SERVICE MANUAL SECTION

ENGINE COOLING SYSTEM

s12003r, Formerly CTS-5071R

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DESCRIPTION

GENERAL

The purpose of the cooling system is to circulate the coolant, maintain efficient operating temperature and protect system components. About one-third of the energy produced when diesel fuel burns is converted into power by the engine. The remaining energy must be disposed of by the exhaust and cooling systems, or the engine components will be damaged by excessive heat and contamination. The cooling system's main components are:

COOLANT

The required coolant is a mixture of antifreeze and coolant conditioner (inhibitor or additive) with water. Refer to COOLANT(See COOLANT, page 20), for recommended antifreeze and conditioner properties and concentration levels.

RADIATOR

The radiator is the main component for cooling system heat dissipation. It is constructed of tubes to circulate the coolant, and fins to disperse excess heat. International uses two basic radiator configurations: Vertical Down Flow (Figure 1) and Horizontal Cross Flow (Figure 2). Refer to RADIATOR(See RADIATOR, page 4).

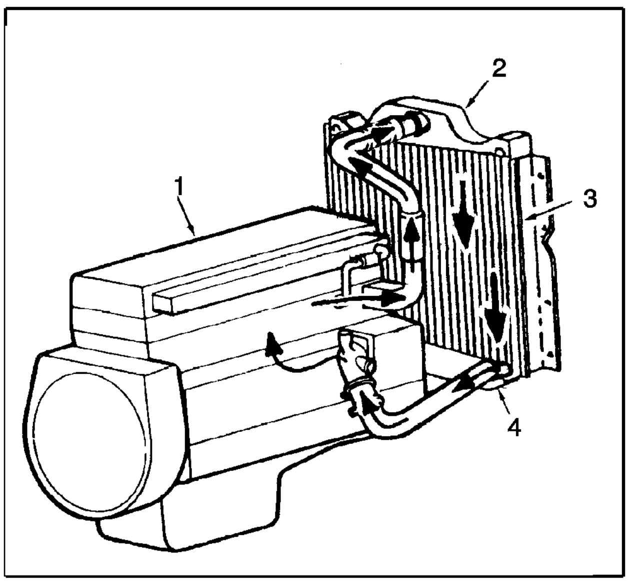

Figure 1 Vertical Flow Radiator

1. ENGINE
2. UPPER TANK
3. RADIATOR
4. LOWER TANK

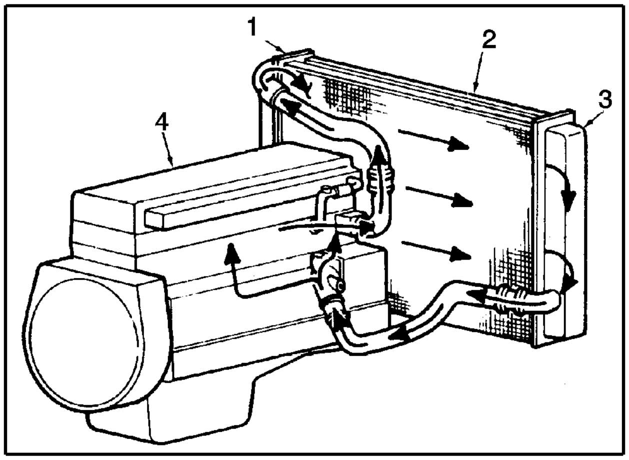

Figure 2 Horizontal Flow Radiator

1. LEFT TANK WITH INLET
2. RADIATOR
3. RIGHT TANK WITH OUTLET
4. ENGINE

WATER PUMP

The purpose of the water pump is to circulate coolant through the water jackets of the engine block and cylinder head(s), where the coolant accumulates engine heat.

THERMOSTAT

The flow of coolant is controlled by the thermostat, which restricts coolant (water) flow through the radiator during engine warm-up, and prevents overheating that can cause coolant loss and engine damage.

ENGINE FAN

The fan pulls air around the radiator tubes to transfer heat from the coolant and decrease coolant temperature. International uses two types of engine cooling fan drives, viscous and on/off.

Viscous Fan drive

The viscous fan drive is standard equipment on International medium-duty vehicles. It works by sensing air temperatures behind the radiator. A bi-metal spring in the fan drive assembly responds to the temperature, engaging the clutch when it is sufficiently hot, and disengaging the clutch when the temperature has lowered.

On/Off Fan Drive

The on/off fan drive is standard on International heavy-duty vehicles. It works by means of a temperature switch that senses coolant temperatures to regulate an air solenoid. The solenoid directs compressed air and engages the fan clutch friction drive when the coolant is hot. When the coolant temperature has lowered, a spring disengages the clutch.

CONTINUOUS DEAERATION SYSTEM

The continuous deaeration (air removal) system is made up of a remote-mounted deaeration (surge) tank, or reservoir, with external vent hoses from the radiator and engine, and a make-up line to the water pump (Figure 3).

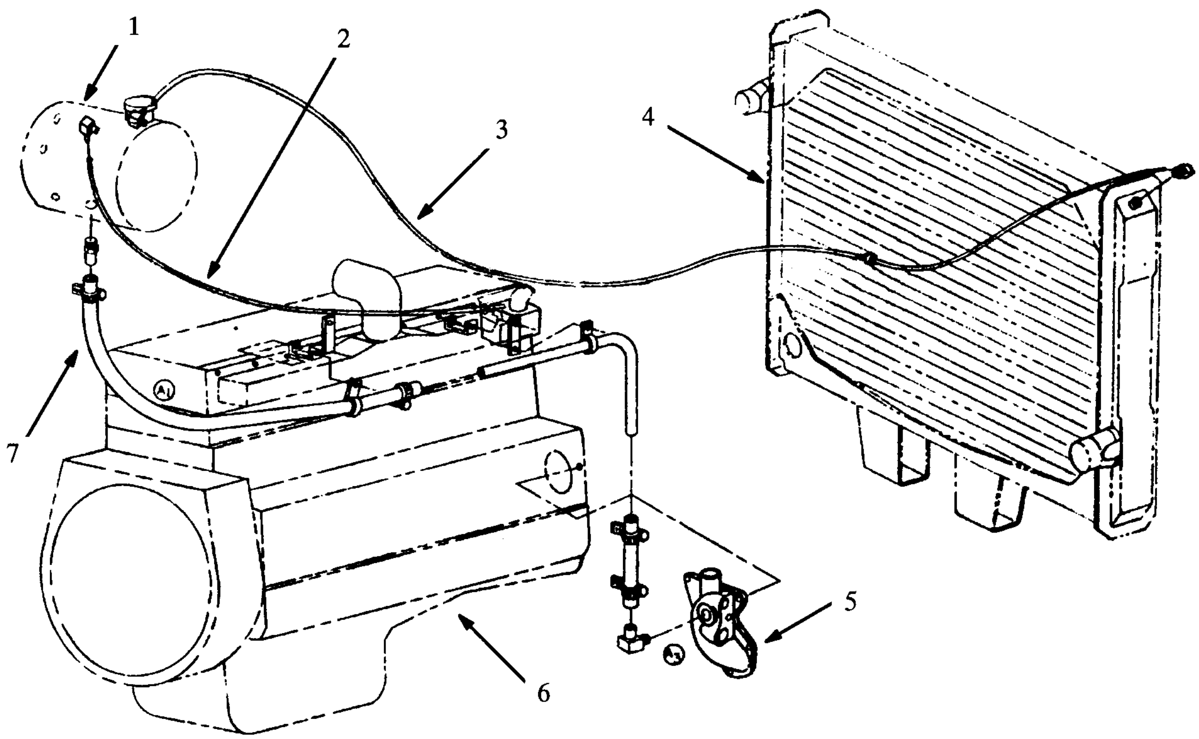

Figure 3 Continuous Deaeration System

1. DEAERATION (SURGE) TANK
2. ENGINE VENT HOSE
3. RADIATOR VENT HOSE
4. RADIATOR
5. WATER PUMP
6. ENGINE
7. MAKE-UP LINE

The main function of the continuous deaeration system is to continuously keep the cooling system free of trapped air. The deaeration tank removes air from the engine when it is cold and when the thermostat is closed. When the engine reaches operating temperature and the thermostat opens, air is also removed from the radiator.

PRESSURE CAP

The pressure cap is constructed with a spring-loaded valve that seats below the overflow pipe in the filler neck to prevent escape of air or coolant while the cap is in the lock-down position. When pressure rises to a predetermined point, the cap valve opens; when the pressure drops below this point, the cap valve closes (Figure 4).

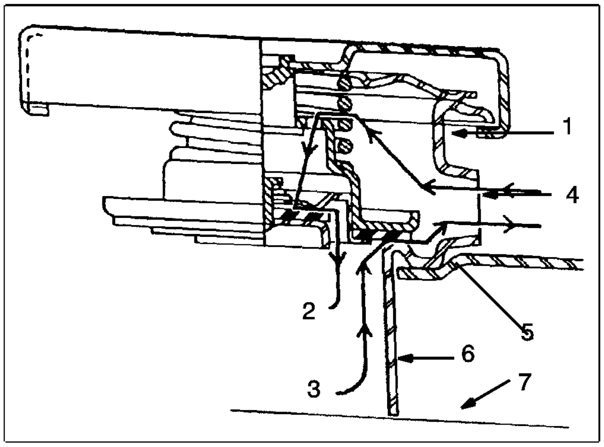

Figure 4 Pressure Cap

1. FILLER NECK
2. VACUUM INLET ROUTE
3. PRESSURE RELEASE ROUTE
4. OVERFLOW TUBE
5. COOLANT RESERVOIR
6. VENT TUBE
7. COOLANT LEVEL

TRANSMISSION OIL COOLER

Automatic Transmission

On vehicles with automatic transmissions, transmission oil is cooled by circulating it through a water-to-oil cooler (heat exchanger) that is located in the bottom radiator tank, or between the radiator and water pump.

Manual Transmission

Some International vehicles with manual transmissions use an air-to-oil cooling unit that may be located in front of the radiator, or inside the fan shroud.

1. OPERATION

1.1. RADIATOR

Vertical Flow (Down Flow)

Vertical refers to the direction of coolant flow through the radiator. The top and bottom tanks distribute coolant to the vertical tubes. The radiator outlet port is located in the lower tank and is connected to the water pump inlet. The radiator inlet port, located in the upper tank is connected to the engine outlet, allowing coolant flow when the engine thermostat is open (Figure 1).

Horizontal Flow (Cross Flow)

Horizontal refers to the direction of coolant flow through the radiator. The end tanks distribute coolant to the horizontal tubes. Radiator cross flow can be either left or right, depending on which tank is connected to the engine outlet. The radiator outlet is connected to the water pump inlet, and the radiator inlet is connected to the engine outlet, allowing coolant flow when the thermostat is open (Figure 2).

1.2. WATER PUMP

The water pump circulates coolant through the engine block water jackets and cylinder head(s), where it accumulates heat. Once the coolant is hot enough to open the thermostat, it flows through the radiator, where it is cooled by air blowing through the radiator fins.

Air trapped in the cooling system hastens corrosion of its components. Air expands more than water heated to the same temperature. This differential can cause coolant loss by expansion, through the overflow pipe. More important, trapped air can cause the water pump to lose its prime, which will stop the flow of coolant.

If coolant flow stops for even a short time, the engine will be in immediate danger of overheating. When the engine is operating at normal speeds, the piston rings can scuff, score or seize in a short period of time if the coolant flow stops. Coolant in the water jacket which is not circulating can boil at points of maximum heat transfer, which forces coolant out the overflow tube and causes the metal at the heat transfer points to overheat. This overheated condition destroys the film of lubricating oil in the cylinders, and expands the pistons, causing scoring. If the overheated condition is not immediately noticed, the engine will be severely damaged.

Damage from overheating shortens engine service life and causes high oil consumption, piston scoring and blow-by, especially on high mileage engines: 200,000 to 400,000 miles (320,000 to 640,000 km).

1.3. ENGINE FAN

Viscous Fan Drive

The viscous fan drive is a silicone fluid coupling. The silicone fluid must be driven at a certain speed before the fan blades will turn. A bi-metal spring reacts to changes in the air temperature behind the radiator, which activates a valve controlling the fluid level in the storage reservoir. The level outside the reservoir controls fan speed.

On/Off Fan Drive

When the on/off type of fan drive is ON, the engine coolant temperature decreases to a predetermined level. This temperature decrease causes the temperature switch to close, sending voltage that turns the fan drive OFF. When the coolant temperature rises again to a predetermined level, the temperature switch opens, which turns the fan drive ON.

1.4. CONTINUOUS DEAERATION SYSTEM

When the cooling system is filled through the pressure cap fill tube, coolant enters the main cooling system through the make-up line, from the deaeration (surge) tank to the suction side of the water pump. Coolant then fills the radiator core and engine from the bottom upward, forcing air out the vent tubes. The vent tubes connect from the radiator core and the engine side of the thermostat housing to ports located above the coolant level in the tank.

When the engine is running, there is a continuous small flow of coolant through the engine vent hose. Once the thermostat opens, there is also a small flow through the radiator vent hose. Any air in the coolant will separate when it reaches the reservoir and will eventually exit through the pressure cap.

Pressure Cap Removal

CAUTION – If the coolant should get extremely low and the engine gets very hot, let the engine cool for approximately 15 minutes before adding coolant. Then add coolant with the engine running. Adding cold coolant to a hot engine can crack the cylinder head or crankcase.

WARNING – Allow the engine to cool down before removing the pressure cap from the deaeration tank. ALWAYS INSULATE the cap by wrapping it with a thick, heavy cloth.

WARNING – To prevent possible injury from scalding water or steam, DO NOT pull the pressure cap off immediately when it has been loosened to the first "notch." Pause momentarily to allow time for excess pressure to release through the overflow tube.

1. Push the pressure cap down, then slowly turn it counter-clockwise to loosen it to the first "notch" position. PAUSE to observe the WARNING.

2. Continue to push down and turn the pressure cap counter-clockwise, then remove it. Keep your face away from cap opening.

2. MAINTENANCE

2.1. EFFECTS OF COOLING SYSTEM NEGLECT

Neglect of cooling system maintenance causes gradual damage, so the effects are often overlooked until major repairs are necessary. Many problems are caused by overheating, but overcooling is troublesome and more difficult to diagnose.

OVERHEATING can cause the following problems:

1. Burned valves.
2. Poor lubrication and increased engine wear.
3. Sticking valves and lifters.
4. Hot spots in the engine.

OVERCOOLING can cause the following:

A. Excessive fuel consumption.
B. Sludge formation in the crankcase.
C. Corrosive acid formation in the crankcase.

To maintain proper operation of the cooling system, install the correct replacement parts for service or repair. DO NOT use radiator cores, tanks or hoses other than those recommended.

NOTE – Check the coolant level daily. The sight glass marks the low coolant level. Correct as necessary.

2.2. FILLING THE COOLING SYSTEM

1. WHEN REPLENISHING THE COOLANT LEVEL, fill the surge tank up to the bottom of the fill tube. It is permissible to quickly fill the tank to overflowing. Filling slowly above the bottom of the fill tube wastes coolant by taking up the expansion volume in the top of the tank, so that when the engine warms up and the coolant expands, excess coolant will drain from the overflow tube.

2. WHEN FILLING AN EMPTY SYSTEM, follow Step 1, and use the following procedures to prevent air being trapped in the system.

   If the upper radiator pipe has a vent cock, open it long enough to allow air to escape. Running the engine at high idle (with the parking brake set) with the radiator covered, or normal road driving, until the engine thermostat has been open for a few minutes will get rid of air pockets.

With the engine still running, add coolant as required to bring the coolant level up to full.

2.3. SYSTEMS WITH LIQUID COOLANT CONDITIONERS

To replenish coolant conditioner on vehicles not equipped with a coolant filter, add Fleetrite conditioner. Refer to the OPERATOR'S MANUAL for proper intervals.

When the coolant and/or supplemental coolant conditioners are overconcentrated, excess silicate "drops out" of the coolant to form silica-gel (hydro-gel) on heat transfer surfaces such as oil coolers, radiators and heater cores. The gel restricts coolant flow and causes overheating.

The gel feels slick or putty-like when rubbed between the fingers. Its color depends on the color of the antifreeze/supplemental coolant additive. It can be blue to blue-green, or red to clear. When coolant evaporates, the gel becomes a white powdery substance. The only way known to remove silica-gel is to agitate the heat transfer component surfaces in a caustic solution.

CAUTION – DO NOT flush an engine with caustic solution. To do so will damage O-rings, gaskets, seals and "soft" metals such as aluminum and solder.

IMPORTANT – Antifreeze formulas made for automobile cooling systems have high silicate content to increase aluminum corrosion protection. Using automobile antifreeze can cause coolant overconcentration because they are not compatible with coolant additives commonly used for heavy-duty diesel cooling systems.

Overconcentration of coolant and/or supplemental coolant additives can cause water pump leakage. The powdery or granulated substance can coat water pump seal contact surfaces, allowing coolant to seep and be expelled at the water pump weep opening. This can be mistaken for a failed water pump seal.

Overconcentration problems can often be resolved by diluting the coolant with water, or by draining and flushing the cooling system, then adding new coolant. Refer to CLEAN AND INSPECT(See CLEAN AND INSPECT, page 14).

Use the following guidelines to avoid silica-gel formation.

1. Maintain antifreeze concentration level in the coolant at about 50% unless more freeze protection is required.

2. Use proper supplemental coolant additive levels; do not overconcentrate coolant conditioners.
3. With any supplemental coolant additive, use an antifreeze with 0.1 percent, or lower, of silicate in the additive package.
4. Do not mix hard water with coolant. Refer to COOLANT(See COOLANT, page 20).

NOTE – Completely drain, flush and refill with water and conditioner, or Fleetrite antifreeze and coolant once a year. This includes all vehicles, regardless of annual mileage.

NOTE – If the cooling system has become rusty or dirty, carefully clean the system with Fleetrite cooling system cleaner and neutralizer. Follow recommendations on the container. Refer to CLEAN AND INSPECT(See CLEAN AND INSPECT, page 14).

2.4. SYSTEMS WITH COOLANT FILTERS

IMPORTANT – The coolant filter on a new vehicle is equipped with a normal service element. The factory fill coolant contains a pre-charge of supplemental coolant additives. In combination with the service element, this provides full protection for the new engine.

CAUTION – Too frequent replacement of the filter element can cause silica-gel to form in the cooling system. This shows as slick gel, or when dry, as white, powdery residue on heat transfer surfaces.

Use a normal service filter element to replace the element after the first 12,000 miles (19,000 km). Make subsequent replacements at 10,000 to 12,000 miles (16,000 to 19,000 km) intervals, or as recommended in GROUP 12-ENGINE in the CTS-5000 Master Service Manual to maintain the required concentration. Change coolant filters if the engine coolant is changed.

CAUTION – Use coolant filters only with ethylene glycol antifreezes that do not contain anti-leak ("stop-leak") additives. The coolant filter element removes anti-leak additives, which can then restrict coolant flow from the filter. Do not use methanol or methoxy propanol (DowTherm 209) -based antifreeze, because it is not compatible with the treated service element.

CAUTION – When changing from older-style borate and chromate water filters, thoroughly drain, then chemically flush the cooling system with inhibited hydrochloric acid or inhibited oxalic acid. Then neutralize the cooling system before using the new-style filters.

Failure to do this prior to using new-style filters can cause plugged radiator and heater cores, and solder deterioration, because the new-style water filters can loosen cooling system scale.

2.5. TESTING COOLANT FOR CONDITIONER CONCENTRATION

Check the coolant for inhibitor effectiveness at each oil change. Use only the test kit prescribed for the inhibitor that is used. When conditioner concentration is too low, add Fleetrite cooling conditioner, change the cooling filter, or drain and change contaminated coolant, as applicable. Refer to COOLANT(See COOLANT, page 20).

> **CAUTION – Inadequate concentration of coolant additive can result in major corrosive damage to cooling system components. Overconcentration can cause silica-gel to form that can plug passages and cause overheating.**

2.6. ENGINE FAN

NOTE – For viscous fan drives, the only repair is replacement. Refer to GROUP 12-ENGINE, VISCOUS FAN DRIVE sections in the CTS-5000 Master Service Manual to determine if a viscous fan drive is faulty. Refer to GROUP 12-ENGINE, FAN DRIVE CLUTCH sections in the CTS-5000 Master Service Manual to determine if an on/off fan drive is faulty, and for repair procedures. On/off type fan drives and controls can sometimes be repaired.

Check the fan frequently for interference and foreign material. Clean the fan and the surrounding area as often as needed to keep it free of debris.

Discard and replace distorted or otherwise damaged fans. Check for damage to the radiator.

Be sure the fan shroud is tight against the radiator core to prevent air recirculation. Air recirculation lowers efficiency of the cooling system.

Fan Drive Belts and Pulleys

Check fan belts daily for proper tension. Refer to BELT TENSION(See BELT TENSION, page 18).

Abrasive material may wear on the pulleys, causing the belts to ride too low in the groove. Some pulleys may be reconditioned. V-belts are to sit above the level of the pulleys. Refer to BELTS(See BELTS, page 17).

Check all belts for cracking and excessive wear. Replace worn belts in sets matched by lot numbers, if applicable.

Clean oil or grease from the belts and pulleys to prevent belt slippage.

2.7. PRESSURE CAP

The pressure cap applies a minimum of 9 psi to the cooling system to raise the coolant boiling point, and to help prevent coolant being lost by evaporation and overflow. To check the integrity of the pressure cap, pressure test it with a cooling system tester. Refer to SPECIAL TOOLS(See SPECIAL TOOLS, page 23).

2.8. ADJUST SHUTTER OPENING

NOTE – Where shutters are used, adjust the shutter thermostat to open the shutters when the engine outlet coolant is 10°F. (5°C.) above the engine thermostat opening temperature.

Example: For a 170°F. (77°C.) thermostat, the shutters should start to open when the engine outlet temperature is 180°F. (82°C.). The shutters should be fully open when the outlet coolant temperature reaches 190°F. (88°C.).

2.9. THERMOSTAT TEST

Pull the thermostat and test its operation in a pan of water. Support the thermostat so it does not touch the bottom of the pan, then heat the water. Agitate the water during the test. Use an accurate high temperature thermometer/thermistor for the temperature readings.

The thermostat should be tightly closed/begin to open/be fully open at the temperatures listed in the chart for each operating mode. Replace the thermostat if it fails the test.

Thermostat Open/Close Temperatures

Table 1

Engine:	**Tightly closed below:**	**Begin to open at:**	**Be fully open at:**
International 7.3L	185°F. (85°C.)	185°F. (85°C.)	212°F. (100°C.)
International DTA-360, DTA-466	180°F. (82°C.)	180°F. (82°C.)	202°F. (94°C.)
International T444E	180°F. (82°C.)	180°F. (82°C.)	195°F. (91°C.)
International I-408	180°F. (82°C.)	180°F. (82°C.)	195°F. (91°C.)
International I-466	180°F. (82°C.)	180°F. (82°C.)	195°F. (91°C.)
International I-530	180°F. (82°C.)	180°F. (82°C.)	195°F. (91°C.)
Cummins L10 - M11	180°F. (82°C.)	180°F. (82°C.)	200°F. (93°C.)
Cummins N14	180°F. (82°C.)	180°F. (82°C.)	200°F. (93°C.)
Detroit Diesel Series 60 - 50	190°F. (88°C.)	190°F. (88°C.)	205°F. (96°C.)
Caterpillar 3176, 3406	190°F. (88°C.)	190°F. (88°C.)	208°F. (98°C.)

3. TROUBLESHOOTING

Table 2 Troubleshooting Chart

CONDITION	POSSIBLE CAUSE	REMEDY
Overheating	Radiator air flow restriction.	Clean debris from radiator fins, charge air cooler fins, AC condenser, air-to-oil transmission oil cooler.
		Open winter front in warmer weather, if so equipped.
	Fan and/or fan shroud missing or damaged.	Repair or replace.
	Loose or damaged drive belts.	Tighten or replace belts; refer to BELTS(See BELTS, page 17).
	Thermostat opening too late or not enough.	Refer to THERMOSTAT TEST(See THERMOSTAT TEST, page 9). Replace thermostat if defective.
	Temperature gauge reading incorrectly.	Replace gauge, sender and/or wiring.

Table 2 Troubleshooting Chart (cont.)

CONDITION	POSSIBLE CAUSE	REMEDY
	220°F. (104°C.) [overheat warning] light does not come ON at the proper temperature.	Replace temperature gauge, sender and/or wiring.
		Replace warning lamp.
	Radiator coolant flow restriction (dirt, corrosion, oil, silica-gel) inside tubes.	Clean out the radiator; refer to CLEAN AND INSPECT(See CLEAN AND INSPECT, page 14).
	Damaged radiator hoses or tubes.	Replace.
	Faulty water pump; leaking or corroded impeller or housing.	Replace pump.
	Low engine oil level.	Add engine oil.
	Engine power increased.	Upgrade cooling system.
	"Stiff" newly rebuilt engine.	Should adjust itself by accruing operating time.
	Viscous fan drive engaging later than needed with re-cored radiator.	Replace radiator to International specifications.
	Viscous fan drive not engaging.	Replace fan drive.
	On/off fan drive malfunctioning.	Repair drive or controls. Refer to GROUP 12-ENGINE, FAN DRIVE CLUTCH in the CTS- 5000 Master Service Manual.
		Replace fan drive.
	Damaged V-belt pulleys.	Recondition or replace.
	Excessive fan tip-to-shroud clearance.	1. Replace shroud if broken. 2. Replace fan if blades are worn or bent.
Overcooling	Thermostat missing.	Install correct thermostat.
	Leaking thermostat; will not close, or stuck open with foreign matter.	Refer to THERMOSTAT TEST(See THERMOSTAT TEST, page 9). Replace thermostat if defective.
	Temperature gauge reading incorrectly.	Replace gauge, sender and/or wiring.
	220°F. (104°C.) [overheat warning] light comes ON with temperature below 190°F. (88°C.)	Replace gauge, sender and/or wiring.
	Short runs or intermittent driving.	Warm up the vehicle adequately.
	Faulty viscous fan drive.	Replace fan drive.

Table 2 Troubleshooting Chart (cont.)

CONDITION	POSSIBLE CAUSE	REMEDY
	Faulty on/off fan drive.	Repair drive or controls. Refer to GROUP 12-ENGINE, FAN DRIVE CLUTCH section in the CTS-5000 Master Service Manual.
		Replace fan drive
	Vehicle has idled too long, water temperature not high enough.	Use correct start-up procedures. Refer to GROUP 12-ENGINE in the CTS-5000 Master Service Manual.
After-boil1	Overconcentration or underconcentration.	Correct the coolant; refer to COOLANT(See COOLANT, page 20).
	High temperature thermostat used with methanol antifreeze.	Change to approved antifreeze; refer to COOLANT(See COOLANT, page 20).
	Thermostat installed incorrectly.	Correct the installation.
	Broken thermostat.	Refer to THERMOSTAT TEST(See THERMOSTAT TEST, page 9). Replace thermostat if defective.
Coolant foaming2	Head gasket leaking.	Replace gasket.
	Radiator hose leaking.	Replace hose.
		Tighten clamps, or replace with smaller clamps
	Leaking water pump seal.	Replace the seal.
Coolant evaporation3	Use of methanol antifreeze.	Change to approved antifreeze; refer to COOLANT(See COOLANT, page 20).
Coolant overflow	Overheated engine.	Refer to EFFECTS OF COOLING SYSTEM NEGLECT(See EFFECTS OF COOLING SYSTEM NEGLECT , page 6).
	Radiator overfilled.	No action needed; system adjusts itself.
	Restriction in make-up line.	Straighten twisted line.
		Replace line tubing.
	Compressed air in cooling system.	Replace air compressor head gasket.
	Combustion gasses in cooling system.	Replace engine head gasket.
	Faulty pressure cap.	Replace pressure cap.
Internal leakage	Water-to-oil transmission oil cooler leaking.	Replace oil cooler.

Table 2 Troubleshooting Chart (cont.)

CONDITION	POSSIBLE CAUSE	REMEDY
	Cavitation erosion of components such as cylinder liners or O-rings.	Replace damaged parts.
		Adjust coolant conditioner level; refer to COOLANT(See COOLANT, page 20).
	Head gasket leakage.	Replace gasket.
	Fuel heater leaking.	Replace fuel heater.
External leakage	Loose hose clamps.	Tighten clamps.
	Defective hoses.	Replace.
	Leak at radiator drain.	Tighten plug, or apply fresh sealant.
		Replace plug.
	Radiator core leaking.	Repair or replace.
	Water jacket core plugs or drain plugs leaking.	Replace plugs.
	Pressure cap not sealing.	Replace cap assembly.
	Cracked engine block or cylinder head.	Replace defective part(s).
	Filler neck damaged.	Replace coolant reservoir.
Engine fails to reach normal operating temperature	Incorrect thermostat.	Replace with a thermostat having the proper range for the application.
	Leaking thermostat; will not close coolant flow, or stuck open with foreign matter.	Refer to THERMOSTAT TEST(See THERMOSTAT TEST, page 9). Replace thermostat if defective.
		(The engine will not warm up properly if accessories such as heaters, air compressors or cooling system water filters are not connected correctly. Do not connect accessories so that outlet coolant flows to the radiator core. Do not connect accessories to the make-up line, because it is not large enough to carry excess coolant).
1 After-boil is the condition of coolant boiling after the engine is shut off (even though boiling did not occur during operation), because coolant is still picking up heat from the engine that cannot be dispersed through the radiator. This condition is most common in cooling systems needing service.		
2 Foaming is caused by air or an engine exhaust gas leak into the cooling system. Because of its excellent insulating properties, foam seriously interferes with circulation.		
3 Evaporation causes low coolant levels. Refer to Coolant Overflow, Internal Leakage and External Leakage on this page for other causes of coolant loss.		

4. CLEAN AND INSPECT

4.1. RADIATOR COMPONENTS

Radiator Tanks

Look for leaks, particularly where the tubes join the headers. Vibration, and heating and cooling cycles can fatigue soldered seams.

Tubes (Core)

Because the radiator tubes are very small, they can become clogged or partially blocked by rust and scale. The general condition of the cooling system and the operating temperature level are indications of the state of cleanliness of the tubes.

Fins

These thin metal sheets radiate, or pass off, the heat picked up from the circulating coolant by the tubes. Keep the fins free of bugs, leaves, straw and other interference to allow free passage of air. Straighten bent fins for maximum efficiency.

4.2. DEAERATION TANK

Filler Neck

The sealing seat must be smooth and clean. Cams on the filler neck must not be bent or worn, as this will not allow the cap to seal properly. Ensure that the overflow tube is not plugged.

4.3. DRAINING THE SYSTEM

Drain the cooling system once a year. Thoroughly flush the system with water, then refill. Refer to FILLING THE COOLING SYSTEM(See FILLING THE COOLING SYSTEM, page 7). If necessary to clear a clogged radiator core, refer to RADIATOR COMPONENTS(See RADIATOR COMPONENTS, page 14) .

Shipping or Storing Engine

Some cooling systems do not drain out completely. Residual amounts of coolant may be trapped in "pockets," especially in engine tube bundles used with an oil cooler or a heat exchanger. Residual coolant made up of only water and a minimal amount of antifreeze — with or without conditioner — can freeze and cause one or more of the tubes to rupture if exposed to freezing temperatures. The resulting leak will be difficult to locate, and can allow coolant to mix with engine oil when the engine is put back into service.

Use one of the following methods to properly prepare the engine for storage or shipment.

1. Fill the cooling system with antifreeze solution, operate the engine until the thermostat opens or until circulation is observed in the radiator core, then drain the cooling system.

2. If conditioned water has been used, drain the engine. Then blow out the residual solution in the cooler tubes with compressed air through one of the drain cocks or plugs in the cooling system.

4.4. CLEANING THE SYSTEM

If coolant is not conditioned with corrosion inhibitor, rust and scale will eventually clog up passages in the radiator and water jackets. In some places, the local water composition causes insoluble salt formations that aggravate radiator clogging.

General

1. Open the coolant shut-off cocks to heaters and other accessories to allow complete circulation during cleaning, flushing and draining.

2. Run the engine until the temperature is up to operating range of 160 to 180°F (71 to 82°C). If necessary, cover the radiator to increase the operating temperature. Stop the engine and remove the pressure cap.

> **WARNING – Allow the engine to cool down before removing the pressure cap from the deaeration tank. ALWAYS INSULATE the cap by wrapping it with a thick, heavy cloth. To prevent possible injury from scalding water or steam, DO NOT pull the pressure cap off immediately when it has been loosened to the first "notch." Pause momentarily to allow time for excess pressure to release through the overflow tube.**

3. Open the drain cocks on the radiator and crankcase to drain the coolant from the system. Disconnect the radiator outlet hose to drain sediment that is too large to pass through the drain cock.

4. Be certain the engine has cooled completely, then install the radiator outlet hose, and close the drain cocks.

5. Pour cleaning solution into the radiator, then fill the system with water. Use a clean drain pan to catch any overflow. Avoid getting cleaning solution on vehicle paint; wipe up spills promptly.

6. Install the pressure cap, then run the engine at moderate speed until the radiator reaches 180°F (82°C), or above.

   If necessary, cover the radiator to increase the operating temperature, but DO NOT allow the cleaning solution to boil.

7. Run the engine until the circulating solution has effectively cleaned the cooling system — AT LEAST TWO HOURS. Check the radiator and replenish the solution level as necessary to maintain circulation.

   DO NOT allow the radiator level to get low enough to interfere with circulation in the cooling system.

DO NOT allow the cleaning solution to boil. Stop the engine as necessary to prevent boiling.

DO NOT drive the vehicle.

8. When the cleaning process is done, stop the engine. Observe the operating temperature; when it has come down and remained stable for several minutes, drain the cooling system.

IF THE CLOGGED RADIATOR CORE IS CLEARED, fill the cooling system. Refer to FILLING THE COOLING SYSTEM(See FILLING THE COOLING SYSTEM, page 7).

IF THE CLOGGED CORE IS RELIEVED, but not yet fully corrected, allow the engine to cool completely, pressure-flush the system, then repeat this cleaning procedure. Refer to PRESSURE FLUSHING THE SYSTEM(See PRESSURE FLUSHING THE SYSTEM , page 16) .

IF THE CLOGGED CORE IS NOT RELIEVED, the radiator core will have to be replaced.

Inspect Engine Water Jacket

CORE PLUGS: Replace core plugs that show signs of leaking or rusting through. Refer to GROUP 12-ENGINE in the CTS-5000 Master Service Manual for core plug replacement.

DRAIN PLUGS: The drain plugs located in the water jacket should receive seasonal care and be kept free of rust and scale.

GASKETS: Gaskets must be in good condition to prevent both internal and external leaks. External leaks around gaskets may indicate there are also internal leaks in the engine. Tighten the head bolts properly with a torque wrench to prevent leaks around the head gasket.

> CAUTION – **Do not use chemical mixtures to stop radiator leaks except in an emergency. Never use such solutions in place of performing necessary radiator repair.**

4.5. PRESSURE FLUSHING THE SYSTEM

NOTE – Pressure-flush conditioned cooling systems every two years.

1. Disconnect from the radiator the hose joining the engine water outlet. Remove the thermostat from the engine water outlet.
2. **For the reverse flushing inlet:** Clamp a suitable length of hose to the radiator outlet.
3. Secure the flushing gun to the hose clamped to the radiator outlet.
4. **For the reverse flushing outlet:** Clamp another suitable length of hose to the radiator inlet.
5. With the system pressure cap tight and the flushing gun nozzle clamped securely to the hose, fill the radiator and engine block with water. Partly cover the engine water inlet so the jacket will fill completely.

   Apply pressurized air in short bursts to loosen sediment in the cooling system. Continue filling with water and applying air until the flushing stream comes out clear.

   > CAUTION – **To avoid damaging the radiator core, apply the pressurized air in short bursts.**

   NOTE – For badly clogged engine water jackets that do not respond to regular pressure flushing, remove the engine cylinder head and the core plugs. Flush the water jackets through the openings with a suitable length of small copper tubing attached to the flushing gun nozzle.

6. For a vehicle equipped with a heater connected to the cooling system, flush the heater using the same procedure as for the radiator.
7. Visually inspect the water pump. If lubricant is dripping from the water pump weep hole, replace the bearing seal. If coolant is dripping from the weep hole, replace the water seal. **Slight drainage of either lubricant or coolant is normal. Continuous flow (dripping) indicates excessive wear on seals.**

On vehicles equipped with International engines, the fan drive mounts on the water pump shaft or pulley. Use the following procedure to test the water pump bearings: grasp one fan blade tip, and move it back and forth from the radiator. Any movement of the water pump pulley indicates failure. Replace the bearings.

8. Clean out the radiator overflow pipe. Clean the thermostat and the pressure cap control valve. Check the thermostat for proper calibration before installation. Refer to THERMOSTAT TEST(See THERMOSTAT TEST, page 9).

9. Blow debris, insects and dirt off the radiator core air passages, using water if necessary.

5. BELTS

Two basic types of drive belts are used with International engines, V-belts and flat belts.

International approves Fleetrite heavy duty truck belts in applications requiring a wedge belt (V-belt), and Fleetrite V-ribbed drive belts for applications requiring a flat belt.

5.1. V-BELTS

V-belts have a wedge-shaped profile in the following common configurations (Figure 5).

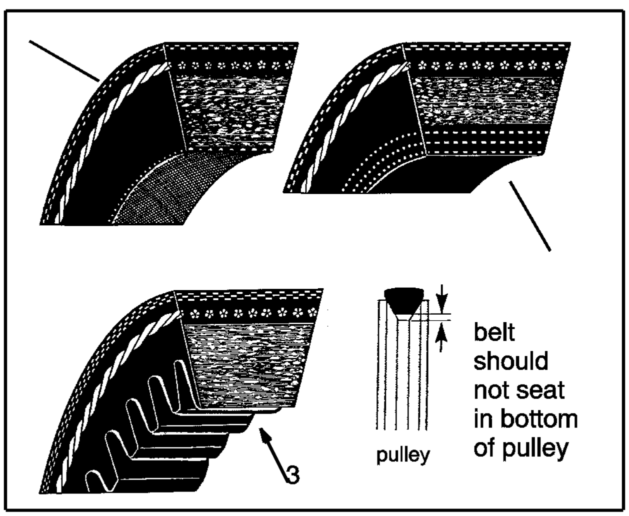

Figure 5 V-Belt Cross-Sections

1. PLAIN HEAVY BELT
2. LAMINATED BELT
3. COG BASE BELT

PLAIN HEAVY BELT - General purpose belt of standard raw edge construction, composed of cable cords and fiber-loaded elastomer.

LAMINATED BELT - Well suited for intermittent and/or heavy loads, because it allows momentary slip relief to reduce heat and shock demands.

COG BASE BELT - Ideal for small pulley diameters or short belt lengths, for maximum flexibility and the stability of full belt depth.

5.2. FLAT BELTS

Flat belts are thin, flexible and light weight. They have high width-to-thickness ratio for good belt-to-pulley surface contact, and perform well at high speeds with minimal wear. Flat belts are available in two standard cross-sections: English and metric rib sizes (Figure 6). Refer to the Flat Belt Size Chart(See Flat Belt Size Chart, page 18).

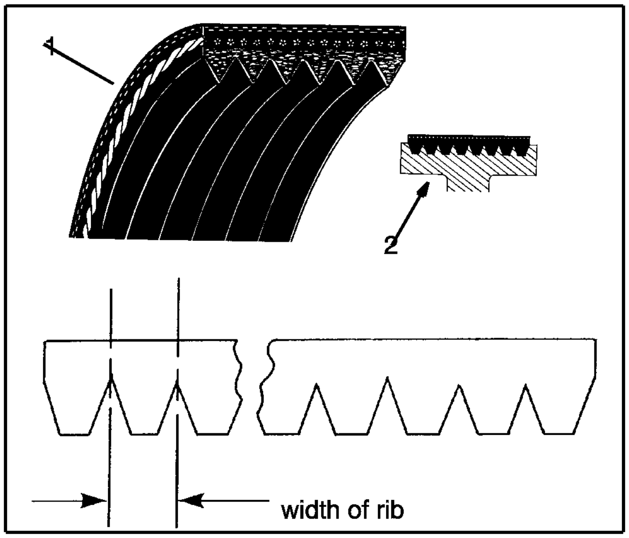

Figure 6 Flat Belt Cross-Section

1. FLAT BELT
2. PULLEY

Flat Belt Size Chart

Table 3 Flat Belt Size Chart

Flat Belt Size Chart	
English Size System	Metric Size System
"K" section =	"PK" section =
0.140 inch wide rib	3.56 mm wide rib
"L" section =	"PL" section =
0.185 inch wide rib	4.70 mm wide rib

5.3. BELT TENSION

NOTE – Manual re-tensioning is not needed on belts equipped with a spring-loaded automatic tensioner/idler (Figure 7).

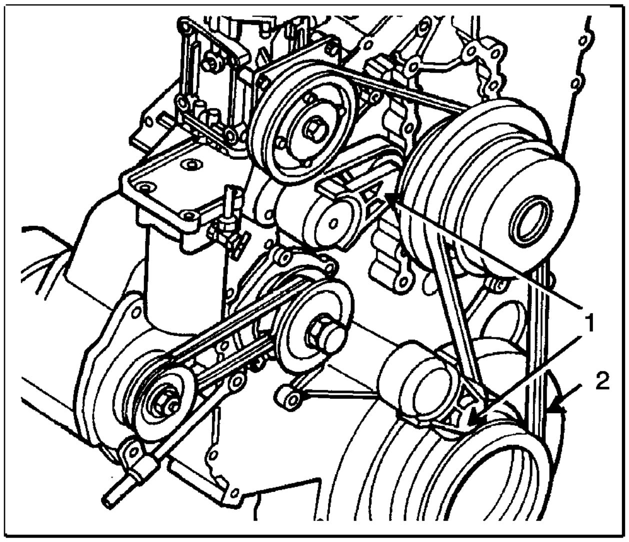

Figure 7 Spring-Loaded Automatic Tensioners

1. AUTOMATIC TENSIONER
2. FLAT BELT

NOTE – If a belt cannot be run immediately after installation, manually rotate the drive a few revolutions to relieve tension on the edge cord.

Belt Tension Schedule

To minimize numerous belt adjustments, and to prevent new belts turning at low tension, use the recommended higher initial tension value when installing a new belt.

Re-tension the belt to the recommended lower value range when it has become seated in the groove(s) — after being run for about five minutes. After that, re-tension belts to the recommended lower value AS REQUIRED, or BY SCHEDULE, after the first 1,000 miles (1,609 km) of use, and thereafter at 5,000 mile (8,045 km) intervals. Refer to the Belt Tension Chart(See Belt Tension Chart, page 19) for tension values.

Belt Tension Chart

Table 4 Belt Tension Chart

Belt Tension Chart			
V-	Initial		100 lbs.
Belt	Re-Tension		70 lbs.
Flat	Initial		25 - 40 lbs. per rib
Belt	Re-Tension		20 lbs. per rib

Recommended Practice For V-Belts

For multiple belt drives, use replacement belt sets that are matched by lot number. Replace all the belts on a drive at the same time. Refer to the BELT TENSION SCHEDULE(See Belt Tension Schedule, page 19).

Recommended Practices For Flat Belts

Refer to the Examples below, and the BELT TENSION SCHEDULE(See Belt Tension Schedule, page 19).

NOTE – English Unit Example: To calculate the total tension for a 6-ribbed flat belt, multiply the recommended pounds (lbs.) PER RIB x 6 [ribs]. Refer to the Belt Tension Chart(See Belt Tension Chart, page 19).

Initial Recommended Tension Range is 25 to 40 lbs. PER RIB: 25 lbs. [PER RIB] x 6 [ribs] = 150 lbs. lower limit total belt tension; 40 lbs. [PER RIB] x 6 [ribs] = 240 lbs. upper limit total belt tension. The proper range of initial total tension for a NEW 6-ribbed flat belt is 150 to 240 lbs.

Re-tension USED flat belt to 20 lb. PER RIB: 20 lbs. [PER RIB] x 6 [ribs] = 120 lbs. total tension for a USED 6-ribbed flat belt.

WHEN TO RE-TENSION: When belt tension is found to be 10 to 15 lbs. PER RIB [60 to 90 lbs. total tension for a 6-ribbed flat belt], or by BELT TENSION SCHEDULE(See Belt Tension Schedule, page 19).

6. COOLANT

CAUTION – Water alone is not an effective or safe coolant for engine components. An approved antifreeze or inhibitor must be added to the water to prevent rust, scale and deposits.

NOTE – Do not use "softened" water from a system using common salt (sodium chloride). This water contains too much chloride, and can interfere with the action of coolant filters.

6.1. ANTIFREEZE

To protect systems against freezing, International engines require low silicate, ethylene glycol-based antifreeze that is compatible with coolant filters. Use the following guidelines.

1. International cooling systems are designed to perform with coolant of about 50% antifreeze concentration. Levels below 40% or above 60% can cause problems typical with under- or over-concentration. However, for arctic service, antifreeze concentration can be as high as 68%.
2. The Coolant Antifreeze Percentage Chart(See Coolant Antifreeze Percentage Chart, page 20) shows the freezing point of antifreeze by its percentage (level of concentration).

Coolant Antifreeze Percentage Chart

Table 5

Coolant Antifreeze (Ethylene Glycol Based) Percentage Chart		
Freezing Point °F (°C)	Percentage Antifreeze Concentration by Volume	Specific Gravity @ 60°F (16°C)
+32 (0)	0	1.000
+20 (-7)	15	1.025
+10 (-12)	25	1.040
0 (-18)	33	1.053
-10 (-23)	40	1.062
-20 (-29)	45	1.070

Coolant Antifreeze (Ethylene Glycol Based) Percentage Chart		
Freezing Point °F (°C)	Percentage Antifreeze Concentration by Volume	Specific Gravity @ 60°F (16°C)
-30 (-34)	48	1.074
-40 (-40)	53	1.080
-50 (-46)	56	1.088
-60 (-51)	59	1.092
-70 (-57)	62	1.095
-80 (-63)	65	1.097
-90 (-68)	67	1.098
-92 (-69)	68	
NOTE: As shown below, a further increase in antifreeze volume raises the freezing point.		
-80 (-63)	71	1.100
-70 (-57)	75	1.106
-60 (-51)	79	1.110
-50 (-46)	83	1.113
-40 (-40)	87	1.117
-30 (-34)	91	1.119
-18 (-28)	95	1.123
- 8 (-22)	100	1.127

1. Coolant with antifreeze retains freeze protection qualities for more than one season, but to maintain corrosion protection, you must add coolant conditioner at recommended intervals.
2. Do not use antifreeze containing sealers or anti-leak additives with International engines, because these additives can plug the cooling system and restrict coolant flow.
3. Methanol or methoxy propanol-based antifreeze (DowTherm 209) is not recommended for use with International engines.
4. Propylene glycol-based antifreeze is acceptable for use with International engines.
5. Recycled coolant has not been approved for use with International engines.

6.2. CONDITIONERS

Cooling system conditioners become depleted during normal vehicle operation. Coolant solution with depleted conditioners can attack and coat (corrode) the surfaces of metal components, reducing heat transfer. To protect cooling system components, periodically add inhibitors. Use the type of coolant conditioner specified for the vehicle: liquid or coolant filter. Refer to MAINTENANCE(See MAINTENANCE, page 6).

Current Fleetrite and factory-installed supplemental coolant additives use the phosphate/molybdate/nitrite chemistry (DCA-4 type). It has these features:

COMPATIBILITY with low-silicate antifreeze, minimizing the formation of silica-gel that can affect heat transfer and coolant flow if the antifreeze concentration level is too high.

PROTECTION of the following areas: solder corrosion, solder bloom, aluminum corrosion, liner cavitation, liner corrosion, oil fouling, copper and brass stress cracking, and seal and gasket degradation.

6.3. SUPPLEMENTAL COOLANT ADDITIVES (SCA'S)

Supplemental coolant additives (SCA's) are important to insure long diesel engine life. Their primary function is to protect the cylinder wall from cavitation erosion (pitting). Secondarily, they bolster the anti-corrosion additives in antifreeze.

In order to insure a uniform concentration level of SCA at time of vehicle delivery, International has recently started to incorporate the SCA in factory fill antifreeze. A combination of quality water, proper percentage of antifreeze and the correct amount of SCA is called FULLY FORMULATED COOLANT.

On or about January 1, 1994, the coolant filter element will be standardized as a four unit service filter for all engines, in lieu of the 12 or 15 unit precharge filters that were previously used.

International's "Fleetrite" filters for OEM and service utilize the "DCA4" formulation of SCA. When using the "DCA4" additives, concentration should be maintained at 1.2 to 3.0 units per gallon when tested with the "DCA4" test kit.

International realizes that some customers prefer "Nalcool" coolant additive. "Nalcool" is completely compatible with "DCA4." When using "Nalcool" as the coolant additive, concentration should be maintained at 800 to 2400 ppm of nitrite when tested with the "Nalcool" test kit.

SCA levels should be maintained by regular coolant filter changes and/or liquid SCA additions to properly maintain the SCA level. Coolant should be tested a minimum of twice a year. When excessive coolant loss occurs and coolant is replaced, dilution of the SCA results. If excessive coolant loss is suspected, coolant should be tested and adequate SCA added to make up for chemical lost due to dilution. **Low levels of SCA's will result in engine cylinder or cylinder wall cavitation erosion.**

Coolant Additive Test Kit

FLEETRITE COOLANT ADDITIVE CONCENTRATION TEST KIT CCR-8-2700

This kit will test the coolant for additive units providing the best chemical protection. The kit can test either DCA or DCA-4 type additives.

NOTE – Kits for the old-style borate additives cannot be used for the new style DCA-4 type additive. New Fleetrite coolant filters use DCA-4 type additive— phosphate/molybdate/nitrite-based.

7. SPECIAL TOOLS

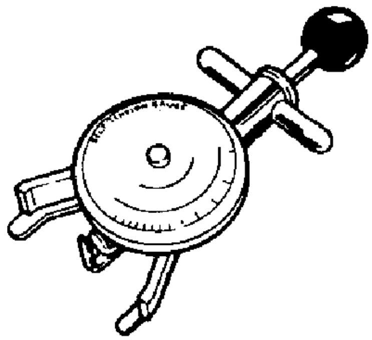

Figure 8 ZTSE2312

Belt Tension Gauge Figure 8 - This gauge is designed and calibrated to accommodate all 3/8 inch through 3/4 inch width main drive and accessory drive belts.

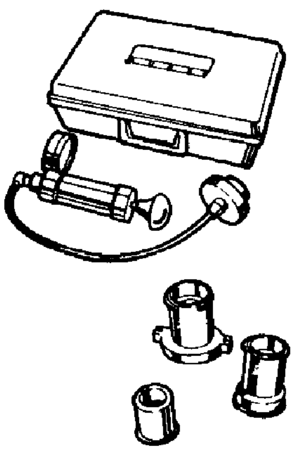

Figure 9 ZTSE2384

Portable Manually Operated Cooling System & Radiator Cap Tester Figure 9 - Quickly and easily allows you to check pressure caps and cooling systems on standard-type trucks. The easy-to-read pressure gauge tells in seconds if the cap is in good condition and whether the cooling system leaks. The gauge allows testing from 1 to 30 pounds pressure. The pump action is much faster and easier to operate than a bulb-type tester. Includes adapter for (2 11/16 inch O.D. "B" size) caps and longer filling necks.

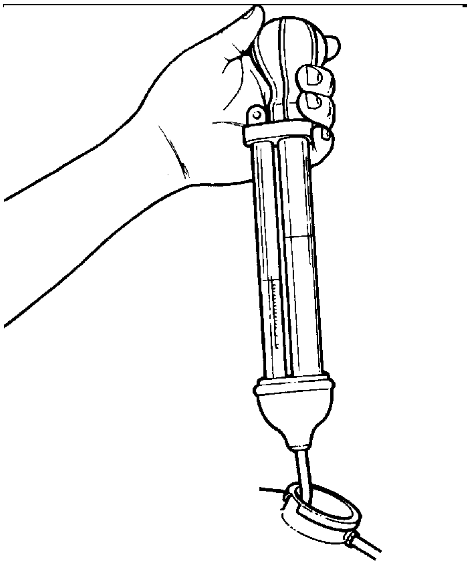

Figure 10 OEM1043

Coolant Tester Figure 10 - Summer and winter universal tester for all types of antifreeze solutions. Hermetically sealed chart and thermometer keep out moisture and dirt and stay legible always. Special heat-treated glass components resist breakage. Float and thermometer are rubber cushioned for durability.

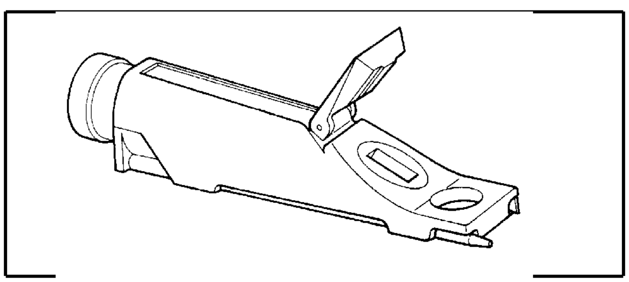

Figure 11 OEM1044

Battery and Antifreeze Tester Figure 11 - A tester designed for quick and accurate checking of antifreeze protection and battery specific gravity readings. Only a few drops of coolant or battery acid are required to take an accurate reading. Checks coolant hot or cold. The heavy die-cast body is covered with a protective vinyl housing for long, accurate performance. Scale for reading measurement is easily read. Tester includes two plastic tubes for obtaining coolant or acid samples and complete operating instructions.