Biodiesel Update
Biodiesel

A fuel comprised of methyl/ethyl ester-based oxygenates of long chain fatty acids derived from the transesterification of vegetable oils, animal fats, and cooking oils. These fuels are commonly known as Fatty Acid Methyl Esters (FAME).

Biodiesel properties are similar to that of diesel fuel, as opposed to gasoline or gaseous fuels, and thus are capable of being used in compression ignition engines.
Biodiesel

B100 - A fuel containing 100 percent biodiesel.

Biodiesel Blend – A fuel comprised of a mixture of petrodiesel and B100 biodiesel. A biodiesel blend is typically designated by the percentage of biodiesel in the blend. For example, B5 is a fuel containing 95 percent petrodiesel and 5 percent B100.

Rapeseed Methyl Ester (RME) diesel - Biodiesel derived from rapeseed oil. RME diesel is the most common biodiesel used in Europe.

Soy Methyl Ester (SME or SOME) diesel - Biodiesel derived from soybean oil. SME diesel is the most common biodiesel used in the United States.
Biodiesel

- Biodiesel is NOT raw vegetable oil or SVO (Straight Vegetable Oil) or refined oil or filtered used cooking oil.

- IT HAS TO BE MANUFACTURED:

  Process reaction:
  - Triglyceride + Alcohols = Glycerine + Esters
    (oil or fat)                      (catalyst)                      (biodiesel)

  Raw Materials:
  - Oils or Fat: Soybean, Corn, Rapeseed, Cottonseed, Sunflower, Beef tallow, Pork lard, Used cooking oils (yellow grease), etc.
  - Alcohol: Methanol, Ethanol
  - Catalyst: Sodium hydroxide, Potassium hydroxide
Benefits

- PM, CO, UHC emissions reduction
- CO2 reduction on a life cycle basis
- Contains no sulfur, aromatics (B100)
- Better lubricity than 500 ppm S fuel
- Renewable energy content
- Local economy, jobs
- Energy security
Market Drivers

- Agribusiness
- Energy Policy
  - Energy independence
  - Renewable energy
- Environmental Policy
  - GHG inventories
  - PM emission benefits
- Market forces
  - Diesel pump price - crude oil price / taxes
  - Mandates
  - Incentives
Trends

- Production increasing globally
- Incentives & mandates increasing
- Biodiesel included in renewable energy policy / plans
- Crude oil price increasing
- Shift from small to big players, integration upstream
- Distribution shifting from special handling to mainstream
- OEM’s announcing support (most approve B5)
- Shift to higher blends B2→B5→B20
- Petroleum diesel standards being revised
- CO2 credit trading (Kyoto ratification is increasing)
- Industry addressing quality
US Biodiesel Capacity

Fitted Line Plot
Annual Capacity = $2.64 \times 10^8 - 263419 \text{ Year} + 65.73 \text{ Year}^2$

2010 Scenario:
2Bgals B100
72Bgals diesel
Biodiesel is part of the solution
Technical Challenges addressed for higher blends than B5

- Fuel quality
- Fuel oxidation stability
- Contamination, microbe growth
- Materials compatibility
- NOx impact
- Fuel filter water separation efficiency
- Cleansing effect on fuel systems
- Potential increase in oil dilution
- Long term durability effects
- Impact on aftertreatment
B20 Approval

- Cummins Announces Approval of B20 Biodiesel Blends – March 21, 2007 (everytime.cummins.com)
- Approval limited to targeted engines - Additional approvals pending further investigation (e.g. HHP, SCR)
- Requirements specified in Cummins Service Bulletin 3379001 and AEB 21.73
Cummins products are quickly converting to higher blend capability

B20 approved engines:
- **On-Highway**: ISX, ISM, ISL, ISC and ISB engines certified to EPA '02 and later emissions standards, and ISL, ISC and ISB engines certified to Euro III
- **Off-Highway**: QSX, QSM, QSL, QSC, QSB6.7 and QSB4.5 engines certified to Tier 3/Stage IIIA, QSM Marine and QSM G-Drive Future products will be compatible with biodiesel

Cummins Components Group provides technologies that enable successful use of biodiesel
Requirements for Using Biodiesel Fuel in Cummins Engines

- Customers choosing to run biodiesel blends above B5 and up to B20 must adhere to the following requirements from Cummins Inc.

- It is strongly recommended that customers running biodiesel blends of B5 or below follow these precautions as well.

1. EMA spec / BQ9000 Suppliers
2. Oil Sampling
3. Fuel Water Separation
4. Biodiesel Fuel Storage
5. Energy Content
6. Materials Compatibility
7. Low Temperature Performance
8. Microbial Growth
9. Biodiesel Additives
Requirements for Using Biodiesel Fuel in Cummins Engines

- There are specifications for biodiesel issued in Europe under EN14214 and in North America under ASTM D6751. These specifications define only the biodiesel used as the blend component with diesel fuel. They are not applicable to fuel blends purchased by the end user.
- Despite the existence of these standards, the general quality of available biodiesel remains inconsistent.

⚠️ CAUTION ⚠️

To successfully use biodiesel, it is imperative that the fuel be of high quality and meet or exceed the specifications outlined in this bulletin or engine damage will occur.
Requirements for Using Biodiesel Fuel in Cummins Engines

- Cummins Inc. provides the specifications found in Table 1 of the Service Bulletin for diesel fuel and biodiesel blends up to B5. For biodiesel blends above B5 and up to B20, Cummins Inc. provides the specifications found in Table 4.

- The specifications in Table 4 of the Service Bulletin (next page) have been developed by the Engine Manufacturers Association (EMA), and are not an approved national or commercial fuel standard. All biodiesel fuel blends are to be comprised of petrodiesel meeting ASTM D975, and B100 meeting either ASTM D6751 or EN14214.
<table>
<thead>
<tr>
<th>Item</th>
<th>Performance Characteristics</th>
<th>Requirements</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D1 Blends</td>
<td>D2 Blends</td>
</tr>
<tr>
<td>1</td>
<td>Flash Point, °C, min.</td>
<td>38</td>
<td>52</td>
</tr>
<tr>
<td>2</td>
<td>Water and sediment, vol %, max.</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>Physical Distillation, T90, °C, max.</td>
<td>343</td>
<td>343</td>
</tr>
<tr>
<td>4</td>
<td>Kinematic Viscosity, cSt@40°C</td>
<td>1.3~4.1</td>
<td>1.9~4.1</td>
</tr>
<tr>
<td>5</td>
<td>Ash, mass%, max.</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>6</td>
<td>Sulfur, wt%, max.</td>
<td>Per regulation</td>
<td>Per regulation</td>
</tr>
<tr>
<td>7</td>
<td>Copper strip corrosion rating, max.</td>
<td>No. 3</td>
<td>No. 3</td>
</tr>
<tr>
<td>8</td>
<td>Cetane Number, min.</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>9</td>
<td>Cloud point (^{1})</td>
<td>Per footnote</td>
<td>Per footnote</td>
</tr>
<tr>
<td>10</td>
<td>Ramsbottom carbon residue on 10% distillation residue, wt %, max.</td>
<td>0.15</td>
<td>0.35</td>
</tr>
<tr>
<td>11</td>
<td>Lubricity, HFRR@60°C, micron, max.</td>
<td>460</td>
<td>460</td>
</tr>
<tr>
<td>12</td>
<td>Acid number, mg KOH/g, max.</td>
<td>0.3</td>
<td>0.3</td>
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<tr>
<td>13</td>
<td>Phosphorus, wt %, max.</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>14</td>
<td>Total Glycerin</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>15</td>
<td>Alkali metals (Na+K), ppm, max.</td>
<td>Nd</td>
<td>Nd</td>
</tr>
<tr>
<td>16</td>
<td>Alkaline metals (Mg+Ca), ppm max.</td>
<td>Nd</td>
<td>Nd</td>
</tr>
<tr>
<td>17</td>
<td>Blend fraction, vol %(^{2})</td>
<td>+/- 2%</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>18</td>
<td>Thermo-oxidative Stability, insolubles, mg/100 mL, max.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>19</td>
<td>Oxidation Stability, Induction time, hours, minimum</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>
For North American markets, Cummins Inc. requires that the biodiesel fuel blend be purchased from a **BQ-9000 Certified Marketer**.

The B100 biodiesel fuel used in the blend must be sourced from a **BQ-9000 Accredited Producer**.

Certified Marketers and Producers can be found at the following website: [http://www.bq-9000.org](http://www.bq-9000.org).

For areas outside of North America, consult your local Cummins representative for applicable fuel quality standards.
Fuel Quality

- Oxidized Fuel
  - Sludge formation
  - Deposits
  - Filter plugging

Deposits from oxidation in a B20 field test
Oil Sampling

- Fuel dilution of lubricating oil has been observed with the operation of biodiesel under certain operating conditions. Fuel dilution monitoring can be accomplished by performing oil sampling.

- Fuel levels in lubricating oil must not exceed 5%. Additional information on oil contamination and oil sampling can be found in Cummins Engine Oil Recommendations, Bulletin 3810340.

- For ISB 07 and ISC/ISL 07 products, end users are required to use oil sampling during the first 6 months of operation with biodiesel to monitor engine oil condition and fuel dilution of lubricating oil in order to determine if the oil change interval needs to be modified.
Fuel Water Separation

- Biodiesel has a natural affinity to water, and water accelerates microbial growth. **Storage tanks must be equipped with a fuel water separator** to make sure that water is stripped out before entering the vehicle tank.
- Make sure that the vehicle and storage tanks are kept full to reduce the potential for condensation accumulating in the fuel tank.
- Due to the solvent nature of biodiesel, and the potential for “cleaning” of the vehicle fuel tank and lines, **new fuel filters must be installed when switching to biodiesel** on used engines. Fuel filters will need to be replaced at half the standard interval for the next two fuel filter changes.
Biodiesel Fuel Storage

- Use biodiesel fuel **within six months** of its manufacture. Biodiesel has poor oxidation stability, which can result in long term storage problems. For this reason, Cummins Inc. does **not** recommend using biodiesel for low use applications, such as standby power or seasonal applications. Consult your fuel supplier for oxidation stability additives.

- The poor oxidation stability qualities of biodiesel can accelerate fuel oxidation in the fuel system, especially at **increased ambient temperatures**.

**CAUTION**

Avoid storing equipment with biodiesel blends in the fuel system for more than three months or fuel system damage can occur.
Biodiesel Fuel Storage (cont.)

- If biodiesel is used for seasonal applications, the engine system **must** be purged before storage by running the engine on pure diesel fuel for a minimum of **30 minutes**.
- Care **must** also be taken when storing biodiesel in bulk storage tanks. All storage and handling systems **must** be properly **cleaned and maintained**. Steps must be taken to **minimize moisture and microbial growth** in storage tanks. Consult your fuel supplier for assistance in storing and handling biodiesel.
Materials Compatibility

- The engines listed in this presentation are compatible with biodiesel blends up to B20. However,
- Vehicle/Equipment manufacturer must be contacted to determine if any of the OEM supplied components are at risk with biodiesel.
Low Temperature Performance

- Biodiesel fuel properties change at low ambient temperatures, which can pose problems for both storage and operation. Precautions can be necessary at low ambient temperatures, such as storing the fuel in a heated building or a heated storage tank, or using cold temperature additives.

- The fuel system can require heated fuel lines, filters, and tanks. Filters can plug and fuel in the tank can solidify at low ambient temperatures if precautions are not taken. A fuel heater is recommended for ambient temperatures below -5°C [23°F]. Consult your fuel and additive supplier for assistance in attaining proper cloud point fuel.
Microbial Growth

- Biodiesel fuel is an excellent medium for microbial growth. Microbes cause fuel system corrosion and premature filter plugging. The effectiveness of all commercially available conventional anti-microbial additives, when used in biodiesel, is not known. Consult your fuel and additive supplier for assistance.
Summary – Key Requirements

- **Capable engine**: Approved engines only
- **Quality fuel**: B100 Accredited Producers
- **Capable Vehicle / Equipment**: Approved Vehicles / Equipment
- **Quality blend / delivery**: B20 Certified Marketers, EMA spec
- **Successful Application**: Application Requirements, i.e. fuel storage, seasonal use, etc.
Biodiesel: Environmental Driver

- Cummins supports the responsible production and use of biodiesel.
- We will use biodiesel in our operations where appropriate and produce products that are capable of operating with biodiesel.
- Biodiesel must not harm the availability or economics of the global food supply.
- Rain forests and water are resources that must be sustained.
Biodiesel offers the environmental benefit of renewable energy

- Can also help to reduce dependency on imported oil
- Provides overall emissions advantage with reduced PM, HC, CO & CO$_2$
- Cummins is working with industry groups to standardize fuel specifications
- Cummins products are quickly converting to B20 capability
Biodiesel quality matters

- Poor quality biodiesel fuel in the market has caused operating problems

- A quality control system for biodiesel all the way to the pump is needed along with compliance and enforcement

- Cummins requires biodiesel used with our products to meet ASTM 6751 or EN14214, the EMA B20 test specification and be sold by a certified marketer (BQ9000 in the US)

- Cummins will continue to participate in improving specifications and quality