

Guidelines of Biodiesel Fuels Used in Diesel Engine

(Updated 6Feb07)

What is & isn't Biodiesel

A fuel comprised of mono-alkyl esters of long chain fatty acids (known as Fatty Acid Methyl Esters or FAME) derived from vegetable oils or animal fats, officially designated as B100 or 100% Biodiesel in compliance with ASTM D6751 (USA) or EN 14214 (Europe) industry specifications. The standard manufacture process to make biodiesel is called **transesterification**.

Soybean Methyl Ester — SME, predominantly in USA

Rapeseed (or Canola) Methyl Ester — RME, predominantly in Europe

Palm Methyl Ester — PME, predominantly in Asia

Other feedstocks include but not limited to:

Animal Fats (beef tallow, pork lard)

Yellow Greases (waste cooking oil or recycled greases)

Cotton Seed

Sunflower Seed

Coconut Oil

Sesame Seed

Biodiesel blended with regular diesel fuel is named Biodiesel Blend, designated as BXX (B2, B5, B20, etc.) where XX is the volume percent of biodiesel used in the blend.

NOTE: Raw pressed / partially refined vegetable oils or recycled greases that have not been processed into biodiesel through **transesterification** are NOT biodiesel and Must Not Be Used in any form or concentration.

Biodiesel Advantages

- Renewable energy alternative, biodegradable & nontoxic
- Reduce dependency on petroleum imports
- B2 level provides significant lubricity improvement
- High cetane, zero aromatics, and minimal sulfur content
- Lower engine PM, HC, CO and life-cycle CO₂ emissions
- Less visible smoke

Biodiesel Technical Challenges

- Increased engine NO_x emission
- Cold weather flow degradation
- Stability & storage issues (moisture absorption, oxidation, microbial growth)
- Hygroscopic nature impacts filtration system (water separator efficiency reduction)
- Thermal degradation at elevated temperatures
- More crankcase dilution caused by higher fuel density & viscosity
- Elastomer seal, gasket, and other material compatibility (Cu, Pb, Zn, and Sn)
- Lower energy content (less power & fuel economy)
- Property variation due to different feedstocks
- Higher cost if there were no government tax incentive

Deere Recommendation

Biodiesel blend up to B5 (5% biodiesel mixed with regular petrodiesel by volume) can be used in John Deere diesel engines, provided that the neat biodiesel or B100 meets ASTM D 6751 (USA) or EN 14214 (Europe) specification as shown in Table A. Furthermore, the petrodiesel portion should meet the requirements of ASTM D 975 (USA) or EN 590 (Europe) commercial standards. Deere also requires that biodiesel and its B5 blend to be purchased from a BQ-9000 accredited producer or BQ-9000 certified marketer / distributor.

We must make certain that our decisions about biodiesel usage and the effect on machine performance are based on factual test experience. Deere is a responsible biodiesel supporter and understands the future prosperity of biodiesel industry rests on product quality control, field customer appreciation, long-term supply and distribution.

Biodiesel blend above B5 could have increasingly more performance related issues. The higher the biodiesel concentration, the more likely the risk associated with its negative aspects. There is no industry standard to regulate the quality & performance of biodiesel blend at this time. In particular, certain properties of biodiesel blend may deviate significantly from its B100 and petrodiesel constituents (synergism or antagonism) and could manifest a highly nonlinear relationship. The following shall be observed during routine practice:

Fuel Quality Assurance

- Ensure the quality of B100 and biodiesel blend (right concentration, uniform mixture)
- One-time splash blending in an immobile tank is inadequate for homogeneous mixing
- Recommend in-line (or proportional) blending to achieve good mixture
- B100 should be kept warm prior to blending in the winter to preclude wax formation
- Keep storage and vehicle tanks as full as possible to minimize moisture condensation
- Monitor water content and microbial growth of the biodiesel fuels regularly
- Sampling fuel periodically to confirm the % level of biodiesel is consistent
- Limit the storage tanks from extreme temperature exposure (direct sun or frost)
- Storage life should be reduced accordingly (one year for B2, six months for B20, etc.)
- Buy fuel from a BQ-9000 accredited producer or a BQ-9000 certified marketer

Vehicle Maintenance Protocol

- Drain and clean fuel storage tank before and after using biodiesel
- All tank caps and covers shall be installed properly to prevent water from entering
- Clean spills immediately to avoid paint corrosion if using B20 or higher blends
- Fuel filter may need to be replaced more often initially due to premature plugging for that biodiesel is a minor solvent capable of removing deposits within the fuel system
- Wax formation of biodiesel in cold environment may also cause filter plugging, use lower blends or better yet 100% petroleum diesel during the winter or storage period
- Check engine oil sump level daily prior to starting, a rising level may indicate crankcase fuel dilution and the need for oil change (biodiesel is less stable)
- Switch to regular diesel fuel for extended periods of storage / idle of the vehicle

Performance Related Issues

- Power loss, and in some instances dangerous power (fueling rate) growth, from B100 or other high concentration biodiesel blends
- Higher biodiesel blend may cause leakage in seals and hoses of Buna-N, Nitrile and natural rubber, use fluorocarbon or Viton type of materials instead which are compatible with biodiesel
- Corrosion of fuel injection equipment particularly for higher biodiesel blend
- Injector nozzle deposits from B20 or higher biodiesel blend
- Lacquering and seizure of internal injection system components
- Injection pump failure caused by water ingestion
- Formation of sludge and sediments
- Reduced engine service life

Consult fuel supplier for additives to improve storage and performance of biodiesel.

Suggested type of additives would be:

- Oxidation stabilizer
- Cold flow enhancer
- Micro biocide

High pressure common rail (HPCR) and rotary fuel injection pumps are most sensitive to biodiesel usage with regard to deposit formation. When using higher biodiesel blend or B100 in a rotary fuel injection pump, the engine oil level must be checked daily if the ambient temperature is -10°C (14°F) or lower. If oil becomes diluted with fuel, oil change intervals must be shortened. Correct oil service intervals may be established by using OilScan or OilScan Plus programs. Another factor due to cold temperature is the Cloud Point (CP) where wax crystals start to form which makes the fuel cloudy, or Cold Filter Plugging Point (CFPP) where wax crystals have grown to some threshold size beginning to plug the filter. Biodiesel demonstrates relatively high CP or CFPP as compared with petroleum diesel fuel.

Our product warranty only covers defects in material and workmanship as manufactured and sold by John Deere. Failures caused by the use of poor quality fuels, be that biodiesel or regular petroleum diesel, are not defects of material and/or workmanship as supplied by John Deere, hence cannot be compensated under our warranty. On the other hand, using biodiesel blends above B5 does not automatically void warranty. Users of John Deere emission certified engines are responsible for obtaining the proper local, state, and national exemptions required for the use of biodiesel.

Emission certified engines are equipped with fuel injection pumps (FIP) that are compatible with biodiesel blends up to B5 maximum in accordance with the common position statement from diesel fuel injection equipment (FIE) manufacturers.

Table A: Biodiesel (B100) Standards

Property	Test Methods		Units	ASTM D 6751	EN 14214
	ASTM	EN & ISO			
Cloud Point	D 2500		°C	Report	
Carbon Residue (on 100% Sample)	D 4530		% mass	0.050 max	
Water and Sediment	D 2709		% volume	0.050 max	
Free Glycerin	D 6584		% mass	0.020 max	
Total Glycerin	D 6584		% mass	0.240 max	
Distillation Temperature, 90% Recovered	D 1160		°C	360 max	
Flash Point	D 93	3679	°C	130.0 min	120 min
Kinematic Viscosity at 40°C	D 445	3104	mm ² /s	1.9 - 6.0	3.50 - 5.00
Sulfated Ash	D 874	3987	% mass	0.020 max	0.02 max
Copper Strip Corrosion	D 130	2160 (3 h at 50°C)	Rating	No. 3 max	Class 1
Cetane Number	D 613	5165		47 min	51.0 min
Acid Number	D 664	14104	mgKOH/g	0.50 max	0.50 max
Phosphorous Content	D 4951	14107	% mass	0.001 max	0.0010 max
Sulfur Content	D 5453	20846 or 20884	% mass	0.0015 max (S15) 0.05 max (S500)	0.0010
Group I Metals (Na + K)	UOP 391	14108 or 14109	mg/kg	5 max	5.0 max
Group II Metals (Ca + Mg)	UOP 389	14538	mg/kg	5 max	5.0 max
Oxidation Stability, 110°C		14112	hours	3.0 min	6.0 min
Cold Filter Plugging Point		116	°C		5 max (Grade A) 0 max (Grade B) -5 max (Grade C) -10 max (Grade D) -15 max (Grade E) -20 max (Grade F)
Ester Content		14103	% mass		96.5 min
Density at 15°C		3675 or 12185	kg/m ³		860 - 900
Carbon Residue (on 10% Distillation Residue)		10370	% mass		0.30 max
Water Content		12937	mg/kg		500 max
Total Contamination		12662	mg/kg		24 max
Iodine Value		14111	gr iodine/100 gr		120 max
Linolenic Acid Methyl Ester		14103	% mass		12.0 max
Polyunsaturated (≥ 4 double bonds) Methyl Esters		TBD	% mass		1 max
Methanol Content		14110	% mass		0.20 max
Monoglyceride Content		14105	% mass		0.80 max
Diglyceride Content		14105	% mass		0.20 max
Triglyceride Content		14105	% mass		0.20 max
Free Glycerol		14105 or 14106	% mass		0.02 max
Total Glycerol		14105	% mass		0.25 max

Note: Please refer to the original documents of ASTM D 6751 and EN 14214 for further detail.

NOTE: Experience shows that biodiesel is not always conforming to the established standards. Furthermore, the specifications listed in Table A are broadly defined which results in variation of the biodiesel quality. It should be clarified that ASTM D 6751 is recommended for blending up to B20 maximum in USA, whereas EN 14214 can be used as a commercial RME B100 fuel in Europe. The B100 composition may change appreciably due to different feedstocks. This quality variation could cause fuel injection system malfunction particularly with wide range of engine design and operating conditions seen in the field. That is why FIE manufacturers, John Deere and Engine Manufacturers Association in general recommend B5 maximum for the time being. Operator must ensure the supply of good quality biodiesel that will not harm any parts of the engine fuel system. To that extent, we require that the biodiesel (B100) and blended biodiesel (B5) be purchased from a BQ-9000 accredited producer or BQ9000 certified marketer / distributor. For regular petroleum diesel its energy content is usually proportional to the level of fuel density and/or aromatics. This rule cannot be applied to biodiesel blends due to opposite trends existed from biodiesel with higher density and lower energy content.

John Deere has developed its own global standards of B100 and B20 for testing purposes with additional requirements such like thermal and oxidation stabilities, among others. A copy of Deere standards is shown in the last page.

Other useful documents and websites are listed below for your convenience.

Biodiesel Handling and Use Guidelines (3rd Edition, September 2006)
<http://www.nrel.gov/docs/fy06osti/40555.pdf>

Common Position Statement from Diesel Fuel Injection Equipment (FIE) Manufacturers
http://www.ufop.de/downloads/FAME_Statement_June_2004.pdf

EMA Test Specifications for Biodiesel Fuel
EMA Technical Position on Use of Biodiesel – Position Statement
EMA Raw Vegetable Oil Technical Statement
<http://www.enginemanufacturers.org/info/division.asp?id=65>

John Deere to use B2 biodiesel fuel in U.S. manufacturing plants
http://www.deere.com/en_US/newsroom/2005/releases/farmersandranchers/050201_biodiesel.html

Use of Biodiesel Fuels in John Deere Construction and Forestry Products with John Deere Engines
<https://bulletins-ced.deere.com/DealerB/bulletins/g1/c8/b179/PS05-119R.pdf>

BQ-9000 Quality Management System: Accredited Producer Requirements

<http://www.bq-9000.org/pdf/BQ-9000%20Accredited%20Producer%20Requirements%20Rev%204%202-1-07.pdf>

BQ-9000 Accredited Producers

<http://www.bq-9000.org/companies/producers.aspx>

BQ-9000 Quality Management System: Certified Marketer Requirements

<http://www.bq-9000.org/pdf/BQ-9000%20Certified%20Marketer%20Program%20Requirements%202-1-07.pdf>

BQ-9000 Certified Marketers

<http://www.bq-9000.org/companies/marketers.aspx>

List of NBB Member Producers & Marketers (USA)

http://www.biodiesel.org/buyingbiodiesel/producers_marketers/default.aspx?AspxAutoDetectCookieSupport=1

Commercial Biodiesel Production Plants (USA)

http://www.biodiesel.org/buyingbiodiesel/producers_marketers/ProducersMap-Existing.pdf

Biodiesel Production Plants Under Construction or Expansion (USA)

http://www.biodiesel.org/buyingbiodiesel/producers_marketers/ProducersMap-Construction.pdf

National Map of Biodiesel Distributors (USA)

<http://www.biodiesel.org/buyingbiodiesel/distributors/default.shtm>

National Map of Biodiesel Retail Fueling Sites (USA)

<http://www.biodiesel.org/buyingbiodiesel/retailfuelingsites/default.shtm>

Material Compatibility of Biodiesel

http://www.biodiesel.org/pdf_files/fuelfactsheets/Materials_Compatibility.pdf

Electrical Conductivity of Biodiesel

http://www.biodiesel.org/pdf_files/fuelfactsheets/electrical_conductivity.pdf

An Overview of Biodiesel and Petroleum Diesel Life Cycles

<http://devafdc.nrel.gov/pdfs/3812.pdf>

Survey of the Quality and Stability of Biodiesel and Biodiesel Blends in the United States in 2004

<http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/38836.pdf>

Biodiesel Effects on Diesel Particle Filter Performance

<http://www.nrel.gov/vehiclesandfuels/npcf/pdfs/39606.pdf>

National Biodiesel Board website at <http://www.biodiesel.org>

National Renewable Energy Laboratory website at <http://www.nrel.gov>

Table B: Biodiesel Standards of John Deere

Property	Test Methods		Units	B100 Standard	B20 Standard
	ASTM	EN & ISO			
Flash Point	D 93	3679	°C	120 min	38 min (No.1-D) 52 min (No.2-D)
Water and Sediment	D 2709	—	% volume	0.05 max	0.05 max
Kinematic Viscosity at 40°C	D 445	3104	mm ² /s	1.9 - 6.0	1.3 - 4.1 (No.1-D) 1.9 - 4.1 (No.2-D)
Sulfated Ash	D 874	3987	% mass	0.02 max	
Ash	D 482	6245	% mass		0.01 max
Sulfur Content	D 5453	20846 or 20884	% mass	Per Regulation	Per Regulation
Copper Strip Corrosion	D 130	2160 (3 h @ 50°C)	Rating	No.3 / Class 1 max	No.3 / Class 1 max
Cetane Number	D 613	5165		47 min	43 min
Cloud Point ⁽¹⁾	D 2500	—	°C	Per Footnote	Per Footnote
Carbon Residue (on 100% sample)	D 4530	—	% mass	0.05 max	
Ramsbottom Carbon, 10% Residue	D 524	10370	% mass		0.15 max (No.1-D) 0.35 max (No.2-D)
Acid Number	D 664	14104	mgKOH/g	0.50 max	0.30 max
Free Glycerin	D 6584	14105 or 14106	% mass	0.02 max	Not Applicable
Total Glycerin	D 6584	14105	% mass	0.25 max	Not Applicable
Phosphorous Content	D 4951	14107	% mass	0.001 max	0.001 max
Distillation Temperature, 90% Recovered	D 1160	—	°C	360 max	
Physical Distillation, 90% Recovered	D 86	3405	°C		343 max
Lubricity	D 6079	12156-1	µm	460 max	460 max
Biodiesel Blend Fraction	—	14078	% volume	100%	20 ± 2%
Particulates	Modified D 6217 ⁽²⁾	—	mg/L	10 max	10 max
Oxidation Stability (induction time)	—	14112 (Rancimat)	hours	3.0 min	6.0 min
Thermal-Oxidative Stability (insoluble deposits)	Modified D 2274 ⁽²⁾	—	mg/100 mL	10 max	10 max
Methanol Content	—	14110	% mass	0.2 max	0.04 max
Group I Metals (Na + K)	UOP 391	14108 or 14109	mg/kg	5.0 max	Not Detectable
Group II Metals (Ca + Mg)	UOP 389	14538	mg/kg	5.0 max	Not Detectable

Superscript:

- (1) The maximum cloud point temperature shall be equal to or lower than the tenth percentile minimum ambient temperature in the geographical area and seasonal timeframe as defined by ASTM D 975.
- (2) Use glass-fiber filter instead.