Operation and Maintenance Manual
Cat Commercial Diesel Engine Fluids Recommendations
Media Number -SEBU6251-24 **Publication Date -01/09/2014** **Date Updated -17/01/2019**

i07582608

Biodiesel

SMCS - 1280

NOTICE

These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

Biodiesel is a renewable fuel that can be made from vegetable oils, animal fat, and waste cooking oil. Soybean oil and rapeseed oil are typically the primary vegetable oil sources. The raw oils or animal fats are chemically processed (esterified) to form a fatty acid methyl ester (referred to as FAME). The esterified product (FAME) is biodiesel fuel that can be used in compression ignition engines. Without the chemical processing referred to as esterification, the oils or fats are not suitable for use as fuel in compression ignition engines. The oil or fat must be esterified and the water and contaminants removed.

Fuel made of 100 percent FAME is referred to as B100 biodiesel or neat biodiesel.

Biodiesel can be blended with distillate diesel fuel. The blends can be used as fuel. The most commonly available biodiesel blends are B5, which is 5 percent biodiesel and 95 percent distillate diesel fuel. Also, B20, which is 20 percent biodiesel and 80 percent distillate diesel fuel. The percentages are volume-based.

U.S. distillate diesel fuel specification "ASTM D975" includes up to B5 (5 percent) biodiesel. Any diesel fuel in the U.S. may contain up to B5 biodiesel fuel without labeling that indicates biodiesel content.

European distillate diesel fuel specification "EN 590" includes up to B5 (5 percent) biodiesel and in some regions up to B7 (7 percent) biodiesel. Any diesel fuel in Europe may contain up to B5 or in some regions up to B7 biodiesel fuel without labeling that indicates biodiesel content.

Biodiesel fuel that is per Caterpillar and Industry recommended specifications (Refer to Table 2 in this Chapter) offers the following advantages:

- Renewable fuel, nontoxic, and biodegradable
- Reduces tailpipe particulate matter (PM), hydrocarbon (HC), and carbon monoxide (CO) emissions from most modern diesel engines
- High lubricity, hence reduces friction
- High cetane number

Biodiesel at B5 blend level has the same attributes as diesel fuel. At blend levels over B5, biodiesel has the following attributes that require management:

- Energy density. At B100, biodiesel has about 8% lower energy density than diesel fuel. At B20 or lower blend levels, the energy density difference from diesel fuel is not significant.
- Oxidation stability, storage stability, cold temperature properties, and materials compatibility. Some of these attributes are controlled by the specifications.
- Tendency to dissolve and absorb water, which is higher than the tendency of diesel fuel to dissolve and absorb water.
- Metal content. Biodiesel can contain certain materials naturally or due to processing (phosphorus, sodium, calcium, potassium, and magnesium). The maximum levels of these materials are controlled by the appropriate specifications.
- Contaminants content due to incomplete esterification or purifying process. These contaminants may include glycerides, mono and di esters, sterol glucosides, and others.

Meeting specifications as detailed in this Chapter is paramount for biodiesel fuel used in engines, to avoid performance issues and engine downtime.

Refer to guidelines given in this Chapter and to Tables 2 and 4 for the biodiesel fuel requirements and specifications.

Note: The user of the engine has the responsibility of using the correct fuel that is recommended by the manufacturer. The fuel must be allowed by the U.S. EPA and other appropriate regulatory agencies.

NOTICE

In North America, the use of biodiesel from "BQ-9000" accredited producers and "BQ-9000" certified marketers is required. Refer to the “Recommendations” section for details.

NOTICE

Failures that result from the use of any fuel are not Caterpillar factory defects. Therefore, the cost of repair would NOT be covered by the

Caterpillar warranty for materials and/or the warranty for workmanship.

Recommendations for the Use of Biodiesel in Caterpillar Nonroad Engines

To be acceptable for blending, the biodiesel constituent must meet the requirements that are listed in Table 4, “Caterpillar Specification for Biodiesel Fuel”, the latest edition of "ASTM D6751", and/or the latest edition of "EN14214".

Biodiesel blends of up to B5 must meet the requirements for the distillate diesel fuel that are listed in Table 51, “Caterpillar Specification for Distillate Diesel Fuel for Nonroad Diesel Engines”, the latest edition of "ASTM D975", and/or the latest edition of "EN 590".

Note: Caterpillar recommendations for most engines have been changed to B20 from historically higher blend level. This change was due to the development of "ASTM D7467" or "EN 16709" specification for B6-B20, which defines quality requirements for B6-B20 blends of biodiesel. This specification helps customers to define the fuel quality. Refer to the detailed requirements given in this Section.

Biodiesel blends of B6 to B20 must meet the requirements listed in the latest edition of "ASTM D7467" "EN 16709" (B6 to B20) **and** must be of an API gravity of 30-45.

The distillate diesel fuel acceptable for blending with biodiesel should be the “Caterpillar Specification for Distillate Diesel Fuel for Nonroad Diesel Engines” table in the "Distillate Diesel Fuel" section of thisSpecial Publication, the latest edition of "ASTM D975", and/or the latest edition of "EN 590". No. 1-D and No. 2-D are examples of fuels that are acceptable for creating biodiesel fuel. Refer to “Fuel Specifications” Chapter in this Special Publication for details.

For Tier 4 applications in the U.S., the diesel fuel portion of the final blend must meet the requirements of S15 fuels (15 ppm sulfur) designations in the latest edition of "ASTM D975" specification. For Stage IIIB and later applications in EU, the diesel fuel portion of the final blend must meet the requirements for sulfur free (10 ppm sulfur) designation in the latest edition of "EN 590". The final blend must have maximum of 15 ppm sulfur.

In North America, obtain biodiesel from BQ-9000 accredited producers and BQ-9000 certified marketers. Look for the BQ-9000 biodiesel quality accreditation program certification logo that is available to distributors that meet the requirements of BQ-9000. In other areas of the world, the use of biodiesel that is BQ-9000 accredited and certified, or that is accredited and certified by a comparable biodiesel quality body to meet similar biodiesel quality control standards, is required. For more information on the BQ-9000 program, go to:

http://www.BQ-9000.org

Table 1

Recommendations for Biodiesel Fuel Application in Caterpillar Nonroad Engines[1]		
Engine Models	**Model Specific**	

		Biodiesel Acceptable Blend Levels
Cat engine models: C7 through C32, CM20, CM25 and CM32, 3400 Series, 3500 Series and 3600 series	Engine models with aftertreatment devices	Up to B20
	Engine models without aftertreatment devices	Up to B20 (For use of higher blend levels up to B100, consult with your Cat dealer)
Cat engine model C175	Tier 4 and EU Stage IIIB model (Locomotive)	Up to B7
	Tier 4	Up to B7
	All other C175 engines	Up to B20 (For use of higher blend levels up to B100, consult with your Cat dealer)
Cat engine models: 3003 through 3066	All engine models	Up to B7
Cat engine models: C0.5 through C3.8	C0.5, C0.7, C1.1, C1.5, C1.6, C2.2, C3.4 engines Tier 2 / Stage II or earlier Emissions Regulation, without aftertreatment devices	Up to B7
	C2.4, C3.3B, C3.8 engines with aftertreatment devices	Up to B7
	C1.3, C1.7, C1.8, C2.4, C2.6, C3.3B, C3.4 engines without aftertreatment devices, and C3.4B engine with aftertreatment devices	Up to B20
	C0.5 through C2.2, all years except as listed above	Up to B20 (For use of higher blend levels up to B100, consult with your Cat dealer)
Cat engine model C4.4	C4.4 engines with aftertreatment devices	Up to B20 (For use of higher blend levels up to B100, consult with your Cat dealer)
	C4.4 engines S/N C4E05524-Up and 44404304 -Up	Up to B20
	Certain C4.4 (S/N 44400001-04303)	Up to B7

Cat engine models C6.4 and C6.6	C6.6 engines with aftertreatment devices	Up to B20
	C6.4, and certain C6.6 engines (S/N CE614624-Up (Machines) and 66609016-Up (Industrial))	Up to B20 (For use of higher blend levels up to B100, consult with your Cat dealer)
	Certain C6.6 engines (S/N CE600001-14623 (Machines) and S/N 66600001-09015 (Industrial)	Up to B7

(1) EU Regulations require the biodiesel blends used in Stage V engines operated within the European Union (EU) to contain no more than B8 (8% v/v FAME) unless specified otherwise in the engine-specific Operation and Maintenance Manual. B8 can be used where B7 is specified.

Table 2

Fuel Recommendations for Caterpillar Nonroad Engines		
Biodiesel Blend Stock	Final Blend	Distillate Diesel Fuel used for blending
Cat biodiesel specification, (1) "ASTM D6751" or "EN14214"	B5 and B7; Cat distillate diesel fuel specification, (2) "ASTM D975" or "EN590"	Cat distillate diesel fuel specification, "ASTM D975" or "EN590"
	B20: "ASTM D7467" or "EN 16709" and "API" gravity 30-45	

(1) Refer to Table +=¯˘ in the Biodiesel section of this Special Publication.

(2) Refer to “Cat Specification for Distillate Diesel Fuel for On-Highway Engines” in the Fuel section of this Special Publication.

Note: Do not change any engine settings when using biodiesel fuel. When the use of biodiesel fuel is planned, simply convert to this fuel. Follow the guidelines, recommendations, and quality specifications given in this Chapter to avoid any performance issues or downtime.

Two methods can be used for determining the volume percent biodiesel in a biodiesel blend:

- "ASTM D7371" - "Test Method for Determination of Biodiesel (Fatty Acid Methyl Esters) Content in Diesel Fuel Oil Using Mid Infrared Spectroscopy (FTIR-ATR-PLS Method)"
- "EN 14078" - "Liquid Petroleum Products - Determination of fatty acid methyl esters (FAME) in middle distillates -Infrared spectroscopy method"

For applications running biodiesel or biodiesel blends, if fuel treatments are needed, consult with your fuel supplier or with a reputable provider. :

Impact of Biodiesel on Engine Oil

Biodiesel fuel has higher density and lower volatility than diesel fuels. As a result, during engine operation, biodiesel fuel that dilutes the crankcase oil may not evaporate as effectively as diesel fuels. For this reason, fuel dilution of crankcase oils may be higher when biodiesel, in particular when higher blends of biodiesel are used.

Also, biodiesel contains oxygen molecules. These oxygen molecules cannot be differentiated from oil oxidation when using current oil analysis techniques. As a result, biodiesel fuel dilution of the crankcase oil can appear to be higher oxidation of the oil.

When using biodiesel fuel and higher fuel dilution and/or apparent oil oxidation are detected in the crankcase engine oil, consider all the other characteristics of the used oil If these characteristics, such as wear metals, soot, viscosity or others, are per Caterpillar guidelines and have not reached condemnation limits, then the oil drain intervals should not be impacted.

To reduce any potential impact of biodiesel fuel dilution on crankcase oil, **the use of Cat S·O·S Services oil analysis is strongly recommended when up to B20 (20 percent) and lower biodiesel blends are used, and required when using biodiesel/biodiesel blends that are B20 or above.** When requesting oil analysis, be sure to note the level of biodiesel being used (B5, B20, and so on).

Use of Biodiesel fuel in Engines with Aftertreatment Emissions Control Systems

Biodiesel fuels as defined in the current ASTM specifications, may contain phosphorous, alkali and alkaline metals (sodium, potassium, calcium, and magnesium) due to processing techniques or due to the natural contents of the biodiesel feedstock. When present in biodiesel, these metals form ash upon combustion in the engine. The ash accumulates in the aftertreatment systems such as Diesel Particulate Filters (DPF), DOC or other systems. The ash can affect the life and performance of aftertreatment emissions control devices and may cause the need for more frequent ash service intervals. For these reasons, biodiesel fuels that contain ash forming metals, even at the concentration levels defined in the current specifications, are limited to B20 blend levels in the engines with aftertreatment devices.

Local and regional regulations may also restrict the blend levels allowed in engines of certain emissions levels. **EU Stage V** regulations REQUIRE the biodiesel blends used in engines operated within the European Union (EU) to be ≤ 8 % volume/volume unless specified otherwise in the engine-specific Operation and Maintenance Manual.

Note: Certain CAT engines that are certified per EU Stage V can use up to B20 biodiesel blends. Refer to your engine specific Operation and Maintenance Manual.

Biodiesel Fuel Stability

Biodiesel fuels key difference from diesel fuel is the ester chemical group (contains two oxygen atoms) in every biodiesel molecule. Biodiesel may also have double bonds (unsaturation) in the carbon chain that can vary based on the feedstock. Due to the ester chemical group and the

unsaturation, the oxidation stability of biodiesel fuels is typically lower than that of diesel fuel. The oxidation stability of biodiesel and biodiesel blends is controlled in ASTM specifications, "D6751" for B100 and "D5467" for B20. Biodiesel fuels that do not conform to these specifications can oxidize quickly during use due to the high temperature and pressure conditions in the engine or during storage and handling practices. Oxidized biodiesel forms acids, gums, high viscosity and deposits, which can plug filters, form deposits, particularly in the fuel injector, and reduce the performance of fuel systems. **Biodiesel fuels meeting or exceeding the oxidation stability limits is critical** to avoid poor performance and downtime of engines.

To avoid the issues associated with oxidized biodiesel fuel, always purchase fuels that conform to or exceed the specifications (refer to Tables 54 and 56 in this Chapter). Also, follow all the guidelines for appropriate storage and handling of this fuel such as avoiding excessive heat and sunlight during storage, exposure to oxygen (air), contact with metals such as copper, lead, tin, zinc, and others. The use of antioxidants can improve the oxidation stability of biodiesel fuel. The antioxidants are most effective when added to new fuels. Consult with your fuel supplier to ensure the quality of the fuel and refer to the details given in this chapter for guidance.

Cat Diesel Fuel System Cleaner (Part number 343-6210). Cat , used as needed or on an on-going basis, is most effective at cleaning and preventing the formation of fuel-related deposits.

Refer to the “Diesel Fuel Conditioner” and “Cat Diesel Fuel System Cleaner” topics in the “Distillate Diesel Fuel” section in this Special Publication for additional information. Consult your Caterpillar dealer for availability of Cat Diesel Fuel System Cleaner. In case a fuel conditioner is needed to improve certain fuel properties, consult with your fuel supplier or with a reputable provider.

Biodiesel Fuel Storage

Storage tanks used for storing diesel fuel are appropriate for storing biodiesel fuels. Fuel storage tanks need to be cleaned thoroughly before converting to biodiesel/biodiesel blends. Conversion to biodiesel/biodiesel blends can loosen fuel system and fuel storage tank deposits. Loosened deposits result in filter plugging with the loosened deposits. For this reason, the change intervals of bulk tank continuous filtration unit, dispensing point filters, and onboard engine filters should be shortened for an extended period to allow for this cleaning effect. Once the systems are cleaned, the typical filter service intervals can be resumed.

Biodiesel fuel is hygroscopic, which implies that biodiesel tends to absorb and dissolve water at a higher concentration than diesel. All precautions and measures must be taken to ensure that storage tanks are protected from water ingress. Follow all the contamination control measures provided in the "Contamination Control" section of this Special Publication.

Guidelines

Information provided in this table refers to biodiesel and biodiesel blends that fully comply with the appropriate specifications as described in the “Biodiesel” section of this Special Publication and to handling and maintenance procedures that follow recommended guidelines.

Table 3

Guidelines and Potential Impacts Associated with the Use of Biodiesel and Biodiesel Blends[1]			

Paragraph reference	Risk/Recommendation	B6-B20	B21-B100
1	Risk of reduction of oil change interval	Low	Medium
2	Fuel filters compatibility risk	Low	Medium
3	Loosening of fuel systems deposits upon conversion to biodiesel	Medium	High
4	Bulk filtration of biodiesel	≤4 microns absolute	≤4 microns absolute
5	Energy content of biodiesel	Minor loss of 1-2 percent	Detectable loss of 5-8 percent
6	Risk of elastomers compatibility	Low	Medium
7	Low ambient temperature issues for both storage and operation	Low-Medium	Medium-High
8	Oxidation stability-Injector deposits risk	Low-Medium	Medium-High
9	Oxidation stability-Duration of storage (2)	8 months(3)	4 months(4)
10	Use in engines with limited operational time	Unacceptable(5)	Unacceptable
11	Microbial contamination and growth-Risk	Medium-High	High
12	Need for water removal	High	High
13	Metal incompatibility	Medium	High

(1) Information provided in this Table refers to biodiesel and biodiesel blends that fully comply with the appropriate specifications as described in the "Biodiesel section" of this Special Publication and to handling and maintenance procedures that follow recommended guidelines.

(2) Testing of biodiesel or biodiesel blend during storage is strongly recommended. Tests should include oxidation, acid number, viscosity and sediments. Tests should be conducted periodically to ensure biodiesel is per specification. Antioxidants are recommended to improve stability of biodiesel. Consult with your fuel supplier for more information.

(3) Testing of B20 blends is recommended at 4 months of storage and on a monthly basis thereafter. Tests should include oxidation, acid number, viscosity, and sediments.

(4) B100 stored for over 2 months should be tested every 2 weeks to ensure that the fuel is not degraded. Tests should include oxidation, acid number, viscosity, and sediments. The use of appropriate additives is required if B100 is stored more than 4 months. Consult your fuel supplier for more information. B100 should be stored at temperatures of 3 degrees C to 6 degrees C (5 degrees F to 10 degrees F) above the cloud point.

(5) If B20 is used in engines of limited operational time, it is recommended that a stabilizer additive is added at the beginning of the storage period. Testing is recommended periodically to ensure the fuel has not oxidized.

The following are details of the Risks and Guidelines listed in Table 3. Refer to the paragraph reference numbers:

1. When using biodiesel fuel, dilution of oil by the fuel may increase. Use S·O·S Services oil analysis to monitor the condition of the engine oil. S·O·S Services oil analysis will also help determine the oil change interval that is optimum. Details are given earlier in this Chapter.

2. Confirm with the filter manufacturer that the fuel filter/filters to be used are compatible with biodiesel. Fuel water separators are preferred when biodiesel is used.

   Note: Cat fuel filters and Cat fuel water separators are compatible with biodiesel fuel.

3. Conversion to biodiesel can loosen fuel tanks and fuel system deposits. During the conversion period fuel filter change intervals should be shortened to allow for this cleaning effect. Once the deposits are removed, convert back to the regular filter service intervals. Filter change interval of 50 hours or less may be expected during initial conversion to B20 biodiesel blend.

4. Filter biodiesel and biodiesel blends through a fuel filter with a rating of 4 microns (c) absolute or less. Filters should be on the device that dispenses the fuel from the bulk storage tank to the fuel tank for the engine. Bulk filtration with fuel water separators is recommended. Series filtration is recommended.

5. Neat biodiesel (B100) typically provides less energy per gallon compared to diesel fuels. The energy content of B100 is 5 percent to 8 percent lower than No. 2 diesel fuel. The energy content of B20 is 1 percent to 2 percent lower than No. 2 diesel fuel, which is not significant. Do NOT attempt to change the engine rating to compensate for the power loss. Any adjustments to the engine in service may result in violation of emissions regulations such as the U.S. EPA anti-tampering provisions. Also, if any tempering with the engine ratings occurs, problems may occur when the engine is converted back to 100 percent distillate diesel fuel.

6. Compatibility of the elastomers with biodiesel is being monitored. Prolonged exposure of certain elastomers, hoses, seals, and gaskets to B100 may cause some degradation and softening of these materials. The condition of gaskets, seals, and hoses should be monitored regularly. The risk of degradation increases with the increase of biodiesel blend level.

   a. In general, Cat engines built early to mid-90s use Viton seals and Viton O-rings in the fuel system. Viton is compatible with biodiesel and degradation upon exposure to this fuel is not expected.

   b. Nitrile hoses typically used in some fuel transfer lines are not compatible with biodiesel. Monitor the condition of the hoses and confirm with the hose manufacturer that the hoses are compatible with the biodiesel blend used. If necessary, replace with hoses of compatible materials.

7. Biodiesel fuels may gel or freeze at low temperatures due to the nature of this fuel. Ensure that the biodiesel pour point is appropriate for the climate of the application. In general the risk of low temperature gelling of biodiesel increases with the increase of blend levels and may depend on the biodiesel feedstock (soy, used cooking oil, animal fats, and others). If the pour point of the biodiesel is not appropriate for the climate of the application, the fuel can gel and plug filters, hoses and transfer lines. At low ambient temperatures, biodiesel fuel may need to be

stored in a heated building or a heated storage tank. Consult your biodiesel supplier for assistance in the blending and attaining of the proper cloud point for the fuel. Refer to "Modifying the Cloud Point" in the "Diesel Fuel" Section of this Special Publication.

Note: The performance of cold flow improvers may be less effective in biodiesel fuel compared to diesel fuel. Consult the fuel supplier for appropriate cold flow improvers if needed.

8. Biodiesel oxidation stability is in general lower than that of diesel fuel, as detailed earlier in this Chapter. The use of biodiesel fuels that are not per specifications can accelerate fuel oxidation in the fuel system. Also, engines with an electronic fuel system operate at higher temperatures and pressures can also accelerate fuel oxidation. Oxidized fuel can form deposits in fuel injection systems and in fuel systems in general. Always use biodiesel fuel that meets or exceeds the stability limits defined in biodiesel specifications as given in this Chapter to avoid fuel oxidation and degradation. The use of appropriate antioxidants can enhance oxidation stability of biodiesel. Refer to “Biodiesel Fuel Stability” section of this chapter for details and guidelines.

9. Due to the chemical nature of biodiesel fuel, biodiesel can age and degrade during long-term storage. Fuel aging and fuel oxidation upon long-term storage may cause the formation of gels, acids and/or deposits. For these reasons, biodiesel should be used within a limited time from production. To ensure appropriate storage duration, testing of the stored biodiesel is recommended. Tests should include oxidation, acid number, viscosity, and sediments. Tests should be conducted periodically to ensure that biodiesel is per specification. Antioxidants are recommended to improve stability of biodiesel and increase the storage time limits. In case a fuel conditioner is needed to improve certain fuel properties, consult with your fuel supplier or with a reputable provider.

    a. B20 biodiesel blend can generally be stored up to 8 months. Testing of B20 blends is recommended at 4 months of storage and on a monthly basis thereafter to ensure that the fuel has not degraded.

    b. B100 biodiesel can generally be stored up to 4 months. Testing of B100 is recommended at 2 months of storage and every two weeks thereafter to ensure that the fuel has not degraded. The use of appropriate additives is required if B100 is stored for more than 4 months. Consult your fuel supplier for more information.

    c. B100 should be stored at temperatures of 3° C to 6° C (5° F to 10° F) above the cloud point. Other storage conditions such as avoiding direct sunlight or heat should be followed.

10. Due to limited oxidation stability and other potential issues, engines with limited operational time (such as seasonal use including school buses, farm machinery, or standby power generation) should either not use biodiesel/biodiesel blends or, while accepting some risk, limit biodiesel to a maximum of B5. Examples of applications that should limit the use of biodiesel are the following: Standby Generator sets and certain emergency vehicles. For more information, refer to the “Seasonal Operation” section.

    a. A high-performance fuel conditioner is recommended for standby generator sets and emergency vehicles using biodiesel/biodiesel blends. The conditioner should be added when the engine is fueled or as early as possible when the fuel is delivered and stored.

Preferably, the conditioner or additive should be added as soon as possible after the fuel is produced.

b. For standby generator sets and emergency vehicles that use biodiesel, sample the fuel in the engine tank monthly. Test the fuel for acid number and oxidation stability. If the test results show that the fuel is degraded and not in specification (provided in Table 4 in this “Biodiesel” section), drain the tank, and flush the engine by running with high-quality fuel.

   Repeat the process until the system is clean. Refill with high-quality fuel following the recommendations provided in this “Fuel” section. For standby generator sets and emergency vehicles that use biodiesel, use fuel with oxidation stability 10 hours or more per "EN 14112" test method.

11. Biodiesel is prone to microbial contamination and growth due to the chemical nature. Microbial contamination and growth can cause corrosion in the fuel system and premature plugging of the fuel filter. Consult your supplier of fuel and additive for assistance in selecting appropriate anti-microbial additives.

12. Biodiesel can absorb and dissolve more water than diesel due to the chemical nature. Care must be taken to prevent water from contaminating the fuel and to remove water from fuel tanks. Water accelerates microbial contamination and growth.

13. Biodiesel is not compatible with some metals. Biodiesel, in particular at blends higher than B20, will oxidize and form sediments upon long-term contact with lead, zinc, tin, copper, and copper alloys such as brass and bronze. These materials are typically not used in the fuels systems. Consult your dealer for more information.

Note: The use of biodiesel at a B2 level improves the lubricity of the final blend by an estimated 66 percent. Increasing the blend level higher than B2 does not improve the lubricity any further.

Note: Use of biodiesel that is per or preferably exceeds the specifications can avoid the issues listed above and reduce the risks listed above.

Seasonal Operation

Seasonally operated engines should have the fuel systems, including fuel tanks, flushed with conventional diesel fuel before prolonged shutdown periods. Applications that should seasonally flush the fuel system include school buses (U.S.) and farm machinery.

Perform the following process before shutting down the engine for prolonged periods:

1. Operate the engine until the fuel level in the tank is low.

2. Refill the fuel tank with high-quality conventional distillate diesel fuel.

3. Repeat steps 1 and 2 a minimum of two times before the engine is shut down for prolonged periods.

If distillate fuel is not available to operate the engine as described above, while accepting some risk, limit biodiesel to a maximum of B5. The use of biodiesel fuel of high oxidation stability can reduce the risks associated with prolonged storage. Follow the recommendations provided in this section and the guidelines given below to reduce the risk:

- Addition of a high-performance diesel fuel conditioner is recommended prior to engine shutdown for prolonged periods. The conditioner should be added when the engine is fueled. Preferably, the conditioner is added to the fuel as soon as possible after the fuel production.
- Addition of Cat Diesel Fuel System Cleaner, part number 343-6210, is recommended when the engine is first operated after the prolonged shutdown period and preferably for a total of two tanks of fuel. Follow the recommendations provided in the Cat Diesel Fuel System Cleaner section in the “Fuel” article in this Special Publication.

Consult your Caterpillar dealer for the availability of Cat Diesel Fuel System Cleaner. In case a fuel conditioner is needed to improve certain fuel properties, consult with your fuel supplier or with a reputable provider

Biodiesel Specification

Biodiesel fuel used that is used for blending must meet the requirements in the following table, the requirements of ASTM "D5761" and/or "EN14214".

The final blend of biodiesel as used in the engine must meet the requirements that are stated in table 4 this “Biodiesel” article.

B100 intended for blending into diesel fuel that is expected to give satisfactory vehicle performance at fuel temperatures at or below −12° C (10.4° F) shall comply with a cold soak filterability limit of 200 seconds maximum. Passing "ASTM D6751" 200 seconds Cold Soak Filterability test limit does not guarantee cold performance for all biodiesel blends at all possible fuel temperatures, but biodiesel that fails this Cold Soak Filterability test requirement will produce biodiesel blends that will likely plug fuel filters when fuel temperatures are below −12° C (10.4° F).

Table 4

Cat Specification for Biodiesel Fuel				
Property	**Test Method**	**Test Method**	**Units**	**Limits**
	United States	**International**	**Specific Properties of Fuel**	
Density at 15°C	"ASTM D1298"	"ISO 3675"	g/cm^3	0.86-0.90
Viscosity at 40°C	"ASTM D445"	"ISO 3104"	mm^2/s (cSt)	1.9-6.0
Flash Point		"ISO 3679"	°C	93 minimum

	"ASTM D93"			
Pour Point - Summer - Winter	"ASTM D97"	"ISO 3016"	°C	6 °C (10 °F) minimum below ambient temperature
Cloud Point	"ASTM D2500"		°C	Report
Sulfur Content	"ASTM D5453"	"ISO 20846" "ISO 20884"	percent weight	0.0015 maximum
Distillation 10 percent Evaporation	"ASTM D86"	"ISO 3405"	°C	To Be Determined
Distillation 90 percent Evaporation	"ASTM D86"	"ISO 3924"	°C	360
Carbon Residue, Conradson (CCR)	"ASTM D4530"	"ISO 10370"	percent weight	0.05 maximum
Cetane Number	"ASTM D613"	"ISO 5165"		45 minimum
Sulfated Ash	"ASTM D874"	"ISO 3987"	percent weight	0.02 maximum
Water/Sediment Content	"ASTM D2709"	"ISO 12937"	percent volume	0.05 maximum
Copper Corrosion	"ASTM D130"	"ISO 2160"		No. 1
Oxidation Stability	"EN 14112"	"EN 14112"	hours	3 minimum
Esterification	"EN 14103"	"EN 14103"	percent volume	97.5 minimum
Acid Value	"ASTM D664"	"EN 14104"	mg KOH/g	0.5 maximum
Methanol Content	"EN 14110"	"EN 14110"	percent weight	0.2 maximum
Monoglycerides	"ASTM D6584"	"EN 14105"	percent weight	0.8 maximum
Diglycerides	"ASTM D6584"	"EN 14105"	percent weight	0.2 maximum

Triglycerides	"ASTM D6584"	"EN 14105"	percent weight	0.2 maximum
Free Glycerin	"ASTM D6584"	"EN 14105"	percent weight	0.02 maximum
Total Glycerin	"ASTM D6584"	"EN 14105"	percent weight	0.240 maximum
Phosphorus Content	"ASTM D4951"	"EN 14107"	percent weight	0.001
Calcium and Magnesium combined	"EN 14538"	"EN 14538"	ppm	5 maximum
Sodium and Potassium combined	"EN 14538"	"EN 14538"	ppm	5 maximum
Cold Soak Filterability	"ASTM D7501"	--	seconds	360 maximum
Cleanliness	"ASTM D7619"	"ISO 4406"	--	(1)

(1) Recommended cleanliness level for fuel as dispensed into machine or engine fuel tank is "ISO 18/16/13" or cleaner per "ISO 4406" or "ASTM D7619". Refer to the “Contamination Control” section in this Special Publication.

Note: Fuels that meet the most current revision level of "ASTM D6751" or "EN 14214" may be used for blending with an acceptable distillate fuel. The conditions, recommendations, and limits that are noted in this Biodiesel section apply.

Referenced Documents

Refer to the “Reference Material - Fuel” section of this Special Publication for the reference material for the information in this section.