AEM
Association of Equipment Manufacturers

# Get CLEAN on Fuel to Protect Your Tier 4 Engine

A comprehensive resource featuring best practices for Tier 4 engine maintenance to ensure maximum equipment performance and value.

# INTRODUCTION

The new Tier 4 engines are here, and they are under the hood of many of the machines in operation today.

The U.S. Environmental Protection Agency (EPA) has been working diligently to clean the air that comes out of every engine that powers our economy. The agency's efforts require equipment owners, operators, technicians, dealerships and manufacturers to be aware of, educated about and dedicated to keeping engines and machines serviced and clean.

Sounds easy enough, right? But having a proper maintenance program, understanding the value of equipment, and working with operators and dealers to ensure your machinery is in top shape isn't enough anymore. We're not talking about Grandpa's tractor we could keep running with a pair of pliers and a crescent wrench.

The requirements the EPA has placed on the manufacturing industry have required that Tier 4 engines and the vast majority of equipment be more technologically advanced and driven by computers and software code. In addition, the machines and attachments of today are working — or more specifically, communicating — together to ensure they are as productive as possible.

In response to these developments, an AEM committee of member experts has developed a campaign to heighten the awareness of the new and mandatory demands placed on the owner, the operator, the technician, the dealers, the distributors and the equipment's manufacturers to maximize uptime and ensure performance expectations are met.

The CLEAN campaign serves to deliver the basic facts regarding the new technology under the hood of every machine with a Tier 4 engine. As a manufacturer, AEM encourages you to spread the message of CLEAN by sharing best practices about how to get the most out of the machinery your business counts on to be up and running every day.

So investigate the CLEAN message. But more importantly, leverage its resources to expand your knowledge and your ability to train others, as well as to gain access to tools to better serve your equipment, so your equipment will better serve you.

# 5 KEY AREAS FOR EQUIPMENT OWNERS

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## COMMIT TO UNDERSTANDING YOUR TIER 4 ENGINE

Today's engines use extremely precise components and very high fuel pressure. These changes require cleaner fuel and better filtration to maintain expected performance, fuel economy and component life.

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## LEARN THE FACTS ABOUT TODAY'S FUEL

Fuel standards alone can't ensure fuel is clean enough to meet Tier 4 engine needs. Today's fuel chemistry creates more challenges with water and allows for growth of bacteria and fungi that can shut you down.

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## EVALUATE YOUR FUEL SOURCE AND FUEL HANDLING

Take cleanliness very seriously. Ask the right questions to choose a supplier that uses best practices for fuel storage, distribution and handling. Ensure that your fuel handling systems are clean and use proper filtration.

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## ALWAYS FOLLOW MANUFACTURER GUIDELINES

They are experts on the unique requirements and maintenance needs for your machine. Make sure all your equipment operators understand and follow the guidelines on fuel for your machine.

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## NEVER TAKE YOUR ROLE FOR GRANTED

Everyone has an important part to play. Whether you are involved with bulk fuel or handling supplier's fuel, doing your part is critical to ensure the uptime and performance you expect on your equipment.

# CLEAN

## Commit To Understanding Your Tier 4 Engine

Understanding your Tier 4 engine and its needs is the first key area to ensure you get the performance and value you expect from your equipment. Be sure to review all 5 key areas to CLEAN on fuel and protect your Tier 4 engine!

Today's engines use extremely precise components and very high fuel pressure. These changes require cleaner fuel and better filtration to maintain expected performance, fuel economy and component life.

Over the past 10 years, EPA standards for allowable nitrogen oxides (NOx) and particulate matter (PM) emissions have been reduced by 90+% compared to pre-2007 levels. Engine manufacturers have been tasked with meeting these requirements while improving fuel economy and power requirements. This has been achieved through the introduction of new technology, both in the exhaust (aftertreatment) and on the engine (in-cylinder).

Aftertreatment exhaust systems now include technology such as diesel particulate filters (DPFs) to remove PM and selective catalytic reduction (SCR) technology to remove NOx. The introduction of the DPF was supported by a reduction in the sulfur levels of diesel fuel to below 15 parts per million (ppm, 0.0015%), though this might be lowered again to below 7 ppm. This is to protect the catalyst as it can be deactivated (referred to also as "poisoned") and become ineffective if exposed to higher levels of sulfur. The use of SCR now requires another fluid to be integrated into operations, diesel exhaust fluid (DEF). DEF is injected in the exhaust stream prior to the SCR to aid in the process of converting NOx to inert NO, $CO_2$, and $H_2O$.

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In-cylinder solutions have also been used to control NOx and PM emissions. Exhaust gas recirculation (EGR) has also been implemented as a strategy to reduce cylinder temperatures and therefore reduce NOx output. Perhaps the most drastic change, advanced fuel injection systems more precisely control the fuel burned in the combustion process. Multiple injections, with precision timing and quantities, have allowed engines to optimize their power and efficiency while maintaining lower emissions.

This precise fuel injection is done using high-pressure common rail (HPCR). In these systems, the entire "rail," or common port that the injectors are tied to is pressurized to the desired injection pressure level, up to 45,000+ psi. The injectors are exposed to this high pressure continuously, and then serve only to modulate and disperse the fuel from the rail into each cylinder. This is done with complex valving and moving parts with extremely tight tolerances (2-5 microns or roughly the size of red blood cell).

It is this high pressure, combined with critical valve seating and tight tolerances, that drives the need for clean fuel to operate effectively and maintain as-designed performance through the service interval of the injector. Any performance issues with the HPCR system can cause:

- decrease in power
- decrease in fuel economy
- increase in NOx and PM emissions

These negative effects are not acceptable in today's demanding operating environments where equipment uptime is the key to a successful operation.

To meet the injector operational requirements (performance and service life), HPCR manufacturers have issued fuel cleanliness specifications. This is typically in the range of ISO 18/16/13 (per ISO 4406), which is about the equivalent of 15 parts per billion (ppb) of dirt in the fuel. Allowable water is typically 0 ppm of undissolved, or free, water.

To alleviate this sensitivity most manufacturers have developed new highly effective filtration (onsite and on machine) to achieve better than ever results under all conditions, so no matter what the cleanliness level of the fuel coming into the site tank (for centrally fueled machines), the desired cleanliness level can be met on the machine. This system and on-engine filtration allows fuel to meet recommended cleanliness levels. However, this high efficiency can sometimes result in a high sensitivity to plugging from extraordinary fuel contamination.

To help alleviate this filter plugging, most manufacturers have a recommended cleanliness spec of the fuel coming into the equipment. This will allow for the filtration on the dispenser (bulk filtration) to achieve the desired incoming fuel cleanliness and prevent large fuel-related problems (like microbial growth, additive/glycerin fallout, cold temperature gelling and water issues) from ever making it onto the equipment, where it would affect operations.

## Commit to understanding your Tier 4 engine:

- Engines have changed dramatically, and they require cleaner fuel and better filtration.
- HPCR technology uses extremely precise components that demand clean fuel.
- Modern high-pressure, common-rail fuel systems (HPCR) have tighter tolerances, which make them less tolerant to poor fuel quality.
- Improved fuel systems require advanced filtration
- EPA & HPCR have created very different engines with HPCR injection systems and advanced filtration.
- New technology maintains emission levels and increases component longevity.
- Fuel has changed.
- Contaminants combined with high fuel pressure (pressure has risen to 45,000 psi) create erosion that negatively impacts performance, fuel economy and component life.

CLEAN

# Learn The Facts About Today's Fuel

## Learning the facts about today's fuel is another key area to ensure you get the performance and value you expect from your equipment. Be sure to review all 5 key areas to get CLEAN on fuel and protect your Tier 4 engine!

Fuel standards alone cannot ensure fuel is clean enough to meet Tier 4 engine needs. Today's fuel chemistry creates more challenges with water and allows for growth of bacteria and fungi that can shut you down.

In the past, diesel fuel used to contain higher levels of sulfur. EPA mandated a reduction in sulfur content by more than 97% to support new standards to reduce emissions from diesel engines. While there are advantages to using ultra-low sulfur diesel fuel (ULSD), there are some disadvantages as well. In the process of removing sulfur, many other beneficial properties are either reduced or eliminated. Additionally, sulfur has natural antimicrobial properties, which are reduced upon the reduction of sulfur.

ULSD is hygroscopic, meaning it easily absorbs water. This can lead to microbial growth and corrosion. Water is the most common contaminant in fuel systems and can lead to many problems if not controlled. ULSD, without the proper additives, contains reduced levels of lubricity. Insufficient lubricity leads to premature wear of fuel system components. However, ULSD controlled to the levels required in ASTM D975, the diesel fuel specification, should be at the right lubricity limits.

Diesel fuel additives serve a variety of purposes. Additives may be added to diesel fuel at any stage — the refinery, pipeline distribution, bulk storage, terminal or end user. An excess of fuel additives injected into diesel fuel may lead to the formation of particulates that can plug fuel filters, causing contamination issues.

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Biodiesel can be used as a blend in conventional diesel fuel, and in some cases, where allowed by the OEM, as a fuel by itself. Most specifications are based on ASTM D975, which include fuel stability, flash point, chemistry (distillation profile, aromatic content), lubricity and other properties. Throughout the fuel distribution and transport, fuel suppliers may add additives to meet the specifications, which may present opportunities for excess additives. This can be significantly exacerbated if end users add additives to the fuel on the assumption of further improvement of the properties. While appropriate additives can help in keeping injectors free of deposits, internal and external, it is best to consult with the fuel supplier before adding aftermarket additives. It is important to note that additives cannot impact contamination in the fuel. Only proper maintenance and filtration can lead to clean fuel.

Biodiesel can be used as a blend in conventional diesel fuel, and is in some cases where allowed by the OEM, can be used as a fuel by itself. Biodiesel's most common blend levels typically range from two volume percent (B2) to twenty volume percent (B20) of the total biodiesel blend. Most engine manufacturers permit the use of B2 and B5. In fact, per ASTM D975, any conventional diesel fuel can contain up to B5 with no labeling required. Regardless of the permitted blend level, nearly every manufacturer stipulates certain use requirements and might increase maintenance or service intervals. When using biodiesel, it is highly recommended to use BQ 9000 accredited suppliers to help maintain the quality and consistency.

Diesel fuel is classified into 1D, 2D and 4D. The difference between these three classes depends on viscosity and pour point. 1D fuel has lower viscosity and is preferred for cold weather, while 2D fuels are used in warmer months. 4D is recommended for use in low- and medium-speed diesel engines in applications involving predominantly constant speed and load. Sometimes a blend of 1D and 2D fuels may be used in winter months. Good fuel suppliers change the fuel blend during winter and summer season to help customers meet the needs of their engines. Diesel fuel has an average "shelf life" of about six months and biodiesel about three months. Proper storage and maintenance are critical to keep fuels clean and free from microbial growth and chemical deterioration.

Always refer to manufacture guidelines for approved biodiesel blend level, special maintenance needs, winter fuel and additive recommendations.

## These are some of the widely followed diesel fuel specifications:

- **ASTM D975:** Standard for diesel fuel oils (allows 5% biodiesel without notice to consumer).
- **ASTM D7467:** Standard for Diesel Fuel Oil, Biodiesel Blend (B6 to B20).
- **ASTM D6751:** Standard for biodiesel fuel blend stock (B100) for middle distillate fuel.

While these standards ensure basic diesel fuel performance/quality, they do not meet all OEM recommendations for fuel cleanliness. For example, some engine manufacturers recommend ISO 4406 values 18/16/13 for particulate size and maximum total water content of 200 ppm, whereas ASTM D975 limits a combined water and sediment to 0.05% (500 ppm) by volume and does not limit the size and mass of particulate in the fuel. In addition, current specifications do not control important items such as additives, cold flow and oxidation stability.

The fuel marketer has several options on how to achieve the desired properties: choice of crude oil, refinery processing, refinery blending, or the use of additives. Fuel marketers may provide a product that meets all applicable specifications. Beyond that, good marketers also ensure their fuel meets important non-specification properties and is fit for use, and they follow cleanliness best practices.

Therefore, it is very important to buy your fuel from someone who maintains best practices throughout the storage and distribution process.

# Evaluate Your Fuel Source and Fuel Handling

## Taking fuel handling and storage seriously is a critical step to ensure you get the performance and value you expect from your equipment. Be sure to review all 5 key areas to get CLEAN on fuel and protect your Tier 4 engines.

Take cleanliness very seriously. Ask the right questions to choose a supplier that uses best practices for fuel storage, distribution and handling. Ensure that your fuel handling systems are clean and use proper filtration.

The process of storing fuel and transferring fuel from the storage tanks to the fuel tank of a piece of equipment can be a major source of fuel contamination. Connections, hoses, pumps, filters and the delivery system all have effects on the fuel. Damage and poor maintenance of these hoses and pipes leave opportunities for debris and water to enter the fuel.

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## Universal best practices to help you maintain your fuel's cleanliness and quality while being stored and transferred, plus some questions regarding common problems, are as follows:

- Use only hoses and piping that are specifically designed to be used with diesel.
  - Are flex hoses stored with caps installed to prevent contamination, or are they open-ended laying in the dirt?
- Check the fuel pumps that enable the movement of the fuel for damage, as they are an easy gateway for particles to enter the fuel.
  - Does the supplier improperly use the same delivery truck regardless of the product carried (diesel, biodiesel, gasoline, ethanol, heating oil, etc.)?
  - Has the nozzle that enters the fuel tank of the equipment been properly cleaned and maintained?
  - Do you allow the nozzle to be stored improperly with the open end exposed to gather rainwater, dust, bugs, etc.?
- Perform preventative maintenance on all transfer equipment.
- Inspect and replace any worn or aged parts including caps, seals, gaskets and filters.
  - Does your tank vent have a filter, or just an open pipe that draws dirty air into the tank as the fuel level drops?
- Purchase the correct fuel and store it according to the environment.
  - Do you purchase biodiesel in the spring, let the tank sit in the summer sun, and expect it to still be good in the fall?
- Completely empty and clean the tanks periodically; your fuel supplier could help you determine the right schedule.
  - Do you use underground tanks, but never check for ground water leakage?

## Owners of bulk fuel tanks:

- Keep a storage tank maintenance log to track intervals for inspection, cleaning and filter changes.
- Ensure your bulk tank has proper filters:
  - An outlet filter that removes water and is rated at 10 micron or less.
  - A desiccant-style vent filter rated at 1 micron.

## Potentially harmful fuel properties:

Diesel engines and aftertreatment systems must be protected from several dirty or substandard diesel fuel properties, each associated with their own failure modes:

- Dirt (Fuel Particle Concentration maximums of 18/16/13 per ISO standard 4406, before being pumped onboard the equipment).
- Water (max 0.02%).
- Wax (cloud point should be 6°C below lowest ambient expected).
- Lubricity (maximum of 520-micron wear scar HFRR).
- Boiling point (minimum of 150°C)
- Cetane (45 minimum).
- Viscosity (1.3 to 4.1 centistokes is acceptable).
- Sulfur (15ppm maximum).
- Ash (maximum 0.02%).
- Organic controls (fungus growth, biodiesel decay, etc.)

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## Biodiesel characteristics:

- High temperatures can shorten biodiesel's shelf life to make it expire sooner, possibly causing a brown sludge to form in the bottom of the storage tank. Shelf life is measured by the oxidation stability; higher is better. Look for fuels with 20+ hours on the EN15751 test method.
- When cold biodiesel fuel is warmed up, the actual temperature required to clear the cloudiness is higher than the cloud point test results, so use a 16-hour Cold Soak Filterability Test (ASTM D7501 test method) with a result that has an adequate margin to your expected environmental conditions.
- When storing equipment for an extended period of time (more than three months), try to run a full tank of biodiesel-free regular diesel fuel prior to engine shutdown for storage.
- Switching from diesel to biodiesel may "clean" tanks and shorten filter life. Be ready to change the fuel filters early.
- Modern fine micron filters may also have shorter life with biodiesel, exhibiting symptoms of low power output, difficulty starting, etc. Blends above B20 (20% bio and 80% diesel) increase the risks.
- Biodiesel holds more water than regular diesel fuel, and the water is bound up with the bio component, so it is more difficult for the coalescing filter to strip out the water.

The Coordinating Research Council Report CRC-667 has good additional information on fuel storage and handling.

# Always Follow Manufacturer Guidelines

## Following manufacturer guidelines is essential. Be sure to review all 5 key areas to get CLEAN on fuel and protect your Tier 4 engine!

They are experts on the unique requirements and maintenance needs for your machine. Make sure all your equipment operators understand and follow their guidelines on fuel.

Your equipment is a big investment, and you want it to be trouble-free and last a long time. So does the company you purchased it from, because it wants to keep your business. Take time to review your machine's owner's manual. Pay special attention to fuel basics such as the grade requirements, blending recommendations for cold weather, and biodiesel blend percentage approval and related guidelines.

Next, review the manual for critically important planned maintenance — what to do, plus how and when to do it. It usually contains some important what-not-to-do's also! All products have service intervals, and most have daily checks — draining fuel system water traps is a prime example. Go through your manual carefully, because Tier 4 engine technology has brought about some changes. ***You really want to be aware and follow all of the guidelines because it pays you in machine uptime to do so!***

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## Examples of some universal best practices:

- Drain fuel system water traps daily.
- Keep a spare fuel filter on hand for each engine.
- Use only manufacturer-approved fuel filters and fuel additives.
- Refill machine fuel tanks at the end of a work shift to reduce condensation.
- Use only clean fuel cans dedicated for diesel use, and keep the dispensing end clean and dry.

## In seasonally cold regions:

- Follow all cold-weather starting procedures.
- If using biodiesel, completely purge your tank before winter.
- Switch to winter blend early to be ready for temperature changes.
- To avoid gelling, confirm your supplier uses a winter blend of #1 and #2 diesel with a low cloud-point temperature.

When you need replacement parts, fluids, filters and fuel additives, see your equipment manufacturer. Sure there are other choices, and sometimes for less money, but they may not be the best value. Here's why: equipment manufacturers closely manage the quality of their parts, because their brand name depends on quality to sell the next machine.

When it comes to fluids, filters and fuel additives, equipment manufacturers choose the top supplier of a given product, and often co-develop that product as needed to create the unique formula or design for that brand.

If you do have a problem with your equipment and need help from the manufacturer, it's always quicker and easier to get to a remedy if you have followed the manufacturer guidelines and used their products. It also rules out any uncomfortable discussions related to warranty eligibility for these areas of consideration.

Bottom line… don't experiment with other suppliers in the hope of finding a better value. You would be gambling with your expensive machine, and the odds would be stacked against you. ***Buy your parts, accessories and supplies from the equipment manufacturer!***

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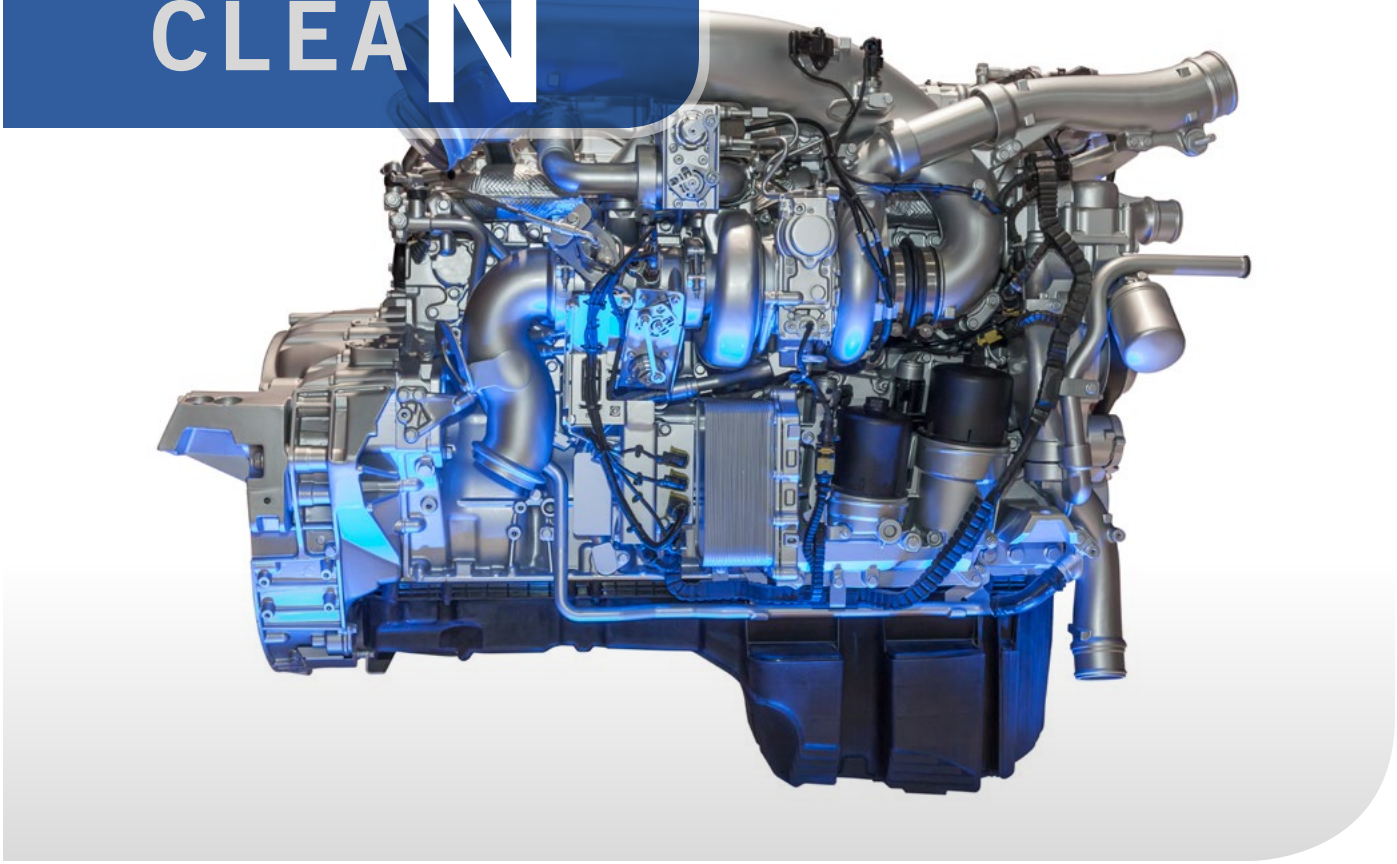

# Never Take Your Role For Granted

Everyone has an important part to play. Whether you are involved with bulk fuel or handling supplier's fuel, doing your part is critical to ensure the uptime and performance you expect on your equipment.

To meet EPA engine emissions air quality standards, OEMs introduced High Pressure Common Rail (HPCR) technology to control fuel combustion, reducing undesirable emissions. These HPCR systems require fuel much cleaner than was ever needed in the past. To do this, much tighter fuel filters have been placed in the fuel system, and they must remove nearly all particulate from the fuel. The role of the end user is to ensure the now much higher performing fuel filters still achieve the desired service interval. This is done by knowing about the fuel being purchased and applying best practices to the storage and handling of that fuel once on site.

Does the fuel meet all necessary ASTM specifications? Always purchase fuel that is made to an ASTM spec.

What percent is biodiesel? More biodiesel can mean better lubricity, but also greater water-carrying capacity and an increased likelihood for microbial growth. More biodiesel also means the fuel will have a higher cloud point and, if operating in colder climates, may cause flow or operability issues. To maximize cold-climate operability using any fuel, always know the cloud point and cold filter plug point of the fuel being purchased. Make sure your fuel is suitable for the local weather conditions, both current and expected.

Your role as an equipment owner or operator should not be taken for granted as it relates to your fuel supply. Check to see the condition of the equipment's fuel tank to make sure dust is not being ingested as fuel is depleted. Best practices would dictate that you also check the tank bottom on a periodic basis to make sure dirt or water are not building up. This is especially important for equipment that is not utilized very often.

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## Bulk fuel storage responsibilities:

You must start with a clean storage tank. The "rag layer" remnants of old fuel, dirt, insoluble additive and water at the bottom of the tank will cause issues with any new tanker of fuel that is delivered. Each contaminant can be a catalyst for additional fuel issues, so hire a reputable tank cleaner who will get the job done right the first time.

If you wish to filter the fuel upon delivery from the supplier, install a filter system upstream of the storage tank (if possible). Doing so will provide you the opportunity to refuse delivery of fuel that would cause equipment downtime. When combined with a freshly cleaned storage tank, this ensures clean fuel both coming in and in storage. To keep it clean in storage, utilize a tank breather filter to remove dirt and moisture as the tank "breathes" due to fuel being pumped in or out.

Water in fuel can be the cause of many issues, so precautions must be taken to keep it out. Water can enter the storage tank in three main forms. First, it can be delivered as free water with the supply of fuel (not very common). Second, all diesel blends especially biodiesels can hold dissolved water. This water will not remain dissolved if the temperature of the diesel drops too much (while settling water will condense out of diesel). Third, the air drawn into the tank contains dissolved moisture and, when exposed to colder temperatures of the tank wall (e.g. over a cool night), it will condense on the surfaces and drop to the bottom.

Diesel should not be stored for long periods, but if this is not avoidable, work with your fuel supplier to ensure the proper additives are being employed. Use periodic (monthly) testing of the fuel to make sure it is still fit for use when needed. Be careful not to use any additional additives in stored fuel without consulting with your fuel supplier. Typically, fuel is sold fit for your purpose, whether for cold flow properties or the need to store it longer. Adding more of anything is rarely a good thing, so be sure to consult the supplier first to make sure your decision is not costing you extra money in additives or lost uptime due to fuel issues.

Finally, having a good dispenser filter will ensure that if there are any issues from the refinery through distribution and storage, they will not be delivered into the equipment where uptime can be lost. A dispenser (or bulk) filter system should be chosen based on desired cleanliness, quantity of fuel being used and pumping pressure available, among other design criteria. Another option is to install water-absorbing elements to ensure no water is delivered with the batch of diesel fuel. Work with a reputable fuel filter manufacturer to ensure all goals are met. Your OEM may have bulk filtration recommendations, which you should follow.

Even with a good filter system, good housekeeping continues afterwards. Be sure fuel nozzles are kept clean and out of exposure to the general atmosphere (where dust is always present). Check to see the condition of the equipment's fuel tank to make sure dust is not being ingested there as fuel is depleted. Speaking of the equipment's fuel tank, best practices would dictate that you also check the tank bottom on a periodic basis to make sure dirt or water are not building up. This is especially important for equipment that is not utilized very often.

## It is best to understand how water forms and to take every precaution against it:

- Use water-absorbing filters on the inlet to stop incoming free water from the supplier (rare).
- Keep the tank full to minimize air condensation in the headspace.
- Use a breather filter to minimize moist air entering the tank headspace.
- Locate the tank in a place where temperatures will be stable (sometimes not possible).
- Check the tank bottom on a periodic (weekly) basis to identify water, dirt, or anything organic (microbial) that may cause filter plugging issues.

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## Emission technology has increased the maintenance responsibilities of the owner/operator:

- Understand the characteristics of today's diesel fuel and get to know your fuel supplier.
- Proper diesel fuel sourcing, storing and supplying are fundamental to your success.
- High-quality OEM-recommended fuel filters are the key to engine performance and longevity.
- Don't ignore basic fuel handling "hygiene." It is critical to keep fuel nozzles clean, filters changed regularly and fuel fresh.
- Biodiesel fuel blends require a unique and higher level of maintenance needs.
- Biodiesel is hygroscopic, collecting water that generates algae, bacteria, fungi and spores.
- Biodiesel begins to gel at much higher temperatures than diesel.
- Biodiesel that is not processed to the required specifications may contain glycerin, which can contribute to rapid filter plugging.

The overall cost of fuel issues and problems outweighs any costs of maintaining your fuel and fuel tanks.

Your role as an equipment owner or operator should not be taken for granted as it relates to your fuel supply. While there are many variables to consider, there are also many best practices that can be followed to ensure issues are kept to a minimum. Know and communicate with your fuel supplier, and follow the guidelines outlined above for the storage and handling of your diesel fuel. This will ensure you not only protect your engine's injection system from damage, but also help meet the filter service intervals and equipment uptime expectations that you have.

# SUMMARY

# Get CLEAN on Fuel to Protect Your Tier 4 Engine Equipment

## 5 KEY AREAS FOR EQUIPMENT OWNERS

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### COMMIT TO UNDERSTANDING YOUR TIER 4 ENGINE

**Today's engines use extremely precise components and very high fuel pressure. These changes require cleaner fuel and better filtration to maintain expected performance, fuel economy and component life.**

Tier 4-compliant diesel engines are dramatically different from their predecessors. Their high-pressure, common-rail (HPCR) fuel systems use extremely precise components, making them less tolerant of poor fuel quality. Because fuel pressure is as high as 45,000 psi, any contaminants can create erosion that negatively impacts engine performance, fuel economy and component life.

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### LEARN THE FACTS ABOUT TODAY'S FUEL

**Fuel standards alone can't ensure fuel is clean enough to meet Tier 4 engine needs. Today's fuel chemistry creates more challenges with water and allows for growth of bacteria and fungi that can shut you down.**

Today's Ultra-Low Sulfur Diesel (ULSD) contains 99% less sulfur, so it has many different qualities than past diesel fuels. Refining techniques and additives may vary from supplier to supplier, so it's important to buy your fuel from someone who maintains best practices throughout their storage and distribution process. Also be aware that today's diesel has an average "shelf life" of about six months, and that extended transportation can change the characteristics of diesel fuel between the refinery and your tank.

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### EVALUATE YOUR FUEL SOURCE AND FUEL HANDLING

**Take cleanliness very seriously. Ask the right questions to choose a supplier that uses best practices for fuel storage, distribution and handling. Ensure that your fuel handling systems are clean and use proper filtration.**

If you use biodiesel, follow manufacturers' recommendations. Biodiesel fuel blends vary by state from B2 to B20. Manufacturers recommend B2 to B5 levels. Recommended biodiesel suppliers should meet BQ-9000® standards.

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### ALWAYS FOLLOW MANUFACTURER GUIDELINES

**They are experts on the unique requirements and maintenance needs for your machine.**
**Make sure all your equipment operators understand and follow the guidelines on fuel for your machine.**

Create maintenance logs with established intervals for inspection, cleaning and filter changes. Keep a spare fuel filter on-hand for each engine and use only manufacturer-approved fuel filters and fuel additives. Drain water traps daily. Refill fuel tanks at the end of a work shift to reduce condensation and only use clean fuel containers dedicated for diesel use.

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### NEVER TAKE YOUR ROLE FOR GRANTED

**Everyone has an important part to play. Whether you are involved with bulk fuel or handling supplier's fuel, doing your part is critical to ensure the uptime and performance you expect on your equipment.**

With Tier 4 engines, manufacturers have increased the maintenance responsibilities of the equipment owner/operator. Therefore, proper diesel fuel sourcing, storage and supply are critical. High-quality OEM-recommended fuel filters are the key to engine longevity, but don't ignore basic fuel handling "hygiene," such as cleaning fuel nozzles, changing filters regularly and keeping fuel fresh. Also remember that biodiesel blends require a new level of maintenance needs.