Cooling System

Description

Kenworth Trucks are standard with Shutterless Cooling. Optional, Shutter-Controlled Cooling is recommended, for operations where ambient temperatures fall below 17° C (0° F) for sustained periods.

With Shutterless Cooling, the operating temperature of the engine is controlled by a full- blocking thermostat (no bleed hole) and the radiator fan. The fan may be directly belt-driven, or mounted to a viscous or automatically engaging fan hub.

Like Shutterless Cooling, the Shutter-Controlled Cooling System employs a thermostat and thermo-modulating or air-controlled shutters. The thermostat allows the engine to quickly reach operating temperature. When the operating temperature is reached, the shutters help maintain proper engine coolant temperature.

Trucks equipped with shutters and air conditioning use an air-operated shutter override as part of the air conditioning protection system. When refrigerant pressure builds up excessively in the air conditioning system, the override opens the shutters and engages the automatic fan, if installed, to maximize air flow around the grilldenser (condenser) elements. When the refrigerant is cooled sufficiently, the pressure is reduced and the override system switches off.

Maintenance Schedule

Daily or as required	20,000 km (12,000 miles)	Spring and Fall
• With the engine off and engine temperature cool: • Check coolant level. See Step 1. • Check for leaks at the following areas with the engine running: ***WARNING! Thermatic type fans may engage suddenly without warning. Keep clear of fan blades and all drive belts.*** Heater and radiator hoses Radiator top and bottom tank Water pump input shaft (at pulley) • With the engine off, check fan belt & hose condition.	• With the engine off and engine temperature cool: • Check & adjust fan belt tension • Check antifreeze concentration • Recharge coolant conditioner. See Step 2. • Check hose clamps for tightness • Check for secure radiator supports and brackets. • Clean debris from radiator core fins	• Clean cooling system See Step 3. • Replace "spongy" or deteriorated radiator hoses. See Step 4. • Replace worn V-belts. • Clean and lubricate shutter mechanism (if fitted). See Step 5.

Steps

1. **Standard System / Low Flow System**

   With the engine cold, coolant should be at the proper level. See Figure 12-1 and Figure 12-2. Do not overfill. Replacement coolant should have the same proportion of antifreeze and corrosion inhibitor as the coolant in the system.

   Recovery System

   Do not remove the radiator cap. Scalding hot coolant could cause injury. Add coolant to the recovery tank only. See Figure 12-3. The upper mark is the Hot Fill Level. The lower mark is the Cold Fill Level. Top up the tank according to engine temperature.

2. The coolant conditioner should be recharged every 16 000-19 000 km (10,000-12,000 miles) or every 250 hours of operation unless specified otherwise in the engine manufacturer's maintenance manual. See "Servicing Coolant Conditioner" on page 4.

3. Semi-annual cleaning is satisfactory for most operations if the cooling system is properly maintained.
4. Check the installation of new V-belts and hoses after operating the engine several hours. V- belts and hose clamps must be at proper tension.
5. If shutter equipped, use a dry-type aerosol lubricant on the linkage. Refer to the section on Vernatherm or air-operated shutters.

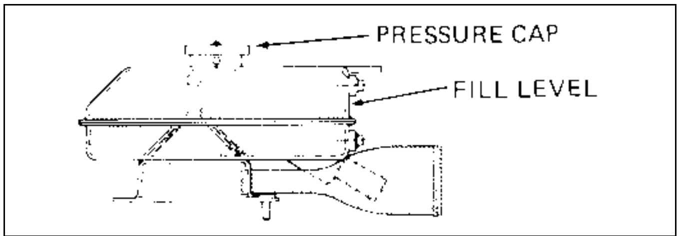


Figure 12-1

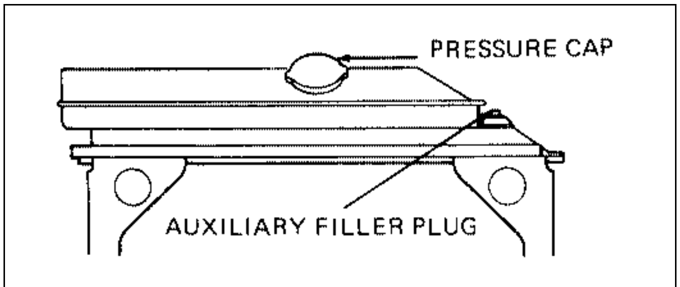


Figure 12-2

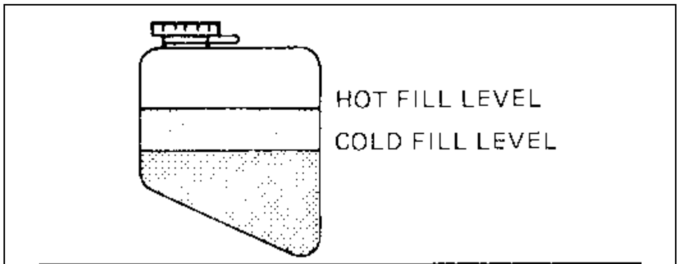


Figure 12-3

Draining—Cleaning—Refilling

Draining

1. Open the heater valve.
2. Remove the radiator cap.

   WARNING! Use extreme caution when removing the radiator cap if the engine has been operated within the previous thirty minutes. Scalding hot coolant could cause injury.

3. Open the radiator and engine block drain taps and drain the system.
4. Empty the expansion tank, if installed.

Cleaning

The cooling system must be clean. Scale in the system slows heat absorption from the water jackets and heat dissipation from the radiator.

Chemical Cleaning

Scale and sediment can clog:

- Radiator core
- Heater core
- Oil cooler
- Block passages

To prevent clogging, chemically clean, neutralize and flush the system.

CAUTION: Do not attempt to clean an Ad-Tech radiator core using caustic cleaning solutions unless the plastic tanks are first removed. Immersing the plastic tanks in a caustic cleaning solution can damage the tanks and O-ring gaskets.

Rust inhibitors can become contaminated and lose their effectiveness. If rust and scale have collected, the system must be chemically cleaned. Use a good quality commercial cooling system cleaner, followed by a neutralizer and flushing. For specific instructions on the use of a chemical cleaner, always refer to the procedure recommended by the supplier. Oxalic Acid or Sodium Bisulfate may be used as a cleaner. Approximately one pound may be used in solution per five gallons of water. Run the engine one-half to one hour. Partial covering of the radiator may be necessary to maintain a desirable temperature. Drain and flush until the water is clear. Fill the cooling system with a solution of approximately one half pound of Sal Soda (neutralizer) per ten gallons of water and nun the engine ten minutes. Drain, flush and refill with coolant.

Pressure Flushing

After chemical cleaning, pressure-flush the radiator and block for the following conditions:

- When adding or removing antifreeze.
- Before installing a DCA water filter on a used engine.
- To purge debris from clogged coolant passages.

This operation requires the use of a flushing gun having air and water fittings. Set the air pressure to 550 kPa (80 psi).

When pressure-flushing the radiator:

1. Open the upper and lower hose connections and screw the radiator cap on tight.
2. Attach the flushing gun nozzle to the lower hose connection and let the water run until the radiator is full.
3. Gradually apply air pressure to avoid damage to the core
4. Shut off air and allow the radiator to refill; then reapply air pressure.
5. Repeat this process until water coming from the radiator is clean.

Sediment and dirt settle into pockets in the block as well as the radiator core. To flush the block:

1. Remove the thermostat.
2. Flush the block with water.
3. Partially restrict the lower opening until the block fills.
4. Apply air pressure and force water from lower opening.
5. Repeat this process until the water coming from the block is clean.

Refilling

Standard System

1. Check that the radiator and engine-block drains are closed.
2. Move the heater control to maximum heat position.
3. Remove the surge tank pressure cap.
4. Fill the system through the surge tank with premixed coolant in an uninterrupted flow until the radiator is full.
5. Start the engine.
6. Idle at low RPM.
7. Complete the filling as quickly as possible.
8. Idle the engine for several minutes.
9. Fill as necessary to raise coolant level to proper level.
10. Replace the surge tank pressure cap.

Check coolant level after each trip when the engine has cooled. Add coolant as necessary. Time must pass for all the entrapped air to be purged from the system.

Low Flow System

The two-pass radiator has two filler locations. See Figure 12-2.

After the cooling system has been drained, open and fill radiator at both locations. Either location may be filled first.

IMPORTANT: The system will retain a large a large air pocket if both locations are not filled. Do not attempt to pressure fill this system.

WARNING! Never remove the 1/2 inch pipe plug filler when the engine is in operation or if the system has not been depressurized.

Recovery System

1. Check that the radiator and engine-block drains are closed.
2. Move the heater control to maximum heat position.
3. Fill the radiator completely.
4. Replace the radiator cap.
5. Fill the recovery tank with coolant to the COLD FILL level.
6. Operate engine until it reaches normal operating temperature and no more air bubbles appear in the recovery tank.
7. Add coolant until reaching the HOT FILL level.
8. Replace the recovery tank cap.

NOTE: After a complete refill the engine must be operated and cooled five or six times before all the air is purged from the system and the coolant level is stabilized.

Coolant

Water

Use water that is clean and free as possible from scale forming minerals and such corrosive chemicals as Chloride, Sulfates and acids. Refer to your engine maintenance/operation manual for specific recommendations.

Antifreeze

Use sufficient low silicate Ethylene Glycol antifreeze as required by the temperatures encountered. Follow the supplier's instructions. Refer to your engine maintenance/operation manual for specific recommendations.

The maximum efficient low silicate Ethylene Glycol antifreeze concentration for low temperature operation is 68%, concentrations exceeding 68% low silicate Ethylene Glycol offer less low temperature protection. See Figure 4. However, to avoid possible overheating in very hot weather, do not use mixtures with more than 50% low silicate Ethylene Glycol antifreeze except in areas where protection below -36° C (-34° F) is required.

A standard Ethylene Glycol hydrometer can be used to check the cold weather protection level of the coolant.

Ethylene Glycol Antifreeze % By Volume	Temperature Protection	
	Deg. C	Deg. F
0	0	32
10	- 4	24
20	- 9	16
30	- 15	4
40	- 24	- 12
50	- 36	- 34
60	- 47	- 63
68	- 68	- 92
70	- 65	- 85
80	- 49	- 57
90	- 35	- 31
100	- 16	4

Figure 12-4 Antifreeze (Ethylene Glycol) Protection Levels

NOTE: For system capacities refer to the Cooling System Section in the Operation and Service Manual or to Part man's Aid 38-1.

Coolant Conditioner

Coolant conditioners that inhibit corrosion and formation of scale in the cooling system are required for Cummins and Caterpillar engines and are recommended for Detroit Diesel engines. Either a DCA (dry chemical additive) water filter or a liquid conditioner (Nalcool 3000) is used in Kenworth cooling systems. These chemical additives neutralize acids to prevent corrosion, keep salt minerals in suspension to prevent scale and suppress air bubble formation to prevent cavitation corrosion.

See engine manufacturer's operation/maintenance manual for specific recommendations on other rust, corrosion and scale inhibitors.

IMPORTANT: Do not add rust inhibitors, radiator sealers or water pump lubricants containing soluble oil. These can make the DCA corrosion resistor ineffective.

Servicing Coolant Conditioner

DCA Filters

DCA spin-on filters should be serviced every 16000-19000 km (10,000-12,000 miles) or after 250 hours of operation, unless specified otherwise in the engine manual.

DCA Service Filters used with Methoxy Propanol (Dowtherm 209) are different from those used with Ethylene Glycol antifreeze:

- Use WF2010 Service Filter with Ethylene Glycol.
- Use WF2011 Service Filter with Methoxy Propanol (Dowtherm 209).

Nalcool 3000

Nalcool 3000 coolant conditioner should be added to the cooling system every 16 000-19 000 km (10,000-12,000 miles). Adding 1 pint of this liquid conditioner per 20 gallons of system capacity is usually sufficient to maintain the proper chemical concentration.

Make-Up Coolant

If make-up coolant is added frequently to the system, the coolant should be treated with DCA liquid or dry. The concentration of DCA inhibitor in the coolant may be checked periodically to insure that it is adequate. Fleetguard DCA Coolant Checking Kit No. 3300846S or a Nalcool 3000 test kit may be used. This is a simple nitrate color test requiring only a few minutes to perform.

Precharging The System

If a DCA filter is used, each time that the cooling system is drained precharge the system with a DCA precharge element or DCA direct additive. Follow the instructions on the container.

DCA chemical is available in three forms for charging a clean, freshly filled cooling system.

- Spin-on Precharge Filters. See Figure 12-5.
- Dry DCA Corrosion Inhibitor. See Figure 12-5
- Liquid DCA Corrosion Inhibitor. See Figure 12-6.

Spin-on Precharge Filters are not available with DCA inhibitor proportioned for use with Dowtherm 209 protected systems. Cooling systems using Dowtherm 209 must be precharged with the dry or liquid DCA inhibitor. Dry DCA must be diluted when precharging a system using Dowtherm 209. Follow the instructions on the container.

Cooling System Capacity	Initial or Precharge Filter
0-8 Gallons	WF2012
8-15 Gallons	WF2013
15-30 Gallons	WF2014

Figure 12-5 DCA Precharge Filters (Ethylene Glycol Systems)

Cooling System Capacity (Gallons)	4 to 7	8 to 11	12 to 15	16 to 19	20 to 23	24 to 27	28 to 31
Number of DCA4 (Dry) or DCA4L (Liquid) Bottles Required to Precharge Cooling System (Plus Service Filter)	0	1	2	3	4	5	6

Figure 12-6 Dry and Liquid DCA Precharge Requirements

Temperature Specifications

This section specifies temperature settings for shutters and automatic fan hubs to provide proper sequencing with engine thermostat temperature ranges, and to reduce operating time of automatic fan hubs.

DETROIT DIESEL / CUMMINS (without low flow cooling)

NOTE: Temperatures shown are for top tank or engine water outlet unless otherwise stated. Radiator bottom tank or engine water inlet temperatures are approximately 5.5° C (10° F) cooler.

COMPONENT	ACTUATION TEMPERATURE (RISING TEMPERATURE)	RESET TEMPERATURE (FALLING TEMPERATURE)
Cummins Engine Thermostat	82.2° C (180° F) Starts To Open 93.3° C (200° F) Fully Open	--------------
Detroit Diesel Engine Thermostat	82.2° C (180° F) Starts To Open 90 5° C (195° F) Fully Open	--------------
Air Shutters with Clutching Fan Hub (Bottom Tank Temperature)	79.4 ± 1.1° C (175 ± 2° F)	76.1 ± 1.1° C (169 ± 2° F)
Air Shutters with Viscous Fan Hub (Bottom Tank Temperature)	71.1 ± 1.1° C (160 ± 2° F)	67.7 ± 1.1° C (154 ± 2° F)
Vemathemm Shutters (Bottom Tank Temperature)	77.7° C (172° F) Starts To Open 86.6° C (188° F) Fully Open	-------------
Bendix, Horton and Kysor Fan Hubs (All Models Except W900B)	90.5 ± 1.1° C(195 ± 2° F)	86.1 ± 1.1° C(187 ± 2° F)
Horton Fan Hub(W900B)	90.5 ± 1.1° C (195 ± 2° F)	86.1 ± 1.1° C(187 ± 2° F)
Bendix and Kysor Fan Hubs (W900B)	90.5 ± 1.1° C (195 ± 2° F)	87.2 ± 1.1° C (189 ± 2° F)
Rockford Fan Hub	87.2° C (189° F) Starts To Engage 94.4° C (202° F) Fully Engaged	84.4° C (184° F) Fully Disengaged
Kysor Performance System	87.7± 1.1° C (190± 2° F) Shutters Open	84.4 ± 1.1° C (184 ± 2° F)

NOTE: Fan engages and disengages at constant 2.7° C (5° F) above shutters.

CATERPILLAR 3306, 3406,3408

NOTE: Temperatures shown are for top tank or engine water outlet unless otherwise stated. Radiator bottom tank or engine water inlet temperatures are approximately 5.5° C (10° F) lower

COMPONENT	ACTUATION TEMPERATURE (RISING TEMPERATURE)	RESET TEMPERATURE (FALLING TEMPERATURE)
Engine Thermostat:	87.7 ± 1.1-1.7° C (190 ± 2-3° F) Starts To Open 97.7° C (208° F) Fully Open	-------------
Shutterstats: Air Shutters with Clutching Fan Hub (Bottom Tank Temperature	85.0 ± 1.1° C (185 ± 2° F)	81.7 ± 1.1° C (179 ± 2° F)

CATERPILLAR 3306, 3406,3408

NOTE: Temperatures shown are for top tank or engine water outlet unless otherwise stated. Radiator bottom tank or engine water inlet temperatures are approximately 5.5° C (10° F) lower

COMPONENT	ACTUATION TEMPERATURE (RISING TEMPERATURE)	RESET TEMPERATURE (FALLING TEMPERATURE)
Air Shutters with Viscous Fan Hub (Bottom Tank Temperature)	79.4 ± 1.1° C (175 ± 2° F)	76.1 ± 1.1° C (169 ± 2° F)
Vernatherm Shutters (Bottom Tank Temperature	77.7° C (172° F) Start To Open 86.6° C (188° F) Fully Open	-------------
Fanstats: Bendix, Horton and Kysor Fan Hubs	96.1 ± 1.1° C (205 ± 2°F)	91.7 ± 1.1° C (197 ± 2° F)
Rockford Fan Hub	83.4° C (194° F) Starts To Engage 93.3° C (200 ° F) Nominal 97.2° C (207° F) Fully Engaged	87.2° C (189° F) Fully Disengaged
Kysor Performance System	93.3 ± 1.1° C (200 ± 2° F) Shutters Open	90.0 ± 1.1° C (194 ± 2° F) Shutters Open

NOTE: Fan engages and disengages at constant 2.7°
17C (5° F) above shutters.

Cooling System

CUMMINS BC III, BC IV LFC, L10, L10 LFC

COMPONENT	ACTUATION TEMPERATURE (RISING TEMPERATURE)	RESET TEMPERATURE (FALLING TEMPERATURE)
Thermostats: BC III & L10	82.2° C (180° F) Start To Open 93.3° C (200° F) Fully Open	-------------
BC IV LFC: Bypass Thermostat (Normally Open)	71.1° C (60° F) Start to Close 85.0° C (185° F) Fully Closed	-------------
Radiator Thermostat (Normally Closed)	79.4° C 175°F) Start To Open 90.5° C (195°F) Fully Open	-------------
L10 LFC (One Thermostat Controls Radiator and Bypass Flow Valves): Radiator Flow Valve (Normally Closed)	79.4° C (175°F) Start To Open	-------------
Radiator Bypass Valve (Normally Open)	79.4° C (175°F) Start To Close 85.0° C (185°F) Full Closed	-------------
(1) Shutterstats: Air Shutters with Clutching Fan Hub: BC IV LFC & L10 LFC	85.0 ± 1.1° C (185 ± 2°F)	81.7 ± 1° C (179 ± 2° F)
BC III & L10	79.4 ± 1.1° C (175 ± 2° F)	76.1 ± 1° C (169 ± 2° F)
Air Shutters with Viscous Fan Hubs: BC IV LFC & L10 LFC	73.8 ± 1.1° C (165 ± 2° F)	70.5 ± 1.1° C (159 ± 2° F)
BC III & L10	71.1 ± 1.1° C (160 ± 2° F)	67.8 ± 1.1° C (154 ± 2° F)
Vernatherm Shutters (Not available for LFC or any T600 engines)	77.7° C (172° F)Start To Open 86.6° C (188° F) Fully Open	-------------
(2) Fanstats: Bendix, Horton and Kysor Fan Hubs	93.3 ± 1.1° C (200 ± 2° F)	90.0 ± 1.1° C (194 ± 2° F)
Rockford Fan Hub (Not available for BC IV LFC)	87.2° C (189° F) Start To Engage 90.6° C (195° F) Nominal 97.4° C (202° F) Full Engaged	84.4 ° C (184° F) Fully Disengaged
Kysor Performance System BC IV LFC & L10 LFC	85.0 ± 1.1° C (185 ± 2° F) Shutters Open	81.7 ± 1.1° C (179 ± 2° F) Shutters Close
	93.3 ± 1.1° C (200 ± 2° F) Fan Engages	90.0 ± 1.1° C (194 ± 2° F) Fan Disengages
BC III & L10	90.5 ± 1.1° C (195 ± 2° F) Shutters Open	87.2 ± 1.1° C (189 ± 2° F) Shutters Close
	93.3 ± 1.1° C (200 ± 2° F) Fan Engages	90.0 ± 1.1° C (194 ± 2° F) Fan Disengages

(1) SHUTTER LOCATIONS:

BCI II & L10 Lower Engine Water Inlet
BC IV LFC Upper Engine Manifold
L10 LFC Engine Thermostat Housing

(2) FANSTAT LOCATIONS:

BC III& L10 LFC Engine Thermostat Housing

L10 Upper Engine Water Outlet
BC IV LFC Upper Engine Manifold

Engine Temperature Control

Sensing Unit	Location	Control Function
Vernatherm	Radiator Bottom Tank	Shutter Control
Thermostat	Top Engine Outlet	Engine Coolant Flow

Figure 12-7 Sensing Location and Function

Efficient engine operation depends upon properly functioning temperature sensing units.

A thermostat that is stuck closed or opens only partially may cause engine overheating. A stuck- open thermostat may cause the engine to run too cold.

Temperature sensing units suspected of malfunctioning should be tested or replaced. The location and function of sensing units are shown in Figure 12-7.

The procedure for testing temperature sensing units is generally more time consuming and expensive than replacing units that are suspected of malfunctioning. Before testing the performance of a unit, examine it for obvious signs of a failure:

1. Check for loose or worn electrical connections.
2. Check for loose or leaking air hose.
3. Check for linkage binding in shutters.
4. Inspect the thermostat seat area for deposits or pitting.
5. Inspect the thermostat for proper seating.

   NOTE: The seating area should appear lightly polished.

6. Inspect the valve action of the thermostat. Replace the thermostat if the valve can be pulled or pushed off its seat with slight effort when the thermostat is cold.

NOTE: When replacing the temperature sensing unit, always use a new seal and gasket

Testing The Thermostat

Thermostat "begin-opening" and "full-open" temperatures for normal operation are listed below in Figure 8. Properly functioning thermostats are accurate within ± 1.5° 17C (3°F).

NOTE: Always check the actual "begin-opening" temperature stamped on the thermostat before testing the unit Engine operating conditions may necessitate thermostat temperature ranges other than those listed in the table below.

ENGINE	BEGIN OPENING	FULL OPEN
Caterpillar	88 +1 -2° C (190 + 2-3° F)	97.7° C (208° F)
Cummins	82° C (180° F)	93° C (200° F)
DDA	82° C (180° F)	90° C (195° F)

Figure 12-8 Thermostat Temperature Ranges

1. Suspend the thermostat and thermometer in a container of water as shown in Figure 12-9. Do not allow the thermostat or thermometer to touch the container.

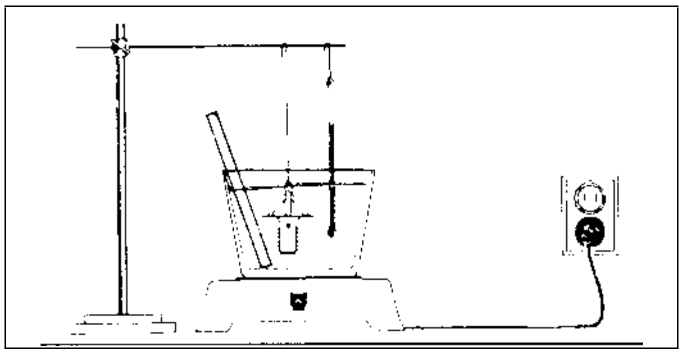


Figure 12-9 Thermostat Testing

2. Stir the water to maintain temperature uniformity while slowly heating the water to the thermostat's rated "start-opening" temperature (usually stamped on the thermostat body).
3. Observe the thermostat's "start-open" temperature. The thermostat should open within tolerance of the temperature listed in Figure 12-8 or stamped on the thermostat body.
4. Continue slowly heating the water to the "full- open" temperature rating of the thermostat and stabilize the water temperature.
5. After several minutes have elapsed (allowing thermostat travel to stabilize), measure the "full-open" travel of the thermostat. The "full-open" travel should comply with the data in Figure 12-10.
6. Replace the thermostat if it does not operate as described above.

ENGINE	MINIMUM FULL-OPEN TRAVEL
Cat. 3406 Cat. 3408 Cat. 3306	9.53 mm Min. (.375" Min.)
Cat. 3208	9.65 mm Min. (.380" Min.)
Cummins	9.53 mm Min. (.375" Min.)
DDA	9.53 mm Min. (.375" Min.)

Figure 12-10 Thermostat Mimimum “Full Open” Travel

Perry Low-Coolant Indicator

The optional low-coolant indicator provides a warning when the coolant in the radiator drops below a safe level.

The warning system consists of:

- A sensitized carbon probe located in the radiator header tank.
- A solid-state control module.
- A warning light.

If the coolant level in the radiator drops below a safe level, the probe transmits an electrical impulse to the control module. The module then triggers the warning light in the cab, alerting the driver of a potentially serious low-coolant situation.

CAUTION: Some radiator stop leak compounds containing aluminum powder will cause the system to malfunction.

Checking The System

Each time that the starter motor is engaged for an engine start, the warning light comes on as long as the key or button is held on START. This provides an automatic check on the system.

Troubleshooting

The following conditions may cause the warning light to come on (excluding the automatic system check and low coolant level):

1. The use of radiator stop-leak compounds containing aluminum powder.
2. Disconnection of the wire leading from the probe to the control module. Refer to the Modular Wiring Diagram Book.
3. Damaged probe.
4. Frozen coolant.

NOTE: An intermittent light indicates sloshing of coolant at a low level.

If the warning light does not come on when cranking the starter, check:

- Light bulb filament
- Wiring connections
- Fuse
- Control module continuity
- Probe

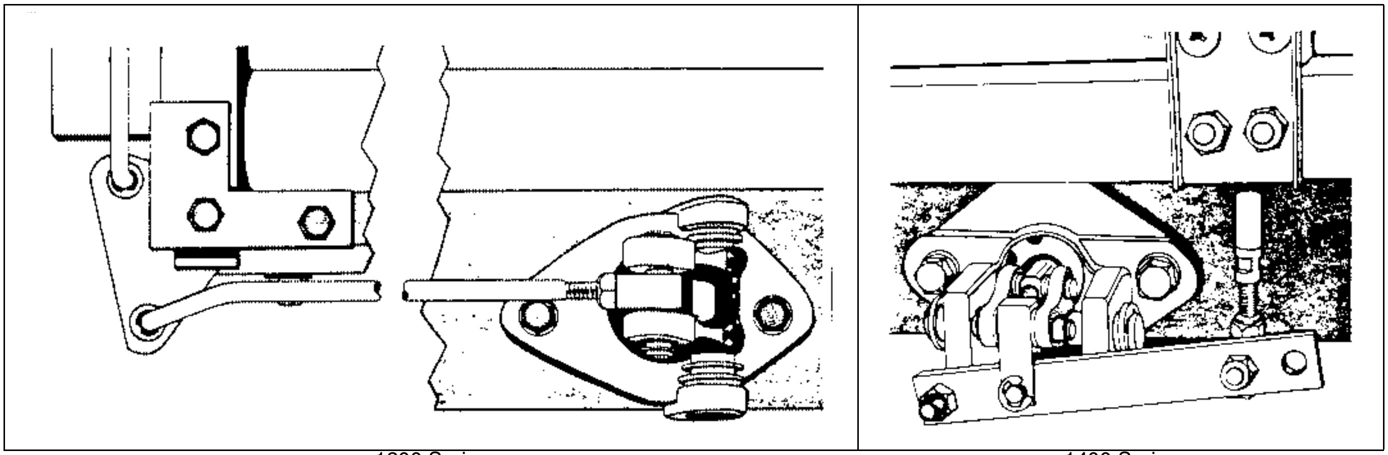
IMPORTANT: If the control module must be replaced, specify negative or positive ground.

Preventive Maintenance

Check the condition of the wiring and connections annually for weak areas and loose or dirty contacts. When cleaning the cooling system, remove probe from header tank. Inspect for damage or deposit build-up. Clean carefully and install.

Cooling System

Vernatherm-Controlled Shutters



1200 Series

1400 Series

Figure 12-11

Thermo-modulating shutters are controlled by Vernatherm power elements which generate their own power as the engine coolant temperature increases. Normal position of the shutters is "closed" whenever the coolant temperature is below the engine operating temperature. The shutter opens only the amount necessary to maintain constant engine temperature. Shutter action is gradual and proportional to engine cooling requirements.

Linkage Adjustment

Adjustment is made to compensate for loss of motion in the linkage, created by normal wear.

With the engine cold, the pull rod turnbuckle must be adjusted so the shutters are just closed with a small amount of free travel in the pull rod. The adjustment can be made by means of the following procedure:

1. With the engine cold (under 66° C, 150° F), manually open the shutters by pushing down on the bellcrank. Insert a strip of paper between the shutter vanes. See Figure 12-12. Release the bellcrank, letting the shutter snap shut on the paper.

   NOTE: On some shutter models, the bellcrank and adjusting sleeve are located between the front bumper and radiator grille. They can be easily reached without tilting the cab or hood. On models where the adjusting sleeve is located on the right side of the radiator, it is necessary to tilt the cab or hood in order to reach the adjusting sleeve.

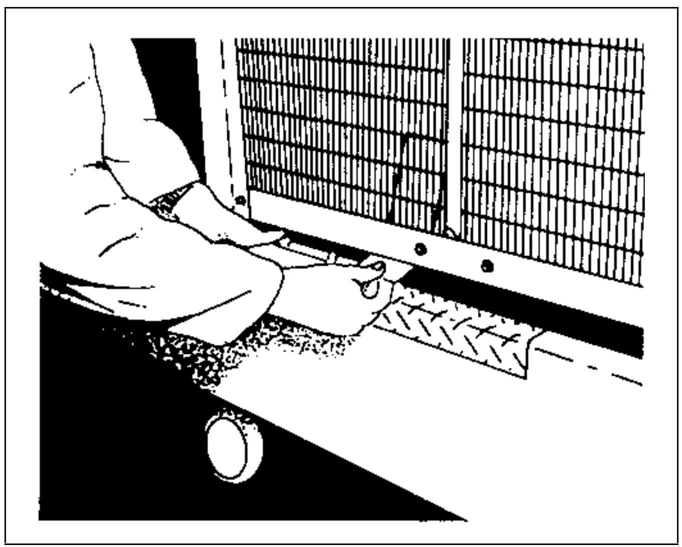


Figure 12-12 Inserting Paper Between Vanes

2. With an open-end wrench, screw the turnbuckle clockwise until the vanes begin to open slightly and the paper can be pulled from between the vanes with slight resistance. See Figure 12-13.

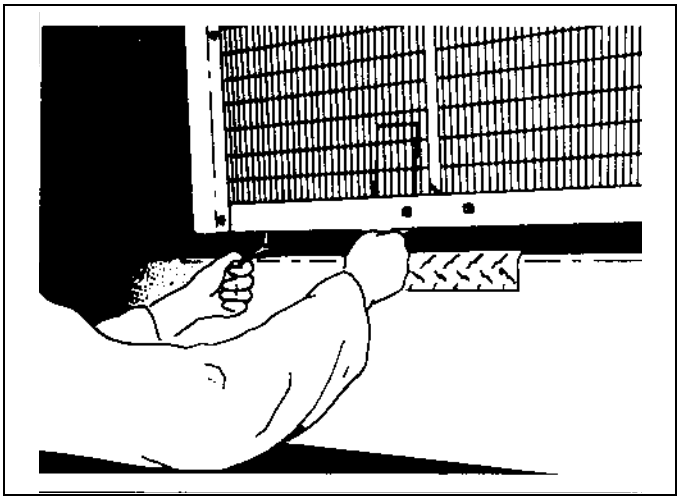


Figure 12-13 Linkage Adjustment

3. Check several times to verify that there is only slight resistance when the paper is pulled from the vanes.
4. Now screw the turnbuckle counterclockwise two complete turns to obtain 2.3 mm (.090 in.) free travel in the pull rod. This provides the necessary free-travel for the power element during engine warm-up. With shutters having the turnbuckle located on the right side, screw the turnbuckle counterclockwise only one turn to obtain the 2.3 mm (.090 in.) free-travel.

   NOTE: To determine if there is actually free travel slide the bellcrank and shaft assembly from side to side. If the bellcrank and shaft cannot be moved sideways, there is no free-travel and the shutter should be readjusted.

5. Manually open the shutter and release slowly to see if there is any binding in the linkage. If the shutter sticks open, turn the adjusting sleeve back and forth slightly until the vanes snap shut.
6. Test the shutter several times by opening it and letting it snap shut. The shutter should snap shut freely, with no binding.

   If binding persists, check the following:

- Verify that the shutter frame is mounted squarely and not damaged.
- Check linkage for interference.
- Verify that the vanes have sufficient end clearance, not to exceed 1.5 mm (1/16 in.). End clearance can be adjusted by loosening screws on the side of the frame that hold the bearing angles. Hold the bearing angles in the correct position and retighten the screws.

Vernatherm Power Unit Adjustment

After removing or replacing the power unit, readjust the setting of the unit. See Figure 12-14.

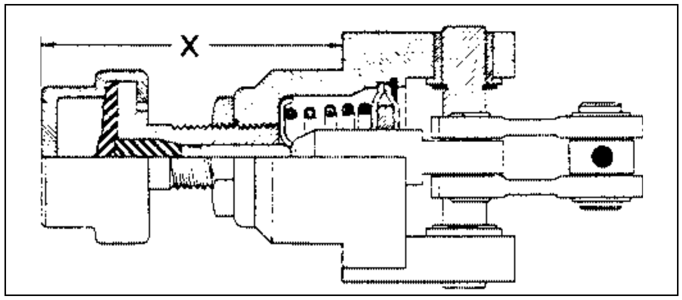


Figure 12-14 Vernatherm Element Setting

To adjust, loosen the jam nut and screw the power unit in or out to achieve the proper "X" dimension shown in Figure 12-15.

Radiator Area, Sq. In.	Vernatherm Element No's.	ELement Setting (Dim. '8: Fig. 3)
970 1200 1360	137, 380, 381, 383	75 mm (2-15/16 in.)
1150 1270 1400	377, 379	79 mm (3 1/8 in.)

Figure 12-15 Vernatherm Element Setting

IMPORTANT: When replacing the power unit, install a new "O"ring and lubricate the piston with silicone lubricant (Evans Part No. 3940). If the piston is removed from the power unit, carefully note if the smell white disc (anti-friction washer) is stuck to the lower end of the piston. If so, reinsert this disc into the power unit

Temperature Balance

If a higher or lower coolant temperature is required due to extreme conditions, a Vernatherm power unit of the next higher or lower rating may be tried.

NOTE: Verify that the cooling system is functioning properly:

Cooling System

Operating temperature ranges for optional Vernatherm power units are listed below in Figure 12-16. The temperatures listed represent bottom-tank coolant temperatures. This is the temperature of the coolant surrounding the Vernatherm power unit

Vernatherm Power Unit No's.	OPERATING TEMPERATURES	
	Closed	Full-Open
137 (Std.)	77° C (170° F)	85° C (185° F)
377	78° C (172° F)	87° C (188° F)
379 (Std.)	72° C (162° F)	81° C (178° F)
380	78° C (172° F)	87° C (188° F)
381	81° C (177° F)	89° C (193° F)
383	72° C (162° F)	81° C (178° F)

Figure 12-16 Operating Temperatures of Vernatherm Power Units

There is an approximately 5° to 7° C (10° to 14° F) temperature drop between the top-tank coolant and the bottom-tank coolant. This temperature drop must be taken into account when coordinating the operating temperatures of the Vernatherm unit, the thermostat and the automatic fan. For example, a NQ 137 Vernatherm unit will begin to open after the top-tank coolant temperature has reached approximately 82° C (180° F) and will be full-open when the top-tank temperature has reached approximately 91°C (195° F). This example is illustrated below in Figure 16.

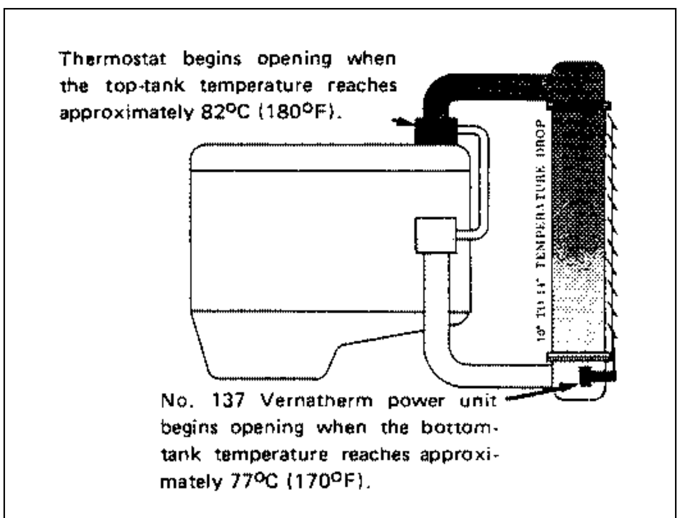


Figure 12-17

In the above example, if the top-tank temperature falls below approximately 91°C (195°F) the shutters will close slightly to help maintain optimum engine temperature.

Maintenance

1. Check the shutters at regular truck inspections. Open and close the vanes manually to verify that they are absolutely free from sticking or binding. The vanes should have approximately 1 mm (1/32 in.) end play. Bushings should be washed out with evaporating-type solvent or high pressure steam and soap cleaner. Blow vanes dry. Graphite or dry lubricants may be applied after the bushings have been cleaned. Do not use oil or grease on nylon or delrin bushings or bearings.
2. Remove the power element periodically and clean the outside of the bulb with sand or glass blast. Remove the piston and inspect for dirt or scored surface. It is important to insert one or two drops of silicone oil (Evans Na 3940) on the piston before replacing it. If neglected, the piston may become gummed-up and travel will gradually be reduced.

   NOTE: Be sure that the nylon disc is in place before inserting piston.

Air-operated Shutters

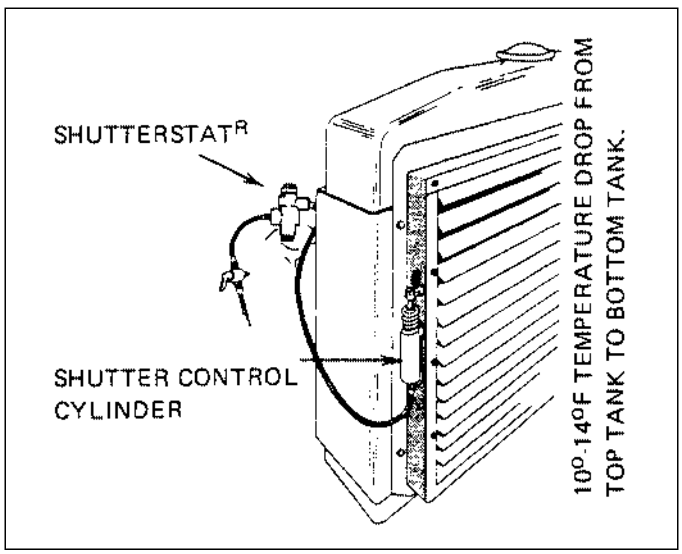


Figure 12-18 Air-Operated Shutter

Air-operated shutters are air-pressure-actuated to close and spring-actuated to open.

Cooling System

A Shutterstat, usually located in the lower engine inlet, directs air pressure to the shutter control cylinder. The Shutterstat is a mechanical air control valve which responds to changes in coolant changes in coolant temperature. See Figure 12-19.

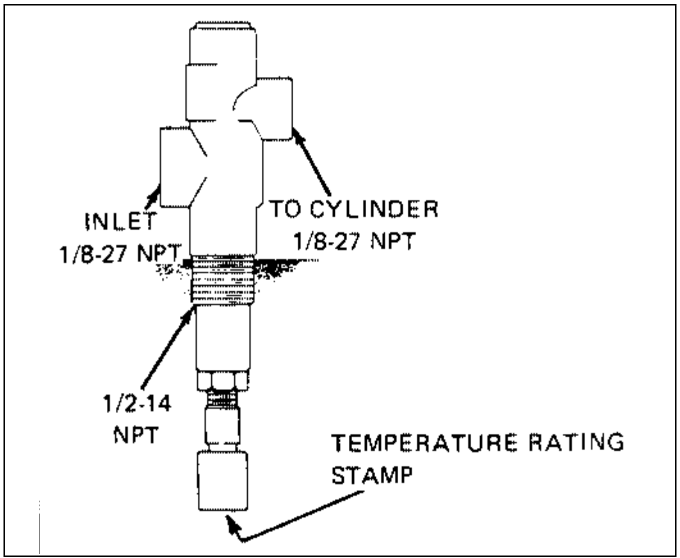


Figure 12-19 Kysor Shutterstat 36000 Series

When the radiator bottom-tank temperature is below 77° C (171° F), the Shutterstat allows air to flow into the shutter control cylinder, closing the shutters.

When the bottom-tank coolant temperature rises to 79° C (175° F), the Shutterstat shuts off air pressure to the shutter control cylinder and allows air in the cylinder to exhaust. With air pressure exhausted, the return springs pull the shutters open.

NOTE: Radiator top-tank temperatures are approximately 5° to 7° C (10° to 14° F) higher than bottom-tank temperatures.

Adjustment

To test if the shutters are closing completely, nun the engine at approximately 900 RPM and place a sheet of paper over the front face of the shutters. If the paper sticks to the face of the shutters, adjust the stroke of the air cylinder rod so that the air cylinder pushes the shutter vanes completely closed.

NOTE: Failure of the shutters to close completely may be due to a leaky or gummed-tip cylinder, a misaligned shutter frame or dirt accumulations on the shutter linkage.

Temperature Balance

Correct temperature balance between the engine thermostat and Shutterstat ratings is essential to the proper function of the radiator shutters. When the Shutterstat is located in the lower engine coolant inlet, the engine thermostat rating may be a maximum 6° C (10° F) lower than the Shutterstat rating. If the Shutterstat is optionally located in the upper radiator pipe, the engine thermostat setting must be a minimum of 6° C (10° F) lower than the Shutterstat setting.

See Temperature Specifications for balanced temperature ratings between the Shutterstat (Air Shutter), the thermostat and the automatic fan, if installed.

NOTE: The temperature rating of a thermostat is the lowest of its operating range where it just starts to open as the coolant temperature is rising. The temperature rating of the Shutterstat, however, is the highest of its operating range where it will exhaust air from air cylinder, opening the shutter. Shutterstat temperature ratings are stamped on the lower end of the element See Figure 18. Shutterstats operate within 1°C (2°F) of their temperature rating.

If higher or lower engine coolant temperature is required due to extreme weather conditions, a Shutterstat of the next higher or lower rating may be tried if the rest of the cooling system is functioning properly. However, the coordinated operation of the air shutter, thermostat and automatic fan must be maintained. See Figure 12-20 for Shutterstat ratings.

Kysor Shutterstats®	
Temperature Rating*	**Part Number**
71° C (160° F)	1047-36000-24
74° C (165° F)	1047-36000-25
77° C (170°º F)	1047-36000-26
79° C (175° F)	1047-36000-27
82° C (180° F)	1047-36000-28
85° C (185° F)	1047-36000-29
88° C (190° F)	1047-36000-30
91° C (195° F)	1047-36000-31
*Temperature at which the Shutterstat exhausts the air cylinder, closing the shutter.	

Figure 12-20 Shutterstat Ratings

Maintenance

Dirt accumulations on the shutter linkage may increase wear and cause binding. Clean the linkage as often as necessary, particularly in the winter.

Shutter linkage may be slightly lubricated with SAE 10W oil or a dry-type aerosol lubricant.

The Shutterstat requires no regular maintenance. Replace if defective.

If conditions of excessive oil, varnish or water in the air lines become evident, Kysor recommends the installation of a Kysor Air Filter and the use of Shutterstat Fluid.

Fan Belts

Optimum belt life is achieved by proper installation, adjustment and maintenance procedures. Neglect or improper procedures may shorten belt life and cause cooling problems or bearing failure.

Installation

1. Reduce the distance between pulley centers sufficiently so that the belt(s) can be installed without force Do not roll or pry belt(s) over the pulleys.

   NOTE: Always install belts in matched sets where two or more belts run in multiple- groove pulleys.

2. Maximum pulley misalignment must not exceed 1.5 mm (1/16 in.) for 305 mm (12 in.) of belt free-span.
3. Belt riding depth in pulley should not vary over 1.5 mm (1/16 in.) on matched belt sets.
4. Do not allow the belt to bottom in the pulley groove or rub against adjacent parts. The top belt edge should not protrude over 1.5 mm (1/16 in.) above the top edge of the pulley groove.

Belt Tension

A good quality commercial gauge may be used to check belt tension. As an alternate method, tighten belts so straight-down pressure of index finger will depress the belt to the value shown in the table below. Force applied will be approximately 58N (13 lbs.). See Figures 12-21 and 12-22.

Cleaning Belts

Belts may slip or squeak because of glaze which forms from dirt or steam cleaning. Do not overtighten the belt to eliminate slippage or squeak. Excessive tightening may damage the belts as well as the bearings.

To clean a belt, wipe it with hydraulic brake fluid. Cleaning in this manner will eliminate most causes of slippage or squeaking.

BELT TENSION*	
BELT WIDTH	**DEFLECTION Per Foot (305 mm) of Span**
12.7 mm (1/2 in.)	10.3 mm (13/32 in.)
17.5 mm (11/16 in.)	10.3 mm (13/32 in.)
19 mm (3/4 in.)	11.1 mm (7/16 in.)
22.2 mm (7/8 in.)	12.7 mm (1/2 in.)
25.4 mm (1 in.)	14.3 mm (9/16 in.)
* This table is used as a guide only. Follow recommendations provided in engine manufacturer's operation/maintenance guide.	

Figure 12-21 Belt Tension

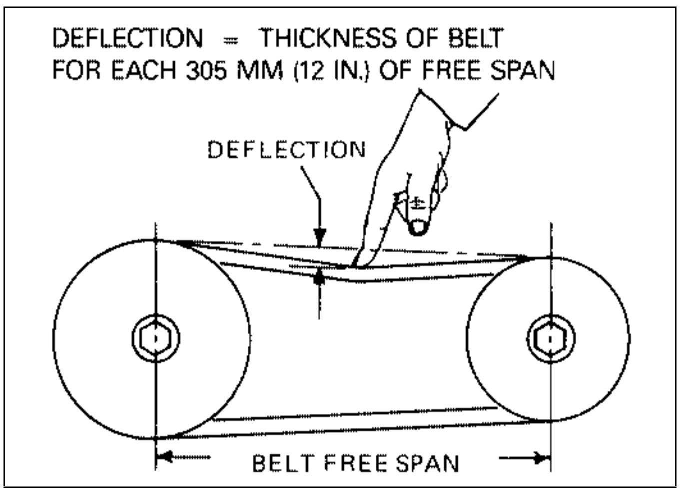


Figure 12-22 Belt Free-Span Deflection

Radiator Removal—Replacement

NOTE: For Ad-Tech radiators, refer to next section.

Removal

In some cases, the radiator may have to be removed for thorough cleaning or specialized repairs.

WARNING! When removing a radiator from an air conditioned vehicle, be very careful not to damage any lines or components containing potentially hazardous Freon gas. Also, never weld, steam-clean, use a blow torch or any other excessive heat on or near any part of the air conditioning system when it is closed to the atmosphere. This could cause a dangerous explosion or turn Freon into Phosphene gas.

1. Remove the drain cover from the front of the radiator bottom tank. Remove the radiator cap and allow the coolant to drain.
2. If the truck is equipped with air-operated shutter controls, remove the shutter air line after opening the air bleed valves at the supply tanks to exhaust air pressure.
3. Loosen the upper and lower radiator hose clamps.
4. Remove the four bolts securing the two radiator mounting pads to the front crossmember. On some models, these four bolts are reached through two access holes in the front crossmember.
5. To gain access to the radiator for hoisting:

   COE Models:

   Tilt the cab to the full-open position.

   Conventional Models:

   Place a support in front of the truck for the hood. After releasing the hood-stop cables, tilt the hood completely upright (90°) upon the support.
6. Attach two lifting eyes that are fabricated to fit the top tank bolt pattern. Each eye should be attached with at least two bolts.

   WARNING! Some anchor brackets for the attachment of the radiator support rods (center of radiator top-tank) do not provide sufficient strength to insure lifting the radiator safely from this point
7. Remove the radiator support rods.
8. Hoist the radiator assembly up and away from the truck, being careful to clear the fan shroud from the fan blades.

Replacement

Radiator installation is essentially the reverse of the removal procedure.

1. Replace any hoses that show signs of cracks, sponginess or embrittlement.
2. Before securing the radiator mounting pads, verify that the shroud is centered around the fan blades.
3. Verify that there are no obstructions around the fan blades.
4. Refill the radiator with coolant. Verify that the cooling system is protected for the lowest prevailing temperature.
5. Check shutter operation, if installed.

Ad-Tech Radiator

Tank Removal And Installation

Special service tools and equipment for servicing AdTech radiators may be ordered from:

Johnson Manufacturing Company
P.O. Box 96
Princeton, IA 52768

- No. 421-CS: Support frame and clamp kit (5 clamps).
- No. 421-03: L-clamp, single with flat and curved pressure pad.
- No. 421-01: Header support frame. U-channel style.

Modine Tank To Header System

The radiator tanks are molded glass-filled nylon and are secured to the core header by one of two methods:

1. Nerfix™ locking strips.
2. Side-lock latching strips. See 12-23.

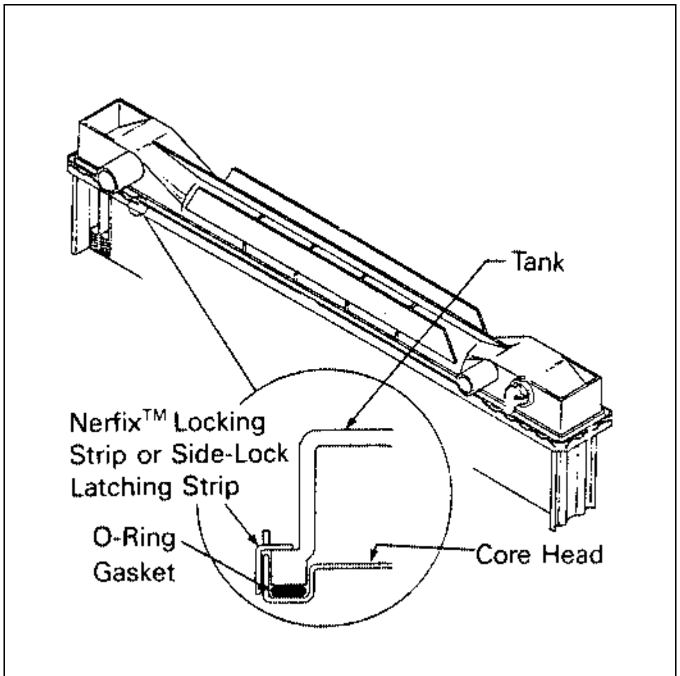


Figure 12-23

Tank Removal

1. Position five (5) header clamps along with the header support frame as shown in Figure 12-24.

   NOTE: If so desired, the header support frame can be constructed as shown in Figure 12-32.

2. Hand tighten header clamps evenly until the Nerfix™ locking strips or side-lock latching strips become loose enough to be removed by hand or with the aid of a small screwdriver—excessive torque is not required.

NOTE: It is very important that the header be completely (all four sides) supported as shown in Figure 12-24 to prevent header distortion. If the treader becomes excessively distorted, the core may have to be replaced.

3. *If the radiator being serviced is equipped with the Nerfix™ locking strips as shown in Figure 24A simply pull the strips out 4 per header. Discard the old strips.*

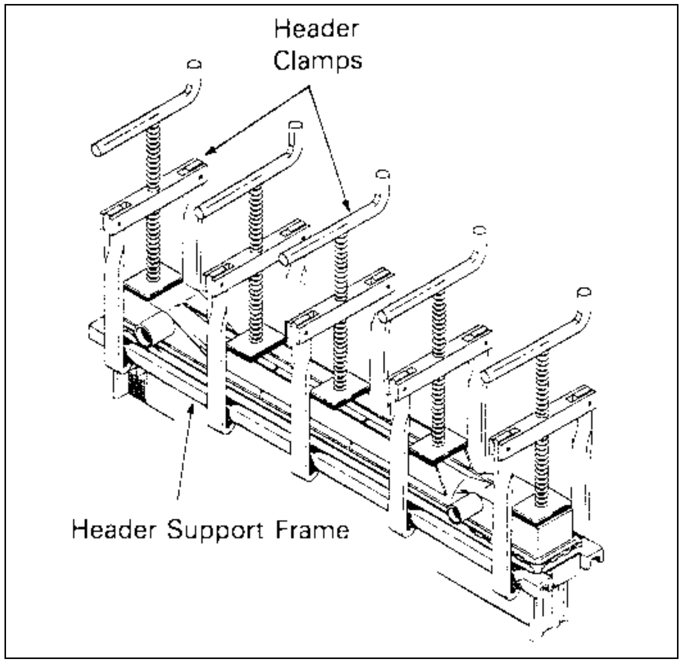


Figure 12-24

If the radiator is equipped with the sidelock latching strips as shown in Figure 12-25B, the retainers as shown in Figures 12-29 and 12-30 must be removed first. To remove the retainer, pry outward on the bottom to disengage the retainer teeth from the header slot then pull the retainer upward as shown in Figure 12-30. If strips are retained with wire rings, cut ring and remove. After the retainers are removed, the side lock latching strips are removed by tapping the strip to the left with a screwdriver and hammer until the tabs of the strip can easily be pulled out of the header slots—6 strips and 4 retainers per header. Discard the old strips and retainers.

4. Loosen and remove header clamps and header support frame.
5. Lift tank from the core header.
6. Remove the O-ring seal from the header. Discard the old O-ring seal.

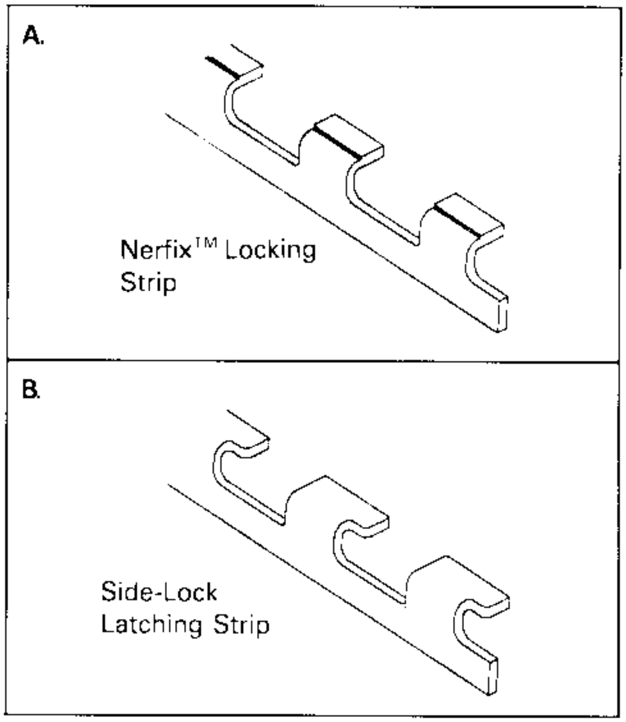


Figure 12-25

Tank Installation

1. Inspect the sealing surface of the radiator core header to be sure it is clean and free of foreign material or damage.
2. Dip the new O-ring in fresh glycol and place the gasket in the header groove.
3. Position the tank to the header using care not to scratch the tank sealing surfaces. Be sure the top and bottom of the tank is positioned properly.
4. Clamp the tank in position on the header with five (5) header clamps and header support frame as shown in Figure 12-24. Tighten the header clamps to compress the O-ring gasket until the latching strips can be inserted by hand.

NOTE: Three different length latching strips, see Figure 25 Each side requires assembly with one 20 tab strip and one 21 tab strip. The 3 tab strips are for assembly at header ends.

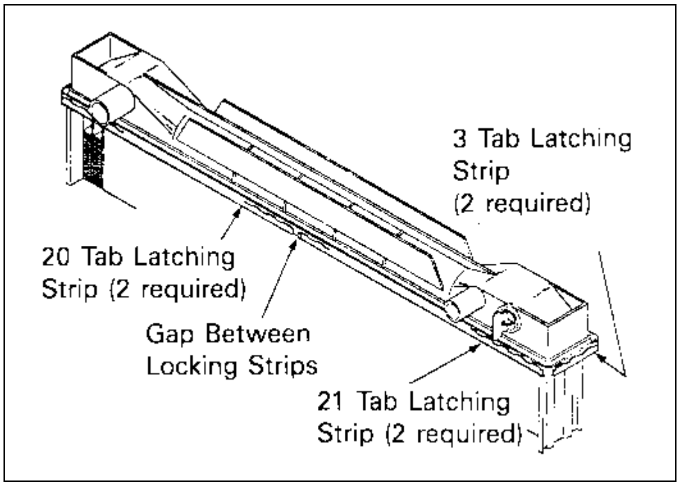


Figure 12-26

5. Insert latching strips, making sure all tabs are positioned into header slots. Tap strips to the right using a screwdriver and hammer as shown in Figure 12-27. This tapping locks the new strip into place. When fully engaged there be an opening in the left hand edge of the header slot, see Figure 12-28.
6. Remove the header clamps and header support from the header core.
7. Lock the latching strips in place with retainers. Install 1 retainer between the 21- tab latching strip and the 20-tab latching strip (2 per header), and 1 retainer at each 3-tab latching strip (2 per header) as shown in Figure 26 When installing the retainers, hook the top of the retainer over the header flange, then pull down as shown in Figure 12-30.

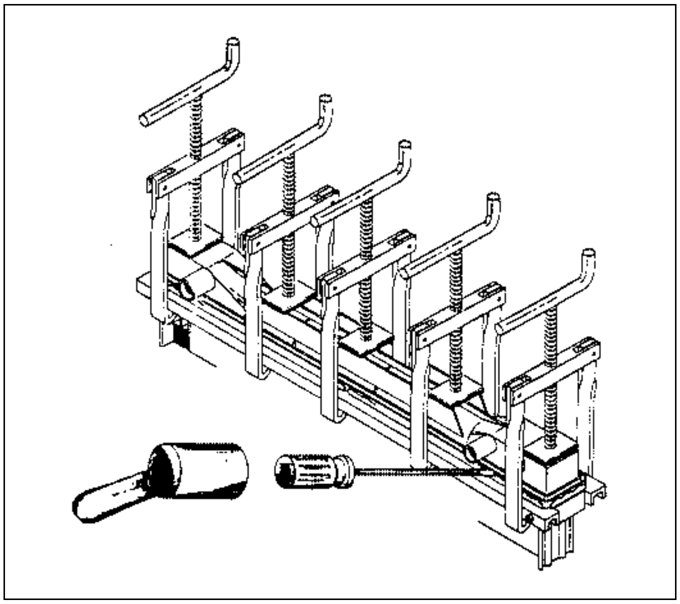


Figure 12-27

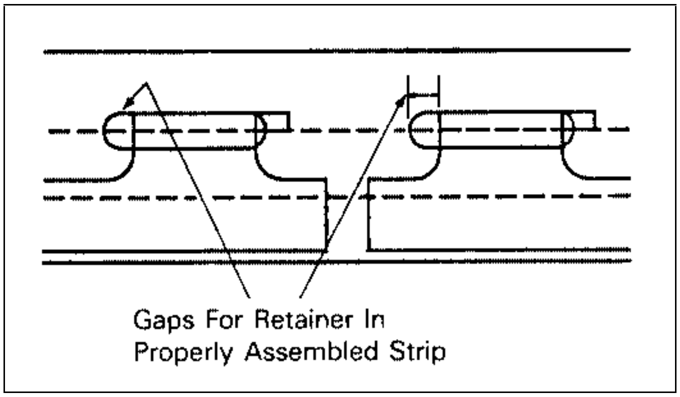


Figure 12-28

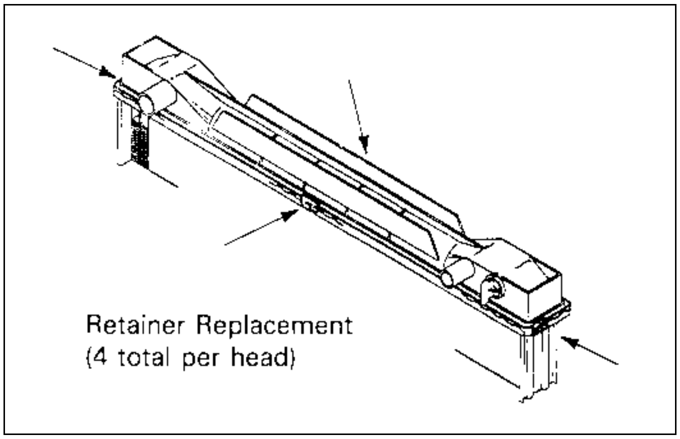


Figure 12-29

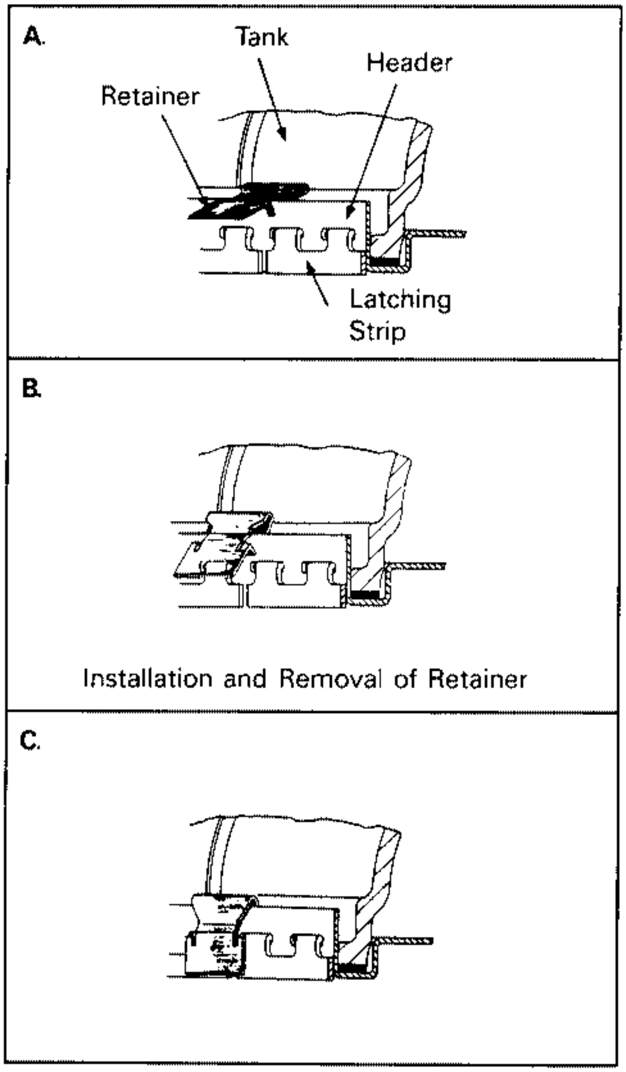


Figure 12-30

The teeth of the retainer must be fully engaged into the header slot at the opening to the left of the latching strip tab as shown in Figure 12-31.

NOTE: At the center of the header, 1 retainer is used to lock 2 latching strips

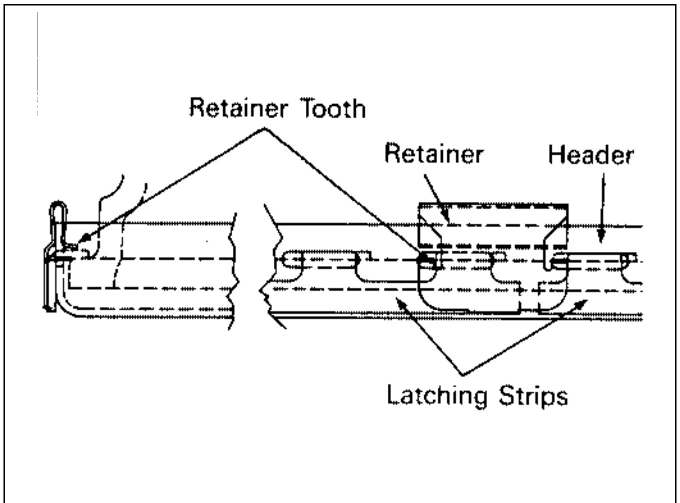


Figure 12-31

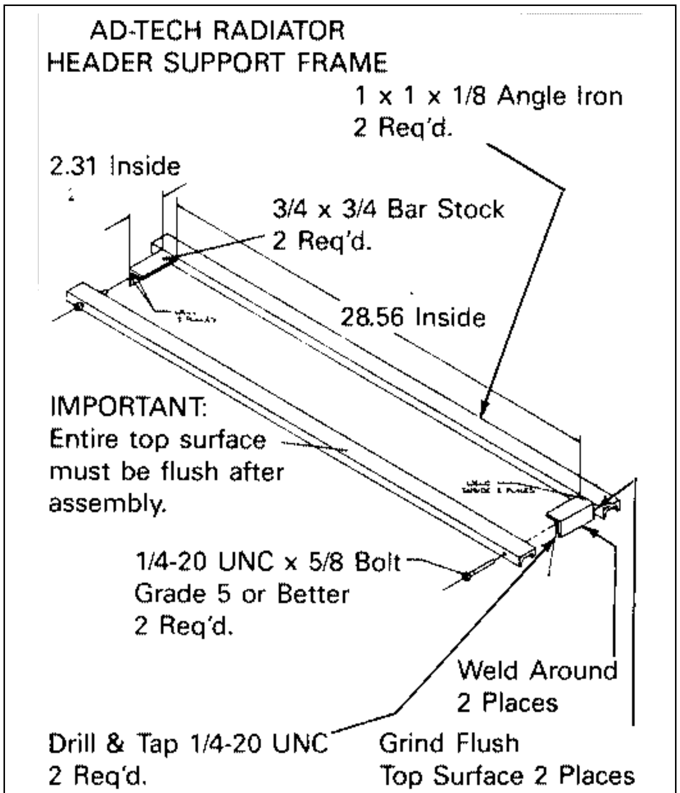


Figure 12-32

Draincock / Vent Fitting Removal And Installation

The draincock and vent fitting are in the plastic radiator tank and can be replaced without disassembling the radiator.

Removal

1. Turn the stem counterclockwise to unscrew the stem. When the stem is unscrewed to the end of the threads, pull the stem from the radiator tank and body.
2. Remove the retainer body from the radiator tank by squeezing the sides together with a pair of needle-nose pliers. Then, pull the retainer body from the tank.

Installation

1. Remove retainer body from draincock or vent fitting stem.
2. Snap retainer body into radiator tank.
3. Snap draincock or vent fitting into retainer body.
4. Tighten draincock or vent fitting by turning clockwise. Tighten to 2.0-7.7 Nm (18-25 in.- lb.).

Radiator Core Repair

The Ad-Tech radiator core is of copper-brass construction and can be repaired by using the usual good radiator shop repair procedures for this type of radiator core. Note, however, that heat must be kept from the header / gasket / tank area, unless the plastic tank is first removed from the radiator core.

CAUTION: Do not attempt to clean on Ad Tech radiator core using caustic cleaning solutions unless the plastic tanks are first removed. Immersing the plastic tanks in a caustic cleaning solution can damage the tanks and O-ring gaskets.

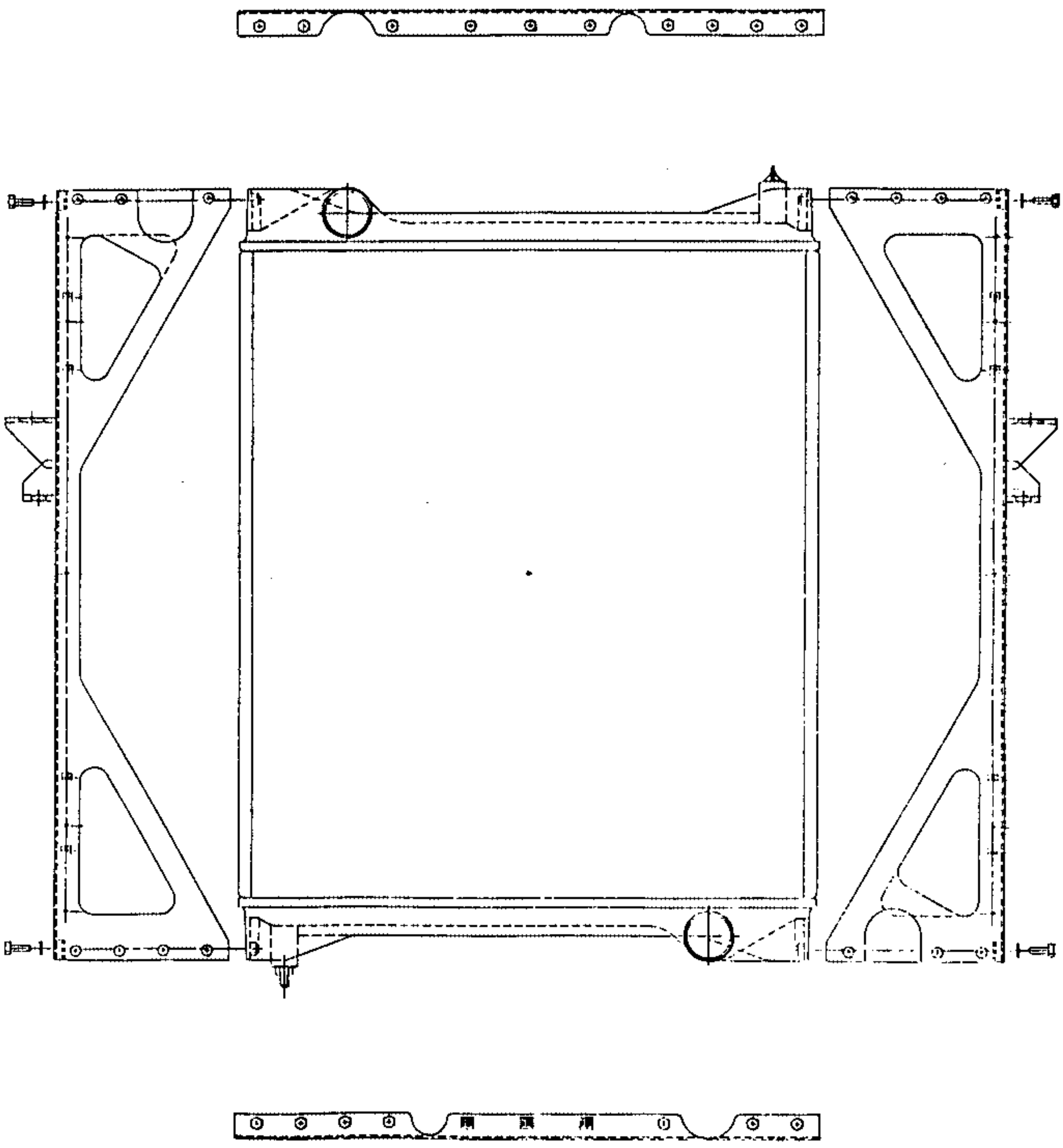
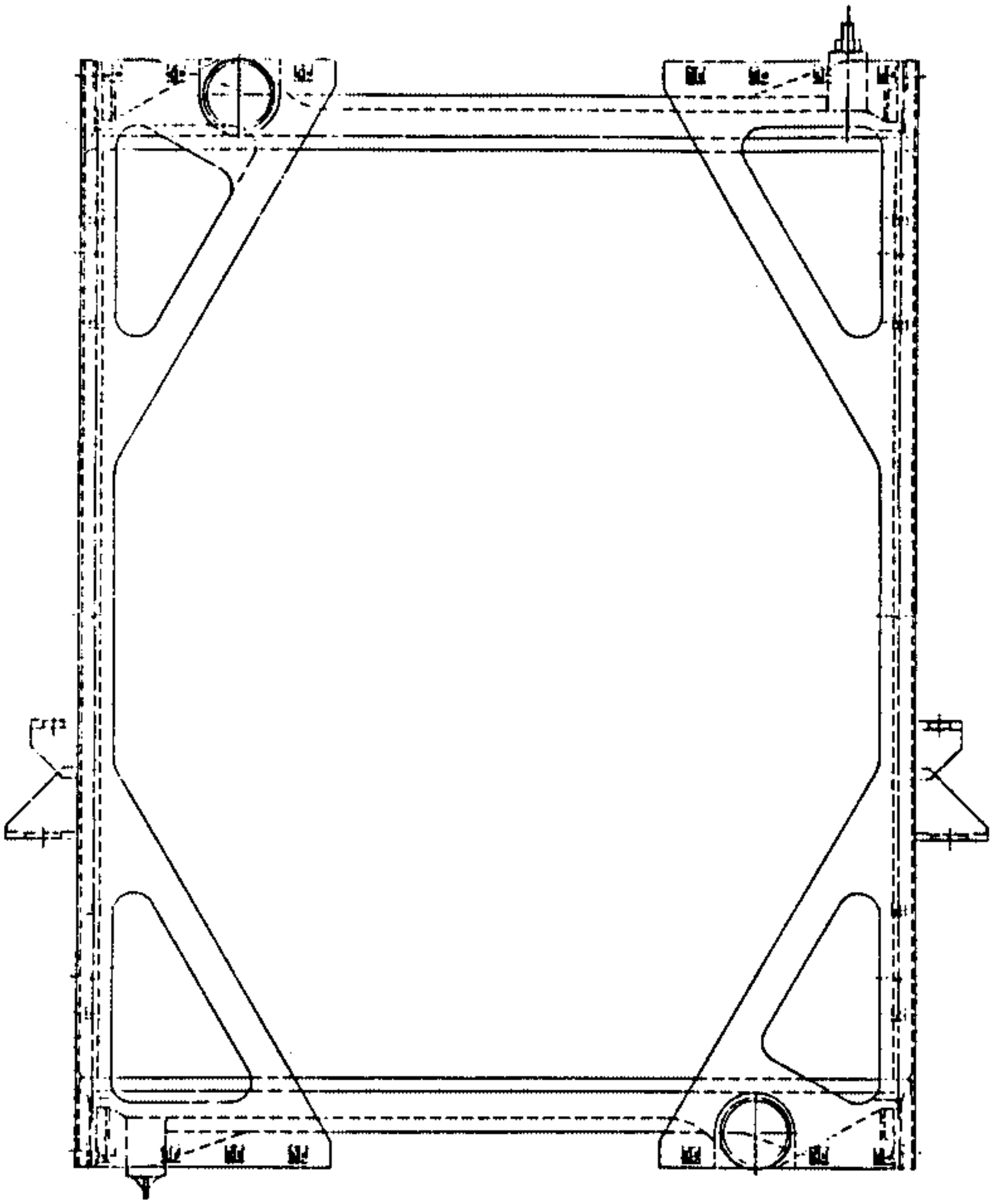
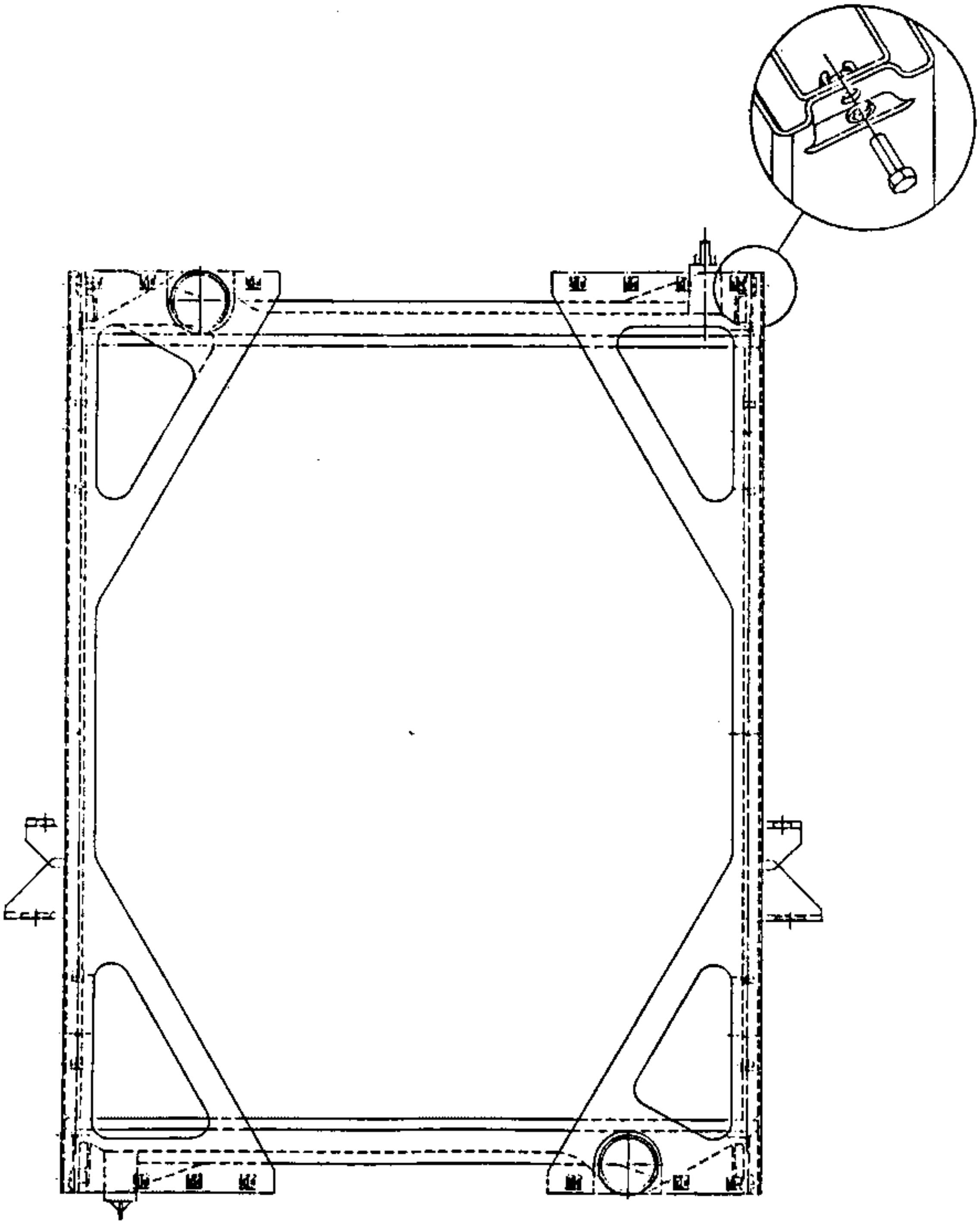


Figure 12-33



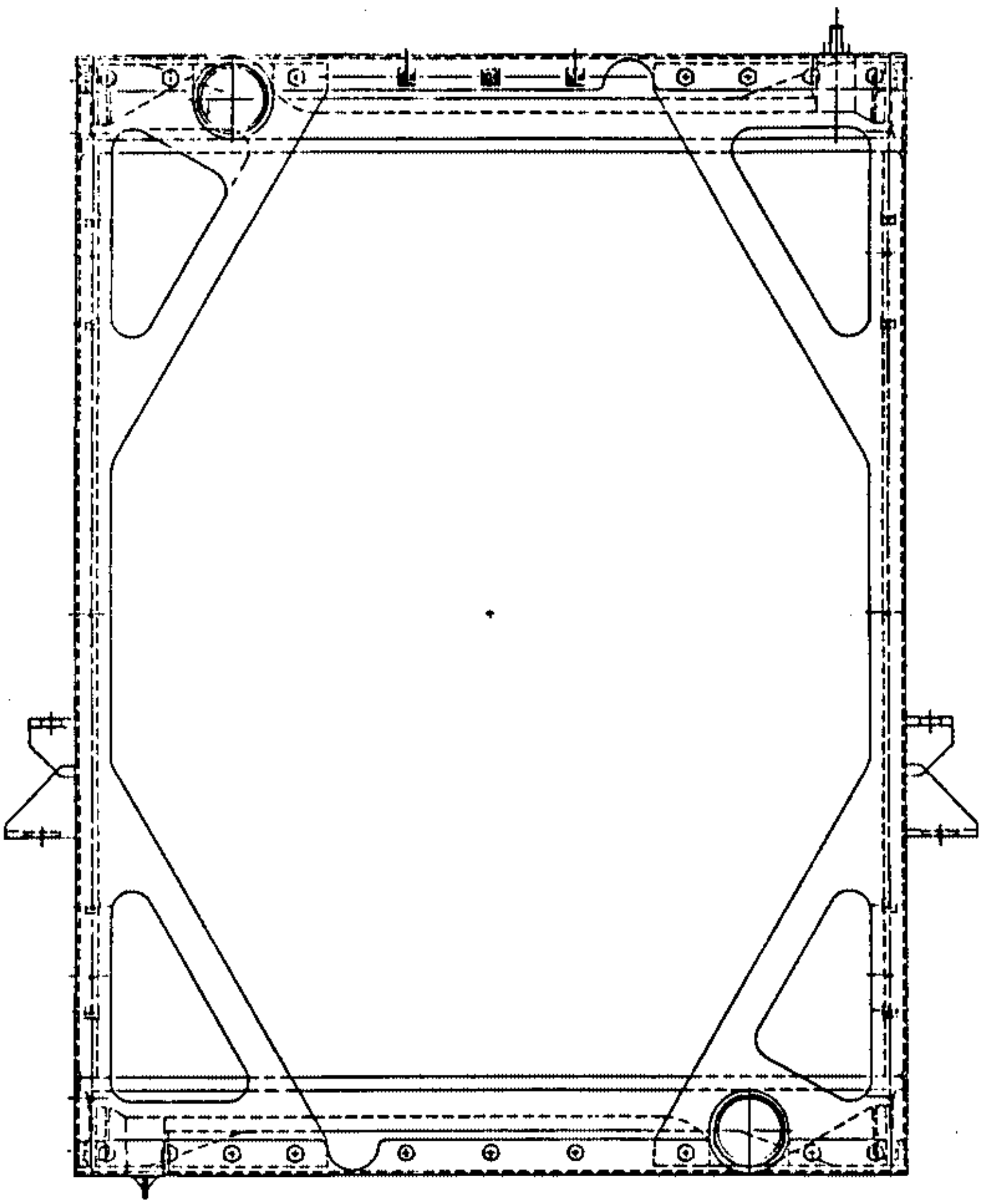
Clamp side assemblies in place. The length of the sides should be flush to the core sides. The offset at each end of the side should be flush to the tank end.

Figure 12-34



Bolt side assemblies to the tanks
using 3/8-16 UNC x 1 in. bolts with lock washers
(nut is contained at each tank end).
Torque bolts to 180-190 in.-lbs.

Figure 12-35



Bolt channel assemblies to side assemblies using 3/8-16 UNC x 1 in. bolts with lock washers (weldnut are attached to side assemblies). Torque bolts to be 180-190 in.-lbs.

Figure 12-36

Troubleshooting

Problem	Possible Cause
Loss of Coolant	**External Leakage** With the engine running at normal operating temperature and the heater On, check for the following: • Leaking heater or radiator hoses. • Leaking seal on water pump. • Leaking heater core. • Leaking radiator core. • Leaking top or bottom tank seals. • Escape of coolant from dirty or malfunctioning radiator cap.
	Internal Leakage Examine the engine for signs of coolant in the oil; for example, white foamy sludge and heavy condensation on dipstick. Check for the following: • Cracked cylinder head, engine block or intake manifold. • Leaking cylinder liner seal. • Leaking head gasket resulting from a warped head or block surface.
Engine Runs Too Hot *(NOTE: Check accuracy of temperature gauge)*	• Coolant level low. • Fan belt loose or belt slipping. • Air flow through radiator core obstructed. • Defective or incorrect thermostat. • Rust corrosion and scale build-up in cooling system • Combustion gases in coolant. • Coolant not circulating, inspect water pump impeller.
	Air-Operated Shutters* Fail to Open Properly • Shutters and/or linkage binding. • Linkage not adjusted properly—shutters not opening fully. • Air cylinder and piston assembly binding; gummed-up cylinder. *NOTE: With the air line disconnected at the cylinder, the shutters should open completely* • Defective internal air cylinder return spring. • Defective Shutterstat—If coolant temperature exceeds the Shutterstat setting by 7° to 8° C (12° to 15° F) the Shutterstat is defective; replace it.

Problem	Possible Cause
Engine Runs Too Hot *(NOTE: Check accuracy of temperature gauge)*	**Thermo-Modulating (Vernatherm) Shutters* Fail to Open properly** • Shutters and/or linkage binding. • Linkage not adjusted properly—shutters not opening fully. *NOTE: Full-open position of the shutters for maximum air flow is at an angle of approximately 70°—not 90°* • Dimensional setting of the Vernatherm power unit not adjusted properly. See Figure 12-15.
Engine Runs Too Cold	• Defective thermostat or gasket.
	Air-Operated Shutters* Fail to Close properly • Shutters and/or linkage binding so that shutters do not completely close. • Air hoses and/or connections leaking. • Air cylinder leaking. • Low air pressure to the cylinder (air pressure required is 6.3 kPa (90 psi, minimum). • Defective or incorrect thermostat. • Shutterstat temperature rating incorrect, replace Shutterstat with next highest rating. See Figure 12-22. • Shutter vanes and seals not sealing tightly when closed.
	Thermo-Modulating (Vernatherm) Shutters* Fail to Close Properly • Shutters and/or linkage binding so that shutters do not completely • Dimensional setting of Vernatherm power unit not adjusted properly. See Figure 12-15. • Linkage (turnbuckle) incorrectly adjusted. • Vernatherm power unit temperature rating incorrect, replace with next highest setting. See Figure 12-17. • Defective or incorrect thermostat.

**Optional equipment*

NOTE: For additional troubleshooting information on Cummins Big Cam IV, see Cummins Engine Shop Manual 3379076-05: No. 83T0-4.

For L10 Optimized Aftercooling, see Cummins Bulletin No. 3810236.