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Survey of Coolant Use in Military Ground Systems to Select Candidates for Evaluation

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1. Introduction

Currently, U.S. Army engine coolant is governed by Commercial Item Description (CID) A-A-52624A, Antifreeze, Multi-Engine Type, which mandates the use of conventional, supplemental coolant additive (SCA) based technology. SCA based coolant lacks key advantages of the newer more widely used Organic Acid Technology (OAT) based coolant, also known as Extended-Life Coolant (ELC). ELC has been commercially available and used in passenger cars since 1995, with General Motors being the first original equipment manufacturer (OEM) to adopt OAT technology in their factory fills, but the Military has not yet adopted the use of OAT technology [1][2]. One disadvantage of SCA coolant is that it has a short life span of two years, and that is only if additives are reinhibited every six months. In 2015, the Ground Vehicle Systems Center (GVSC) learned from the U.S. Army Combined Arms Support Command (CASCOM) that the reinhibition process was not occurring at field level maintenance, and instead a full flush and refill was conducted annually. This unnecessarily increases the maintenance burden and quantity of coolant being used by the Army.

In contrast to conventional SCA technology, ELC generally has an increased lifespan of 150,000 miles or 5+ years of service because the additives do not deplete as quickly over time [1]-[5]. Additionally, conventional coolant technology is often said to offer less protection to aluminum engine components from cavitation corrosion and provide lower heat transfer compared to some ELCs [1][6][7]. These advances in coolant technology over the last 25 years have brought to light the need for the Army to transition from conventional to extended-life coolant.

2. Project Background

This survey report is in support of a development effort starting in FY21 funded by the U. S. Army Combat Capabilities Development Command Ground Vehicle Systems Center (CCDC GVSC) titled “Enhanced Performance Coolants” (EPC). The objective of this development effort is to evaluate commercially available ELCs and define military-specific coolant requirements to ultimately transition Army ground vehicles from SCA-based coolant to ELC. Thus, GVSC wanted to identify current OEM recommended coolants in each Army ground platform to help ease the transition. By knowing what is already recommended, GVSC will have some foresight when discussing the eventual transition with platform managers. Unfortunately, not all platforms use the same OEM. Which means not all platforms use the same type of coolant technology either and there will be cases where the original recommended ELC may not be part of the draft specification and future Qualified Products List.

The results of this survey were used to identify commercially available coolant candidates to be used in this development effort. A market survey was also conducted in tandem with this survey, the results of which were also used to aid the selection of coolant candidates. The market survey was for data collection only and the report has DTIC #AD1112055. Test candidates selected from these surveys will be tested for baseline performance characteristics on benchtop tests within

ASTM D6210, heat transfer capability, compatibility between different ELC technologies, simulated service, and field testing.

3. Approach

This survey effort consisted of internet searches, expanding on previous work done by the Fuels and Lubricants Branch, and direct communication with various platform points of contact between November 2019 and May 2020. First, a list of all vehicle and equipment platforms for all Army ground vehicles and equipment was developed. Then, each engine manufacturer and model was determined for each platform. Depending on the engine type, GVSC determined if liquid coolant was required or not, which narrowed the survey.

Once the engine information was known, the manufacturer recommended extended life coolant (ELC) could be determined, either using internet searches, engine manuals, or direct communication with OEMs. Lastly, the type of coolant technology (OAT, HOAT, NOAT, etc) described in the following sections was determined for each recommended ELC.

All data was captured in an excel file to easily organize and sort. Pertinent data from the excel file is summarized in Table 1 in the Discussion & Conclusion section, showing the OEMs and their recommended ELCs.

4. Discussion & Conclusion

Coolant Technologies

The three main coolant technologies recommended across the platforms using liquid coolant are Organic Acid Technology (OAT), Hybrid Organic Acid Technology (HOAT), and Nitrited Organic Acid Technology (NOAT).

OAT coolants use either aromatic or aliphatic carboxylic acid additives for corrosion protection. HOAT coolant is a combination of Inorganic Acid Technology (IAT), which is the same technology used in SCA-based conventional coolants, and OAT. NOAT coolant is a subset of the HOATs since it is an OAT with nitrite added for supposedly more corrosion protection. No clear evidence is available to demonstrate nitrited coolants perform better than nitrite-free coolants or that any issues have been identified with the use of nitrated coolants.

Survey Results

For this survey, 112 different ground vehicles and pieces of equipment were reviewed. Out of the 112 platforms, 40 either do not use liquid coolant, are too early in production to know what coolant will be used, or use propylene glycol (PG) based coolant. For this effort, we are only interested in ethylene glycol (EG) based coolant. From July 2018 to June 2020, the U.S.

Department of Defense (DoD) procured 23 times more EG coolant than PG coolant (source: FEDMALL, DLA orders). Additionally, the current CID PG coolant is more expensive than its EG counterpart. Since the demand is not there for PG coolant, the effort involved to further investigate and implement PG based ELC in this development effort is not worthwhile; the money saved by switching to PG based ELC is not significant enough to pursue. This information narrowed the survey from 112 to 72 platforms.

Within the 72 platforms using liquid coolant, GVSC found 11 unique engine manufacturers. They are: Cummins, Detroit Diesel, Caterpillar, Banks Power, GEP, Perkins, Case, John Deere, Kubota, Navistar and Mack. Each manufacturer typically recommends their own ELC (e.g. a vehicle with a CAT engine will be recommended to use CAT ELC). The 11 OEMs span all three main OAT technologies: OAT, HOAT, and NOAT. Some OEMs, like Detroit Diesel, also provide a list of other approved coolants that meet their specification and are acceptable for use. In general, OEMs accept the use of other coolants provided that they meet their own performance specifications, as well as ASTM 6210, *Standard Specification for Glycol Based Engine Coolant for Heavy-Duty Engines* [8]. Table 1 below summarizes the results from this survey.

Table 1. OEM Recommended Extended-Life Coolant (ELC) and Technologies		
OEM	ELC Product	Technologies
Cummins	ES Compleat	HOAT
Detroit Diesel	Refer to their approved coolants list; ES Compleat OAT and Final Charge Global OAT are on the list	OAT
Caterpillar	CAT ELC	NOAT
Banks Power	DEX-COOL ELC	OAT
AM General/GEP	Does not recommend any particular brand of coolant	
Perkins	Perkins ELC	HOAT
Case	Actifull OT ELC or ES Compleat	OAT or HOAT
John Deere	John Deere Cool-Gard II	HOAT
Kubota	Any long-life EG coolant	All
Navistar	Unknown	Unknown
Mack	Mack Premium Long-Life Coolant	OAT

It is important to capture all three technologies in the candidate coolant selection used in the EPC research effort. Especially since compatibility testing between the different technologies will be part of GVSC's development effort.

Down Selection & Conclusion

Using data from the Market Survey in tandem with the Field Survey results, GVSC selected five EG based extended-life coolant candidates for use in the EPC development effort:

- Cummins ES Compleat (HOAT)
- John Deere Cool-Gard II (HOAT)
- Cummins ES Compleat (OAT)
- Final Charge Global OAT Extended Life Coolant (OAT)
- Cat ELC (NOAT)

These candidates were chosen because they cover all three different coolant technologies that are used commercially and recommended by Army OEMs. Additionally, this candidate matrix includes the most commonly seen OEMs in Army ground vehicles using liquid coolant, making them applicable choices for candidates. Out of the 11 OEMs seen across all platforms, not all were widely used, such as Perkins and Mack. If an OEM was only seen in a couple of platforms, they were not selected. Lastly, candidates were chosen based on availability. Some coolant was not easily attainable and therefore not selected. In the case of Cummins ES Compleat OAT and Final Charge Global OAT, while not directly seen in any platforms, both were on Detroit Diesel's approved coolants list, and that is why those candidates were chosen. All selected coolant candidates have been secured by GVSC and internal benchtop testing began in FY21 Q1.

5. References

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