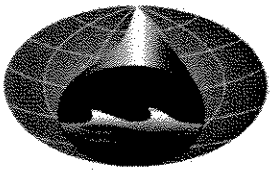
RDECOM
Technology to the Warfighter Quicker



PETROLEUM & WATER
BUSINESS AREA

Antifreeze Recycling User's Guide

March 2005

U.S. Army Tank-automotive and Armaments Command
Research, Development, and Engineering Center

Warren, MI 48397-5000

CONTENTS

I. Purpose

II. Background

III. Recommendations for Recycling Used CID A-A-52624 Antifreeze

IV. Point of Contact

V. References

Attachments

A. Summery Chart of Evaluated Recycling Units/Services

B. Details/Diagram of KFM Coolant Purification System (CPS)

C. Details/Diagram of Finish Thompson Inc. System

D. Testing Protocol and Evaluation Methodology

Users Guide for Recycling Military Antifreeze

I. **Purpose.**

This User's Guide provides recommendations to military and civilian personnel on appropriate procedures to be followed for recycling used military antifreeze which initially was procured under Commercial Item Description (CID) A-A-52624 entitled Antifreeze, Multi-Engine Type. In 1997, CID A-A-52624 was adopted to replace Military Specifications MIL-A-46153 entitled Single Package, Heavy Duty, Inhibited Ethylene Glycol Antifreeze and MIL-A-11755 entitled Artic-Type Antifreeze. The guidance within this User's Guide is to be used in conjunction with the detailed instructions provided by the manufacturer of the commercial recycling unit identified under paragraph III B of this guide.

II. **Background.**

The three main reasons for recycling used antifreeze are to conserve natural resources, to reduce the cost of purchasing new antifreeze, and to reduce both the cost of and the problems associated with used antifreeze disposal. The latter reason is becoming a stronger impetus for recycling due to the increasing trend of federal, state, and local governing agencies enacting more restrictive legislation on environmental protection matters. In some states, these more limiting regulations include identifying ethylene glycol (EG) and propylene glycol (PG), the base materials of antifreeze, as hazardous materials. Such designations substantially raise the handling and storage expenses of both new and used antifreeze.

Due to its less restrictive chemistry, antifreeze is easier to recycle when compared to automotive oils and fluids (i.e. transmission fluid, engine oil, etc.). New antifreeze is a precise balance of either water and EG or water and PG, which provides both low and high temperature protection. The antifreeze is treated with chemical inhibitors, which supply corrosion protection to the engine's cooling system and protection against foaming. The water/glycol balance is changed during normal use and must be carefully reestablished for recycled antifreeze to be as reliable and effective as new antifreeze. Therefore, a recycling method must effectively reclaim the EG or the PG by completely removing all contaminants, oxidation products, and depleted/residual inhibitors that are typically present in used antifreeze.

There are two options for recycling antifreeze: on-site recycling via a TARDEC certified recycling unit or employment of off-site recycling services. On-site recycling can be performed at warehouse level by installation personnel. A recycling unit (listed in this guide) can be purchased and utilized to reduce procurement and disposal costs of antifreeze. This guide will provide instructions to recycle antifreeze. Off-site recycling services can be employed via contract. This option includes either sending usable antifreeze off-site to a TARDEC certified recycler or having a service come to the installation with their TARDEC certified recycling unit. In each case an outside vendor will handle all aspects of antifreeze recycling, including mixing the recycled antifreeze with new, concentrated antifreeze.

The recommendations contained within paragraph III of this guide are intended for use by government organizations operating vehicles and equipment using CID A-A-52624 antifreeze. Where the information in this User's Guide is in conflict with other published data, the recommendations and guidance provided by this publication should prevail. For vehicles

and equipment under warranty, the manufacturer's instructions relative to use or non-use of recycled antifreeze take precedent during the warranty period.

In addition, NSNs have been established for recycled antifreeze that can be procured directly from Defense Logistic Agency. The use of these NSNs would allow users that do not have personnel or desire to recycle on-site to still promote the use of environmentally friendlier products. This recycled antifreeze must meet the same requirements as new/virgin antifreeze.

Table 1 gives a list of National Stock Numbers (NSNs) for recycled antifreeze.

Table 1: Recycled Antifreeze National Stock Numbers

CID Type	Glycol Type	Container Size	NSN
IA	EGAF 100%	1 Gal	6850-01-464-9125
IA	EGAF 100%	5Gal	6850-01-464-9137
IA	EGAF 100%	55 Gal	6850-01-464-9152
IB	EGAF 60%	1 Gal	6850-01-464-9266
IB	EGAF 60%	5 Gal	6850-01-464-9263
IB	EGAF 60%	55 Gal	6850-01-464-9096
IIA	PGAF 100%	1 Gal	6850-01-464-9131
IIA	PGAF 100%	5 Gal	6850-01-464-9107
IIA	PGAF 100%	55 Gal	6850-01-464-9124
IC	EGAF 50%	1 Gal	6850-01-471-6530
IC	EGAF 50%	5 Gal	6850-01-471-6534
IC	EGAF 50%	55 Gal	6850-01-471-6521

III. **Recommendations for Recycling Used CID A-A-52624 Military Antifreeze.**

A. Used Antifreeze Feedstock

Avoid contaminating used antifreeze intended for recycling with engine oil, brake fluid, transmission fluid, hydraulic fluid, gear oil, solvent, gasoline, diesel fuel, aviation turbine fuel, heating oil, kerosene, and preservative oil by collecting the used antifreeze in a dedicated, labeled 55-gallon drum. Petroleum based fuels, fluids/oils, brake fluids, etc., will clog the recycling system if admixed with used antifreeze.

B. Certified Recycling Units

The Fuels and Lubricants Technology Team (FLTT) has evaluated five (5) different recycling technologies, including ion exchange, vacuum filtration, chemical pretreatment and filtration, ultra-filtration, and reverse osmosis. Each technology was evaluated for feasibility and performance. A summary chart of the processes evaluated can be found in Appendix A. Of the five processes, only two were found to be acceptable for Department of Defense (DOD) use. The first of these is the KFM Coolant Purification System (CPS), formerly known as the BG Cool'r Clean'r. The second is the BE Series Engine Coolant Recyclers by Finish-Thompson Inc.

1. The **KFM Coolant Purification System (CPS)** has been evaluated and found to perform satisfactorily for reclaiming military antifreeze. A diagram of this system is provided on attachment B. Details on the KFM Coolant Purification System are as follows:

Manufacturer: KFM, LLC

Address: 506 Camson Rd. Anderson , SC 29625

Phone: 800-736-1404

Fax: 864-224-6601

POC: Mr. Glenn Van Romer

Model - CPS Coolant Purification System

Process – Ion Exchange

Process Rate – 150 gal / hr

Power Requirements – 110v AC

Inhibitor Required – KFM inhibitor (P/N570P) and pH Adjuster (KFM P/N570K)

Hazardous Waste – Used Filters

National Stock Numbers (NSNs):

CC1 CPS w/1 set of tanks	4250-01-380-9047
CC2 CPS w/2 sets of tanks	4250-01-380-9034
570P P- Corrosion inhibitor	6810-01-525-3850
570 K – KOH pH Adjuster	6810-01-525-3850

The KFM CPS unit is for recycling drum-stored, base-used antifreeze. It is recommended that antifreeze be recycled directly from drums as follows.

1. Do not disturb the used antifreeze for several days to allow solids to settle and any oil to float to the top. Use the included oil-only sorbent or other method (drum skimmer with 1" drop) to remove any surface oil. With the 40-mesh intake screen attached, lower the black inlet hose into the drum of used antifreeze about 4-6 inches from the bottom. Never intake from the bottom of the drum. The solids that have settled there may clog the machine.
2. Place the red outlet hose into the clean poly drum. Turn on machine and flow approximately 53 gallons of recycled fluid into the clean drum.

Under normal operating conditions, the outflow will be clear. When the resin beds start to weaken, the outflow will turn pale green and get progressively darker. When the conductivity level reaches the maximum allowable limit the red indicator light will come on, indicating that it is time to change the stainless steel resin tanks. It is recommended the filters are changed as well at this point.

3. Check the clarity of the recycled antifreeze from the outlet hose .The fluid should be clear as clean water. If it starts to become cloudy or murky in color or oily (brownish to yellowish or red) in appearance, immediately stop the unit. These non-green colors indicate the presence of contaminates, such as fuels, transmission or brake fluids, or other hydrocarbon-based automotive fluids. It is time to check the T-strainer (may be a "Y" strainer) and changes the filters and resin tanks if fouled.
4. After the used antifreeze has been recycled, check the freeze point of the clean antifreeze with a refractometer. Adjust the freeze point of the antifreeze/water mixture to -62° F (-52°C) or 60% glycol and 40% water. If necessary, new CID A-A-52624 antifreeze or water can be used to adjust the freeze point.

NOTE: Because the KFM additive package is pre-measured for a 50/50 mix of EG (ethylene glycol) and water, the approach needs to be modified slightly. After recycling, adjust the freeze point with EG to -34°F, complete steps 5-9, then use virgin concentrated, inhibited AF to lower the freeze point to -62° F.

5. Thoroughly mix or agitate the barrel contents before and after blending.
6. Pour the entire contents of the two ounce bottles of K pH (P/N 570K) in first. Thoroughly mix entire barrel. **(Avoid splashing. Can be harmful to eyes and skin)**
7. Now slowly add the entire bottle of P inhibitor (P/N570P), mixing thoroughly to prevent foaming. Adding too quickly may cause silicate dropout.
8. Mix thoroughly to disperse completely the additive package.
9. Check the Nitrite level and pH with an antifreeze freeze point and corrosion Test Kit A-A-51461 to insure the antifreeze has been prepared correctly. A properly processed antifreeze will be identified by a Nitrite pad color in the "OK or satisfactory" range of the test kit color chart. A recycled antifreeze having a color not in the OK or unsatisfactory range should be reprocessed until a satisfactory reading is obtained.
10. After the proper Nitrite level and pH has been verified, the recycled antifreeze is now ready for use.

2. The **BE Series Engine Coolant Recycler** manufactured by Finish-Thompson Inc. (FTI) has been evaluated and found to perform satisfactorily for reclaiming military antifreeze. A diagram of this system is provided in Attachment C. Details on the BE Series recycler are as follows:

Manufacturer - Finish-Thompson Inc., 921 Greengarden Road, Erie, Pennsylvania 16501-1591, POC: Sales - Mr. Troy Hurley, (814) 455-4478; Technical Support – Roger Leopold, (800) 888-3743.

Model – BE-55C

Process – Vacuum Distillation

Process Rate – BE-55C: 3.06 – 3.44 gal/hr

Power Requirements - BE-55C: 240V / 3 Phase / 60Hz /40A

Number of Operators Required - One (1)

Inhibitor Required – Finish Thompson Premium Inhibitor J104016 (5-gal) or J103447 (55-gal)

Hazardous Waste – Liquid waste (EG/PG, broken down corrosion inhibitors, dye, dirt, heavy metals, etc.)

National Stock Numbers (NSNs):

BE-55C	6850-01-387-2551
Reinhibitor (55 gal)	6850-01-397-1960
Premium inhibitor (5 gal)	J104016

Recommended procedures for recycling antifreeze when using the BE Unit:

a. Follow instruction manual for the BE unit.

b. After the used antifreeze has been recycled:

(1) Add FTI reinhibitor in the amount prescribed in the manufacturer's instruction manual to the recovered ethylene glycol (EG) or propylene glycol (PG). Mix thoroughly to disperse completely the additive package.

(2) Combine the inhibited antifreeze with FTI recovered water and/or other clean water available to adjust the freeze point to -34°F (-37°C) or approximately 50% antifreeze and 50% water. If necessary, new CID A-A-52624 can be used to adjust the freeze point. Check the freeze point protection of the antifreeze/water mixture with an Antifreeze Coolant and Battery Tester (NSN 6630-00-105-1418) or an Antifreeze freeze; Freeze point and corrosion Test Kit.

(3) Check the nitrite level with an Antifreeze Freeze Point and Corrosion Test Kit to insure that the antifreeze has been prepared correctly. Properly processed antifreeze will be

identified by a nitrite pad color in the "O.K." or "Satisfactory" range of the test kit color chart. Recycled antifreeze having a color not in the "O.K." or "Satisfactory" range should be reprocessed until a satisfactory nitrite reading is obtained.

(4) Add new, concentrated antifreeze to the recycled antifreeze to make up for losses during operation and recycling.

a. The recycled antifreeze is ready for use after the proper freeze point and nitrite levels have been verified.

b. To determine malfunctions for the Finish-Thompson Inc. BE Series unit, the recovered water and the recovered ethylene glycol (or propylene glycol) should be visually examined for cleanliness. If either solution contains any debris, the unit should be checked for possible problems. In addition, the used antifreeze should be examined for excessive engine oil, transmission fluid, etc. contamination.

C. Recommendations and Precautions

1. The recycled antifreeze can be employed in vehicles until the solution tests below the "O.K." or "Satisfactory" range of the Antifreeze Freeze Point and Corrosion Test Kit or until it contains excessive debris as determined visually. In either case, the antifreeze should then be recycled using a certified recycling unit (listed in this guide). The certified recycling unit is designed to recycle used antifreeze continually as long as sufficient glycol is present and engine oil, transmission fluid, solvent, etc. contamination is kept at a minimum level.

2. This guide advocates the use of those recycling systems which have been evaluated against an established testing protocol which determines the clean-up capability and the compatibility of individual systems with recycling used military antifreeze. The "Testing Protocol and Evaluation Methodology for Commercial Antifreeze Recycling Systems" is provided as Attachment C.

D. Disclaimer

The recommendations given in this guide relative to use of the recycling system listed are not meant as an endorsement of any recycling unit as such, but are given merely to identify the commercially-marketed recycling system that collectively was found to produce a satisfactory quality of recycled military antifreeze, CID A-A-52624. If it can be demonstrated by use of the established testing protocol (Attachment C) that new systems effectively reclaim and are compatible with military antifreeze, this guide will be revised to include those units.

IV. **Point-of-Contact**

Should questions arise relative to this User's Guide and its contents, the following individual should be contacted:

Ms. Hena Das

POLhelp@tacom.army.mil

Any comments, recommendations, etc. to improve the overall utility of this User's Guide should be sent to the following address:

US Army TARDEC
AMSRD-TAR-D / MS 110 (H. Das)
6501 E. 11 Mile Rd
Warren, MI 48397-5000

V. **References**

The following references were used to write this guide and should be consulted for additional information concerning the recycling of used antifreeze:

1. U.S. Army Tank-Automotive Command, Mobility Technology Center-Belvoir, Ft Belvoir VA, Letter Report #96-6. "Certification Testing Results On Central Texas Diesel Injection Service Reverse Osmosis Antifreeze Recycling System," Dwayne Davis, February 1996.

2. U.S. Army Tank-Automotive Command, Mobility Technology Center-Belvoir, Ft Belvoir VA, Technical Report #TR 13638, "Second Military Antifreeze Recycling Study," Dwayne Davis, May 1994.

3. General Motors Service Technology Group, taken from a presentation given by Wayne H. Bradley and Dale Jurette, November 1992.

4. Society of Automotive Engineers, SAE Paper #921636, "Heavy-Duty Coolant Regeneration by Dual-Resin Deionization," Rene D. Wiebe and John M. Dick, September 1992.

5. Society of Automotive Engineers, SAE Paper #921634. "An Evaluation of Engine Coolant Recycling Technology," Wayne H. Bradley, September 1992.

6. Society of Automotive Engineers, SAE Paper #921633, "Recycling Coolants From Heavy Engines," Richard D. Hercamp, September 1992.

7. U.S. Army Belvoir Research, Development, and Engineering Center, BRDEC Report #2520, "An Evaluation of Three Commercial Processes for Recycling Used Military Antifreeze MIL-A-46153," Dwayne Davis, June 1992.

8. U.S. Environmental Protection Agency, Office of Research and Development, "Automotive and Heavy-Duty Engine Coolant Recycling by Filtration," Arun R. Cavaskar, Robert F. Olfenbuttel, Jody A. Jones, and Paul H. Webb, Battelle, October 1991.

9. U.S. Environmental Protection. Agency, Office of Research and Development, "Automotive and Heavy-Duty Engine Coolant Recycling by Distillation," Arun R. Gavaskar, Robert F. Olfenbuttel, and Jody A. Jones, Battelle, October 1991.

10. U.S. Army Belvoir Research, Development, and Engineering Center, BRDEC Letter Report #90-4, "Evaluation of Octagon Antifreeze Clean-Up Using a Glyclean Antifreeze Recycler," Dwayne Davis, May 1989.

11. Society of Automotive Engineers, SAE Paper #881270, "Filtration of Coolants for Heavy Duty Engines," R. D. Hudgens and Richard D. Hercamp, September 1988.

12. Society of Automotive Engineers, SAS Paper #790415, "Research and Development Efforts in Military Antifreeze Formulations," James H. Conley and Robert G. Jamison, February 1979.

13. U.S. Army Mobility Equipment Research and Development Command, MERADCOM Report #2265, "Development of An Antifreeze Extender and Water Inhibitor for Automotive Cooling Systems," James H. Conley and Robert G. Jamison, December 1978.

14. U.S. Army Mobility Equipment. Research and Development Command, MERADCOM Report #2168, "Reclaiming Used Antifreeze," James H. Conley and Robert C. Jamison, March 1976.

15. Military Specification MIL-A-46153 Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package.

16. Military Specification MIL-A-11755 Antifreeze, Arctic- Type Antifreeze.

17. Military Specification MIL-A-53009 Additive, Antifreeze Extender Liquid Cooling Systems.

18. Commercial Item Description A-A-870 Antifreeze/Coolant, Engine: Ethylene Glycol, Inhibited Concentrated.

19. Commercial Item Description A-A-53426 Tester, Antifreeze and Battery Electroyte Solution.

20. Commercial Item Description A-A-51461 Test Kit, Antifreeze Freeze Point and Corrosion.

21. Commercial Item Description A-A-52624 Antifreeze, Multi-Engine Type.

Attachment A

Summary Chart of Evaluated Recycling Units/Services

Table A1: Comparison of Commercial Antifreeze Recycling Units/Services Evaluated for Department of Defense Certification

System/Service	Cool'r Clean'r	BE Series	Glyclean	Kleer-Flo	Service
Manufacturer	BG Products Inc.	Finish-Thompson Inc.	FPPF Chemical Co.	Kleer-Flo Co.	Central Texas Diesel Injection Service
Process Type	Ion Exchange	Vacuum Distillation	Chemical Pretreament and Filtration	Ultra-Filtration	Reverse Osmosis
Process Rate (gal/hr)	180	1 - 3.2	150	6	90 - 100
Feedstock Limitations	Oil Contamination	Oil Contamination	Oil Contamination	Oil Contamination	Oil Contamination
Replacement Filter(s) Required	Yes (1 & 5 Micron Filters)	None	Yes (1 & 5 Micron Filters)	Yes (0.0025 & 5 Micron Filters)	N/A
Filter Replacement Interval	Every 200-250 Gallons	N/A	Every 100-300 Gallons	Every 100 Gallons	N/A
Supplemental Additives Required	Yes (1 & 5 Micron Filters)	Yes	Yes (1 & 5 Micron Filters)	Yes	Yes
Ease of Operation	Moderate Difficulty	Moderate Difficulty	Moderate Difficulty	Low Difficulty	N/A
Personnel Required	1	1	1	1	N/A
Hazardous Waste Remaining	Spent Filters	Distillation Residue	Spent Filters	Spent Filters	None
Recommended Change Interval for Recycled Antifreeze	Check Regularly; Change when Necessary	Check Regularly; Change when Necessary	Check Regularly; Change when Necessary	Check Regularly; Change when Necessary	Check Regularly; Change when Necessary
Results of Evaluation:					
Quality of Reclamation	Satisfactory	Satisfactory	Marginal	Unsatisfactory	Unsatisfactory
Compatible with CID-A-A-52624	Yes	Yes	No	No	No
Recommended for DOD Use	Yes	Yes	No	No	No

Attachment B

Details/Diagram of KFM

Coolant Purification System

KFM LLC Coolant purification System (CPS)

Initial Set-Up and Operating Instructions

1. After removing all packing materials from the CPS carefully inspect for any shipping damage.
2. Attach the **Black** hose to the inlet on the machine
3. Attach the **Red** hose to the outlet on the machine
4. Remove the rear cover of the machine. Place the free ends of the rubber hoses through the handles of the sides of the machine to keep them out of the way.
5. Check both rear wheels. Lock both front wheels
6. Install the **Yellow** (cation) deionization tank in the right side of the machine with the inlet connector on the right.
7. Install the **Black** (anion) deionization tank in the left side of the machine with the inlet connector on the right, outlet connector on left.

Caution: Never reverse the position of the two tanks or the CPS™ will not function properly

8. Remove the outlet and inlet fittings caps. These caps must not be discarded because they will be used during storage and shipping.
9. Remove two hoses from the handles and connect the hose with the yellow connector to the inlet (right hand) side of the yellow (cation) tank , and connect the hose with the black connector to the out let (left hand) side of the black (anion) tank.

NOTE: The slide fittings are tapered, both male and female, and can only be installed in one direction. For ease of assembly, coat connections with **KFM** silicon lubricant which is included in the kit.

11. Install the coupling hose between the inlet (right hand) side of the Black (anion) tank and the outlet (left hand) side of the Yellow (cation) tank
12. Check all lines and fittings for cracks and leaks before operation.
13. Ensure that the CPS™ Main Power switch is in the off position before plugging in unit.
14. The CPS unit must be connected to a ground outlet.

Use the included sorbent pad or an oil skimmer to skim any oil that has collected on top of the used antifreeze.

15. Although the CPS™ is shipped "dry", it rarely needs to be primed. If this becomes necessary, disconnect the screen from the inlet hose, elevate the hose and fill it with new or used antifreeze. The fluid will flow from the hose, through the strainer and into the pump, which is now primed.

16. Place both the inlet and outlet hoses in the container of used coolant. Turn on the machine power and press **Recycle** and allow the machine to run until the fluid level in the container stays constant.

17. While circulating the coolant, remove the rear and lower front panels, and inspect for leaks, tighten any loose fittings.

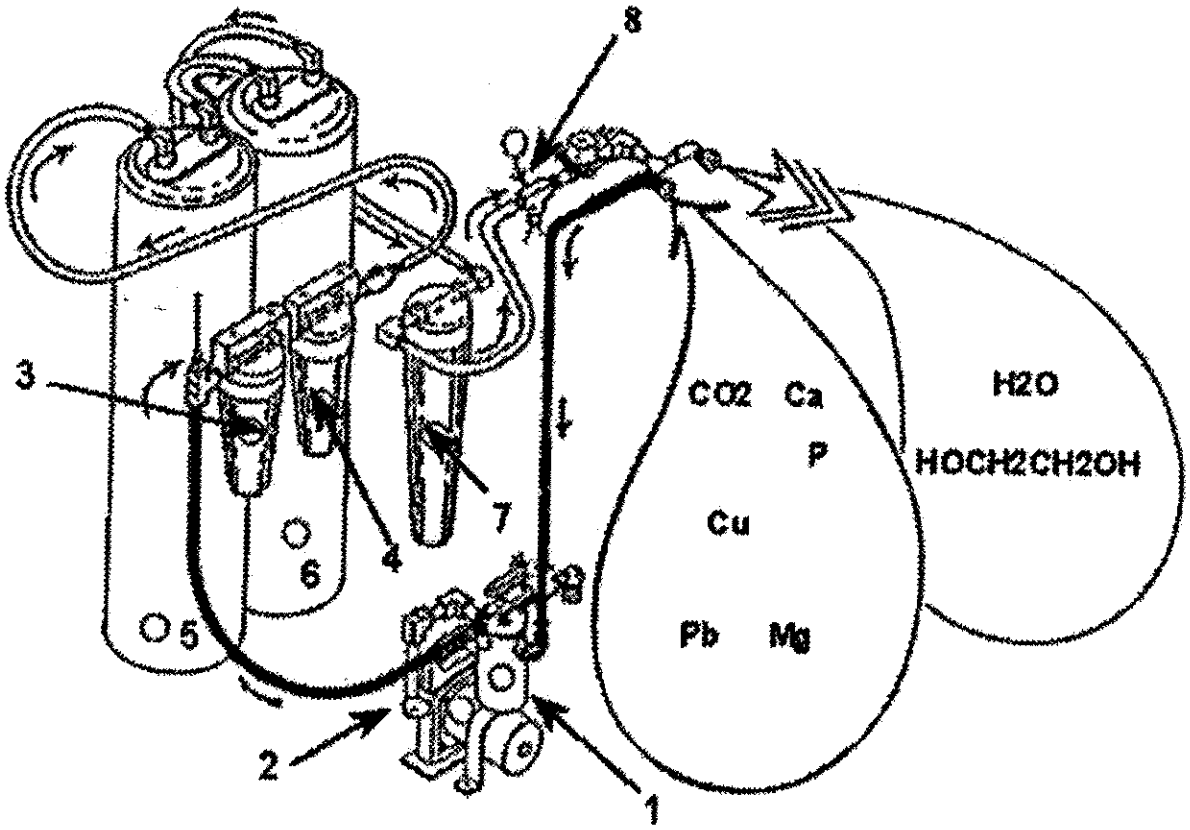
18. During initial setup, the red light will come on. This is normal. It will turn green when unit becomes operational. If the deionization tanks have been sitting for several months, this might take 10-15 minutes. When the red light comes on during recycling, and the used antifreeze is going in green and coming out green, it is time to exchange the deionization tanks. Keep a spare set of tanks to remain operational while the used tanks are being regenerated.

19. Place the **Red** outlet hose into the clean poly drum and let flow approximately 53gallons of recycled fluid into the clean drum.

20. It is always necessary to check the freeze protection of the coolant after processing and add the required amount of CID-A-A-52624 antifreeze or water in order to achieve the desired freeze protection. *The processed, purified coolant will have a freeze protection equal to an average of the coolant which was already in the machine and the coolant drawn from the used antifreeze containers.*

21. Turn to Page 6 and complete steps 4-9.

Coolant Processing



Filtration begins with the intake and "T" strainer (1) removing large particulates such as stop leak materials that are greater than 115μm in size. The strainer's main purpose is to protect the system pump (2) and to extend cartridge filter (3, 4) life. Cartridge filter (3) removes suspended solids greater than 20 μm is followed by a 1μm cartridge filter (4). This helps protects the ion-exchange resins from organic fouling which renders the resins ineffective. Since oil can be a common engine contaminant, this is an important design concept.

After the filtration stages, the coolant, now free of particulates and heavy organics, flows in to the cat-ion exchange tank (5) where it flows evenly contacting the ion exchange resins. All positively charged ions (cat-ions) are replaced by hydrogen (H+) ions during this stage. In stage 6, all negatively charged ions (anions) are exchanged for hydroxide ions (OH-). The H+ and OH- ions exchanged in stages 5 and 6 combine to form water in an amount depending on the number of equivalents (moles of Charge) of ions removed from the used engine coolant. The resulting purified fluid flows into a final activated carbon filter to absorb organics (7) and remove any entrained gases from the liquid stream.

Finally, the completely purified Glycol/H2O mixture passes through an in-line conductivity probe (8) which measures the conductivity of the solution as an indication of the degree of purification by the ion exchange system in stages 5 and 6. The probe is designed to show a green light when the conductivity is below 50microsiemems per centimeter (μS/cm).This ensures high quality effluent and also gives the operator a visible indication that the process is under control and that the ion-exchange beds have not exceeded their capacity. When the ion-exchange resins are exhausted, dissolved solids remain in solution and the conductivity of the effluent rises and quickly exceeds the set point of the probe assembly at 50 μS/cm. This trips the green light off and lights a red light, indicating to the operator that the ion- exchange tanks must be removed for regeneration and replaced with a fresh set of tanks. The μS/cm set point is normally reached within a few seconds after the beds have been exhausted, and maximum Total Dissolved Solids (TDS) at the 50μS/cm point is 53 mg /L (as NaCl). Since glycol suppresses the conductivity of ions in solution, this suppression must be taken in to consideration in all calculations of Total Dissolved Solids.

Attachment C

Details/Diagram of Finish-Thompson Inc. System

Name of Company: Finish Thompson Inc.
Address: 921 Greengarden Rd.
Phone: 814-455-4478
Fax: 814-455-8518
POC: Technical Support – Roger Leopold; Sales – Troy Hurley

Unit Designation: BE-55C

Unit Description: 55 Gallon Coolant Recycler with Chiller

Technology: Vacuum Distillation

Throughput/Capacity: 55 Gallons

Other Requirements: Air Supply / Max. 125 psi

Power Requirements: 240 v / 3 phase / 60 Hz / 40 amp

Size/Space Requirements: L – 48" / H – 63" / D – 30"

Operator Requirements: None

Unit Cost: GSA Price = 11,133.56 / Part Number – PBER005

Contract Number: GS-07F-9999H

Cost of Replacement Filters: None Required

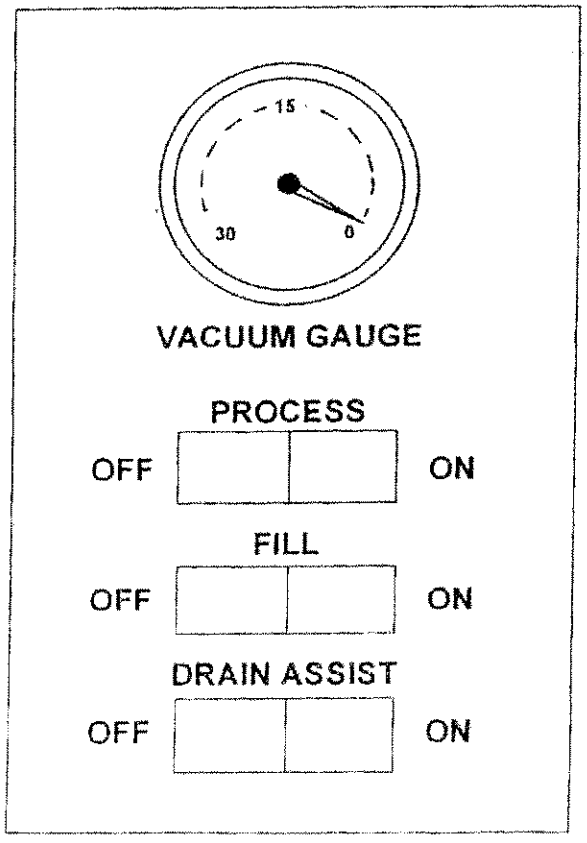
~ Operating the BE-55C ~

CAUTION: ALWAYS WEAR SAFETY GOGGLES, PROTECTIVE CLOTHING, AND GLOVES WHEN OPERATING THIS UNIT.

1. Position your two collection drums to the right of the BE-55C and insert the unit's hoses into the drums. Take care to not allow the level of the processed liquid to cover these hoses to prevent over-pressure or liquid from being drawn back into the process tank.

2. Insert the clear, braided Fill Hose into your waste coolant drum.

3. Close both the Fill Valve and the Drain Valve.



4. Depress the Fill Switch. The vacuum will begin to register on the Vacuum Gage. When the vacuum reaches –10" to –15" Hg., open the Fill Valve to allow the waste coolant to be drawn into the process tank. The Fill Switch will automatically disengage when approximately 55 gallons are drawn into the tank. Close the Fill Valve. If less than 55 Gallon is to be processed, manually disengage the Fill Switch when the waste coolant drum is empty and close the Fill Valve.
NOTE: Do not over-fill the process tank. Fill only from a 55-gallon drum. Processing batches less than 55 gallons can result in inconsistent yields.
NOTE: The BE-55C is not designed to process motor oils. Every attempt must be made to prevent oil and debris from entering the Process Tank. Failure to do so will result in poor quality product and could damage the BE-55C.

5. Depress the Process Switch to the ON position. The switch's light will illuminate, the cycle will begin, and will now function automatically. When the process is complete (Usually less than 20 hours), the Process Switch will move to the OFF position, and the light will go out.

NOTE: If the Fill Switch illuminates during the process while the Fill Switch is in the OFF Position, the distillate overtemp switch has activated. This indicates that the unit is in a cool-down mode. The process will resume when the distillate temperature cools.

6. The Processed Water and Processed Glycol are now ready for mixing and re-inhibiting (refer to the Adding Reinhibitors/Freeze Point Check instructions at the end of the manual). The Processed Glycol normally contains about 10-20% water.

7. Allow the BE-55C to cool for at least two to three hours.
   NOTE: Warm residues flow easier than cold residues.

8. Use the Drain Assist to remove the residues from the process tank to a waste container.

⚠ CAUTION:
LIQUID DRAINED FROM THE PROCESS TANK CAN REMAIN VERY HOT FOR MANY HOURS. USE EXTREME CARE WHEN DRAINING.

Place the Black Drain Hose into a metal waste container. Depress the Drain Assist Switch and carefully open the Drain Valve. Air will begin to push the residues into your waste container. When residue no longer is flowing, and only air is coming out of the hose, close the Drain Valve and push the Drain Assist Switch to the "off' position. Open the manual drain valve and allow any remaining liquid to flow into a catch pan, then close the valve.
NOTE: Use only the special high temperature Black Drain Hose on the air assisted residue drain. Other hose types may burst due to high temperature.

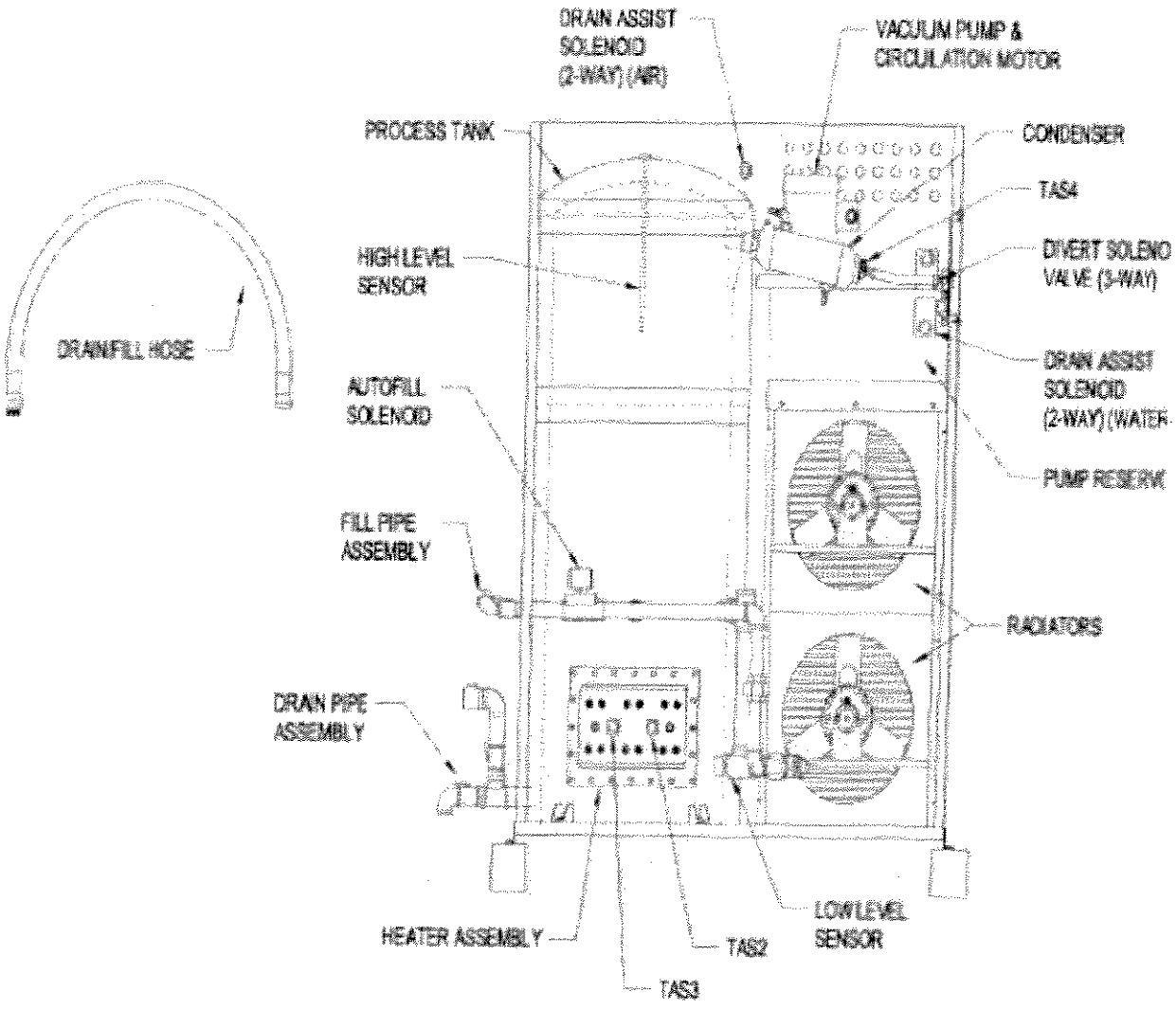
9. Dispose of residue properly in accordance with Federal, State and Local regulations.

10. Perform maintenance as outlined in the "Maintenance Schedule" section of this manual.

NOTE: Residues must be drained after every run. Failure to do so will result in poor quality product and will damage the BE-55C.

NOTE: If less than 5 gallons of residue is drained, or the material is the consistency of tar, a cleaning cycle must be performed before attempting another waste coolant cycle (refer to the "Maintenance Schedule" section of this manual).

NOTE: Never re-run residues or mix residues with waste coolant to re-run. Doing so will result in poor quality product and will damage the BE-55C.



BE-55C PARTS LOCATION DIAGRAM

TAS2 - 385°F – Overtemp.
TAS3 - 280°F – Divert Switch
TAS4 - 180°F – Distillate overtemp. (condenser)

Drain assist 2-way, air sol. is N.C.
Drain assist 2-way, water sol. is N.O.
Autofill sol. is N.C.

Attachment D

Testing Protocol and Evaluation Methodology

Testing Protocol and Evaluation Methodology for Commercial Antifreeze Recycling Systems

I. **Background.** FLTT previously completed a detailed investigation and evaluation of five methods of antifreeze recycling which are commercially marketed. The evaluated technologies included vacuum distillation, chemical pretreatment/filtration, ultra-filtration, ion exchange, and reverse osmosis. Due to limited time and funding, only four (4) recycling units and one (1) recycling service were evaluated for their ability to recycle MIL-A-46153, which was replaced by CID A-A-52624 in 1997. Of the five processes, only two were found to be acceptable for Department of Defense (DOD) use and only two are currently commercially available.

This testing protocol has been updated to provide a means to have other commercially available systems and services evaluated for their ability to recycle CID A-A-52624. The updated protocol focuses primarily on (1) assessing the degree of contaminant removal, (2) verifying the performance and quality of the recycled antifreeze, and (3) determining the compatibility of each system's inhibitor package system with CID A-A-52624 antifreeze.

The most effective recycling methods for used CID A-A-52624 are those which consistently remove essentially all contaminants including dirt, metals, oxidation products, and depleted corrosion and other inhibitors. Complete removal of contaminants and inhibitors provides a clean starting material to which a balanced inhibitor package can be added without chemical interferences.

II. **Definitions.** The following definitions apply to this testing protocol:

On-site recycling unit or service – An antifreeze recycling system or service provided by a company that performs recycling on the premises where the used antifreeze is generated. The recycling units are usually semi-portable, self-contained, and small enough to fit in a garage. On-site service is usually performed from a small van which contains the recycling system.

Off-site recycling service – A company which offers pick-up of the used antifreeze and delivery of the recycled antifreeze. The used antifreeze is collected in bulk, recycled at a plant, and then returned to the customer.

Synthetic used solution – A 50/50 aqueous solution of new CID A-A-52624 antifreeze and ASTM corrosive water[1,2], adulterated with glycolic acid, formic acid, iron, copper, lead, and aluminum. This solution typically represents a worst case example of used CID A-A-52624 antifreeze.

Pre-diluted recycled antifreeze – The antifreeze solution generated after processing the synthetic used solution through a recycling system whose resultant product is a glycol and water mixture.

---

[1] ASTM corrosive water is prepared by dissolving the anhydrous salts of sodium sulfate (148 mg), sodium chloride (165 mg), and sodium bicarbonate (138 mg) in one (1) liter of distilled water.

[2] ASTM methods can be found in the Annual Book of ASTM Standards, Vol 15.05. A copy of this book can be obtained from ASTM Headquarters, 1916 Race Street, Philadelphia, PA 19103.

III. **Synthetic Used Solution.** The following procedure should be followed to contaminate an antifreeze sample to be used to evaluate a recycling unit.

1. Purchase new Commercial Item Description antifreeze concentrate, CID A-A-52624 (Type I for Ethylene Glycol based coolant or Type II for Propylene Glycol based coolant), from current suppliers. To obtain a list of current suppliers, contact the Defense Supply Center Richmond, Freedom of Information Office, 8000 Jefferson Davis Highway, Richmond, Virginia 23297-5000, Phone: 804-279-3566.

2. Prepare a 50/50 antifreeze solution using new CID- A-A-52624 and ASTM corrosive water. Prepare a sufficient amount of the 50/50 solution to complete testing of the before and after recycling samples. See Table C1 for the list of required tests.

3. To the 50/50 CID A-A-52624 solution, add the contaminants listed in Table C2 so the final synthetic used solution has the concentrations shown. The reference solution should be thoroughly agitated prior to all testing to insure that a representative sample is employed.

4. Check the pH, freeze point, and nitrite values of the synthetic used solution.

IV. **Testing Protocol:**

1. After thoroughly mixing, process the used reference solution through the system being evaluated. If the recycling system produces an antifreeze concentrate, mix the concentrate with water (preferably distilled) so that the resultant solution has a freeze point of approximately -34°F (-37°C). If the recycling system produces a prediluted antifreeze, prepare the solution such that the resultant antifreeze solution has a minimum freeze point of -34°F (-37°C) when tested as specified in ASTM D3321.

2. Subject the used reference solution to pH, nitrite value and freeze point (FP) testing (note: a refractometer may be used to determine freeze point according to ASTM D3321). Subject the prediluted recycled antifreeze to all the tests in Table C1. The results will only be accepted from a certified, independent laboratory. Producing a prediluted recycled antifreeze that does not meet the physical, chemical, and performance requirements listed in Tables C3 and C4 constitutes failure of the test. For the non-ASTM tests, the following procedures are given.

2.1. **Compatibility Test.** The antifreeze shall be compatible with ASTM D3585 reference fluid when tested in accordance with (IAW) the following test method. Obtain a sample of antifreeze and a sample of reference fluid IAW ASTM D3585. Prepare a 60% by volume solution of each, using corrosive water IAW ASTM D1384. (Note: For 50% and 60% glycol concentration by volume, do not use with corrosive water; use as is.) In a suitable glass stopped 100-millilieter (ml) graduated cylinder, combine 50 ml of the diluted antifreeze solution and 50 ml of the diluted reference fluid solution. Thoroughly mix the resultant solution. Allow this solution to stand undisturbed in a lighted area at room temperature for 24 hours. After 24 hours, observe the solution for any precipitate, phase separation, turbidity, or cloudiness. For an additional 24 hours, place the stopper solution in an oven at 60 degrees Celsius (°C). After 24 hours, remove the solution from the oven and again observe the solution for any precipitate, phase separation, turbidity, or cloudiness. Report observations. The observation of turbidity or cloudiness, or precipitates or phase separations in excess of 0.5% by volume of the total solution constitute failure of this test.

2.2. **Metal and Acid Content.** Determine metal content of used reference solution and recycled prediluted antifreeze using atomic absorption, atomic emission, or other quantitative techniques that can be shown to have similar accuracy. Determine the glycolic acid and formic acid content using liquid chromatography or other quantitative techniques that can be shown to have similar accuracy. Report concentrations to the nearest 1 ppm. Concentrations above those in Table C3 constitute failure of this test.

2.3. **General Appearance.** Observe the sample and report observations. The prediluted recycled antifreeze shall be translucent in appearance, but free of any insoluble suspensions, such as dirt, undissolved matter, or foreign matter. The presence of the any of aforementioned constitutes failure of this test.

3. Test results will be analyzed by FLTT. If all specification requirements are met, a unit will be certified as acceptable for use by the ARMY. Those systems not able to meet all specification requirements may be re-tested at the expense of the manufacturer.

V. **Point-of-Contact.** Should questions arise relative to this testing protocol and its contents, the following individual should be contacted:

Ms. Hena Das

POLhelp@tacom.army .mil

Phone: 586-574-4219

Any comments, questions, or suggestions to relative this testing protocol should be sent to the following address:

US Army RDECOM
AMSRD-TAR-D / MS 110 (H. Das)
6501 E. 11 Mile Rd
Warren, MI 48397-5000

Table CI : Antifreeze Tests

ASTM D1119	Ash Content of Engine Coolants antirusts
ASTM D1121	Reserve Alkalinity (RA) of Engine Antifreeze, Antirusts and Coolants
ASTM D1177	Freeze Point of Aqueous Engine Coolants
ASTM D1287	pH of Engine Antifreezes, Antirusts, and Coolants
ASTM D1384	Corrosion Test for Engine Coolants in Glassware
ASTM D1881	Foaming Tendencies of Engine Coolants in Glassware
ASTM D2570	Simulated Service Corrosion Testing of Engine Coolants
ASTM D2809	Cavitation Erosion-Corrosion characteristics of Aluminum Pumps with engine coolants
ASTM D4340	Corrosion of Cast Aluminum Alloys in Engine Under Heat –rejecting Conditions
ASTM D5827	Analysis of Engine Coolant for Chloride and Other Anions by Ion Chromatography

Modified Test Methods:

Modified ASTM D5185: Use aqueous standards and distilled water as the sample solvent and blank in place of petroleum solvent prescribed.

Modified Federal Test Method 2540C: Use a 0.7 micron glass frit filter instead of the prescribed 0.45 micron filter.

Non ASTM Tests:

Compatibility Test
Metal and Acid Content
General Appearance

Table C2: Contaminants

Contaminants	Concentration
Glycolic Acid	2000 ± 100 ppm
Formic Acid	900 ± 20 ppm
Iron (Fe)	60 ± 5 ppm
Aluminum (Al)	30 ± 5 ppm
Lead (Pb)	30 ± 5 ppm
Copper (Cu)	30 ± 5 ppm

Table C3: Chemical and Physical Requirements for Recycled Prediluted 50-50 Antifreeze

Property	Value	Test method
Freeze Point, °F	-34 min	ASTM D1177
Ash Content, mass %	5.0 max	ASTM D1119
pH	7.5 to 11.0	ASTM D1287
Reserve Alkalinity, mL	report	ASTM D1121
Glycolate, ppm	900 max	IC
Formate, ppm	300 max	IC
Chloride, ppm	25 max	ASTM D5827
Nitrite, ppm		
Concentrated Antifreeze	2400 min	ASTM D5827
50 vol % in Distilled Water	1200 min	
Nitrite + Molybdate, ppm	780 min	ASTM D5827
Total Dissolved Solids		
Concentrated Antifreeze	4% max	Modified Federal Test Method 2540C
50 vol % in Distilled Water	2% max	
Iron (Fe), ppm	10 max	ICP/AA
Lead (Pb), ppm	5 max	ICP/AA
Copper (Cu), ppm	5 max	ICP/AA
Aluminum (Al), ppm	5 max	ICP/AA
Silicon, ppm	250 max	Modified ASTM D5185
Appearance	translucent, no visible contaminants	N/A

Table C4: Performance Requirements of Prediluted Recycled 50-50 Antifreeze

Property	Value	ASTM Method
Glassware Corrosion Weight Loss, mg/coupon		D1384
Copper	10 max	
Solder	30 max	
Brass	10 max	
Steel	10 max	
Cast Iron	10 max	
Aluminum	30 max	
Simulated Service, Weight Loss, mg/coupon		D2570
Copper	20 max	
Solder	60 max	
Brass	20 max	
Steel	20 max	
Cast Iron	20 max	
Aluminum	60 max	
Foaming		D1881
Volume, mL	150 max	
Break Time, sec	5 max	
Cavitation-Erosion Rating of Water Pump	8 min	D2809
Corrosion of Cast Aluminum Alloys in Engine Coolants Under Heat-Rejecting Conditions	1.0 max	D4340