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## MC-9 MAINTENANCE MANUAL

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# SECTION 6

# COOLING SYSTEM

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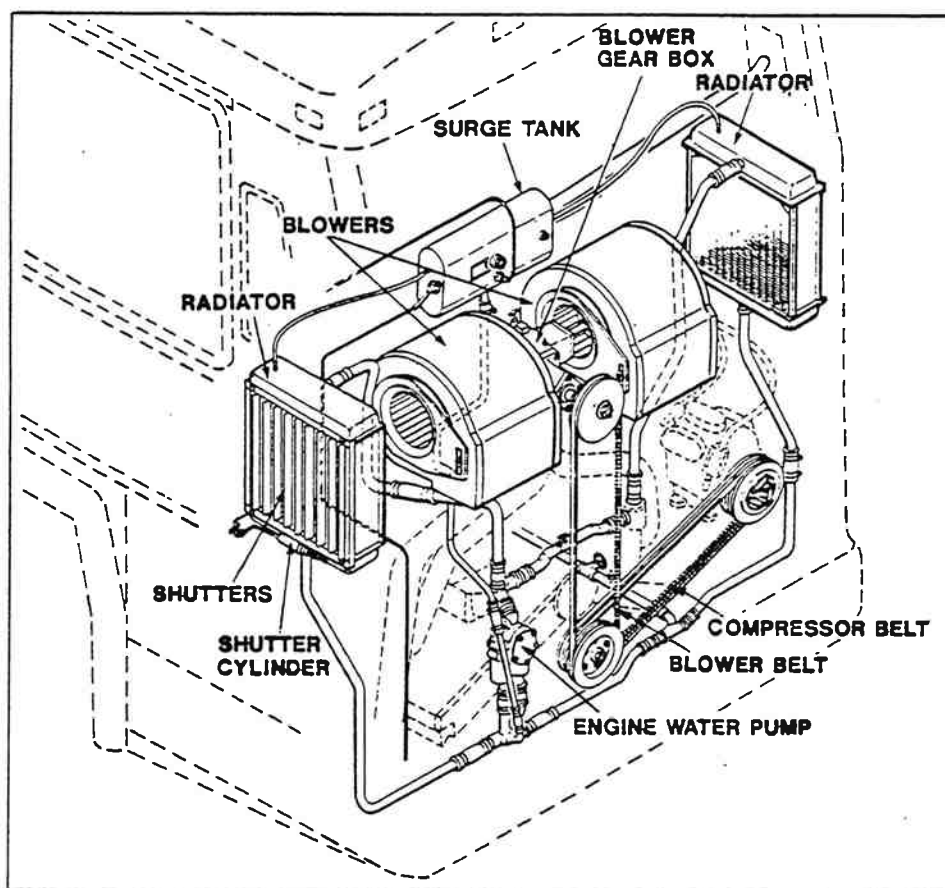


Figure 6-1. Cooling System Components.

## COOLING SYSTEM

One radiator is mounted on each side of the coach above the engine. Cores are of fin and tube construction. Dual centrifugal blowers are belt driven from the engine crankshaft through a gear box. They pull outside air through the radiators into a sealed, insulated blower compartment when the air operated, thermostatically controlled shutters are open.

When engine coolant is below normal operating temperature the shutters are automatically closed. With shutters closed, no air is pulled across the radiators and horsepower required to drive the centrifugal blower becomes significantly reduced.

The blower gear box includes a sight gauge for checking lubricant level and an easily accessible oil filler tube. Belt tension is maintained through an automatic, air controlled belt tightener.

The surge tank is mounted in the upper blower compartment. The coolant filler neck and pressure release valve are mounted behind the access door on the right rear side of the coach. A coolant level check can be done rapidly by means of a sight glass installed on the surge tank. Thermostats and alarms are provided at the front of each cylinder head.

The function of the coolant is to absorb the heat which develops as a result of the combustion process in the engine. In addition, the heat absorbed by the oil is removed by the engine coolant in the oil cooler.

The engine water pump circulates coolant through the engine oil cooler, block, cylinder heads and aftercooler. From the aftercooler it flows through the thermostats to the radiators and down to the water pump completing the cycle. Anything that interferes with this process of heat transfer can cause engine components to overheat, often resulting in serious engine damage. See figure 6-1.

## COOLANT TEMPERATURE

The heat-dissipating capacity of the V-92 Series engine cooling system and related components must be sufficient to prevent the coolant-out temperature from rising above the maximum allowable coolant-out temperature limit of 210°F (98.9°C).

This temperature must not be exceeded under any engine operating conditions, regardless of altitude, type of coolant used, or cooling system condition. Exceeding these limits can result in malfunction or serious engine damage.

## TEMPERATURE CONTROL COMPONENTS

The engine is designed to operate with thermostats which, combined with a radiator, regulate coolant temperature. Radiator shutters, and fans, are used to help control coolant temperature. These "add on" cooling system components

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must operate in proper sequence to prevent coolant temperature instability and/or engine overheating. An improper operating sequence can also have a detrimental effect on the life of the "add on" components as well.

The following chart gives the **nominal** temperature settings for the 180°F (82°C) thermostat and shutterstat controls, along with standard and optional alarmstat settings. These settings should not be exceeded, under any engine operating condition, regardless of operating altitude, type of coolant used, or cooling system condition. Exceeding the settings will unnecessarily increase the engine coolant and lubricating oil temperature.

**NOTE: Coolant temperature instability will result from improper component operating sequence.**

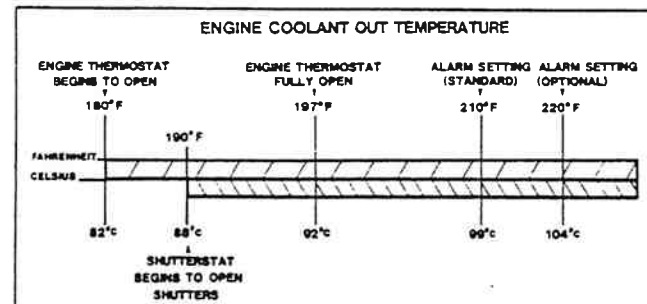


Figure 6-2. Nominal Settings For Coolant Temperature Controls.

The major components of the cooling system are the coolant, radiators, blower gear box and surge tank. These components, as well as the minor ones, are covered in more detail later in this section.

## HOSE INSPECTION

Swollen, cracked or worn out hoses or loose hose connections are frequent causes of cooling system problems.

Serious overheating is often caused by old hose collapsing or from deteriorated rubber shedding from hoses and clogging the coolant passages.

Connections should be inspected periodically and hose clamps tightened. Replace any hose found to be cracked or swollen. When installing a new hose, clean pipe connections and apply a thin layer of a non-hardening sealing compound. Replace worn out clamps or clamps that pinch hoses.

## TESTING ANTIFREEZE SOLUTIONS

Always test solution before adding water or antifreeze. Engine should be warmed to operating temperature. Fill and empty tester several times before using, and ensure that tester is clean inside and out.

If a coolant filter is used, replace the element every 500 hours or 20,000 miles (32,000 km).

Commercial cooling system cleaners of alkaline or acid type may be used. Exercise extreme caution and follow the manufacturer's recommendations when using these types of cleaners.

Problems may develop from leaks and seepage at the engine water pump and thermostat housings hose connections. These may be caused by deformation and rough surfaces on the castings at the hose mounting surfaces. It is recommended that Dow Corning RTV-102 Compound be applied to cast surfaces prior to hose installation.

**CAUTION: Castings should be clean and free of oil and grease before applying compound. No other sealer should be used with RTV compound.**

## COLD WEATHER OPERATIONS

Although not recommended, plain water with an inhibitor may be used as a coolant where temperatures do not reach below 32°F (0°C). In colder regions antifreeze must be used.

Before adding antifreeze the cooling system should be inspected for winter operation. Cylinder head gaskets should be tightened or replaced where necessary to avoid the possibility of coolant leaking into engine and exhaust gases blowing into cooling system.

After antifreeze has been added, the entire system should be inspected regularly to ensure against the development of leaks.

If the cooling system becomes frozen, place the coach in a warm area until the ice is completely thawed. Under no circumstances should the engine be operated when the cooling system is frozen.

## PREVENTIVE MAINTENANCE

A program of maintenance of the cooling system components is essential to ensure maximum system efficiency, and trouble-free operation. Observe the following guidelines:

1. Check, on a daily basis, the coolant level in the surge tank. Keep tank filled with the coolant required for proper operation in the extremes of seasonal temperatures.

2. Every 20,000 miles (32,000 km) perform the following checks:

a. Check belts for condition and tension. Tighten loose belts and replace those frayed or worn.

b. Check water pump operation and installation. A leaking pump will suck air into the cooling system, causing corrosion of engine and cooling system components, and decreasing the efficiency of the coolant. Correct all leaks at once.

c. Check the radiators and all hoses for leaks. Repair leaking components. Clean the radiator cores with low pressure air to remove all dirt and thus provide optimum heat dissipation. Check and tighten radiator mounts as required. Repair all leaks.

d. If a coolant filter is used, replace the element at this interval.

3. The following procedures are necessary every 100,000 miles (161,000 km):

a. Check the strength of the antifreeze with a hydrometer. If too weak, drain a quantity of coolant from the system, and replace with the same quantity of coolant (water/antifreeze mixture) in proper proportion to result in correct overall solution strength.

b. Check the strength of the inhibitor in the coolant. Use a test kit or strip made available by the manufacturer of the inhibitor in use. Follow the instructions of the inhibitor manufacturer. Add inhibitor only in the amount necessary to reach manufacturer's strength recommendations.

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**NOTE: Specific instructions are set forth below concerning coolant requirements, antifreeze, use of water in the system, corrosion inhibitors, silicate gel formation and coolant testing.**

## COOLANT REQUIREMENTS

Coolant solutions must meet the following basic requirements:

1. Provide for adequate heat transfer.
2. Provide a corrosion-resistant environment within the cooling system.
3. Prevent formation of scale or sludge deposits in the cooling system. Figure 6-3 contains water quality data.
4. Be compatible with cooling system hose and seal materials.
5. Provide adequate freeze protection during cold weather operation and boil-over protection in hot weather.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol-based antifreeze solutions are recommended for year-round use.

## WATER

Whether of drinking quality or not, any water will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness, and total dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) cause deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion, or a combination of any of these. Chlorides, sulfates, magnesium and calcium are among the materials which make up dissolved solids. Water within the limits specified in Table 1 (figure 6-3) is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution is shown in Table 2.

TABLE 1		
	PARTS PER MILLION	GRAINS PER GALLON*
Chloride (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

Refer to Table 2 for evaluation of water intended for use in a coolant solution.  
\* 4.5 liters

TABLE 2	
Determine The Concentrations Of Chlorides, Sulfates, And Total Dissolved Solids In The Water	
Chlorides Under 40 ppm, And Sulfates Under 100 ppm, And Total Dissolved Solids Under 340 ppm.	Chlorides Under 40 ppm, Or Sulfates Under 100 ppm, Or Total Dissolved Solids Over 340 ppm.
Determine Total Hardness Of The Water	Distill, De-mineralize Or De-ionize The Water.
Total Hardness Under 170 ppm	Water Suitable for Use As Coolant
Total Hardness Over 170 ppm	Plus Inhibitors
Soften The Water	
Water Suitable for Use As Coolant	
Plus Inhibitors	

Figure 6-3. Cooling Fluid Characteristics.

## ANTIFREEZE

When freeze protection is required, use an antifreeze that meets the GM 6038M formulation, which limits silicate to 0.15% maximum, or an equivalent formulation meeting the 0.15% maximum silicate and GM 1899M performance requirements.

Solutions of less than 30% do not provide adequate corrosion protection. Concentrations over 67% adversely affect freeze protection, heat transfer rates, and silicate stability. A 50% antifreeze solution is normally used as factory-fill.

Ethylene glycol base antifreeze is recommended. Methyl alcohol base antifreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxy propanol base antifreeze is not recommended due to the presence of fluoro-elastomer seals in the cooling system.

The inhibitors in antifreeze solutions should be replenished with a non-chromate corrosion inhibitor supplement when indicated by testing the coolant. Engine coolant should be checked at approximately 500 hour or 20,000 mile intervals. (See Coolant Testing, below.)

Antifreeze solutions should be used year-round to provide freeze protection in the winter, boil-over protection in the summer, and a stable environment for seals and hoses in the cooling system of the engine. (See figure 6-4.)

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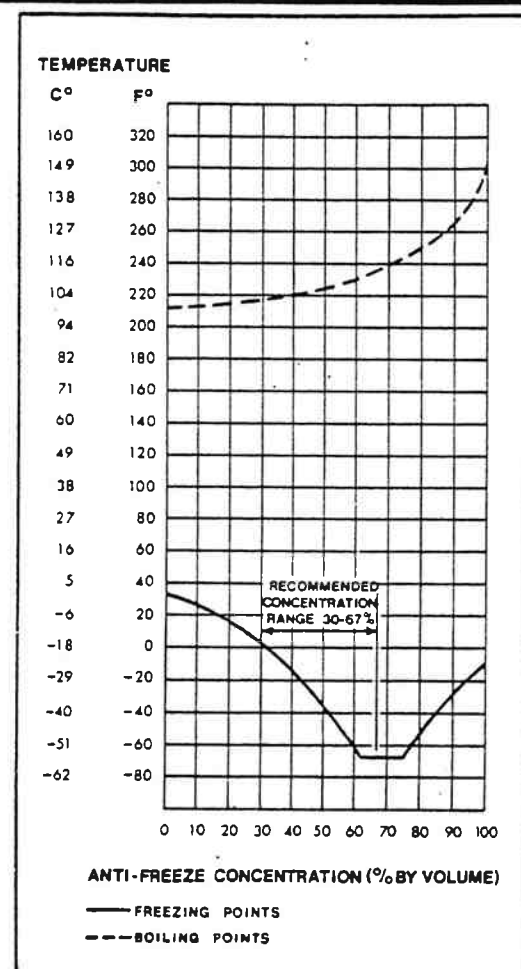


Figure 6-4. Freezing and Boiling Temperatures of Coolant (at sea level).

## CORROSION INHIBITORS

A corrosion inhibitor is a water-soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites, and soluble oil. (*Soluble oil is not recommended as a corrosion inhibitor.*) Depletion of all types of inhibitors occurs through normal operation. Therefore, strength levels must be maintained by adding inhibitors as required after testing the coolant.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, or — worse — no inhibitors at all invites the formation of rust and scale deposits within the cooling system. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a  $\frac{1}{16}$ " deposit of rust or scale on 1" of cast iron is equivalent to  $\frac{1}{4}$ " of cast iron in heat transferability.

An engine affected in this manner overheats gradually — over a period of weeks or months. Liner scuffing, scoring, piston seizure, and cylinder head cracking are the inevitable results. An improperly inhibited coolant can also become corrosive enough to "eat away" coolant passages and seal ring grooves

and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod.

An improperly inhibited coolant can also contribute to *cavitation erosion*. Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

**NON-CHROMATES** — Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either a water or water-and-antifreeze solution.

**CHROMATES** — Sodium chromate and potassium dichromate are two of the most commonly used water system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors *should not be used in antifreeze solutions*. Chromium hydroxide, commonly called "green slime," can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate and resulting in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy-duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

**SOLUBLE OIL** — *Soluble oil is not recommended as a corrosion inhibitor.* It has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example, 1.25% of soluble oil in the cooling system increases fire deck temperature 6%, and 2.50% concentration raises fire deck temperature up to 15%.

**INHIBITOR SYSTEMS AND ADDITIVES** — An inhibitor system is a combination of chemical compounds which provide corrosion protection, pH control, and water-softening ability. pH control is used to maintain an acid-free solution. The water-softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms, such as coolant filter elements, liquid and dry inhibitor additives, and as integral parts of antifreeze.

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant. Both chromate and non-chromate systems are available, and care should be taken regarding inhibitor compatibility with other coolant constituents.

*Non-chromate inhibitor systems are recommended.* These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control, and water softening. Most non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, they

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require no additional hardware or plumbing.

All inhibitors become depleted through normal operation, and additional inhibitor must be added to the coolant as required to maintain original strength levels.

**NOTE: Over-inhibiting antifreeze solutions can cause silicate dropout. Always follow the supplier's recommendations on inhibitor usage and handling.**

## SILICATE DROPOUT

Excessive amounts of chemicals in the engine coolant can cause silicate dropout, which creates a gel-type deposit that reduces heat transfer and coolant flow. Silicate dropout may also occur in coolants using extremely hard water and/or unusually high operating temperatures.

The gel takes on the color of the coolant solution in the wet state but appears as a white powdery deposit when dry. Although silica gel is non-abrasive, it can pick up solid particles in the coolant and become a gritty, abrasive deposit that can cause excessive wear of water pump seals and other cooling system components.

If it is suspected that a coach cooling system has a gelling problem (indicated by engine overheating or coach underheating), first try to remove the gel in its "wet" condition. Use an alkaline cleaner (Nalprep 2001 or equivalent) as directed by the manufacturer, so that the silica-gel is not allowed to dry. If using the cleaner once does not correct it, repeat the procedure. If available, ultrasonics is another process that can be used to remove the gel without damage to cooling system components.

If silica-gel has been allowed to dry inside a cooling system component, removing the gel becomes more difficult. The gel tends to form in low areas of the cooling system, i.e., radiator bottom tank or areas within the engine oil cooler. If gel can be reached for mechanical cleaning (removal of radiator bottom tank or "rodding" out a radiator core), then that method can be used.

Finally, dried silica-gel may be removed from a cooling system component by removing that component from the coach and agitating it in a caustic solution. Extreme care must be taken when handling such caustic solutions. Safety glasses and protective gloves should be worn. **Do not flush engine cooling system with caustic solutions because damage can occur to both metallic and non-metallic components.**

The following recommendations are made to prevent silica-gel formation:

- Use antifreeze that meets GM-6038M formulation which limits the amount of silicate to 0.1% maximum.
- Use antifreeze solutions at the concentration required for freeze protection in your operational area, but **do not** use more than 67% antifreeze or less than 30% antifreeze.
- Never use 100% antifreeze for make-up coolant. Mix the make-up solution at the same concentration as the original fill.
- Use corrosion inhibitor supplements only as required to maintain proper system protection. The system should be tested to determine the need for additional inhibitor. Test kits and test strips are commercially available to check engine coolant for corrosion inhibitor strength level. Coolant should be tested to determine the need for corrosion inhibitor supplements and the amount required. Do not use one manufacturer's test to measure the inhibitor strength level of another manufac-

turer's product. Always follow the manufacturer's recommended test procedures. New additives Nalcool 3000 with stabil-aid and Fleetguard DCA4 have been developed to help prevent silicate dropout and this may be added to the system when need arises.

- As much as possible, avoid using what can be considered "hard" water when mixing with antifreeze.

A list of available antifreeze products that meet GM-6038M is shown below:

Company	Product
Texaco (1)	2055 (was JC-04)
BASF Wyandotte (1)	241-7
International Harvester (1)(5)	I.H. Antifreeze
Old World Trading Co. (1)	Full Force Advance
Northern Petro-Chemical (2)	All Weather (NPC 220)
Dow Chemical Canada(3)	731
Houston Chemical Corp. (4)	Security (701)

- (1) Generally available in U.S.A.  
 (2) Generally available within 750-mile radius of Chicago  
 (3) Generally available in Canada  
 (4) Generally available in northeastern U.S.A.  
 (5) I.H. antifreeze in Canada has high silicate content

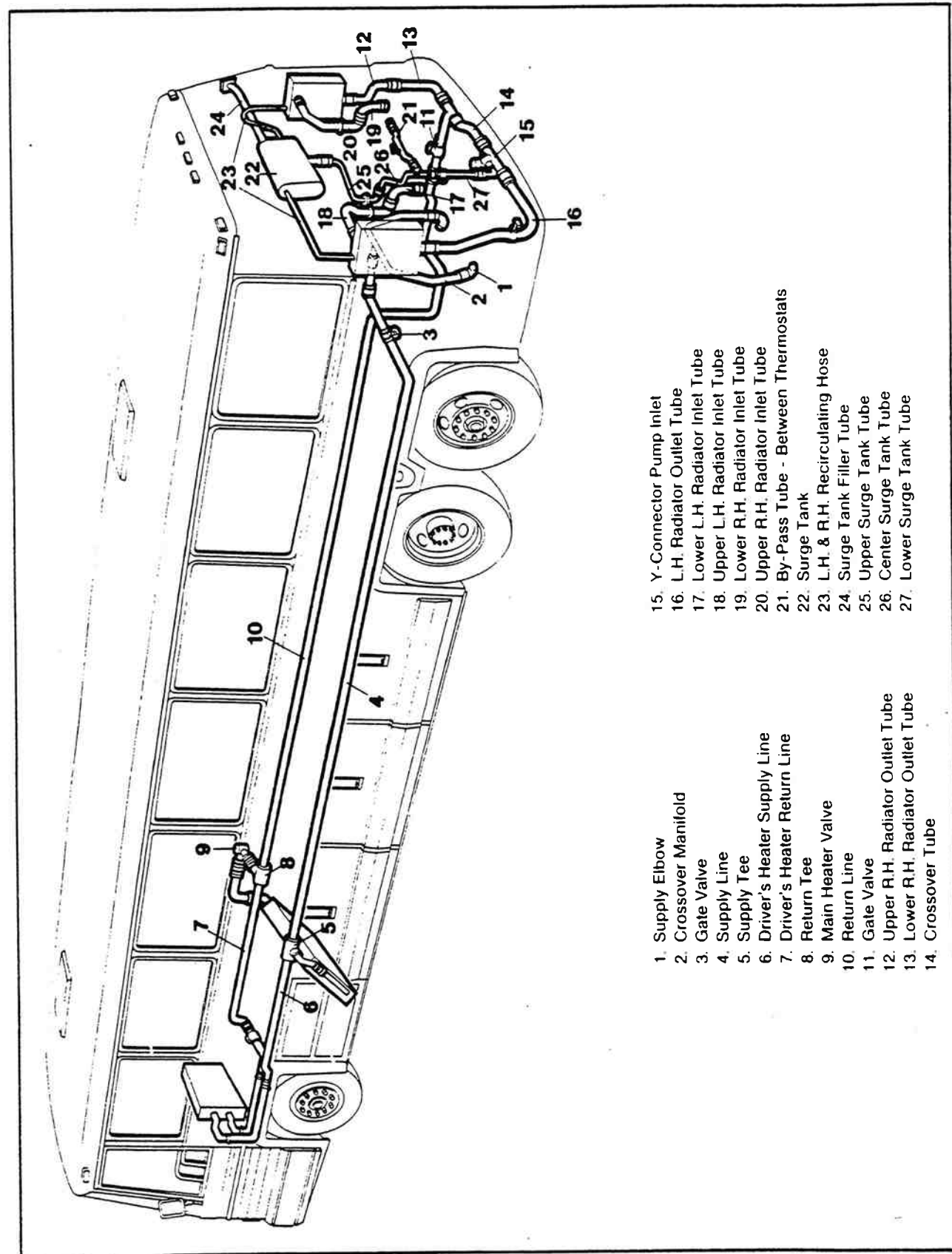
## COOLANT FILTERS - GENERAL

Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.

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- 1. Supply Elbow
- 2. Crossover Manifold
- 3. Gate Valve
- 4. Supply Line
- 5. Supply Tee
- 6. Driver's Heater Supply Line
- 7. Driver's Heater Return Line
- 8. Return Tee
- 9. Main Heater Valve
- 10. Return Line
- 11. Gate Valve
- 12. Upper R.H. Radiator Outlet Tube
- 13. Lower R.H. Radiator Outlet Tube
- 14. Crossover Tube

- 15. Y-Connector Pump Inlet
- 16. L.H. Radiator Outlet Tube
- 17. Lower L.H. Radiator Inlet Tube
- 18. Upper L.H. Radiator Inlet Tube
- 19. Lower R.H. Radiator Inlet Tube
- 20. Upper R.H. Radiator Inlet Tube
- 21. By-Pass Tube - Between Thermostats
- 22. Surge Tank
- 23. L.H. & R.H. Recirculating Hose
- 24. Surge Tank Filler Tube
- 25. Upper Surge Tank Tube
- 26. Center Surge Tank Tube
- 27. Lower Surge Tank Tube

Figure 6-5. Coach Cooling System.

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## RAINING COOLING SYSTEM

The cooling system may be completely or partially drained by using the following procedures.

**CAUTION:** After draining the cooling system attach a suitable tag to the steering wheel indicating that the cooling system is dry.

To drain the entire system leave the two gate valves open and proceed with the following: (See figures 6-5, 6-6 and 6-7.)

1. Depress the vent button at the radiator filler cap.
2. Open the filler cap.
3. Remove the drain plug at the radiator return line tee, located below the engine water pump.
4. When the coolant has drained, open the bleeder valve on the driver's heater core.
5. Remove the drain plugs from the suction line, the engine oil cooler, and the air compressor.

To drain only the engine and related components, close the two gate valves and proceed as follows:

1. Depress the vent button on the radiator filler cap.
2. Open the radiator filler cap to allow air into the system as the coolant drains.
3. Remove the drain plug at the radiator return line tee, located below the water pump.

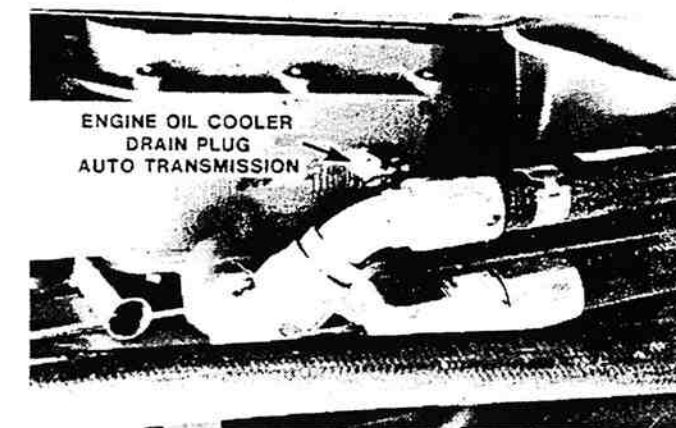
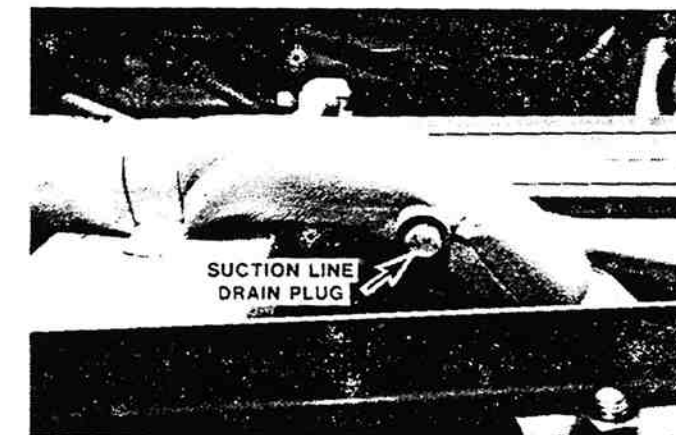
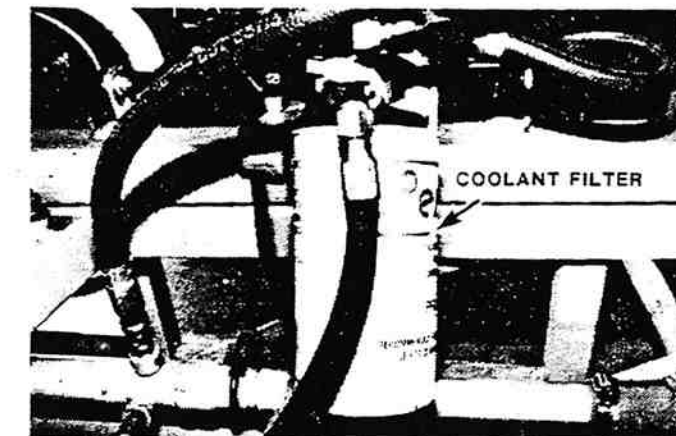
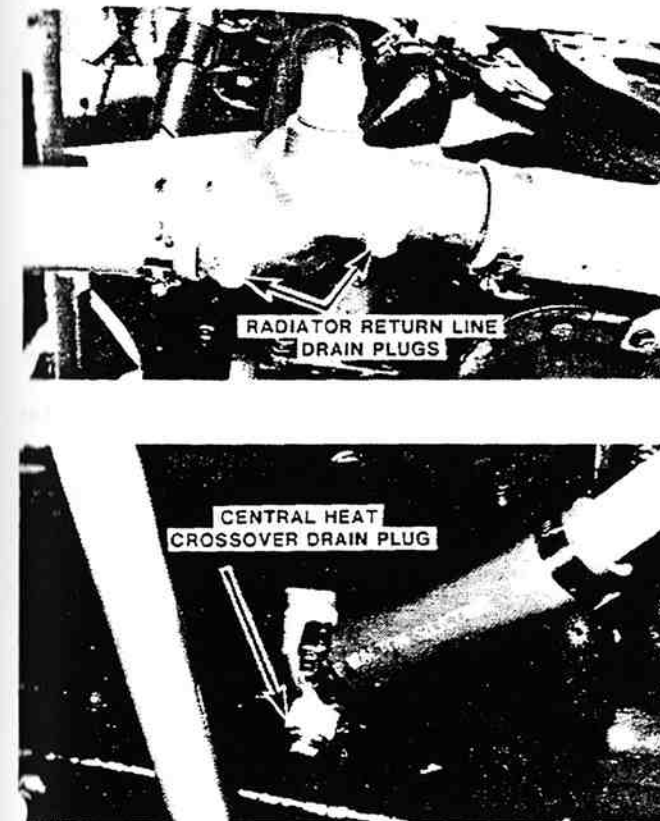


Figure 6-6. Drain Plugs and Coolant Filter.

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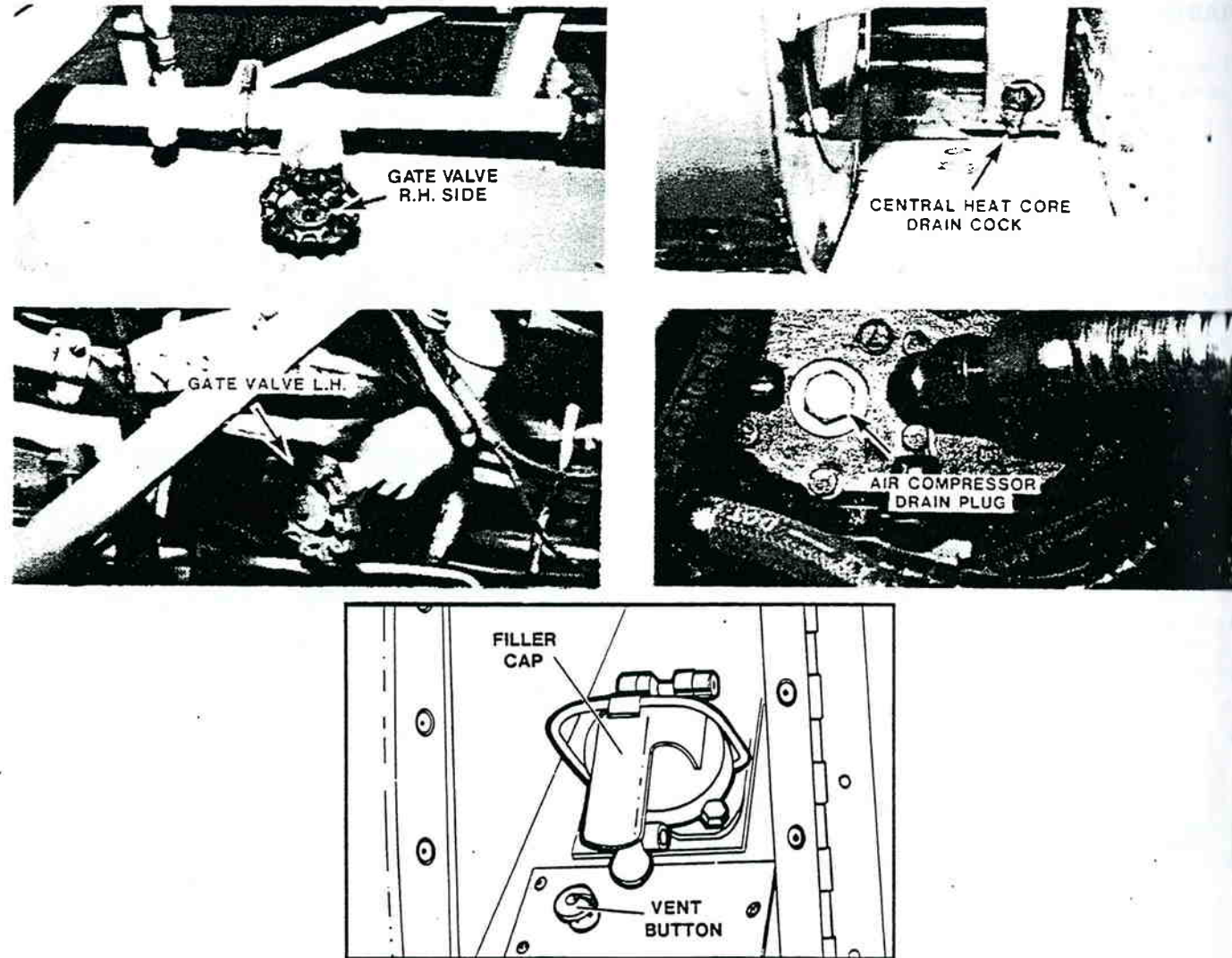


Figure 6-7. Cooling System Drains and Valves.

## REFILLING COOLING SYSTEM

To fill the system, close all drain plugs and cocks, open the gate valves and fill the system halfway with a 50-50 mixture of water and ethylene glycol antifreeze. Start the engine and fill the system completely. The cooling system is completely filled when coolant shows approximately halfway up in the surge tank sight glass. See figure 6-8.

When the cooling system is filled to capacity with cold coolant solution, expansion of the coolant takes place as it heats up. During this initial warm-up period it is possible to lose as much as a gallon and a half of coolant. No further coolant loss should be experienced after this period.

**CAUTION: Never pour cold coolant into a hot engine. The sudden change in temperature may crack the cylinder head or block.**

## COOLANT FILTER

A spin-on coolant filter is available as optional equipment. The filter can be reached through the right hand side engine compartment service door

The element should be replaced every 500 hours, or 20,000 miles (32,000 km). MCI/TMC recommend the use of Perry Filter PFC-22B (MCI/TMC P.N. 6F-8-131) replacement element.

To remove the filter element, close the two shut-off cocks at the filter mounting head and remove the old element.

Clean the area around the mounting head and install the



Figure 6-8. Surge Tank Sight Gauge.

replacement element. Be sure to follow the manufacturer's instructions when installing a new element.

Open the two shut-off cocks at the filter.

For the location of main cooling system components, refer to figure 6-9.

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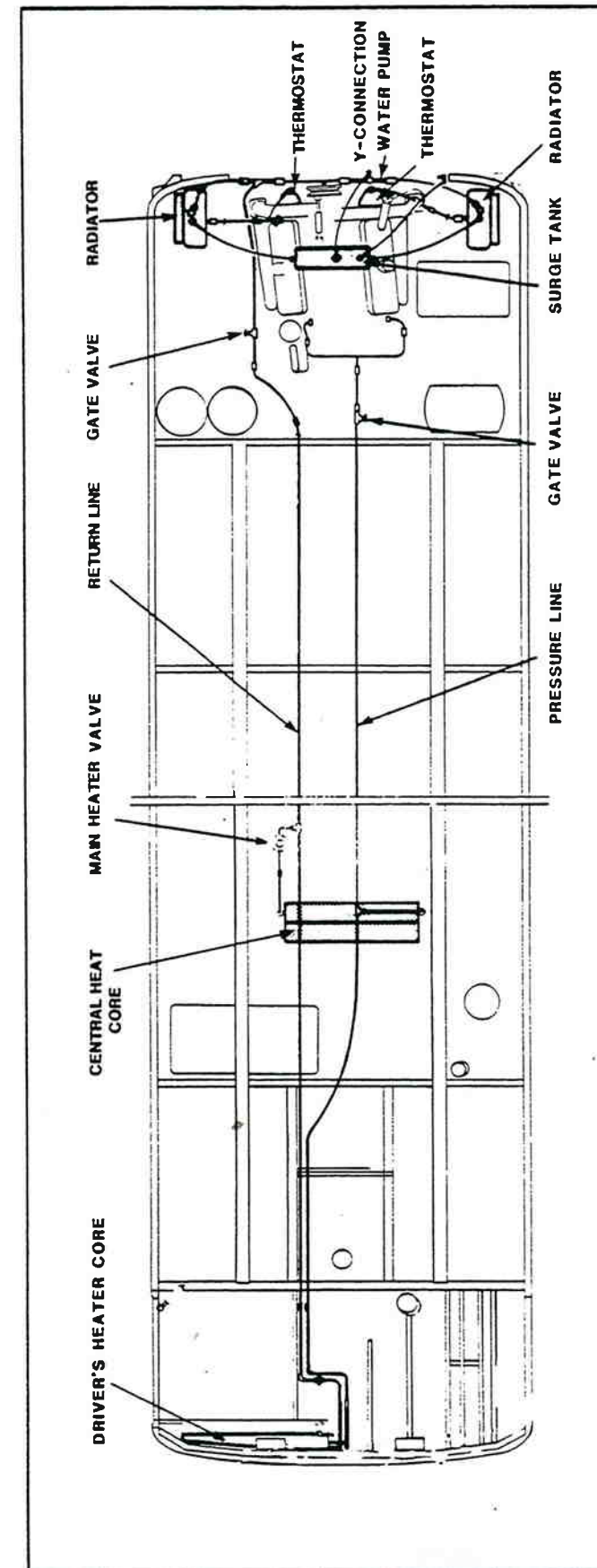


Figure 6-9. Cooling System Component Locations.