

Guidelines of Biodiesel Fuels Used in Diesel Engine

(Updated 30Oct05)

What is & isn't Biodiesel

A variety of ester-based (oxygenated) fuels collectively known as Fatty Acid Methyl Esters or FAME, officially designated as B100 or 100% Biodiesel. The standard manufacture process to make biodiesel is called **transesterification**. The most common source of biodiesel is soybean in the U.S. and rapeseed in Europe such as:

Soybean Methyl Ester — SME or SOME

Rapeseed Methyl Ester — RME

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

Palm Oil

Biodiesel blended with regular diesel fuel is named Biodiesel Blend, designated as BXX (B2, B5, B20, etc.) where XX is the 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
- Minimal sulfur
- Lower engine PM & HC emissions

Biodiesel Technical Challenges

- Increased engine NOx 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
- 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 listed in Table A.

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 (see Bosch-Tipps on next page). 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.)

Vehicle Maintenance Protocol

- 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 biodiesel blend (less than B20) during winter time
- 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 due to higher biodiesel blend, up to 8% fuel economy penalty for B100
- 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
- Formation of sludge and sediments
- Reduced engine service life

Bosch-Tipps

Damages caused by the use of unsuitable fuel in VE injection pumps

Schäden durch ungeeignete Kraftstoffe an Verteiler-Einspritzpumpen

Die Qualität und Zusammensetzung, der am Markt erhältlichen Biodiesel ist sehr unterschiedlich und nicht kontrollierbar. Ein Kraftstoff, der die Anforderungen der DIN Norm EN 590

- The quality and compositions of Biodiesel in the market is variable and it is not controlled. The suitable Diesel fuels comply the standard DIN EN 590

a. Fuel with free water b. Poorly filtered fuel c. Fuel with poor lubricity

d. Fuels called alternative (Biodiesel, RME, PME, FAME)

Impure fuel mixed with gasoline, oil, alcohol, kerosene

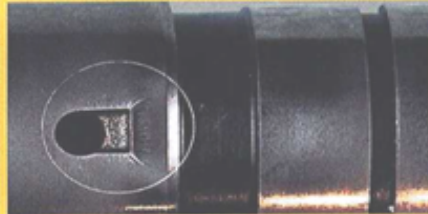
Example of damages:

a. Fuel with free water



Corrosion and chipping

b. Poorly filtered fuel



Mechanical wear caused by particles

c. Fuel with poor lubricity



Cam plate claw: Visible wear which can also be seen on drive shaft claw and yokes

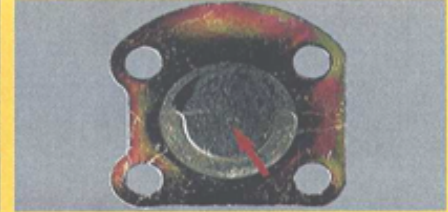
d. Sog. Alternative fuel (Biodiesel, RME, PME, FAME)



Timing device piston damaged: The use of Biodiesel causes filter plugged, and air comes into VE pump (timing device piston area). It causes the failures.



Aggressive components of FAME causes erosion in ELAB



Aggressive components of FAME attacked the coating of the cover

d. weitere Beispiele

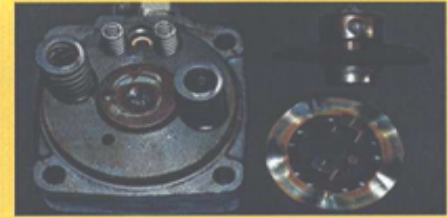


Illustration A: Damage caused by unsuitable fuel (PME, RME, FAME). Consequence: Hysteresis and consequential high wear, changes to mapped data and an associated wide range of potential faults.

Illustration B: Damage of the mechanism due to use of an undefined PME fuel (biodiesel). Actuator mechanism heavily gummed up with sticky reddish brown deposits from RMD



Aggressive components oxidated the surface of copper parts in the HDK-regulator (black color)



Deposits, gumming and destruction of rubber seals

Warranty: Bosch will reject any warranty claims for damage to components of distributor injection pumps (mechanical and EDC) arising from the use of unsuitable fuels even if the original equipment manufacture / vehicle manufacturer permits the use of other fuels



BOSCH

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	0.80 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
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
Oxidation Stability, 110°C		14112	hours		6.0 min
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
Group I Metals (Na + K)		14108 or 14109	mg/kg		5.0 max
Group II Metals (Ca + Mg)		14538	mg/kg		5.0 max

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

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

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 aftermarket 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, with the exception of engines using Delphi DP200 series FIP. Refer to Table B for a parts list needed to make the Delphi DP200 compatible with biodiesel blends up to B5. Consult your local ADS shop for all other FIP.

Table B: Delphi (Lucas) DP200 Series Fuel Injection Pump			
Line Sequence Number	Part Number	Quantity	Description
Without Boost Control:			
106	7185-816	1	Drive Shaft Seal
With Boost Control:			
106	7185-816	1	Drive Shaft Seal
732	7185-781A	1	Boost Diaphragm Assembly
802	5855-30GG	1	O-Ring

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. The B100 composition may change appreciably due to different feedstocks. This quality variation could cause fuel injection system malfunction with wide range of engine design and operating conditions in the

field. That is why 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. When ever possible, B100 should be procured from a BQ-9000 Accredited Producer or a BQ-9000 Certified Marketer as recommended by the National Biodiesel Board.

For online reference, we suggest **2004 Biodiesel Handling and Use Guidelines** available at <http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/tp36182.pdf> or visit National Biodiesel Board at <http://www.biodiesel.org>