Biodiesel - U.S. Overview

- Many U.S. Customers requiring certification for ≤ B20 operation.
  - "EPACT"(*) tax incentives encourages certain fleet use of B20.
- Some state Legislation will require biodiesel use.
  - Minnesota requires B2 in July 2005.
  - Some other states, legislation in process.
- Existing ASTM spec. insufficient to protect consumer.
  - No Oxidation Stability measure.
  - No blend (e.g. B20) specification.
- Working with our customers to better define system effects from using U.S. sourced biodiesel fuels.
  - European experience with different feed stocks not necessarily transferable.

(*) Energy Policy Act, requires Fed. Gov. fleets to reduce by 20% petroleum usage.

BOSCH

Soy vs. Rapeseed FAME (Fatty Acid Methyl Ester)

Carbon Chains: # C : dbl-bonds	Soy	Rapeseed (Canola)
	%	%
14/15	1	
16 : 0	12	5
18 : 0	4	2
18 : 1	25	63
18 : 2	52	20
18 : 3	6	9
20 +		1
% of US oil / fat feedstock (1)	53.8	1.8
Total: 3.5 billion gal/yr (1)		
(1)=circa 2000		

- As % of double bonds increase...
  - Cetane Number declines
  - Oxidation Stability declines
  - Cold flow properties negatively effected
  - Viscosity declines
- As # C / fatty acid decrease…
  - Cetane Number declines
  - Viscosity declines

Biodiesel - Characteristic Problem Areas

Characteristic	Consequences for the FIE	Vehicle Consequences
Free glycerin	Corrosion, sediments, lacquering	Poor performance, increased smoke, no start
Alkali (Na+K, Ca+Mg)	Sediment; pump & injector failure	Poor performance, increased smoke, no start
Cold flow (Viscosity+)	Shortened system life, poor atomization	Stalling, no start
Aging Products (from insufficient Oxidative Stability)		
Polymers, insoluble (gum, sludge)	• Filter clogging • Deposit formation inside FIE • Seizure of moving parts • Injection coking	• Poor performance, stalling • No start • Stalling, no start • Poor performance, increased smoke
Polymers, soluble	• Resins formed inside FIE	• Stalling; no start
Aging acids	• Corrosion of metal parts • Soap formation with metal ions from wear or corrosion	• Poor performance, increased smoke • Stalling; no start
Peroxides	• Embrittlement of elastomers	• Fuel leakage, poor performance

Biodiesel - Critical Needs

- Critical fuel parameters…
  - Oxidation Stability
    - Method chosen must reflect oxidative ‘reserve’ of fuel or blend. [e.g. Induction hours, IP306(mod)]
    - Acid Nr. not measure for stability, rather an indication that fuel has aged. (ASTM D664, EN14104).
  - Alkaline and Alkaline-earth ions content limits
- Controlled Fleet tests necessary with the following characteristics:
  - ‘Borderline’ quality fuel to expose vehicle/systems to environment customers could encounter in the field.
  - Duty cycles to stress areas of concern.
    - Oxidative Stability
    - Contamination
      - Water
      - Biological
- Adequate specification AND Quality system to assure fuels in field meet them.

Biodiesel - Activity status

1. OEM Customer support:

- Definition of test programs
- Identifying risks associated with Biodiesel use.
- DFIE evaluation at test conclusion

2. Bosch Fh testing:

- B1 to B45 fueled DFIE systems evaluated.
  - Varnishing / contamination observed (B20 and up blends)
  - Performance degradation occurred in some cases
  - Surface coating deterioration with B20
- B20 CRS Component soak testing.
  - (Test 1) Ambient temperature (23 deg C)
  - (Test 2) Cycled temperature with fuel circulation.

Biodiesel - Activity status (cont'd)

Bosch Fh Soak test results:

Test 1

- **Test Fuel:** B20 (soy based) from retail outlet (Chelsea, MI).
- **Test cycle and temperature:** static testing for 8 weeks @ 23°C
- **Test results:** Sludge formed, consistent with oxidized BD.

Test 2

- **Test Fuels:** B20 (soy based) and 2D Diesel fuel (control)
- **Test cycle:** 4 weeks, fuel circulated in vessel
- **Temperature cycle:** 20°C (6hrs) to +70°C (6hrs)
- **Test results:** B20 results- sludge coated most components. Zinc coatings showed deterioration. Some O-ring swelling was observed.
- **Baseline:** Nr. 2D fuel- fuel appeared clear and bright, surface coatings unaffected, no sludge observed.

Biodiesel - Characteristic Problem Areas

BOSCH

Property	Unit	Limits EN 14214		Limits ASTM D 6751	
		Min	Max	Min	Max
Ester content [a]	% (*m/m*)	96,5 [b]			
Density at 15 °C [c]	kg/m^3	860	900	missing	missing
Viscosity at 40 °C [d]	mm^2/s	3,5	5,0	1.9	6.0
Flash point	°C	120	–	130	-
Sulfur content [f]	mg/kg	–	10,0		500 15
Carbon residue (on 10 % distillation residue) [g]	% (m/m)	–	0,30	-	0,0
Cetane number [h]		51,0		47	
Sulfated ash content	% (m/m)	–	0,02	-	0,02
Water content		–	500 mg/kg	-	500 mg/l
Total contamination [i]	mg/kg	–	24	-	
Copper strip corrosion (3 h at 50 °C)	rating	class 1		class 3	
Oxidation stability, 110 °C	hours	6,0	–	missing	
Acid value	mg KOH/g		0,50		0,80
Iodine value			120		missing
Linolenic acid methyl ester	% (m/m)		12,0		
Polyunsaturated (>= 4 double bonds) methyl esters [j]	% (m/m)		1		
Methanol content	% (m/m		0,20		
Monoglyceride content	% (m/m)		0,80		
Diglyceride content	% (m/m)		0,20		
Triglyceride content [k]	% (m/m)		0,20		
Free glycerol [k]	% (m/m)		0,02		0,02
Total glycerol	% (m/m)		0,25		0,24
Group I (alkali) metals (Na+K) [l] Group II metals (Ca+Mg) [m]	mg/kg mg/kg		5,0 5,0		missing
Phosphorus content	mg/kg		10,0		10
Distillation Temp, T90	°C		missing		360