EXHAUST SYSTEM AND TURBOCHARGER

CONTENTS

GENERAL INFORMATION

TURBOCHARGER SHUT-DOWN PROCEDURE

The most common turbocharger failure is bearing failure related to repeated hot shutdowns with inadequate “cool-down” periods. A sudden engine shut down after prolonged operation will result in the transfer of heat from the turbine section of the turbocharger to the bearing housing. This causes the oil to overheat and break down, which causes bearing and shaft damage the next time the vehicle is started.

Letting the engine idle after extended operation allows the turbine housing to cool to normal operating temperature. The following chart should be used as a guide in determining the amount of engine idle time required to sufficiently cool down the turbocharger before shut down, depending upon the type of driving and the amount of cargo.

EXHAUST SYSTEM

The diesel engine exhaust system consists of an engine exhaust manifold, turbocharger, exhaust pipe, resonator, extension pipe (if needed), muffler and exhaust tailpipe.

The exhaust manifold is a one piece design and is constructed of cast iron. Spacers are used between the fasteners and the manifold to reduce the impact of thermal stress on the manifold and fasteners.

The exhaust system must be properly aligned to prevent stress, leakage and body contact. If the system contacts any body panel, it may amplify objectionable noises from the engine or body.

When inspecting an exhaust system, critically inspect for cracked or loose joints, stripped screw or

TURBOCHARGER ″COOL DOWN″ CHART

Driving Condition	Load	Turbocharger Temperature	Idle Time (in minutes) Before Engine Shut Down
Stop & Go	Empty	Cool	Less than 1
Stop & Go	Medium	Warm	1
Highway Speeds	Medium	Warm	2
City Traffic	Max. GCWR	Warm	3
Highway Speeds	Max. GCWR	Warm	4
Uphill Grade	Max. GCWR	HOT!!	5

GENERAL INFORMATION (Continued)

bolt threads, corrosion damage and worn, cracked or broken hangers. Replace all components that are badly corroded or damaged. DO NOT attempt to repair.

When replacement is required, use original equipment parts (or their equivalent). This will assure proper alignment and provide acceptable exhaust noise levels.

CAUTION: Avoid application of rust prevention compounds or undercoating materials to exhaust system floor pan exhaust heat shields. Light overspray near the edges is permitted. Application of coating will result in excessive floor pan temperatures and objectionable fumes.

DESCRIPTION AND OPERATION

AIR INTAKE / BOOST SYSTEM

The air intake system consists of the air cleaner/housing assembly, turbocharger, charge air cooler piping, charge air cooler, intake air grid heater, and the intake manifold.

Intake air is drawn through the air cleaner and into the turbocharger compressor housing. Pressurized air from the turbocharger then flows forward through the charge air cooler (Fig. 1) located in front of the radiator. From the charge air cooler the air flows back into the intake manifold.

The charge air cooler is a heat exchanger that uses air flow from vehicle motion to dissipate heat from the intake air. As the turbocharger increases air pressure, the air temperature increases. Lowering the intake air temperature increases engine efficiency and power.

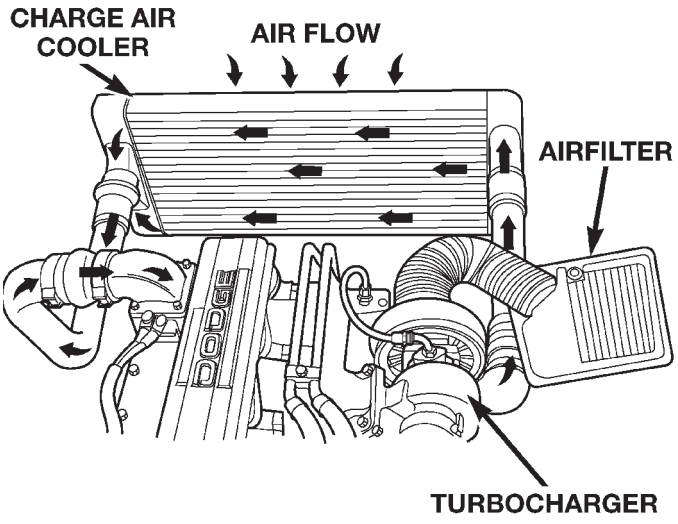

Fig. 1 Intake Air Circulation

CAUTION: The charge air cooler must be cleaned following turbocharger failure involving an oil leak. Oil leaking from the turbocharger can cause engine runaway, possibly leading to engine failure. Refer to Charge Air Cooler Removal and Installation in this group.

TURBOCHARGER

CAUTION: The turbocharger is a performance part and must not be tampered with. The wastegate bracket is an integral part of the turbocharger. Tampering with the wastegate components can reduce durability by increasing cylinder pressure and thermal loading due to incorrect inlet and exhaust manifold pressure. Poor fuel economy and failure to meet regulatory emissions laws may result. Increasing the turbocharger boost WILL NOT increase engine power.

DESCRIPTION

The turbocharger is an exhaust-driven supercharger which increases the pressure and density of the air entering the engine. With the increase of air entering the engine, more fuel can be injected into the cylinders, which creates more power during combustion.

The turbocharger assembly consists of four (4) major component systems (Fig. 2) (Fig. 3):

- Turbine section
- Compressor section
- Bearing housing
- Wastegate

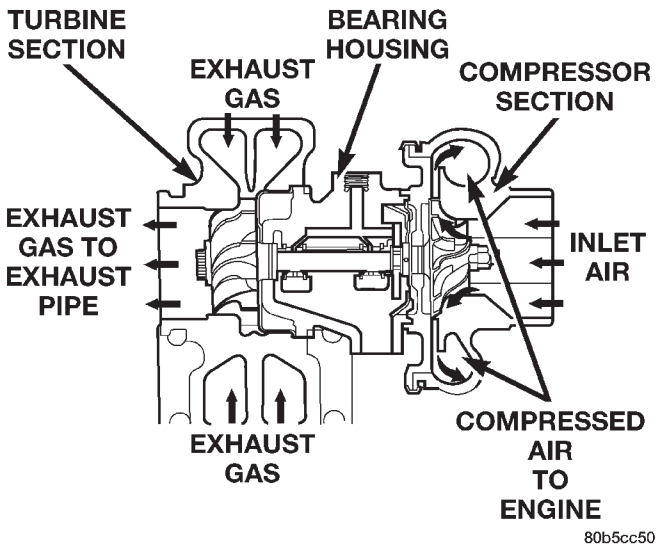

Fig. 2 Turbocharger Operation

DESCRIPTION AND OPERATION (Continued)

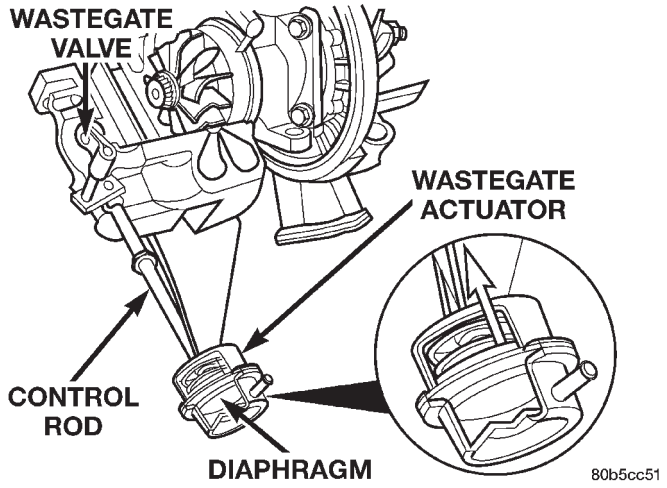

Fig. 3 Turbocharger Wastegate

OPERATION

Exhaust gas pressure and energy drive the turbine, which in turn drives a centrifugal compressor that compresses the inlet air, and forces the air into the engine through the charge air cooler and plumbing. Since heat is a by-product of this compression, the air must pass through a charge air cooler to cool the incoming air and maintain power and efficiency.

Increasing air flow to the engine provides:

- Improved engine performance
- Lower exhaust smoke density
- Improved operating economy
- Altitude compensation
- Noise reduction.

The turbocharger also uses a wastegate (Fig. 4), which regulates intake manifold air pressure and prevents over boosting at high engine speeds. When the wastegate valve is closed, all of the exhaust gases flow through the turbine wheel. As the intake manifold pressure increases, the wastegate actuator opens the valve, diverting some of the exhaust gases away from the turbine wheel. This limits turbine shaft speed and air output from the impeller.

LUBRICATION

The turbocharger is lubricated by engine oil that is pressurized, cooled, and filtered. The oil is delivered to the turbocharger by a supply line that is tapped into the oil filter head. The oil travels into the bearing housing, where it lubricates the shaft and bearings (Fig. 5). A return pipe at the bottom of the bearing housing, routes the engine oil back to the crankcase.

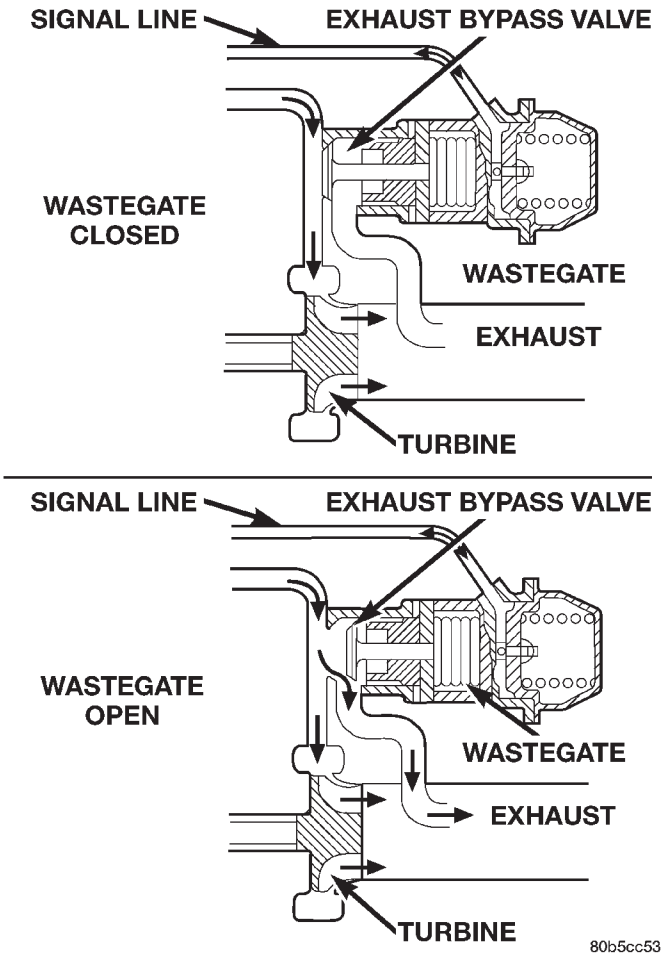

Fig. 4 Wastegate Operation

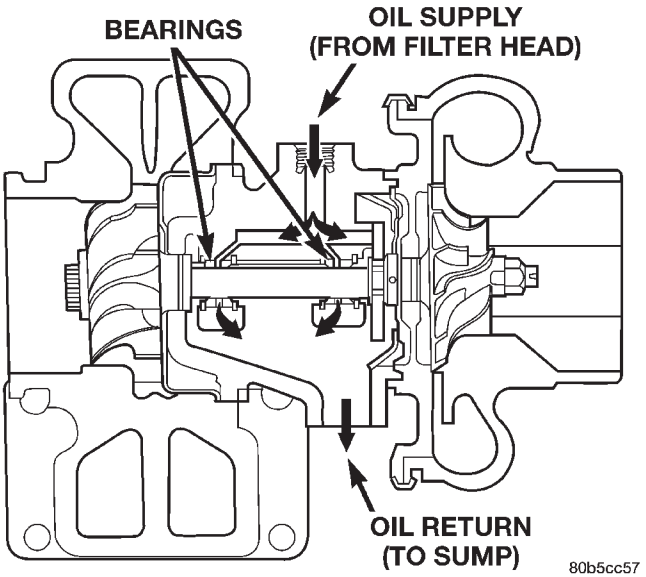

Fig. 5 Turbocharger Oil Supply and Drain

DIAGNOSIS AND TESTING

EXHAUST SYSTEM DIAGNOSIS CHART

EXCESSIVE EXHAUST NOISE OR LEAKING EXHAUST GASES	
POSSIBLE CAUSE	**CORRECTION**
Leaks at pipe joints.	Tighten clamps/bolts at leaking joints.
Rusted or blown out muffler.	Replace muffler. Inspect exhaust system.
Broken or rusted out exhaust pipe.	Replace exhaust pipe.
Exhaust pipe leaking at manifold flange.	Tighten/replace flange attaching nuts/bolts.
Exhaust manifold cracked or broken.	Replace exhaust manifold.
Leak between exhaust manifold and cylinder head.	Tighten exhaust manifold to cylinder head bolts.
Turbocharger mounting flange cracked.	Remove turbocharger and inspect. Refer to Turbocharger Removal and Installation in this group.
Restriction in exhaust system.	Remove restriction, if possible. Replace restricted part if necessary.

TURBOCHARGER / AIR INTAKE SYSTEM DIAGNOSIS

CAUTION: Never operate the engine with the turbocharger air inlet hose and air cleaner housing removed. The turbocharger is a precision component and it is imperative that it always recieves filtered air. Otherwise, premature turbocharger and/or engine failure can result.

Proper turbocharger/air intake system diagnosis is critical when it involves low power or noise complaints. Low power, noise, and oil leak complaints can be easily misdiagnosed as a faulty turbocharger, resulting in the unnecessary replacement of an expensive component. Therefore, it is essential that the following diagnosis be performed prior to any turbocharger/air intake system service.

LOW POWER/NOISE DIAGNOSIS

NOTE: Before proceeding with turbocharger and boost system diagnosis, verify that there are no performance related DTC's or fuel and emission system faults present.

It is normal for the turbocharger to emit a "whine" sound that varies in intensity depending on engine speed and load. The sound is caused by the very high rotational speed of the rotor assembly (up to 130,000 rpm) and the method used to balance the rotor assembly during manufacturing. Consequently, the sound will be more audible at full speed.

Leaks in the air system intake and/or exhaust components can produce excessive noise. These noises are typically a high pitched "whine" or sucking sound, depending on which side of the compressor they are located. Lower pitched noises or rattles at low engine speeds may indicate debris in the system or an impeller-to-housing rubbing condition.

(1) Make sure engine is off (not running).

(2) Install a DRB III to the vehicle and check for any performance related DTC's. Repair DTC setting failures before further diagnosis. Refer to Group 25, Emission Control Systems for the correct procedures.

(3) Remove the air cleaner housing from the vehicle and inspect for obstructions. Replace the air filter as necessary. Refer to Group 14, Fuel System for air filter housing and Filter Minder® procedures.

(4) Inspect the turbocharger:

(a) Visually inspect the impeller and compressor wheel fins for nicks, cracks, or chips. Note: Some impellers may have a factory placed paint mark which, after normal operation, appears to be a crack. Remove this mark with a suitable solvent to verify that it is not a crack.

(b) Visually inspect the compressor and turbine housing for an impeller rubbing condition. Apply light side to side pressure to the nose of the impeller to see if contact with the housing will restrict impeller rotation. Replace the turbocharger if an impeller to housing rubbing condition exists.

(c) Measure rotor shaft axial end play and radial bearing clearances. Refer to procedure in this group. Replace turbocharger if measurements are outside of specifications.

(5) Inspect and test boost system for leaks:

(a) Visually inspect boost system for cracked tubes and rubber connectors, poor connections and

DIAGNOSIS AND TESTING (Continued)

loose clamps. Verify torque at all boost system clamps at 8 N·m (71 in. lbs.) torque.

(b) Leak test boost system. Obtain the Charge Air Cooler Tester Kit #3824556 from Cummins® Service Products.

(I) Disconnect boost tube from the air inlet/intake manifold. Cap off the tube end.

(II) Install the appropriate test plug from the kit to the turbocharger air inlet.

(III) Apply 172 kPa (25 psi) to the boost system. Listen for leaks and repair as necessary. Use a solution of soap and water at connections and on suspect areas to help determine possible leak areas.

(IV) If the charge air cooler is suspected of leaking, remove the boost tubes and install the necessary cap and test plug from the CAC tester kit. Apply 172 kPa (25 psi) to the charge air cooler and replace if found to be leaking.

(6) Inspect the wastegate signal line for cracks and verify wastegate operation and adjustment. Refer to Wastegate Verification/Adjustment in this group.

(7) Perform the Boost Pressure Test to determine if there are any intake system restrictions, plugging, or damage. Refer to Group 14, Fuel System for the correct procedure.

TURBOCHARGER OIL LEAKS

Turbocharger oil leaks can be classified as one of two types: external or internal. External leaks are usually limited to the turbocharger oil supply line fitting and the oil drain tube flange and gasket. Internal leaks, however, are more complicated to detect. Many turbocharger internal oil leaks are caused by problems in systems outside of the turbocharger.

NOTE: A light trace of oil present in the turbine or compressor housing is acceptable and repair is not necessary. Repair is only necessary when oil is dripping or wet to the touch.

NOTE: When a component fails causing engine oil migration into the intake air/boost system, the charge air cooler and related tubing must be flushed. Refer to Charge Air Cooler Removal/Installation for the related procedures.

TURBOCHARGER OIL LEAK DIAGNOSIS CHARTS

EXTERNAL OIL LEAKS	
POSSIBLE CAUSE	**CORRECTION**
Oil supply line or o-ring leaking	Disconnect the oil supply line and inspect o-ring. Replace if necessary. Install and tighten line fitting to 20 N·m (133 in. lbs.) torque.
Oil drain tube leaking.	Inspect drain tube flange and gasket. Replace gasket if necessary.
Turbocharger bearing housing leaking.	Replace turbocharger assy.

INTERNAL LEAKS (OIL FOUND IN COMPRESSOR HOUSING)	
POSSIBLE CAUSE	**CORRECTION**
Dirty air cleaner or restricted air inlet system.	Inspect air cleaner, housing, and inlet duct for restriction. Repair/replace as necessary.
Foreign object in exhaust manifold.	Remove exhaust manifold and inspect for obstruction. Refer to Exhaust Manifold Removal and Installation in this group.
Restricted exhaust system.	Repair/replace restricted component as necessary.
Restricted turbocharger oil drain tube, causing engine oil to migrate past the seal.	Remove tube and inspect for obstructions.
Restricted crankcase breather.	Remove crankcase breather and inspect for obstructions.
Defective turbocharger compressor seal.	Replace turbocharger assy.
Engine mechanical problem.	Excessive crankcase pressure (blow-by). This condition does not allow the oil to drain, and oil is drawn past the compressor seal and into the engine. Refer to Group 9, Engine.

DIAGNOSIS AND TESTING (Continued)

INTERNAL LEAKS (OIL FOUND IN TURBINE HOUSING)	
POSSIBLE CAUSE	**CORRECTION**
Restricted turbocharger oil drain tube, causing engine oil to migrate past the seal.	Remove tube and inspect for obstructions.
Restricted crankcase breather.	Remove crankcase breather and inspect for obstructions.
Engine mechanical problem.	Remove turbocharger assy. Inspect turbine inlet for the presence of engine oil. If oil is present, then engine oil consumption problem exists. Refer to Group 9, Engine. If no oil is present at turbine inlet, replace turbocharger.
Defective turbocharger turbine seal.	Replace turbocharger assy.

REMOVAL AND INSTALLATION

EXHAUST PIPE

WARNING: IF TORCHES ARE USED WHEN WORKING ON THE EXHAUST SYSTEM, DO NOT ALLOW THE FALME NEAR THE FUEL LINES.

REMOVAL

(1) Disconnect the battery negative cables.
(2) Raise and support the vehicle on a hoist.
(3) Saturate the bolts and nuts with heat valve lubricant. Allow 5 minutes for penetration.
(4) Remove the exhaust pipe-to-extension pipe clamp. Separate the exhaust pipe and extension pipe.
(5) Remove the exhaust pipe-to-turbocharger elbow bolts (Fig. 6).
(6) Remove the exhaust pipe from the transmission support (Fig. 6).

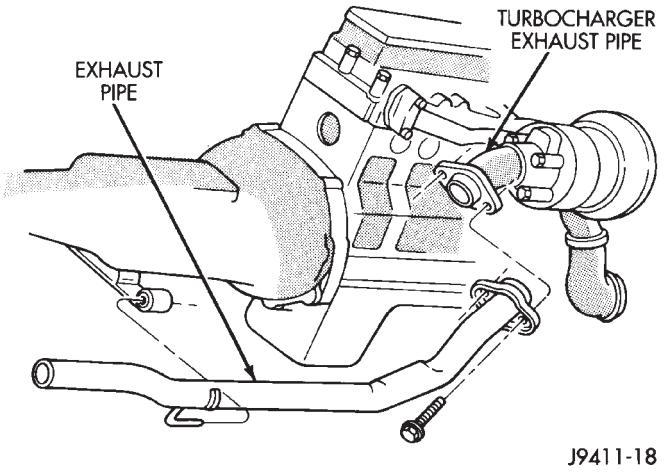

Fig. 6 Exhaust Pipe Removal/Installation

INSTALLATION

(1) Install the exhaust pipe into the transmission support and onto the turbocharger flange (Fig. 6).
(2) Install the exhaust pipe-to-turbocharger elbow bolts and tighten to 34 N·m (25 ft. lbs.) torque.
(3) Install the extension pipe and clamp to the exhaust pipe using a new clamp and tighten the clamp nuts to 43 N·m (32 ft. lbs.) torque.
(4) Lower the vehicle.
(5) Connect the battery negative cables.
(6) Start the engine and inspect for exhaust leaks and exhaust system contact with the body panels. Adjust the alignment, if needed.

RESONATOR

WARNING: IF TORCHES ARE USED WHEN WORKING ON THE EXHAUST SYSTEM, DO NOT ALLOW THE FLAME NEAR THE FUEL LINES.

REMOVAL

(1) Disconnect the battery negative cables.
(2) Raise vehicle on hoist.
(3) Remove the exhaust clamps from the resonator to extension pipes (Fig. 7).
(4) Separate the resonator from the front and rear extension pipes (Fig. 7) and remove the resonator from the vehicle.

INSTALLATION

(1) Assemble the resonator to the front and rear extension pipes (Fig. 7).
(2) Install new exhaust clamps, align the exhaust system, and tighten the exhaust clamps to 43 N·m (32 ft. lbs.) torque.
(3) Lower the vehicle.
(4) Connect the battery negative cables.
(5) Start the engine and inspect for exhaust leaks.

MUFFLER

WARNING: IF TORCHES ARE USED WHEN WORKING ON THE EXHAUST SYSTEM, DO NOT ALLOW THE FLAME NEAR THE FUEL LINES.

REMOVAL AND INSTALLATION (Continued)

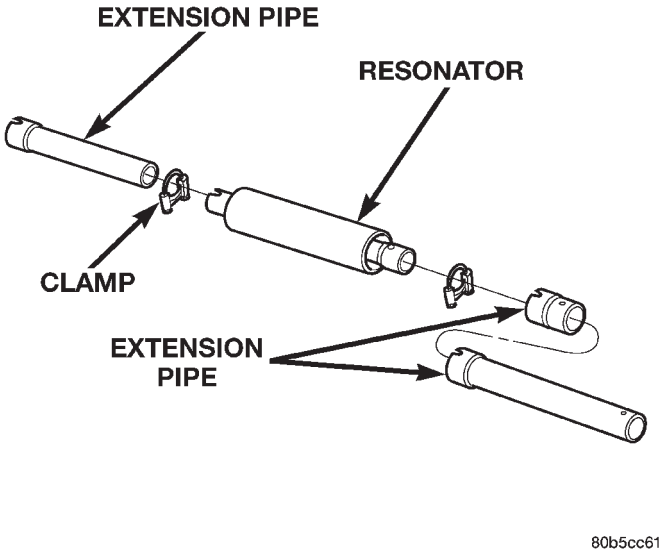

Fig. 7 Resonator Removal/Installation

REMOVAL

(1) Disconnect the battery negative cables.
(2) Raise and support the vehicle.
(3) Remove the muffler to tail pipe and extension pipe clamps (Fig. 8).
(4) Disconnect the muffler from the hanger isolators (Fig. 8).
(5) Disconnect the muffler from the tailpipe.
(6) Disconnect the muffler from the extension pipe and remove from the vehicle..

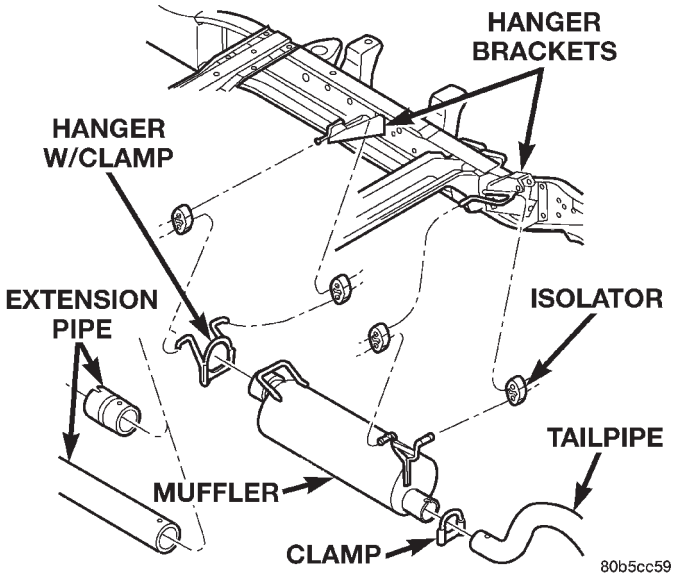

Fig. 8 Muffler Removal/Installation

INSTALLATION

(1) Install the muffler hanger rods into the isolators (Fig. 8).
(2) Install the muffler into the extension pipe.
(3) Install the muffler into the tail pipe.
(4) Install the exhaust clamps, align the exhaust system, and tighten the exhaust clamps to 43 N·m (32 ft. lbs.) torque.
(5) Lower the vehicle.
(6) Connect the battery negative cables.
(7) Start the engine and inspect for exhaust leaks and exhaust system contact with the body panels. Adjust the alignment, if needed.

TAILPIPE

WARNING: IF TORCHES ARE USED WHEN WORKING ON THE EXHAUST SYSTEM, DO NOT ALLOW THE FLAME NEAR THE FUEL LINES.

REMOVAL

(1) Disconnect the battery negative cables.
(2) Raise and support the vehicle.
(3) Saturate the clamp nuts with heat valve lubricant. Allow 5 minutes for penetration.
(4) Disconnect the exhaust tailpipe support hanger isolators (Fig. 9).
(5) Remove the muffler-to-tailpipe clamps (Fig. 9).
(6) Remove the tailpipe from the vehicle.

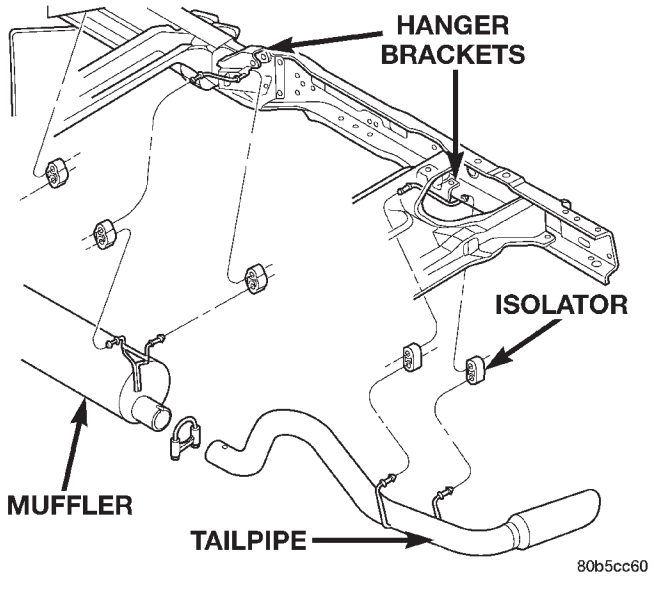

Fig. 9 Tailpipe Removal/Installation

REMOVAL AND INSTALLATION (Continued)

INSTALLATION

(1) Install the tailpipe into the muffler.

(2) Install the tailpipe hanger rods into the isolators (Fig. 9)

(3) Install the exhaust clamp, align the exhaust system, and tighten the clamp 43 N·m (32 ft. lbs.) torque.

(4) Lower the vehicle.

(5) Connect the battery negative cables.

(6) Start the engine and inspect for exhaust leaks and exhaust system contact with the body panels. Adjust the alignment, if needed.

HEAT SHIELDS

REMOVAL

(1) Raise and support the vehicle.

(2) Remove the nuts or bolts holding the exhaust heat shield to the floor pan, crossmember or bracket.

(3) Slide the shield out around the exhaust system.

INSTALLATION

(1) Position the exhaust heat shield to the floor pan, crossmember or bracket and install the nuts or bolts.

(2) Tighten the nuts and bolts.

(3) Lower the vehicle.

EXHAUST MANIFOLD

REMOVAL

(1) Disconnect the battery negative cables.

(2) Raise vehicle on hoist.

(3) Disconnect the exhaust pipe from the turbocharger elbow (Fig. 10).

(4) Lower vehicle.

(5) Disconnect the turbocharger air inlet hose (Fig. 11).

(6) Disconnect the turbocharger oil supply line and the oil drain tube from the turbocharger (Fig. 12).

(7) Disconnect the charge air cooler inlet pipe from the turbocharger (Fig. 12).

(8) Remove the turbocharger and gasket from the exhaust manifold.

(9) Remove the cab heater return pipe nut from the exhaust manifold stud. Position the tube out of the way.

(10) Remove the exhaust manifold-to-cylinder head bolts and spacers (Fig. 13).

(11) Remove the exhaust manifold and gaskets (Fig. 13).

CLEANING

Clean the cylinder head and exhaust manifold sealing surfaces with a suitable scraper. Use a Scotch-Brite™ pad or equivalent.

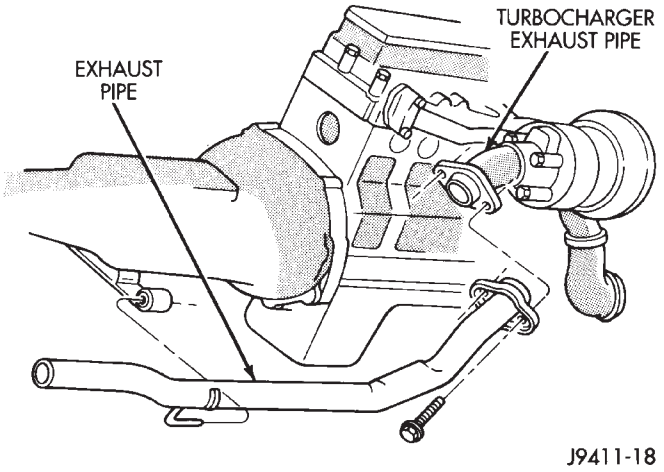

Fig. 10 Exhaust Pipe

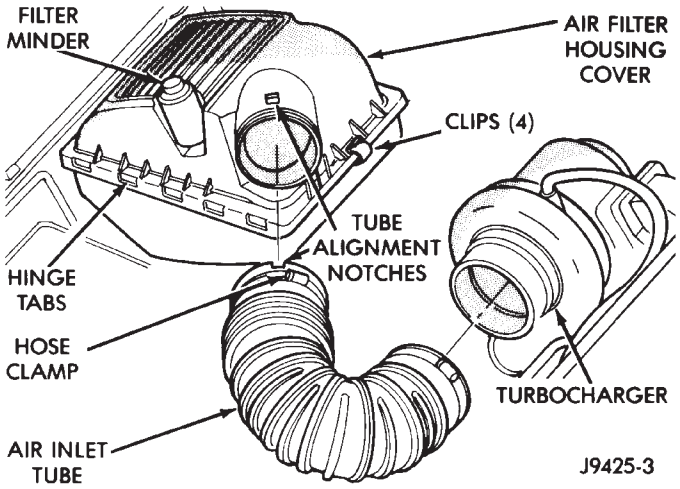

Fig. 11 Turbocharger Air Inlet Hose

INSPECTION

Inspect the exhaust manifold for cracks. Measure the exhaust manifold for flatness. Place a ruler over all of the exhaust ports and insert a feeler gauge between the port flange and the ruler.

INSTALLATION

(1) Using new gaskets, install the exhaust manifold and gaskets. Install the bolts and spacers and tighten the bolts in the sequence shown in (Fig. 13) to 43 N·m (32 ft. lbs.) torque.

(2) Install the cab heater return hose to the manifold bolt stud. Tighten the nut to 24 N·m (18 ft. lbs.) torque.

(3) Install the turbocharger. Apply anti-seize to the studs and then tighten the turbocharger mounting nuts to 32 N·m (24 ft. lbs.) torque.

(4) Install the oil drain tube and oil supply line to the turbocharger. Tighten the drain tube bolts to 24 N·m (18 ft. lbs.) torque.

REMOVAL AND INSTALLATION (Continued)

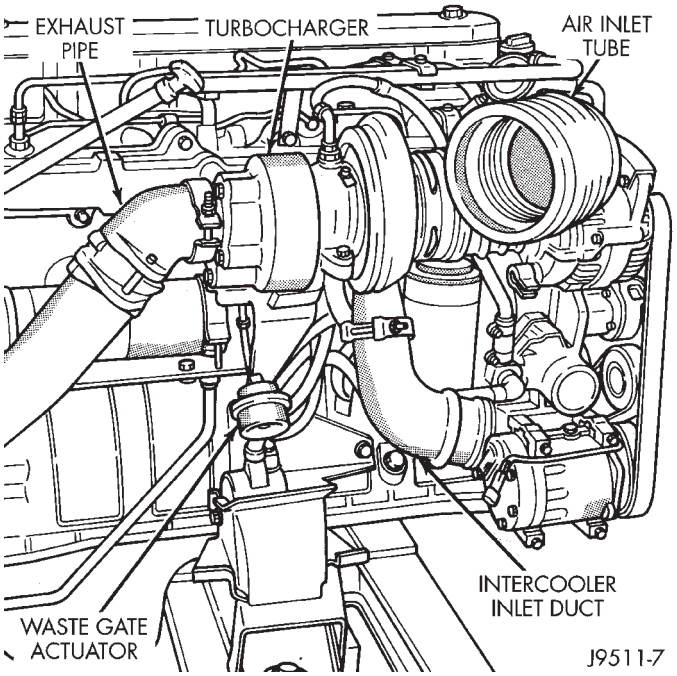

Fig. 12 Oil Supply Line and Charge Air Cooler Inlet Duct

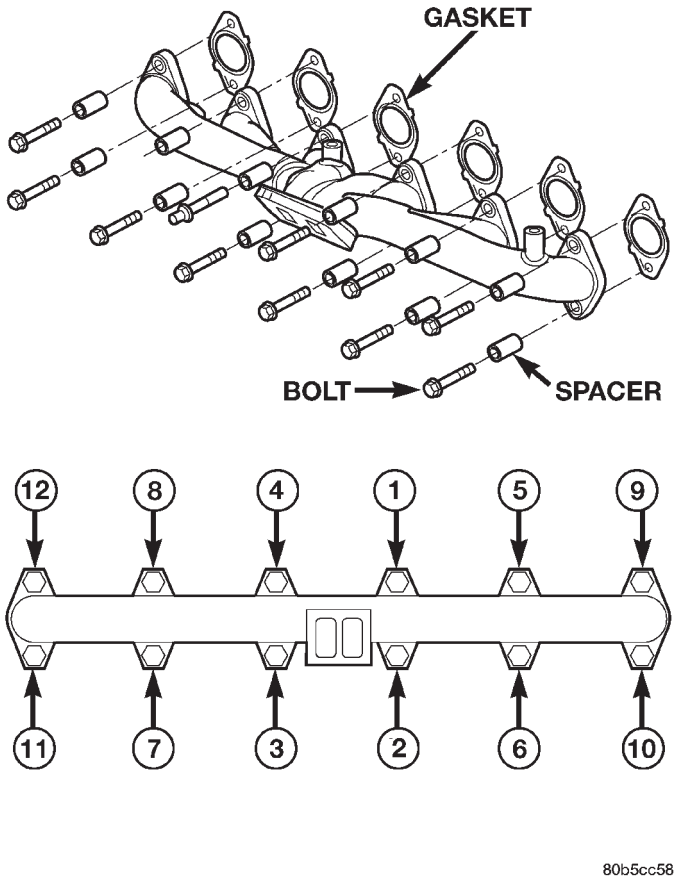

Fig. 13 Exhaust Manifold and Gaskets

EXHAUST MANIFOLD FLATNESS
0.20 mm (0.008 in.) MAX.

(5) **Pre-lube the turbocharger.** Pour 50 to 60 cc (2 to 3 oz.) clean engine oil in the oil supply line fitting. Rotate the turbocharger impeller by hand to distrubute the oil thoroughly.

(6) Install and tighten the oil supply line fitting nut to 20 N·m (133 in. lbs.) torque.

(7) Position the charge air cooler inlet pipe to the turbocharger. With the clamp in position, tighten the clamp nut to 8 N·m (72 in. lbs.) torque.

(8) Position the air inlet hose to the turbocharger (Fig. 11). Tighten the clamp to 8 N·m (72 in. lbs.) torque.

(9) Raise vehicle on hoist.

(10) Connect the exhaust pipe to the turbocharger (Fig. 10) and tighten the bolts to 34 N·m (25 ft. lbs.) torque.

(11) Lower the vehicle.

(12) Connect the battery negative cables.

(13) Start the engine to check for leaks.

INTAKE MANIFOLD COVER

REMOVAL

(1) Disconnect the battery negative cables.

(2) Remove the charge air cooler outlet tube from the air inlet housing (Fig. 14).

(3) Remove the engine oil dipstick tube mounting bolt (Fig. 14). Position dipstick tube to the side.

(4) Disconnect the air grid heater power cables at the cable mounting studs (Fig. 15).

(5) Remove the four (4) air inlet housing mounting bolts (Fig. 15) and remove the housing from top of the heater elements.

(6) Remove the intake air grid heater from the manifold (Fig. 16).

(7) Remove the high pressure fuel lines. Refer to Group 14, Fuel System for the correct procedure.

(8) Remove the remaining intake manifold cover-to-cylinder head bolts.

(9) Remove the intake manifold cover and gasket. Keep the gasket material and any other material out of the air intake.

(10) Clean the intake manifold cover and cylinder head sealing surface.

INSTALLATION

(1) Using a new gasket, install the intake manifold cover.

(2) Install the cover-to-cylinder head bolts that do not hold down the high pressure fuel line support brackets. Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

REMOVAL AND INSTALLATION (Continued)

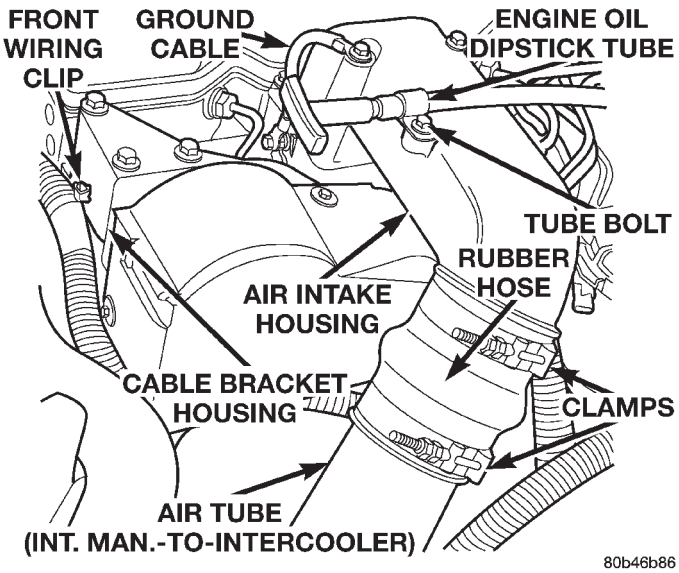

Fig. 14 Charge Air Cooler Air Tube

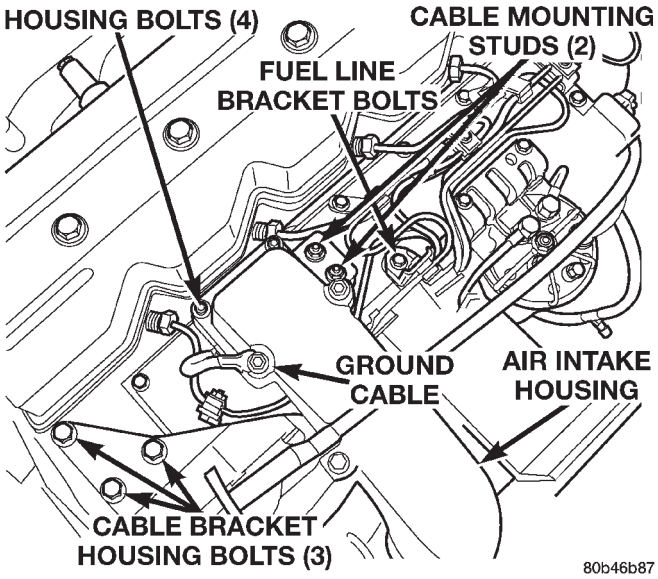

Fig. 15 Air Inlet Housing

(3) Install the high pressure fuel lines. Refer to Group 14, Fuel System for the correct procedure.

(4) Install the high pressure fuel line support bracket-to-intake manifold cover bolts and tighten to 24 N·m (18 ft. lbs.) torque.

(5) Using two (2) new gaskets, install the intake air grid heater and air inlet housing (Fig. 15). Position the ground cable and install and tighten the bolts to 24 N·m (18 ft. lbs.) torque.

(6) Install and tighten the air intake heater power supply nuts to 14 N·m (120 in. lbs.) torque.

(7) Install the engine oil dipstick tube and mounting bolt (Fig. 14).

(8) Position the charge air cooler outlet tube onto the air inlet housing (Fig. 14). Tighten the clamps to 8 N·m (72 in. lbs.) torque.

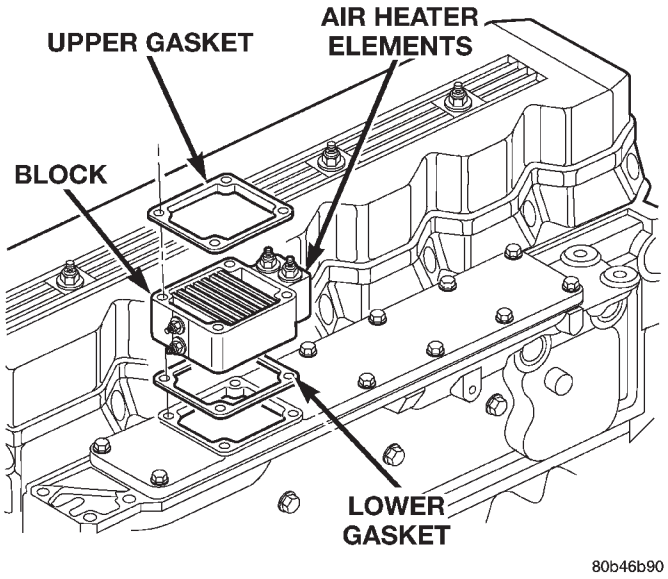

Fig. 16 Intake Air Grid Heater

(9) Perform the fuel system air bleed procedure. Refer to Air Bleed Procedure in Group 14, Fuel System.

(10) Connect the battery negative cables.

TURBOCHARGER

CAUTION: Failed turbochargers introduce engine oil and metal into the charge air cooler and air intake system. The charge air cooler and air intake system MUST be flushed of oil and metallic debris to prevent engine runaway and/or damage.

REMOVAL

(1) Disconnect the battery negative cables.

(2) Raise vehicle on hoist.

(3) Disconnect the exhaust pipe from the turbocharger elbow (Fig. 17).

(4) Lower vehicle.

(5) Disconnect the turbocharger air inlet hose (Fig. 18).

(6) Disconnect the turbocharger oil supply line and the oil drain tube from the turbocharger (Fig. 19).

(7) Disconnect the charge air cooler inlet pipe from the turbocharger (Fig. 19).

(8) Remove the turbocharger and gasket from the exhaust manifold.

(9) If the turbocharger is not to be installed immediately, cover the opening to prevent material from entering into the manifold.

(10) If replacing the turbocharger, transfer the discharge elbow and clamp to the new assembly.

(11) Clean and inspect the sealing surface.

REMOVAL AND INSTALLATION (Continued)

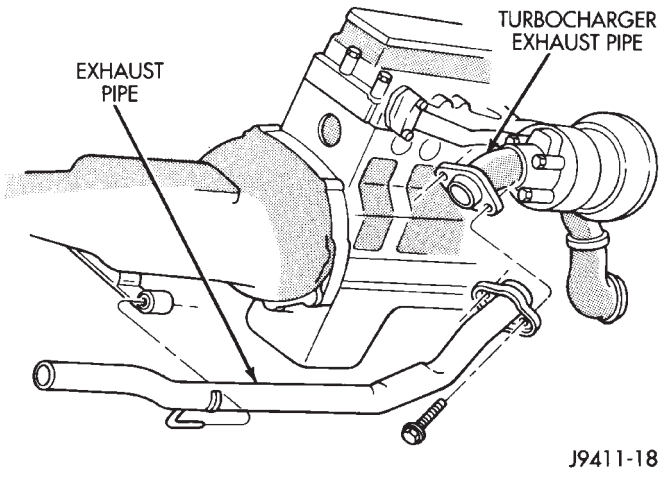

Fig. 17 Exhaust Pipe

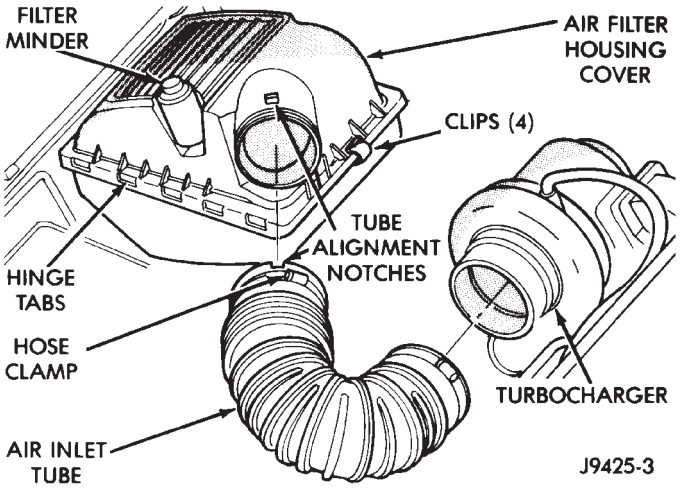

Fig. 18 Turbocharger Air Inlet Hose

CAUTION: The turbocharger is only serviced as an assembly. Do not attempt to repair the turbocharger as turbocharger and/or engine damage can result.

CLEANING

Clean the turbocharger and exhaust manifold mounting surfaces with a suitable scraper.

INSPECTION

Visually inspect the turbocharger and exhaust manifold gasket surfaces. Replace stripped or eroded mounting studs.

(1) Visually inspect the turbocharger for cracks. The following cracks are NOT acceptable:

- Cracks in the turbine and compressor housing that go completely through.
- Cracks in the mounting flange that are longer than 15 mm (0.6 in.).
- Cracks in the mounting flange that intersect bolt through-holes.

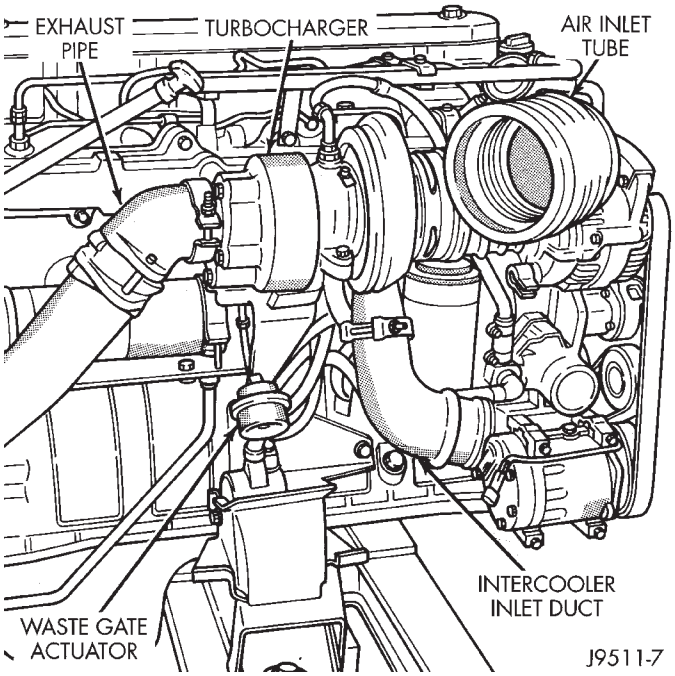

Fig. 19 Oil Supply Line and Charge Air Cooler Inlet Duct

- Two (2) Cracks in the mounting flange that are closer than 6.4 mm (0.25 in.) together.

(2) Inspect the turbocharger compressor housing for an impeller rubbing condition (Fig. 20). Replace the turbocharger if the condition exists.

(3) Measure the turbocharger axial end play:

(a) Install a dial indicator as shown in (Fig. 21). Zero the indicator at one end of travel.

(b) Move the impeller shaft fore and aft and record the measurement. Allowable end play is 0.038 mm (0.0015 in.) MIN. and 0.089 mm (0.0035 in.) MAX. If the recorded measurement falls outside these parameters, replace the turbocharger assembly.

(4) Measure the turbocharger bearing radial clearance:

(a) Insert a narrow blade or wire style feeler gauge between the compressor wheel and the housing (Fig. 22).

(b) Gently push the compressor wheel toward the housing and record the clearance.

(c) With the feeler gauge in the same location, gently push the compressor wheel away from the housing and again record the clearance.

(d) Subtract the smaller clearance from the larger clearance. This is the radial bearing clearance.

(e) Allowable radial bearing clearance is 0.326 mm (0.0128 in.) MIN. and 0.496 mm (0.0195 in.) MAX. If the recorded measurement falls outside these specifications, replace the turbocharger assy.

REMOVAL AND INSTALLATION (Continued)

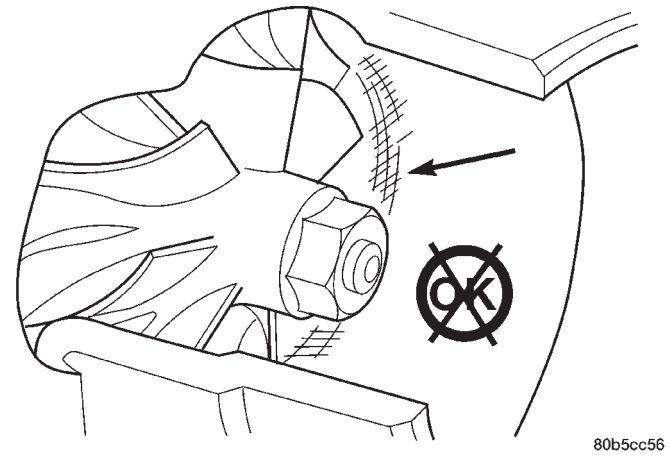

Fig. 20 Inspect Compressor Housing for Impeller Rubbing Condition

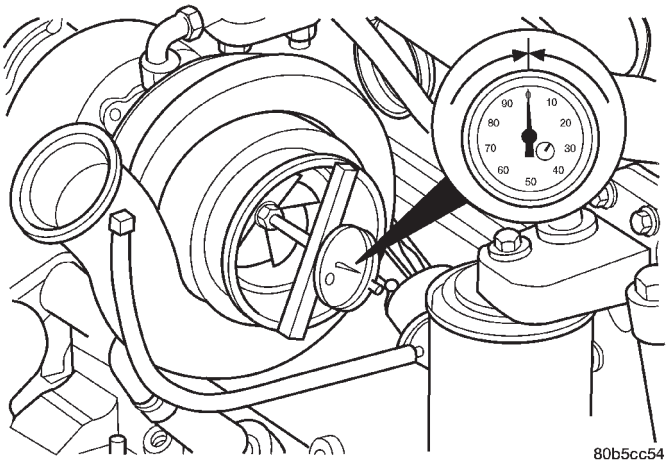

Fig. 21 Measure Turbocharger Axial End Play

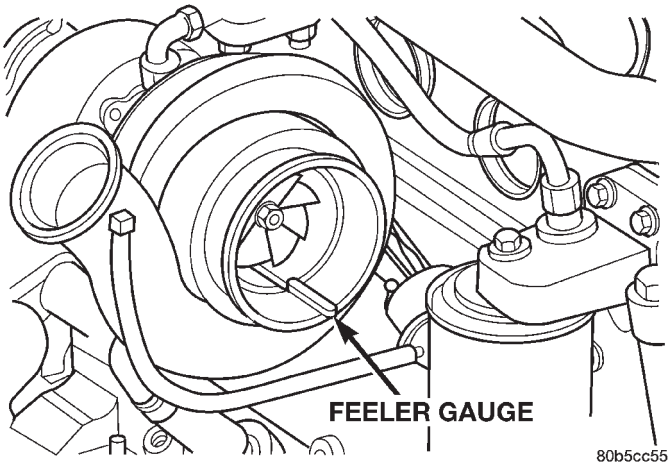

Fig. 22 Measure Turbocharger Bearing Radial Clearance

INSTALLATION

(1) Install the turbocharger. Apply anti-seize to the studs and then tighten the turbocharger mounting nuts to 32 N·m (24 ft. lbs.) torque.

(2) Install the oil drain tube and oil supply line to the turbocharger (Fig. 19). Tighten the drain tube bolts to 24 N·m (18 ft. lbs.) torque.

(3) **Pre-lube the turbocharger.** Pour 50 to 60 cc (2 to 3 oz.) clean engine oil in the oil supply line fitting. Carefully rotate the turbocharger impeller by hand to distribute the oil thoroughly.

(4) Install and tighten the oil supply line fitting nut to 20 N·m (133 in. lbs.) torque.

(5) Position the charge air cooler inlet pipe to the turbocharger. With the clamp in position, tighten the clamp nut to 8 N·m (72 in. lbs.) torque.

(6) Position the air inlet hose to the turbocharger (Fig. 18). Tighten the clamp to 8 N·m (72 in. lbs.) torque.

(7) Raise vehicle on hoist.

(8) Connect the exhaust pipe to the turbocharger (Fig. 17) and tighten the bolts to 34 N·m (25 ft. lbs.) torque.

(9) Lower the vehicle.

(10) Connect the battery negative cables.

(11) Start the engine to check for leaks.

CHARGE AIR COOLER

REMOVAL

WARNING: IF THE ENGINE WAS JUST TURNED OFF, THE AIR INTAKE SYSTEM TUBES MAY BE HOT.

(1) Disconnect the battery negative cables.

(2) Remove the front bumper. Refer to Group 13, Frame and Bumper for the correct procedure.

(3) Remove the front support bracket.

(4) Discharge the A/C system and remove the A/C condenser (Fig. 23) (if A/C equipped). Refer to Group 24, Heating and Air Conditioning for the correct procedures.

(5) Remove the transmission auxiliary cooler (Fig. 23) (if equipped). Refer to Group 7, Cooling System for the correct procedure.

(6) Remove the boost tubes from the charge air cooler (Fig. 24).

(7) Remove the charge air cooler bolts. Pivot the charge air cooler forward and up to remove.

CLEANING

(1) If the engine experiences a turbocharger failure or any other situation where oil or debris get into the charge air cooler, the charge air cooler must be cleaned internally.

REMOVAL AND INSTALLATION (Continued)

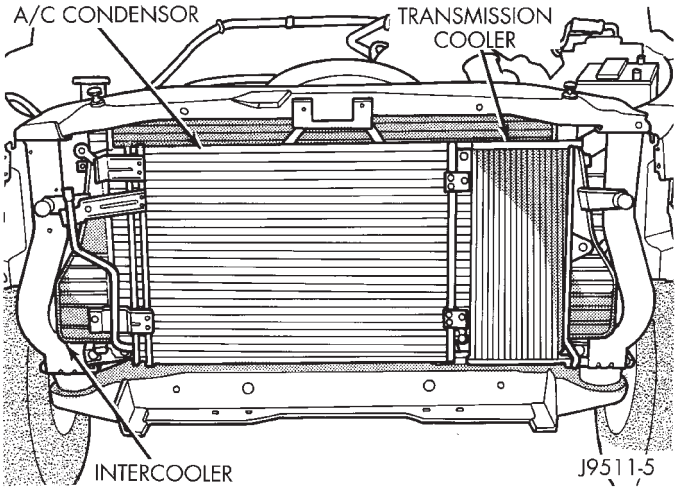

Fig. 23 Condenser and Transmission Auxiliary Cooler

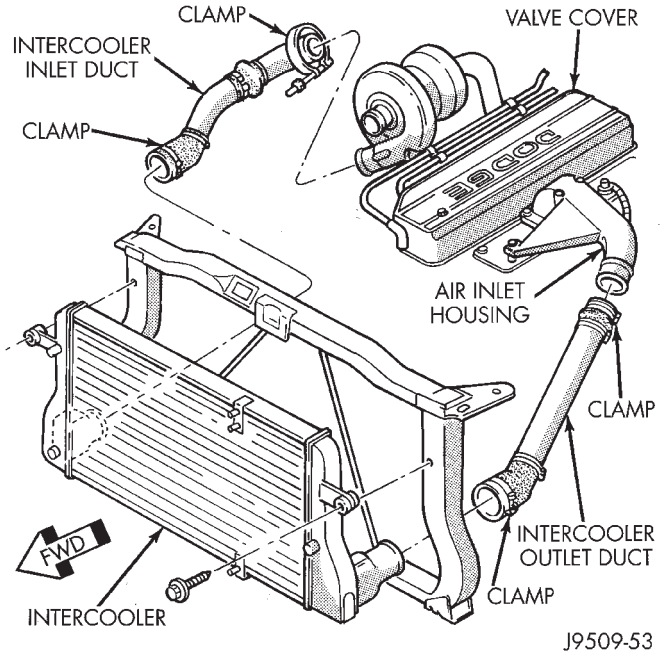

Fig. 24 Air Intake System Tubes

CAUTION: Do not use caustic cleaners to clean the charge air cooler. Damage to the charge air cooler will result.

(2) Position the charge air cooler so the inlet and outlet tubes are vertical.

(3) Flush the cooler internally with solvent in the direction opposite of normal air flow.

(4) Shake the cooler and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris.

(5) Continue flushing until all debris or oil are removed.

(6) Rinse the cooler with hot soapy water to remove any remaining solvent.

(7) Rinse thoroughly with clean water and blow dry with compressed air.

INSPECTION

Visually inspect the charge air cooler for cracks, holes, or damage. Inspect the tubes, fins, and welds for tears, breaks, or other damage.

Pressure test the charge air cooler, using Charge Air Cooler Tester Kit #3824556. This kit is available through Cummins® Service Products. Instructions are provided with the kit.

INSTALLATION

(1) Position the charge air cooler. Install the bolts and tighten to 2 N·m (17 in. lbs.) torque.

(2) Install the air intake system tubes to the charge air cooler. With the clamps in position, tighten the clamps to 8 N·m (72 in. lbs.) torque.

(3) Install the transmission auxiliary cooler (if equipped). Refer to Group 7, Cooling for the correct procedures.

(4) Install the A/C condenser (if A/C equipped). Refer to Group 24, Heating and Air Conditioning for the correct procedures.

(5) Install the front support bracket. Install and tighten the bolts.

(6) Install the front bumper. Refer to Group 13, Frame and Bumpers for the correct procedures.

(7) Connect the battery negative cables.

(8) Start engine and check for boost system leaks.

CLEANING AND INSPECTION

CHARGE AIR COOLER

CLEANING

(1) If the engine experiences a turbocharger failure or any other situation where oil or debris get into the charge air cooler, the charge air cooler must be cleaned internally.

CAUTION: Do not use caustic cleaners to clean the charge air cooler. Damage to the charge air cooler will result.

NOTE: If internal debris cannot be removed from the cooler, the charge air cooler MUST be replaced.

(2) Position the charge air cooler so the inlet and outlet tubes are vertical.

(3) Flush the cooler internally with solvent in the direction opposite of normal air flow.

(4) Shake the cooler and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris.

(5) Continue flushing until all debris or oil are removed.

CLEANING AND INSPECTION (Continued)

(6) Rinse the cooler with hot soapy water to remove any remaining solvent.

(7) Rinse thoroughly with clean water and blow dry with compressed air.

INSPECTION

Visually inspect the charge air cooler for cracks, holes, or damage. Inspect the tubes, fins, and welds for tears, breaks, or other damage. Replace the charge air cooler if damage is found.

Pressure test the charge air cooler, using Charge Air Cooler Tester Kit #3824556. This kit is available through Cummins® Service Products. Instructions are provided with the kit.

TURBOCHARGER

CLEANING

Clean the turbocharger and exhaust manifold mounting surfaces with a suitable scraper.

INSPECTION

Visually inspect the turbocharger and exhaust manifold gasket surfaces. Replace stripped or eroded mounting studs.

(1) Visually inspect the turbocharger for cracks. The following cracks are NOT acceptable:

- Cracks in the turbine and compressor housing that go completely through.
- Cracks in the mounting flange that are longer than 15 mm (0.6 in.).
- Cracks in the mounting flange that intersect bolt through-holes.
- Two (2) Cracks in the mounting flange that are closer than 6.4 mm (0.25 in.) together.

(2) Visually inspect the impeller and compressor wheel fins for nicks, cracks, or chips. Note: Some impellers may have a factory placed paint mark which, after normal operation, appears to be a crack. Remove this mark with a suitable solvent to verify that it is not a crack.

(3) Visually inspect the turbocharger compressor housing for an impeller rubbing condition (Fig. 25). Replace the turbocharger if the condition exists.

(4) Measure the turbocharger axial end play:

(a) Install a dial indicator as shown in (Fig. 26). Zero the indicator at one end of travel.

(b) Move the impeller shaft fore and aft and record the measurement. Allowable end play is 0.038 mm (0.0015 in.) MIN. and 0.089 mm (0.0035 in.) MAX. If the recorded measurement falls outside these parameters, replace the turbocharger assembly.

(5) Measure the turbocharger bearing radial clearance:

(a) Insert a narrow blade or wire style feeler gauge between the compressor wheel and the housing (Fig. 27).

(b) Gently push the compresser wheel toward the housing and record the clearance.

(c) With the feeler gauge in the same location, gently push the compressor wheel away from the housing and again record the clearance.

(d) Subtract the smaller clearance from the larger clearance. This is the radial bearing clearance.

(e) Allowable radial bearing clearance is 0.326 mm (0.0128 in.) MIN. and 0.496 mm (0.0195 in.) MAX. If the recorded measurement falls outside these specifications, replace the turbocharger assy.

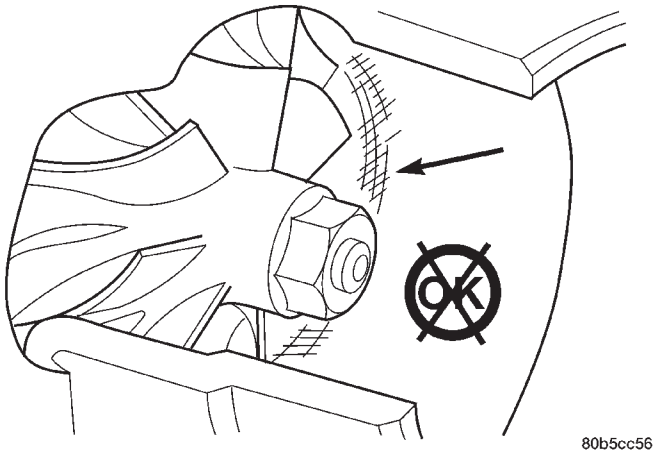

Fig. 25 Inspect Compressor Housing for Impeller Rubbing Condition

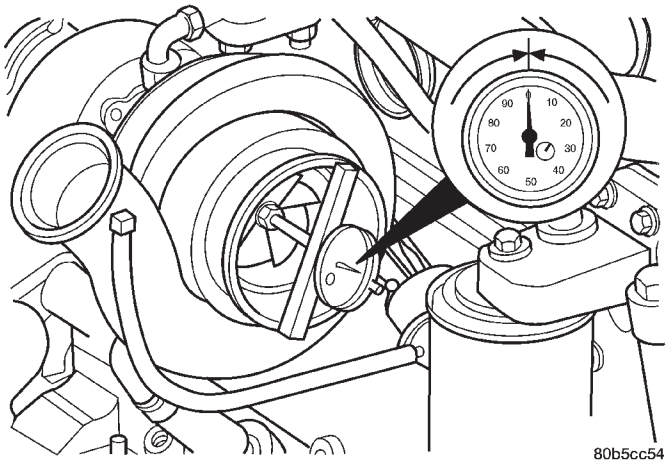

Fig. 26 Measure Turbocharger Axial End Play

EXHAUST MANIFOLD

CLEANING

Clean the cylinder head and exhaust manifold sealing surfaces with a suitable scraper. Use a Scotch-Brite™ pad or equivalent.

CLEANING AND INSPECTION (Continued)

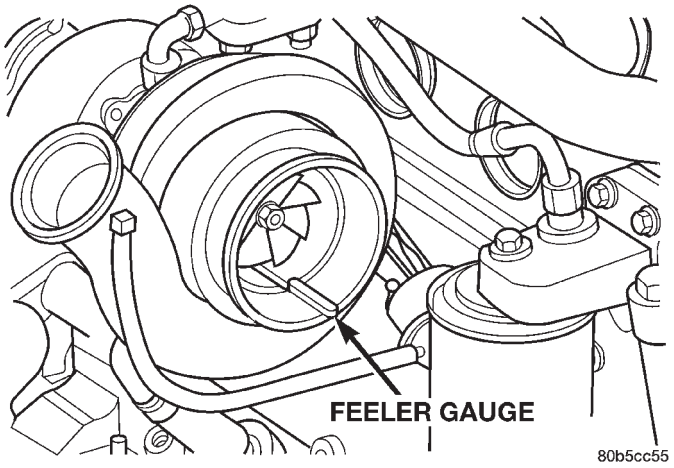

Fig. 27 Measure Turbocharger Bearing Radial Clearance

INSPECTION

Inspect the exhaust manifold for cracks. Measure the exhaust manifold for flatness. Place a ruler over all of the exhaust ports and insert a feeler gauge between the port flange and the ruler. Replace any manifold that is cracked or warped.

EXHAUST MANIFOLD FLATNESS
0.20 mm (0.008 in.) MAX.

ADJUSTMENTS

WASTEGATE ADJUSTMENT

The wastegate turbocharger provides additional low speed boost without over-boost at high speeds. This increases low speed torque and better driveability.

Proper adjustment of the wastegate assembly is critical to the operation of the wastegate turbocharger (Fig. 28). The control rod is set at the factory and no adjustment should be necessary, unless wastegate assembly is damaged.

CAUTION: DO NOT adjust the wastegate so that higher pressures are required to open the wastegate valve. The turbocharger speed will be increased and can cause damage to the turbocharger and cause a loss of engine performance.

(1) Remove signal line from wastegate actuator. **The signal line may be installed with tamper-proof clamps. These can be discarded and replaced with standard worm-gear clamps.**

(2) Connect regulated air pressure to the wastegate actuator (Fig. 29). Install a dial indicator to measure the control rod movement. Apply 103 - 138 kPa (15 - 20 psi) to seat the components and take any slack out of the control rod. Release the air pressure and zero the dial indicator gauge.

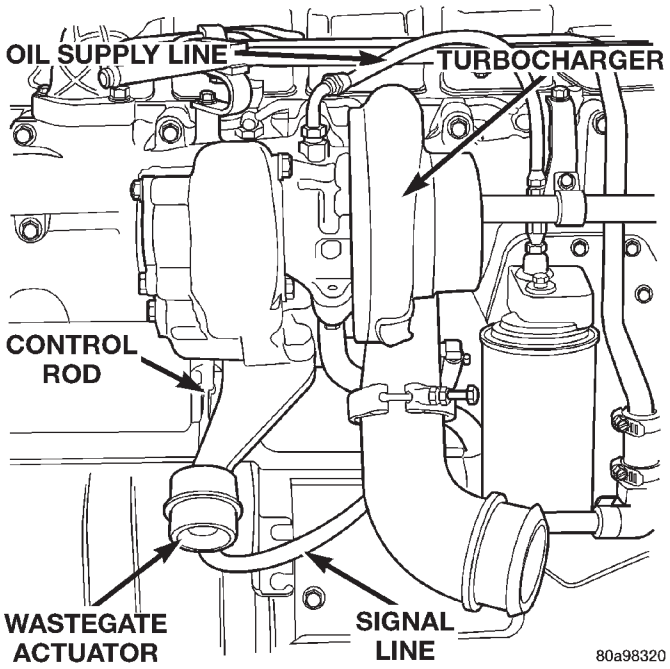

Fig. 28 Wastegate Turbocharger

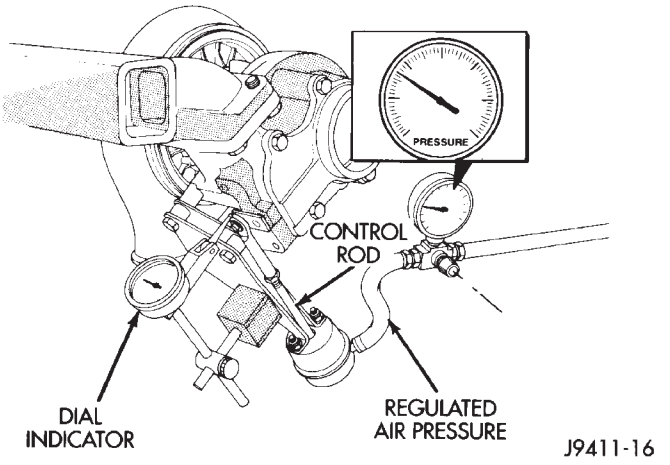

Fig. 29 Wastegate and Dial Indicator

(3) Apply 144.8 kPa (21 psi) air pressure to the actuator. The control rod should move 0.33 - 1.27 mm (0.013 - 0.050 in) total travel. If the rod travel is out of limits, the wastegate linkage must be adjusted.

(4) To adjust the wastegate linkage, apply air pressure to the actuator to release the spring tension on the lever. Remove the control rod from the wastegate lever (Fig. 30). Pull the wastegate lever toward the actuator (closed position).

(5) Adjust the length of the clevis end of the control rod to align the clevis pin hole to the wastegate lever. Install the adjusting link and retaining clip (Fig. 30).

ADJUSTMENTS (Continued)

CAUTION: DO NOT pull, push or force the alignment of the clevis pin.

(6) After the adjustment is complete, tighten the actuator rod jam nut.

(7) Recheck the travel on the wastegate control rod. Adjust, if necessary.

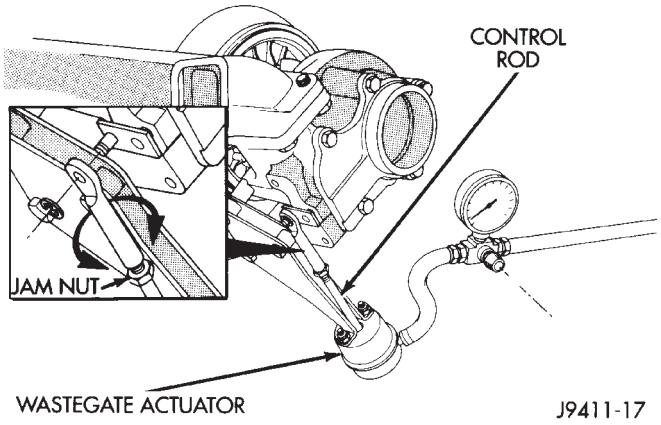

Fig. 30 Adjustment of Wastegate Actuator

SPECIFICATIONS

TORQUE SPECIFICATIONS

DESCRIPTION	TORQUE
Air Grid Heater Power Supply	
Nuts	14 N·m (124 in. lbs.)
Air Inlet Housing	
Bolts	24 N·m (18 ft. lbs.)
Charge Air Cooler/Boost System Pipes	
Clamps	8 N·m (72 in. lbs.)
Charge Air Cooler Mounting	
Bolts	2 N·m (17 in. lbs.)
Exhaust Clamps (All)	
Nuts	43 N·m (32 ft. lbs.)
Exhaust Manifold to Cylinder Head	
Bolts	43 N·m (32 ft. lbs.)
Exhaust Pipe to Manifold	
Bolts	34 N·m (25 ft. lbs.)
Intake Manifold Cover	
Bolts	24 N·m (18 ft. lbs.)
Turbocharger-to-Exhaust Manifold	
Nuts	32 N·m (24 ft. lbs.)
Turbocharger Oil Drain Tube	
Bolts	24 N·m (18 ft. lbs.)
Turbocharger Oil Supply Line	
Fitting	15 N·m (133 in. lbs.)
Turbocharger V-Band Clamp	
Nut	9 N·m (75 in. lbs.)