SERVICE MANUAL SECTION

AIR-TO-AIR CHARGE AIR COOLER

s12006, Formerly CTS-5087

03/31/1996

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DESCRIPTION

CHARGE AIR COOLER SYSTEM

International equips all its vehicles with charge air coolers to improve fuel economy, increase horsepower and decrease gaseous emissions.

The air-to-air charge air cooler is composed of cast aluminum inlet and outlet tanks, with a tube-and-fin structure cooler core (Figure 1). The core disperses heat to cool and condense the air from the turbocharger before it enters the engine air intake manifold. This, in turn, decreases the system operating temperature and increases engine durability and reliability.

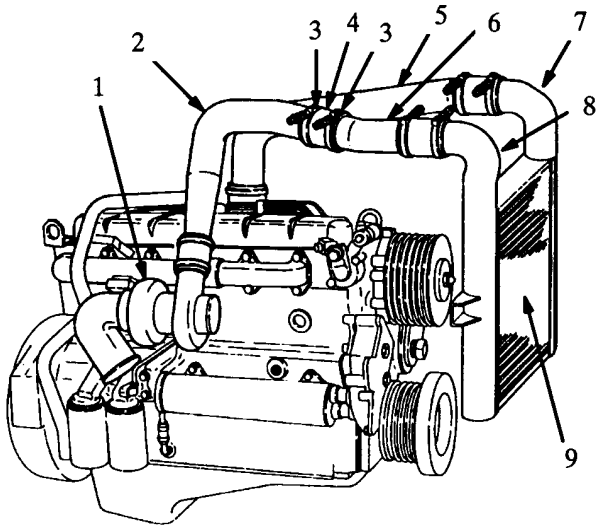

Figure 1 Charge Air System Components

1. TURBOCHARGER
2. TURBOCHARGER-TO-CHARGE AIR COOLER (HOT SIDE) ELBOW
3. T-BOLT HOSE CLAMP
4. CONNECTING AIR HOSE
5. CHARGE AIR COOLER-TO-ENGINE AIR INLET ("COLD" SIDE) PIPE
6. CONNECTING AIR PIPE
7. CHARGE AIR COOLER OUTLET TANK
8. CHARGE AIR COOLER INLET TANK
9. COOLER CORE (TUBE AND FIN CONSTRUCTION)

Hoses fastened with T-bolt hose clamps are used to form connections to the turbocharger exhaust and engine air intake manifolds. Silicone hoses are **always** used on the hot side, and silicone or EPDM (Ethylene Propylene Diene Monomer rubber) hoses are used on the "cold" side. Figure 2 , Figure 3 , Figure 4 , and Figure 5 show examples of charge air cooler installation configurations.

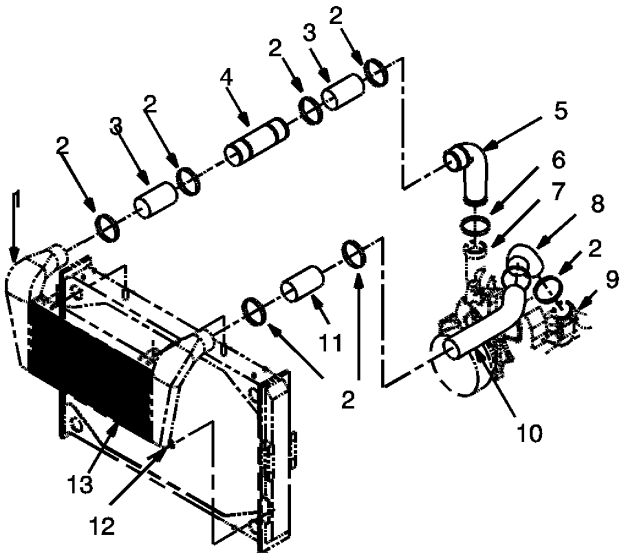

Figure 2 Radiator Mounted Charge Air Cooling System and Piping, 8200/8300

1. CHARGE AIR COOLER INLET TANK ("HOT" SIDE)
2. SPRING-LOADED T-BOLT CLAMP
3. SILICONE "HUMP" HOSE
4. TURBOCHARGER EXHAUST PIPE
5. TURBOCHARGER EXHAUST ELBOW
6. V-BAND CLAMP
7. TURBOCHARGER EXHAUST
8. EPDM ELBOW
9. ENGINE AIR INTAKE
10. AIR INTAKE PIPE
11. EPDM HOSE
12. CHARGE AIR COOLER OUTLET TANK ("COLD" SIDE)
13. RADIATOR ASSEMBLY

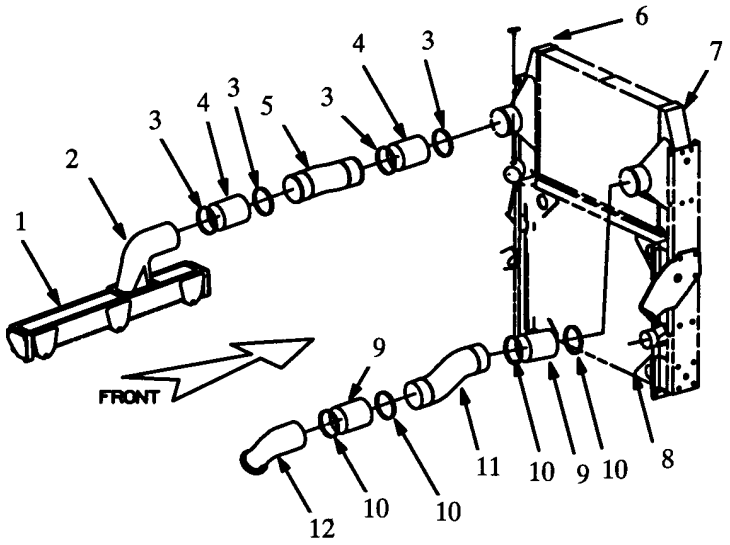

Figure 3 Charge Air Cooling System Mounted Stacked With Radiator, 9600/9700

1. ENGINE AIR INTAKE MANIFOLD
2. PIPE ELBOW
3. T-BOLT HOSE CLAMP
4. EPDM STRAIGHT HOSE
5. CHARGE AIR COOLER OUTLET PIPE
6. CHARGE AIR COOLER OUTLET TANK
7. CHARGE AIR COOLER INLET TANK
8. RADIATOR
9. SILICONE "HUMP" HOSE
10. (HEAVY-DUTY) SPRING LOADED T-BOLT CLAMP
11. CHARGE AIR PIPE
12. TURBOCHARGER ELBOW

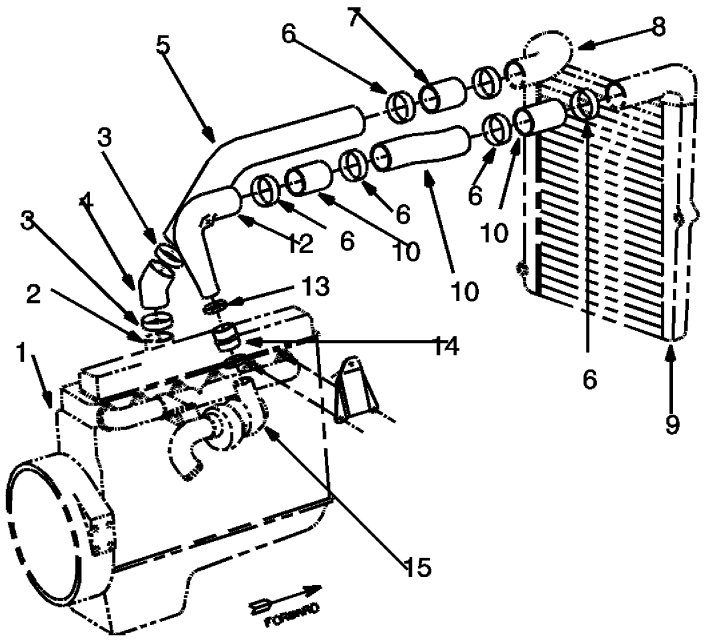

Figure 4 Radiator Mounted Charge Air Cooling System and Piping, 4700/4800 (DTA-360 With PTO)

1. ENGINE
2. ENGINE AIR INTAKE
3. HEAVY-DUTY SPRING-LOADED T-BOLT CLAMP
4. REDUCER ELBOW HOSE
5. CHARGE AIR COOLER OUTLET PIPE
6. HEAVY-DUTY SPRING-LOADED T-BOLT CLAMP
7. EPDM STRAIGHT AIR HOSE
8. CHARGE AIR COOLER OUTLET TANK
9. CHARGE AIR COOLER INLET TANK
10. SILICONE "HUMP" HOSE
11. CHARGE AIR COOLER INLET PIPE
12. TURBOCHARGER OUTLET PIPE
13. HOSE CLAMP
14. AIR HOSE
15. TURBOCHARGER OUTLET

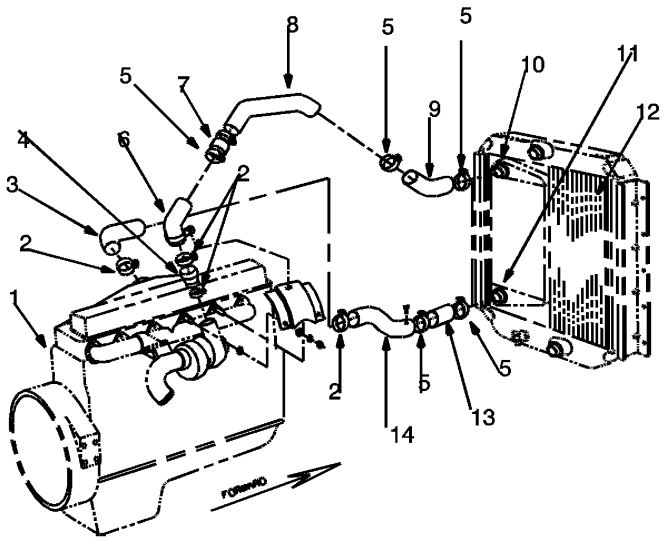

Figure 5 Charge Air Cooling System Mounted in Frame With Radiator, 3600/3800, 4700/4800 (Without PTO)

1. ENGINE
2. HOSE CLAMP
3. AIR INTAKE HOSE
4. TURBO ADAPTER HOSE
5. HEAVY-DUTY SPRING LOADED T-BOLT CLAMP
6. INLET PIPE ELBOW
7. TURBOCHARGER AIR HOSE
8. CHARGE AIR COOLER INLET PIPE ("HOT" SIDE)
9. CHARGE AIR COOLER INLET HOST ELBOW ("HOT" SIDE)
10. CHARGE AIR COOLER INLET
11. CHARGE AIR COOLER OUTLET
12. RADIATOR
13. CHARGE AIR COOLER OUTLET HOSE
14. CHARGE AIR COOLER OUTLET PIPE ("COLD" SIDE)

1. OPERATION

From the air intake, air passes through the air cleaner to remove dust and grit from the air supply. Then the air is routed to the turbocharger, which is mounted directly on the outlet flange of the engine exhaust manifold (Figure 6).

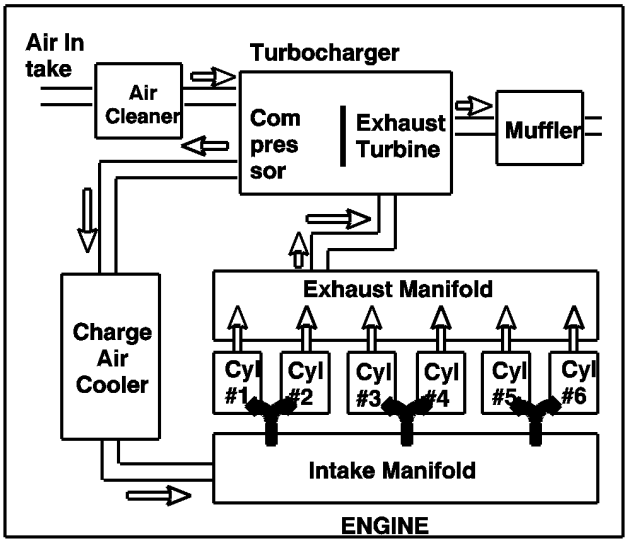

Figure 6 Charge Air Cooling Diagram

The turbocharger is powered by energy extracted from exhaust gasses to turn a turbine wheel. A shaft connects the turbine wheel to the compressor wheel. The compressor wheel blades pressurize (charge) the air, then route it to the charge air cooler (Figure 7).

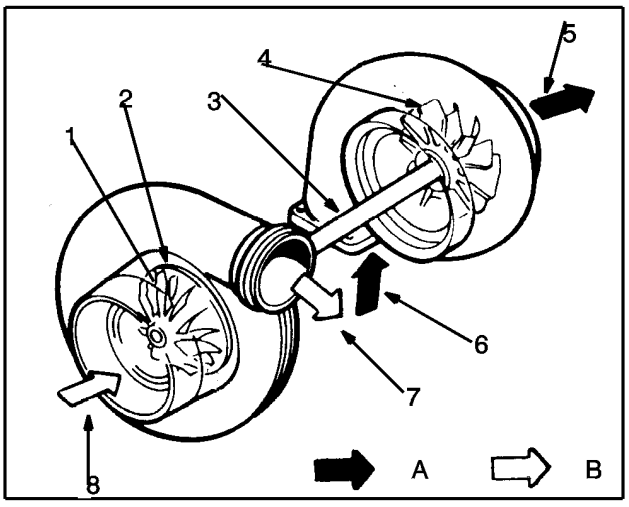

Figure 7 Turbocharger Air Flow Diagram

A. EXHAUST GAS FLOW
B. COMPRESSED AIR FLOW
1. COMPRESSOR WHEEL BLADES
2. COMPRESSOR WHEEL PLATE
3. SHAFT
4. TURBINE EXHAUST WHEEL
5. TURBINE EXHAUST GAS OUTLET TO MUFFLER (A)
6. EXHAUST GAS INLET FROM EXHAUST MANIFOLD (A)
7. COMPRESSED AIR DISCHARGE TO CHARGE AIR COOLER (B)
8. AMBIENT AIR INLET FROM AIR CLEANER (B)

The charge air cooler core transfers heat to the atmosphere to lower the temperature of the charged air as it passes through - from about 300'F. (149'C.) to about 120'F. (49'C.). The reduced-temperature charged air is then delivered to the engine air intake manifold. The cooled air is also condensed, so that more air can be "packed" into the cylinder combustion chamber to improve engine efficiency.

The engine fan draws ambient air through the radiator and charge air cooler cores, and around the engine. This provides needed air flow, especially when the vehicle is moving slowly.

2. MAINTENANCE

The system MUST BE CLEAN inside the charge air cooler tanks and core tubes, as well as the inlet and outlet connection pipes. Timely replacement of the air cleaner filter is the best and easiest way to maintain the cooler system. Monitor the air restriction gauge to determine when to replace the air cleaner filters.

2.1. AIR RESTRICTION GAUGE

Use an air restriction gauge to monitor the condition of the air filter (Figure 8). The yellow diaphragm entering the red zone, or the red piston locking in the visible position indicates the air cleaner needs service.

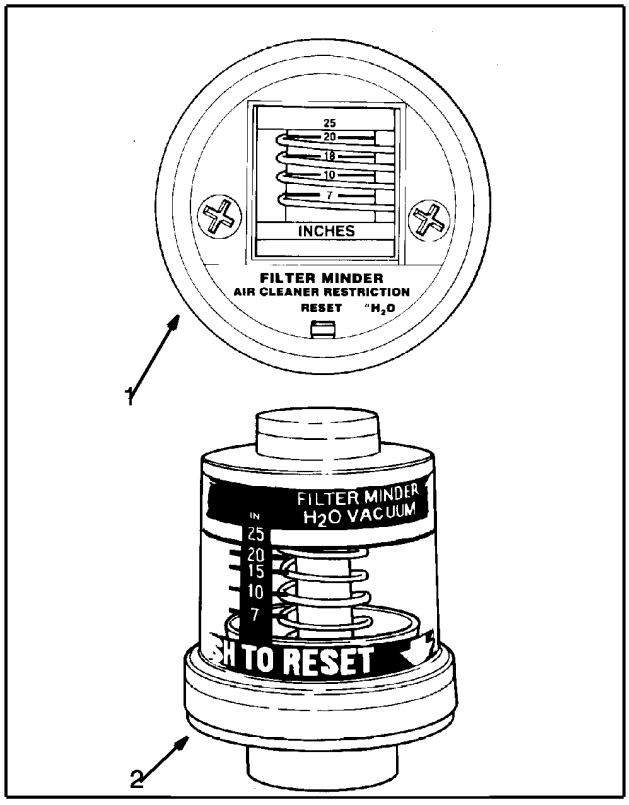

Figure 8 Air Restriction Gauges

1. DASH MOUNTED
2. AIR CLEANER OR INTAKE PIPE MOUNTED, DEPENDING ON THE MODEL

2.2. AIR CLEANER AND AIR FILTERS

Assure the air cleaner is properly maintained and can deliver sufficient filtered air to the engine:

1. Be sure the air cleaner housing is air-tight, and securely assembled to the air intake pipe. Clean or replace air cleaner elements and components as required. Repair or replace a damaged air cleaner or elements immediately.

2. Use the recommended air filter service element to replace the dirty element.

3. TROUBLESHOOTING

3.1. WINTER FRONTS

Winter fronts and other air flow restriction devices that mount in front of the radiator are not recommended for use with charge air cooled engines. The resulting air flow restriction can cause higher exhaust temperatures, power loss, excessive fan usage and a reduction in fuel economy.

If a winter front is used, it must have a circular or diamond-shaped opening - minimum area of 120 inch2 (77 400 mm2) - that is directly in line with the fan drive. This will provide uninterrupted air flow for the fan blades, and air temperature sensing for viscous fan drives.

Trucks parked overnight at very cold ambient temperatures and/or high winds may need winter fronts to provide sufficient water jacket insulation to make the sleeper warm enough. If the winter front is closed at night for sleeping, it must be opened in the morning to prevent engine damage and loss of fuel economy with normal operation.

3.2. VEHICLE POWER LOSS

A LARGE, SUDDEN DROP in boost pressure and power, and/or smoke, especially when climbing a grade, can mean failure of the connecting hoses, a large hole in the cooler core, or a loose hose clamp. Avoid sustained vehicle operation.

A SLIGHT REDUCTION in power or response, or a small increase in exhaust temperature may indicate a small air leak in the charge air cooler core or piping.

3.3. SPRING-LOADED T-BOLT HOSE CLAMPS

Because of extreme temperature changes, hoses will HEAT-SET, making the hose less resilient and the outside diameter smaller. This can cause the hose clamps to loosen and leak, resulting in vehicle power loss. Using spring-loaded T-bolt hose clamps will help prevent hose clamp failures.

3.4. TROUBLESHOOTING CHART

Table 1 Troubleshooting Chart

Condition	Possible Cause	Possible Remedy
Low vehicle power	Cooler leak	Refer to AIR LEAK TEST (See AIR LEAK TEST, page 11).
		Replace cooler assy. as needed.
	Cooler contamination	Replace cooler assembly.
	Dirty turbocharger compressor wheel and housing	Clean with shop solvents and a soft bristle brush.
Dirty air cooler system	Turbocharger oil seal bearing failure	Replace the oil seal. Refer to engine manual.

Table 1 Troubleshooting Chart (cont.)

Condition	Possible Cause	Possible Remedy
	Plugged air filter element, hole in air filter element, element not seated properly	Replace air filter and/or element.
		Seat element properly.
Excessive smoke	Cooler leak	Refer to AIR LEAK TEST (See AIR LEAK TEST, page 11).
		Replace cooler assembly.
	Hose leak, hose clamp not secure	Tighten to the value found in the TORQUE CHART (See TORQUE CHART, page 17).
		If there is no bridge gap, replace too-large clamp with smaller one. Refer to Figure 9 .Tighten to value in the TORQUE CHART (See TORQUE CHART, page 17).

4. CLEAN AND INSPECT

4.1. DAILY INSPECTION

With the engine turned off, visually inspect the cooler core DAILY. Carefully remove debris from the outside of the core, using high pressure air or steam. Blow the steam or air through the cooler core toward the front, opposite normal vehicle airflow.

4.2. PERIODIC INSPECTION

Inspect the charge air cooler for damage and leaks AT EACH OIL CHANGE:

1. Thoroughly clean the exterior of the charge air cooler, using the following procedure:
   a. Disconnect the cooler at the inlet and outlet manifolds. Remove the inlet and outlet air hoses. Disassemble and reserve the fasteners holding the unit on the radiator bracket, then remove the unit from the vehicle.

> **CAUTION – To prevent foreign matter from entering the engine, cover the turbocharger outlet and the engine intake manifold while the piping is disassembled.**

   b. Blow the steam or air through the cooler core toward the front, opposite normal vehicle airflow.
   c. Put the cooler assembly into a tank containing non-caustic cleaner (a solution of mild liquid detergent and water works well). Submerge the ENTIRE CORE of the unit, and allow it to soak for at least 30 minutes.

NOTE – Either seal off the manifold pipes, or keep them above the fluid level, to avoid getting solution into the cooler.

   d. Remove the cooler assembly from the tank and repeat Step B.
   e. Drain any liquid that may have seeped into the charge air cooler and allow the unit to dry completely. If necessary, you can force-dry the inside of the core with pressurized air.

f. Re-install the cooler assembly to the vehicle. Check mounting brackets for security and condition. Connect all air hoses, and tighten the hose clamps to the values found in the TORQUE CHART (See TORQUE CHART, page 17).

2. Use a small screwdriver, or a pair of small needle-nose pliers to CAREFULLY straighten bent fins. Fins are made of thin strips of aluminum alloy, and are quite malleable.

3. Check the security of the hose clamps; tighten all clamps to the values found in the TORQUE CHART (See TORQUE CHART, page 17).

NOTE – Check spring-loaded clamps to see if there is sufficient bridge gap (Figure 9) when the clamp is torqued to the value found in the TORQUE CHART (See TORQUE CHART, page 17). If the bridge gap has been taken up, replace the clamp with the next smaller diameter.

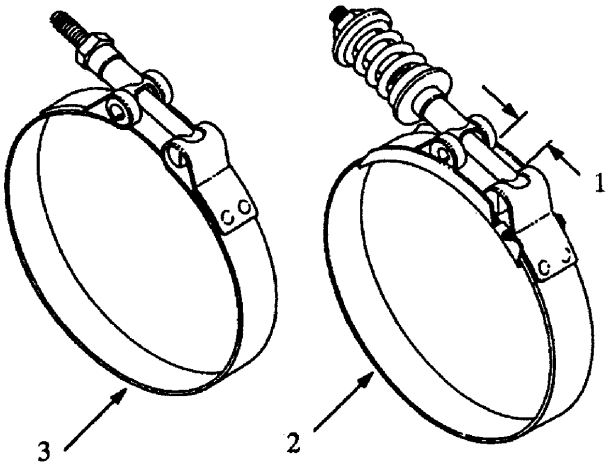

Figure 9 T-Bolt Hose Clamps

1. MINIMUM BRIDGE GAP AT RECOMMENDED TORQUE VALUE TO BE 1/8 INCH (3 MM)
2. SPRING-LOADED T-BOLT CLAMP
3. STRAIGHT T-BOLT CLAMP

4.3. AIR INDUCTION SYSTEM

Inspect the air induction system pipes, hoses and clamps a MINIMUM OF ONCE EACH YEAR. Use the following guidelines:

1. Chlorine in the air induction system (from salt deposits) causes the aluminum piping to corrode and flake. The aluminum flakes then contaminate the engine.

   Disassemble the joints of each aluminum component and inspect for salt deposits. Clean salt build-up from the inside of the pipes with a wire brush; wash hoses with a mild detergent solution and dry them thoroughly before assembling the components.

2. Over a period of time, even a very tiny crack in the air intake system will allow in enough dust to damage the engine.

When assembling components, carefully inspect the entire air intake system, looking for cracks and openings of any size. Use Loctite Make-A-Gasket No. 2, or Superflex™ RTV Silicone to seal pitted joints against leakage. Clean up excess material (that could be pulled into the engine) from inside the pipe.

3. Replace any defective part(s).

> **CAUTION – DO NOT service the air cleaner with the engine running, because this will allow dirt to enter the engine.**

4.4. TURBOCHARGER

Inspect the turbocharger regularly to be certain it is clean. Visually inspect the turbocharger compressor wheel. If only the blades are dirty, this means that dirt and/or moisture is getting through the air filtering system (Figure 7). Clean the compressor wheel and housing with standard shop solvents and a soft bristle brush. Refer to AIR CLEANER AND AIR FILTERS (See AIR CLEANER AND AIR FILTERS, page 7).

Turbocharger Failure

If oil is found on the back side of the compressor wheel plate (Figure 7), suspect a leaking oil seal. This condition can result from extended engine operation at low idle, and/or plugged air filter elements. Refer to AIR CLEANER AND AIR FILTERS (See AIR CLEANER AND AIR FILTERS, page 7), and to the appropriate ENGINE MANUAL.

> **CAUTION – DO NOT OPERATE the engine in the event of turbocharger failure, because serious engine damage and air system contamination may result.**

Cooler Contamination

In the event the charge air cooler is contaminated internally from turbocharger failure or from any cause, cleaning the unit IS NOT RECOMMENDED. The only effective service is to REPLACE the entire unit. Refer to AIR LEAK TEST (See AIR LEAK TEST, page 11).

5. AIR LEAK TEST

NOTE – Charge air coolers are not required to be leak-proof. DO NOT test the cooler core for leakage by submerging it in a radiator test tank. Almost all cooler units will show leakage if they are submerged. It is not necessary to remove the charge air cooler from the vehicle to perform this test.

Before performing the leakage test, VISUALLY INSPECT the core, tanks and welds for cracks and holes. If the cooler fails this visual inspection, REPLACE the charge air cooler.

Use the following procedure to test the charge air cooler for EXCESSIVE LEAKAGE.

5.1. LEAKAGE TESTER HOOK-UP

Charge Air Cooler Inlet Connection (Turbocharger Exhaust "Hot" Side)

> **CAUTION – To prevent foreign matter from entering the engine, cover the turbocharger exhaust and intake piping while the charge air cooler is disconnected.**

1. Disconnect the turbocharger exhaust piping (Item 1, Figure 10) from the charge air cooler hose (Item 5, Figure 10). Refer to the , CAUTION page 12.

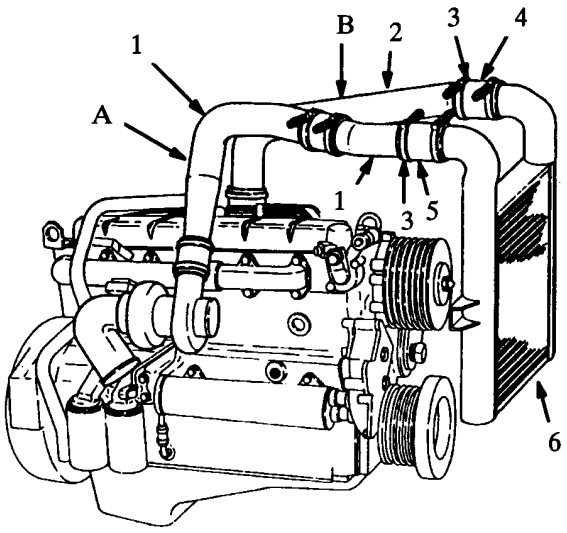

Figure 10 Typical Charge Air System

A. TURBOCHARGER EXHAUST (HOT SIDE)
B. ENGINE AIR INTAKE (COLD SIDE)
1. HOT SIDE PIPE
2. COLD SIDE PIPE
3. HOSE CLAMP
4. COLD SIDE HOSE
5. HOT SIDE HOSE
6. CHARGE AIR COOLER

Refer to Figure 11 for the following items in parentheses, unless otherwise stated.

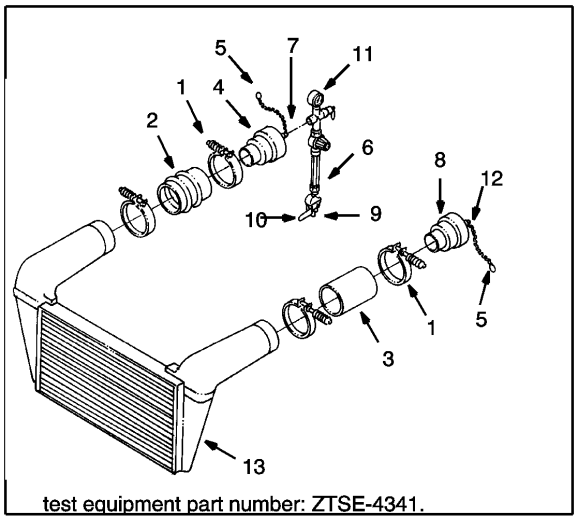

Figure 11 Test Equipment Hook-Up

1. HOSE CLAMP
2. EXHAUST (HOT SIDE) HOSE
3. INTAKE (COLD SIDE) HOSE
4. GAUGE COUPLER
5. SAFETY CHAIN
6. GAUGE-REGULATOR ASSEMBLY
7. QUICK DISCONNECT FITTING
8. BLEED-OFF COUPLER
9. QUICK DISCONNECT FITTING
10. AIR VALVE
11. AIR GAUGE
12. BLEED-OFF VALVE
13. CHARGE AIR COOLER

2. Install the gauge coupler (Item 4, Figure 11) to the charge air cooler hose. Secure the coupler with a clamp so it is AIR TIGHT. Tighten the clamp to the value in the TORQUE CHART (See TORQUE CHART, page 17).

3. Connect the safety chain (Item 5) to any convenient capscrew on the radiator bracket.

> **WARNING – To prevent possible injury from the coupler blowing off the charge air cooler hose during the test, CONNECT THE SAFETY CHAIN BEFORE APPLYING AIR PRESSURE.**

4. Install the gauge-regulator assembly (Item 6) on the gauge coupler (Item 4) at the quick disconnect fitting (Item 7) on the coupler.

Charge Air Cooler Outlet Connection (Engine Air Intake "Cold" Side)

CAUTION – To prevent foreign matter from entering the engine, cover the turbocharger exhaust and intake piping while the charge air cooler is disconnected.

1. Disconnect the engine air intake piping (Item 2, Figure 10) from the charge air cooler hose (Item 4). Refer to the CAUTION page 14.

Refer to Figure 11 for the following items in parentheses.

2. Install the bleed-off coupler (Item 8) to the charge air cooler hose (Item 3). Secure the coupler with a clamp so it is AIR TIGHT. Tighten the clamp to the value in the TORQUE CHART (See TORQUE CHART, page 17).

3. Connect the safety chain (Item 5) to any convenient capscrew on the radiator.

WARNING – To prevent possible injury from the coupler blowing off the charge air cooler hose during the test, CONNECT THE SAFETY CHAIN BEFORE APPLYING AIR PRESSURE.

5.2. LEAK TEST (AIR PRESSURE APPLICATION)

1. Connect a filtered air supply to the quick disconnect fitting (Item 9) on the gauge-regulator assembly (Item 6).

2. Open the air valve (Item 10) slightly, and increase the air pressure SLOWLY until the gauge (Item 11) reads 30 psi (205 kPa). Close the valve and monitor the gauge with a stop watch for 15 seconds. Note any decrease in air pressure.

WARNING – To prevent possible injury from the adapters blowing off during testing, increase air pressure SLOWLY.

WARNING – After testing, relieve the pressure SLOWLY through the bleed valve before removing the test equipment from the charge air cooler.

3. Repeat the test at least three times to verify the results.

   a. THE CHARGE AIR COOLER PASSES if the pressure drop is 5 psi (34 kPa) or less in 15 seconds.

      If the charge air cooler passes, the test is complete. Bleed air from the system by depressing the bleed-off valve (Item 12) on the bleed-off coupler (Item 8). Remove the air hose, gauge-regulator assembly and both couplers. Connect the charge air hoses to the turbocharger exhaust piping and

the engine air intake piping. Tighten the hose clamps to the value in the TORQUE CHART (See TORQUE CHART, page 17).

b. THE CHARGE AIR COOLER FAILS if the pressure drop is more than 5 psi (34 kPa) in 15 seconds.

Check for air leaks by using a pump spray bottle to apply a soapy solution to the hoses and the charge air cooler hose connections and test equipment. No bubbles should appear.

If the charge air cooler fails or any hoses fail, REPLACE the defective part. Assemble the charge air cooler and hoses; tighten the hose clamps to the value found in the TORQUE CHART (See TORQUE CHART, page 17). Repeat the AIR LEAK TEST (See AIR LEAK TEST, page 11).

6. CHARGE AIR COOLER HOSES AND CLAMPS

6.1. HOSES AND CLAMPS FOR EXHAUST (HOT) SIDE

The correct material for the exhaust hose is silicone. It is a color other than black, frequently red or blue. Some silicone hoses have two humps with three wire reinforcements in the center (Figure 12).

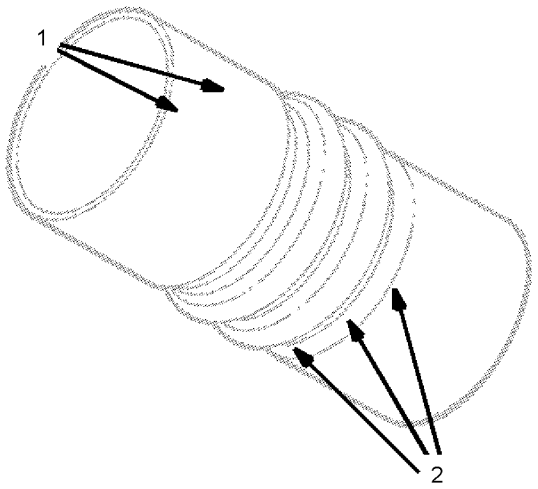

Figure 12 Silicone (Hump) Hose

1. HUMP
2. WIRE REINFORCEMENT

Always use a spring-loaded, T-bolt style hose clamp (Figure 9) to hold the silicone hose in place at the ends of the pipes to be joined. Place the clamp around the hose over the pipe end at each side of the joint, snug to the beaded end (Figure 13). Tighten the clamp to the value found in the TORQUE CHART (See TORQUE CHART, page 17).

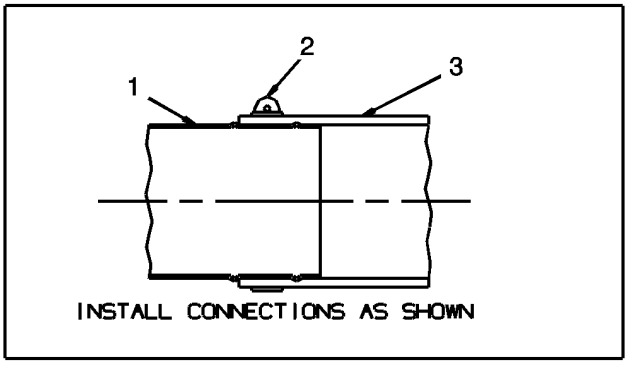

Figure 13 Hose Clamp Installation

1. PIPE
2. CLAMP
3. HOSE

6.2. HOSES AND CLAMPS FOR INTAKE (COLD) SIDE

The correct material for the intake hose is EPDM, which is synthetic rubber. The color is always black.

A straight T-bolt clamp (Figure 9) may be used to hold the EPDM hose in place at the ends of the pipes to be joined. Place the clamp around the hose over the pipe end at each side of the joint, snug to the beaded end (Figure 13). Tighten the clamp to the value found in the TORQUE CHART (See TORQUE CHART, page 17).

NOTE – The "cold" side of the charge air cooler may be upgraded with the spring-loaded T-bolt clamps and silicone hoses specified for the hot side. CONSTANT TORQUE (SPRING LOADED) CLAMPS MUST BE USED ON SILICONE HOSES.

CAUTION – DO NOT DOWNGRADE THE HOT SIDE of the charge air cooler with EPDM hose lengths, or with straight T-bolt clamps specified for the "cold" side. EPDM is not made to withstand the higher temperatures, the straight T-bolt clamps are not constant torque type, and the hoses will blow off the pipes during vehicle operation.

7. TORQUE CHART

Table 2 Torque Chart

Spring-loaded and Straight T-bolt Hose Clamps		
Pipe	Torque	
Material	For New Hoses	For Heat-Set Hoses
Aluminum	50 - 60 in-lb.	50 in-lb.
	(5.65 - 6.78 N•m)	(5.65 N•m)
Steel	65 - 75 in-lb.	65 in-lb.
	(7.34 - 8.37 N•m)	(7.34 N•m)
ENGINE	TORQUE VALUE	
Medium-duty engine (DTA-360 or DTA-466)	50 - 60 in-lb. (5.65 - 6.78 N•m) [65 in-lb (7.34 N•m) is the maximum torque that aluminum pipe can withstand].	
Heavy-duty engine (Cummins, Cater-pillar, Detroit Diesel)	70 - 75 in-lb.	
	(7.91 - 8.47 N•m)	

8. TEST EQUIPMENT

The test equipment to perform the air leakage test is available from service parts. The part number is: ZTSE-4341.