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The general function of engine coolant is simple—to remove and transfer heat produced by the engine into the cooling system. This process is accomplished as the coolant absorbs heat from engine components and is then circulated through the cooling system, where the heat dissipates as it passes through the radiator. A thermostat regulates the temperature at which the cooling system keeps the engine coolant during this circulation. It cannot be understated that no matter how simple this process sounds, coolant technology and maintenance is extremely important to the function of an engine. To provide an example of how hard your cooling system works, a typical heavy duty cooling system will circulate the equivalent of a 16,000 gallon swimming pool worth of coolant every hour.

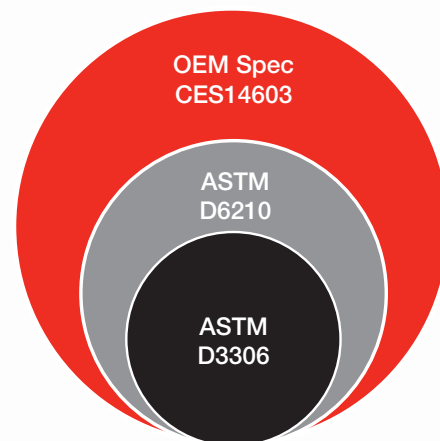


In order to properly remove heat from the engine, coolant must protect the entire cooling system, especially from problems such as corrosion, cavitation, and scale that can commonly appear in heavy duty diesel engines. The appropriate chemical formula of coolant ensures that the coolant positively interfaces with the variety of different surfaces it will encounter within an engine cooling system, all while removing engine heat and even managing the temperature of other engine fluids. Furthermore, industry research has shown that more than 40% of all engine problems are found to originate in the cooling system,

meaning that selecting and maintaining your coolant is critical to protecting your equipment.

Classification of Coolants

Determining which coolant product is right for your application can be a difficult decision. Many customers mistakenly choose based on the color of the coolant, however, manufacturers do not use standard color conventions and coolants of the same color are not guaranteed to be similar in composition. A working knowledge of how coolants are classified can be helpful in determining the difference between coolant products and understanding which product is appropriate for each application and situation. Typically, coolants are classified in two different ways: performance and product type.



The performance classification generally refers to the measured performance of the coolant when tested according to industry standards or OEM specifications. This testing may also encompass the measured chemical compatibility of a coolant

with cooling system materials. The American Society for Testing and Materials, ASTM, has developed tests that are commonly used in the coolant industry. ASTM D3306 and ASTM D6210 are today's most commonly referred to industry standards for coolants. ASTM D3306 contains several tests that define requirements for light duty coolants. The specification measures key physical properties of the coolant like freezing and boiling points. D3306 also contains performance requirements that evaluate the corrosion protection of a coolant under different conditions and tests for protection against water pump cavitation.

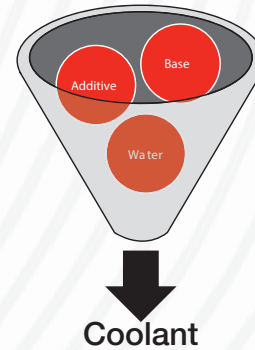
ASTM D6210 includes all of the testing required for D3306, as well as additional testing that evaluates the performance of the coolant for heavy duty applications. The primary additional requirements test the ability of the coolant to protect against cavitation of wet liners, as well as the ability to protect hot surfaces against scale. When looking for a Heavy Duty coolant, it is crucial to look for an indication that the coolant meets the 6210 standard.

Passing industry standardized testing indicates that the coolant meets minimum performance requirements. Also note many OEMs, including Cummins, require additional testing beyond the ASTM standards. OEM requirements provide performance or compatibility information that the OEM feels is important to the protection of their equipment. For instance, Cummins coolant specifications include an elastomer compatibility component. The OEM specification is typically the most stringent specification and includes all the requirements found in the ASTM standards.

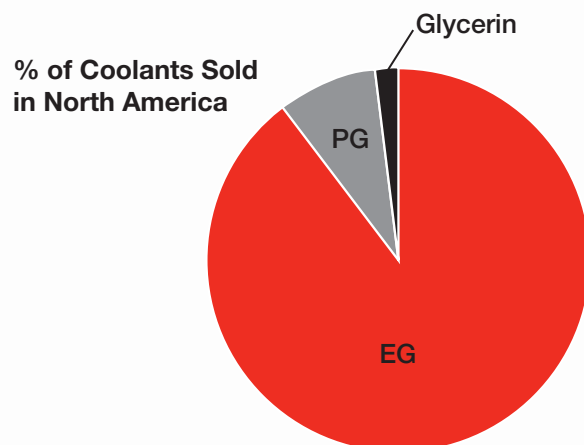
Coolants can also be classified based on product type. Typically type classifications are generic terms that are related to the base type and additives used in the coolant. Although these terms can be useful in the general classification of coolant, coolants within each type will vary in composition and performance.

What's in a Coolant?

When discussing coolant types, it is important to understand the composition of a coolant. Coolants are made up of three parts: water, a base, and additives. Type classifications are made with respect to the base type and the additive type. Almost all commercially available coolants use water as a component because of its natural ability to transfer heat successfully.



There are three different base types that are commercially used in engine coolants: EG, PG, and Glycerin. EG, or ethylene glycol, based coolants are by far the most common and account for around 90% of coolants sold in North America. EG based coolants are the most common because of their ability to be used in almost all climates. The drawback of EG is that it is toxic if ingested. PG, or propylene glycol, coolants are typically used by customers who are looking for non-toxic coolant. PG is not as widely used as EG because it is more expensive and cannot be used in arctic climates. The last type, Glycerin, is similar to PG in that it is non-toxic and is only suitable for moderate climates. Glycerin based coolants make up the smallest portion of the US market.



You may wonder why the base is so important, especially if water is so efficient at transferring heat. The reason the base is so important is that mixing water with a base lowers the freeze point and raises the boiling point of the coolant, allowing the coolant to transfer heat in more extreme temperature conditions than water alone can handle. The boiling point of the coolant is especially important in applications using EGR or exhaust gas recirculation. The EGR Cooler produces high levels of heat that may cause the coolant to boil if not enough base is present. When coolant boils, it forms a layer of steam next to the hot surface and prevents heat from being transferred from the component, resulting in fatigue and failure. Most OEMs require that the base be present in a concentration between 40-60%; this can be checked in the field using a refractometer.

Conventional, Hybrid and OAT Coolants

Coolants can also be classified based on additive content. Additives are the chemicals added to the product to protect from corrosion, cavitation, and scale. There are three generic terms that you will hear to describe additive chemistry: conventional, hybrid and OAT (Organic Additive Technology). Each of these coolant types will have a base, meaning that there are conventional EG, Hybrid EG, and OAT EG products in this category. Conventional coolants use the oldest additive technology and typically have the lowest initial cost, but also have short service intervals and the shortest overall life. Conventional coolants will have the highest total cost of ownership and can cost up to ten times more than premium ELC coolants over the life of a vehicle. Hybrid coolants mix older additive technology with organic additive technology to provide extended service intervals and moderate initial investment. Hybrid coolants typically have a longer life and service interval than conventional coolants, but may have more maintenance requirements than OAT type coolants. OAT coolants use the newest type of additive chemistry and will typically have the fewest maintenance requirements.

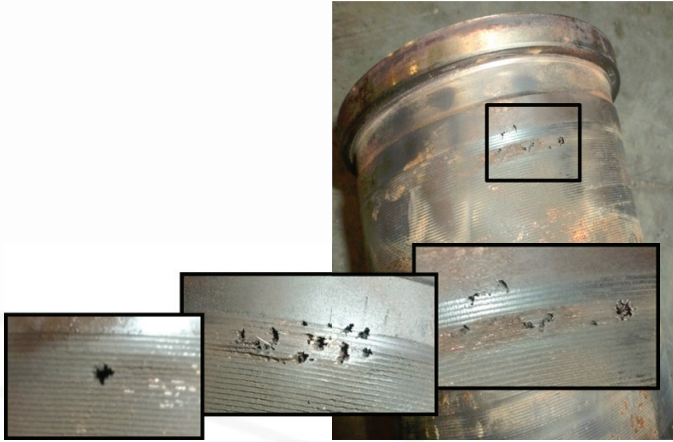
OAT coolants are also more tolerant of system contamination than other coolant types and is the preferred coolant type of OEMs.

	Conventional	Hybrid or HOAT	Organic Additive Technology
Technology	Good	Better	Best
Coolant Life (Miles)	300,000-400,000	600,000-1,000,000	600,000-1,000,000
Maintenance Time	High	Medium	Low
Maintenance Highlights	Proper top-off plus addition of SCAs or extenders	Proper top-off plus addition of SCAs or extenders	Proper top-off (extenders may be required depending on the product)

When choosing and maintaining your coolant, be sure to look at the service interval and maintenance interval of the product. Conventional coolants usually have less than half the life of hybrid and OAT coolants and require more frequent maintenance. Also note that service intervals vary within each group. Commercial Heavy Duty OAT coolants have coolant lives that range from 600,000 to 1,000,000 miles depending on the manufacturer. Fleetguard ES Compleat™ OAT is one of the few products in the industry that can claim a 1,000,000 mile life. Using a 1,000,000 mile coolant can save owners up to 35% in total costs over coolants with a 600,000 mile life.

Diagnosing Common Cooling System Issues – Liner Pitting

Selecting the appropriate coolant and properly maintaining the system is important to preventing costly failures. Let's walk through some of the most common failures that occur in the field and discuss the best way to protect your equipment from these failures. The first potential failure is liner pitting, which is specific to the heavy duty diesel industry. If not properly formulated or maintained, coolants may not be capable of protecting the liner surface against cavitation. A lack of protection can result in small pits forming on the surface of the liner, typically occurring in the thrust/anti thrust directions. In some cases, this results in pits that perforate all the way through the liner and allow coolant and oil to mix. This failure requires a full engine rebuild in order to correct the issue. As mentioned earlier, you should ensure that the coolant used for any heavy duty applications



meets ASTM D6210. This specification requires validating the ability of the coolant to effectively protect liners from pitting through engine testing. Most coolants will list the standards that the product meets on the coolant packaging or in a product brochure, so be sure to look for indication that the products meets ASTM D6210 before using on a heavy duty application. It is also important to know what the maintenance requirements are for your product. Typically conventional and hybrid coolants need to be tested in the field and serviced to maintain liner protection throughout the life of the coolant. Some OAT coolants will also require periodic maintenance. Also, make sure that units are topped up with proper coolant. Note that diluting with water or improper coolant can cause liner pitting protection to be compromised.

Diagnosing Common Cooling System Issues—Additive Dropout

If additives become unstable they can cause issues in the cooling system and leave your system unprotected against corrosion. There are a number of reasons this may occur including: contamination, over addition of SCA's (supplemental coolant additives), and poor formulation. Some additives will collect in the cool areas of the engine when instability occurs and impede heat transfer. On the right is a cross section of a radiator with plugged tubes due to over treatment with SCA's.

To protect from additive dropout, it is important to make sure the water used for mixing coolant is of good quality; some tap water will meet the



requirements, but most will not. Hard water can react with additives causing them to become insoluble. When adding SCA's or extenders, only add the recommended amount. It may be tempting to add extra to the system, however in the case of coolant additives, more is not always better. If the additive concentration gets too high, the coolant will not be able to hold all of the additives in solution. OAT coolants are typically more resistant to system contamination and do not require the addition of SCA's or extenders as frequently as conventional and hybrid products. Some OAT products, like Fleetguard ES Compleat OAT, do not require the addition of any SCAs or extenders when properly maintained.

Diagnosing Common Cooling System Issues—Water Pump Failures

Another common failure mode that can be related to additive instability are deposits on water pump face seals. Deposit can come from additive dropout or from particulate. Some particulate may be present in the engine from the manufacturing process; this can include core sand, rust, and other contaminants.

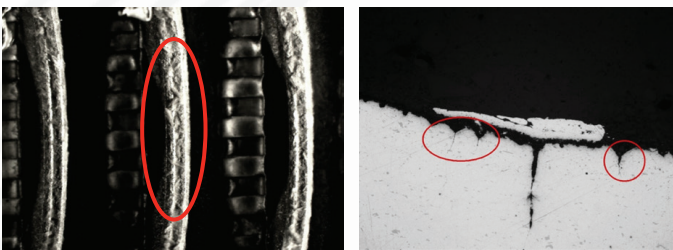
To protect your water pump seals, make sure to choose the proper coolant and avoid over addition of SCA's and the addition of hard water. In some cases, you may not be able to avoid contamination in the system. There will be some contamination from the manufacturing process that will be present in a new engine.

However, using a water filter will help capture particulate before it deposits on to face seals and causes leakage.

Diagnosing Common Cooling System Issues—Corrosion

As engines and cooling systems evolve, more and more aluminum is used in the cooling system for heavy duty engines and the use of aluminum radiators and oil coolers has become common in the heavy duty industry. In addition to this, the preferred method of manufacturing aluminum radiators uses a process that can introduce contamination into the system and cause corrosion.

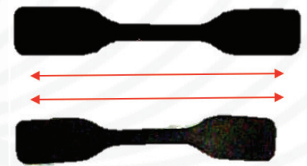
A residual brazing compound coats the surfaces of the radiator as seen in the image below left. This residual compound will dissolve into the coolant, introducing contaminants. When exposed to large surface areas of aluminum and simultaneously exposed to contamination, it can be difficult for some coolants to properly protect the system. Some of the additives in conventional and hybrid technologies become less stable under these conditions and are unable to properly protect all the aluminum surfaces. When corrosion begins to occur, the aluminum is weakened and is prone to suffer from stress fractures as seen in the image below right.



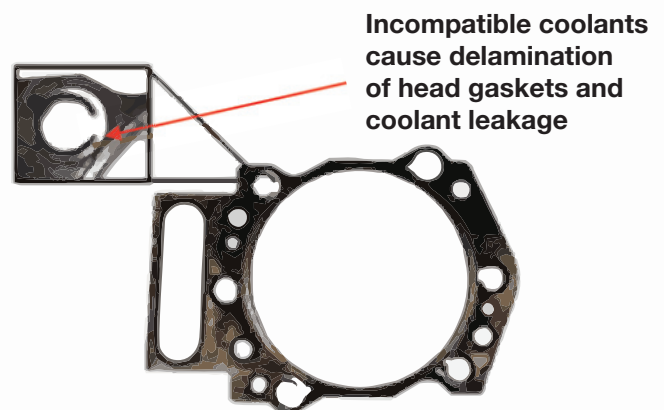
Because new radiators contain contamination from the manufacturing process, it can be difficult for users to control the amount of contamination. OAT coolants are typically more robust for protecting against this type of contamination in the cooling system. NOAT or (nitrited OAT) Hybrid, and conventional products tend to be less robust toward flux contamination and are more likely to be compromised in this environment. In severe cases, new systems may need to be flushed after a few hours of use to reduce the amount of contamination.

Some additives used in commercially available coolant products have a negative effect on gasket and hose materials that are used in cooling systems. These additives will cause silicone gaskets and hoses to degrade and become brittle, also shrinking the size of the material. This change in material affects the ability of the material to seal properly and will result in leakage.

Depending on the location of the leakage, this issue can have varying levels of severity. One of the more severe failures is seen in head gasket seals.



Shown below is a picture of a head gasket that has been affected by incompatible coolant additives. The silicone seal material around the head gasket ports has delaminated due to shrinkage and material deterioration. This causes the seal to become ineffective and results in



leakage of exhaust gas into the coolant and leakage of coolant into the combustion chamber. Exhaust gas will quickly deteriorate the coolant and promote corrosion of other components.

Keys to remember:

- Pay attention to coolant classification when picking the right coolant for your needs... don't simply choose a product based on color as it's not a fool-proof way of picking the right product.
- When selecting a coolant, remember that a less expensive coolant may require more maintenance and cost more in the long run. Even the difference between a 1,000,000 mile OAT and a 600,000 mile OAT product can represent up to 35% in total cost savings.
- Make sure the coolant is approved by the equipment and engine OEM to ensure the coolant is compatible. Many products on the market are not compatible with all seal and hoses used in cooling systems.
- When looking for a Heavy Duty coolant, it is important to look for an indication that the coolant meets the 6210 standard. This ensures the coolant meets minimum requirements for protecting engine liners from pitting.
- If your application is prone to contamination, an OAT coolant may be the best selection for your equipment.

For Additional Information, Contact:

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What You Don't Know Can Hurt Your Engines: An Introduction to Coolant Technology and Best Practices (03/2015)
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