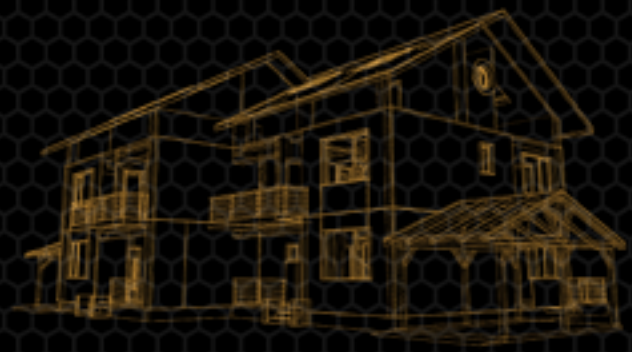
A Liquid Fuels Handling Guide for

Marine, Rail, Transportation, and Heating Oil



A Note to the Reader:

Advanced Fuel Solutions (AFS) is pleased to share this publication, A Liquid Fuels Handling Guide for Marine, Rail, Transportation, and Heating Oil, as a practical resource for professionals responsible for managing fuel quality from production through final consumption. This guide reflects decades of real-world experience across the liquid fuels supply chain and is intended to support sound decision-making, operational discipline, and consistent performance as biodiesel, renewable diesel, and advanced heating oil blends continue to scale across multiple markets. The insights contained herein are grounded in field experience, laboratory validation, and best practices proven under demanding operating conditions.

This publication has been made available as a complimentary resource through the generosity and leadership of Clean Fuels Alliance America and the United Soybean Board, along with their dedicated staff and technical partners. Their continued investment in education, research, and market development plays a critical role in ensuring that low-carbon liquid fuels are deployed responsibly, reliably, and at scale. Fuel quality is not a theoretical exercise. It is a daily operational responsibility that directly impacts safety, equipment performance, customer confidence, and long-term market credibility. This guide is designed to help readers anticipate challenges, apply disciplined handling practices, and move beyond minimum specifications toward consistent, dependable outcomes. Should you have questions regarding any of the information contained in this publication or wish to discuss fuel quality management within your own operations, we invite you to contact our corporate office or your AFS representative.

AFS

ADVANCED FUEL SOLUTIONS

Introduction

Decades of rigorous field experience and laboratory development have proven that biodiesel and renewable diesel are dependable, high-quality fuels capable of delivering outstanding performance when supported by proper storage, blending and distribution protocols. This confidence is based on real-world data and successful use across the entire value chain.

To achieve and sustain optimal fuel performance, oversight vigilance is non-negotiable. From production through transportation, storage, and end-use, common sense strategies and disciplined best practices are required. Monitoring for water, controlling contamination, and ensuring sound storage conditions are essential steps that will protect your reputation and gain your customer's trust for all fuels which you provide them.

It is also imperative to recognize that ASTM fuel specifications represent minimum standards, not performance guarantees. Meeting the ASTM specifications of any fuel is a baseline, but unlocking the full value of these fuels requires going beyond the minimum. Strategic fuel treatment and proactive maintenance elevate fuels from "acceptable" to "exceptional," delivering consistency and reliability that keeps operations running smoothly.

Biodiesel, renewable diesel, and various blend levels have never been more advanced, but their optimum performance depends on continuous monitoring across the entire value chain. Oversight, fuel treatment, and disciplined maintenance are the cornerstones of ensuring all fuels exceed the customers' expectations.

This guide has been designed to help share best practices for maintaining fuel quality and provide field troubleshooting procedures when required. It is intended for professionals working with liquid fuels from production to consumption. Whether you're involved in production, terminaling, transportation, storage, or end-use, fuel quality issues can arise unexpectedly and require immediate attention. This guide will help identify and resolve such issues efficiently and cost effectively.

To safeguard your operations, maintain customer satisfaction, ensure high-quality fuel, and support leak-free performance of storage systems, the Steel Tank Institute and fuel industry professionals recommend routine monitoring for water in fuel storage sytems—and prompt removal whenever water is detected. Monitoring water and removal should be a standard part of both buyers and sellers' operations. According to the EPA, installing a new or upgraded storage system is a good start, but proper operation and continuous maintenance is essential. This includes consistent water monitoring and removal to preserve system integrity and fuel quality.

Contents

Terminology

The terms “diesel fuel,” “heating oil,” “biodiesel,” and “renewable diesel” refer to liquid fuels commonly used in diesel engines and home heating applications. While these fuels share similar performance characteristics, each one has its own unique properties and is defined by a specific ASTM designation.

Diesel Fuel

Diesel fuel is a combustible liquid derived primarily from crude oil and used in compression ignition engines, such as those found in trucks, buses, trains, ships, and some light duty vehicles. It has a higher energy density than gasoline, allowing for greater fuel efficiency in heavy-duty applications.

Diesel fuel is classified under ASTM D975, which defines seven grades suitable for various diesel engine applications.

These include:

- Grade No. 1-D S15
- Grade No. 1-D S500
- Grade No. 1-D S5000
- Grade No. 2-D S15
- Grade No. 2-D S500
- Grade No. 2-D S5000
- Grade No. 4-D

The “S” designation refers to the sulfur content:

- S15 = Ultra-Low Sulfur Diesel (ULSD), max 15 ppm sulfur
- S500 = Low Sulfur Diesel, max 500 ppm sulfur
- S5000 = High Sulfur Diesel, max 5000 ppm sulfur

Each sulfur grade follows the same sulfur limits across its respective classification.

For more information about diesel fuel log into:

eia.gov/energyexplained/diesel-fuel

Renewable Diesel

Renewable diesel is a hydrocarbon fuel derived from renewable sources (such as fats, oils, and greases) and is chemically like petroleum diesel. It meets the same ASTM D975 specifications as conventional diesel as well as ASTM D396 and can be used as a drop-in replacement for decarbonization of conventional heating oil and diesel equipment without equipment modifications.

For more information about renewable diesel log into:

afdc.energy.gov/fuels/renewable-diesel

Biodiesel

Biodiesel is a renewable, cleaner-burning diesel replacement that meets ASTM D6751 specification and can be used in diesel engines without modification. It is available in pure form (B100) or blended with petroleum diesel (B20). Biodiesel offers environmental benefits such as reduced greenhouse gas emissions and lower levels of pollutants, while also supporting agricultural industries and reducing reliance on fossil fuels.

For more information about biodiesel, log into:

afdc.energy.gov/fuels/biodiesel-basics

Bioheat® Fuel

Bioheat® is a registered trademark for a blend of ultra-low sulfur heating oil and renewable biodiesel, derived from organic and recycled materials like used cooking oil, soybean oil, and animal fats.

This environmentally friendlier fuel can be used in existing home heating systems without modification, offering reduced emissions and a more efficient burn than conventional heating oil. The blends are identified by percentages of biodiesel, such as B5 for 5% biodiesel and B20 for 20%.

More information about becoming a Bioheat® fuel registered dealer:

cleanfuels.org/supporting-pages/bioheat-trademark-agreement

Coverage of Bioheat Blends:

- B5 (up to 5.49%): Considered equivalent to conventional heating oil. It is covered under the same specifications as No. 1 and No. 2 fuel oils (e.g., No. 1 S15, No. 2 S15), without requiring separate designations.
- B6 to B20: These blends are explicitly defined in D396 as a separate grade (e.g., B6–B20 S15), acknowledging its unique properties and ensuring compatibility with heating systems.
- Be certain to place the actual blend percentages on bill of ladings and delivery tickets.

Field performance has shown positive results for biodiesel blends above B20 when used in residential and commercial heating systems, provided both the biodiesel and the heating oil meet their respective specifications. However, it is essential that users maintain a strong working relationship with their suppliers, understand the biodiesel and renewable diesel specifications and storage/handling requirements, as well take appropriate precautions to ensure accurate performance.

For more information on Bioheat® log into:

www.mybioheat.com

ASTM D396

ASTM D396 is the Standard Specification for Fuel Oils, which defines the requirements for various grades, including Renewable Diesel, Biodiesel, Ultra-Low Sulfur Diesel, Ultra-Low Sulfur Heating Oil, and Kerosene, or combinations thereof.

These fuel grades are formulated to serve as energy sources for a wide range of combustion systems and operating environments, spanning diesel and marine engines to residential and industrial heating systems.

Grade No. 1 S15 and Grade No. 2 S15

The “S15” designation indicates that the fuel contains no more than 15 parts per million (ppm) of sulfur, making it ultra-low sulfur.

These grades are middle distillate fuels suitable for:

- Domestic heating systems
- Small industrial burners
- Vaporizing-type burners where low pour point is required
- Diesel Engines
- Marine Engines

Why Ultra-Low Sulfur Matters:

- Reduces sulfur dioxide emissions, improving air quality
- Minimizes corrosion in heating systems and storage tanks
- Complies with increasingly strict state and federal environmental regulations

Other Grades in ASTM D396

ASTM D396 also includes:

- No. 1 and No. 2 S500 / S5000 (low and high sulfur variants)
- B6–B20 blends with biodiesel
- No. 4, No. 5, and No. 6 for commercial and industrial use

Each grade must meet specific limits for:

- Flash point
- Water and sediment
- Viscosity
- Sulfur content
- Pour point
- Ash and carbon residue

No. 1 and No. 2 ULSD Applications and Specifications

No. 1 Ultra Low Sulfur and No. 2 ULSD are commonly used in on-road applications, such as trucks and buses. Both grades may also be used in off-road equipment and as heating fuels, depending on regional regulations and seasonal requirements.

The primary differences between No. 1 and No. 2 ULSD classifications, especially when comparing transportation diesel versus off-road or heating oil use, are:

Cloud Point and Pour Point

Fuel properties that determine how the fuel performs in cold temperatures.

- No. 1 Diesel has a lower cloud and pour point, making it more suitable for cold climates
- No. 2 Diesel has higher values and is typically used in milder conditions

Cetane Number

Cetane is a measure of ignition quality.

- For on-road diesel, cetane number is a required specification under ASTM D975
- For off-road and heating oil applications, cetane is not a required specification

Biodiesel (B100) and ASTM D6751 Compliance

ASTM D6751 is the critical specification for B100 biodiesel intended for blending with petroleum diesel. It defines stringent quality standards that ensure fuel performance, engine compatibility, and emissions compliance.

Unlike ASTM D396 and D975, D6751 includes additional parameters essential for biodiesel quality—such as total and free glycerin, acid number, and specific limits that cover both production limits and fuel performance.

It also accommodates both S15 (ultra-low sulfur) and S500 (low sulfur) classifications, reinforcing its versatility across different regulatory environments. Adherence to D6751 (as well as all fuel specifications) is vital to prevent engine deposits, injector fouling, fuel system corrosion, and storage contamination, making it a cornerstone of reliable and clean biodiesel usage.

How to Purchase Fuel:

Ensuring Quality from the Start

When purchasing bulk fuel, you should always request the fuel specifications from your supplier. Confirm that the fuel's properties—such as cetane number, sulfur content, stability ranking and cold flow characteristics—are appropriate for your intended application. For example, if you're buying diesel fuel during winter months, it's essential to verify the documented cold weather performance (e.g., cloud point and pour point) to ensure it aligns with your local climate conditions. Also ask if the fuel has any cold flow additives that have been blended in beforehand. If the fuel has previously been treated, it is advisable not to add any additional cold flow additives.

Reliable fuel performance begins with products that meet ASTM benchmark standards. ASTM International sets rigorous, consensus-based specifications for both petroleum- based and renewable fuels, ensuring consistency, safety, and compatibility across the value chain. With a high-quality fuel, it's critical to maintain it "on-spec"—meaning you ensure it continues to meet the same ASTM quality standards as when it was delivered. Always request a Certificate of Analysis (COA) from your supplier to verify compliance and be certain that the COA is current with the fuel being off-loaded into your system.

Maintaining clean, water-free storage tanks is essential to preserving fuel quality. Water contamination is one of the most common causes of fuel degradation and microbial growth.

To further ensure quality, source biodiesel from BQ-9000® accredited producers or fuel marketers whenever possible, this will ensure that you have the highest industry standards for production, handling, and distribution specifically to the biodiesel portion of that fuel blend. Look for the BQ-9000® symbol of quality as a mark of assurance. While the BQ-9000® program is not a product quality guarantee, the accredited facilities have been subjected to independent annual audits to help ensure they are following the latest industry requirements and guidelines

For more information visit:

www.bq-9000.org

Ask your fuel delivery provider—whether by truck, rail, or marine vessel—to explain their fuel handling practices during your discovery process. This should include the use of clean, well-maintained equipment to ensure that the fuel you receive arrives on-spec and meets all applicable quality standards. Ask your trucking company how they handle transition loads, cleaning procedures between loads of dissimilar fuels so that your fuel doesn't become contaminated.

Finally, visually inspect all incoming fuel deliveries. Look for signs of haze, sediment, or cloudiness, which may indicate the presence of water, wax, or other contaminants.

This important and often ignored procedure can prevent the introduction of compromised fuel into your storage system and help maintain long-term fuel integrity. A quick field evaluation is an ASTM haze rating test, see graphic below.

Sampling, Handling, & Fuel Packaging

*Fuel sampling devices

Maintaining the integrity of a fuel sample is essential for obtaining accurate and meaningful analysis results. The most effective approach is to collect a representative sample—or a composite of multiple samples—that reflects the contents of a truck, storage tank, filter dispenser or filter cartridge. Depending on the sampling location and the purpose of the analysis, various types of equipment may be used to properly collect the fuel sample.

Best Practices for Fuel Sampling

- Use clean, contamination-free sampling devices and containers to avoid introducing foreign materials into the sample.
- Always collect a minimum of one quart, along with a backup sample for retention and potential retesting.
- Fill containers to approximately 80% capacity to allow for thermal expansion during transport.
- Use appropriate equipment for bottom sampling, especially when checking for water or sediment accumulation.
- Composite sampling—collecting fuel from the top, middle, and bottom of the tank—provides the most accurate representation of bulk fuel.
- Line sampling may be used in bulk plants when direct access to tanks is limited.
- Dispenser and above-ground tank samples can be retrieved from the top of the tank or directly from the fuel nozzle.
- Delivery truck samples represent fuel as received from the terminal and should be inspected before offloading.

If you are unable to properly obtain representative samples, independent organizations exist that can provide this service at a cost.

Sample Handling & Packaging

All major international ground and air carriers have specific packaging requirements for shipping Ultra Low Sulfur Diesel, Renewable Diesel, and Biodiesel. To ensure full compliance, consult your carrier for the most up-to-date policies and procedures. The following information is provided as a general guideline for shipping these fuels.

1. Determine Classification

Diesel fuel is considered a combustible liquid, not flammable, because its flash point is above 100°F (37.8°C). This means:

- It may not be classified as hazardous under certain conditions and quantities
- However, some carriers still treat ULSD, RD, and Biodiesel as a regulated hazardous material, especially for air shipments

2. Become an Approved Shipper

To package and ship ULSD, RD, and Biodiesel:

- You may be required to become carrier specific certified as a hazardous materials shipper

3. Packaging Requirements

Package ULSD as follows:

- Leak-proof containers rated for combustible liquids
- Secondary containment to prevent spills
- Durable outer packaging that can withstand transport stress

4. Labeling and Documentation

You must:

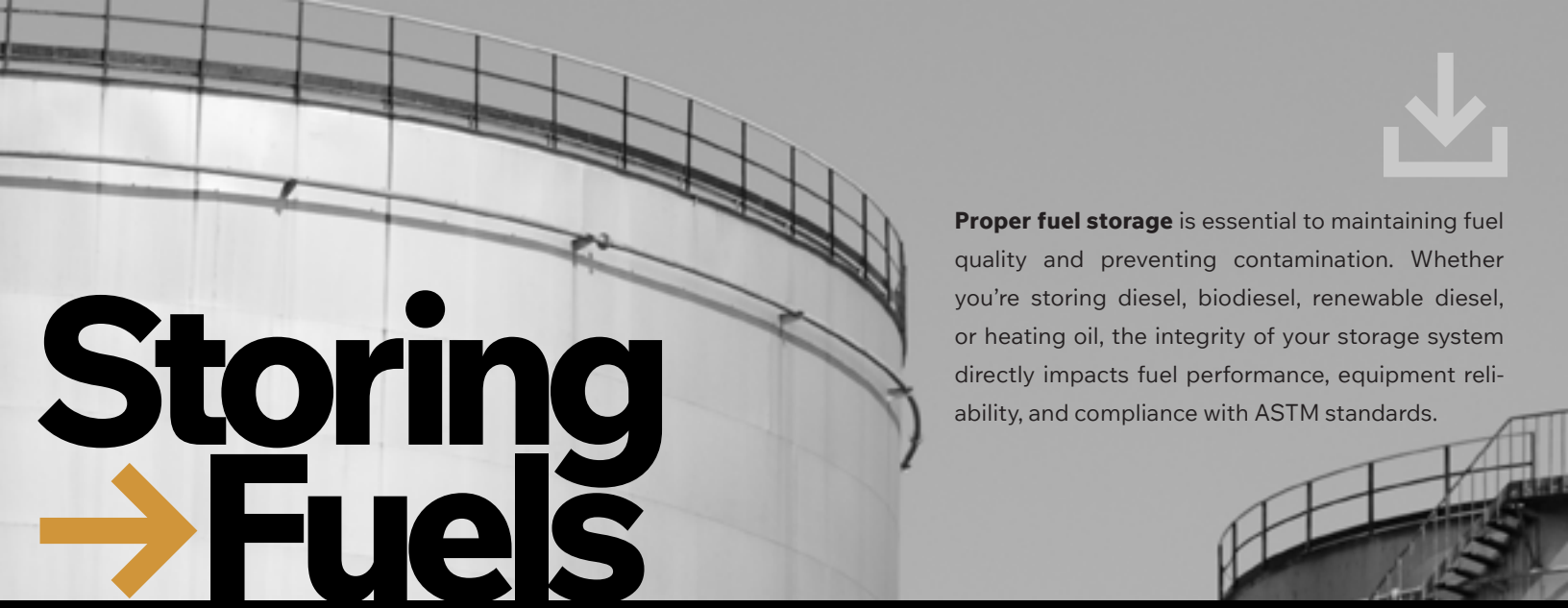
- Use proper hazard labels (e.g., “Combustible Liquid”)
- Include Safety Data Sheets (SDS)
- Complete a Shipper’s Declaration for Dangerous Goods if shipping by air

5. Contact your Carrier

Contact your carrier’s Hazardous Materials Support Center to obtain specific information for packaging and shipping Ultra Low Sulfur Diesel (ULSD).

- Federal Express: 1-800-463-3339 — Ask for Dangerous Goods
- United Parcel Service: 1-800-554-9964
- DHL: 1-866-817-3794

Proper sampling and handling practices are essential to maintaining fuel quality and ensuring compliance with ASTM standards. Treat every sample as a critical data point—because it is.



Storing Fuels

Proper fuel storage is essential to maintaining fuel quality and preventing contamination. Whether you're storing diesel, biodiesel, renewable diesel, or heating oil, the integrity of your storage system directly impacts fuel performance, equipment reliability, and compliance with ASTM standards.

Tank Considerations

- Ensure tanks have an accessible inspection port at the top to allow for routine checks for water, sludge, and sediment.
- Remove accumulated water and sediment regularly to prevent clogging of strainers, filters, fuel lines, nozzles, and injectors.
- Outdoor tanks (USTs) should be in cool, shaded areas to minimize exposure to heat and UV radiation, which can accelerate fuel degradation.
- Outdoor tanks may also need additional considerations during colder weather to help ensure that the fuel does not cool to temperatures that would allow the formation of precipitates and waxes.
- Petcocks located at the bottom of truck saddle tanks and bulk storage tanks should be used to drain water and sediment, especially during seasonal temperature fluctuations.

Piping & Material Considerations

- Use compatible materials for tanks and piping: aluminum, steel, fluorinated polyethylene, fluorinated polypropylene, Teflon, and most fiberglass are acceptable.
- Avoid materials such as brass, bronze, copper, lead, tin, and zinc, which can catalyze fuel oxidation and contribute to contamination.

Why This All Matters

Contaminated fuel can lead to:

- Filter plugging
- Injector fouling
- Microbial growth
- Corrosion of fuel system components
- Reduced combustion efficiency

Maintaining clean, water-free storage systems is a proactive step toward preserving fuel quality and ensuring that the fuel remains "on-spec"—meeting the same ASTM standards as when it was delivered.

Fuel Additives:

Enhancing Performance & Reliability in Cold Weather

Advancements in Additive Chemistry

The use of fuel additives is a critical component of maintaining fuel quality and ensuring reliable performance—especially in cold weather conditions. Whether you're working with heating oil, diesel, biodiesel, or renewable diesel, additives can significantly improve operability, reduce maintenance issues, and extend equipment life. Find suppliers with hands-on field experience who are ready to support the problem-solving process, or take proactive steps to implement preventative measures that minimize the likelihood of issues arising.

Recent innovations in cold flow additive technologies have significantly improved the ability to blend biodiesel and renewable diesel for winter use.

These include:

- Cold flow improvers that reshape wax crystal formation
- Pour point depressants tailored to specific biodiesel feedstocks
- Multi-functional additives that enhance cold flow, oxidation stability, and microbial resistance
- Oxidation stability
- Injector cleanliness and lubricityseasonal temperature fluctuations.

By combining technical precision, quality base fuels and modern additive solutions, operators can achieve successful blends that meet customer expectations and perform reliably in even the harshest climates.

For biodiesel which naturally has higher cloud and pour points than petroleum diesel, cold weather performance may be greatly enhanced using anti-gel additives, wax anti-settling agents, dispersants, cold flow improvers, and pour point depressants, depending upon the individual fuel components.

These additives modify and disperse the wax crystal formation in fuel, preventing filter plugging and fuel line blockages during freezing temperatures. Other ways to modify risk include indoor vehicle storage or warmer fuel storage conditions, including line heat tracing.

It's highly recommended to use custom additive packages tailored to specific biodiesel feedstocks and blend ratios, ensuring compatibility and optimal performance across various operating environments. Once you've chosen and committed to a reliable fuel source, screening the fuel with the right additives is invaluable for establishing a baseline for successful winter operability. While renewable diesel (RD) seems to have excellent cold weather properties, its performance ultimately depends on how it was manufactured, with isomerization playing a crucial role in this process.

To ensure optimal results:

- Source fuel from BQ-9000® certified suppliers.
- Apply additives based on seasonal needs and local climate conditions.
- Maintain clean, water-free storage systems to prevent additive degradation and microbial growth.
- Refrain from treating fuel previously treated upstream.
- Add the cold flow additives while the fuel is +10F above the fuels cloud point.

Incorporating the appropriate additive components is not just a best practice, it's a proactive step toward fuel system reliability, regulatory compliance, and sustainable operations.

For more on that log into:

afdc.energy.gov/fuels/renewable-diesel

Storage Tank Maintenance Procedures:

Protecting Fuel Quality and System Integrity

Maintaining fuel quality begins with proper storage practices. Whether you're storing diesel, biodiesel, renewable diesel, or heating oil, your tank system plays a critical role in preserving fuel integrity and preventing contamination. Implementing a proactive maintenance strategy helps ensure that fuels remain on-spec and perform reliably across all applications.

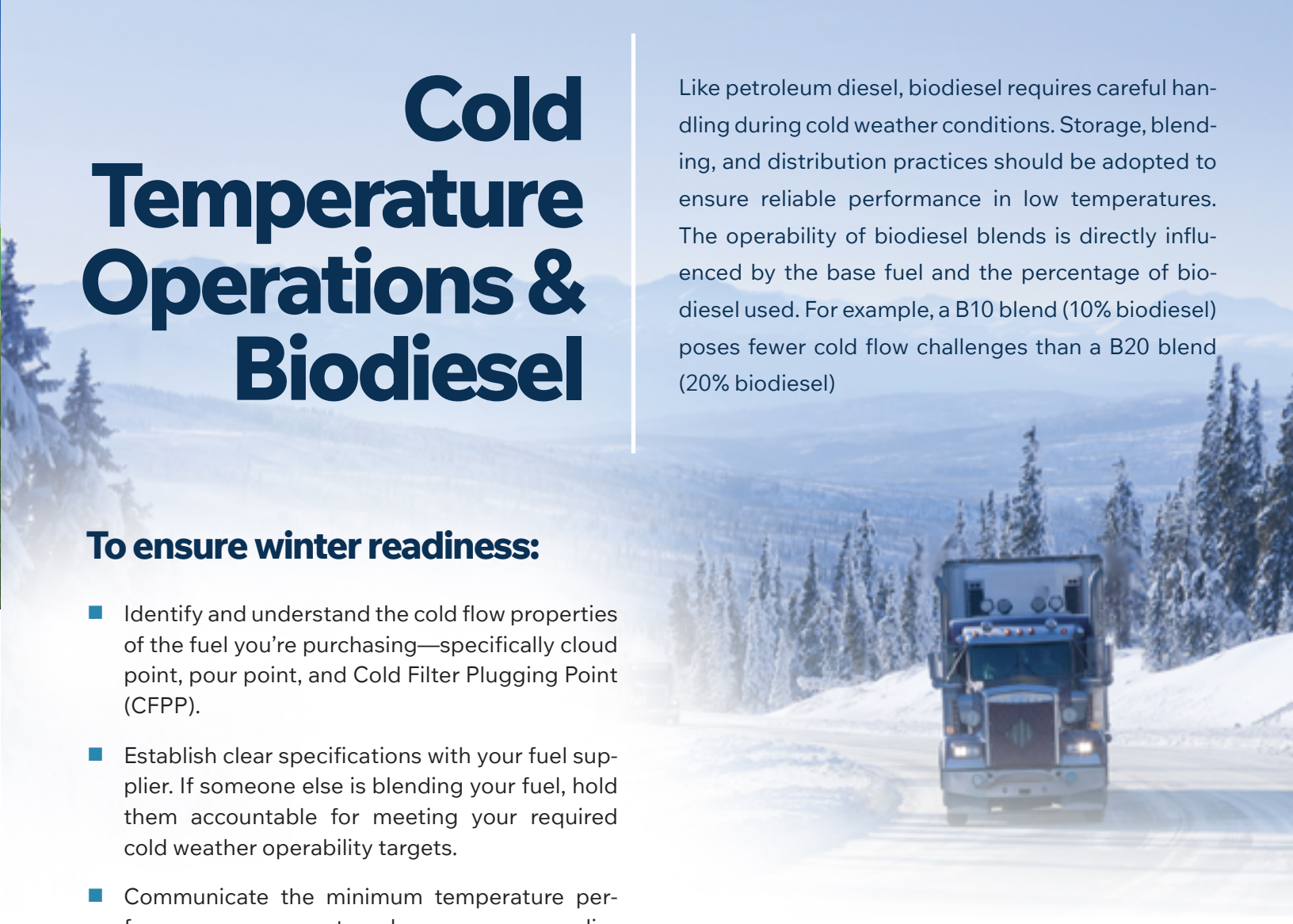
KEY FUEL QUALITY STRATEGIES

- Keep tanks topped off whenever possible to reduce air space and minimize condensation, which can lead to water contamination.
- Understand the operability values of your fuels—such as cloud point, pour point, and Cold Filter Plugging Point (CFPP)—to ensure seasonal readiness.
- Monitor and eliminate water promptly. Water is the leading cause of microbial growth and fuel degradation.
- Partner with a certified analytical lab for routine fuel testing and diagnostics.
- Avoid over-treating fuel with additives. Do not add new additives to previously treated fuel unless recommended by a qualified fuel specialist.
- Do not use additives once fuel has reached or dropped below its posted cloud point, as they may no longer be effective.
- Always request fuel specifications from your supplier. For large bulk tanks, perform top, middle, and bottom sampling to verify fuel consistency and quality.
- Inspect fill and vapor caps for damage or missing gaskets. Replace as needed and consider installing desiccant dryers on vent pipes to reduce moisture ingress.
- Conduct microbiological evaluations at least once per year to detect and prevent microbial contamination.
- Schedule periodic tank cleaning by qualified professionals to remove sludge, sediment, and biofilm buildup.
- For tanks exposed to outdoor conditions, install heating elements, insulation, and tank mixers to maintain fuel fluidity and prevent stratification during cold weather.
- Use a floating suction system at the fuel intake to draw fuel from above settled contaminants, reducing the risk of sediment entering the supply line.

By following these best practices, you can significantly reduce the risk of fuel contamination, maintain compliance with ASTM fuel quality standards, and ensure optimal performance of your fuel systems year-round.

Cold Temperature Operations & Biodiesel

Like petroleum diesel, biodiesel requires careful handling during cold weather conditions. Storage, blending, and distribution practices should be adopted to ensure reliable performance in low temperatures. The operability of biodiesel blends is directly influenced by the base fuel and the percentage of biodiesel used. For example, a B10 blend (10% biodiesel) poses fewer cold flow challenges than a B20 blend (20% biodiesel)



To ensure winter readiness:

- Identify and understand the cold flow properties of the fuel you're purchasing—specifically cloud point, pour point, and Cold Filter Plugging Point (CFPP).
- Establish clear specifications with your fuel supplier. If someone else is blending your fuel, hold them accountable for meeting your required cold weather operability targets.
- Communicate the minimum temperature performance you expect, and ensure your supplier uses appropriate strategies—such as kerosene dilution, blend control, or cold flow additives—to meet those requirements.

Recent advancements in fuel additive chemistry have significantly improved cold weather performance for biodiesel and renewable diesel.

These include:

Advanced cold flow improvers that modify wax crystal formation to prevent filter plugging. Pour point depressants tailored for biodiesel feedstocks. Multi-functional additives that combine cold flow enhancement with oxidation stability and microbial control.

By leveraging these technologies and maintaining strict fuel specifications, you can ensure that biodiesel and renewable diesel perform reliably even in harsh winter conditions.

Renewable Diesel and Cold Weather

While the industry often assumes that renewable diesel is immune to cold flow issues, we believe it's important to offer additional guidance for those purchasing and using RD within their market. Depending on the manufacturing process of RD, cloud point challenges can still arise and should be taken into consideration.

This publication will not recommend specific additive brands but must state that BD/RD/ ULSD require attention, first by monitoring general quality parameters like water contamination, followed by oversight of fuel properties and consistent treatment strategies to support safe storage and blending principles.

Evaluating RD Handling

Renewable diesel behaves differently than traditional petroleum diesel, especially in cold temperatures. Like petroleum diesel, its winter performance is defined by three critical cold flow properties: Cloud Point (CP), Cold Filter Plugging Point (CFPP), and Pour Point (PP).

At the Cloud Point, wax crystals first begin to appear. As the temperature drops further and the CFPP is reached, these crystals begin to restrict fuel flow through filters. By the Pour Point, the fuel thickens to the point where it can no longer flow at all.

However, the cold flow behavior of renewable diesel (RD) isn't uniform — it's largely determined by where and how it's produced. The depth of isomerization during refining (the process that rearranges molecular structure to improve cold weather operability) dictates how low these temperature values can go. Simply put, renewable diesel produced with deeper isomerization in advanced hydroprocessing units delivers superior cold flow performance, while fuels from less intensive processes or warmer climates may have higher cold flow limits that restrict winter use.

Fuel suppliers increasingly report that untreated renewable diesel stored near its CP will gel within 24 hours. This makes heated transportation, insulated storage, and the strategic use of Cold Flow Improvers (CFIs) important tools for ensuring operability.

Effective treatment depends on careful lab testing, understanding the local climate, and tailoring additive chemistry to the specific batch of fuel.

Renewable diesel is a powerful tool for reducing carbon intensity, but it demands greater attention to detail than conventional diesel. Success requires acknowledging its variability, respecting its narrower cold flow margins, and applying proactive strategies, monitoring, blending, and treating with the right additives at the right time.

With disciplined handling, renewable diesel can deliver both the environmental benefits and the reliable performance demanded of today's decarbonization timelines.

To Ensure Winter Readiness:

Cloud Point (CP)

- The cloud point is the temperature at which wax crystals begin to form in the fuel, making it appear cloudy
- Renewable diesel typically has a lower cloud point than biodiesel, often ranging from 14°F to -4°F, depending on the feedstock and production method
- The degree of isomerization of paraffins during production significantly affects the cloud point

Cold Filter Plugging Point (CFPP)

- CFPP indicates the lowest temperature at which fuel will still flow through a filter
- Renewable diesel generally has a better CFPP than biodiesel, making it more resistant to gelling and filter clogging in cold weather

Freezing Point

- Renewable diesel can freeze solid if stored near its cloud point, especially in extreme cold
- The Freezing Point test helps determine safe storage and handling temperatures

Fuel Stability

- Renewable diesel is chemically like petroleum diesel, which helps it remain stable in freezing temperatures and resist gelling

Additives and Blending

Cold flow improvers can enhance cold weather performance, though they are not always necessary for renewable diesel

Blending renewable diesel with low-cloud-point biodiesel can further lower the freezing point and improve operability

Storage and Handling Tips

- Store renewable diesel above its cloud point to prevent crystallization.
- Use underground tanks or insulated systems in colder climates.
- Always check supplier technical data for specific cold weather performance metrics.

Proper Techniques for Successful Fuel Blending

Maintaining the integrity of a fuel sample is essential for obtaining accurate and meaningful analysis results. The most effective approach is to collect a representative sample—or a composite of multiple samples—that reflects the contents of a truck, storage tank, filter dispenser or filter cartridge. Depending on the sampling location and the purpose of the analysis, various types of equipment may be used to properly collect the fuel sample.

- Identify the cold flow protection requirements specified by the customer, including target operability temperatures.
- Source a base fuel with the lowest possible cold flow values, such as cloud point, pour point, and Cold Filter Plugging Point (CFPP), to maximize blending flexibility.
- Use a combination of kerosene and advanced fuel additives to lower the
- operability values of the base fuel. This enables higher biodiesel blend ratios while
- maintaining cold weather performance. For example, a B20 blend using soy methyl ester may reduce cold flow operability by up to 10°F.
- Blend biodiesel into diesel fuel and test the final product to confirm it meets the required cold flow specifications.
- When splash blending is the only option, ensure the biodiesel is heated to above 100°F to prevent flash freezing when introduced into cold metal tanks.
- When ratio blending, maintain the biodiesel temperature at least 10°F above its cold flow properties. For higher blend ratios, consider heating the biodiesel to 20°F above those values to ensure proper integration.
- Dilution blending with kerosene remains a viable option, though it may present economic and supply challenges depending on market conditions.
- Once properly blended using these techniques, biodiesel and diesel fuels will remain stable and homogeneous, ensuring consistent performance.

EQUIPMENT:

Blending Infrastructure

As biodiesel blending increases, terminal operators looking to incorporate higher volumes of biodiesel and renewable diesel into Ultra Low Sulfur Heating Oil (ULSHO) and Ultra Low Sulfur Diesel (ULSD) are prompting a shift in infrastructure.

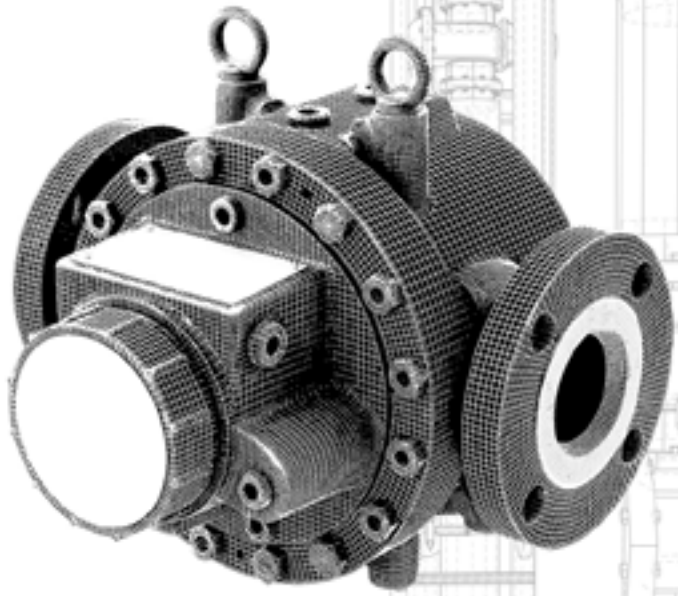
To support these higher-percentage blends, blending equipment engineers are installing larger, more precise metering systems capable of accurately handling both low and high flow rates.

It's important to confirm the anticipated future blend rates at your terminal location. Standard biodiesel blending systems typically require two meters: a 4" diesel meter and a dedicated biodiesel meter designed to accurately inject biodiesel into the diesel stream.

If your goal includes higher blend ratios—or the ability to load 100% biodiesel—a 3" Positive Displacement (PD) Meter with enhanced resolution is recommended for the biodiesel line.

This configuration ensures accurate measurement across a wide range of blend scenarios, from low-percentage blends like B5 to high-percentage blends such as B80.

For optimal performance and long-term flexibility, consult with your equipment service provider to design a blending system that aligns with your renewable fuel goals.



A positive displacement meter designed to inject biodiesel into a ratio blending rack system

Identifying Engine Shutdowns & Tank Issues:

The Importance of Fuel System Management

Engine failures caused by fuel filter starvation are a clear reminder of how critical it is to properly manage your fuel systems and maintain fuel quality. As the saying goes, “You can pay me now, or you can pay me later.” Proactive maintenance and operational discipline are key to avoiding costly breakdowns and downtime.

Addressing Diesel Equipment Breakdowns

- Drain the bottom of the tank using the petcock to inspect for water and sediment accumulation. Regular bleeding helps identify contamination before it reaches the engine.
- Verify fuel transfer pump operation to ensure consistent fuel delivery.
- Replace all in-line filters—typically two primaries and one secondary—to restore flow and prevent further clogging.
- Inspect the removed filter by turning it upside down and pouring out any remaining fuel. This can help determine whether the issue is caused by waxing or icing.
- If waxing is identified, dilute the fuel with kerosene to lower its cold flow properties. Use heat or garage the vehicle to melt wax crystals. Do not use cold flow additives at this stage, as they are ineffective once the fuel has reached its cloud point.
- If icing is the issue, thaw the fuel or use emergency anti-icing additives containing alcohols or solvents. These should be used sparingly, as overuse can damage fuel pump seals and elastomers over time.
- Be aware that fuel lines—often narrow and containing multiple 90° brass fittings—can become restricted. Warming these lines may be the only solution to restore flow.
- Once the engine is operational, collect fuel samples from both the saddle tank and the bulk storage tank. Send them to a certified lab to test for Cloud Point, Pour Point, and Cold Filter Plugging Point (CFPP).
- If you observe black, slimy residue on the filter media, request a microbiological evaluation to check for microbial contamination. You may also submit the used filter for lab analysis to identify specific contaminants.
- Use the event documentation sheet provided on the next page to record all fuel-related issues for future reference and troubleshooting.

Proper operational techniques and timely diagnostics are essential to maintaining fuel system integrity, especially in cold weather conditions. By following these steps, you can minimize downtime, protect your equipment, and ensure your fuel remains on-spec and ready for use.

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 problem is the fleet experiencing? _____

_____

_____

_____

When was the first indication of the problem? _____

_____

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?

_____

_____

_____

_____

ASTMTest Methods for Diesel, Biodiesel, Renewable Diesel, & Blended Fuels

Accurate fuel testing is essential for ensuring quality, performance, and compliance with industry standards. ASTM International provides a comprehensive suite of test methods for evaluating both petroleum-based and renewable fuels. Recent updates and innovations have expanded the scope and precision of these methods, especially for cold weather operability, contamination detection, and blend integrity.

Different test methods may apply to different fuels, different accuracies, or even apply to different circumstances. Understanding the purpose and scope of each method may be helpful when speaking to your laboratory partner.

Cold Flow Properties:

- **Cloud Point** — **ASTM D5773** (automated method), **ASTM D2500** (manual method)

  Determines the temperature at which wax crystals begin to form and become visible in the fuel.

- **Cold Filter Plugging Point** (CFPP) — **ASTM D6371**

  Measures the lowest temperature at which fuel will pass through a standardized filter, indicating operability in cold conditions.

- **Pour Point** — **ASTM D97** (manual method), **ASTM D5949** (automated method)

  Identifies the lowest temperature at which fuel remains pourable.

Contamination & Stability

- **Microbial Contamination — No single ASTM method**

  Labs use culture-based and ATP testing to detect bacteria and fungi that can clog filters and damage fuel systems.

Water & Sediment

- **ASTM D2709**

  Evaluates contamination levels that can lead to corrosion and injector fouling.

Flash Point

- **ASTM D93**

  Determines the temperature at which fuel vapors ignite, critical for safety and regulatory compliance.

Biodiesel-Specific Tests

- **Free and Total Glycerin — ASTM D6584**

  Measures residual glycerin and unconverted fats, which can cause injector deposits and filter plugging.

Oxidation Stability (Rancimat Test)

- **EN 14112 (commonly used in conjunction with ASTM standards)**

  Assesses the long-term stability of neat biodiesel (B100).

Sulfated Ash

- **ASTM D874**

  Quantifies residual catalyst and other ash-forming compounds that may contribute to engine deposits.

Acid Number

- **ASTM D664**

  Indicates the presence of free fatty acids, a sign of poor manufacturing or oxidative degradation.

New and Emerging Methods

- **ASTM D874**

  A newly published method using Vacuum Ultraviolet (VUV) spectroscopy to analyze diesel and biodiesel blends (B1–B20) with high precision. It measures aromatic content, FAME concentration, and PAHs in a single platform—streamlining analysis and reducing lab complexity.

- **ASTM D975 (2024 Updates)**

  Now includes enhanced guidance for biodiesel blends, stricter sulfur limits, and higher minimum cetane numbers to improve ignition quality and reduce emissions.

These test methods are essential for maintaining fuel quality across the supply chain—from production and blending to storage and end-use. By adhering to ASTM standards and leveraging the latest technologies, fuel professionals can ensure reliable performance, regulatory compliance, and environmental responsibility.

Resources

Clean Fuels Alliance America — cleanfuels.org
605 Clark Avenue
PO Box 104898
Jefferson City, MO 65100-4898
(800) 841-5849

Steel Tank Institute — stispfa.org

US Environmental Protection Agency (EPA) – epa.gov

Petroleum Equipment Institute – pei.org

BQ-9000® – bq-9000.org

NREL Biodiesel Handling and Use Guide:
https://afdc.energy.gov/files/u/publication/biodiesel_handling_use_guide.pdf

ASTM International – astm.org

International Fuel Testing Labs

Intertek – intertek.com

SGS – sgs.com

Bureau Veritas - group.bureauveritas.com

Amspec – amspecgroup.com

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