Agenda

- Diesel Fuel Properties Important to Mining
- Types of Diesel Fuels
  - Comparison - Seasonal Diesel/Biodiesel, #1 Diesel, Mining Diesel
- Biofuel Regulations
- Types of Renewable Fuel Blends – FAME/Biodiesel vs. HRD
- Latest Research
  - Biodiesel Blends & Low Temperature Operability
  - HRD & HRD Blends
- Operating Challenges

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Diesel Fuel Properties Important to Mining

- Flash Point
- Sulphur
- Low Temperature Operability
- Lubricity
- Density

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Diesel: Flash Point

- ***What is it?***
  - The lowest temperature at which a volatile material can vaporize to form an ignitable mixture in air
- ***Why is it important?***
  - It is used to help characterize the fire hazards so that it can be safely handled
- ***What is the flash specification?***
  - CGSB national standard - minimum flash point of diesel fuel in Canada is 40°C
  - A higher flash point may be specified for underground mining applications in certain provinces
  - Suncor Mining Diesel minimum flash point is 52°C

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Diesel: Sulphur

- ***What is it?***
  - Diesel fuel contains sulphur, which is derived from the original crude oil and can still be present after refining
- ***Why is it important?***
  - Sulphur levels in diesel fuel can contribute to emissions and particulates in exhaust
  - Ultra low sulphur diesel (ULSD) ensures compatibility with exhaust after-treatment technology
- ***What is the specification?***
  - Sulphur in diesel regulations:
    - Max 15 ppm production and import limit
    - Max 15 ppm for use in On and Off-Road vehicles

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Diesel: Low Temperature Operability (LTO)

- ***What is it?***
  - Cloud point defines the temperature at which the smallest observable cluster of hydrocarbon crystals (wax crystals) first appears in a fuel upon cooling under prescribed test conditions. Cloud point is the most common measure of low-temperature operability.
  - Low-temperature operability can also be determined by the Low Temperature Flow Test (LTFT), which is a timed filterability test
- ***Why is it important?***
  - Wax crystals may block fuel filters on diesel engines and in distribution lines.
- ***What is the specification?***
  - LTO specifications are based on the 2.5% low-end design temperature data for the last 30 years for the location of intended use.

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Cloud Point Map / Schedule

TABLE 3 - CLOUD POINT SCHEDULE REQUIREMENTS FOR ONTARIO (MAXIMUM °C)

Periods	Zones							
	ON-1 GTA SW Ontario	ON-2 Ottawa	ON-3 Barrie Bracebridge Huntsville Orillia	ON-4 Pembroke Petawawa Barry's Bay	ON-5 North Bay Sudbury S.S. Marie	ON-6 Chapleau Timmins Wawa	ON-7 Thunder Bay Dryden Kenora Red Lake Sioux Lookout	ON-8 Armstrong Pickle Lake Hearst
Jan 1 – 15	-23	-25	-25	-30	-29	-36	-34	-36
Jan 16 – 31	-22	-25	-24	-30	-29	-34	-34	-35
Feb 1 – 15	-20	-22	-22	-28	-28	-32	-34	-36
Feb 16 – 28/29	-18	-21	-21	-27	-23	-30	-29	-26
Mar 1 – 15	-16	-19	-18	-23	-22	-28	-18	-34
Mar 16 – 31	-12	-12	-13	-16	-16	-22	-21	-29
Apr 1 – 15	-7	-9	-7	-8	-10	-15	-14	-23
Apr 16 – 30	-3	-1	-2	-5	-5	-9	-8	-16
May 1 – 15	-1	-1	-1	-3	-1	-4	-4	-9
May 16 – 31	-1	-1	-1	-1	-1	-2	-2	-5
Jun 1 – 15	-1	-1	-1	-1	-1	-1	-1	-2
Jun 16 – 30	-1	-1	-1	-1	-1	-1	-1	-1
Jul 1 – 15	-1	-1	-1	-1	-1	-1	-1	-1
Jul 16 – 31	-1	-1	-1	-1	-1	-1	-1	-1
Aug 1 – 15	-1	-1	-1	-1	-1	-1	-1	-1
Aug 16 – 31	-1	-1	-1	-1	-1	-1	-2	-1
Sep 1 – 15	-1	-1	-1	-2	-1	-3	-4	-5
Sep 16 – 30	-2	-2	-2	-4	-4	-6	-6	-10
Oct 1 – 15	-6	-6	-7	-8	-10	-15	-16	-20
Oct 16 – 31	-9	-13	-10	-15	-14	-20	-22	-27
Nov 1 – 15	-16	-18	-17	-23	-22	-28	-29	-33
Nov 16 – 30	-18	-22	-19	-26	-26	-32	-33	-37
Dec 1 – 15	-23	-25	-25	-29	-29	-36	-34	-36
Dec 16 – 31	-23	-25	-25	-30	-29	-36	-34	-36

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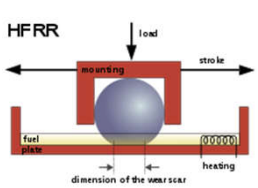
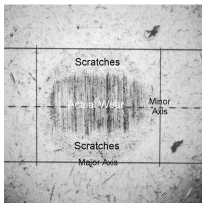
Diesel: Lubricity

- ***What is it?***
  - Lubricity is a measure of the lubricating quality of a diesel fuel. Diesel fuel with sufficient lubricity will protect most fuel pumps and fuel injectors from premature wear.
- ***Why is it important?***
  - Processes used to desulphurize diesel fuel reduce the natural lubricating qualities of the diesel fuel
  - Since diesel fuel acts as a lubricant for injection systems and pumps, the diesel fuel should have sufficient lubricity to give adequate protection against excessive wear
  - FAME biodiesel has excellent lubricity
  - Additives may be used to improve diesel fuel lubricity
- ***What is the specification?***
  - Specified in CGSB specs and can be tested by different test methods





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Diesel: Density

- ***What is it?***
  - Density is the weight of fuel (in kilograms) per litre or m3 at 15 °C.
- ***Why is it important?***
  - Denser fuel has higher energy content - giving higher power output or greater fuel economy in a diesel engine. Since petroleum fuels expand at higher temperatures and contract at lower temperatures, density is measured at ambient conditions but converted to density at 15 °C to harmonize with international trading practices.
- ***What is the specification?***
  - Not a CGSB specification
  - Typical diesel density is in range of 830-850 kg/m3

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Types of Diesel Fuels – Comparison

- Seasonal diesel – #2 ULSD (Ultra Low Sulphur Diesel) or Type B, CGSB
  - Conventional (Petroleum) - B0
  - Biodiesel Blend (5% FAME + 95% Petroleum) - B5
- #1 Diesel or Type A, CGSB
- Mining Diesel - #2 ULSD or Type B, CGSB

Property	Seasonal Diesel, Seasonal Biodiesel (B5)	#1 Diesel	Suncor Mining Diesel	Key Benefits
Flash	≥ 40˚C	≥ 40˚C	ON ≥ 60˚C AB ≥ 52˚C	Higher flash point provides safer working conditions
Sulphur	Max 15 ppm	Max 15 ppm	ON – typically <1 ppm AB – typically <5 ppm	Fuel with lower sulphur content produces less sulphur dioxide (SO_2) and less particulates when burned - improved air quality and emissions
Cloud Point	Varies seasonally by location ON typically 0 to -20˚C AB typically 0 to -40˚C	No seasonal variation ON max -36˚C year-round AB max -43˚C year-round	Minimal seasonal variation ON - typically < -30˚C AB - typically -20 to -40˚C	Better low temperature operability allows simpler storage and less concerns with tank inventory turn over in fall

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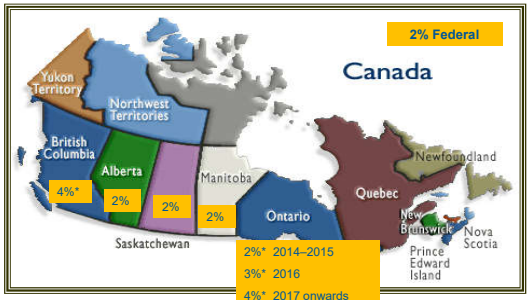
Biofuel Regulations

- **Existing regulations** - Federal & Provincial regulations for bio-content in diesel have been in place for many years
  - Some regulations factor in carbon intensity (CI) such as the Low Carbon Fuel Standard (LCFS) in BC
  - CI is the full lifecycle greenhouse gas emissions from the production (petroleum & renewable), processing, transport, storage, dispensing and use of a fuel

Min Volume % of Diesel Biofuel in Diesel Pool



*CI: Carbon Intensity regulations

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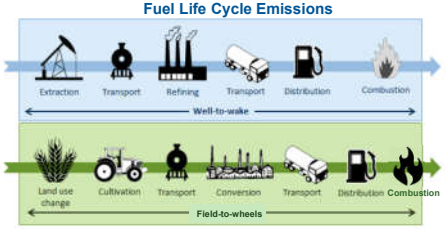
Biofuel Regulations

- **Pending regulations** - Clean Fuel Standard (CFS) / Clean Fuel Regulation (CFR)
- CFR requires liquid fossil fuel primary suppliers (i.e. producers and importers) to reduce the average carbon intensity (CI) of liquid fuels used in Canada from 2016 baseline levels. The CI reduction is expected to deliver greater than a 20 Mt CO_2e reduction in GHG emissions in Canada by 2030.
  - There are various options to reduce the carbon intensity of fuel combustion – blending biofuels, co-processing biomass during refining, and fuel-switching such as electrification or hydrogen fuel cells
- Growing requirement for lower carbon biofuels to help meet net zero
  - Regulations will push fuel suppliers to increase renewable content in fuels
  - Directionally better emissions with more HRD
  - More winter blending of biodiesel with cold flow improver additive
  - Provincial regulations may also push the requirement for low carbon fuels

Fuel Life Cycle Emissions



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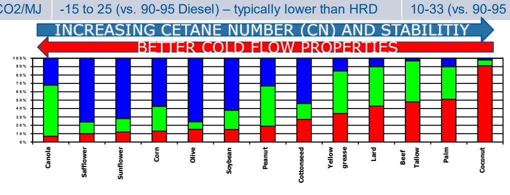
Types of Renewable Fuel Blends – FAME/Biodiesel vs HRD

	FAME / Biodiesel (Fatty Acid Methyl Ester)	HRD (Hydrotreated Renewable Diesel)
Technology	Transesterification	Hydroprocessing
Feedstock	Typically more plant based - virgin oil seed (soy or canola). Can also be tallow/lard, used cooking oil (UCO)	Plant, animal or waste based
Quality Issues	Low temperature quality issues Cold flow improver additive required in winter	Indistinguishable to diesel Amount adjusted to meet LTO
Cloud Properties	High Cloud	Lower Cloud than FAME
Stability	Marginal	Good
Blending Season	May be seasonal	Year Round
Blending Percentage	Typically up to 5% (B5) Options for B10, B20	Typically up to 30%
Location	At select terminals	At select terminals
Carbon Intensity, gCO2/MJ	-15 to 25 (vs. 90-95 Diesel) – typically lower than HRD	10-33 (vs. 90-95 Diesel)

Effects of Feedstock on FAME Properties



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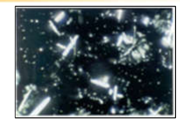
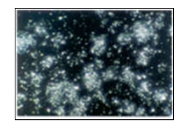
Graph Source:http://www.biodiesel.org/docs/default-source/ffs-performace_usage/cold-flow-basics---ppt.ppt%3Fsfvrsn%3D6&sa=U&ei=XwGsVIXpC5KVyATm5YCgAw&ved=0CAUQFjAA&client=internal-uds-cse&usg=AFQjCNH5s0i2dwbCO3WylBMKiV3Wqnmcgw

Latest Research – Biodiesel Blends & Low Temperature Operability

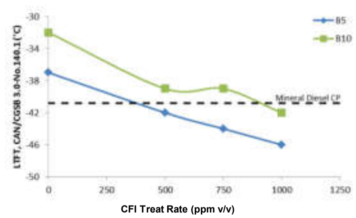
- Researching ability to utilize biodiesel through winter months
  - Performed low temperature operability testing of additized biodiesel blends
- Cold flow improver (CFI) additive is added to biodiesel to improve flow in cold weather and allow use of biodiesel through the winter
  - Cold flow improver additive modifies crystals and prevents agglomerations of crystals that would normally plug a filter.
  - The crystals still exist, thus cloud point testing is not used. Instead, use Low Temperature Flow Test (LTFT), which is representative of field performance. LTFT test was designed for heavy duty equipment in Canada.

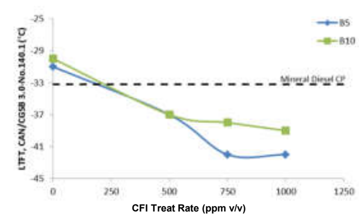


Without CFI



With CFI





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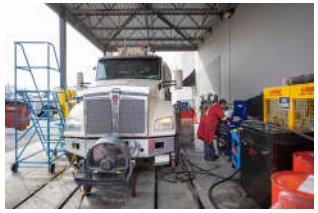
Latest Research – HRD & HRD Blends

- Current HRD blend limits are typically 30% maximum.
- Researching higher blends (50% and 100%) of HRD renewable diesel, in the lab and in the field.
- Why? Alternatives of more sustainable fuels for our customers and for the environment.
- Lab testing - Gen-set / Heavy-duty trucks / Engine testing: as applicable to power, marine and truck applications
- Field Testing in northern and southern BC (northern BC started in February)
  - Northern trial showed that HRD is truly a drop-in fuel. Southern trials are on-going and showing excellent results.



- https://www.pumptalk.ca/2021/03/supporting-a-lower-carbon-future-with-petro-canadas-hydro-treated-renewable-diesel-trials.html

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Operating Challenges

- **Storage Issues**
  - Diesel product in storage must be kept clean and dry to prevent unacceptable levels of contaminants and filter plugging.
  - Tanks should be "dipped" regularly for water with water-finding paste or a tank bottoms sample should be checked for presence of water or particulates. Pump/drain any water off tank bottoms.
    - Solubility of water in fuel changes with temperature. On cooling, excess water can drop out of diesel resulting in free water. Cloudy/hazy fuel is often the result of free water in fuel that hasn't settled out yet.
    - If the fuel temperature is below 0°C, the water can turn into ice crystals, which can cause filter issues
    - Biodiesel has a higher capacity to hold water than conventional diesel.
    - Water bottoms in fuel can lead to microbial growth and corrosion. Microbial growth is rare, but possible in warmer temperatures.
  - Drain any fuel/water separators regularly
  - If using biodiesel blends, recommend using glass fiber filters
  - If heating fuel in the winter, you should prevent over-heating of product that could lead to product degradation.
  - Vent on fuel storage tank should be designed to prevent ingress of water.

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Operating Challenges

- **Seasonal Transition**
  - Carrying too much summer diesel into the winter can result in insufficient tank turnover and low temperature operability problems, such as plugging filters, when the cold weather hits
  - Tank inventories should be run to lower levels in the fall to allow sufficient tank turnover to lower cloud diesel
  - Unadditized biodiesel blends (no cold flow improver) should be turned over to conventional diesel prior to winter unless tanks are heated

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Thank you!

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Appendix

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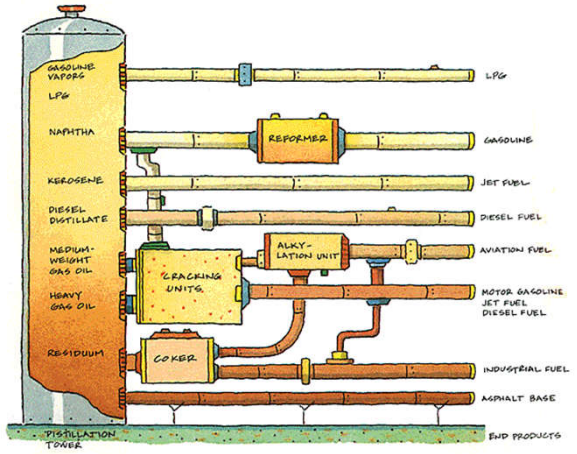
Simplified Gasoline and Diesel Production at a Refinery



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