

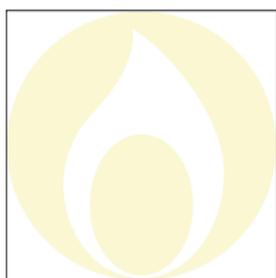
Fuel Quality and Performance Guide

A Troubleshooting Checklist For Diesel Fuel, Biodiesel and Bioheat Users

This guide contains recommendations for maintaining fuel quality, along with field troubleshooting procedures. The guide is intended for people who work with liquid fuels in general. No matter where you are in the supply chain, there will be times when fuel quality issues develop that require your immediate attention. This guide can help you isolate and resolve those issues in an efficient, cost effective manner.

The Steel Tank Institute suggests that in order to safeguard your business, maintain good customer relations, ensure high-quality fuel, and leak-free operation of your storage systems, you must monitor for water in those systems and remove water whenever it is detected.

This must be a routine part of your operations and maintenance procedures. The EPA states that a new or upgraded storage system is a good start, but the system must be properly operated and continuously maintained. This includes water monitoring and removal.



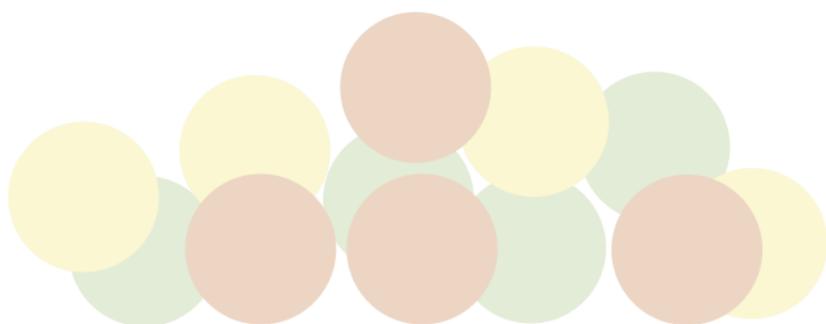
diesel



biodiesel



bioheat



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Terminology

The terms “diesel fuel”, “heating oil” and “biodiesel” describe fuels that are used for diesel engine use and home heating oil purposes. They are very similar in performance characteristics however each fuel carries its own ASTM designation:

1. Diesel fuel (S15 - S500 or higher) ASTM D975
The specification has the same sulfur limits for the same sulfur grades
2. Heating oil (2000 ppm or higher) ASTM D396
D396 includes these fuels with corresponding sulfur limits:

Fuel Class	No. 1 LS	No. 1	No. 2 LS	No. 4 Light	No. 4	No. 5 Light	No. 5 Heavy	No. 5
Sulfur PPM	500	5000	500	5000				

No. 1 Low Sulfur (LS) Diesel and No. 2 LS Diesel are used for on road applications and No. 1 and No. 2 diesel may be used for off road or heating fuel applications. The main distinction between the two fuel classifications for on-road versus off-road and furnace is cloud and pour points. The cetane is a specification in on-road applications, but not off-road and heating.

3. Biodiesel (B100 ASTM D6751)
D6751 includes classes for both S15- and S500 sulfur levels, and has different limits for distillation and density, as well as additional test parameters not contained in D396 and D975 such as total and free glycerin and acid number.

ASTM stands for the American Society for Testing and Materials. They have committees that review and establish the values, benchmark properties, and uniform standards by which petroleum products are evaluated — and products for a wide range of industries and endeavors. Understandably, their website is extensive and we recommend you refer to the website, if only to get an idea of the size and scope of ASTM activities.

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
Phone: 610-832-9585
www.astm.org

To learn about petroleum testing laboratories, as well as instrument companies that sell sampling equipment, we suggest referring to either the print or web version of Thomas Register.
<http://www.thomasregister.com>

How to Buy Fuel

When purchasing bulk fuels, ask for the fuel specifications. Verify that the fuel properties are suitable for the intended use. If you are buying diesel fuel in the winter you should know what the documented cold weather characteristics are so that you can prepare accordingly for local climate conditions.

Problem free fuel performance begins by demanding ASTM benchmarked fuels. Once you have obtained a quality fuel you must keep the fuel “on-spec.” In other words, at the same ASTM quality as you originally received it. Make it a practice to always request a certificate of analysis from your supplier.

Ensuring that your fuel storage tanks are free of contamination, (most notably, free of water) is a positive step in preserving the quality specifications of the fuel which you have purchased. Another way to ensure that you are starting with quality product is to obtain your biodiesel from BQ-9000 accredited producers or certified fuel marketers. Look for the symbol of quality.



It is always a good idea to inspect incoming fuel for cleanliness and haze which could indicate the presence of water or wax (in cold weather). Suspended water in fuel may result in water in all stages of fuel distribution. Inspect regularly with all bulk quantities of fuel before accepting it for delivery. The purpose of visual inspection is to prevent picking up fuel that may hold contaminants and water.

EXAMPLE OF DISTILLATE FUEL HAZE RATING STANDARD USING ASTM CLEAR AND BRIGHT TEST

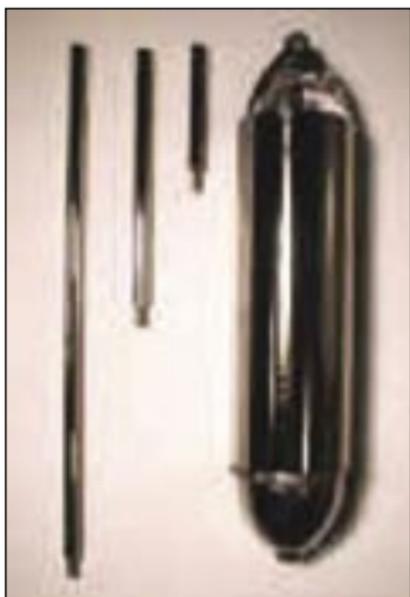


Fuel Sampling

The integrity of a fuel sample is critical to generating useful information from a fuel analysis. The best method is to obtain a sample or a mixture of several samples that represent the material in a truck or storage tank. Depending on where you are sampling from and for what purpose, there are several different types of devices that can be used to collect a fuel sample.

Sampling Tips

- ▲ Use clean sampling devices and containers.
- ▲ Always retrieve a minimum of one quart sample of fuel and a backup sample to be kept and retained for your own testing should it be necessary.
- ▲ Fill sample containers to a safe level, normally 80% of capacity, which allows for expansion during transport to laboratories.
- ▲ Use the appropriate device for pulling bottom samples.
- ▲ Bulk samples are best rated when a top, middle and bottom sample (known as a tank composite) is evaluated.
- ▲ Line samples are an option in bulk plants when tank samples are inaccessible.
- ▲ Dispenser and above ground storage tank samples are retrievable through the top of the tank or at the fuel dispenser nozzle.
- ▲ Samples can be taken from the fuel delivery truck which represents what was retrieved from the fuel terminal.
- ▲ An appropriate sample must be contained in a clean quality plastic container (preferably fluorinated type container, available through ASTM testing laboratories). All filled containers should have a tightly sealed cap, be inserted into a plastic bag sealed with a conventional bag seal, then enclosed in corrugated box for shipping to a lab of your choice.



BACON BOMBS WITH
EXTENSION RODS TO
SAMPLE TANK BOTTOMS.

THE 1-INCH DIAMETER UNIT
IS ALSO REFERRED TO AS
THE PENCIL BOMB.

BOTTOM SAMPLES BEING TAKEN FROM
HEATING OIL STORAGE TANK
WITH A PENCIL BOMB OR FUEL THIEF.



Storing Fuels

Tank Considerations

- ▲ An accessible port should be at the top of the tank to allow for periodic inspection for water and sludge. Accumulated tank sedimentation and or water should be removed on a routine basis so that it does not clog strainers, lines, filters or nozzles and injectors.
- ▲ Locate outdoor tanks (UST) in cool, shaded areas if possible to minimize exposure of the fuel to high temperatures from direct sun.
- ▲ Petcocks normally located on the bottom of both truck saddle tanks and bulk storage tanks enable you to remove any bottom water and sediment that accumulate during seasonal temperature swings.

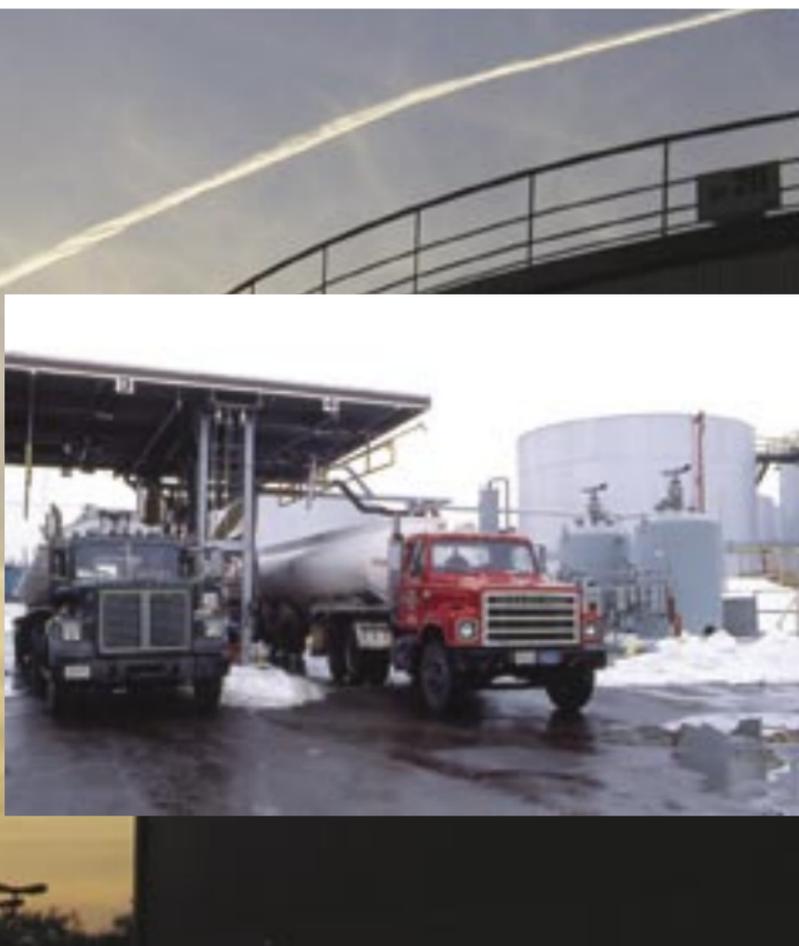
Piping Considerations

- ▲ Acceptable storage tank materials include aluminum, steel, fluorinated polyethylene, fluorinated polypropylene, Teflon and most fiberglass. Materials such as brass, bronze, copper, lead, tin and zinc may accelerate the oxidation of your fuels and should be avoided.



About Additives

- ▲ B100 (neat biodiesel) cannot presently be treated successfully with conventional winter fuel additives.
- ▲ Biodiesel blends can be adjusted with a combination of kerosene and cold flow improvers designed for generic fuel. The combination of both these elements will perform the necessary wax modification on the generic fuel which ultimately will reduce the flow properties of the generic portion, making room for the biodiesel mixture. As a rule of thumb, B20 blends using a soy methyl ester biodiesel will compromise operability up to +10°F — before the addition of kerosene or an additive — precisely why either kerosene or an additive is needed.
- ▲ If storage of neat biodiesel or blended fuels is intended beyond six months it is recommended that you add a fuel stabilizer. Biodiesel requires a specific stabilizer which can be obtained through a reputable fuel additive supplier.



Storage Tank Maintenance

Fuels need to be protected in order for product quality to be maintained. This can be accomplished by following some basic, however critical, fuel quality strategies.

- ▲ Keep tanks topped off whenever possible.
- ▲ Know the operability values of these fuels, (cloud, pour, cold filter plugging point).
- ▲ Monitor and eliminate water when it is present.
- ▲ Source an analytical lab for future fuel testing.
- ▲ Do not add additives to previously treated fuel. (Using more additives is not helpful.)
- ▲ Additives should not be used once a fuel meets or falls below its posted cloud point.
- ▲ Ask for fuel specifications. For larger bulk tanks, at the very least have a top, middle and bottom sampling performed to determine if the fuel maintains specifications.
- ▲ Inspect fill and vapor caps for damage and missing gaskets, replacing if necessary. Consider a desiccant dryer on vent pipes to limit moisture contamination.
- ▲ It is a good idea to have a lab run a microbiological evaluation of your fuel at least once per year to ensure that no contamination exists in your tanks.
- ▲ Have the tank periodically cleaned by qualified professional contractors as an added safety measure.
- ▲ All tanks exposed to outdoor conditions should be equipped with heating elements, insulation and tank mixers for satisfactory cold weather storage and distribution of either fuels or a combination of both.
- ▲ A floating suction at the fuel intake may help reduce the amount of sediment drawn into the supply line.



BY THE SAMPLE TO LEFT, THIS TANK HAS A PROBLEM WITH EXCESSIVE WATER ACCUMULATION. YOU CAN ALSO DETECT THIS MUCH WATER WITH WATER-INDICATING PASTE ON A STICK.



THIS SAMPLE CONTAINS HEAVY AMOUNTS OF DEGRADED FUEL PRODUCTS AND WATER.

Cold Temperature Operations and Biodiesel

Similar to diesel fuel, biodiesel requires close attention when storing, blending and distributing in cold weather markets. Biodiesel blends affect operability in direct relationship to the fuels which they are blended. Obviously a generic fuel that contains 2% biodiesel would be less cause of concern than one with 20%.

Identify cold flow properties of the fuel that you are buying. Exercise precaution through specification management. If you are dependent on someone to blend your diesel fuels, make them accountable for the winter operability specification. You must advise that individual or company what temperatures you wish the fuel to function to and depend on them to make it happen. Their options will be to use kerosene, additives specific to the generic fuel, and control of biodiesel blend to achieve your desired goals.



Adhering to the criteria below is crucial for successful blends.

- ▲ Identify the cold flow protection anticipated by the customer.
- ▲ Obtain a generic fuel with the lowest “temperature operability value” possible (cloud, cold filter plugging point and pour point).
- ▲ Use a combination of a proven fuel additive and kerosene to reduce the generic fuels operability value to levels low enough to accommodate the percent of biodiesel desired by the end user. Remember that a 20% blend of biodiesel produced from soy methyl ester will reduce your cold flow values by 10°F in some cases. Lower blends obviously reduce these values to a lesser degree.
- ▲ Blend biodiesel into diesel fuel and test the product for operability values.
- ▲ When splash blending is your only option, the hotter the biodiesel the more likely you will have a successful blending experience. To eliminate the possibility of the biodiesel flash freezing when introduced into a cold aluminum tank truck, successful blenders have heated the fuel to temperatures in excess of 100°F.
- ▲ In-line or wild stream blending requires that the biodiesel be kept at a minimum of 10°F higher than the cold operability properties of the biodiesel feedstock to ensure successful blending into the diesel and heating oil. For higher temperature blends, consider warming the biodiesel to temperatures 20°F above those same values.
- ▲ Dilution blending with kerosene is also an option for biodiesel blends. However, the downside remains the economic challenges as well as supply challenges associated with kerosene.
- ▲ Once you have blended biodiesel into the diesel fuel or heating oil following the above general blending principals the fuels will stay together.

Identifying Engine Shutdown & Tank Issues

Engine failures due to fuel filter starvation provide convincing evidence of how important it is to manage your fuel systems and fuel quality as discussed in this guide. There is truth to the statement, "You can pay me now, or you can pay me later."

Addressing Diesel Equipment Breakdowns

- ▲ Drop bottom of tank contents through petcock relief. Bleed bottoms to review tank bottom sedimentation and water.
- ▲ Verify that the fuel transfer pump is operating.
- ▲ Replace all in-line filters; normally two primaries and a secondary swap out will be necessary.
- ▲ Take the questionable filter and turn it upside down, pouring out any remaining liquids to determine if the problem revolves around waxing or icing.
- ▲ If waxing is the primary issue, it will be necessary to cut the contents of your fuel with kerosene to regain operation. You must make provisions to allow the wax to melt which can be accomplished by heat or garaging. Do not use cold flow additives at this point because the fuel has reached its cloud point and the performance of additives will be questionable at best.
- ▲ More often than not, moisture in fuel can freeze at higher temperatures (32°F). If you find icing is blocking fuel flow, your only recourse is to thaw out fuel or utilize emergency anti-icing additives that contain alcohols and solvents which will immediately melt away the ice. These additives should only be used in emergency situations and must be used judiciously. Overdosing additives can cause fuel pump failure over the long term by drying out elastomers that are used as sealing devices in the pump.

- ▲ There are approximately six feet of quarter-inch fuel lines that travel from saddle tank to combustion. Along with this narrow piping, a minimum of four 90° brass fittings which carry the fuel may also become restricted — affecting fuel flow. The only recourse you would have with plugged lines in this case is to warm them up.
- ▲ Once up and running, you should package a quart of fuel retrieved from the saddle tank and one from the bulk storage tank from which the truck was fueled. Send it to a local laboratory to determine the cold flow properties, cloud, pour, and cold filter plugging point. If you visually observed any black slimy substance on the fuel filter media, ask them to have a microbiological evaluation done on the fuel as well. You can also bundle up a fuel filter for lab reference on specific contamination found on the filter media.
- ▲ On the next page you will find an event sheet for use when documenting fuel related issues that you may confront.



Fuel Event Sheet

Operability Issue Information Worksheet

(To be completed for use with fuel supplier and testing laboratory.)

Date: _____

Fleet Affected: _____

Fleet Primary Contact: _____

What problems is fleet experiencing?

When was the first indication?

How many vehicles or pieces of equipment are affected?

What types of vehicles and equipment are affected?

What location(s) was affected?

Location: _____

Avg. Volume _____

Date of Last Receipt of Fuel: _____

Product Source: _____

Blend Level: _____

Hauled by: _____

Two Previous Loads:

Date: _____

Source: _____

Hauler: _____

When was the storage tank last checked for water?

Age of Storage Tanks: _____

Above/Below Ground _____

What percentage of biodiesel was blended into this fuel?

Has any after market additives been added to this fuel?

If yes, what brand and dosing range?

ASTM tests recommended for diesel fuel, biodiesel and blends of both:

- ▲ **Cloud Point (D5773, D2500)** determines the temperature at which wax crystals grow large enough to precipitate out of the fuel and become visible.
- ▲ **Cold Filter Plugging Point (D6371)** determines the lowest operating limits of a diesel fuel.
- ▲ **Pour Point (ASTM D97, D5949)** determines the lowest observed temperature at which a fuel will flow.
- ▲ **Microbial Contamination** determines if the fuel sample is infected by harmful micro-organisms, primarily bacteria and fungi. These contaminants can cause plugging of strainers, filters, nozzles and injectors as well as form deposits that can damage fuel tanks, fuel lines and fuel pumps.
- ▲ **Flash Point (D93)** determines the temperature at which the fuel vapors will ignite.
- ▲ **Water and Sediment (ASTM D2709)** a high content of water and sediment usually results from poor handling and storage of the fuel. This can cause corrosion of equipment and plugging a system with tight tolerances such as a fuel injection system.
- ▲ **Free and total glycerin (ASTM D6584)** measures the amount of unconverted or partially converted fats and by-product glycerin present in the fuel.
- ▲ **Acid Number (ASTM D664)** is an indicator of free fatty acids (natural degradation products of fats and oils) and can be elevated if a fuel is not properly manufactured or has undergone oxidative degradation.
- ▲ **Sulfated Ash (ASTM D874)** measures the amount of residual alkali catalyst present in the biodiesel as well as any other ash forming compounds that could contribute to injector deposits or fuel system fouling.
- ▲ **Rancimat Test** is a modified stability test for “neat” 100% biodiesel.

*All tests are relevant to diesel fuel, heating oil and biodiesel however the final three tests glycerin, rancimat, acid number and sulfated ash are biodiesel specific tests.

Diesel Fuel ASTM D975

Property	ASTM Method	Limits	Units
Flash Point	D93	52 min.	Degrees C
Water and Sediment	D2709	0.050 max	% vol.
Kinematic Viscosity,40C	D445	1.9 - 4.1	mm ² /sec.
Ash	D482	0.01 max.	% mass
Sulfur (Grade No.2)	D129	0.50 max.	% mass
Sulfur (Grade No. 2- Low Sulfur)	D2622	0.05 max.	% mass
Copper Strip Corrosion	D130	No. 3 max.	
Cetane	D613	40 min.	Degrees C
Pour Point	D97	-----	Degrees C
Cloud Point or LTFT/CFPP	D2500 D4539 D6371	Depends on location Depends on location	% mass
Density, 15°C	D1298	-----	kg/m ³
Ramsbottom Carbon Residue	D524	0.35 max.	mg KOH/gm
Cetane Index or Aromaticity	D 976 D1319	40 min. 35 max.	% vol.
Distillation Temperature, 90% Recovered	D86	282-338	Degrees C

Heating Oil ASTM D396

Property	ASTM Method	Limits	Units
Flash Point	D93	38 min.	Degrees C
Water and Sediment	D2709	0.050 max	% vol.
Kinematic Viscosity, 40C	D445	1.9 - 3.4	mm ² /sec.
Ash	D482	-----	% mass
Sulfur (Grade No. 2)	D129	0.50 max.	% mass
Sulfur (Grade No. 2- Low Sulfur)	D2622	0.05 max.	% mass
Copper Strip Corrosion	D130	No. 3 max.	
Cetane	D613	-----	Degrees C
Pour Point	D97	-6	Degrees C
Cloud Point or LTFT/CFPP	D2500 D4539 D6371	----- -----	% mass
Density, 15C	D1298	876	kg/m ³
Ramsbottom Carbon Residue	D524	0.35 max.	mg KOH/gm
Cetane Index or Aromaticity	D 976 D1319	----- -----	% vol.
Distillation Temperature, 90% Recovered	D86	282-338	Degrees C

Biodiesel (B100) ASTM D6751

Property	ASTM Method	Limits	Units
Flash Point	D93	130.0 min.	Degrees C
Water and Sediment	D2709	0.050 max	% vol.
Kinematic Viscosity, 40°C	D445	1.9 - 6.0	mm ² /sec.
Sulfated Ash	D874	0.020 max.	% mass
Sulfur	D5453	0.05 max.	% mass
Copper Corrosion	D130	No. 3 max.	
Cetane Number	D613	47 min.	
Cloud Point	D2500	By Customer	Degrees C
Carbon Residue	D4530	0.050 max.	% mass
Acid Number	D664	0.80 max.	mg KOH/g
Free Glycerin	D6584	0.020 max.	% mass
Total Glycerin	D6584	0.240 max.	% mass
Phosphorus Content	D4951	0.001 max.	% mass
Distillation Temperature, Atmospheric Equivalent Temperature, 90% Recovered	D1160	360 max.	Degrees C

Resource Information

National Organizations

National Biodiesel Board

www.biodiesel.org

800-841-5849

BQ-9000 Accreditation Commission

www.bq-9000.org

573-635-3893

Other Important Websites

Steel Tank Institute

www.steeltank.com

US Environmental Protection Agency (EPA)

www.epa.gov

Petroleum Equipment Institute

www.pei.org

Thomas Register

(To search for local labs in your area or testing equipment companies.) www.thomasnet.com

Biodiesel Magazine Industry Directory

www.biodieselmagazine.com

www.biodieselindustrydirectory.com

National Laboratories (Fuel Testing)

PetroLab Co. – AMTEK

www.petrolab.com

518-783-5133

OleoTek

www.oleotek.org

418-338-1318

InterTek Caleb Brett

www.intertek.com

713-844-3200 x 3248

Natural Tribology Services Inc.

www.natrib.com

East 978-535-9990 x 29

West 775-783-4688

National Renewable Energy Laboratory (NREL)

2004 Biodiesel Handling & User Guidelines

<http://www.nrel.gov/>

[vehiclesandfuels/nbf/pdfs/tp36182.pdf](http://www.nrel.gov/vehiclesandfuels/nbf/pdfs/tp36182.pdf)