

SECTION 8**AIR INTAKE AND EXHAUST SYSTEMS**

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ENGINE MAINTENANCE MANUAL

SECTION 8

AIR INTAKE AND EXHAUST SYSTEMS

TURBOCHARGER

DESCRIPTION

The turbocharger assembly, Fig. 8-1, is primarily used to increase engine horsepower and provide better fuel economy through the utilization of exhaust gases. As shown in cross-section, the turbocharger has a single stage turbine with a connecting gear train. The connecting gear train is necessary for engine starting, light load operation, and rapid acceleration. Under these conditions there is insufficient exhaust heat energy to drive the turbine fast enough to supply the necessary air for combustion, and the engine is actually driving the turbocharger through the gear train assisted by exhaust gas energy. When the engine approaches full load, the heat energy in the exhaust, which reaches temperatures approaching 1000° F., is sufficient to drive the turbocharger without any help from the engine. At this point, an overrunning clutch in the drive train disengages and the turbocharger drive is mechanically disconnected from the engine gear train.

The turbine shaft is driven by the engine gear train through a series of gears in the turbocharger. A turbocharger drive gear, which is a part of the spring drive gear assembly, meshes with the turbocharger idler gear, driving the carrier drive gear. The carrier shaft drives the sun gear on the turbine shaft through three planet gears when the turbocharger is being driven by the engine. The sun gear meshes with the planet gears which, in turn, mesh with a ring gear in the overrunning clutch assembly. The ring gear is fixed, when the engine is driving the turbine, because the direction of torque at the ring gear locks the overrunning clutch. When the turbine is being driven entirely by exhaust gas energy, the direction of torque is reversed and the clutch overruns, allowing the ring gear to rotate.

The overrunning clutch consists of 12 rollers in tapered slots. The slots are formed by the combination of a stationary clutch support and the pockets in the cam plate. The cam plate, ring gear support, and the ring gear are dowelled and bolted together, and rotate as a unit. When the engine is driving the turbine, the rollers are wedged in the

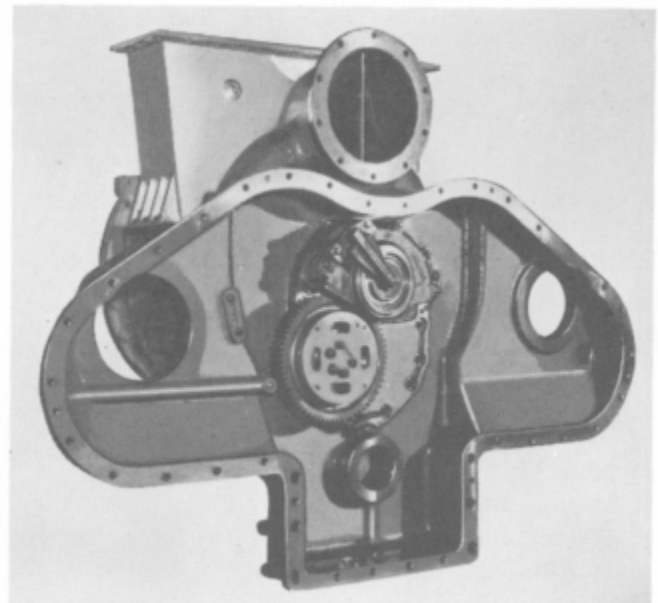
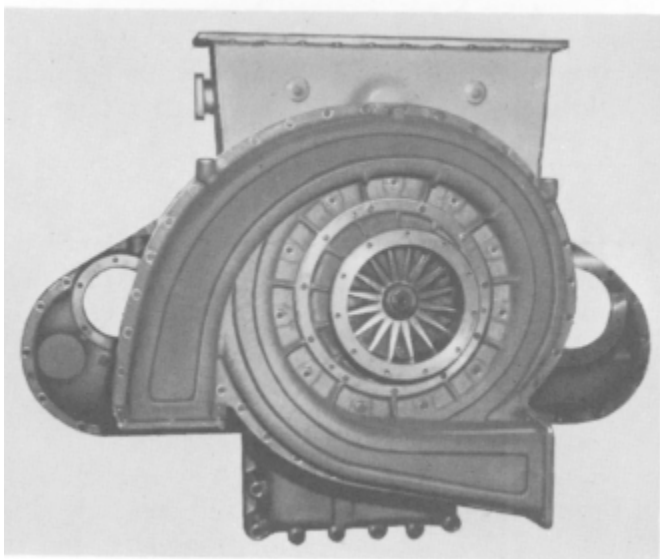


Fig. 8-1 - Turbocharger Assembly

small side of the cam plate pockets, as a result of the direction of torque, locking the cam plate to the stationary clutch support. This locking action prevents the ring gear from turning. Because the planet gear shafts are driven as a part of the carrier shaft, the planet gears rotate in the locked ring gear to drive the sun gear on the turbine shaft. When the exhaust energy becomes great enough to drive the turbine without help from the engine, the torque at the sun gear, planet gears, and ring gear reverses direction. This causes the rollers to move to the wide end of the cam plate pocket, unlocking the clutch, permitting it to overrun, and allowing the ring gear to rotate. From this point on, with increased load and speed, the turbocharger overruns the engine drive and the planet gears slowly turn the ring gear.

MAINTENANCE

Since it would not be practical to attempt any reconditioning of the turbocharger in the field, it is recommended that it be returned to EMD for this service. The following removal and installation procedures are provided for field service.

REMOVAL

1. Remove roof hatch.
2. Disconnect and remove the water lines to and from the aftercooler assemblies.
3. It is advisable to remove the aftercoolers from the ducts rather than to remove them as an assembly, because of the weight involved.
4. Remove the oil line clamp from the right aftercooler duct.
5. Remove both aftercooler duct assemblies. 6. Remove the auxiliary drive assembly.
7. Remove the oil separator assembly.
8. Remove the expansion joint between the turbocharger and the engine exhaust manifold.
9. Disconnect the exhaust elbow from the top of the turbine exhaust duct. Remove the elbow.
10. Remove air duct assembly from turbocharger air inlet assembly and remove air inlet.
11. Connect lifting chains to eyes screwed into the four tapped bosses on the turbocharger. Maintain even tension on all four chains so that turbo-

charger will hang properly. If a hand-operated chain hoist is available, it should be used between the chain device and the main lifting crane to simplify vertical positioning and tension adjustment during turbocharger removal. Do not allow chains to drag against the exhaust duct.

12. Remove bolts attaching turbocharger housing to camshaft gear train housing. The turbocharger is now held in position by the No. 2 idler gear stubshaft and lifting device.

CAUTION: Before removing the turbocharger, be sure to remove (if applied) two studhead bolts which hold the aftercooler piping bracket to the turbocharger.

13. Using jackscrews between the turbocharger housing and the gear train housing, jack the turbocharger away from the engine until the turbocharger clears the No. 2 stubshaft.

NOTE: Care should be exercised, when removing turbocharger, that No. 2 idler gear is not disengaged from camshaft drive gear, as engine timing will have to be checked if gear is disengaged.

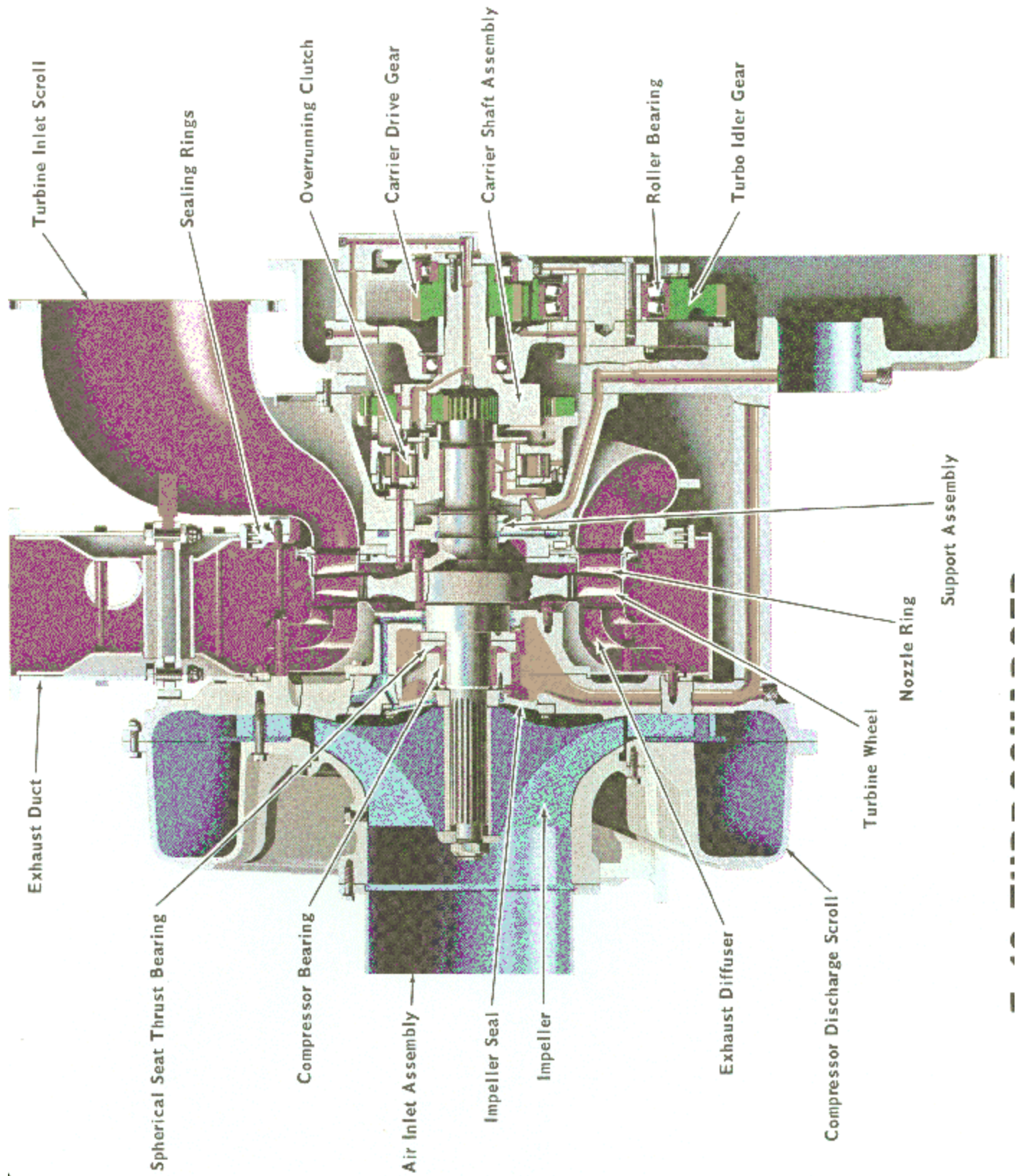
14. Using a 1-ton crane, lift the turbocharger clear of the engine and place it in shipping container for transportation.

PREPARATION FOR INSTALLATION

The following Steps should be adhered to if the turbocharger is being replaced because of a failure, if not, some of the Steps may be ignored. The turbocharger should remain in the shipping container until actual application.

AIR BOX INSPECTION

1. Clean the air box to remove all evidence of aluminum dust and chromate or borate water stains.
2. Inspect the cylinder assemblies for broken valves, valve blow, cracked pistons, broken piston rings, scored pistons and liners.
3. Determine the cause of the turbocharger failure and correct any conditions that might have aggravated the failure.
4. Clean all gasket surfaces on the engine, the turbocharger to be applied, and the air ducts.



E-16 TURBOCHARGER

Remove any nicks or burrs so as to present a smooth surface.

GEAR TRAIN INSPECTION

1. Visually check the gear train for nicks, burrs, evidence of improper backlash, and uneven or excessive wear. Make any necessary corrections.
2. Clean the No. 2 idler turbocharger locating stub-shaft, using an oil stone. Remove all indications of fretting. Inspect the seal groove for nicks and burrs, and smooth the surface after removal of any nicks or burrs.
3. Check the gear train area and remove any metallic debris that might be found.

EXHAUST MANIFOLD INSPECTION

1. Inspect the exhaust manifold for foreign material, and completely remove any found. The manifold should be removed, if in doubt, to look for cracked leg baffles which should be removed, and cracked expansion joints, which should be replaced.
2. Inspect the condition of the exhaust manifold leg gaskets and the torque on the bolts, which should be 176 N-m (130 ft-lbs). Also, check the manifold connector fasteners which should be 108 N-m (80 ft-lbs). Check the condition of the adapter to turbocharger bellows connections, and other locations where possible leaks might occur in the exhaust system.
3. Inspect the adapter assembly between rear expansion joint and chamber assembly for condition of screen. If foreign material is present in the exhaust manifold, it is recommended that the screen be magnaflux inspected.

CAUTION: Inspect the exhaust silencer (if applicable) for foreign material and remove any which may be found.

LUBRICATING OIL SYSTEM

1. Remove the disposable turbocharger oil filter and the soak back oil filter elements. Install new elements and check that the filter bowls are full of clean lubricating oil, and that the springs and gaskets are in place.
2. If required, drain and completely clean the system.

- a. If the oil system is contaminated with debris, flush the system and install new filter elements.
- b. Install new main oil filter elements, and clean and check the main oil filter relief valves.
- c. Recharge the oil system after the replacement turbocharger is applied and the oil system and all filters have been conditioned to receive the new clean oil.
- d. Check the soak back pump function and operation. Check the pump bypass relief valve for proper operation.

AIR INTAKE FILTER INSPECTION

Before installing the turbocharger, the engine air intake filters should be checked for foreign material. Completely clean filter if foreign material is found.

INSTALLATION

1. Apply the lifting device to the turbocharger as described in the turbocharger removal procedure. (The turbocharger shipping container, plus the masking of all openings on the turbocharger is the best protection and insurance against damage, rust, and contamination that can be given the turbocharger prior to installation.)
2. To determine the impeller eye clearance, remove the air inlet assembly before removing the turbocharger from the container pedestal. Chalk mark an impeller blade at the 12 o'clock position so that the impeller can be returned to this position when the eye clearance is rechecked after turbocharger installation. Two sets of feeler gauges should be used when making this check. Clearances should be determined with a heavy drag on the feelers. Perform check as follows:
 - a. Insert approximately the same feeler gauge thicknesses at the ends of the impeller blades at the 3 and 9 o'clock positions simultaneously to determine the available horizontal clearance. Record the clearances.
 - b. A feeler gauge should be used at the 12 o'clock position to determine the upper vertical clearance. Leaving the feeler gauge in position at the 12 o'clock position, use another

feeler to determine clearance at the 6 o'clock position. Record the clearances obtained.

3. Apply a thin coat of gasket compound to the camshaft drive housing and apply a new gasket to the housing.
4. Apply a new "O" ring seal to the engine No. 2 idler stubshaft.
5. Apply some clean lubricating oil to the No. 2 idler stubshaft and to the turbocharger drive gear.
6. Lift the turbocharger and remove covering from all openings, except the exhaust stack and exhaust inlet duct.
7. Align the turbocharger, guiding it onto the No. 2 idler stubshaft and into position. Care must be taken to ensure proper mesh of the turbocharger idler gear and the turbocharger drive gear on the engine.
8. Use hardened washers and damper springs with the 3/4" bolts, and apply all the turbocharger to camshaft drive housing bolts before removing the lifting device. Snug up bolts, but do not tighten.
9. Install the auxiliary drive assembly on the turbocharger and check the gear backlash between the camshaft drive gear and the auxiliary drive gear.

Check the backlash with a dial indicator, Fig. 8-2. Attach a small "C" clamp to the coupling flange so that clamp contacts the outer edge of the flange. Position the dial indicator with the contact point touching the "C" clamp. Remove play from gear teeth by turning the coupling flange. Set the dial indicator to zero and move flange in the opposite direction of the previous movement and note reading on dial indicator. Refer to Service Data for backlash limits. Backlash is adjusted by loosening the turbocharger mounting bolts and repositioning the turbocharger on camshaft drive housing.

10. When the correct backlash is obtained, torque the 1/2" turbocharger and auxiliary drive mounting bolts to 88 N·m (65 ft-lbs), the 3/4" bolts to 238 N·m (175 ft-lbs), and the 3/8" bolts to 32 N·m (24 ft-lbs). After the bolts are

properly tightened, recheck the auxiliary drive gear backlash.

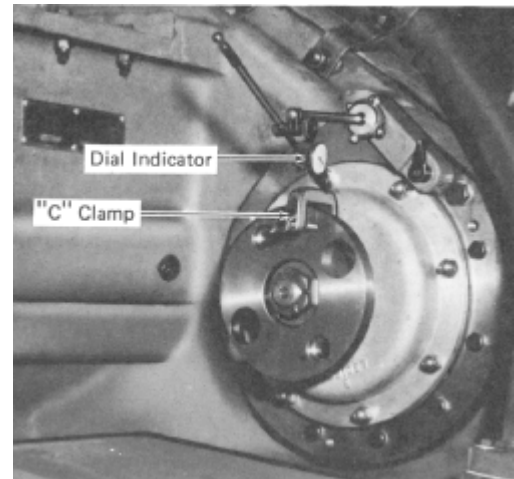


Fig. 8-2 -Checking Auxiliary Drive Gear Backlash

AIR DUCT AND AFTERCOOLER APPLICATION

If a different aftercooler core is to be installed, proper core alignment to the duct must be ensured before application can be made. The air ducts must be removed from the engine to accomplish alignment. Remove the lockwire from the support pad bolts at the rear of the duct, and loosen the bolts. Position the core in the duct until the dowels on the core align with the dowel holes in the support pad. Tighten support pad bolts, torque to 176 N·m (130 ft-lbs), and lockwire. Remove the core and proceed as follows with application.

1. Apply the gaskets to the air duct assemblies.
2. Carefully maneuver the right bank air duct into position and apply the bolts at the engine and turbocharger flanges. Four bolts at the engine flange must be installed from inside the duct. Make sure that air duct flange on the engine side is not touching the camshaft drive housing. Snug the bolts only at the turbocharger end, but torque the bolts at the engine end to 88 N·m (65 ft-lbs). Then remove the bolts from the turbocharger end of the air duct and with the gasket in place, and using a 0.20 mm (.008") feeler gauge, determine the clearance at the mating flanges. If a 0.20 mm (.008") feeler gauge can be entered between the turbocharger and the air duct, the duct must be relocated. If necessary, the holes in the engine flange may be enlarged to position the duct properly.

3. Apply the left bank air duct using the same procedure as used on the application of the right bank air duct.
4. Place the hardened washers on bolts and tighten the air duct to turbocharger bolts to 81 N·m (60 ft-lbs). Refer to Service Data for correct bolt application.
5. Using a 0.001 " feeler gauge, check that no clearance exists between the gasket and turbocharger flange, and the gasket and air duct flange.
6. Apply gaskets to air ducts. Using a lifting device, install aftercoolers in air ducts. Apply attaching bolts, and beginning at the center bolt and moving to the ends, torque bolts to 61 N·m (45 ft-lbs).
7. Attach water pipes to aftercoolers and torque bolts to 47 N·m (35 ft-lbs).
8. Attach water pipes to engine and torque bolts to 47 N·m (35 ft-lbs).
9. Clamp oil line to tapping pad on right aftercooler air duct.

FINAL ASSEMBLY

1. Apply gaskets and install oil separator/ejector assembly.
2. Install the expansion joint between the turbine inlet scroll and the engine exhaust manifold. When assembling the expansion joint, the tapered end of the interior liner should be facing toward the front of the engine. This taper will not be evidenced by external viewing of the expansion joint.
3. Coat the threads of the expansion joint bolts with high temperature thread lubricant, apply, and torque to 122 N·m (90 ft-lbs).
4. In bolting the expansion joint in the manifold, it is recommended that one flange of the expansion joint be securely bolted to the manifold before attempting to bolt the other flange. If the holes of the second flange do not align with the flange of the inlet scroll, do not pry into alignment. This will result in undue stress placed on the expansion joint and will also reduce the internal liner clearance required for trouble-free operation. If alignment can not be acquired through repositioning the expansion joint, enlarge the holes in

the flange until bolts can be freely inserted and tightened.

5. Attach the exhaust elbow to the top of the turbine exhaust duct with bolts coated with high temperature thread lubricant.
6. Check the impeller eye clearance as previously done in Step 2 of "Installation" to see if the measurements can be duplicated. If the clearances cannot be duplicated, it indicates that the turbocharger has been distorted in installation. In this event, the air ducts should be removed and eye clearance rechecked. If turbocharger is still distorted the turbocharger mounting bolts must be loosened and the turbocharger realigned so that no stresses or distortion are introduced during installation.
7. Install the air inlet assembly and air duct assembly on turbocharger.
8. Replace decking and panels.

STARTING THE ENGINE

1. Make sure the soak back pump is running.
2. Make the necessary preparations and start the engine.
3. When starting the engine, do not force the injector hand control lever beyond the idle position in an effort to aid the engine in starting. If the engine is forced on starting, the excess fuel and the resulting engine exhaust might cause an increase in load on the turbocharger thrust bearing when it should not be loaded.
4. Perform load test to qualify engine for service.

EXHAUST MANIFOLD DESCRIPTION

The exhaust gases from the engine cylinders are discharged from the cylinder heads into the exhaust manifold, Fig. 8-3, and to the turbocharger turbine. Going through the turbine, the gases expand to atmospheric pressure, pass through the turbocharger ducting, and are then expelled from the engine.

The exhaust manifold is made up of chamber assemblies, expansion joints, and adapter assembly. The expansion joints, which are used between chamber

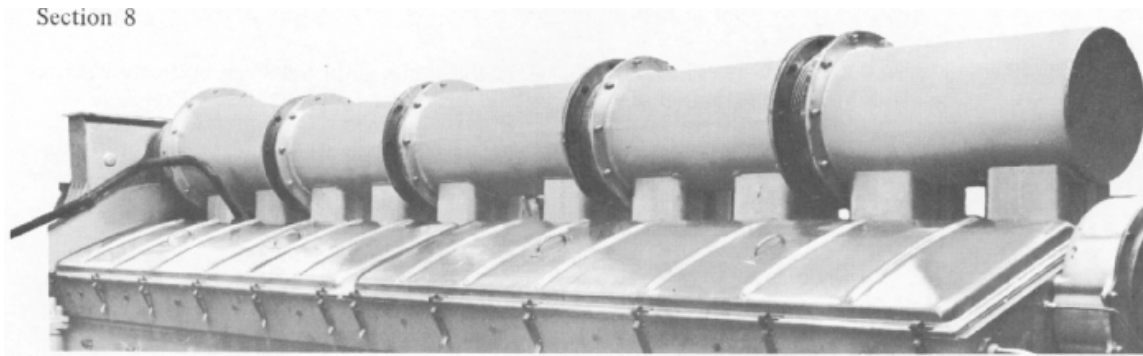


Fig. 8-3 - Exhaust Manifold

assemblies and between the adapter and screen assembly and the turbocharger, provide the necessary flexibility to compensate for expansion and contraction of the manifold due to temperature changes. The adapter assembly contains a trap type screen to prevent the entry of foreign objects into the turbocharger. A trap box is attached to the outer body which collects small debris.

MAINTENANCE

Inspect the adapter and screen assembly between rear expansion joint and chamber assembly for condition of screen. If foreign material is present in the exhaust manifold it is recommended that the screen be magnaflux inspected.

NOTE: The trap type screen must be removed and cleaned out at intervals specified in the Scheduled Maintenance Program.

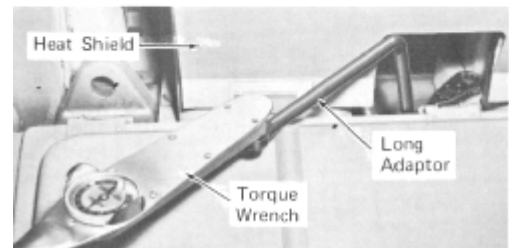
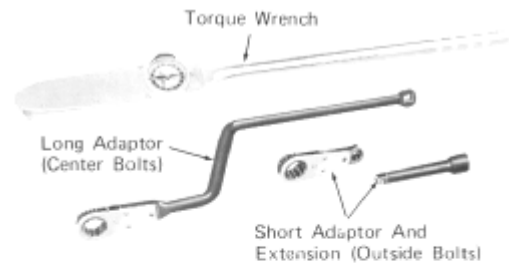
The exhaust manifold is essentially "maintenance free." but should the manifold be disassembled for any reason, the following assembly provisions should be observed.

When applying the exhaust manifold gasket it is important that the gasket be positioned properly, and that the bolts be torqued and retorqued as recommended. Gasket should be applied as follows:

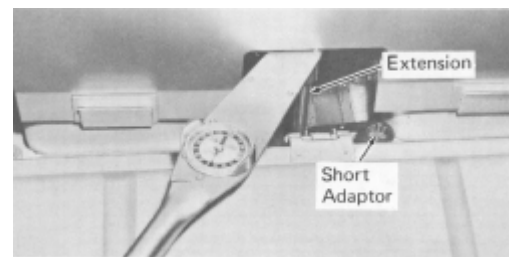
1. Check that the gasket area on the engine is clean and free of obstructions.
2. Apply the gasket making sure that the side of the gasket having the part number and the stamp "THIS SIDE UP" is in the UP position. This will ensure that the crimped side of the gasket is down.

CAUTION: If the gasket is incorrectly installed (crimped side up), gasket damage and subsequent exhaust leakage will occur.

3. Lubricate manifold mounting bolts with high temperature thread lubricant and torque the bolts in two passes, using the manifold torque tool set. Fig. 8-4. The first pass torque should be approximately 68 N-m (50 ft-lbs). The final torque is 176 N-m (130 ft-lbs). When long adapter, Fig. 8-4, is used the torque wrench



OUTSIDE BOLT TIGHTENING



CENTER BOLT TIGHTENING

Fig. 8-4 - Manifold Gasket Torquing

dial should show 103 N-m (76 ft-lbs). This will provide the required 176 N-m (130 ft-lbs). When short adaptor, Fig. 8-4, is used, the torque wrench dial should show 176 N-m (130 ft-lbs) for the required torque.

NOTE: To correctly torque the center bolts, the torque wrench must be attached to the long adaptor in a straight line as shown in Fig. 8-4.

To obtain maximum service life from the gasket application, retorquing instructions MUST be followed.

1. On new units, bolts MUST be retorqued at intervals stated in the Scheduled Maintenance Program.
2. If an engine has been overhauled or changed out, the bolts MUST be retorqued after load box test, in addition to the intervals stated in the Scheduled Maintenance Program.
3. If the engine is not tested, the bolts MUST be retorqued after approximately eight hours of service.

When retorquing, it is not necessary to remove the heat shields, if the torque tool set is used.

On 20-cylinder engines, the flange at one end of the center and two intermediate chamber assemblies has an offset bolt hole at the bottom of the flange. To prevent misalignment during assembly, the flange with the offset hole must face toward the accessory end of the engine. The offset hole in the adjacent expansion joint must mate with the chamber flange offset hole.

When assembling the expansion joints, the welded end of the interior liner should be facing toward the front of the engine. This weldment will not be evidenced by external viewing of the expansion joint.

In bolting the expansion joints to the chamber assemblies, it is recommended that one flange of the expansion joint be securely bolted to the chamber assembly before attempting to bolt the other flange. If the holes of the second flange do not align with the flange of the turbo-charger inlet scroll, do not pry into alignment. This will result in undue stress being placed on the expansion joint and will also reduce the internal liner clearance required for trouble-free operation. If alignment can not be acquired through repositioning the expansion joint, enlarge the holes in the flange until bolts can be freely inserted and tightened.



SERVICE DATA AIR INTAKE AND EXHAUST SYSTEMS

SPECIFICATIONS

Clearance and dimensional limits listed below are defined as follows:

1. New limits are those to which new parts are manufactured. (Drawing tolerances.)
2. Minimum, maximum, and tolerance measurements are provided as service limits. At time of rebuild or any time unscheduled maintenance is performed, the service limits should not be exceeded. Engine components within these limits may be reused with the assurance that they will perform satisfactorily until the next scheduled overhaul.

Aftercooler To Turbocharger Air Duct Bolt Application

8-cyl. & 12-cyl.

Right Bank

- (8) 7/16"-14 x 1-7/8" bolts
- (16) 7/16" hardened washers (under bolts heads & nuts)
- (8) 7/16"-14 nuts

Left Bank

- (4) 7/16"-14 x 2-1/4" bolts
- (4) 7/16"-14 x 1-1/2" bolts
- (12) 7/16" hardened washers (under bolt heads & nuts)
- (4) 7/16" nuts (use with 7/16"-14 x 2-1/4" bolts)

16-cyl. & 20-cyl.

Right Bank

- (6) 7/16"-14 x 1-7/8" bolts (use w/spline nuts)
- (2) 7/16"-14 x 1-1/4" bolts
- (8) 7/16" hardened washers

Left Bank

- (7) 7/16"-14 x 1-7/8" bolts (use w/spline nuts)
- (1) 7/16"-14 x 1-1/4" bolt
- (8) 7/16" hardened washers

Clearances And Backlash

Backlash between camshaft and auxiliary drive gears	0.25-0.56 mm (.010"-.022")
Clearance between turbocharger and turbocharger end of air duct (with turbocharger to duct bolts removed)	Less than 0.20 mm (.008")
Clearance between gasket and turbocharger flange (bolts installed and torqued, and using a 0.001 " feeler gauge) . . .	0.0 mm (.000")
Clearance between gasket and air duct flange (same condition as Step above)	0.0 mm (.000")

EQUIPMENT LIST

	<u>Part No.</u>
Thread lubricant high temperature (1 qt.)	8278929
Turbocharger Lifting Sling	8293333
Exhaust manifold torque tool kit.....	8463511
Long adaptor	8463512
Short adaptor	8463513
Extension	8463514
Torque wrench	8463515