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TARDEC

Antifreeze Recycling Field Demonstration

March 1998

U.S. ARMY ENVIRONMENTAL CENTER
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This report describes a one (1) year recycling field demonstration meant to assist in the installation, start-up, and operation of antifreeze recyclers at selected Active Army (FORSCOM and TRACDOC), Army Reserve, and Army National Guard units. The report identifies any problems that existed in the operation of the Finish Thompson Inc "BE Series Engine Coolant Recycler" and the KFM Coolant Purification System. Guidance on recycling antifreeze is included. An Antifreeze Recycling Questionnaire was submitted to each participating installation at the conclusion of the field demonstration. Responses were favorable towards both coolant recycling machines. A summary of the findings is included in this report. Recycled antifreeze was monitored in vehicle performance for a one (1) year period and no performance problems were found at any participating installation.

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ANTIFREEZE RECYCLING DEMONSTRATION
- CONTENTS –

I. INTRODUCTION

Background

The three main reasons for recycling used antifreeze are to conserve our natural resources, reduce the cost of new antifreeze purchases, and reduce both the cost and 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. Some states with more restrictive regulations include identifying ethylene glycol (EG), the base material for most of today's antifreezes, as a hazardous material. Such a designation substantially raises the handling and storage expenses of new as well as used EG based antifreezes.(1)[1]

Army Hazardous Waste Minimization (HAZMIN) Policy mandates that all Army installations including National Guard units must reduce the quantity and toxicity of hazardous wastes generated by antifreeze products. Installations using EG based antifreeze may recycle used antifreeze to reduce the necessity of used antifreeze disposal. Acceptable recycling units may be used at posts, camps and stations to reduce antifreeze disposal costs and enhance raw material conservation. During FY1992, the Tank Automotive Research, Development and Engineering Center (TARDEC) identified and approved two units for use in the field. These commercial units include the "BE Series Engine Coolant Recyclers" manufactured by Finish-Thompson Inc (FTI) and the "Cool'r Clean'r® Coolant Purification System" manufactured by Kasco Fuel Maintenance (KFM, formerly BG Products Inc). Both units produced a recycled product equivalent in performance to and chemically compatible with new military antifreeze.(4),(5)

Due to start-up problems in the field with antifreeze recycling systems, many systems were not being used. The U.S. Army Environmental Center (AEC) funded TARDEC to perform a lessons learned study on the two approved antifreeze recycling systems to determine start-up problems in the field. At the conclusion of the study, updated TARDEC user manuals would incorporate any problems field users were having.

[1] Parenthetical numbers correspond to documents in the Reference Section.

Objective

The objective of this recycling demonstration is to assist in the installation, start-up, and operation of antifreeze recyclers at selected Active Army (FORSCOM and TRADOC), Army Reserve, and Army National Guard units and identify problems that may exist in the training and operating of antifreeze recyclers in the field. Sample analysis was only performed as a spot check on the quality of the recycled products. Therefore, only analysis from the Ft. Bliss test site will be provided as representative for all sites.

II. INVESTIGATION

Approach

A representative of the Fuels and Lubricants Technology Team (FLTT) and from AEC installed one (1) antifreeze recycling system at each participating site for operation during this demonstration. The KFM, formerly BG Products Inc., Cool'r Clean'r Coolant Purification System was installed at Ft Bliss, TX, during 07-08 February 1996 and at the 88th Regional Support Group of the Army Reserve, Ft Benjamin Harrison, IN, during 23-25 April 1996. The FTI BE Series Engine Coolant Recycler was installed at Ft Drum, NY, during 20-24 May 1996 and at Camp Dodge, IA, during 15-18 July 1996. Each participating site operated the antifreeze recycling equipment and provided test vehicles to evaluate the performance of the recycled antifreeze.

The performance of the recycled antifreeze was monitored by taking eight (8) ounce samples from test vehicles on a quarterly basis for laboratory testing. The FLTT supplied each participating site with an adequate number of sample bottles. Quarterly samples shipped to the FLTT laboratory were to be tested for the following properties:

- pH, ASTM D1287
- Reserve Alkalinity (RA), ASTM D1121
- Freeze Point, ASTM D3321
- Trace Metals Analysis for Lead, Aluminum, Iron, Copper, Atomic Adsorption (AA)
- Glycolate and Formate, Liquid Chromatography

In addition, the following data were collected from site test vehicles:

- Mileage accumulated
- Hours of engine operation
- Vehicle performance/driver observations
- Cooling system component inspections

Following the demonstration, FLTT distributed questionnaires to participating installations to determine the likes and dislikes of operating the recycling equipment, the methods used to monitor quality of used and recycled antifreeze, the external supplies necessary to make recycling antifreeze easier, and the measures taken to contain any hazardous substances (i.e., inhibitors). A sample questionnaire is included as Attachment 1.

Results and Discussion

New antifreeze is a precise balance of water and EG, which provides both low and high temperature protection, and is treated with chemical inhibitors that provide both corrosion protection to the engine's cooling system and protection against foaming. This balance is changed during normal engine use and therefore must be carefully re-established for a recycled antifreeze to be as reliable and effective as new antifreeze. The two recyclers (i.e., the KFM Cool'r Clean'r Coolant Purification System and the FTI BE Series Engine Coolant Recycler) use different processes to recycle spent coolant (i.e., ion exchange and distillation, respectively). Both these recyclers have been evaluated and found to perform satisfactorily for reclaiming military antifreeze. [1]

Ft Bliss operated the KFM Cool'r Clean'r Coolant Purification System using 55-gallon batches of spent coolant as feedstock. The Ft Bliss demonstration site, the Department of Public Works and Logistics (DPW&L), services 25 to 30 vehicles a month from various organizations. Only heavy-duty construction, heavy combat, and heavy tactical vehicles (i.e., tractors, Bradley's, HEMTT's, M113's, etc.) are serviced. Test vehicles included two (2) 130G Mill Caterpillars, one (1) M1009, and one (1) M983. Their mileage and hour accumulation will be used as a representative example of all four demonstration sites and is shown in Table 1.

Mileage accumulated for the demonstration is below average compared to commercial vehicles. For example, while military vehicles may accumulate 1,000 to 5,000 miles per year, passenger cars and light trucks may average 12,000 to 14,000 miles per year and commercial large trucks and heavy duty trucks may average 150,000 to 180,000 miles per year.

Table 1. Ft Bliss Mileage Accumulation

Ft Bliss Vehicle Type	Miles/ Hours @ 0-Months	Miles/ Hours @ 3-Months	Miles/ Hours @ 6 Months	Miles/ Hours @ 9-Months	Miles/ Hours @ 12-Month	Total Miles/ Hours in one year
M983	3212/208	3511/290	3959/413	4140/473	4149/492	937mi/284hr
M1009	52015/na*	52204/na	52623/na	53006/na	53165/na	1150 miles
130G Mill Caterpillar	na/773	na/960	na/1090	na/1143	na/1181	408 hours
130G Mill Caterpillar	na/3363	na/3486	na/3705	na/3773	na/3786	423 hours

*"na" = not applicable

The Ft Benjamin Harrison demonstration site, an Army Reserve Center, operated the KFM Cool'r Clean'r Coolant Purification System using 55-gallon batches of spent coolant from their 270 Army tactical vehicle fleet. The four (4) test vehicles at Ft Benjamin Harrison included two (2) Chevrolet Blazers, one (1) 5-ton wrecker, and one (1) 10-ton truck.

Ft Drum operated the FTI BE Series Engine Coolant Recycler, also using 55-gallon batches of spent coolant as feedstock. Ft Drum test vehicles included two (2) M1009, one (1) MHE22, one (1) MHE21 from the Directorate of Logistics (DOL). The Camp Dodge demonstration site, a Maintenance Training Center, trains a different active Army, Army Reserve, or Army National Guard unit every month on direct support procedures for servicing Army combat/tactical vehicles. This support includes engine, chassis, and braking system parts repair and/or replacement. Engine overhauls are not included.

Camp Dodge operated the FTI BE Series Engine Coolant Recycler using 55-gallon batches of spent coolant as feedstock. In addition to teaching to a varied student population, the Camp Dodge training center services 20 to 30 vehicles monthly from various Army units. The Camp Dodge test vehicles included two (2) M882, one (1) M1008, and one (1) M1009. The following table summarizes the four demonstration sites, the recycling process, and the "Start Date" which refers to the equipment installation date.

Table 2. Summary of Demonstration Sites

Demo site	Activity	Recycler Type*	Process	Start Date
Ft Bliss NY	DPW&L	Cool'r Clean'r	Ion Exchange	Feb 1996
Ft Benjamin Harrison IN	ARC	Cool'r Clean'r	Ion Exchange	April 1996
Ft Drum NY	DOL	BE Series	Distillation	Sept 1996
Camp Dodge IA	Iowa ANG	BE Series	Distillation	Sept 1996

*- See Attachment 2 for the initial start-up and operating instructions for the Cool'r Clean'r Coolant Purification System. See Attachment 3 for the initial start-up and operating instructions for the BE Series Engine Coolant Recycler.

FLTT provided directions for the operation of the equipment during installation of the equipment (see Attachments 2 and 3). The directions can also be found in the Antifreeze Recycling Users Guide[1]. The following additional supplies were necessary to make engine coolant recycling easier at each demonstration site:

- A minimum of two (2) 55-gallon plastic drums for used and recycled coolant storage, preferably clear plastic with volume markings on the side of the drum
- Either a drum mixer or a drum pump for mixing inhibitors into processed antifreeze
- Oil absorbent pads to skim off any oil contaminants prior to recycling
- Plastic graduated cylinders or other useful containers for measuring liquid volumes (i.e., ounces) when adding inhibitors
- CID A-A-53426 Tester, Antifreeze and Battery Electrolyte Solution
- CID A-A-51461 Test Kit, Antifreeze Freeze Point and Corrosion
- Suitable chemical storage container for chemical inhibitors

Each demonstration site accumulated spent coolant until a sufficient volume (i.e., 55 gallons) was available for processing with either the FTI or the KFM equipment. Spent coolant should have at least 40% EG by volume with a freeze point of -12°F or lower. After initial set-up and electrical hook-up, the FTI BE Series Engine Coolant Recycler operates automatically once the machine's reservoirs are filled with the appropriate amount of spent coolant and the recycler is turned on. The water in the spent coolant will begin to boil off (distill) at approximately 225°F, then the FTI machine cycles to its vacuum mode where the

glycol is distilled at approximately 285°F. The FTI machine shuts off automatically and after cooling the sludge should be drained. The FTI machines require cleaning after every 2-3 runs by running the FTI machine with water through the distillation process until clean. Prior to the initial use of the KFM Cool'r Clean'r Coolant Purification System, the system's tanks must be primed using 5 to 7 gallons of coolant with a glycol content between 50% and 60% EG by volume since each tank contains approximately 4.5 gallons of water upon initial shipment. Placing the inlet hose in a drum of spent coolant to be recycled and the outlet hose in a clean plastic drum allows the operator of the KFM recycler to recycle 55 gallons of spent coolant. The pressure release switch must be turned on to release system pressure before turning off the recycling unit when the outlet drum is almost full. See Attachments 2 and 3 for detailed operating instructions of both systems.

After processing the spent coolant via distillation or ion exchange, the recycled EG must be properly reinhibited for use as an engine coolant. Each recycler uses a proprietary chemical package to restore the inhibitors in the processed antifreeze. Past efforts to formulate a single reinhibition package for use with all approved recyclers (i.e., either the distillation or the ion exchange recycler) proved unsuccessful.[3] The reinhibition steps of the distillation and the ion exchange products vary slightly because the processed coolant will be either a concentrate of purified EG or a prediluted mixture of purified EG and purified water. In general, reinhibition involves adjusting the freeze point of the processed coolant along with adding corrosion inhibitors (chemicals) for engine protection. Freeze point is based on ethylene glycol content; for example, if a coolant's freeze point is higher than desirable, more EG coolant concentrate is necessary to lower the freeze point. Safety equipment such as goggles and gloves should be worn when dealing with chemical inhibitors.

For the KFM Cool'r Clean'r Coolant Purification System which uses ion exchange technology, the processed coolant will be a mixture of ethylene glycol and water. The freeze point must be checked and adjusted by adding either EG concentrate or water prior to reinhibition with the two part heavy-duty inhibitor package (i.e., 4 ounces of each inhibitor per gallon of coolant). On the other hand, the distillation process used in the FTI BE Series Engine Coolant Recycler results in two separate fractions: a recovered (purified) ethylene glycol fraction and also a recovered (purified) water fraction. The purified EG fraction must be reinhibited with FTI additives in the amounts prescribed in the manufacturer instructions (i.e., 4 ounces of each inhibitor per one gallon purified glycol) and mixed thoroughly. After reinhibiting the recovered EG, the EG concentrate must be

diluted with the appropriate amount of recovered water or other available clean water to adjust the freeze point to the desired level (see Attachment 3).[1]

Finally, for both products (i.e., the KFM reinhibited coolant or the FTI reinhibited coolant), the reserve alkalinity (RA) must be checked with an Antifreeze Freeze Point and Corrosion Test Kit[13] to insure the antifreeze has been prepared correctly. A properly processed antifreeze will be identified by an RA pad color in the "O.K. or satisfactory" range of the test kit color chart. A recycled antifreeze having a color not in the "O.K. or satisfactory" range should be reprocessed until a satisfactory RA reading is obtained.[1],[13] A complete listing of the desired physical and chemical properties for a recycled 50% by volume EG coolant is shown in Table 3. Once a recycled coolant has the proper freeze point and a satisfactory RA reading, it is ready for use as engine coolant.

Table 3. Desired Chemical and Physical Requirements for Recycled Prediluted (50% EG by volume) Antifreeze

Property	**Value**	**Test Method***
Freeze Point, °F	-34 min	ASTM D1177
pH	7.5 to 11.0	ASTM D1287
Reserve Alkalinity, mL	6.0 to 16.0	ASTM D1121
Ash content, mass%	2.0 max	ASTM D1119
Glycolate, ppm	900 max	LC
Formate, ppm	300 max	LC
Chloride, ppm	25 max	LC
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
Appearance	Translucent, no visual contaminants	Visual inspection

*-ASTM standards are available directly from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA, 19428-2959.
"LC"= liquid chromatography or other reliable technique with similar accuracy
"ICP/AA"= atomic adsorption, atomic emission, or other reliable technique with similar accuracy

Earlier recycling studies showed that both the KFM Cool'r Clean'r Purification System and the FTI BE Series Engine Coolant Recycler produce a product chemically compatible with and equal in performance to virgin military coolant.[1],[4],[5] As with mileage and hour data, coolant data obtained from Ft Bliss will serve as a representative sample for our demonstration sites as shown in Tables 4 and 5. Slight fluctuations in all sample

characteristics (i.e., pH, Reserve Alkalinity, trace metals, etc.) between the zero and three months are a result of normal vehicle cooling system chemical dynamics. In some cases, a small amount of the original antifreeze remaining in the cooling system because of incomplete flushing during the vehicle preparation may cause these fluctuations.

Table 4. Ft Bliss Reserve Alkalinity, pH, and Freeze Point Data

Vehicle Type and No.	Time	RA (mL)	pH	FP (°F)
Type: M983 No. 3B-142	Before Demo	5.4	8.8	-10
	Zero Month	13	7.5	-32
	3 Months	11	8.4	-34
	6 Months	Not tested	Not tested	-34
	9 Months	Not tested	Not tested	Not tested
	12 Months	19.1	7.3	Off scale #
Type: M1009 No. MD4-1	Before Demo	11.7	7.5	Off scale
	Zero Month	12.2	8.3	-23
	3 Months	11.9	7.9	-58
	6 Months	Not tested	Not tested	-57
	9 Months	Not tested	Not tested	Not tested
	12 Months	14.2	7.6	Off scale
Type: 130G Mill Caterpillar No. E571	Before Demo	17.4	7.6	Off scale
	Zero Month	17.6	7.5	Off scale
	3 Months	13.7	8.1	-42
	6 Months	Not tested	Not tested	-57
	9 Months	Not tested	Not tested	Not tested
	12 Months	14.5	7.9	-40
Type: 130G Mill Caterpillar No. E579	Before Demo	19.2	7.4	Off scale
	Zero Month	13.2	8.2	-35
	3 Months	13.8	7.9	-50
	6 Months	Not tested	Not tested	-47
	9 Months	Not tested	Not tested	Not tested
	12 Months	17.3	7.6	Off scale

#-“off scale” = freeze point below –60°F

Table 5. Ft Bliss Metal Content, (mg/L)

Vehicle Type and No.	Time	Lead	Copper	Iron	Aluminum
M983 No. 3B-142	Before Demo	8.4	0.48	1.9	<0.50
	Zero Month	0.54	<0.10	2.2	<0.50
	3 Months	6.1	0.22	0.72	<0.50
	6 Months	15	0.34	1.0	<0.50
M1009 No. MD4-1	Before Demo	5.2	<0.10	22	<0.50
	Zero Month	0.50	<0.10	3.1	<0.50
	3 Months	1.2	<0.10	0.72	<0.50
	6 Months	3.6	<0.10	0.80	<0.50
130G Mill Caterpillar No. E571	Before Demo	89	5.0	9.2	1.0
	Zero Month	0.70	<0.10	2.6	<0.50
	3 Months	109	3.4	6.0	<0.50
	6 Months	27	2.2	3.0	<0.50
130G Mill Caterpillar No. E579	Before Demo	11	0.34	17	<0.50
	Zero Month	0.62	<0.10	3.1	<0.50
	3 Months	11	0.32	17	<0.50
	6 Months	100	1.4	19	<0.50

The 3B-142 “Before Demo” recycling sample is believed to be propylene glycol (PG) based coolant from a previous vehicle demonstration held at Ft Bliss between June 1994 and June 1995. The 3B-142 “Before Demo” sample characteristics correspond to data collected during the PG antifreeze demonstration.[2] The effects of PG antifreeze are negligible because of the relatively small amount of PG when compared to the amount of EG in the recycled batch. The general quality of the recycled antifreeze vehicle samples are all in acceptable ranges as shown in Tables 5 and 6, except for E571 “Zero Month” recycling sample’s freeze point. Judging by the very low freeze point (i.e., below -60°F) the sample presumably contains more than 60% by volume EG.

The four demonstration sites reported zero problems with the recycling equipment, the recycled coolant, or the test vehicles’ engine cooling system. Overall, the recycled antifreeze performed adequately in all test vehicles at the four demonstration sites.

Following the demonstration, FLTT submitted an antifreeze recycling questionnaire to each demonstration site (see Attachment 1). When asked to describe any likes or dislike of the systems (both the KFM and the FTI recycler), all four

demonstration sites responded they liked the equipment because it was easy to operate. Dislikes included:

- mixing chemicals in the 55-gallon drums for either the FTI or KFM processed coolant
- changing the filters in the KFM recycler (especially if spent coolant contained any “Stop Leak” additives)
- distinguishing between commercial antifreeze and MIL-A-46153[7] antifreeze
- removing any oil contamination from the FTI BE Series Engine Coolant Recycler
- maintaining freeze point protection (EG content) in the KFM Cool’r Clean’r Coolant Purification System

Both the KFM and the FTI instruction manuals were easy to understand and follow. Each installation needed extra supplies such as plastic drums, measuring cups, chemical storage units, etc. All four demonstration sites stored inhibitors in a suitable chemical storage container. The demonstration sites used visual inspections, refractometers, test kits, and our laboratory analysis to ensure quality of the recycled product. The feedstock of spent coolant should also be tested for freeze point to ensure that the EG levels are adequate for recycling (i.e., at least 40% EG with a freeze point of -12°F or lower).

III. CONCLUSIONS

Participating installations found both recyclers, the KFM Cool’r Clean’r Coolant Purification System and the FTI BE Series Engine Coolant Recycler, easy to operate. The instruction and/or owner’s manuals for both units were easy to understand and provided sufficient information to operate the machines successfully. No major changes in the operating steps (found in Attachments 2 and 3) were necessary for recycling military antifreeze.

The installations disliked or found difficulty in handling, measuring, and mixing the reinhibition chemicals for the processed glycol. Reinhibition restores the corrosion protection of the processed coolant and cannot be eliminated. Drum pumps or drum mixers are helpful when mixing inhibitors into drum size volumes of processed coolant. Plastic measuring cups or graduated cylinders should be used for measuring liquid volumes of inhibitor. Attachments 2 and 3 describe the quantity of each inhibitor necessary. The reinhibitor chemicals must be added according to the manufacturer’s recommendations and should treated with caution; wear safety equipment such as gloves and goggles and store chemicals in proper containers when not in use.

IV. RECOMMENDATIONS

The recycled antifreeze can be employed in vehicles until the solution tests below the "O.K. or satisfactory" color chart range of the Antifreeze Freeze Point and Corrosion Test Kit[13] or contains excessive debris as determined visually. If the antifreeze tests unsatisfactory or is visually contaminated with dirt or other debris, the antifreeze should be recycled using either system.

Do not use MIL-A-53009[9] Additive, Antifreeze Extender Liquid Cooling Systems with the recycled antifreeze. MIL-A-53009 was designed to extend the service life of MIL-A-46153[7] military antifreeze. Use of MIL-A-53009 with recycled antifreeze may result in compatibility problems.[1]

Each system is designed to recycle used antifreeze continually as long as sufficient glycol is present (i.e., coolant with at least 40% glycol by volume or possessing a freeze point of -12°F or lower[12],[13]). Also contamination with engine oil, transmission fluid, solvent, etc., needs to be kept at a minimum level (i.e., no contamination) to avoid clogging the recycling unit. Coolant contaminated with oil must sit for approximately two (2) weeks to allow the coolant to separate from the contaminants. If oil contamination is at a minor level, an oil absorbent pad may be used to skim the oil layer off the coolant layer. Alternatively, the coolant layer may be drained or pumped off if the oil contamination layer is too large to be skimmed off. Dispose of the oil layer per standard oil disposal procedures.

Antifreeze (virgin or recycled) should be stored in a suitable size plastic container (i.e., 55-gallon drum). Storing antifreeze in metal containers will deplete the corrosion protection of the coolant and may cause engine failures.[6] Other items useful to the recycling process include but are not limited to: drum mixers or drum pumps to mix inhibitors with processed antifreeze, oil adsorbent pads to skim off any oil contaminants, plastic measuring cups for adding inhibitor chemicals, and proper storage containers for chemicals and recycled antifreeze.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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

1. U.S. Army Tank-automotive and Armaments Command Research, Development and Engineering Center, “Antifreeze Recycling Users Guide”, May 1997.

2. U.S. Army Tank-automotive Command, Mobility Technology Center-Belvoir, Ft Belvoir VA, Technical Report #TR-13644, “Propylene Glycol Antifreeze Study”, February 1996.

3. U.S. Army Tank-automotive Command, Mobility Technology Center-Belvoir, Ft Belvoir VA, Technical Report #TR-13646, “Single Reinhibition Package Study for Use with Certified Antifreeze Recycling Systems”, by Dwayne Davis, February 1996.

4. U.S. Army Tank-automotive Command, Mobility Technology Center-Belvoir, Ft Belvoir VA, Technical Report #TR-13638, “Second Military Antifreeze Recycling Study”, by Dwayne Davis, May 1994.

5. 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”, by Dwayne Davis, June 1992.

6. U.S. Army Belvoir Research, Development, and Engineering Center, Letter Report, “Analysis of Contaminated Military Antifreeze Stored in an Unlined Metal 55-gal Drum,” by Dwayne Davis, May 1989.

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

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

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

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

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

12. Commercial Item Description A-A-53426 Tester, Antifreeze and Battery Electrolyte Solution.

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

ATTACHMENT 1:
ANTIFREEZE RECYCLING QUESTIONNAIRE

ANTIFREEZE RECYCLING QUESTIONNAIRE

Please take a moment to answer the following questions regarding the installation and operation of your antifreeze recycling unit.

Ms. Maria E. Goetz
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Which recycling unit are you using? Please circle one: FTI BE Series KFM (BG) Cool'r Clean'r

What did you like about your antifreeze recycling unit? _____

What did you dislike about your antifreeze recycling unit? _____

What were some items that were difficult when recycling antifreeze? _____

Was the owner's manual easy to follow? If not, what was difficult to understand? _____

What would you do to make recycling easier? Would you change any steps that were included in the manual? _____

What types of external supplies did you use when recycling? Did you need to purchase any supplies other than what was given to you? _____

What measures did you take to contain hazardous substances used (such as inhibitors)? Did you store them in a specified area and container? _____

How did you monitor quality of the used antifreeze prior to recycling? _____

How did you monitor quality of the recycled product? _____

Did you pre-treat the used antifreeze in any way prior to recycling? _____

ATTACHMENT 2:
START-UP AND OPERATING INSTRUCTIONS
KFM COOL’R CLEAN’R COOLANT PURIFICATION SYSTEM

INITIAL START-UP AND OPERTING INSTRUCTIONS FOR KFM COOIANT PURIFICATION SYSTEM[1]

1. Remove bucket and bucket contents (hoses, etc). Place empty bucket under side drain hose.

2. Place the hose with the two (2) female fittings on inlet fixture and place the hose with the two (2) male fittings on outlet fixture.

3. Place both inlet and outlet hoses in bucket to catch any overflow.

4. Check pressure release valve for looseness at nut. Tighten nut if necessary.

5. Place tanks in unit. Place yellow-marked tank on yellow side of unit and place second tank accordingly. Place tanks such that the "in" and "out" signs on each tank are clearly readable to a user facing the rear of the unit.

6. Attach tank hoses to tanks by lifting sleeves. Hoses are attached for "in series" flow pattern.

7. Remove excess engine oil, brake fluid, and/or transmission oil, etc., from used antifreeze to be recycled. Make sure antifreeze contains at least 40% ethylene glycol or has a freeze point of -12^{0}F or lower. Place inlet hose in plastic drum of used antifreeze to be recycled. Place outlet hose in a clean plastic drum (the outlet drum).

8. Add 220 ounces of KFM Additive Part A to the empty, clean drum (the outlet drum).

9. Turn on unit and allow 10 to 15 gallons of recycled antifreeze to enter drum. Stop unit. Add 220 ounces of KFM Additive Part B to the outlet drum.

10. Turn on unit and continue to recycle until the outlet drum is almost full. Do not completely fill outlet drum. Allow outlet drum space for expansion.

ll. Before turning unit off, release any system pressure by turning on the pressure release switch. System pressure also should be released before removing /changing tanks, filters, and/or charcoal canisters.

U.S. Army Tank Automotive Command, Mobility Technology Center-Belvoir, April 1996.

Helpful Tips for KFM Coolant Purification System

The recycled antifreeze may have a different freeze point than the spent coolant feedstock due to the contents of the tanks. For example, each tank contains approximately 4.5 gallons of water upon initial shipment.

The recycled antifreeze should appear clear as water before the additives are added. A constant red (conductivity) light and slightly colored recycled antifreeze indicate tanks should be changed. New tanks may cause the red light to flicker periodically due to air in the tanks.

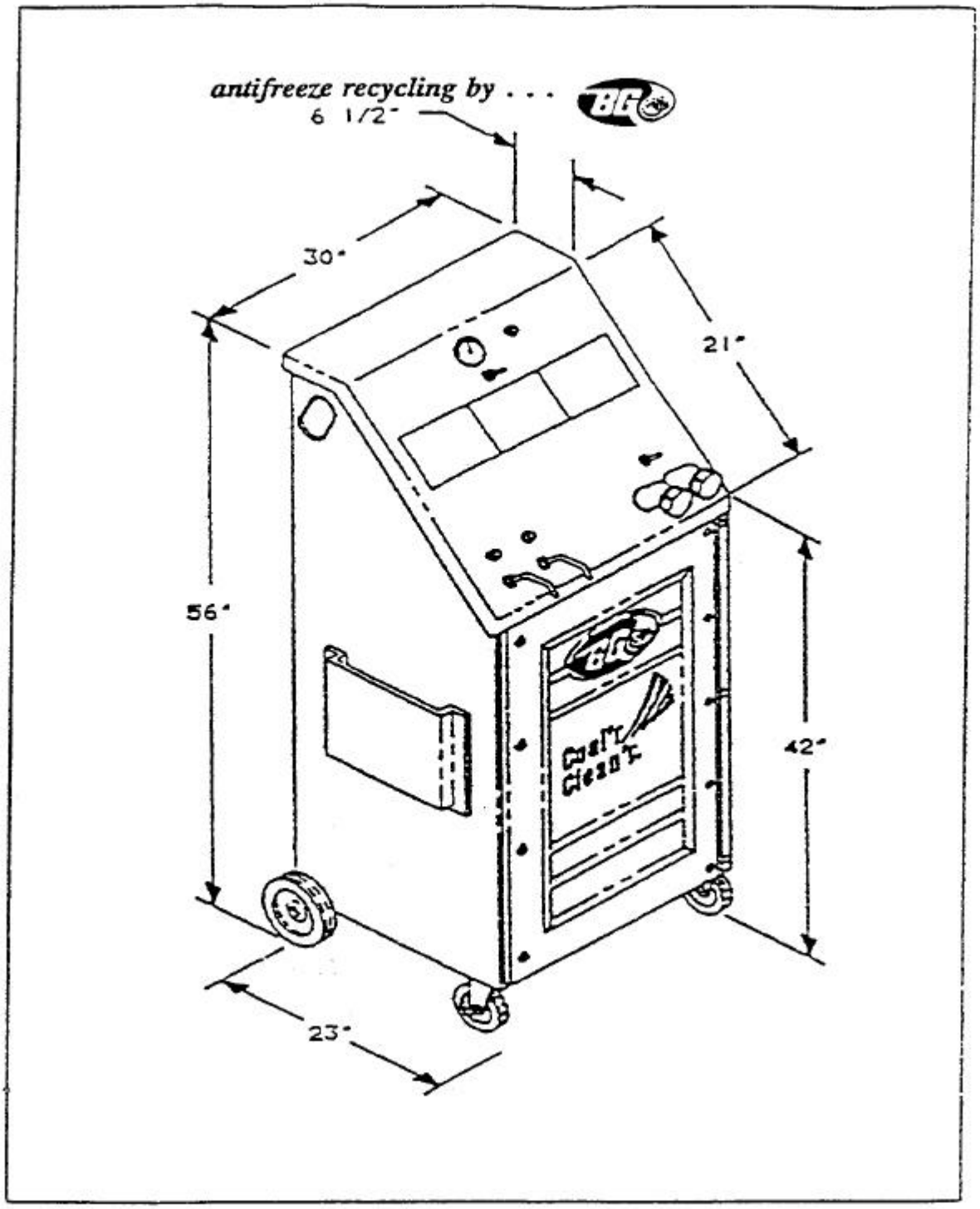
Clogged micron particle and/or charcoal filters cause the unit to “run slow" and the filter/pump pressure to rise above the normal operating pressure range of 35 to 40 psi. Change filters when pressure becomes excessive and unit runs noticeably slow.

Guide for adding KFM inhibitors

Coolant Volume		Inhibitor	Coolant Volume		Inhibitor	Coolant Volume		Inhibitor
Quarts	Gallons	Add A,B (oz)	Quarts	Gallons	Add A,B (oz)	Quarts	Gallons	Add A,B (oz)
1.00	0.25	1	50.00	12.50	50	99.00	24.75	99
2.00	0.50	2	51.00	12.75	51	100.00	25.00	100
3.00	0.75	3	52.00	13.00	52	101.00	25.25	101
4.00	**1.00**	**4**	**53.00**	**13.25**	**53**	**102.00**	**25.50**	**102**
5.00	1.25	5	54.00	13.50	54	103.00	25.75	103
6.00	1.50	6	55.00	13.75	55	104.00	26.00	104
7.00	1.75	7	6.00	14.00	56	105.00	26.25	105
8.00	**2.00**	**8**	**57.00**	**14.25**	**57**	**106.00**	**26.50**	**106**
9.00	2.25	9	58.00	14.50	58	107.00	26.75	107
10.00	2.50	10	59.00	14.75	59	108.00	27.00	108
11.00	2.75	11	60.00	15.00	60	109.00	27.25	109
12.00	**3.00**	**12**	**61.00**	**15.25**	**61**	**110.00**	**27.50**	**110**
13.00	3.25	13	62.00	15.50	62	111.00	27.75	1ll
14.00	3.50	14	63.00	15.75	63	112.00	28.00	112
15.00	3.75	15	64.00	16.00	64	113.00	28.25	113
16.00	**4.00**	**16**	**5.00**	**16.25**	**65**	**114.00**	**28.50**	**114**
17.00	4.25	17	66.00	16.50	66	115.00	28.75	115
18.00	4.50	18	67.00	16.75	67	116.00	29.00	116
19.00	4.75	19	68.00	17.00	68	117.00	29.25	117
20.00	**5.00**	**20**	**69.00**	**17.25**	**69**	**118.00**	**29.50**	**118**
21.00	5.25	21	70.00	17.50	70	119.00	29.75	119
22.00	5.50	22	71.00	17.75	71	120.00	30.00	120
23.00	5.75	23	72.00	18.00	72	121.00	30.25	121
24.00	**6.00**	**24**	**73.00**	**18.25**	**73**	**122.00**	**30.50**	**122**
25.00	6.25	25	74.00	18.50	74	123.00	30.75	123
26.00	6.50	26	75.00	18.75	75	124.00	31.00	124
27.00	6.75	27	76.00	19.00	76	125.00	31.25	125
28.00	**7.00**	**28**	**77.00**	**19.25**	**77**	**126.00**	**31.50**	**126**
29.00	7.25	29	78.00	19.50	78	127.00	31.75	127
30.00	7.50	30	79.00	19.75	79	128.00	32.00	128
31.00	7.75	31	80.00	20.00	80	129.00	32.25	129
32.00	**8.00**	**32**	**81.00**	**20.25**	**81**	**130.00**	**32.50**	**130**
33.00	8.25	33	82.00	20.50	82	131.00	32.75	131
34.00	8.50	34	83.00	20.75	83	132.00	33.00	132
35.00	8.75	35	84.00	21.00	84	133.00	33.25	133
36.00	**9.00**	**36**	**85.00**	**21.25**	**85**	**134.00**	**33.50**	**134**
37.00	9.25	37	86.00	21.50	86	135.00	33.75	135
38.00	9.50	38	87.00	21.75	87	136.00	34.00	136
39.00	9.75	39	88.00	22.00	88	137.00	34.25	137
40.00	**10.00**	**40**	**89.00**	**22.25**	**89**	**138.00**	**34.50**	**138**
41.00	10.25	41	90.00	22.50	90	139.00	34.75	139
42.00	10.50	42	91.00	22.75	91	140.00	35.00	140
43.00	10.75	43	92.00	23.00	92	141.00	35.25	141
44.00	**11.00**	**44**	**93.00**	**23.25**	**93**	**142.00**	**35.50**	**142**
45.00	11.25	45	94.00	23.50	94	143.00	35.75	143
46.00	11.50	46	95.00	23.75	95	144.00	36.00	144
47.00	11.75	47	96.00	24.00	96	145.00	36.25	145
48.00	**12.00**	**48**	**97.00**	**24.25**	**97**	**146.00**	**36.50**	**146**
49.00	12.25	49	98.00	24.50	98	147.00	36.75	147

Guide for adding KFM inhibitors

Coolant Volume		Inhibitor	Coolant Volume		Inhibitor
Quarts	Gallons	Add A,B (oz)	Quarts	Gallons	Add A,B (oz)
148.00	**37.00**	**148**	**197.00**	**49.25**	**197**
149.00	37.25	149	198.00	49.50	198
150.00	37.50	150	199.00	49.75	199
151.00	37.75	151	200.00	50.00	200
152.00	**38.00**	**152**	**201.00**	**50.25**	**201**
153.00	38.25	153	202.00	50.50	202
154.00	38.50	154	203.00	50.75	203
155.00	38.75	155	204.00	51.00	204
156.00	**39.00**	**156**	**205.00**	**51.25**	**205**
157.00	39.25	157	206.00	51.50	206
158.00	39.50	158	207.00	51.75	207
159.00	39.75	159	208.00	52.00	208
160.00	**40.00**	**160**	**209.00**	**52.25**	**209**
161.00	40.25	161	21O.O0	52.50	210
162.00	40.50	162	211.00	52.75	211
163.00	40.75	163	212.00	53.00	212
164.00	**41.00**	**164**	**213.00**	**53.25**	**213**
165.00	41.25	165	214.00	53.50	214
166.00	41.50	166	215.00	53.75	215
167.00	41.75	167	216.00	54.00	216
168.00	**42.00**	**168**	**217.00**	**54.25**	**217**
169.00	42.25	169	218.00	54.50	218
170.00	42.50	170	219.00	54.75	219
171.00	42.75	171	220.00	55.00	220
172.00	**43.00**	**172**			
173.00	43.25	173			
174.00	43.50	174			
175.00	43.75	175			
176.00	**44.00**	**176**			
177.00	44.25	177			
178.00	44.50	178			
179.00	44.75	179			
180.00	**45.00**	**180**			
181.00	45.25	181			
182.00	45.50	182			
183.00	45.75	183			
184.00	**46.00**	**184**			
185.00	46.25	185			
186.00	46.50	186			
187.00	46.75	187			
188.00	**47.00**	**188**			
189.00	47.25	189			
190.00	47.50	190			
191.00	47.75	191			
192.00	**48.00**	**192**			
193.00	48.25	193			
194.00	48.50	194			
195.00	48.75	195			
196.00	**49.00**	**196**			


antifreeze recycling by . . .
6 1/2"
30"
21"
56"
42"
23"

ATTACHMENT 3:
START-UP AND OPERATING INSTRUCTIONS
FTI BE SERIES ENGINE COOLANT RECYCLER

~ Operating the BE-55C ~

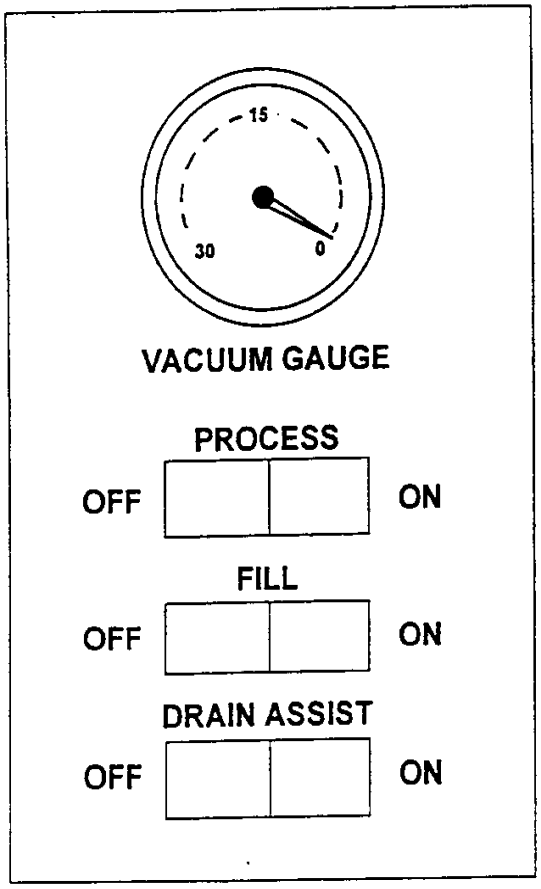
CAUTION:

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. Them 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 is drawn into the tank. Close the Fill Valve. If less than 55 gallons 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 illuminate, the cycle begins, 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 Reinhibiting 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.

7. 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.

8. 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.

MIL-SPEC
Adding Reinhibitors/Freeze Point Check

Caution: Follow these steps to ensure that: the distilled glycol is property reinhibited:

Step	Add 4 ounces of reinhibitor #1 for each gallon of distilled ethylene glycol. Mix well.

1	
Step 2	Add 4 ounces of #2 for each gallon of distilled glycol. Mix well.
Step 3	Pour or pump 4 ounces of the @6ited glycol distillate into the supplied measuring cup or other suitable container as a test sample.
Step 4	Add 4 ounces of BE processed water or tap water to a 4 ounce test sample of inhibited, distilled ethylene glycol.
Step 5	Using a refractometer (for most accurate results) or hydrometer, check the freeze point of the test sample.
Step 6	Use chart 1 below to add the correct volume of water to produce a 50/50 coolant mixture.
Step 7	Recheck the freeze point after the addition of the water. 50/50 coolant has a freeze point of -34^0 F

Gallons of Distilled Ethylene Glycol					
Freeze Point	3 Gallons	6 Gallons	9 Gallons	12 Gallons	15 Gallons
-34^0 F	3.0	6.0	9.0	12.0	15.0
-30^0 F	2.8	5.6	8.4	11.2	14.0
-25^0 F	2.6	5.2	7.7	10.3	12.8
-20^0 F	2.3	4.6	6.9	9.2	11.5
-15^0 F	2.0	4.0	6.0	8.0	10.0
-10^0 F	1.7	3.4	5.1	6.8	8.5
-5^0 F	1.3	2.6	4.0	5.3	6.7
-0^0 F	.9	1.8	2.8	3.7	4.7

Gallons of Water Required for a 50/50 mixture

Chart 1

CHART OF WATER ADDED TO REGAIN 50/50

GALLONS OF ETHYLENE GLYCOL DISTILLATE

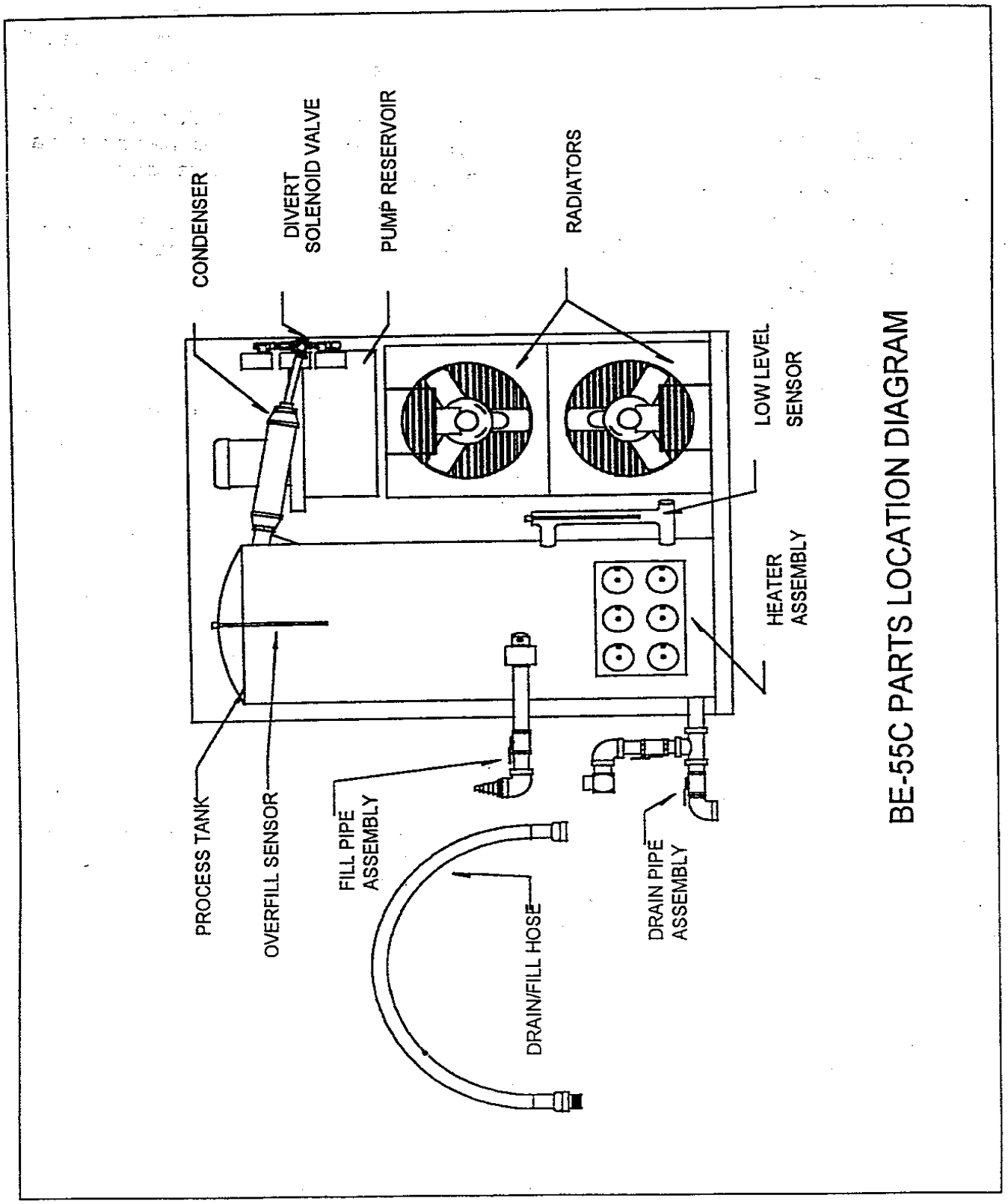
FREEZE POINT (°F)	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35
-34	1.0	3.0	5.0	7.0	9.0	11.0	13.0	15.0	17.0	19.0	21.0	23.0	25.0	27.0	29.0	31.0	33.0	35.0
-33	1.0	3.0	4.9	6.9	8.9	10.8	12.8	14.8	16.7	18.7	20.7	22.6	24.6	26.6	28.5	30.5	32.5	34.4
-32	1.0	2.9	4.8	6.8	8.7	10.6	12.6	14.5	16.5	18.4	20.3	22.3	24.2	26.1	28.1	30.0	31.9	33.9
-31	1.0	2.9	4.8	6.7	8.6	10.5	12.4	14.3	16.2	18.1	20.0	21.9	23.8	25.7	27.6	29.5	31.4	33.3
-30	0.9	2.8	4.7	6.6	8.4	10.3	12.2	14.0	15.9	17.8	19.7	21.5	23.4	25.3	27.1	29.0	30.9	32.8
-29	0.9	2.8	4.6	6.4	8.3	10.1	12.0	13.8	15.6	17.5	19.3	21.2	23.0	24.8	26.7	28.5	30.4	32.2
-28	0.9	2.7	4.5	6.3	8.1	9.9	11.8	13.6	15.4	17.2	19.0	20.8	22.6	24.4	26.2	28.0	29.8	31.6
-27	0.9	2.7	4.4	6.2	8.0	9.8	11.5	13.3	15.1	16.9	18.6	20.4	22.2	24.0	25.8	27.5	29.3	31.1
-26	0.9	2.6	4.4	6.1	7.8	9.6	11.3	13.1	14.8	16.6	18.3	20.1	21.9	23.5	25.3	27.0	28.8	30.5
-25	0.9	2.6	4.3	6.0	7.7	9.4	11.1	12.8	14.6	16.3	18.0	19.7	21.4	23.1	24.8	26.5	28.2	30.0
-24	0.8	2.5	4.2	5.9	7.6	9.2	10.9	12.6	14.3	16.0	17.6	19.3	21.0	22.7	24.4	26.0	27.7	29.4
-23	0.8	2.5	4.1	5.7	7.4	9.0	10.7	12.3	13.9	15.6	17.2	18.9	20.5	22.1	23.8	25.4	27.1	28.7
-22	0.8	2.4	4.0	5.6	7.2	8.8	10.4	12.0	13.6	15.2	16.8	18.4	20.0	21.6	23.2	24.8	26.4	28.0
-21	0.8	2.4	3.9	5.5	7.1	8.6	10.2	11.8	13.3	14.9	16.5	18.0	19.6	21.2	22.7	24.3	25.9	27.4
-20	0.8	2.3	3.8	5.3	6.9	8.4	9.9	11.5	13.0	14.5	16.0	17.6	19.1	20.6	22.2	23.7	25.2	26.7
-19	0.7	2.2	3.7	5.2	6.7	8.2	9.7	11.2	12.6	14.1	15.6	17.1	18.6	20.1	21.6	23.1	24.6	26.0
-18	0.7	2.2	3.6	5.1	6.5	8.0	9.4	10.9	12.3	13.8	15.2	16.7	18.1	19.5	21.0	22.4	23.9	25.3
-17	0.7	2.1	3.5	4.9	6.3	7.7	9.2	10.6	12.0	13.4	14.8	16.2	17.6	19.0	20.4	21.8	23.2	24.6
-16	0.7	2.1	3.4	4.8	6.2	7.5	8.9	10.3	11.6	13.0	14.4	15.7	17.1	18.5	19.8	21.2	22.6	23.9
-15	0.7	2.0	3.3	4.6	5.9	7.3	8.6	10.0	11.3	12.6	13.9	15.3	16.6	17.9	19.3	20.6	21.9	23.2
-14	0.6	1.9	3.2	4.5	5.8	7.1	8.4	9.7	10.9	12.2	13.5	14.8	16.1	17.4	18.7	20.0	21.3	22.5
-13	0.6	1.9	3.1	4.4	5.6	6.9	8.1	9.4	10.6	11.9	13.1	14.4	15.6	16.8	18.1	19.3	20.6	21.8
-12	0.6	1.8	3.0	4.2	5.4	6.6	7.8	9.1	10.3	11.5	12.7	13.9	15.1	16.3	17.5	18.7	19.9	21.1
-11	0.6	1.8	2.9	4.1	5.3	6.4	7.6	8.8	9.9	11.1	12.3	13.4	14.6	15.8	16.9	18.1	19.3	20.4
-10	0.6	1.7	2.8	3.9	5.1	6.2	7.3	8.5	9.6	10.7	11.8	13.0	14.1	15.2	16.4	17.5	18.6	19.7
-9	0.5	1.6	2.7	3.8	4.9	5.9	7.0	8.1	9.2	10.3	11.3	12.4	13.5	14.6	15.7	16.7	17.8	18.9
-8	0.5	1.5	2.6	3.6	4.6	5.7	6.7	7.7	8.8	9.8	10.8	11.9	12.9	13.9	15.0	16.0	17.0	18.1
-7	0.5	1.5	2.3	3.4	4.4	5.4	6.4	7.4	8.4	9.3	10.3	11.3	12.3	13.3	14.3	15.3	16.2	17.2
-6	0.5	1.4	2.3	3.3	4.2	5.1	6.1	7.0	8.0	8.9	9.9	10.8	11.7	12.6	13.6	14.5	15.4	16.4
-5	0.4	1.3	2.2	3.1	4.0	4.9	5.8	6.7	7.5	8.4	9.3	10.2	11.1	12.0	12.9	13.8	14.7	15.5
-4	0.4	1.2	2.1	2.9	3.7	4.6	5.4	6.2	7.1	7.9	8.7	9.6	10.4	11.2	12.1	12.9	13.7	14.6
-3	0.4	1.2	2.0	2.7	3.5	4.3	5.1	5.9	6.7	7.4	8.2	9.0	9.8	10.6	11.4	12.2	12.9	13.7
-2	0.3	1.1	1.8	2.6	3.3	4.0	4.8	5.5	6.3	7.0	7.7	8.5	9.2	9.9	10.7	11.4	12.1	12.9
-1	0.3	1.0	1.7	2.4	3.1	3.7	4.4	5.1	5.8	6.5	7.1	7.8	8.5	9.2	9.9	10.5	11.2	11.9
0	0.3	0.9	1.6	2.2	2.8	3.4	4.0	4.7	5.3	5.9	6.6	7.2	7.8	8.4	9.0	9.7	10.3	10.9

STEP 1 > **Mix a small amount of REINHIBITED FINISH THOMPSON "BE" SERIES DISTILLATE with an equal amount of water or "BE" processed water.**

STEP 2 > **Check freeze point with a REFRACTOMETER or HYDROMETER (A refractometer gives the more accurate results.)**

STEP 3 > **REGAIN 50/50 - Determine the amount of water to be added to the glycol distillate by using the chart above.**

EXAMPLE **If you start with 7 gallons of glycol distillate having a freeze point of -23 degrees Fahrenheit (when diluted 50/50), you would add 5.7 gallons of water to regain 50/50.**


CONDENSER
DIVERT SOLENOID VALVE
PUMP RESERVOIR
RADIATORS
LOW LEVEL SENSOR
HEATER ASSEMBLY
PROCESS TANK
OVERFILL SENSOR
FILL PIPE ASSEMBLY
DRAIN/FILL HOSE
DRAIN PIPE ASSEMBLY
BE-55C PARTS LOCATION DIAGRAM