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An Introduction to Heavy Duty Engine Coolants

The first coolants were made of common household items, but as today’s heavy duty engines have evolved – so too have their coolants.

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Introduction

In the emerging days of the heavy duty industry, as liquid-cooled engines were being developed and heaters were added to allow winter driving, finding the right antifreeze/coolant (AF/C) could be as easy as taking a trip to your pantry. In that era, generally from 1910 to around 1925, a variety of different compounds were tried as coolants, some of which were common kitchen ingredients such as sugar, honey and molasses. Over the years, AF/Cs, in any form, became a crucial component in the operation of an industrial vehicle because, when working properly, they provide four key functions:

- They provide efficient heat transfer to control critical metal temperatures
- They increase the cooling index to help prevent boilover and overheating failures
- They provide freezing protection to prevent freezeups or non-starts in the lowest temperatures
- They provide effective inhibition of corrosion for all cooling-system metals through a wide range of temperatures and operating conditions

If the AF/C is unable to satisfy these requirements, the heavy duty vehicle’s emissions, fuel economy, horsepower and durability of engine components could be compromised.

After some trial and error, it was determined that ethyl alcohol (yes, the colorless liquid that gives beer, wine and spirits their “kick”) possessed the proper “antifreeze” properties to be used as an engine coolant during winter’s coldest temperatures. There were, however, some significant drawbacks to using ethyl alcohol as a “coolant” during the hotter temperatures of the summer. First, it is highly flammable, which could cause overheating and a number of safety risks for the driver and his or her passengers. Also, ethyl alcohol was prone to boilover, which could cause overheating and corrosion in the cooling system, as well as dispersing an unpleasant odor. The biggest drawback was that although it worked well in the winter it had to be drained in the summertime and replaced with water. This repeated seasonal switch between ethyl alcohol and water could lead to a situation where the driver could never be totally sure just how much freeze protection the vehicle was receiving.



The modern age of permanent year-round/all-season antifreeze/coolant dawned in 1927, when Prestone® developed and introduced to the market a new cooling-system liquid consisting of ethylene glycol, which is an organic compound that is an odorless, colorless, viscous liquid. Known as “Eveready,” Prestone’s new inhibited antifreeze/coolant when diluted with water would not boil away or burn in the summer, freeze in the winter, was comparatively odorless, and did not need to be replaced each season. This gave it a number of distinct advantages over the ethyl alcohol/water-based coolants that were being used at the time.

Today, inhibited ethylene glycol – along with propylene glycol, a similar, less toxic, odorless, colorless, viscous organic compound – remains the major component of antifreeze/coolant. Recent years have seen a number of new inhibitor technologies for these formulations enter the market as heavy duty engine manufacturers have refined the capabilities of their products. This white paper will provide an introduction to the world of heavy duty vehicle AF/C and let the reader know what to keep in mind when required to choose the correct one for his or her heavy duty vehicle’s unique engine, application and/or cooling-system characteristics.

The Challenge

Most people don’t realize that pure AF/C actually freezes at a higher temperature and transfers less heat from an engine than a 50% AF/C and water solution. That’s why it’s recommended that AF/C be mixed at a proper 50% proportion of both water and AF/C. If the concentration is less than 30% AF/C, the following problems may occur: temperature extremes; overheating with boilover; freezeup that can cause cracks in the head or block; cooling-system component corrosion; and increased incidence of pitting in the cylinder liner. On the other hand, cooling systems with a concentration of AF/C that exceeds 70% may experience temperature extremes; slushing of the AF/C; poor heat transfer that can result in overheating; additive precipitation; water-pump leaks; cooling-system corrosion; and cooling-system component fatigue.

Since both water and AF/C are colorless, manufacturers add a colored dye to the solution so the user can differentiate between it and other under-hood fluids and more readily know if a heavy duty engine is experiencing a coolant leak. Traditionally, most commonly used AF/C has been dyed green.

The growth in the number of available AF/C formulations has forced manufacturers to use different color dyes for different types of AF/Cs. The American Trucking Associations’ Technology & Maintenance Council (TMC), in its “Recommended Practice RP 351,” proposes guidelines for standardization of color based on AF/C type:

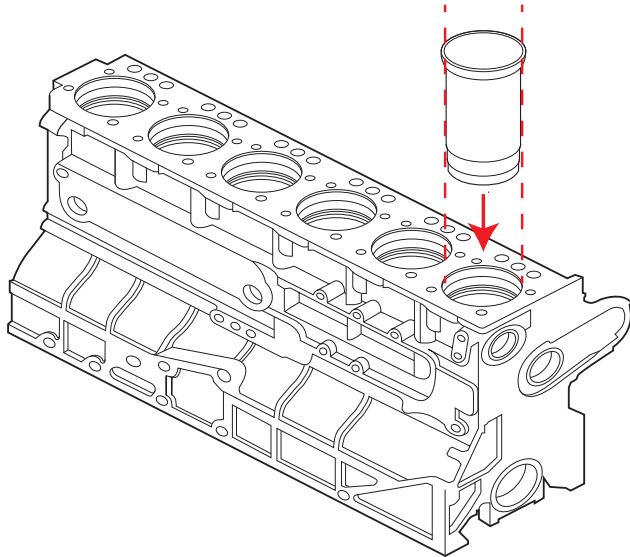
Antifreeze/Coolant Type	TMC Spec	Suggested Color Code
TMC A – Conventional Low-Silicate	RP 302A	Green (PMS #374-376)
TMC B – Fully Formulated Ethylene Glycol	RP 329	Purple/Pink (PMS #235-241)
TMC C – Fully Formulated Propylene Glycol	RP330	Blue (PMS #297-301)
TMC D – Organic Acid Technology (OAT)	Per OEM Specs*	Red (PMS #190-193)

*OAT AF/Cs are defined by meeting one or more of the following manufacturers’ specifications:

- International—Class 8, B-1, Type III
- Detroit Diesel 7SE298 9804
- Caterpillar EC-1
- Mack 014 GS 17009

*These OEM specifications are performance-based requirements for original fill AF/C.

TMC Recommended Practices (RP) are guidelines and not hard-and-true regulations, which means manufacturers may still choose their own dyes as they see fit and as a result, AF/C color should not be used as a positive indicator. The original, green-dyed AF/Cs are called conventional low-silicate, but the technical name for this type of AF/C and its inhibitor package is **Inorganic Acid Technology (IAT)**. In the beginning, there was no specific AF/C for heavy duty vehicles. As a user, you started with a low silicate-based product design for cars and light-duty trucks. This product required dilution with water, then you needed to “pre-charge” it with specific amounts of supplemental coolant additives (SCAs) to make it ready to protect heavy duty engine cylinder liners from destructive pitting corrosion. Theoretically, after the pre-charge, one had to follow a regular maintenance protocol, where fleet owners are supposed to test to determine the concentration of SCA and then adjust the required dose of SCA (i.e. DCA-2 or DCA-4) to the recommended level. Another option to maintaining the correct SCA level is the use of a spin-on filter containing a proper type/dose of SCA chemicals. In many cases, the cooling systems were regularly over-dosed with SCAs, leading to instability of the AF/C formulation and resulting in additive dropout, corrosion and formation of the infamous “green goo.”



Antifreeze/coolant is designed to protect many engine components, in addition to providing essential cooling and freezing protection. Prestone Command® Heavy Duty Extended Life Coolant provides outstanding protection from cavitation corrosion on the wet sleeve and other metal surfaces within the engine.

Today, most of the “conventional low-silicate” AF/Cs in the market are fully formulated with a pre-charge of SCA to protect the cooling systems of heavy duty engines against corrosion, cavitation, liner pitting, freezing and boilover. These coolants are based on Extended Service Interval Technology and do not require the addition of SCA until the first maintenance interval, at 25,000 miles, or as specified by the engine manufacturer.

A second formulation of AF/C is known as **Hybrid Organic Acid Technology (HOAT)**, which is a combination of some of the inhibitors used in inorganic IAT and organic OAT coolants. This technology is typically based on a low-silicate, nitrite technology and, like the IAT coolants, it is recommended to have SCA added at the first maintenance interval, at 25,000 miles, or as specified by the engine manufacturer (see RP-365). HOAT coolants are most commonly found dyed yellow or orange. They are not compatible with either NOAT or OAT coolants and should not be mixed with them.

A third AF/C technology used in heavy duty applications is often referred to as Extended Life Coolant, because the antifreeze/coolants do not require a supplement, referred to as an extender, until 300,000 miles or 6,000 engine hours to achieve the full 600,000 miles or 12,000 engine hours service life. These AF/Cs use organic acids (organic additive technology), nitrite and/or molybdenum as part of their inhibitor package and are referred to as **Nitrited Organic Acid Technology (NOAT)** antifreeze/coolants.

Another form of AF/C is the straight **Organic Acid Technology (OAT)**. This is an OAT coolant without nitrite added. These AF/Cs typically provide 600,000 miles or 12,000 engines hours service life, but their performance life can be

drastically reduced if contaminated with nitrite-containing coolants.

While the TMC recommends specific colors for specific AF/Cs, manufacturers are not required to follow those recommendations. Therefore, it is imperative that the AF/C purchaser recognizes the formulation and/or the manufacturer they choose. One cannot rely solely on the packaging to help you determine what is in the bottle as some manufacturers may place a red cap on a container of purple-dyed AF/C, or a purple cap on a container of green-dyed AF/C, which might give the impression that it is a red extended-life or purple fully formulated coolant. As is the case with most purchases, “Let the buyer beware.”

In addition to protecting the engine from overheating, another key requirement of AF/C is to prevent the cooling system from degrading. To that end, because glycol and water are naturally corrosive, manufacturers add different inorganic and/or organic salts and other chemicals to the coolant in order to prevent the cooling-system components from corroding. These additives are known as corrosion inhibitors, with some of the more common ones being:

- **Silicate/Silicone** – provides protection for the aluminum components in a vehicle’s cooling system
- **Triazoles/Thiazoles** – protect copper and brass components
- **Sodium Molybdate** – protects ferrous metals, cast iron and steel from corrosion
- **Nitrate** – protects against pitting and crevice attack in aluminum components
- **Nitrite** – prevents cylinder-liner pitting in cast-iron components in heavy duty engines
- **Organic acids** – used as a replacement for other inhibitors, such as silicate/silicone, nitrites, nitrate, phosphates, amines and borates
- **Anti-foam** – added to AF/C to minimize foaming when the coolant is mixed with water

Because additives in conventional (IAT) and hybrid organic acid (HOAT) coolants are consumed during the vehicle’s operation, they must be refortified with supplemental coolant additives (SCA) in order to maintain effective corrosion protection. On the other hand, OAT and NOAT coolants do not require SCAs. Also note that the inhibitor package does not determine the level of freeze or boilover protection in the AF/C; the inhibitor is responsible for corrosion protection only.

The Solution

As an inventor of modern-day antifreeze/coolant, Prestone remains committed to providing the best cooling-system fluids to the heavy duty vehicle market. Prestone is the only national brand that manufactures all of its products in the United States in its own, proprietary facilities. The company’s U.S.-based state-of-the-art Technology Center works closely with major engine manufacturers to create antifreeze/coolant formulations that are best-in-class both today and into the future.



Prestone's latest standard-setting product in the AF/C market is its new Prestone Command® line for heavy duty on- and off-road vehicles used in construction, mining, oil, gas and agricultural applications. Designed to provide reliable engine and cooling-system protection in the most trying of conditions, from the stifling heat of Death Valley to the numbing cold of Alaska's Alcan Highway, Prestone Command® is available in three formulations:

- **Heavy Duty Extended Service Interval SCA Pre-Charged (ESI)** — this purple-dyed AF/C is a blend of ethylene glycol and a specially formulated inhibitor package that has been designed for heavy duty cooling-system applications. It is compatible with any conventional heavy duty AF/C and all filter technologies, and will eliminate the initial pre-charge of SCAs on new vehicles and recharged systems. Also available in a 50/50 formulation for convenient top-offs.
- **Heavy Duty Extended Life (ELC)** — this red-dyed patented AF/C is a blend of ethylene glycol and a specially formulated OAT inhibitor package that is silicate-, phosphate- and borate-free and designed for heavy duty cooling systems. It is formulated for a service life of 600,000 miles or 12,000 hours, when an extender is added at 300,000 miles or 6,000 hours. It is compatible with other ELC products as well as conventional AF/Cs, though its extended life benefits will be reduced in those circumstances. Also available in a 50/50 formulation for convenient top-offs.
- **Heavy Duty Nitrite Free Extended Life (ELC)** — this yellow-dyed AF/C is an Organic Acid Technology (OAT) intended for use and compatibility with any OAT Extended Life heavy duty AF/C in any diesel powered commercial vehicle engine or stationary engine with aluminum or other engine metals. Premium long-lasting inhibitors provide up to 600,000 miles/12,000 hours of protection against temperature extremes, rust, corrosion, scale and premature water pump failure. The phosphate- and borate-free formulation provides long lasting inhibition and corrosion protection, protecting aluminum and all other engine metals. Also available in a 50/50 formulation for convenient top-offs.

The complete Prestone Command® line of AF/C formulations meet or exceed the performance requirements of many industry specifications, including, but not limited to, ASTM D-6210, ASTM D-3306 and TMC RP 329, along with those of numerous OEMs, such as but not limited to Cummins, Navistar, Detroit Diesel and Mack.

Conclusion

Antifreeze/coolant is the lifeblood of a heavy duty vehicle's cooling system. It is also a jack-of-all-trades that performs many specific duties during vehicle operation. Therefore, it is imperative that the driver and/or fleet owner be aware of the type of AF/C that is in the engine and how it must be

maintained, which is becoming more and more important as additional AF/C formulations and engine types are being developed. By maintaining a U.S.-based Technology Center and working with engine OEMs, Prestone stands at the forefront of AF/C development, as it has for more than 85 years, which is epitomized by its development of Prestone Command® antifreeze/coolant for heavy duty vehicles.

About the Author:

Colin Dilley, Ph.D, is the Vice President of Technology for Prestone Products Corporation. Colin can be reached at: Colin.Dilley@Prestone.com. Headquartered in Lake Forest, IL, Prestone Products Corporation manufactures and markets Prestone®, a leading brand of AF/C and related products. Prestone Command® Heavy Duty products, lead by patented AF/C technologies, deliver value by keeping Heavy Duty truck engines in optimal condition in the most demanding heavy-duty-on-road and off-road applications. Anywhere. Anytime. Any Engine™. You can find more at www.prestonecommand.com.

Properly Maintaining Your Cooling System

The American Trucking Associations' Technology & Maintenance Council (TMC) – whose stated goal is to improve transport equipment, its maintenance and maintenance management – is a valuable resource for operators of heavy duty trucks and vehicles. For 30 years, the TMC has produced its *Recommended Practices Manual*, which contains more than 250 Recommended Practices (RP), including RP 313C, which is dedicated to Cooling System Maintenance.

Short of reading RP 313C, there are three basic things to remember when thinking about cooling-system maintenance in heavy duty vehicles:

- Use an AF/C that satisfies industry standards and performance requirements
- Maintain proper additive levels and regularly top off AF/C at regular service intervals
- Test the AF/C regularly for proper additive levels and freeze protection

More specifically, certain chemical, physical and performance properties of an engine coolant must be checked periodically to ensure that it meets the specific requirements of the cooling system. A variety of laboratory and field tests have been developed to help ensure that the AF/C is preventing both the corrosion of metal components and does no harm to other cooling-system materials.

Most modern-day coolants have been formulated to meet the performance requirements for the life of the engine. But in heavy or severe-duty conditions, taking the proper care to maintain the cooling system and its fluids will help keep the heavy duty vehicle running at its efficient and reliable best throughout its serviceable life. This includes choosing an AF/C that is fully formulated to be used in heavy duty vehicles that are powered by diesel engines.

For additional information on properly maintaining your heavy duty vehicle's cooling system, two other organizations, ASTM International and SAE International, have made a commitment to developing proper heavy duty vehicle maintenance regulations.

