Diesel Fuel & Alternative Fuels

Now and for the Future

Jack Blanchard

Captains Three Marine Services

Today's Topics

- Diesel Fuel
- Bio-Diesel
- Fischer Tropsch Fuel

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Diesel Fuel is changing composition.

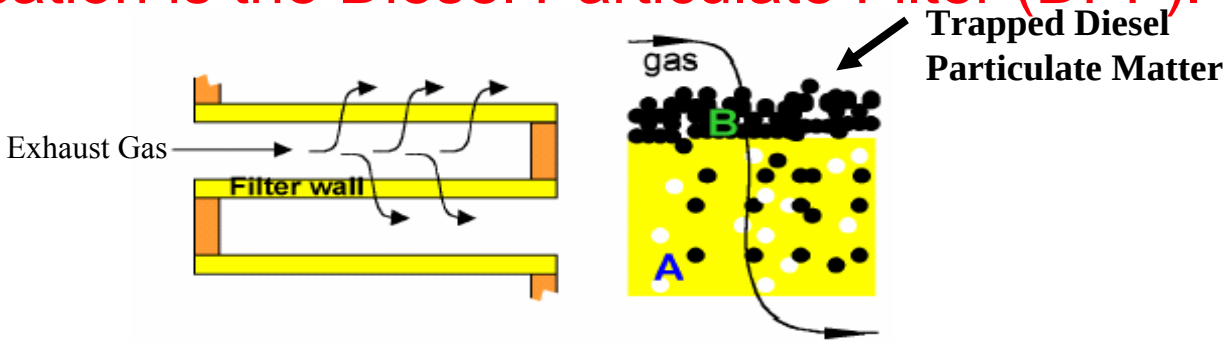
- The change started in June of 2006

Why is there a change in diesel fuel?

- Emission regulations for on-highway vehicles creates requirements for lower sulfur fuels.

- Aftertreatment devices do not function properly with sulfur level above 15 ppm. The device that is being used on most automotive application is the Diesel Particulate Filter (DPF).

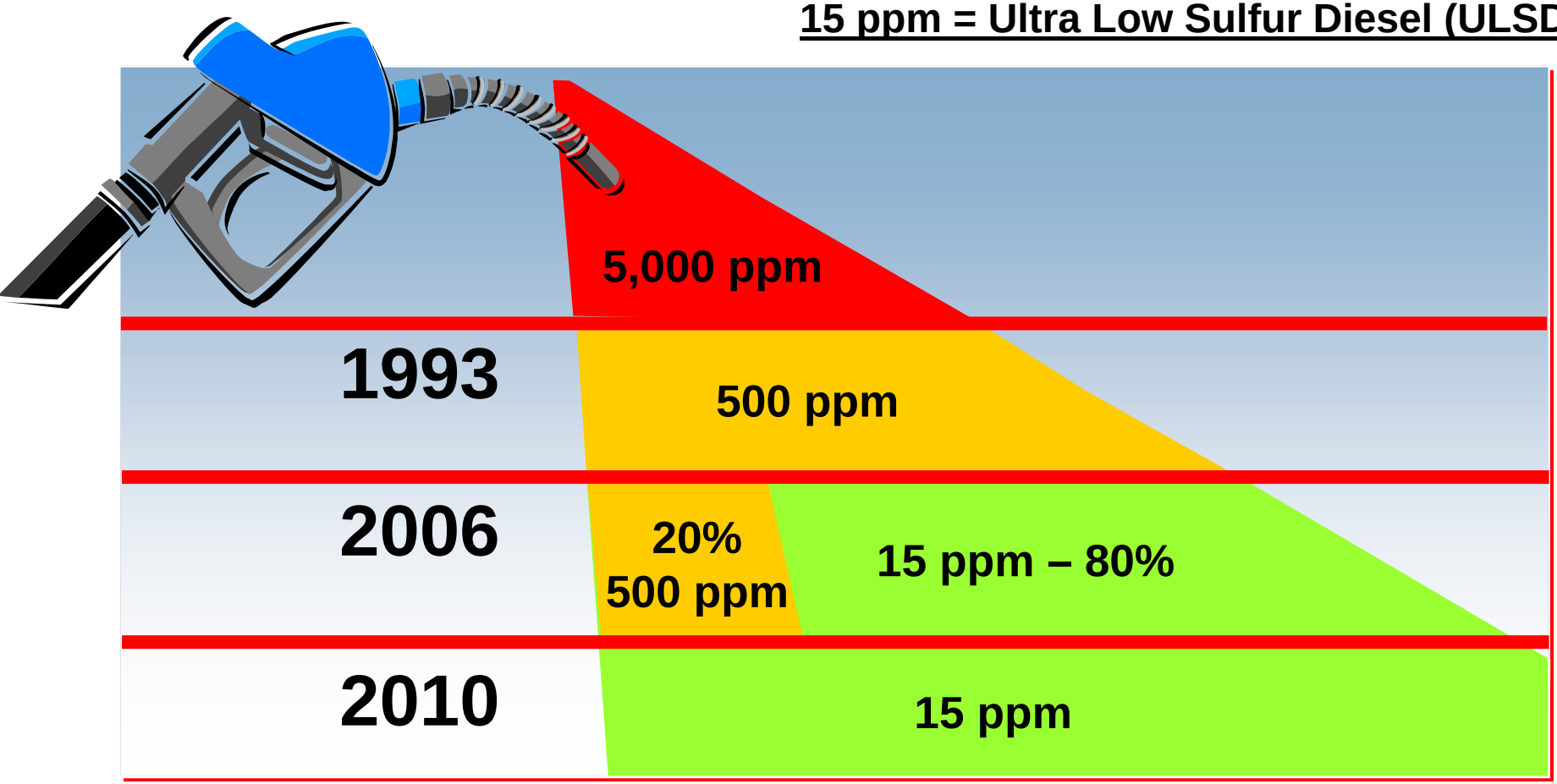
How the DPF Works



The EPA plans to roll out **new** emissions standards for off highway, marine and industrial operations. They have started a systemic reduction in the sulfur that is contained in diesel fuel to assist the manufactures in meeting the emissions requirements.

Reducing Diesel Fuel Sulfur

15 ppm = Ultra Low Sulfur Diesel (ULSD)



Who knows what diesel fuel you are using now?

DIESEL FUEL SPECIFICATIONS
(ASTM D 975 SUMMARY)

	Low Sulfur No. 1-D	Low Sulfur No. 2-D	No. 1-D[A]	No. 2-D[A]
Flash Point, °F, minimum	100	125	100	125
Cloud Point, °F	[B]	[B]	[B]	[B]
Water & Sediment, % vol. max.	0.05	0.05	0.05	0.05
Distillation Temperatures, °F				
90% recovered, minimum	--	540	---	540
maximum	550	640	550	640
Viscosity @ 40°C, cSt				
minimum	1.3	1.9	1.3	1.9
maximum	2.4	4.1	2.4	4.1
Sulfur, % weight, maximum	0.05	0.05	0.50	0.50
Cetane Number, minimum	40	40	40	40
One of the following properties must be met:				
(1) Cetane Index, minimum	40	40		
(2) Aromatics, % vol., max.	35	35		

[A] Grades No. 1-D & 2-D are required to contain a sufficient amount of red dye to meet tax agency regulations.

[B] The cloud point should be approximately 11°F colder than the lowest temperatures that will occur 90% of the time.

Diesel Fuel Specifications

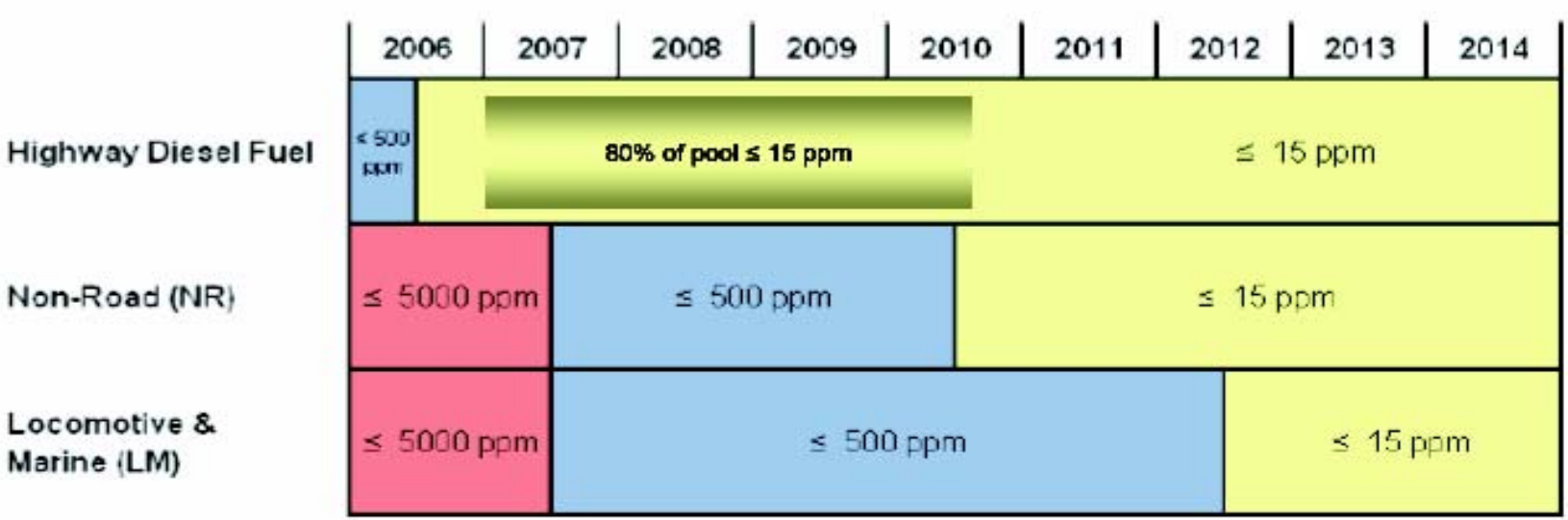
How is the sulfur Level Identified?

5000 ppm sulfur = .500 % weight

500 ppm sulfur = .050 % weight

15 ppm sulfur = .0015 % weight

ULSD Timeline



≤ 15 ppm = ULSD
≤ 500 ppm = LSD
≤ 5000 ppm = HSD

Sulfur Levels of other products Today

Off-highway / heating oil <5000 ppm

Jet Fuel <3000 ppm

Kerosene <2000 ppm

Low sulfur diesel <500 ppm

Ultra low sulfur diesel < 15 ppm

Sulfur Levels of other products June 2007

Heating oil <5000 ppm

Jet Fuel <3000 ppm

Kerosene <2000 ppm

Off Highway/Low sulfur diesel <500 ppm

Ultra low sulfur diesel < 15 ppm

Concerns

- Lubricity
- Seal Compatibility
- Switch Loading
- Fuel Stability
- Contamination

Lubricity:

- Ultra-Low-Sulfur-Diesel (ULSD) fuel lacks sulfur components that contribute to lubricity. New ASTM Standards **do** mandate lubricity levels in the fuel.
- New/Future systems will be compatible with ULSD fuels-
  - Compatibility with higher sulfur fuels???
- Legacy (old) systems are at risk since designed for today's fuels.
  - Fuel Pump and Injectors manufacturers already advising of problems for legacy systems when using ULSD.

Seal Compatibility

–ULSD fuel will have lower aromatic contents which affects how seals react.

–Legacy (old) systems exposure to lower aromatic fuels could result in fuel leakage due to seal shrinkage. Aged seals, which do not have the elasticity to adapt to this change, appear to fail sooner.

–The new ULSD fuels are expected to be more susceptible to oxidation. The resulting oxidation products (peroxides) could attack the seal material and cause it to prematurely age.

–Should elastomer failures occur, they are expected to be sporadic. Seals in some engines may fail while similar seals in other engines using the same fuel may not.

–Past experience indicates that the common denominator is expected to be nitrile rubber (Buna N) seals that have seen long service at high temperatures.

– High temperatures have a tendency to accelerate seal aging. The reduction in sulfur content is not responsible for the problem.

Switch loading

–Switching back and forth between fuels can affect how materials and elastomers/seals react.

- There is a “curing” time for different sulfur level in fuels for materials/seals.
- Materials/Seals also have a “curing’ time for aromatics which can introduce fuel leakage and switch loading can damage seals.

Accelerated Stability

–Diesel fuel should be stable under normal storage and use conditions. Unstable fuel will darken and form black particulate materials which will cloud fuels and create gum residues in the fuel system.

–**There are two types of stability:**

- **–Thermal Stability**
- **–Oxidation Stability**

Thermal Stability. ASTM D975 does not include a specification for thermal stability; however, the standard does include thermal stability guidelines for normal and severe use.

The requirement is particularly important with respect to ULSD fuels, as the natural thermal stability of diesel fuel is expected to decrease as sulfur is removed during the refining process used to produce these fuels.

Oxidation Stability - ASTM D975 does not include a specification for oxidation stability. The natural anti-oxidation properties of diesel fuel are expected to decrease as sulfur is removed during the refining process.

Fuel Contamination

–A certain amount of water is always found in fuel oil and additional water can come from condensation in the storage tank and during tank filling.

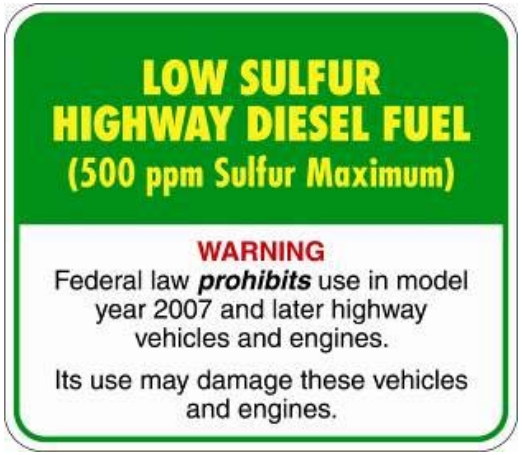
–The water normally separates out and remains at the bottom of the fuel tank in direct contact with the metal surface.

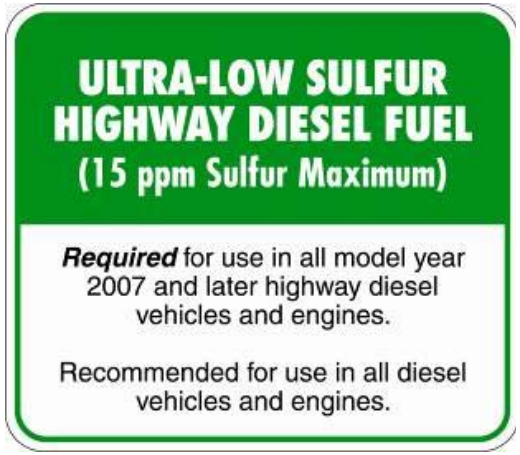
–Under the right conditions, microorganisms can grow at the water/oil interface and contribute to an increased in the amount of sediment in the tank.

–Water Coalescing elements can be added to help remove water.

Diesel Fuel

Labels Required Beginning June 1, 2006





Today's Topics

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- Bio-Diesel
- Fischer Tropsch Fuel

Biodiesel

A fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable or animal fats, designated B100.

(ASTM D6751)

How is Biodiesel Made?

Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil.

The process leaves behind two usable products –

- Methyl esters (the chemical name for biodiesel)
- Glycerin

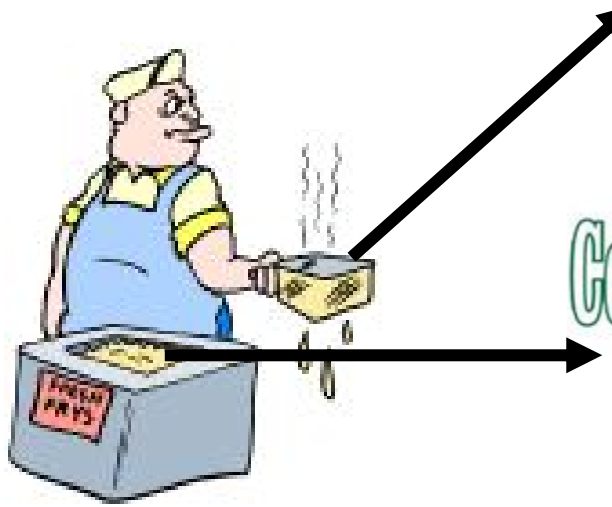
How can Biodiesel be used?

The 100% biodiesel is blended with regular diesel fuel:

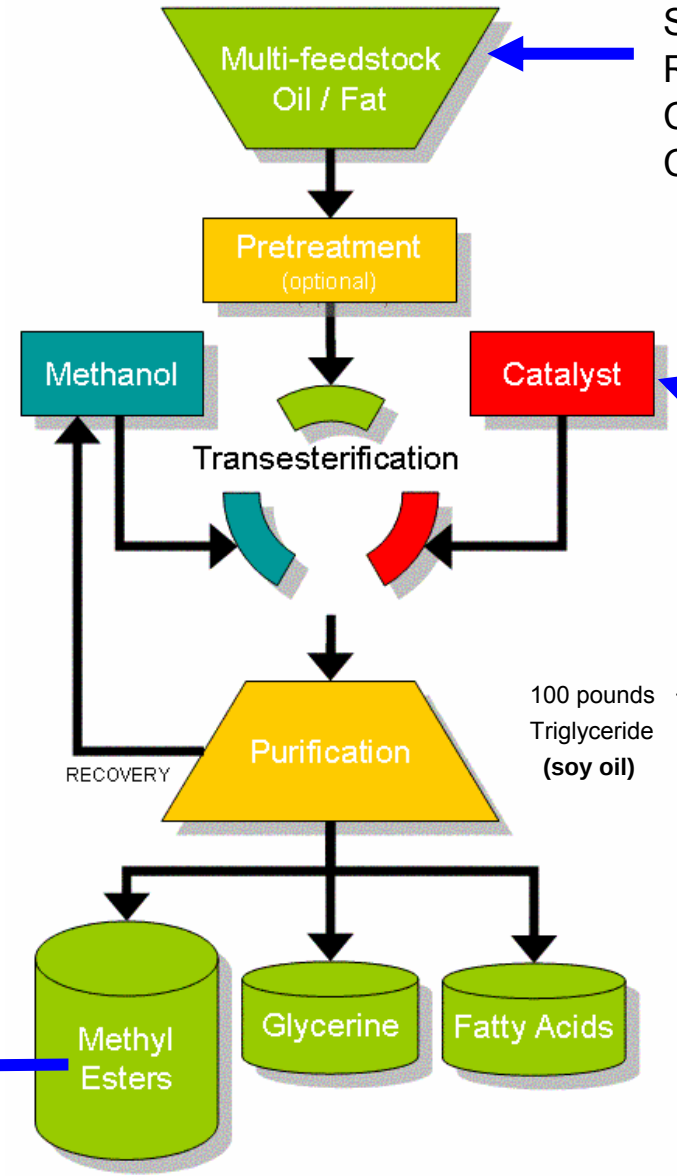
- ❑ In low levels with diesel (1 to 5%) (B1 to B5)
- ❑ As a higher blend with diesel (20%) (B20)
- ❑ B20 is the most commonly proposed blend for future use

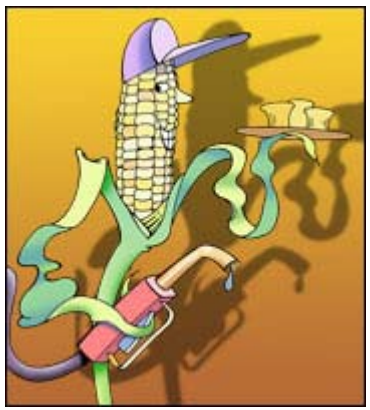
What can biodiesel be made from

- A man in Germany proposed using dead cats.
- Another plan was to use chicken manure
  - That could be called CS Biodiesel
- Recycled vegetable oil
- Virgin vegetable oil
- Soybean oil
- Rapeseed oil
- Sunflower oil
- Jatropha
- Animal Fat



Superior™ Continuous Transesterification Process





Biodiesel

US Park Service
Channel Islands National Park

- Launched in October 2001
- Powered by twin Caterpillar 3406 engines specified for neat biodiesel.
- Average biodiesel use @ 800-1,000 gallons per month.

58’ Fiberglass

Some points you should be aware of when using biodiesel:

- Less energy content
- Low temperature properties
- Compatibility with seals & elastomers
- Coking and deposits
- Oxidation stability
- Microbial contamination
- Lube oil degradation
- Fuel Filter Effectiveness

Less energy content

- **Biodiesel has less energy content than standard diesel fuel.**
- **If you are using B20, power, torque, and fuel economy should be between 1% and 2% lower compared to standard diesel fuel.**
- **As the percent biodiesel in the blend is lowered, any differences in energy content become diminished.**

Low temperature properties

The chart below shows results for biodiesel and Number 2 diesel fuel at various concentrations. The data shows that the mixture starts to gel sooner as the concentration of biodiesel increases. High concentrations of biodiesel (i.e. blends over 20%) may not be appropriate for use in cold climates.

Biodiesel Concentration (vol %)*	Cloud Point Degrees F
0	3
10	5
20	7
30	14
50	18
100	32

*** Blended with Number 2 diesel fuel**

Compatibility with seals & elastomers

- Elastomer compatibility with biodiesel remains unclear; therefore, when biodiesel fuels are used, the condition of seals, hoses, gaskets, and wire coatings should be monitored regularly.
- Nitrile rubber hoses degrades in biodiesel. If a vessel's fuel system does contain these materials, replacement with biodiesel compatible elastomers such as Viton B is recommended.
- As biodiesel oxidizes it can form peroxides which can cause brittle failures or softening

Compatibility with metallic compounds

- Brass, bronze, copper, lead, tin, and zinc may accelerate the oxidation process of biodiesel creating fuel insolubles or gels and salts. Lead solders and zinc linings should be avoided, as should copper pipes, brass regulators, and copper fittings. Affected equipment should be replaced with stainless steel, carbon steel, or aluminum.

  - Additives help to mitigate this
  - Blends of B20 and lower reduce the impact of metal compatibility issues.

- Biodiesel is a good solvent, may harm some painted surfaces and clog filters when first switching.

Coking and deposits

- Neat biodiesel and higher percentage biodiesel blends can cause a variety of engine performance problems, including injector coking, piston ring sticking and breaking.

Oxidation stability

- **Biodiesel has a greater tendency to oxidize than standard diesel fuel and, thus, has a shorter storage life than standard diesel fuel. Frequent turnover of fuel in the tank is recommended to minimize problems.**

- **B20 may degrade faster than diesel if oxidizing metals such as copper, bronze, brass, or zinc are in fueling systems. If filter clogging occurs more frequently with B20 than with diesel, the fueling system should be checked for these materials and they should be replaced with biodiesel compatible parts.**

Microbial contamination

- Biodiesel, due to its biodegradability, is more water absorbent than fossil fuels. Water has to be tightly controlled in order to avoid severe engine fuel system problems, fuel problems, and microbial growth which can grow explosively in biodiesel/water environments.

Lube oil degradation

"***Biodiesel fuel may cause a chemical reaction with lube oil resulting in oil sludging***"

Fuel Filter Effectiveness

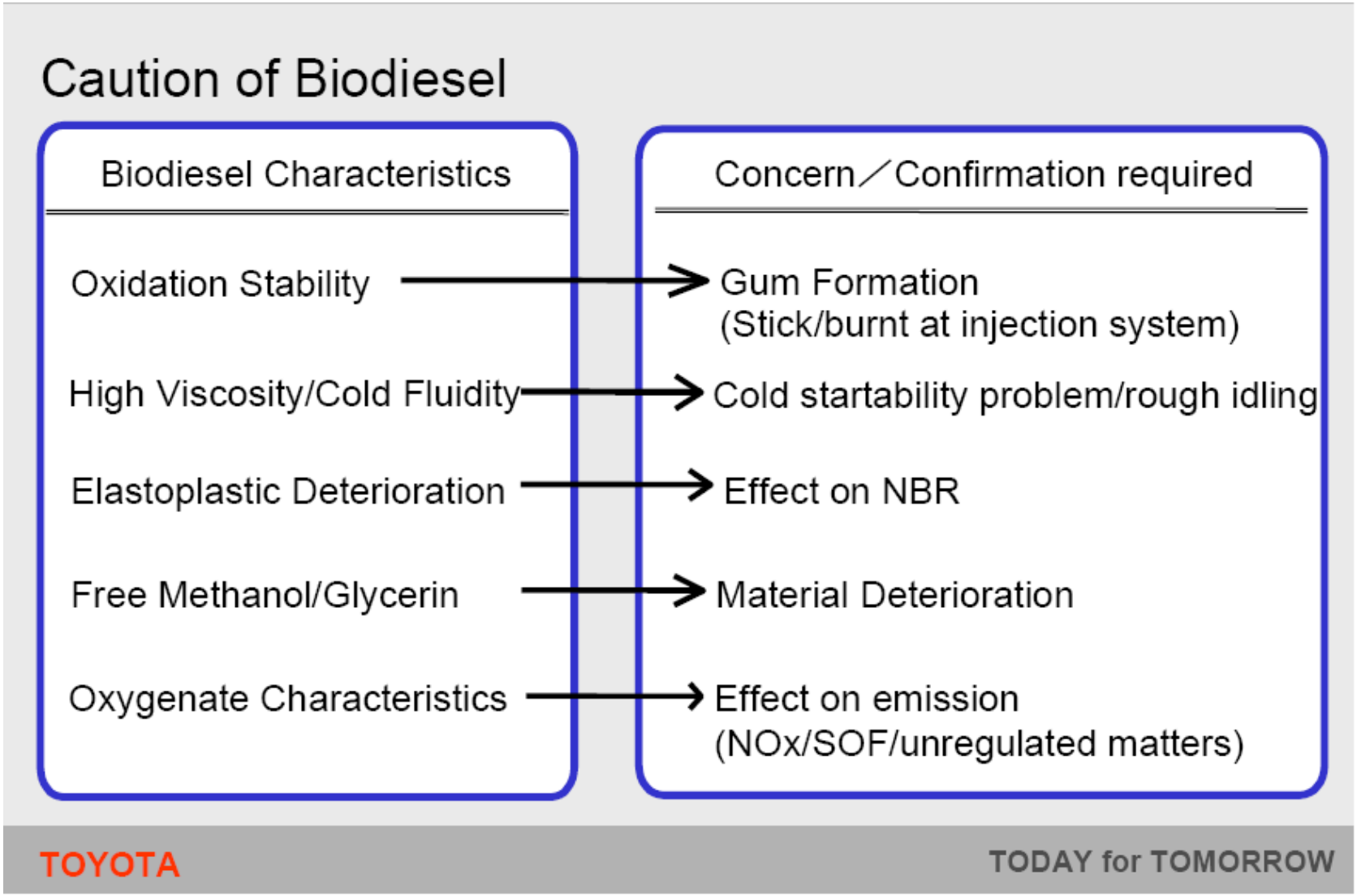
- **Biodiesel reduces the surface tension of the blended fuel, which results in the water separator coalescing element in your vessel's fuel filter to be ineffective.**
  - **Any water in the fuel will pass through the filter and may cause corrosion damage to the fuel system.**
- **Biodiesel affects cellulose type filters and can lead to fuel filter failure.**
- **Biodiesel has a cleaning effect on accumulated sediments in tanks, and filter plugging may be experienced.**

Recent Biodiesel Quality Concerns

Minnesota B2 Quality Problems

- The state of Minnesota was the first in the nation to require diesel fuels sold in the state to be blended with biodiesel at 2 vol%.
- The state has had numerous quality problems since its B2 program began in September 2005, The most recent waiver was granted in January 2006.
- Some of the biodiesel produced in the state is not meeting, with preliminary testing showing that a few batches of biodiesel contain high levels of glycerin.
- At the same time, truckers complained of sputtering, stalled vehicles during cold spells and gummy deposits that are plugging fuel lines.
- Of 90 fleets responding, 62% experienced fuel filter plugging and of those, 66% experienced repeated plugging on the same truck, reporting a black sludge or wax in their filters.

This shows that all manufactures have concerns:



EPACT

In 1998, Congress passed the Energy Conservation Reauthorization Act (ECRA). This legislation modified the 1992 Comprehensive Energy Policy Act allowing EPACT credits to be satisfied with biodiesel purchases. Specifically, the purchase and consumption of 450 gallons of biodiesel (used in a 20% blend or higher) by a fleet results in one EPACT credit.

Under EPACT most Federal and State controlled fleets and Alternative Fuel Provider fleets are mandated to purchase alternative fuel vehicles for up to 90% of all new vehicle purchases. The biodiesel provisions under ECRA makes biodiesel use one of the most cost effective means of complying with the EPACT mandates.

Additional Biodiesel Information is available from:

NBB Technical Library

National Biodiesel Board

www.biodiesel.org

1-800-841-5849

Remember that the National Biodiesel Board is a marketing organization that is trying to promote biodiesel.

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Fischer-Tropsch process (fĭsh’ar-trōpsh) ,

A method for the synthesis of hydrocarbons and other aliphatic compounds. Synthesis gas, a mixture of hydrogen and carbon monoxide, is reacted in the presence of an iron or cobalt catalyst; much heat is evolved, and such products as methane, synthetic gasoline and waxes, and alcohol's are made, with water or carbon dioxide produced as a byproduct. An important source of the hydrogen–carbon monoxide gas mixture is the gasification of coal. The process is named after F. Fischer and H. Tropsch, the German coal researchers who discovered it in 1923.

Its chemical equation is $(2n + 1)H_2 + nCO \rightarrow C_nH_{2n+2} + nH_2O$

Currently, only a handful of companies have commercialized their FT technology.

- Shell in Bintulu, Malaysia, uses natural gas as a feedstock, and produces primarily low- Sulfur diesel fuels and food-grade wax.
- Sasol in South Africa uses coal and natural gas as a feedstock, and produces a variety of synthetic petroleum products. Sasol produces most of the country's diesel fuel.

Fischer-Tropsch process can produce diesel fuel from:

- ☑ **natural gas**
- ☑ **coal**
- ☑ **tar sand**
- ☑ **bio-mass.**

In Sept. 2005, Pennsylvania governor Edward Rendell announced a venture with Waste Management and Processors Inc. -- using technology licensed from Shell and Sasol -- to build an FT plant that will convert so-called waste coal (leftovers from the mining process) into low-sulfur diesel fuel at a site outside of Mahanoy City, northwest of Philadelphia.

Reasons for use of **Fischer-Tropsch**

Gas-to-Liquids (GTL) Conversion

- Some remote natural gas can now be economically converted through a GTL process into an ultra-clean fuel for diesel engines.
- Discussions are underway to develop a GTL production facility in Alaska to produce 40,000 barrels per day (23% of our current demand) with a goal to produce 300,000 bbl/d. However, with existing technology, oil pipeline capacity and North Slope gas reserves over 1,000,000 bbl/d could be produced.
- Natural gas, is four times more expensive to transport than oil.
- Converting natural gas to a liquid through a Fischer-Tropsch technology provides an opportunity to expand the use of the natural gas and lower the transportation cost from remote sources of low-cost gas.

Questions

The End