On-Road Fleet/Buses HDEO Training

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Today's Topics

- Industry Trends/Media Articles
- Syn Blend vs Synthetic
- Top Issues and Solutions
- HDEO - Duron
- ATF
- Gear Oils
- Grease

Heavy Duty Engine Oil (HDEO) Market Overview

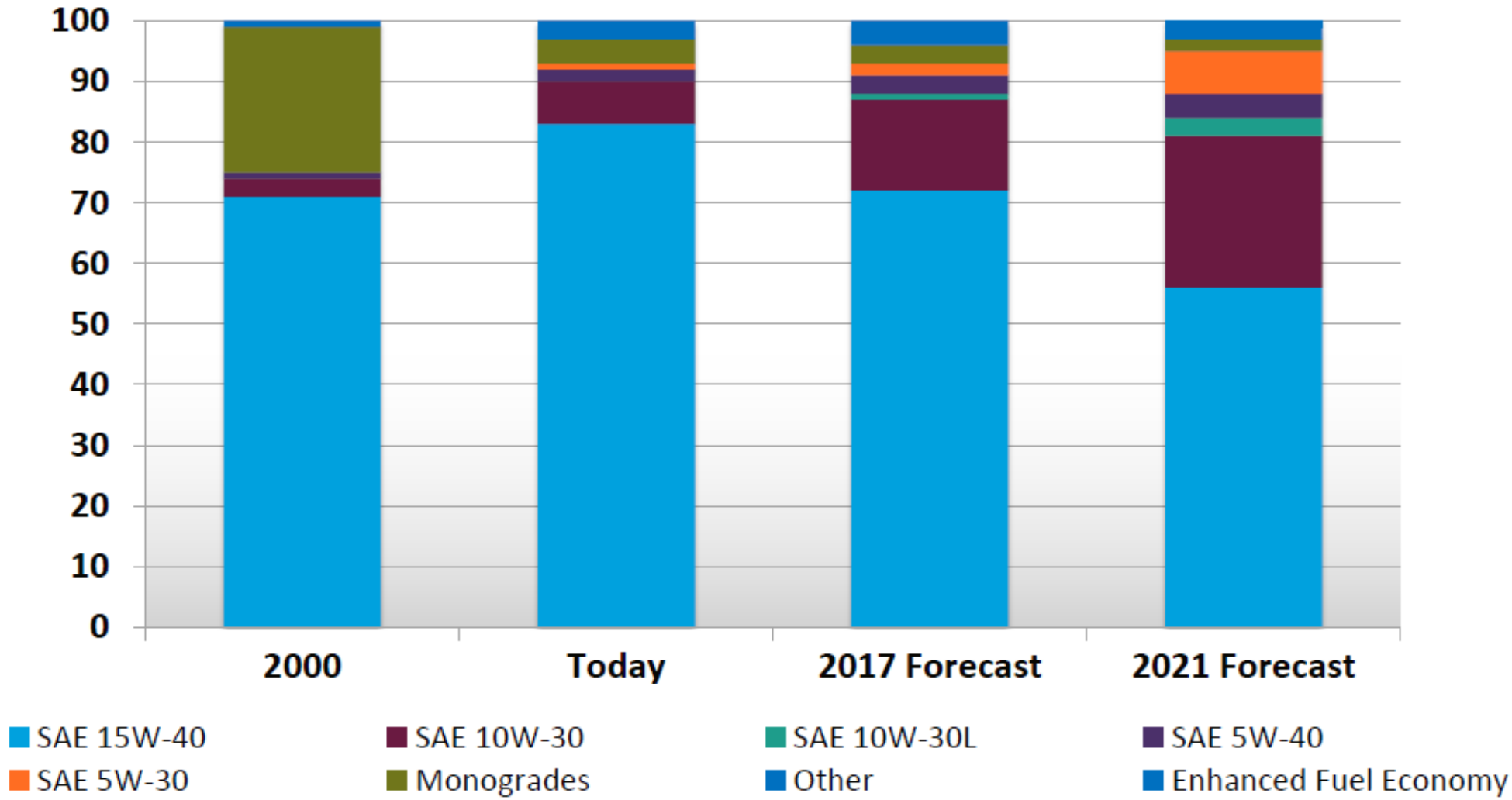
North American HDEO Market Overview

North American HDEO market is on the heels of the largest and most complex industry change in the last decade.

- Both new categories (API CK-4 and FA-4) launched on Dec 1, 2016
- Driven by new government regulations requiring Class 8 trucks to deliver higher levels of **fuel economy** to reduce green house gas emissions.
- The industry has mostly completed the transition from API CJ-4 to API CK-4 quality products.
- In addition, the new fuel economy category (API FA-4) has added complexity along with performance benefits.
- Anticipate adoption of API FA-4 products to be slow.

North American HDEO Market Overview

Viscosity Grade Trends



Industry Initiatives

Fleet Efficiency Targets

Fuel Economy is a priority in NA & Europe

Need to educate them…

- Look at entire truck (tires etc). All adds up to savings.
  - 4% savings through lubricants
- Partner with transmission manufacturers if driver training is an issue.
  - Move to automatic transmissions
  - X% savings on driver training

Maximize Asset Availability

99% speak about cost/mile & truck/driver availability

- Trucks need to be on the road
- Metrics tracked to determine if they need to invest in their workshop or outsource maintenance

Industry Initiatives

Optimizing Drain Intervals (North America)

Major target for larger fleets (equal to fuel economy)

- Proof through oil analysis but 90% do not sample & stick to OEM recommendation
- Need to educate: save on labor & maintenance
- Convince them to trial

Environment (reduced emissions)

Understanding the purpose of PC-11 oils & new standards

- Better protection for diesel engines
- Meeting more rigorous environmental regulations
- New US standards calling for 24% reduction in emissions for 2021-2027 year rigs

Syn Blend vs Synthetic

- Group II with Group III
- No industry standard
- No Monitoring how much Grp III
- Lower Pour Point then conventional
- Longer lasting?
- Recordable Fuel Savings over conventional for the 10W viscosity.
- CK4 only

- Group III, Group III+ or Group IV
- Higher TBN
- Longer Lasting
- Longer Drain Intervals
- Better wear protection
- Recordable Fuel Savings
- CK4 and FA4

Top Maintenance Issues

Top 3 Fleet Issues – With Solutions

- ***Premature Engine Wear***
  - Use a tougher HDEO that meets and exceeds today's standards and OEM requirements such as **DURON HP, SHP, or UHP**
  - Always use in conjunction with a Used Oil Analysis and monitoring program
  - Engine Coolant monitoring – 40% of all engine wear or failures are due to coolant issues

- ***Premature Differential Wear or Failure***
  - Use **TRAXON Synthetics** – they are designed to reduce wear, providing protection through the heavy loads that differential gears are under

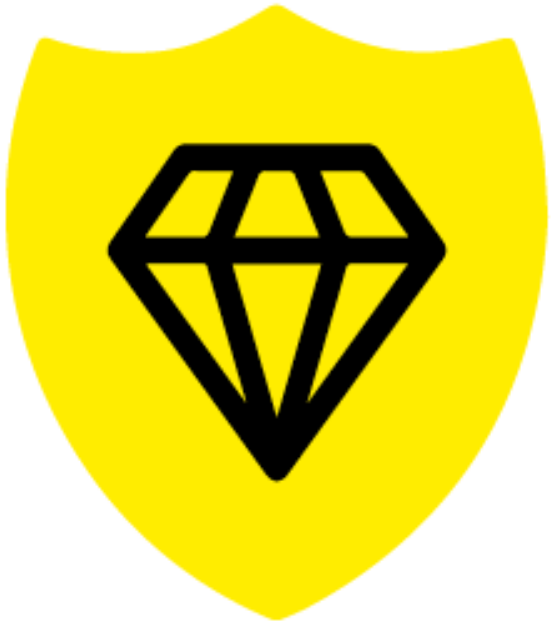
- ***Premature Transmission Wear or Failure***
  - On-Road - HD Automatic Transmission – use **DuraDrive HD Synthetic Blend ATF** to reduce wear
  - On-Road - Manual Transmissions – use **TRAXON Synthetic MTF** to help reduce wear

** Whenever it is possible to add Used Oil Analysis and Monitoring to your routine PM, you have now become Proactive and even Predictive in your maintenance program instead of commonly reactive.*

Duron

- Features and Benefits

Durability



- The future will demand even more protection from your engine oil. DURON is built around DURABILITY. We have improved Oxidation Resistance, Aeration Control and Shear Stability
  - Durability is formulated in the HDEO through it’s base stock and additive package, which in turn provide better engine protection and ability for extended drain intervals.

Oxidation Control

Benefit: Full engine protection sustained throughout the drain* and the potential to improve fuel economy due to less oxidative thickening.

- Good Oxidation Control aids in the HDEO lasting longer due to the resistance to Oxidize or become Acidic, this is done through a balanced formula of base stocks and additives.

* Extending drain intervals should always be undertaken in conjunction with an oil analysis program.
** PCL would look to condemn the oil at 25 abs\cm-1 however there is no standard for HDEOs on oxidation.

Engine Protection

- We have significantly improved engine protection capability. This includes performance in the Daimler OM 646 LA test and Cummins ISB. You want proof, we have proof.
  - There are stringent wear tests for all Manufacturers that must be passed for OEM approvals
  - We exceed all of the testing.

Wear Protection

- This results in outstanding engine wear protection and long engine life, well past 60,000 km (37,500 miles) and in heavily loaded conditions – significantly below the OEM condemning limit range.
  - Only quality lubricants with balance formulas will be able to pass and exceed the OEM Wear Tests.

Navistar MaxxForce

Optimized Drains

- Your business demands an increase to your bottom line while maintaining a margin. DURON engine oils increase the ‘uptime’ between drain intervals. What's more, we can prove it.
  - Fleets can Optimize Drain Intervals through a comprehensive Preventative Maintenance program that includes oil sampling and analysis.

Extreme Conditions

- Our DURON reputation is built on superior performance in cold and hot temperatures. This capability is the result of blending with our highly purified Group II and Group III base oils in combination with advanced performance technology.
  - Group II and Group III is quickly becoming the industry standard.

Fuel Economy – Point of Difference

- We have led the way from the very beginning - using our lower viscosity engine oils to deliver improved fuel economy AND provide engine protection.

Duron Product Line

PETRO-CANADA LUBRICANTS

		Durability	Engine Protection	Extended Drain	Extreme Temperature	Fuel Economy
DURON HP *High Performance*	**DURON HP** 15W-40 CK-4	◆	✓	◆		
DURON SHP *Super High Performance*	**DURON SHP** 15W-40 CK-4	◆◆	✓✓	◆◆		
	DURON SHP 10W-30 CK-4	◆◆	✓✓	◆◆	❄	⛽
DURON UHP *Ultra High Performance*	**DURON UHP** 10W-40 CK-4	◆◆◆	✓✓✓	◆◆◆	❄	
	DURON UHP E6 10W-40 CJ-4 E6	◆◆◆	✓✓✓	◆◆◆	❄	
	DURON UHP 5W-30 CK-4	◆◆◆	✓✓✓	◆◆◆	❄❄	⛽⛽
	DURON UHP E6 5W-30 CJ-4 E6	◆◆◆	✓✓✓	◆◆◆	❄❄	⛽⛽
DURON ADVANCED	**DURON ADVANCED** 10W-30 FA-4 API FA-4	◆◆	✓✓	◆◆	❄	⛽⛽⛽
	DURON ADVANCED 5W-30 FA-4 API FA-4	◆◆◆	✓✓✓	◆◆◆	❄❄	⛽⛽⛽

ATF

- **Allison - TES 295**
  - What's Coming
- **Voith**
  - New Approvals

Allison Transmission – recommendations

- Allison transmission recommends that customers use an Allison approved TES 295 automatic transmission fluid to extend drain intervals and to enhance transmission performance and durability in all operating environments.

- Customers may continue to choose from a wide variety of Allison approved fluids.

- Dexon®-Vi fluids may be used in the 1000 and 2000 Product Families transmissions beginning with s/n 6310670488 and 6320784373; and in the 3000 and 4000 Product Families transmissions beginning with s/n 6510717281 and 6610220990. Dexron®-Vi shall not be used in Allison 500, 600 or 700 series transmissions (at, mt, ht, ht/V/Clt products).

- Schedule One TES 389 and Dexron®-Vi fluids will have the same fluid change intervals as the current Allison approved non-TES 295 fluid intervals.

- C4 fluids are no longer recommended in any commercial on-highway transmissions. a complete list of approved fluids can be found at www.allisontransmission.com; click service, then Fluids.

Allison – next generation – TES 668

- TES 668 will supersede TES295
  - Will be Synthetic
  - Will be backword compatible
  - As with TES 295 will have limited licensing
    - PC – R&D in development of new TES 668 w/ Allison

Voith

- Voith - 150.014524.xx(maximum drain, 100,000 miles) xx-VTI-DIWA Service Bulletins 013 and 118
  - PC DuraDrive HD Long Life ATF

Gear Oils

Gear Oils are designed to protect gears, bearings and cross shafts from premature failure, assure reliable equipment operation and increase transmission and differential service life.

Purpose of the Automotive Gear Oil

- Minimize friction and wear - a film must be maintained between gear teeth at all times to prevent metal to metal contact under extreme pressure

- Cooling Components - prevent destructive over-heating by circulating oil through bearing and gear mesh zones where frictional heat is generated

- Maintain long clutch life and maintain seal integrity.

- Inhibit rust and corrosion

Properties of Gear Oils

- Gear oils must have additives that protect against Extreme Pressure (EP) , which results from pinion/ring gear forces during rolling & sliding contact. See next slide.
- Gear Oils do not contain detergents & dispersants which are critical to engine oil function: No combustion by-products to suspend or clean off.
- Oil viscosities tend to be high in order to provide a high film strength under the sliding contact pressures involved.
- The oils must provide strong anti-wear properties & be non-corrosive to gear materials :- Bronzes & Steels.
- Need to resist shear-down in viscosity, and remain deposit- free over a long life

ADDITIVE	Engine Oils	ATF	General R&O Oil	AW Hydraulic	Industrial Gear Oil	Automotive Gear Oil	Grease
Detergents	✓	✓					
Dispersants	✓	✓					
Anti-Oxidants	✓	✓	✓	✓	✓	✓	✓
Rust Inhibitors	✓	✓	✓	✓	✓	✓	✓
Anti-Wear	✓	✓		✓	✓	✓	✓
E.P. Agents					✓	✓	✓
VI Improvers	✓	✓		Some	Some	Some	
Pour Point Depressants	✓	✓	✓	✓	✓	✓	
Anti-Foam	✓	✓	✓	✓	✓	✓	
Dyes		✓					✓
Friction Modifiers		Gas Only ✓					

Properties of Gear Oils - cont

- Automotive gear oils are more commonly required to contend with the following conditions than their industrial counterparts:
  - extremes of temperature from summer to winter. That's why they are "multigrades"
  - long periods of continuous use without top-up or replacement, thus a need for thermal and oxidative stability. Industrial gearboxes are more accessible.
  - Concentration of power supplied to the "differential" gearbox. Thus the potential for heavy wear on gear teeth, and the need for "EP".

Properties of Gear Oils - cont

- "Thermal" stability refers to the ability of an oil to maintain its properties when subjected to **heat** alone. Instability results in additives altering & dropping out, or reacting with the oil to produce a change.
- "Oxidative" or "Oxidation" stability refers to the ability of the oil to resist change as a result of **reacting with oxygen** in the air (not exclusively at high temperatures). Lack of stability leads to unwanted increase in viscosity, to acidity, & to solid deposits which interfere with lubrication
- Sometimes changes in an oil occurs as a result of both processes.

Why is this important ?

- Changes in vehicle design have raised temperatures in the drive train (gearboxes, axles, etc) because of higher loads & smaller components
- Oil temperatures of 85-110°C were previously common
- Temperatures can now exceed 150°C
- Deposits of sludge & varnish are a result of this, as well as oil thickening, and an accompanying “drag” on fuel economy.

Axle Manufacturers' Recommendations

Manufacturer	Quality	Viscosity Grade
Clark	GL-5	85W140
Dana	GL-5	80W90. 80/85W140
Eaton	GL-5	75/80W90, 80/85W140
Mack	GO-J	75/80W90, 85W140
	GO-J +	75W90
Navistar	GL-5	80W90
Rockwell	GL-5	80W90, 75/85W140
Spicer	GL-5	80W90, 80/85W140

Grease

Agenda

- Introduction to Grease
- Category Snapshot

INTRODUCTION TO GREASES

Grease is a Thickened Oil, Not a Thick Oil

BASE OIL (50-95%)[1]

THICKENER (3-45%)

ADDITIVES (2 - 10%)

[1]Lubrizol

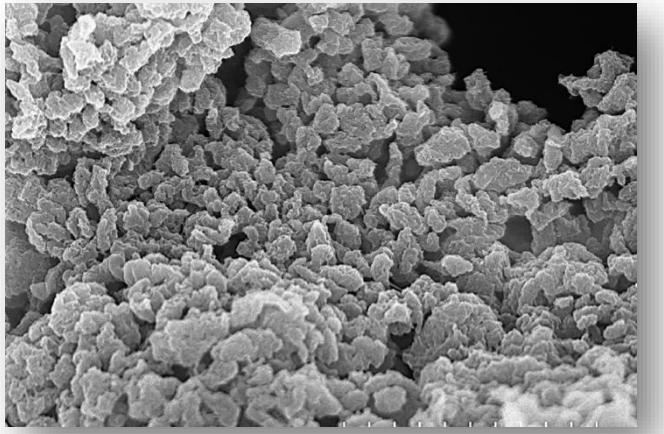
How Does a Grease Work?

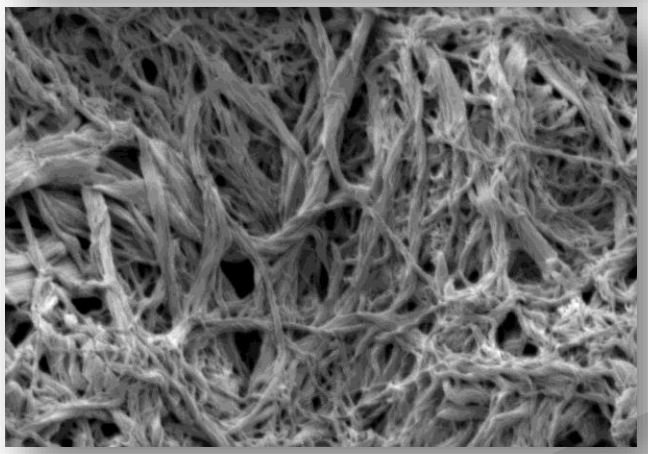
- **Thickener is the key**. It forms a 3D structure, fibrous or particulate, traps within it the liquid lubricant and additives.

- In use, the oil is squeezed out, it's a "sponge" that traps the oil.

- ***More than just a carrier***, it provides lubrication and determines many properties of the grease: consistency, shear stability and flow, water resistance.

- Can transition between semifluid and semisolid states.





Grease Composition - Thickeners

The thickener plays a key role. It possesses a type of structure, usually fibrous, which traps within it the liquid lubricant.

The thickener performs a number of functions including:

- Controls how stiff the grease will be (more thickener = stiffer)
- Determines the "dropping point" or "melting point" of the grease
- Influences the natural water resistance of the grease
- Determines how shear stable the grease is under prolonged working conditions
- Influences the pumpability of the grease
- Affects long-term oxidation stability

Why Are Greases Used Instead of Oils?

- Grease “stays in place”, has good adhesion, and is designed to lubricate equipment where a continuous oil supply can not be retained, which leads to lower costs (long term).
- Allows unattended service for long periods (SEAL-FOR-LIFE).
- Requires less frequent application for less accessible locations.
- Allows for simplification of the lubrication system and reduction in the cost of the equipment design and manufacture.

Why Are Greases Used Instead of Oils?

- Their sealing effect protects against corrosion and ingress of abrasive solids and moisture.
- Wide serviceability (load, speed, temperature & environment).
- Better under extreme conditions of temperature, pressure, shock loading low speed or intermittent operation.
- Greases allow for the use of solid additives, which can improve performance for protection of bearings and gear surfaces.

Summary of Thickener Types

- Simple Soaps
  - <150F Service
  - Most used globally
- Complex Soaps
  - <500F Service
  - Water resistant
  - Elevated Heat
- Organic Material
  - >500F Service
  - “NO Melt”
- Polymeric
  - Polyurea
  - Extended Life Service

LITHIUM COMPLEX

- General attributes of these greases are that they have high “dropping points” (melting points).
- Withstand higher temperatures of operation than simple soap greases.
- Are compatible (can be safely mixed) with simple lithium greases (very common)
- Provide very good rust protection
- Are well suited to multipurpose use

ALUMINUM COMPLEX

- Also have high dropping points, so can be used in hotter applications.
  - A unique property of aluminum complex greases is that when they are exposed to temperatures above their drop point they will melt, but will revert to their original state/structure when the temperature drops
- Resist water wash-off well.
- Are efficient as thickeners to make multipurpose greases.
- Are slow to oxidise and stiffen.
- Typically better adhesiveness than other thickeners.

CALCIUM SULPHONATE COMPLEX

- Make **excellent** multipurpose greases, but require higher levels of thickener to achieve a required degree of stiffness
- Have **superb** rust prevention properties, and will even absorb a significant amount of water before softening.
- Strong high temperature/long-life properties.
- Excellent built-in anti-wear/EP properties.
- They are typically sensitive (not suitable) to very low temperatures. Low temperature pumping is more difficult than with some other greases

BARIUM COMPLEX

- Makes greases with high thickener contents.
- Thickener is **very stringy** in nature.
- Well suited to wet applications where **adhesion & resistance to rub-off** is important.
- Good anti-wear and EP properties, but **not suited to higher-speed bearings.**
- Good for specialty greases, rather than Multipurpose.
- Petro-Canada no longer offers barium greases due to concerns with the environmental impact.

CLAY THICKENER (BENTONITE)

- These are one of the few types of **non-melt** grease.
- Can be used in very hot applications- - limited only by the life of the oil which accompanies the thickener, and the rate at which the grease is replenished .
- If left too long the grease will form “rocks” in the bearing.

Calcium Sulfonate Greases are Special

- Functionality is inverse of most other greases
- Thickener does the work
- Base oil allows the thickener to move
- Ideally permanent emulsification of oil and water
- High Dropping Point
- Inherent EP protection (thickener)
- Inherent corrosion protection (thickener)
- Inherent adhesion (thickener)
- Oxidation Stable (thickener)
- Thickener travels through bearing load zone

Make Sure the Thickeners are Compatible

- If Incompatible:
  - Typically an issue at various temperatures above 200F
  - Silica Gel and Clay may not be compatible with other greases at all temperatures
  - Thickeners may release base oil and harden
  - Thickeners may loose structural stability and soften
- Solution:
  - Completely purge old grease from service with new grease

Make Sure the Thickeners are Compatible

General Guidelines
*Exceptions are Possible

	Aluminum Complex	Calcium Stearate	Calcium Sulfonate	Calcium 12 Hydroxystearate	Calcium Complex	Clay	Lithium Stearate	Lithium 12 Hydroxystearate	Lithium Complex	Polyurea	Sodium Soap
Aluminum Complex	C	C	I	I	I	I	I	I	C	I*	I
Calcium Stearate	I	C	C	C	I	I	C	B	C	I*	I
Calcium Sulfonate	I	C	C	C	C	I	C	C	C	I*	I
Calcium 12 Hydroxystearate	I	C	C	C	B	I	C	C	C	I*	I
Calcium Complex	I	I	C	B	C	I	I	I	C	C	I
Clay	I	I	I	I	I	C	I	I	I	I	I
Lithium Stearate	I	C	C	C	I	I	C	C	C	I*	I
Lithium 12 Hydroxystearate	I	B	C	C	I	I	C	C	C	I*	I
Lithium Complex	C	C	C	C	C	I	C	C	C	I*	I
Polyurea	I*	I*	I*	I*	C	I*	I*	I*	I*	C	I
Sodium Soap	I	I	I	I	I	I	I	I	I	I	C

C	Compatible
I	Incompatible
B	Borderline Compatible
I*	Incompatible Depends on Type

Table 4.2—Compatibility Chart

Published by NLGI

The Power of Additives

- Enhance and add to functionality of base oil and/or thickener
- The right utilization of additives can render almost any grease effective in almost any service
- Common Additives
  - Extreme Pressure (i.e. Sulfur Phosphorus)
  - Tackifier (i.e. polymers)
  - Solid Lubricants (i. e. molybdenum disulfide)
  - Corrosion Inhibitors
  - Anti-oxidants
  - Friction Modifiers (graphite)
  - Dye (i.e. red, green, blue)

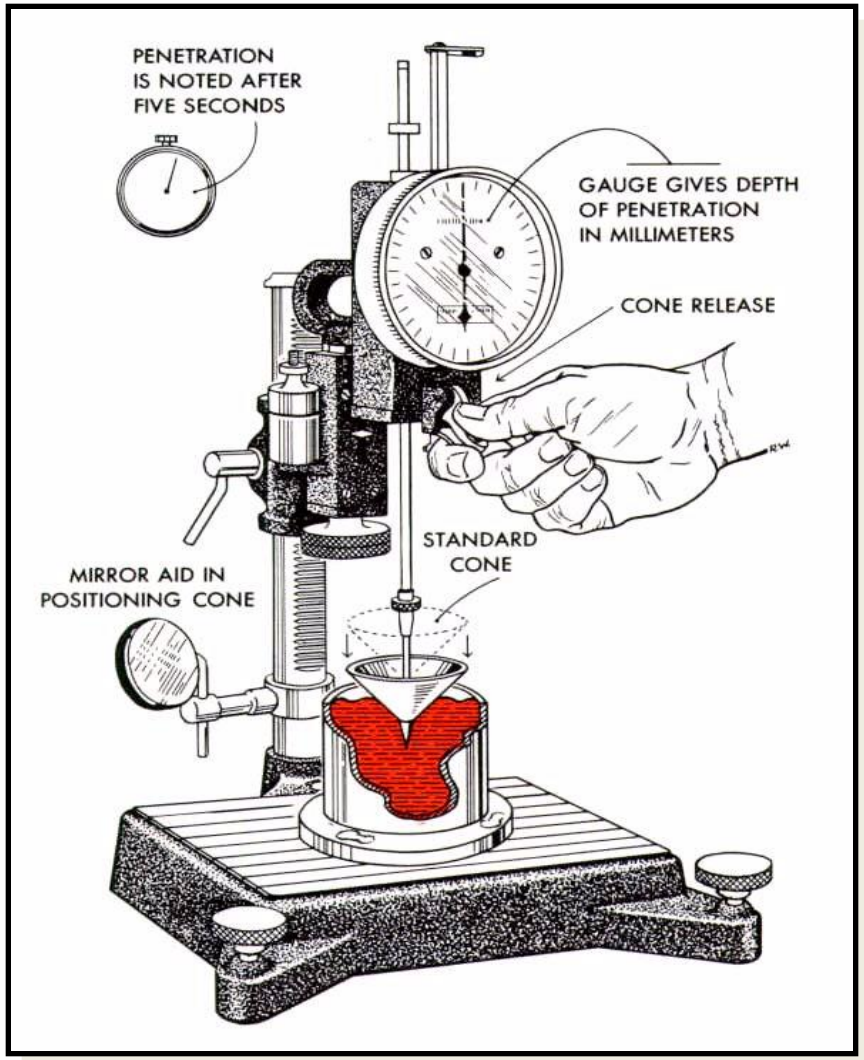
Tackifier

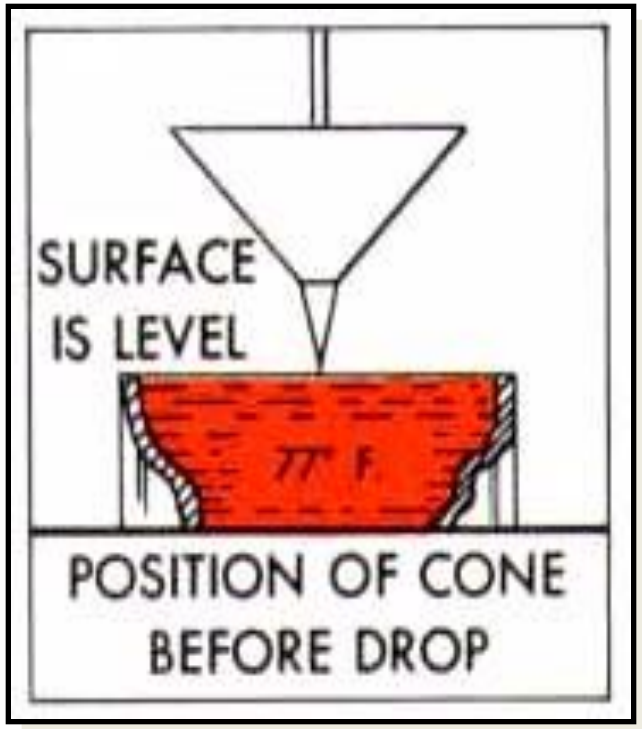
- Resists water wash
- Resists slinging
- Resists squeeze out
- Resists high temp run out
- Decreases Mobility
- Decreases pumpability

NATIONAL LUBRICATING & GREASE INSTITUTE (NLGI) CLASSIFICATION

- Greases are commonly classified according to their stiffness (or lack of it), and referred to by their NLGI Number as described on the next pages.
- That number will frequently appear in the Product name, e.g: Precision XL EP **2.**
- The NLGI grade will normally be given in any case on the TechData sheet.
- The NLGI penetration or stiffness is a function of the thickener type, thickener concentration and base oil viscosity.

PENETRATION TEST





DYE

- **Color of grease is essentially meaningless**
  - i.e., Petro-Canada's red grease may be very different from other companies' red greases
- Color is the result of a dye which is added to the grease for visual identification purposes only.

Applications

Automotive: wheel bearings, chassis pts, fifth wheels

Mining/Forestry: open gears, pinions, bearings

General Industrial: multi-service bearings, conveyor belts, threads

What Are The Primary Challenges for Grease Users?

THE PETRO-CANADA GREASE PORTFOLIO

The Petro-Canada Grease Portfolio

PETRO-CANADA LUBRICANTS

VULTREX™
NO COMPROMISE

PRECISION™
TRUSTED PROTECTION & PERFORMANCE

PEERLESS™
DEMAND THE BEST

Precision XL EP 2

PETRO-CANADA LUBRICANTS

PRECISION XL greases are formulated with Petro-Canada Hydro-treated base oils and other selected oils, water-resistant adhesive polymers, extreme pressure additives and inhibitors against oxidation and corrosion.

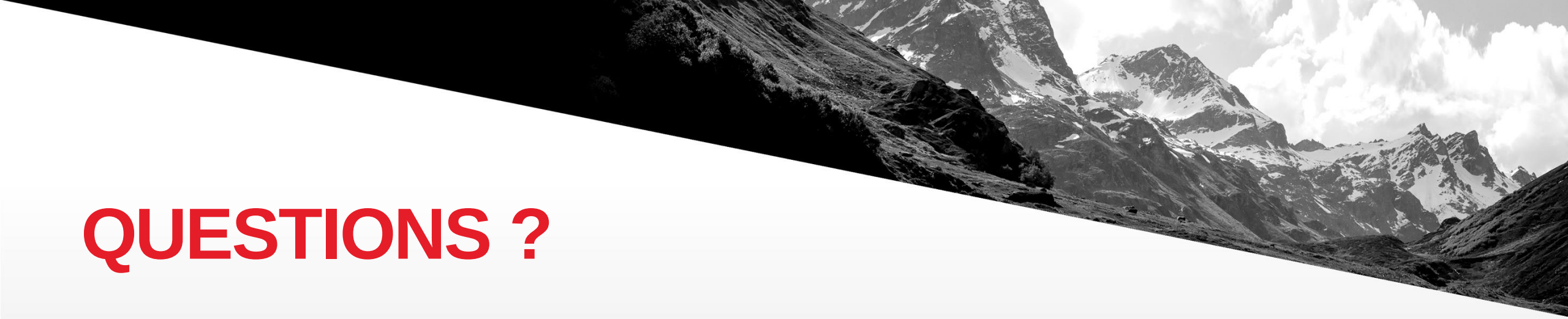
- STAY IN SERVICE UNDER TOUGH CONDITIONS
  - Water Washout 3.8% ASTM D1264
  - Operating Temperature Range -4°F to 320°F
  - Excellent rust and corrosion protection ASTM D4048 - 1B
- HIGH MECHANICAL STABILITY IN SEVERE OPERATING CONDITIONS.
  - Can also lower maintenance costs as a result of reduced product breakdowns under low tomoderately high shear conditions.

PEERLESS OG2 RED

- PEERLESS OG2 RED exceeds the NLGI's GC-LB certification for performance in automotive and heavy duty chassis applications, U-joint greasing and wheel bearing lubrication.

- Reduce bearing failure under high heat, heavy duty, moisture laden applications including some of the toughest conditions like pellet mill production and pulp press roller bearings.

- ✔ STAY IN SERVICE UNDER TOUGH CONDITIONS
  - ✔ Water Washout 2.8% ASTM D1264
  - ✔ Operating Temperature Range -13°F to 325°F
  - ✔ Excellent rust and corrosion protection ASTM D4048 - 1B
- ✔ REDUCE RE-GREASING INTERVALS
  - ✔ Reduce by up to 50% (Andritz Pelletizer)



QUESTIONS ?

THANK YOU FOR YOUR PARTICIPATION

PETRO-CANADA LUBRICANTS

A HOLLYFRONTIER BUSINESS