



Renewable Fuels for Diesel Applications

Biodiesel and Renewable Diesel

Many contexts and discussions of renewable fuels often use the terms biofuel, biodiesel and renewable diesel (and others) interchangeably. From our perspective, these terms are not interchangeable, and the products themselves may or may not be as well.

What is Biodiesel?



A renewable Advanced Biofuel commercially derived from a diverse array of fats and oil by-products and used in normal diesel engines. It is also one of the few renewable fuels to have its own standard specification.

Biodiesel Defined

- **Biodiesel**, n. -- a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, **meeting ASTM D6751**, designated B100.
- **Biodiesel Blend**, n. -- a blend of biodiesel fuel with petroleum-based diesel fuel designated BXX, where XX is the volume percent of biodiesel (D975 or D7467).
- **EPA Definition 40 CFR 80.1401 - Advanced Biofuel** means renewable fuel, other than ethanol derived from cornstarch, that has **lifecycle greenhouse gas emissions** that are at least **50 percent less** than baseline lifecycle greenhouse gas emissions (i.e., diesel fuel)



Biodiesel Specifications

TABLE 1 Detailed Requirements for Biodiesel (B100) Blend Stocks

| Property | Test Method ^A | Grade No. 1-B S15 | Grade No. 1-B S500 | Grade No. 2-B S15 | Grade No. 2-B S500 |
|--|--------------------------|----------------------|-----------------------|----------------------|-----------------------|
| Sulfur, ^B % mass (ppm), max | D5453 | 0.0015 (15) | 0.05 (500) | 0.0015 (15) | 0.05 (500) |
| Cold soak filterability, seconds, max | D7501 | 200 | 200 | 360 ^C | 360 ^C |
| Monoglyceride content, % mass, max | D6584 | 0.40 | 0.40 | ... | ... |
| Requirements for All Grades | | | | | |
| Calcium and Magnesium, combined, ppm (µg/g), max | EN 14538 | 5 | 5 | 5 | 5 |
| Flash point (closed cup), °C, min | D93 | 93 | 93 | 93 | 93 |
| Alcohol control | | | | | |
| One of the following shall be met: | | | | | |
| 1. Methanol content, mass %, max | EN 14110 | 0.2 | 0.2 | 0.2 | 0.2 |
| 2. Flash point, °C, min | D93 | 130 | 130 | 130 | 130 |
| Water and sediment, % volume, max | D2709 | 0.050 | 0.050 | 0.050 | 0.050 |
| Kinematic viscosity, ^D mm ² /s, 40°C | D445 | 1.9-6.0 | 1.9-6.0 | 1.9-6.0 | 1.9-6.0 |
| Sulfated ash, % mass, max | D874 | 0.020 | 0.020 | 0.020 | 0.020 |
| Copper strip corrosion, max | D130 | No. 3 | No. 3 | No. 3 | No. 3 |
| Cetane number, min | D613 | 47 | 47 | 47 | 47 |
| Cloud point, ^E °C | D2500 | Report | Report | Report | Report |
| Carbon residue, ^F % mass, max | D4530 | 0.050 | 0.050 | 0.050 | 0.050 |
| Acid number, mg KOH/g, max | D664 | 0.50 | 0.50 | 0.50 | 0.50 |
| Free glycerin, % mass, max | D6584 | 0.020 | 0.020 | 0.020 | 0.020 |
| Total glycerin, % mass, max | D6584 | 0.240 | 0.240 | 0.240 | 0.240 |
| Phosphorus content, % mass, max | D4951 | 0.001 | 0.001 | 0.001 | 0.001 |
| Distillation temperature, | D1160 | 360 | 360 | 360 | 360 |
| Atmospheric equivalent temperature, | | | | | |
| 90 % recovered, °C, max | | | | | |
| Sodium and Potassium, combined, ppm (µg/g), max | EN 14538 | 5 | 5 | 5 | 5 |
| Oxidation stability, hours, min | EN 15751 | 3 | 3 | 3 | 3 |

^A The test methods indicated are the approved referee methods. Other acceptable methods are indicated in 5.1.

^B Other sulfur limits may apply in selected areas in the United States and in other countries.

^C B100 intended for blending into diesel fuel that is expected to give satisfactory vehicle performance at fuel temperatures at or below -12°C shall comply with a cold soak filterability limit of 200 s maximum.

^D See X1.3.1. The 6.0 mm²/s upper viscosity limit is higher than petroleum based diesel fuel and should be taken into consideration when blending.

^E The cloud point of biodiesel is generally higher than petroleum based diesel fuel and should be taken into consideration when blending.

^F Carbon residue shall be run on the 100 % sample (see 5.1.12).

Ease of Use and Performance

Using Biodiesel Blends is Easy! Up to B20:

- Biodiesel blends can be used in any diesel engine/vehicle per manufacturer's recommendations
- B5 – B20 blends do not void OEM warranties
- “Drop-in” replacement for diesel fuel
- No vehicle modifications needed
- Similar, seamless performance compared to diesel
- Dispensed through existing fueling stations
- Comparable fuel prices to diesel
- Low overall cost of ownership
- High biodiesel energy balance – 5.54 : 1 (B100)
- 30-40 percent fuel efficiency gains with diesel engine over gasoline



What is Renewable Diesel?



A renewable Advanced Biofuel commercially derived from a diverse array of fats and oil by-products and used in normal diesel engines meeting the current diesel fuel specifications.

Renewable Diesel Defined

- Renewable Diesel does NOT have a uniform definition within any regulatory standards nor in the marketplace
- Renewable Diesel should NOT be a straight vegetable oil, waste grease, or any other recycled oil used or blended back into petroleum diesel fuel.
- However, the EPA program to register all fuels and fuel additives (FFA) has registered products that ASTM and OEM's agree should not be contained within any fuel.



Renewable Hydrocarbon Diesel

- There are legitimate renewable diesel fuels that when produced properly are hydrocarbon fuels with the potential to provide excellent qualities as a replacement liquid transportation fuel.
- RHD (HDRD, NERD) meets the current ASTM diesel fuel specifications (D975) as a neat fuel.
- The National Biodiesel Board serves as the U.S. trade association for both domestic biodiesel and renewable hydrocarbon diesel.



Molecular Differences

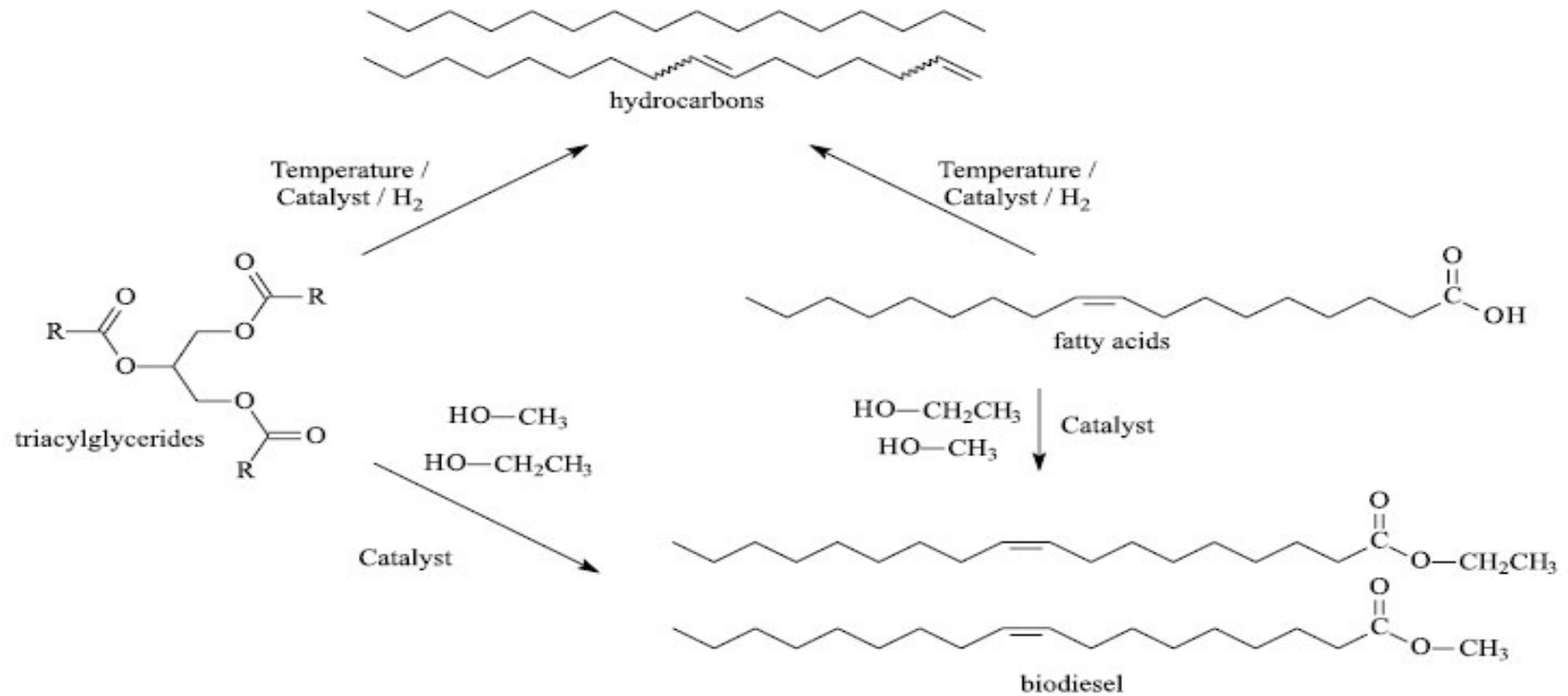


Figure 2. Biofuels (hydrocarbons and biodiesel) obtained from triacylglycerides and fatty acids. Adapted from reference 13.

Comparing RHD to ULSD

- To ensure that renewable hydrocarbon diesel fuel is properly produced, and that the process is complete, the NBB has implemented a fuel quality provision for our RHD members to include a limit on oxygen content (500 ppm max by E385) and on oxidation stability (2.5 mg/100mL max by D2274) that are above and beyond D975
- Additionally, RHD typically has a Cetane value greater than 70; well in excess of the minimum 40 required in D975
- RHD also has negligible amounts of aromatic compounds found in petroleum diesel fuels

Comparing RHD to ULSD

- While RHD has the potential to offer superior cold weather performance, the process for full isomerization is costly
 - The ASTM specifications for diesel fuel do not have any parameter limits to ensure cold-flow performance (they do have tables for regional and seasonal guidance)

Blending RHD and ULSD

- Reportedly, the marketplace considers renewable diesel to be more of a “drop-in” replacement for diesel over biodiesel and chemically indistinguishable from petroleum diesel fuel
- While somewhat difficult to distinguish, RHD does have some properties that are leading OEM’s to consider limits on the percentages of RHD within petroleum diesel fuel
 - The lack of aromatics in the fuel may impact the performance of elastomers and hoses used within the engine and fuel system.
 - Additionally, RHD also has slightly less energy content when compared to ULSD – approx. 5% less
 - RHD has a higher Gravity than ULSD and could possibly stratify when storing the fuel

OEM Positions

- Other vehicle and engine manufacturers, such as Volvo, Mack, and Mercedes-Benz, have announced higher approvals for “renewable diesel”.
- Others have yet to announce formal positions, although retailers out in California have begun selling blends of R98/R99 to the general public.

Implementation

- Renewable Diesel qualifies as a biomass-based diesel fuel, along with biodiesel, under both federal and state programs.
- 2016 volume totals under the federal RFS program include 1.90 billion gallons of Biomass-based Diesel Fuel and 3.61 gallons of Advanced Biofuel.
- Under the California Low Carbon Fuel Standard (LCFS), the 2016 volumes of biomass-based diesel fuel are projected to total approximately 379 million gallons; with renewable diesel fuel expected to account for nearly 45% of that total.

Renewable Fuel Growth

| | Jan. 2016 (MG) | Feb. 2016 (MG) | March 2016 (MG) | April 2016 (MG) | May 2016 (MG) | YTD Total 2016 | Percent of Volumes |
|---|----------------------|----------------------|-----------------------|-----------------------|---------------------|-------------------|--------------------------|
| Total Biodiesel & Renewable Diesel | 141 | 144 | 183 | 215 | 233 | 917 | |
| Domestic Product | 96 | 106 | 142 | 145 | 153 | 646 | 70% |
| Imported Product | 45 | 38 | 40 | 70 | 80 | 271 | 30% |

Product Labeling

- The Federal Trade Commission (FTC) has developed retail pump labels as seen here.
- Because of the difficulty in quantifying renewable diesel from petroleum based fuels, it is unclear which regulatory agencies may be currently checking for the proper labels.
- Blends up to 5% by volume do not require labels nor any disclosure.
- These are the only currently known labeling requirements, and other documentation such as BOLs and PTDs may not list renewable fuel contents.



Co-Processed Renewable Diesel



A process wherein a petroleum refiner includes a renewable feedstock into their process to further maximize the diesel output of their refinery. Several refiners in the U.S. Gulf Coast have experimented with this, but have not steadily employed the process. While typically added when hydro-treating the diesel stream to remove sulfur, several have investigated (including the DoE) “bio-crudes” that could be implemented from the beginning of the refining process. These techniques are typically limited at 2-3% of the process capability because of the negative affect of the “bio” feedstock on the catalytic activity. Brazil (Petrobras) probably has the most experience.



Thank you Questions?

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