

# Cooling Systems

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# Cooling Systems

## Safety

The purpose of this safety summary is twofold. First, it is to help ensure the safety and health of individuals performing service and maintenance on, or operation of, this Blue Bird product. Second, it is to help ensure the protection of equipment. Before performing any service, maintenance or operating procedure on this product, individuals should read and adhere to the applicable warnings, cautions and notes located throughout this Blue Bird Service Manual.

## Warnings

Warnings apply to a procedure or practice that, if not correctly adhered to, could result in injury or death. Particular attention should be paid to sections of this manual where warnings appear.

## Cautions

Cautions apply to a procedure or practice that, if not correctly adhered to, could result in damage to or destruction of equipment.

## Notes

Notes are used to explain, clarify, or otherwise give additional insight for a given subject, product or procedure. Please note that on occasion, notes too may advise of potential safety issues.

## Introduction

This section contains information pertaining to the cooling systems on Blue Bird All American school buses equipped with Cummins ISB, ISC and Caterpillar 3126 engines.

## Warning

*Rapid venting or rapid removal of radiator cap while the engine is hot will allow hot coolant to spray out. To prevent serious burns, slowly vent pressure, then remove radiator cap with extreme caution.*

## Warning

*Anti-freeze is toxic to the skin and eyes. Skin and eye protection is required. Avoid repeated or prolonged contact. Drain coolant fluid in a well-ventilated area.*

## Warning

*Properly discard anti-freeze that is drained from cooling system. Anti-freeze can cause an allergic reaction in humans.*

## General Specifications

### Note

*A 10 PSI cap applies for all three of the following engines.*

### ISB Engine

Coolant capacity—10.5 quarts (engine only)  
Thermostat (fully open)—190° F  
Pressure cap—7.0 psi (minimum allowable)

### ISC Engine

Coolant capacity—10.7 quarts (engine only)  
Thermostat (starts to open)—181° F  
(fully open)—203° F  
Pressure cap—(minimum allowable) 7.0 psi

### Caterpillar 3126 Engine

Coolant capacity—13.9 quarts (engine only)  
Thermostat (starts to open)—181° F  
(fully open)—203° F  
Pressure cap (minimum allowable) 9.0 psi

## Type(s) of Coolant

### ISB Engine

- 50% water and 50% ethylene-glycol base anti-freeze
- May be mixed to as much as 60% anti-freeze and 40% water for temperatures below  $-34^{\circ}\text{F}$  ( $-37^{\circ}\text{C}$ )
- DCA-4 should be used as a supplemental cooling additive

### ISC Engine

- 50% water and 50% ethylene-glycol base anti-freeze
- May be mixed to as much as 60% anti-freeze and 40% water for temperatures below  $-34^{\circ}\text{F}$  ( $-37^{\circ}\text{C}$ )

#### Note

*Never exceed a 70% anti-freeze/30% water mix.*

- DCA-4 must be used as a supplemental cooling additive.

### Caterpillar 3126 Engine

- 50% water and 50% ethylene-glycol base antifreeze
- May be mixed to as much as 60% anti-freeze and 40% water for temperatures below  $-34^{\circ}\text{F}$  ( $-37^{\circ}\text{C}$ )

#### Note

*Never exceed a 60% anti-freeze/40% water mix.*

- DCA-4 must be used as a supplemental cooling additive

#### Note

*For information regarding pump flow rate, see appropriate engine manual.*

## Coolant Capacities

Option Number	Description	Capacity (qts)
Std	Radiator, de-aeration tank and hose	11-12
Std	90K BTU All American front heater	3.19
Std	12K BTU driver's heater	.025
1325	50K BTU front under seat heater	1.56
1330	50K BTU rear under seat heater	1.56
1332	50K BTU rear RH under seat heater	1.56
1336	80K BTU front under seat heater	2.34
1342	80K BTU rear under seat heater	2.34
Std	Per 1 foot of heater hose	.17

## Routine Maintenance

Routine maintenance generally consists of checking and replenishing coolant, flushing the system and periodic changing of the coolant. For detailed requirements and for procedures to accomplish those requirements, refer to the appropriate engine manufacturer's manual.

## Surge Tank Coolant Level

### Warning

*Rapid venting or rapid removal of radiator cap while the engine is hot will allow hot coolant to spray out. To prevent serious burns, slowly vent pressure, then remove radiator cap with extreme caution.*

Check the coolant level at the surge tank by observing the level in the sight glass. If liquid is visible in the sight glass, the system

contains adequate quantity of fluid. If coolant is not visible in the sight glass, add coolant as necessary to bring the level up to the level of the sight glass. If the surge tank is empty or nearly empty, and the low coolant warning has not activated, check the low coolant sensor for contamination or corrosion. Clean or replace the sensor as necessary. If the warning system does not activate after cleaning or replacing the sensor, check wiring and connections in the low coolant warning system. If all wires and connections appear to be ok, replace the low coolant warning module. After correcting any faults in the low coolant warning system, be sure to adequately service the system with coolant.

## **Hose Connections**

Hose connections should be checked and tightened, as necessary. Hose clamps used on silicone hoses in the cooling system may require tightening at several intervals after initial tightening. This is a normal compression characteristic of new or replacement silicone hoses. Check and re-tighten clamps until subsequent checks verify that there is no need for further tightening. Replace cracked, swollen, or deteriorated hoses as necessary.

## **Radiator, Charge Air and Heater Cores**

Check the radiator core, charge air cooler core and heater cores regularly for leaks and for accumulation of dirt or other foreign materials that may obstruct the flow of air. In addition, be sure to check the area between the charge air cooler and the radiator. Sometimes obstruction may occur between the two cores. Clean the cores with an air hose using low-pressure air. It may be necessary to use water to remove heavy accumulations from the cores. In some severe cases, it may be necessary to remove the charge air cooler in order to gain access to the area between it and the radiator.

## **Cooling System Leaks**

Repair all cooling system leaks as soon as they are detected. If they are not beyond repair, most radiator, charge air cooler and heater core leaks can be repaired locally using common radiator repair techniques. Refer to the appropriate engine service manual for procedures on repairing or replacing leaking cylinder head gaskets, and for removal and replacement of water pumps.

## **Mounting Hardware**

Inspect radiator and charge air cooler mounting hardware. Tighten mounting and attaching bolts as necessary.

## **Cooling Fan**

Refer to **Section 170—Hydraulic Fan Drive** to verify the operation of the fan. Inspect for proper clearance between the fan and the radiator core and between the fan and the fan shroud. If a "swing-out" radiator is installed, check that the fan shroud is properly secured. An unsecured fan shroud could seriously damage both the fan and the radiator core.

## **Water Filter**

Inspect and service any water filter as directed by the filter manufacturer.

## **Engine Thermostat**

If the engine operating temperature deviates from the normal range for that engine, remove and check the thermostat(s). A defective thermostat that remains closed, or only partially open, will restrict the flow of coolant and cause the engine to overheat. A thermostat that is stuck in the full open position will cause the engine to run below its normal operating temperature, which will eventually lead to shortened engine life.

## Engine Coolant

### Warning

*Properly discard anti-freeze that is drained from the cooling system. Anti-freeze can cause an allergic reaction in humans.*

The buses covered by this manual have pre-mixed coolant, appropriate to the engine manufacturer's recommendations installed at initial assembly. Refer to the appropriate engine manufacturer for proper coolant, coolant mix ratio, and supplemental cooling additives (SCAs). All engines used in Blue Bird buses should have anti-freeze solution used year-round to provide freeze and boil-over protection, as well as a stable environment for seals and hoses.

### General Coolant Recommendations

Always maintain the proper coolant level. Check this daily.

Overfilling a cooling system can result in the unnecessary loss of coolant, and in some cases, cause the engine to overcool, especially during extreme cold weather operation.

The cooling system must be pressurized to prevent localized boiling of the coolant. The system must be kept clean and leak-free. The fill cap must always be installed and periodically checked for proper operation.

### Testing Anti-Freeze Solution

#### Warning

*Anti-freeze is toxic to the skin and eyes. Skin and eye protection is required. Avoid repeated or prolonged contact. Drain coolant fluid in a well-ventilated area.*

To ensure freeze protection, always test the anti-freeze solution before and after adding water or anti-freeze, using a standard anti-freeze tester. Fill and empty the tester several times to warm it before using. Keep the tester clean inside and out. Follow the instructions of the tester manufacturer for the most accurate results.

## Description of Operation

### Engine Cooling System

The system consists of the radiator, de-aeration tank, thermostat, fan, water pump and liquid coolant. The cooling system is designed to adequately cool the engine across the entire speed and load range. Heat generated by the engine is transferred to the coolant, which is circulated by the water pump to the radiator. As the fan pulls across the finned surfaces of the radiator, excess engine heat is dissipated to the atmosphere. Engine coolant is also circulated through the transmission oil cooler to remove heat from the transmission fluid. Refer to **Section 160—Transmission** for information on the transmission cooler. **Figure 1.1** and **Figure 1.2**.

In addition to removing heat from the engine and transmission, the cooling system also distributes heat in the form of warm coolant into the driver's and bus body heating systems.

### Heat Control and Monitoring

Heat control and monitoring are accomplished by a combination of mechanical and electrical means. A thermostat, located in the engine, controls the flow of coolant into the radiator. A low coolant probe mounted in the de-aeration tank monitors the coolant level. If the coolant level drops below the probe, the low-coolant module illuminates a light to alert the driver, and turns on the low coolant

telltale light on the instrument cluster. Coolant temperature is monitored by the coolant temperature sensor, which signals the engine ECM. For more information on the low coolant and temperature warning systems, refer to the engine and chassis electrical systems.

## **Circulation**

Coolant flows from the engine water pump through the engine oil cooler, through the cooling passages in the engine up to the thermostat. If the temperature has not raised enough for the thermostat to open, the main flow of coolant stops until engine heat has raised enough to cause the thermostat to open.

To prevent the water pump from cavitation, fluid from the de-aeration tank is supplied to the pump. Once the thermostat opens, coolant flow continues from the engine into the top of the radiator. As the coolant flows from the top of the radiator through the core to the bottom of the radiator, air flowing across the radiator causes a heat exchange to take place, lowering the temperature of the coolant.

After flowing out of the outlet pipe at the bottom of the radiator, the coolant then flows through a hose to the transmission cooler, where a heat exchange takes place between the coolant and the transmission's fluid. From the transmission cooler, the coolant then flows back to the water pump, beginning the cycle again.

A pipe and ball valve located on the right hand corner of the engine (front for Caterpillar 3126 and rear for Cummins' engines) diverts hot coolant from the engine block out of the heater system. After passing through the heater cores, the coolant is returned to the system through a ball valve and "T" connection at the transmission cooler.

## **Low Coolant Warning System**

A coolant level sight glass located in the surge tank provides for visual inspection to determine coolant level. In addition, a low coolant warning system is installed to warn the driver of a low coolant condition while operating the vehicle. An electrically conductive probe is located in the surge tank (de-aeration tank). As long as coolant is at a level with the probe, current flows to a low coolant-warning module. A three-second delay is built into the module to allow for sloshing of the coolant. If the coolant falls below the probe for a period of greater than three seconds, then the current to the module is broken. The module then sends a signal to the instrument cluster that lights a telltale light and sounds a warning. The low coolant-warning module is located next to the relay panel located behind the driver's side windshield wiper motor door.

## **Charge Air**

In an effort to improve fuel consumption, to lower emissions to meet government regulations, and in some cases, to permit increased horsepower, the engine intake air is cooled after it has been compressed in the turbo-charger. The hot compressed air is passed through a heat exchanger similar to the radiator. A heat exchange takes place between the hot air in the core and the cool ambient air passing through it. This charge air cooler is attached to the radiator so that the cool air passes through the charge air cooler first (in other words, on the outside of the radiator).

## **System Components**

### **Water Pump**

Water pumps are integral to the engine. See the appropriate engine manual for further description.

## Hoses, Clamps and Fittings

Hoses, clamps and fittings vary according to option. Coolant hoses may be either rubber or silicone. Based on the type of hose, the clamps and their torque values will be different. Mixing different hoses with the wrong type of clamps could damage the hose or cause leaking.

## Radiator

The radiator is located directly in front of the engine facing forward on forward engine units. For rear engine buses, the radiator is located to the left of the engine and faces the street side of the bus. **Figure 2** and **Figure 3**.

## Surge Tank (de-aeration tank)

The surge tank is attached to the body and located in front of and directly above the engine on a forward engine unit, and behind and to the left of the engine on a rear engine unit.

## Low Coolant Warning System

The low coolant warning system is made up of the following components:

- Sensor—located in the surge (de-aeration) tank
- Module—located next to the relay panel that is behind the driver's side wiper motor door
- Light—located in the instrument cluster

## Charge Air Cooler

The charge air cooler is located directly in front of and attached to the radiator.

## Heater Components

Each heater consists of valves, cores/heat exchangers, hoses and fittings.

## Removal and Replacement Procedures

Refer to the diagrams at the end of this section for help in performing the following service procedures.

### Warning

*Properly discard anti-freeze that is drained from cooling system. Anti-freeze can cause an allergic reaction in humans.*

## Draining and Filling the Cooling System

Coolant drain points are provided on the bottom of the radiator and on the engine. Refer to the specific engine manual for location.

With heating supply and return lines isolated, the cooling system can be drained without draining the heater lines. A bleed valve is provided near the surge tank to allow bleeding air from the heater supply and return lines.

### Draining

1. Remove the surge tank filler cap.
2. Open the radiator and engine drains, capturing coolant in suitable containers.

### Filling

1. Close all drain cocks.
2. Slowly fill the system through the surge tank until coolant is at the level of the filler cap.
3. Start the engine and run it at "high idle" (fast idle) until normal operating temperature is reached.
4. Return the engine to normal idle.

5. Check the water level and add as necessary.
6. If coolant level is very low, bleed the heating system. Refer to heater system bleeding.
7. Install filler cap.

## Radiator and Charge Air Cooler

The radiator is removed as an assembly with the charge air cooler.

### Warning

*Anti-freeze is toxic to the skin and the eyes. Skin and eye protection is required. Avoid repeated or prolonged contact. Drain coolant fluid in a well-ventilated area.*

## Removal (Forward Engine)

Figure 1.1 and Figure 1.2.

1. Remove the front grill panel as described in **Section 060—Engine**.
2. Drain the cooling system as previously described.
3. Loosen the hose clamps on the charge air cooler inlet and outlet pipes and remove the hoses.
4. Disconnect all hose connections to the surge tank to the radiator.
5. Loosen the hose clamps on the radiator inlet and outlet pipes, then remove the inlet and outlet hoses.
6. Remove the mounting bolts, washers and insulators attaching the engine to the frame.
7. Supporting the radiator and charge air cooler with a suitable lifting device, remove the assembly from the vehicle.

Once removed, removing the attaching hardware may separate the radiator and charge air cooler.

## Installation (Forward Engine)

1. If the radiator and charge air cooler were separated, they must be re-connected. Torque attaching bolts to 30 foot-pounds,  $\pm 5$  foot-pounds.
2. Set the radiator/charge air cooler assembly in place on the radiator mounting points on the chassis.
3. Make sure that insulators are installed at this time.
4. Loosely install the mounting bolts and washers.
5. Loosely attach the radiator inlet and outlet pipes and hoses.
6. Torque mounting hardware.
7. Torque hose clamps.
8. Fill the cooling system as described earlier in this section.
9. Check for system leaks.

## Removal (Rear Engine)

### Note

*For best results, the bus should be elevated enough to facilitate the removal of the radiator/charge air cooler assembly from under the side of the bus.*

1. Drain the cooling system, as previously described. **Figure 2** and **Figure 3**.
2. Loosen the hose clamps on the charge air cooler inlet and outlet pipes.
3. Remove the hoses.
4. Disconnect all hose connections between the surge tank and the radiator.
5. Loosen the hose clamps on the radiator inlet and outlet pipes.
6. Remove the inlet and outlet hoses.
7. Remove baffles and seals from radiator/charge air cooler assembly.
8. Remove radiator shroud assembly from the radiator with fan and fan motor attached.



## Note

*Do not drain the hydraulic system.*

9. Remove the mounting bolts, washers, braces and insulators attaching the radiator to the chassis.
10. Supporting the radiator and charge air cooler from below, remove the assembly from the vehicle by moving it away from the engine and down between the side of the bus and the radiator mounting platform.

Once removed, the radiator and charge air cooler may be separated by removing the attaching hardware.

## Installation

1. If the radiator and charge air cooler were separated after removal, they must be reconnected. Torque attaching bolts to 30 foot-pounds  $\pm$  5 foot-pounds.
2. Set the radiator/charge air cooler assembly in place on the radiator-mounting platform on the chassis.
3. Make sure that insulators are installed at this time.
4. Loosely install the mounting bolts, washers and braces.
5. Prepare and install baffles and seals around the radiator and charge air cooler assembly.
6. Install radiator shroud assembly, insuring that there is adequate clearance between the fan and the core. Ensure that fan motor hoses are not bound, kinked or twisted.
7. Loosely attach the radiator inlet and outlet pipes and hoses.
8. Torque mounting hardware.
9. Torque hose clamps.
10. Fill the cooling system as described earlier in this section.
11. Check for system leaks.

## Removing Only the Charge Air Cooler

The charge air cooler can be removed separately without removing the radiator or draining the cooling system.

## Removal

1. Forward Engine—remove front grill panel as described in **Section 060—Engine**.
2. Rear Engine—remove baffles and seals from radiator and charge air cooler assembly.

## Note

*For best results, the bus should be elevated enough to facilitate the removal of the charge air cooler from under the side of the bus.*

3. Loosen the hose clamps on the charge air cooler inlet and outlet pipes and remove the hoses.
4. While supporting the charge air cooler, disconnect the three bolts attaching the charge air cooler to the radiator.
5. Remove the charge air cooler.

## Note

*Rear engine bus charge air cooler is removed by sliding the cooler down and under the side of the bus.*

*Installation is the reverse of the removal procedure.*

## Sight Glass Replacement

1. Ensure that fluid level is below the sight glass.
2. Twist the glass counter-clockwise to remove the glass and O-ring.
3. Reverse the procedure to install a new glass.
4. Check for leaks.

## Surge Tank Replacement

See **Figure 1.2**, **Figure 2** and **Figure 3**.

1. Remove the surge tank fill cap.
  2. Drain coolant to a level so that none remains in the surge tank.
  3. Disconnect and tag all electrical wires from the low coolant probe.
  4. Disconnect and tag all hoses from the surge tank.
  5. Remove the mounting hardware and remove the surge tank from the engine compartment.
  6. Replace parts as necessary and reverse the procedure to install the surge tank.
2. Reattach the heater hose to the transmission cooler and torque the clamp.
  3. Open the isolation valves at the engine and oil cooler.
  4. Service the cooling system as previously described.
  5. Bleed the heater system.
  6. Bring the engine to operating temperature.
  7. With the engine at normal idle, open the small bleed line valve located above the radiator (both forward and rear engine applications).

## Heater Core Replacement

### Removal

1. Isolate the heater system from the cooling system by closing the valves at the engine and oil cooler.
2. Carefully loosen the heater hose clamp at the transmission cooler and remove the heater hose, capturing the coolant from the heater circuit in a suitable container.
3. Disconnect the heater hoses from the appropriate heater core and remove the heater core.

### Note

*Depending upon which type of heater core is being removed, a seat may need to be removed.*

### Installation

1. Install the appropriate heater core, attach hoses and torque hose clamps.

### Warning

*Anti-freeze is toxic to the skin and eyes. Skin and eye protection is required. Avoid repeated or prolonged contact. Drain coolant fluid in a well-ventilated area.*

### Warning

*Properly discard anti-freeze that is drained from cooling system. Anti-freeze can cause an allergic reaction in humans.*

8. Observe fluid flow from the bleed line and capture in a suitable container.
9. Add coolant to the system until a steady stream of fluid flows from the bleed line.
10. Close the bleed line valve and install the fill cap.

## Water Pump

Reference the appropriate engine manufacturer's instructions.

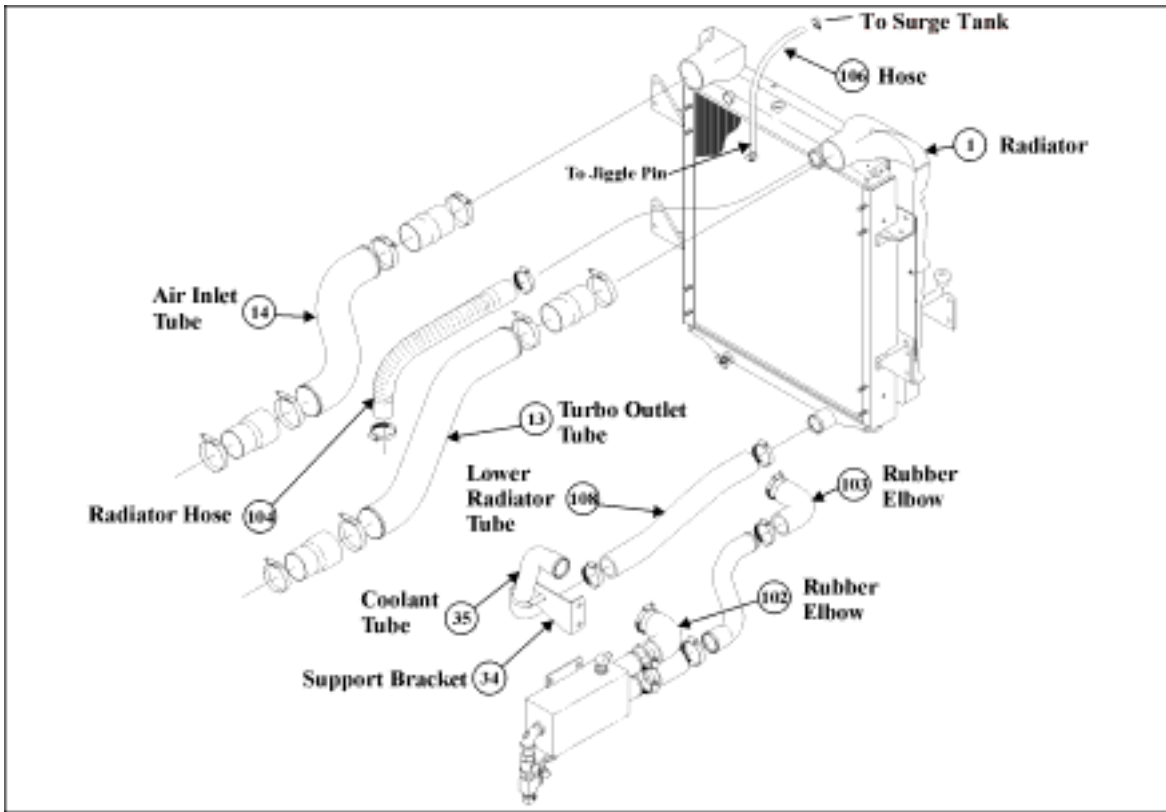


Figure 1.1—Cooling System, All American Forward Engine with ISB Engine (1 of 2)

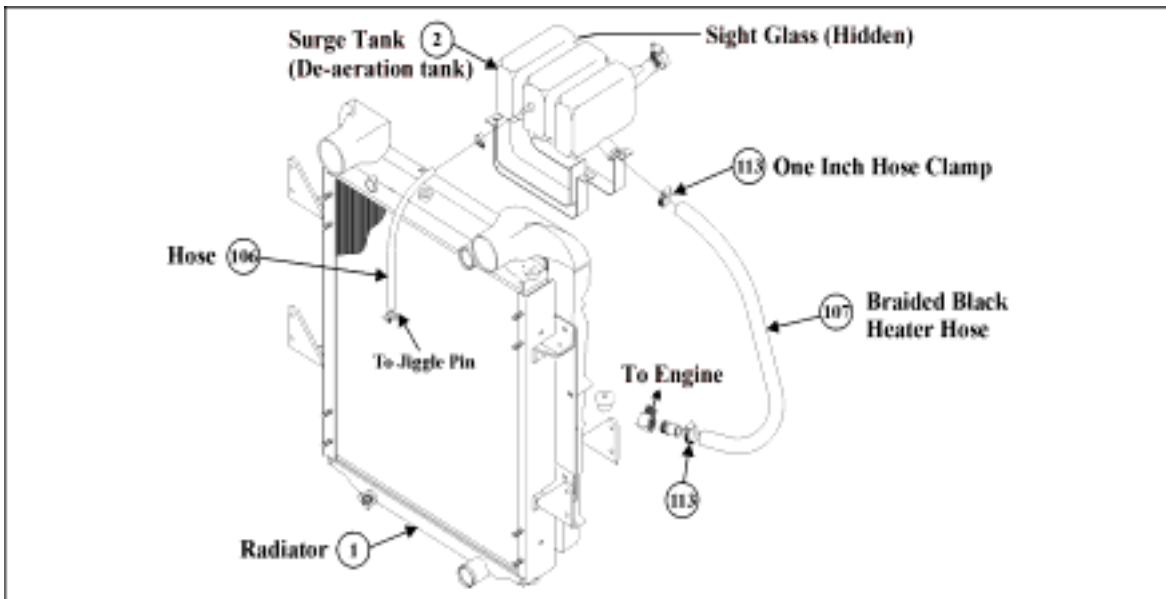
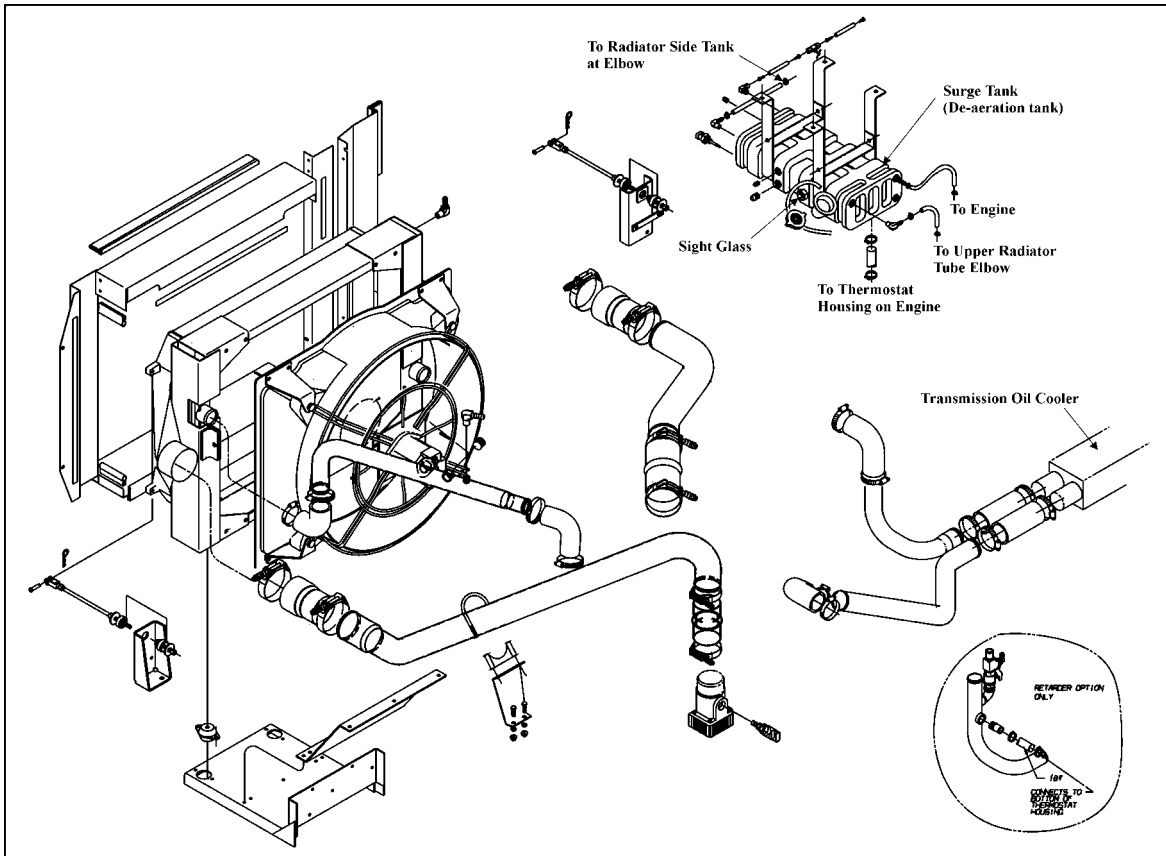
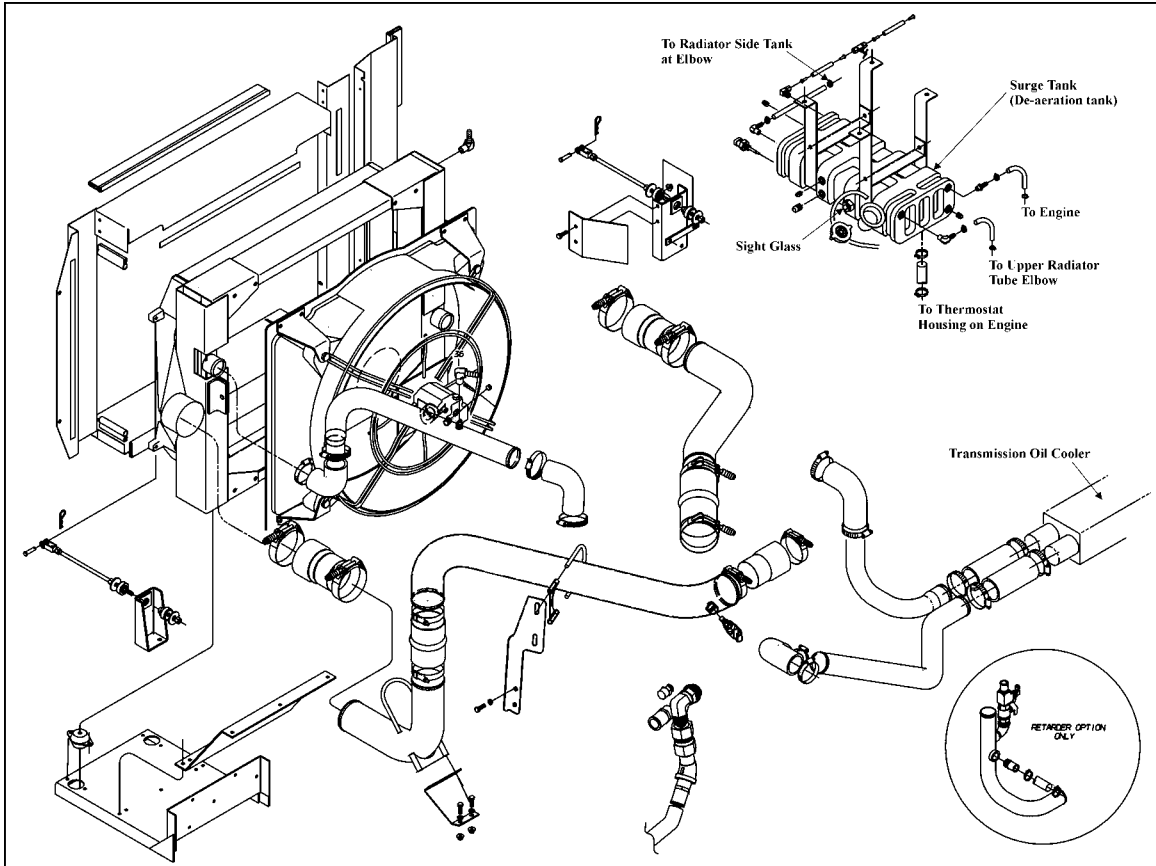


Figure 1.2—Cooling System, All American Forward Engine with ISB Engine (2 of 2)



**Figure 2—Cooling System, All American Rear Engine with ISB Engine**



**Figure 3—Cooling System, All American Rear Engine with ISC Engine**

## Coolant System Shutters

### Description of Operation

Shutters are installed on the radiator/charge air cooler assembly to assist in warming the engine quicker during cold weather operations of the vehicle. Consisting of a series of pivoting blades (similar to Venetian blinds), the blades close when the engine is cold, restricting the flow of cooling air through the radiator and charge air cooler.

Shutters can be located on the fan side or on the outside of the radiator and charge air cooler package. As the engine warms, a cylinder actuates, causing the blades to pivot open which, in turn, allows air to flow through the radiator and charge air cooler, resulting in the normal operation of the cooling system.

Two types of shutter systems are available for All American school buses. One shutter system utilizes engine oil to hydraulically actuate the cylinder. **Figure 4**. This system may be found on either air or hydraulic brake equipped vehicles. The other shutter system uses air from the vehicle air system. **Figure 5** and **Figure 6**. This system is only available on air brake equipped vehicles.

In both systems, an electrical signal from the water temperature sensor activates the shutter solenoid. The solenoid then opens to allow air or oil (as appropriate) to flow through to and operate the actuator cylinder.

### Routine Maintenance

The shutters require no lubrication but must be cleaned as required. This is at least every 2 years or 24,000 miles, whichever occurs first. In addition, periodic visual inspections

for leaks or loose or missing parts should be conducted.

## **Troubleshooting and Diagnostics**

### **Shutters do not Operate (Open or Close)**

1. Visually check for physical binding or blocking of the blades.
2. Visually check for cut air or hydraulic lines and loose fittings.
3. Check for operation of the water temperature alarmstat. Refer to Section 170—Hydraulic Fan Drive.
4. Check operation of the solenoid. With the solenoid electrical plug disconnected, apply 12 volts to one pin of the plug and ground the other. If the solenoid does not operate, replace the solenoid.
5. If the solenoid is operating but the blades do not open, disconnect the actuator cylinder from the blades. Perform the procedure in Step 4 above and determine if the cylinder is actuating. When the solenoid operates with air or hydraulic pressure on the

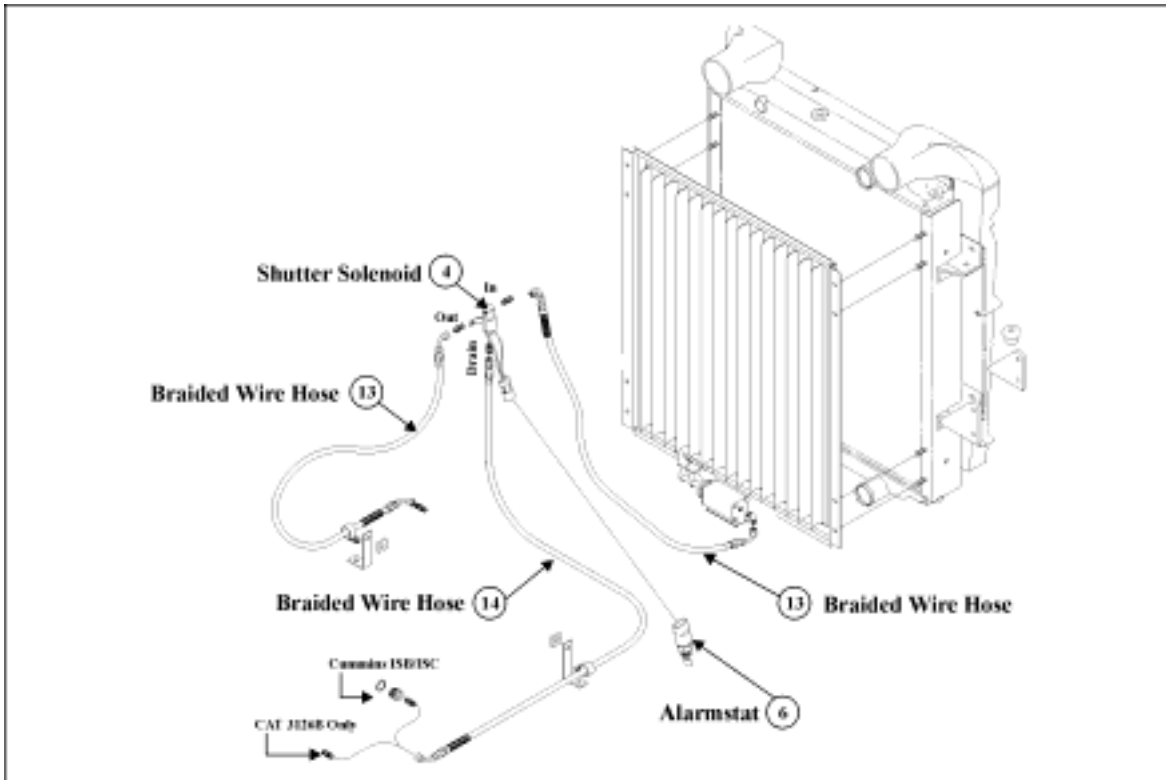
system, the cylinder should extend or retract. If it does not, replace the actuating cylinder.

6. If the actuator cylinder is operating correctly while it is still disconnected, attempt to manually move the blades. The blades should be held open by spring pressure, and are closed by the actuator. If the blades cannot be moved with reasonable pressure, replace the shutter assembly.

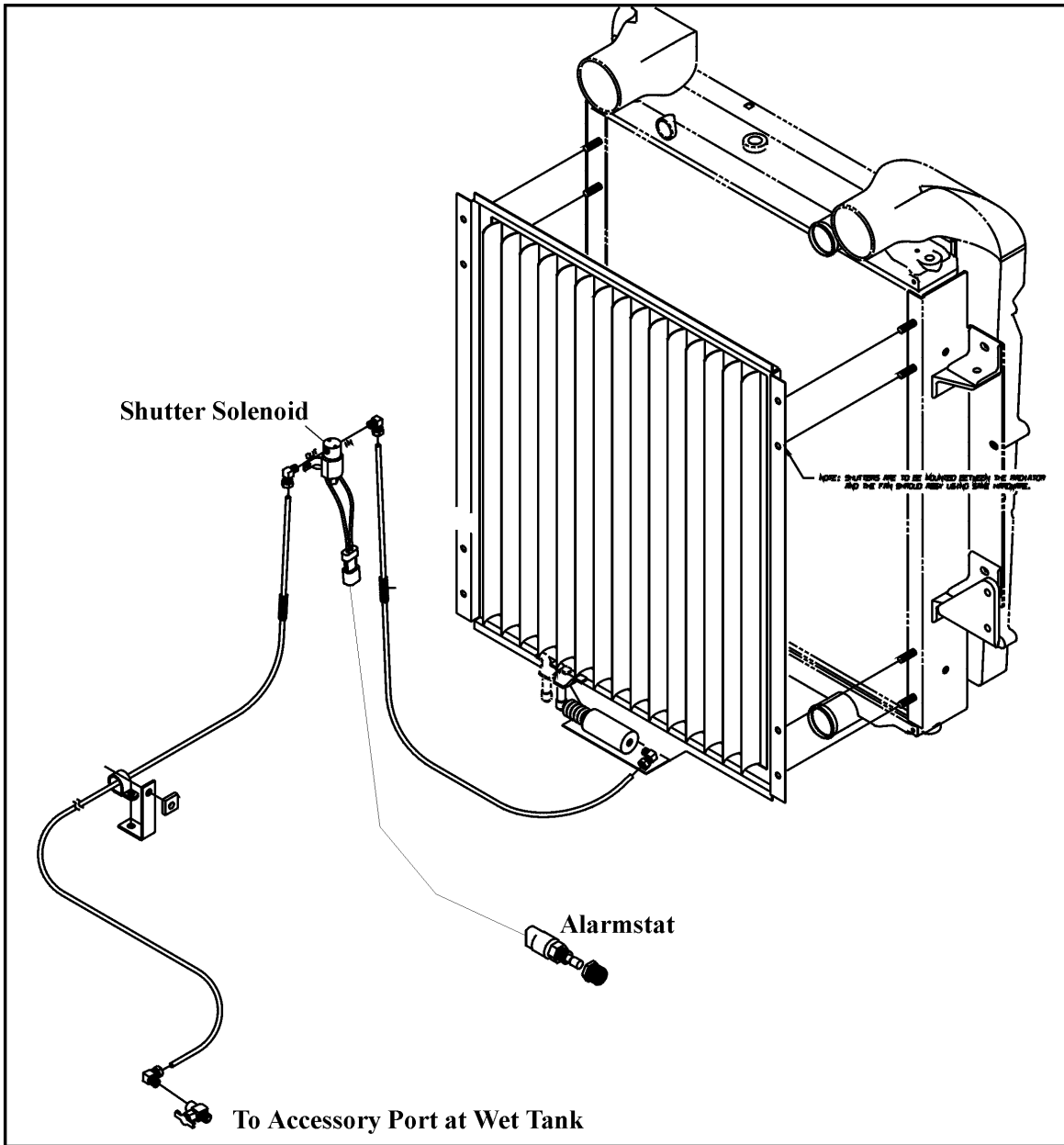
## **Removal and Replacement**

On front engine applications with the shutters attached to the outside of the radiator and charge air cooler package, the shutter assembly can be removed after removing the access door and grill assembly. The radiator and charge air packages do not need to be removed.

On all other applications, remove the radiator and charge air package as described in this section, and disconnect the shutter assembly from the removed radiator/charge air package.



**Figure 4—Shutter Assembly, Hydraulic All American Forward Engine**



**Figure 5—Shutter Assembly, Air, All American Forward Engine**



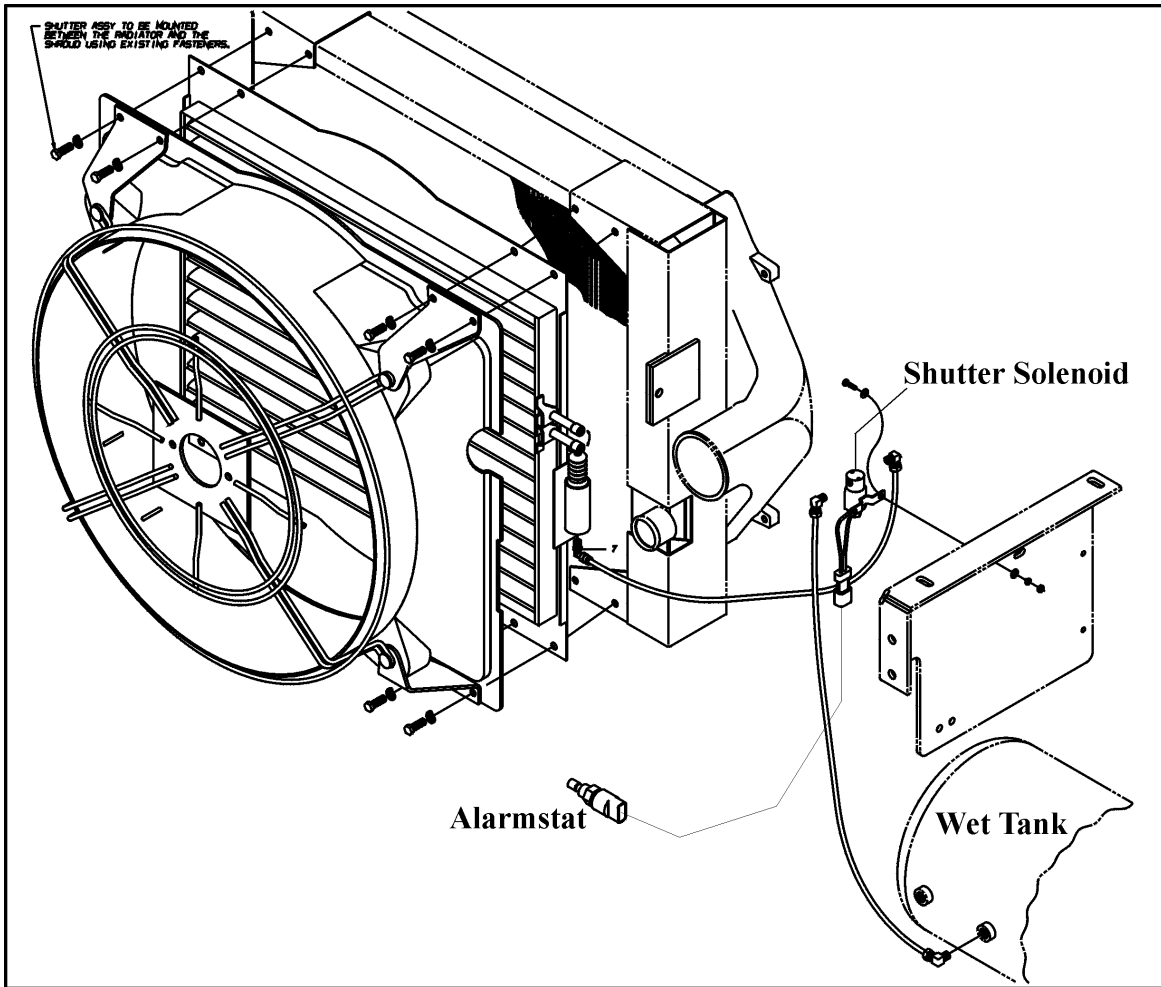


Figure 6—Shutter Assembly, Air, All American Rear Engine

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