacts





• Anything with Moving Parts!



Grease Applications - Bearings







- Load
- Temperature
- Bearing Type and Size
- Environment





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Grease Applications - Bearings









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Grease Applications - Gears









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More Grease Applications







- Grease is packaged into a variety of containers:
- 3-oz. tube
- 14-oz. tube
- 1-lb. can
- 4-lb. tub
- Aerosol can
- 35-lb. pail
- 120-lb. keg
- 400-lb. drum
- 2400-lb. tote
- Bulk







Grease tubes should be stored upright to prevent oil separation and leakage of oil from the tube



- Grease should be stored indoors, out of direct sunlight and where water cannot accumulate on the container lid
- Containers should be stored upright
- Minor oil separation may occur at the grease surface during storage
- Separated oil should be remixed with a <u>clean</u> tool before use
- When grease is removed from a container, the surface of the remaining product should be smoothed flat to minimize oil separation
- Inclusion of air bubbles in grease should be avoided



• A clean, well organized lube room promotes proper lubricant handling and application





Grease Fittings

• Zerk Fittings











Using a Grease Gun

- Locate and clean the grease zerk
- Verify that the grease gun contains the proper product
- Purge a small amount of grease out of the hydraulic fitting at the end of the hose wipe and dispose of properly
- Attach the hydraulic fitting to the zerk
- Apply the required number of shots
- How much per shot?



Using a Grease Gun

- A hand operated grease gun can produce up to 15,000 psi of pressure
- Care must be taken to avoid injection of grease
- High pressure injection of petroleum hydrocarbons under the skin can cause severe injury. Most damage occurs in the first few hours. Seek medical attention immediately.

Troubleshooting Grease Problems

- Grease issues can be difficult to troubleshoot
- Essential to obtain a representative sample of grease from the load zone in the lubricated equipment
- Photos of the application before removing samples are very helpful
- Always pack grease samples in impervious containers (metal, plastic, or glass), never on wood, cardboard, or paper, and never in contact with cloth or paper rags
- Wide mouth containers are preferred
- Failed parts should be placed in plastic bags with the grease intact
- All samples submitted should be labeled clearly and completely
- Tests may need to be adapted due to small sample size

Lubricant Related Failures

What Percent of all premature bearing failures are lubricant related?



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Grease on the Plant Floor

• What issues do you see in this picture?



How to Sell Lubricating Grease

- Grease is often thought of as a specialty product
- Some greases are commodities, while others are very specialized
- Grease is a higher margin, but lower volume product
- Grease can be a door opener at an account
- A grease that performs well can help to keep business
- Look for opportunities to solve grease lubrication problems
 - "Tell me what keeps you awake at night."
- Use the CITGO Answer Line as a resource

Questions

• Please post your questions using the Q&A function.

How to Contact Us

- Lubes Answer Line
- 800-248-4684
 - 8:00 AM 12:00 PM, 1:00 PM 5:00 PM- Monday through Friday
- lubeshelp@citgo.com
 - Available 24/7

Webinar Schedule

• June 22, 2018 Subject TBD

APPENDIX

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NLGI



- Formerly National Lubricating Grease Institute
- Organized in 1933
- The objectives of NLGI are to disseminate information that can lead to the development of better lubricating greases for the consumer and to provide better grease lubrication engineering service to the industry
- Publish a standard defining grease consistency
- Bi-monthly technical journal NLGI Spokesman
- Annual meeting in June with multiple technical presentations and education courses
- Sister organizations: NLGI India Chapter, ELGI, CLGI

ASTM International



- Previously American Society for Testing and Materials
- Global organization devoted to producing and maintaining standard test methods, specifications, practices, and guides
- Committee D02 covers all aspects of petroleum products, liquid fuels, and lubricants
- Committee D02 was formed in 1904
- Over 800 standards related to fuels and lubricants
- Specifications for gasoline, diesel fuel, jet fuel, etc.
- Specifications for automotive engine oils, diesel engine oils, greases, etc.
- Test methods for all fuels and lubricants
- Meets in June and December
- Approximately 2500 members in Committee D02

STLE



- STLE is the premier technical society serving the needs of more than 13,000 individuals and 200 companies and organizations that comprise the tribology and lubrication engineering business sector
- STLE's mission is to advance the science of tribology and the practice of lubrication engineering in order to foster innovation, improve the performance of equipment and products, conserve resources, and protect the environment
- Annual international meeting held in May many technical presentations and training courses
- Local sections hold monthly technical meetings
- Monthly publications *Tribology and Lubrication Technology* (TLT) and *Tribology Transactions*

SAE International



- Originally known as the Society of Automotive Engineers
- SAE International is the knowledge source for mobility engineering
- Focus areas are aerospace, automotive, and commercial vehicle engineering
- Publishes standards related to all facets of mobility engineering (i.e. engine oil and automotive gear oil viscosity grades)
- Two standards related to automotive and heavy duty greases
- Multiple conferences and symposia throughout the year
- Multiple publications, including *Automotive Engineering*, *Off-Highway Engineering*, and *Mobility Engineering*
- Local sections hold monthly technical meetings

AGMA



- AGMA is the global network for technical standards, education, and business information for manufacturers, suppliers, and users of mechanical power transmission components
- Founded in 1916
- Currently over 400 member companies
- Produces standards for all aspects of gear technology
- Many technical committees
- Education courses
- Annual meeting in May