

**DIRECT TO:**

- ☒ Service Manager
- ☒ Parts Manager
- ☒ Product Specialist

Service Letter

SL #: 5345
Date: 7 July 2015
Product: All Products
Subject: Diesel Fuel for Bobcat Equipment

This letter replaces SL5345 dated 3 September 2013.

The changes required to meet Tier 4 emissions standards were dramatic. Understanding today's fuel and how it relates to current engine requirements is crucial to our shared success.

Dealers are asked to review this information in detail with all your staff and share it with your customers to promote product satisfaction.

ULSD - What you need to know

Diesel is a complex mixture of thousands of different chemical compounds, each with varying characteristics that affect the overall fuel properties. In 2010, Ultra Low Sulfur Diesel (ULSD) became the fuel requirement for all diesel engines in the US. ***Since that time, fuel refiners, suppliers and end users have all been learning how best to adjust to this significant fuel chemistry change.***

ULSD is produced with sulfur levels less than 15 parts per million (ppm). Reducing sulfur enables diesel engines to utilize advanced control devices to reduce emissions.

Figure 1



[Figure 1] All current Bobcat products require ULSD and all older diesel engine equipped Bobcat models can use ULSD fuel.

While dramatically reducing sulfur content in fuel was necessary as part of the lower emissions strategy, doing so also brought some disadvantages. ***First, the fuel's ability to store and potentially discharge static electricity during refueling increased.*** To review facts on static electricity risk, see the *Best Practice Guidance Bulletin 6/13* published by the Association of Equipment Manufacturers (AEM).

In addition, the current chemistry has made it harder for suppliers to consistently provide fuel that performs as well in cold climates. The process used to remove sulfur also removes most nitrogen and oxygen compounds and increases saturates, which increases the Cloud Point (CP). Much of the chemistry added to replace the beneficial properties of sulfur, nitrogen and oxygen has a significant impact on how water acts in fuel. Today's fuel has a greater tendency to attract and hold water in suspension.

The chemistry and variations of ULSD compared to prior fuel create the following cold weather challenges:

- Greater potential for fuel filter freeze up due to higher water content in fuel
- Increased tendency to gel and plug the fuel filter because of the higher CP temperature
- Effectiveness of existing fuel additives may vary substantially depending on combined chemistry
- More difficulty bringing fuel back from gelled to normal because a higher temperature is required

Fuel Standards and Cleanliness

The American Society for Testing and Materials (ASTM) is the premier standard setting organization for fuels worldwide. ASTM standard D975 specifies the required properties for petroleum based diesel fuel and ASTM standard D6751 outlines the required biodiesel properties. EN590 is a fuel standard used in Europe.

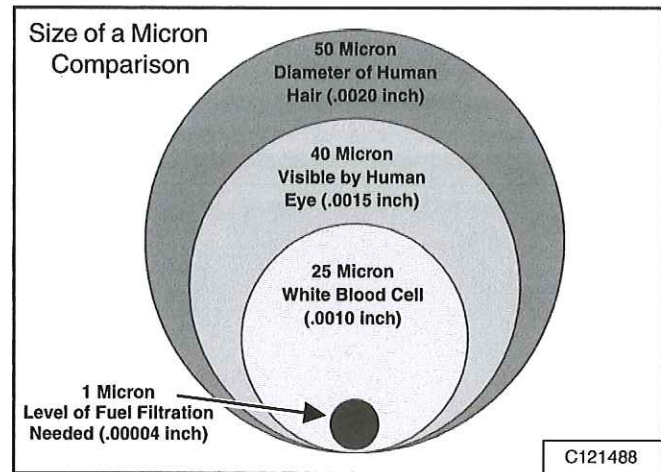
Current fuel standards do not adequately address all the requirements brought by ULSD and High Pressure Common Rail (HPCR) engine technology. There is ongoing work to revise fuel standards in key areas such as fuel cleanliness and cold weather operability test methods.

Engine Design and Today's Fuel Requirements

Looking back in time fuel systems were much simpler, and much less sensitive to contaminants. Fuel system pressures were much lower than today as were flow rates. There was little concern over deterioration of fuel system components and the effect on emissions. Parts were relatively inexpensive and easy to replace. Bobcat fuel filters were liberal in what was allowed to pass to the components. In those days the machine operator's measure of producing good power was the amount of visible black smoke. There was little incentive for anyone to pursue cleaner fuel.

While today's diesel engines are more efficient and burn cleaner, HPCR technology uses extremely precise components that demand clean fuel to maintain emissions levels and component longevity. Fuel pressures have risen from about 3500 psi a few years ago to as high as 30,000 psi. Fuel flow rates are greater also, as unburned fuel is used to lubricate and cool the fuel pump. A fuel cooler is now required to prevent fuel temperatures from exceeding specified limits. Bobcat uses a thermostatic control to bypass the cooler unless needed, to allow the fuel to warm enough to help prevent gelling in cold weather.

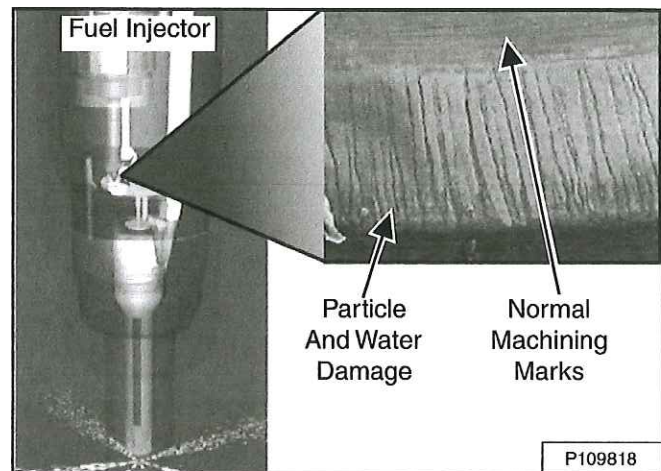
Figure 2



[Figure 2] The fuel pump and injectors are manufactured with very tight tolerances and amazingly small orifice sizes, sometimes as small as 1 micron – ***40 times smaller than the human eye can see.***

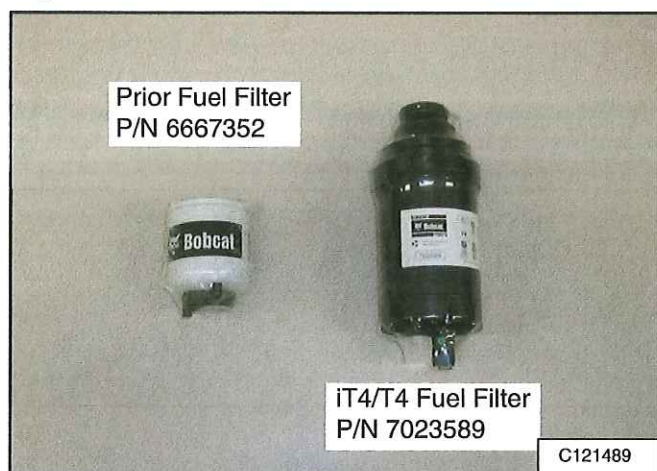
Contaminant is an abrasive, even when it's smaller than the eye can see. Combine that abrasive with high fuel pressure and it can become much like a sandblaster inside the fuel system of an engine. The erosion that can take place inside the precision components will negatively impact performance, fuel economy and component longevity.

Figure 3



[Figure 3] Damage from contamination is by far the most frequent root cause of problems attributed to fuel injectors - preventing this contamination is critical. ***Today's engines must have cleaner diesel than is commonly available from the supplier, so it must be adequately filtered.***

Figure 4



FUEL FILTER EFFICIENCY COMPARISON		
P/N	PARTICLE REMOVAL	EMULSIFIED WATER REMOVAL
6667352	50% @ 3 Micron	58%
7023589	99.6% @ 1 Micron	95%

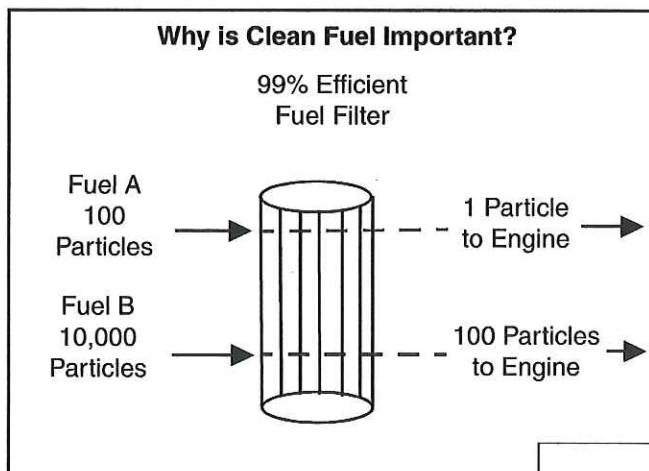
[Figure 4] The fuel filter chosen for HPCR engine equipped Bobcat products is highly effective at trapping down to 1 micron contaminants and removing free and emulsified water. While the filter capacity is much greater than our prior fuel filters, it can become plugged in just a few hours of operation if highly contaminated fuel is used – **because it is so effective at protecting the fuel system**. Other filters tested by Bobcat, some used by our competitors, did not meet the level of protection required to provide the HPCR component longevity our customers expect.

Owners should always observe the following fuel system best practices:

- Always use a Bobcat brand fuel filter
- Drain the water trap daily
- To avoid contamination, never prefill a new filter
- To avoid contamination, never open fuel connections in the system upstream of the fuel filter
- Fill equipment at the end of the work day, to reduce the chance of creating condensation when the fuel tank cools to ambient temperature.

Although micron rating is the common and most important rating of a filter, no filter is 100% efficient at removing contaminants. **Some particles will get through, and minimizing this by using the cleanest fuel possible can provide substantial long term payback.**

Figure 5



[Figure 5] In this example the filter is 99% efficient at the given micron rating. It shows that using highly contaminated fuel B can be just as damaging as using fuel A with no filtration.

Buying fuel based solely on price at the pump is not a good value for today's equipment owners. There has been little motivation for distributors and suppliers to provide fuel that is cleaner than in the past, and water free. Adding filtration at the distributor/supplier level is a filter maintenance expense as well as a cost in loss of volume relative to water removed. Fuel that is clean, water free and blended appropriately for the climate could sometimes cost more at the pump, but it will pay back daily in lower fuel consumption, allow fewer filter changes and deliver longer fuel system component life.

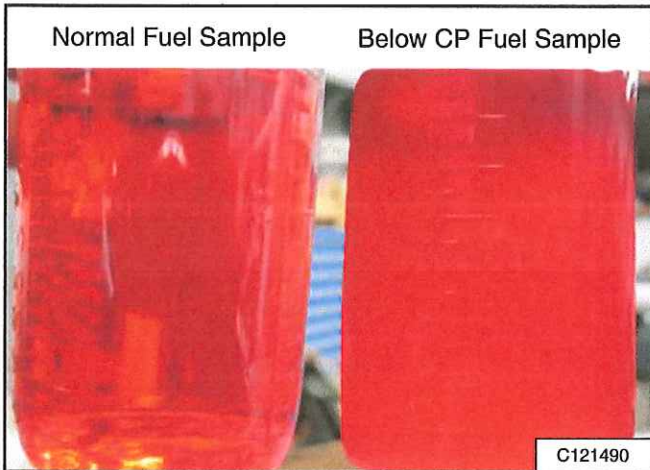
Ultimately, consumers must be proactive in seeking diesel that will meet their needs. Choosing a reputable supplier is critical to avoiding problems and ensuring uptime. Asking key questions will help consumers choose a supplier, for example:

- What is the filter rating on your fuel delivery lines? (should be 10 micron or lower and water removing)
- What is your maintenance interval for tank cleaning, water removal and filter replacement?

Cold Weather Considerations

A good fuel distributor will provide diesel that meets expectations for cold weather operability for the climate. This is a challenge in the marketplace as the cost difference between #1 and #2 is significant, making it very difficult for suppliers to factor in a generous margin when blending. **Cloud Point (CP) is the best specification to use when considering cold weather performance.**

Figure 6



[Figure 6] CP is the temperature where wax begins to drop out of fuel creating a translucent appearance. The wax forms crystals 50 to 200 microns in size that can quickly plug the fuel filter. This often is referred to as gelling.

The target for fuel CP from the refinery is based on the geographic location and the time of the year (typical temperature range) the fuel is intended to be consumed. For example, fuel made for use in Texas in July will have a very different CP than fuel made for use in North Dakota in September. Blending of a #2 fuel made for July consumption will require a higher percentage of #1 fuel to lower the CP to the desired level, than blending a #2 fuel made for September consumption. When untypical cold temperatures are experienced, problems with gelling can affect a large territory.

Cold Filter Plug Point (CFPP) is a method for comparing diesel fuels low temperature flow characteristics. This test however uses a 45 micron test patch versus today's fuel filters with 2 to 3 micron filter elements. **This means CPFF only has value in a comparative sense and it will not indicate whether a fuel filter will plug.**

The use of biodiesel dramatically increases the risk of fuel filter plugging and should be avoided in cold weather if possible - see the biodiesel section of this letter.

Winter blend is a general term, asking the following additional key questions will help consumers choose a supplier during cold weather, for example:

- Are you blending with #1 or just using additives? **(additives can reduce the size of wax crystals but only #1 will lower the CP and provide reliable results)**
- What is the CP temperature of the fuel?

While purchasing clean fuel with the needed CP temperature is most important, owners should always observe all cold weather best practices, including:

- Keep a spare fuel filter on hand for every machine.
- Follow the Cold Starting procedures listed in the Operation & Maintenance manual.
- Purchase cold weather accessories and approved diesel fuel products as needed from Bobcat Parts.

Fuel Storage Practices

Dealers and customers that have their own storage tanks must properly manage the stored fuel so it meets their needs. Storage tanks should be inspected for water/sludge and cleaned as needed. A tank that requires cleaning may be indicated by new filters being plugged quickly.

To help track problems, maintain a preventative maintenance log for the tank that includes maintenance history, filter changes, and particle counts that were taken.

Figure 7

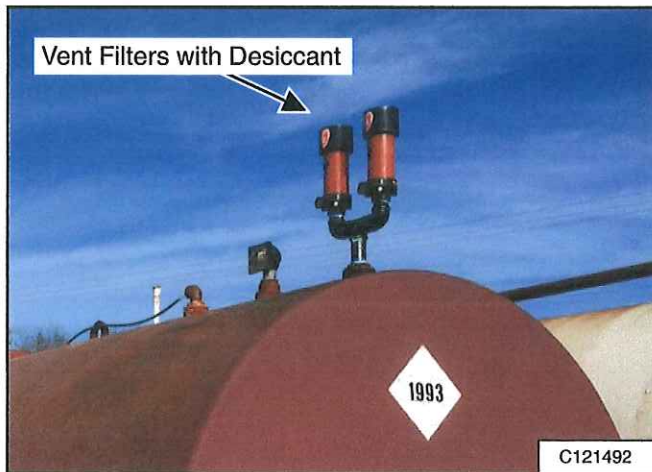


[Figure 7] A filter that is 10 micron or less and water removing should be used at the storage tank's fuel dispensing point.

Also, any fuel entering the storage tank should pass through a dispensing filter. This will increase the effectiveness of the tank's filter and help prevent contaminants from entering.

Fuel containers and tanks should never be uncapped, and the tank breather (vent) must be filtered.

Figure 8



[Figure 8] The tank breather should have a 1 micron filter with desiccant to remove moisture. As fuel is dispensed, air is sucked in through the breather, and tanks without a filter can allow particles and water to be introduced in the tank.

Biodiesel

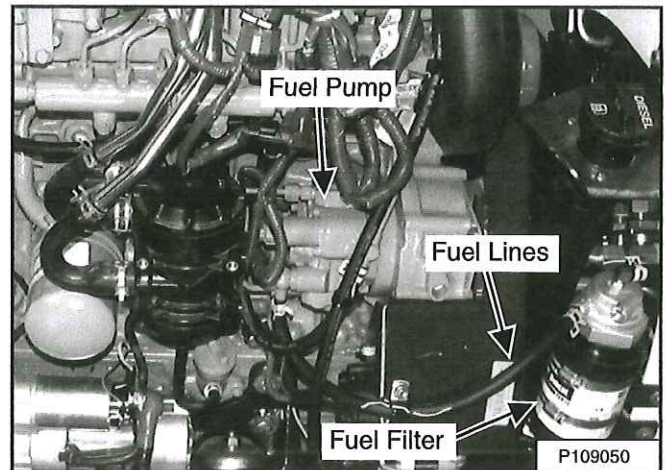
Biodiesel is an alternative fuel produced from a variety of domestic resources, primarily soybean oil in North America or rapeseed oil in Europe. Biodiesel in pure form contains no petroleum, but it can be blended at various levels with petroleum diesel to create a biodiesel blend. A common biodiesel blend is B5, which refers to a fuel mixture containing 5% biodiesel and 95% petroleum diesel.

Since biodiesel can be refined from a wide variety of raw materials, biodiesel available to consumers may have a wide range of properties and specifications. **A significant amount of biodiesel on the market today does not meet ASTM and EN590 standards.** Never use any fuel that does not meet standards or fuel in which the contents cannot be identified.

The unique qualities of biodiesel should be considered before it is used in any diesel engine. Biodiesel compared to petroleum diesel is unstable by nature and can cause unfavorable results. However, blends containing less than 5% biodiesel should have limited adverse effects. Concentrations of biodiesel greater than 5% could have harmful effects on engine performance, accelerate engine oil degradation and reduce fuel system durability.

The effects, outlined below, become more serious as the concentration of biodiesel increases.

Figure 9



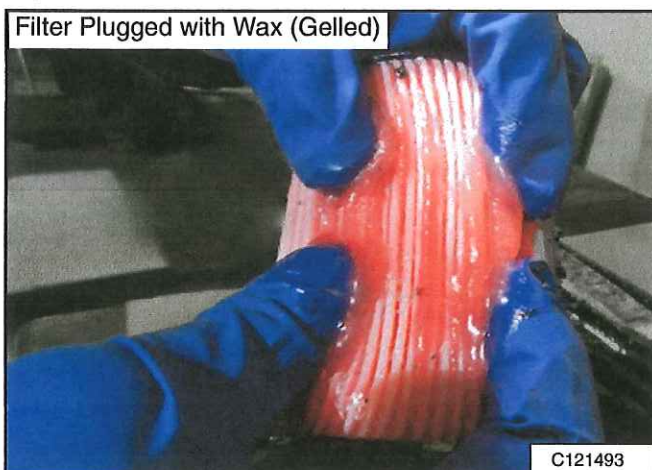
[Figure 9] Compounds contained in biodiesel attack composite materials such as copper, brass, lead, tin, zinc, certain rubbers and plastics. High concentrations of biodiesel may reduce engine service life by corroding internal components of the fuel pump, fuel lines and degrading seals.

Biodiesel works as an effective solvent which can loosen deposits where petroleum diesel fuel was previously used. Once these deposits are loosened in storage tanks or the machine fuel system they may prematurely plug fuel filters. If biodiesel is spilled on painted surfaces the paint can be damaged.

Under normal engine operation, a small amount of any fuel will seep past the piston rings and into the oil pan due to incomplete combustion of the fuel. Biodiesel has a higher viscosity than petroleum diesel which results in greater incomplete combustion and more contamination of engine oil compared to petroleum diesel. This reduces engine oil service life and requires engine oil change intervals to be shortened.

Typically biodiesel has a higher CP and will form wax at a higher temperature than petroleum diesel. As the concentration of biodiesel in a blend increases, the CP also increases. **Cases of unreported and sometimes high concentrations of biodiesel causing filter plugging in cold weather are common.**

Figure 10



[Figure 10] The use of biodiesel dramatically increases the risk of fuel filter plugging and should be avoided in cold weather if possible.

Storage of biodiesel for extended periods of time is challenging. Shelf life of biodiesel is roughly 3 months compared to 24 months for petroleum diesel.

Biodiesel is hygroscopic, meaning it absorbs water. The increased water content provides an excellent medium for microbial growth and contamination. Water and microbial contamination can corrode fuel system components and prematurely plug fuel filters.

Pure biodiesel does not have the same energy content when compared to the same quantity of petroleum diesel. Biodiesel provides lower engine power and fuel economy compared to petroleum diesel.

Only a biodiesel fuel blend that contains 5% or less biodiesel by volume is approved in Bobcat products equipped with a diesel engine. Fuel blends greater than 5% biodiesel by volume are not approved.

Using 5% or less biodiesel blend does not affect the current service schedule intervals, however the added recommendations below do apply.

- Because biodiesel absorbs water, strictly adhere to the daily fuel filter draining interval. Also, the fuel tank should be kept full and the fuel cap tightly secured.
- Biodiesel does not have long term stability. **DO NOT** use biodiesel if a machine will not be operated for periods of time exceeding 3 months.
- When preparing a machine for storage, flush the fuel system by draining the machine fuel tank, refill the tank with pure petroleum diesel then operate the engine at least 30 minutes before storage.

Diesel Fuel Products

The following fuel related products can be helpful and have been approved for use. Bobcat Company cannot test each commercially available product. If a non-recommended product must be used, make sure it is compatible with iT4 / T4 engines, DOC/DPF, ULSD, and CJ-4 engine oil.

Fuel Additives

Bobcat Company's fuel additive recommendations are currently being reviewed. This letter will be updated promptly at the completion of that review.

Microbial Testing and Treatment

A Bug Alert Biological Test Kit (P/N 7274815) is offered for monitoring fungi and bacteria levels. The kit contains everything necessary to perform 10 tests. No special tools or training is required.

Biocide Treatment (P/N 7276490) will be made available soon through Bobcat Parts. It can be sourced currently through many fuel product suppliers.

Fuel Testing and Analysis

Two fuel analysis test kits are available. The basic kit measures cleanliness, including percentage of water. The advanced kit measures the same, plus six other categories including cloud point.

Basic Fuel Analysis Kit (P/N 7257731)

Advanced Fuel Analysis Kit (P/N 7257732)

Water Finding Paste (P/N 7261295) is available to help detect water in fuel storage tanks.

Warranty Impact

Fuel used in Bobcat equipment does not affect warranty for materials or workmanship. Failures caused from mis-filling or from the usage of substandard or unapproved fuels are not factory defects, therefore the cost of repair is not covered by warranty.

The following websites can be viewed for more information. Bobcat Company does not necessarily endorse the views expressed or information provided.

<http://www.biodiesel.org>

<http://www.dieseln.net>

<http://www.enginemanufacturers.org>