SECTION 10

COOLING SYSTEM

ELECTRO-MOTIVE

ENGINE MAINTENANCE MANUAL

SECTION 10

COOLING SYSTEM

DESCRIPTION

The engine cooling system consists of engine driven centrifugal water pumps, replaceable inlet water manifolds with an individual jumper line to each liner, cylinder head discharge elbows, and an outlet manifold through which cooling water is circulated. The two centrifugal water pumps (one on 8-cyl.) are mounted on the accessory drive housing and are driven by the governor drive gear. A representative illustration of the engine cooling system is shown in Fig. 10-1.

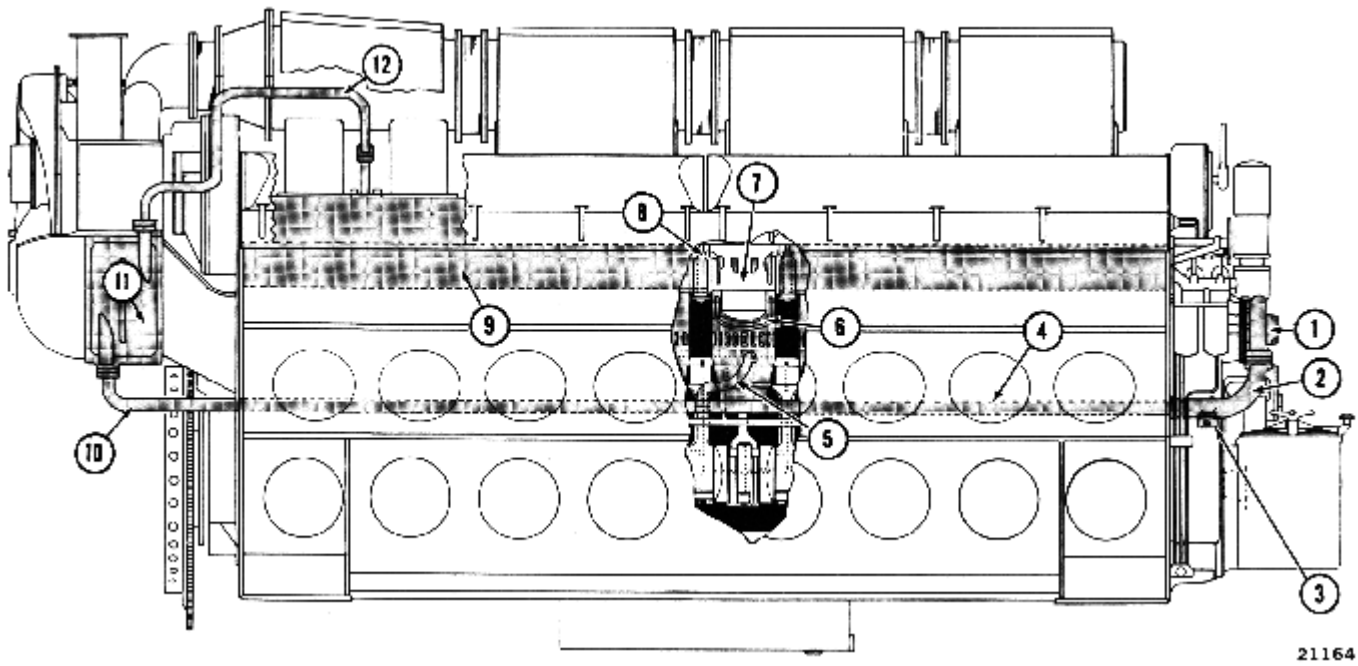
Engine water is also circulated through each aftercooler, Fig. 10-1, located in the turbocharger air discharge duct, to cool the air before it enters the engine air box. The engine discharge water flows through an external cooling system to dispel the heat taken up in the engine. This system consists of a water tank, water level gauges, temperature gauges, radiators, and connecting piping.

MAINTENANCE

ENGINE WATER TEMPERATURE

Temperature gauges are provided in the cooling system to visually check that the engine water temperature is within the recommended limits. Automatic temperature controls are set to maintain the water temperature within set limits.

CAUTION: It is desirable that engine coolant temperature be 49° C (120° F) or higher before full load is applied to the engine. After idling at low ambient temperature, increase to full load level should be made gradually.



1. Water Pump
2. Water Inlet Elbow
3. System Drain Flange
4. Water Inlet Manifold
5. Water Inlet Tube
6. Liner Water Passage
7. Cylinder Head
8. Cylinder Head Outlet Elbow
9. Water Discharge Manifold
10. Water Line To Aftercoolers
11. Right Bank Aftercooler
12. Aftercooler Water Discharge

Fig. 10-1 - Typical Cooling System Schematic

A hot engine alarm indicates excessively high water discharge temperature. Hot engine water could result from faulty water cooling equipment or excessive loss of cooling water. In the event of a hot engine alarm, engine load should be reduced in an attempt to obtain normal temperature. Before resuming operation, the cause of the hot engine water should be found and the condition corrected.

ENGINE COOLANT SOLUTION

Coolant solutions are composed of water, corrosion inhibitor and, if necessary, antifreeze. The selection and maintenance of a proper coolant solution are necessary for efficient cooling system operation. Failure to recognize the importance of these factors can result in cooling system damage, increased maintenance costs, and unnecessary equipment down time.

Coolant samples should be taken from the cooling system for analysis at intervals as specified in the Scheduled Maintenance Program.

COOLING SYSTEM PIPING

DESCRIPTION

Refer to Fig. 10-2 for piping details. Pump outlet elbows conduct water from the pumps to the removable water inlet manifolds located in each air box. Each manifold is connected at the rear end plate to an aftercooler water inlet pipe. The rear end flange of the manifold is equipped with two seals, which prevent the leakage of air from the air box. A flange at the front end of the manifold contacts the outer face of the front end plate when the manifold is installed.

Each liner is individually supplied with coolant from the water manifold through a water inlet tube assembly. A deflector is used at each liner water inlet to divert the water and prevent direct impingement on the inner liner wall. Water enters the cylinder head through 12 discharge holes at the top of the liner. A counterbore around each hole accommodates a heat dam and a water seal. A water discharge elbow is bolted to each cylinder head to provide a water passage to the water discharge manifold which extends along the top of the crankcase. The crankcase has two "built-in" siphon tubes inside the water discharge manifold. One is located at the second cylinder from the rear end on the right bank, and the other at the second cylinder from the front end on the left bank. When engine water is drained, this will provide for engine cooling water draining in the event the engine is not level.

MAINTENANCE

PIPING INSTALLATION

After the cylinder head and liner are properly installed in the engine, the water inlet manifold and liner water inlet tube may be applied.

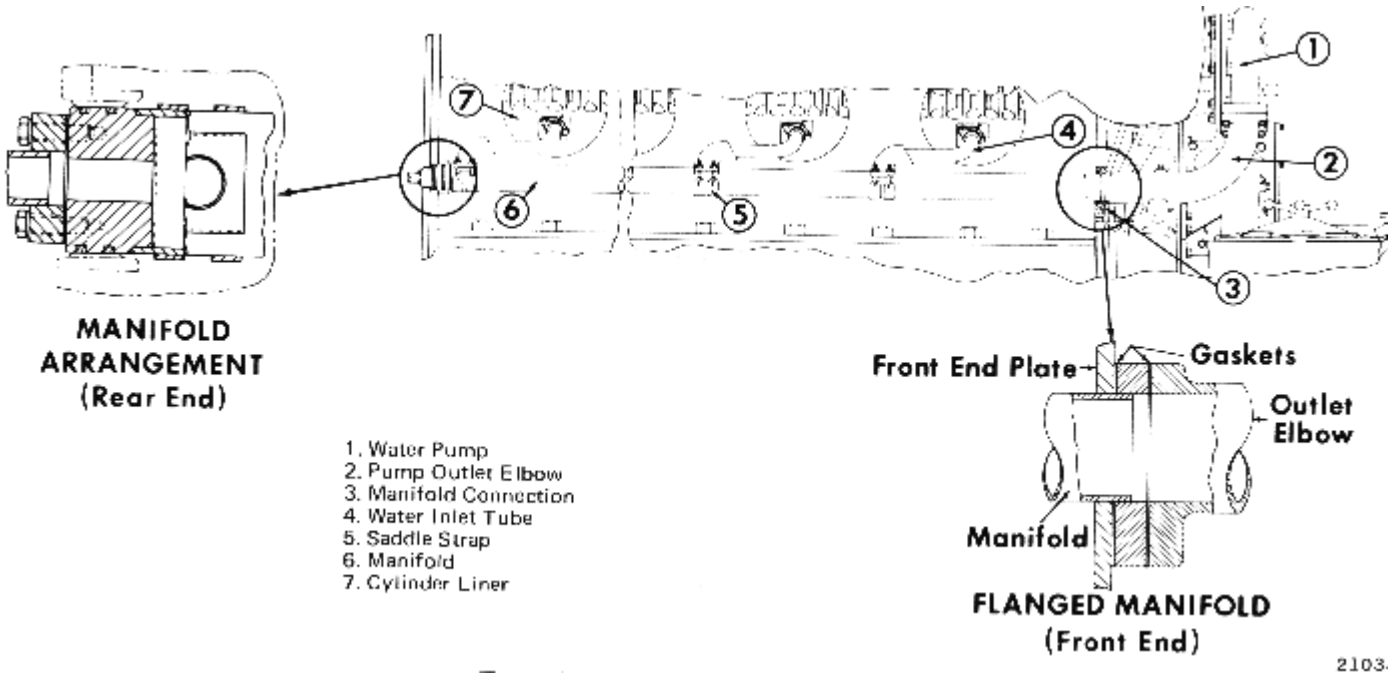


Fig. 10-2 - Cooling System Piping

1. Inspect the water manifold for any dirt or roughness in the area of the discharge holes and at the front end plate flange.

2. Place the manifold flange gasket over the manifold and insert the manifold into the air box.

3. Carefully guide the end of the water manifold into the rear end plate so that seals are not damaged. When positioned correctly, the manifold should be firmly supported at the end.

4. Apply and tighten the manifold flange to front end plate bolts. Temporary bolts may be used if the water pump discharge elbow is not ready to be applied.

5. Place a new seal in the groove at the liner end of the water inlet tube.

6. Position saddle straps around the water manifold, and through the inlet tube flange.

7. After the strap nuts have been applied and tightened finger tight, check that the seal is seated in the groove, position the tube on the liner, and finger tighten the bolts.

8. Take a new gasket and shape it to fit around the water manifold. Insert the gasket between the tube flange and manifold making sure the sides of the gasket are flush with the sides of the flange, and that the ends of the gasket are within the clamping radius of the flange.

9. Torque the strap nuts to 20 N-m (15 ft-lbs). 10. Prior to torquing the tube to liner bolts, remove the bolts and washers from the flange. If the tube moves, it must be repositioned on the water manifold; if no movement is detected, the tube to liner bolts and washers may be re-applied and torqued to 41 N-m (30 ft-lbs).

11. After all liner water inlet tubes are properly applied, the manifold will be securely held and the temporary bolts, if applied, should be removed and the water pump discharge elbow connected.

WATER LEAKS

If loss of water in the cooling system is noticed, check for leakage at piping, pump seals, jumper tube connections, cylinder head discharge elbow, junction of head to liner, and check for liner or cylinder head cracks.

Unless very obvious, the location of a crack in the cylinder head or liner is very difficult to find, and requires careful examination. Any indication of a water leak in the head or liner requires removal and thorough inspection. Inspect cylinder interior through liner ports. Water may leak and enter the lube oil at the cylinder head discharge elbow seals. These seals can be replaced without disturbing the cylinder head, provided a crab nut and crab are removed and the water is drained. Water contamination of lubricating oil will necessitate draining the oil. Before the oil is renewed, the system should be flushed.

Lube oil contamination is best determined by laboratory analysis, but in the absence of such means, the following method of checking for water in the oil may be used.

Draw or dip a gallon of lube oil from the bottom of the engine lube oil sump. Let it stand for about 10 minutes, then spill about 3/4 of the oil from the container. Place the remaining 1/4 in a glass bottle and allow sample to stand another 10 minutes. If any water is indicated in the bottom of the bottle, it is recommended that the lube oil system be drained and flushed. Replace with new oil after source of contamination is eliminated.

AFTERCOOLER

DESCRIPTION

An aftercooler is located on each side of the turbocharger to cool the air entering each bank of the engine. Cooling the air compressed in the turbocharger reduces the temperature of the air, which increases air density and improves engine operating efficiency.

The aftercoolers are heat exchangers of box-like construction consisting of a tube nest, through which water is circulated, and fins to aid in the transfer of heat from the compressed air entering the engine air box. The aftercoolers receive water directly from the discharge side of the engine water pumps, and the water leaving the aftercoolers is piped to the engine discharge manifold. No valves are located in the aftercooler piping, so cooling water is provided whenever the engine is running.

MAINTENANCE

With the engine shut down, an interior inspection of the engine end of the aftercooler air duct will usually detect any sign of core leakage. Evidence of leakage will necessitate removal of the aftercooler.

A check for aftercooler plugging may be made by removing two mounting bolts (5th from top) across the aftercooler core and applying hoses from a water manometer at the bolt holes (with engine shut down or at idle speed).

CAUTION: Do not remove hoses with engine at high speed. Do not apply or remove hoses singly.

With engine at full speed, with or without load, the maximum allowable depression across the aftercooler is listed in the Service Data.

The aftercooler should also be removed and cleaned at intervals as specified in the Scheduled Maintenance Program.

REMOVAL

1. After draining the engine water, disconnect the water discharge or vent line flange at the top of the aftercooler.

2. Loosen the water inlet line at the bottom of the aftercooler.

3. Remove the mounting bolts securing the aftercooler to the air duct, both at the front and at the back, and free the assembly. Jacking screws in the aftercooler flange will break the joint between the air duct and aftercooler.

4. When the aftercooler is sufficiently free, apply an aftercooler lifting tool, Fig. 10-3, and using a suitable hoist, remove the entire assembly from the air duct.

CLEANING

CAUTION: Do not use a caustic cleaner, as aluminum core fins will be damaged. Cleaning procedures should be in accord with accepted practice or as recommended by the supplier of cleaning material.

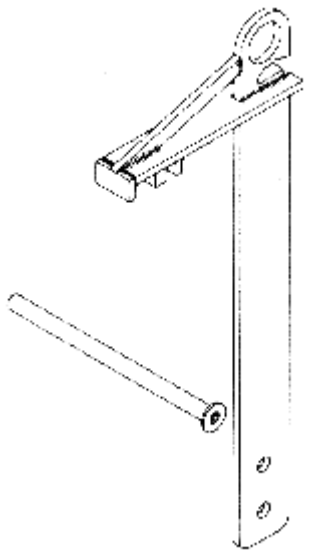


Fig. 10-3 - Aftercooler Lifting Tool

CORE REPLACEMENT

In the event that an aftercooler is removed due to a leaking core, the core may be replaced using the following procedure.

1. Gaskets used in the aftercooler assembly should be prepared in advance of assembly by being soaked in ASTM (American Society For Testing Materials) No. 3 oil for 15 minutes at a temperature of 71° C. (160° F.). After soaking, the gaskets should be removed and permitted to drain before using.

2. Place the core on the work bench and apply the cover gasket and cover.

3. Apply the cover bolts and tighten to 47 N-m (35 ft-lbs). Tighten from the center bolt out to the end bolts.

4. Invert the assembly and apply the header to core gasket and header.

5. Apply the header to core bolts and tighten from the center bolt out to the end bolts. Tighten the bolts to 47 N-m (35 ft-lbs).

6. After the assembly has been completed, blank off all flanges except one, and apply an air test arrangement on the remaining flange.

7. With 345 kPa (50 psi) air pressure in the water passage of the core, submerge the assembly in water and check for leaks.

8. After water test, recheck the torque of the header and cover bolts to 47 N-m (35 ft-lbs).

INSTALLATION

1. Check the air duct and aftercooler mounting surfaces to make certain that there are no nicks, dirt or roughness on these areas.

2. Apply the support pad to the back plate dowels of the aftercooler, Fig. 10-4, with the gasket in position at the outside so as to contact the air duct.

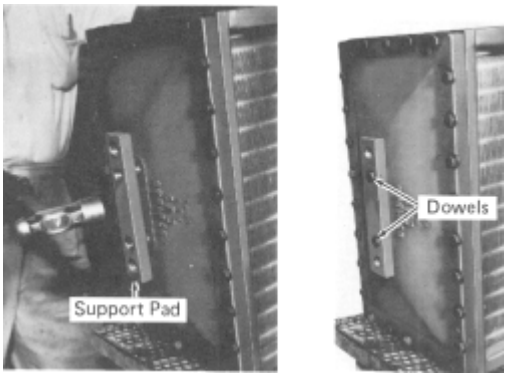


Fig. 10-4 - Support Pad To Dowel Installation

3. Apply the aftercooler to air duct gasket over two guide dowels, and using the aftercooler lifting tool and hoist, install the aftercooler in the air duct.

4. Line up the support pad bolt holes, Fig. 10-5, at the back of the air duct and apply, but do not tighten the support pad bolts.

5. Correctly position the aftercooler flange over the air duct gasket and flange holes, apply and tighten the bolts holding the aftercooler to the air duct.

6. When the aftercooler flange bolts have been tightened, tighten the support pad bolts at the back of the air duct, Fig. 10-5, to 176 N-m (130 ft-lbs) and lockwire.

WATER PUMPS

DESCRIPTION

The two engine cooling water pumps (one on 8-cyl. engines), Fig. 10-6, are self-oiling and selfdraining centrifugal pumps, which rotate in the opposite direction of the engine crankshaft. The components of the water pump are identified in Fig. 10-7.

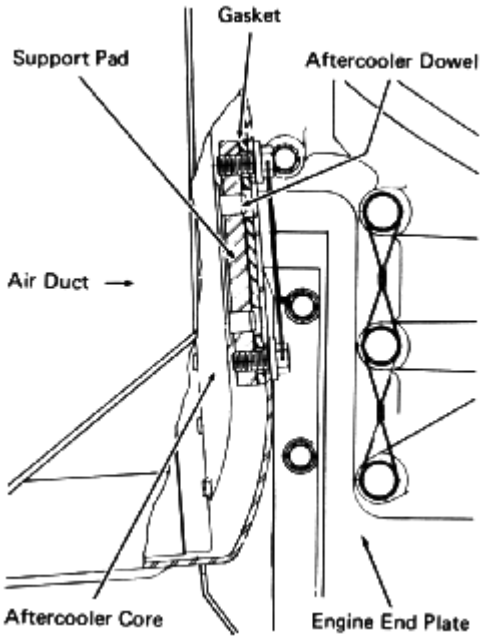


Fig. 10-5 - Air Duct Support Pad Application

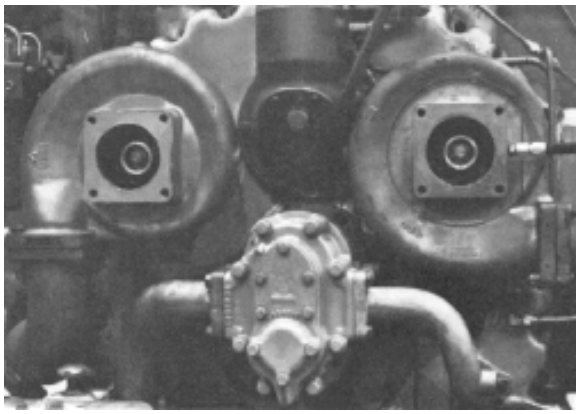


Fig. 10-6 - Water Pump Installation

The pumps are carried under two part numbers to identify the right and left bank pumps. The only difference between right and left bank pumps is the position of the impeller housing in relation to the pump shaft housing. The position of the impeller housing may be changed on either pump to permit use on the opposite bank.

The pump drive shaft is supported in the main pump housing by two ball bearings separated by a steel spacer. The bearings receive lubricating oil from the engine oil system through a drilled passage in the pump housing. The outer bearing adjoins a water slinger which bears against a shoulder on the staft.

The inner bearing is held in place by a retainer and snap ring to absorb any thrust in the shaft. The pump drive gear is keyed to the pump shaft abutting the inner bearing, and is held on the shaft by a washer and nut.

The stationary bushing, Fig. 10-7, is applied to the drive shaft housing. The carbon of the seal assembly, Fig. 10-8, faces against the smooth inner surface and is held by a spring. Any water leakage past the seal is indicated at a tell-tale drain in the drive shaft housing, which permits runoff, and prevents water from reaching the engine side of the pump.

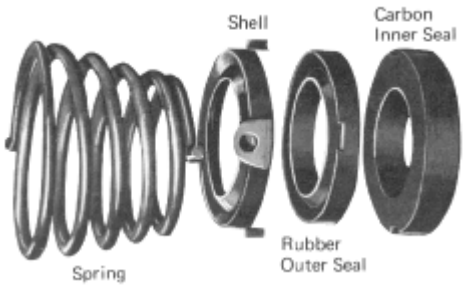
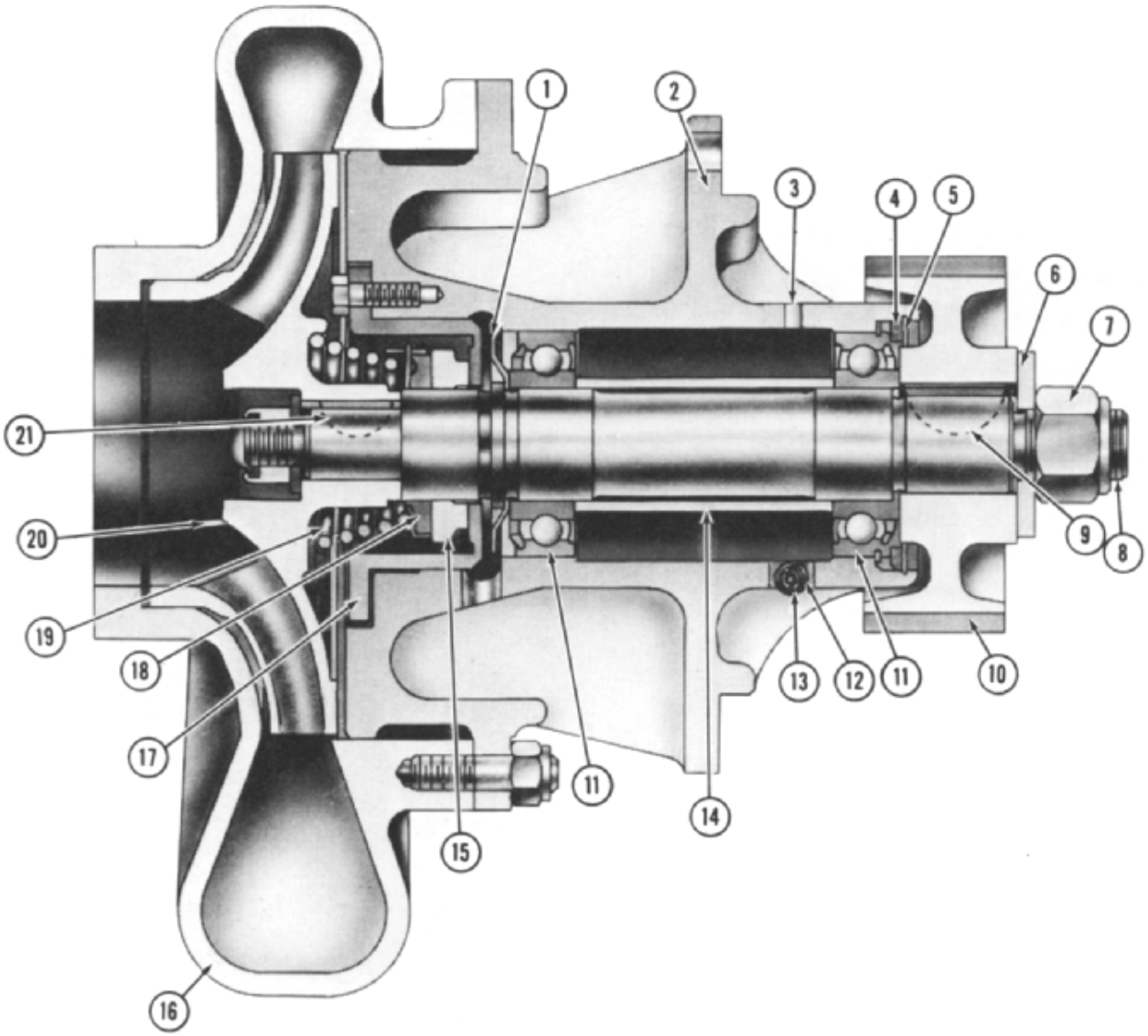


Fig. 10-8 - Spring And Seal Assembly



1. Water Slinger
2. Support Housing
3. Oil Inlet
4. Bearing Retainer Ring
5. Snap Ring
6. Gear Retainer Washer
7. Gear Retaining Nut
8. Water Pump Shaft
9. Drive Gear Key
10. Drive Gear
11. Bearing Assembly
12. Oil Outlet
13. Roll Pin And Spring
14. Bearing Spacer
15. Carbon Seal
16. Impeller Housing
17. Stationary Bushing
18. Outer Seal
19. Seal Retainer Spring
20. Impeller
21. Impeller Retainer Key

Fig. 10-7 - Water Pump, Cross-Section

The impeller is keyed to the pump shaft and is secured to the shaft by a washer and nut. It is enclosed by the impeller housing, which is assembled to the main pump housing by eight studs and nuts.

MAINTENANCE

PUMP REMOVAL

1. Drain cooling system.

2. Remove water pump inlet connection.

3. Disconnect pump discharge flange connection.

4. Remove mounting bolts and pump from engine.

HOUSING, DRIVE GEAR, SHAFT AND BEARING ASSEMBLY, AND IMPELLER REMOVAL

1. Remove nuts securing impeller housing to pump support housing.

2. Assembly threaded pressure plate, Fig. 10-9, to hydraulic ram head.
3. Place socket end of ram adapter over nut securing impeller to shaft so adapter bottoms out on impeller.

4. Secure pressure plate to impeller housing with four 1 /2-13x l 1/2" hex head bolts. Ensure that ram head is aligned with machined end of adapter.

5. Operate hydraulic ram until impeller housing separates from pump support housing.

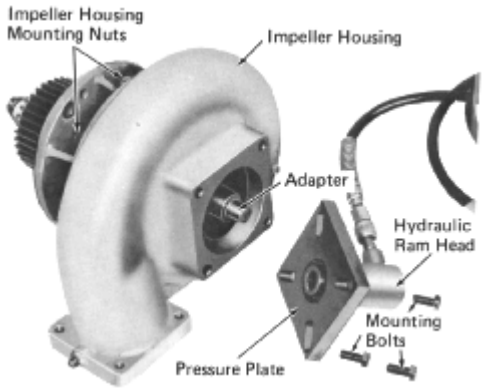


Fig. 10-9 - Impeller Housing Removal

6. Place mounting flange of pump in a vise having jaw protectors.

7. Remove drive gear nut and washer.

8. Using a block of wood to prevent impeller movement, remove the impeller nut and washer.

9. Apply impeller gear puller, Fig. 10-10, and remove pump drive gear and key.

10. Remove snap ring and bearing retainer ring. Fig. 10-7.

11. Place the extension tip of the impeller puller over shaft threads at impeller end of pump. 12. Apply impeller puller with legs placed behind support housing flange, Fig. 10-11.

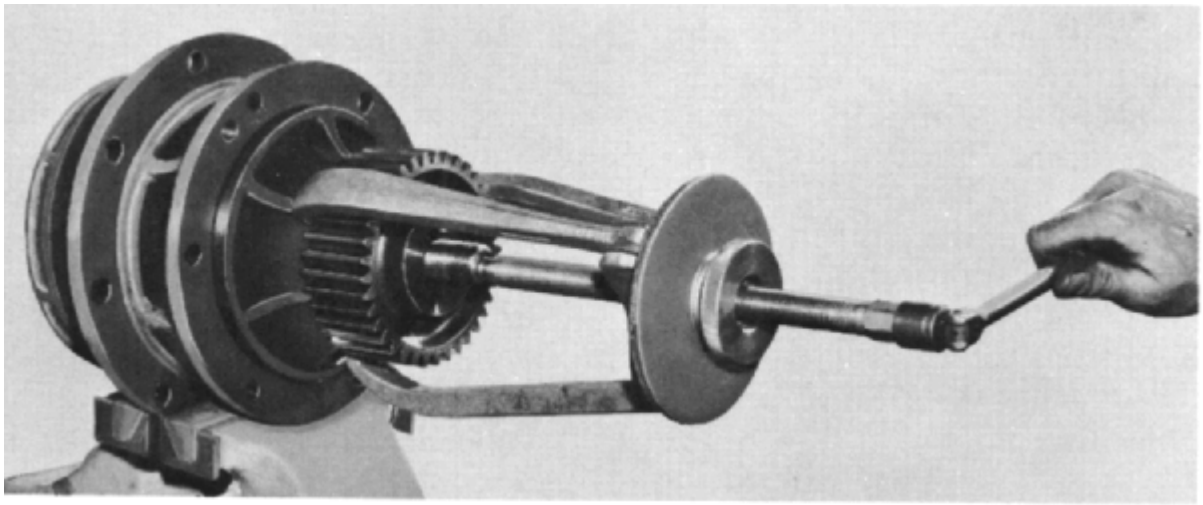


Fig. 10-10 - Drive Gear Removal

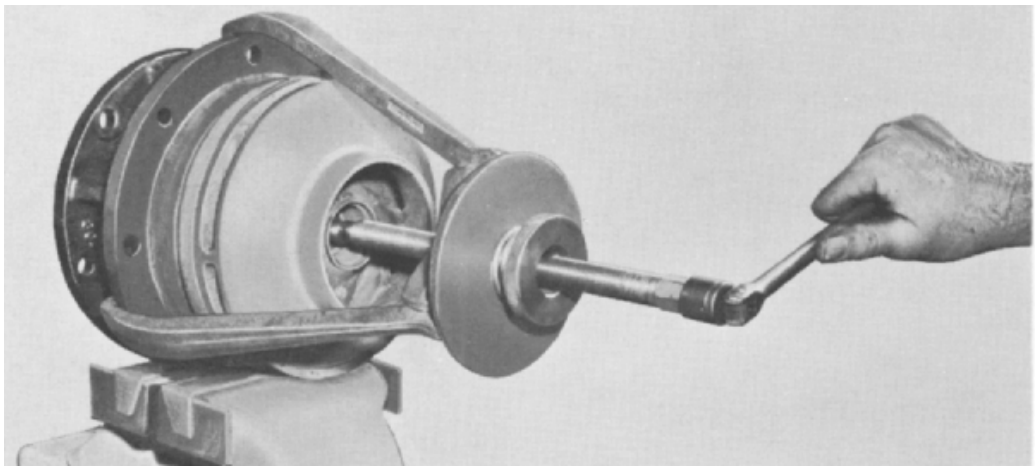


Fig. 10-11 - Impeller Removal

13. Apply wrench to the nut part of the tool and turn until shaft and bearing assembly is free of pump housing. Remove impeller.

REMOVAL AND APPLICATION OF PUMP SEALS
SEAL REMOVAL

1. After impeller removal. remove spring and seal assembly, Fig. 10-7. Use care to prevent damage to the stationary bushing seal surface.

2. Remove the bolts from the stationary bushing in the event the bushing is not easily removed, insert 3/8" x 2" bolts in the puller holes provided in the bushing and force the bushing out from the housing. Sometimes the bushing may be loosened by tapping on the bushing flange with a rawhide mallet, allowing removal without using puller bolts.

SEAL APPLICATION

1. Clean the stationary bushing and pump shaft.

CAUTION: The sealing surface of the stationary bushing must be absolutely smooth and flat to prevent wear of the carbon washer. A stationary bushing having a rough surface must be replaced with a new bushing.

2. Before applying the stationary bushing, be sure the bushing and mounting surfaces are clean. Foreign material can cause the bushing to cock and interfere with effective sealing. Also, be sure that the smooth flat carbon seal surface of the bushing is clean and dry. Apply new stationary bushing gasket and bushing.

   Tighten the bolts evenly and torque to 11.3 N-m (100 in-Ibs).

   After applying the stationary bushing. check runout of' the carbon seal surface using an indicator mounted on the end of the pump shaft. If runout limit is exceeded, reposition bushing 180° and/or scrape off mounting surface in area of' high reading.

3. Install the new seal assembly. Fig. 10-8. Apply carbon inner seal with the narrow end contacting the stationary bushing. Check carbon face for cleanliness. Apply rubber outer seal to shell, and apply to carbon seal so cars of shell fit into the slots in the carbon seal. One end of the drive spring fits into the shell while the other end must be fitted into a slot at the bottom of the impeller when it is assembled.

BEARING REMOVAL

1. Place shaft and bearing assembly in arbor press and remove bearings. Bearing at impeller end may have remained in housing when shaft was removed.
2. Clean and inspect parts for defects and replace damaged parts.

   Bearings with seals or shields on both sides should be wiped clean but not washed. Inspect bearings for excessive end play, roughness, seizing. galled. worn or abraded surfaces. broken or bent seals or shields. and fractured outer races.

   Pump shaft seal contact surfaces must be smooth.

   See Service Data at end of section for wear limits.

SHAFT, BEARING, AND DRIVE GEAR ASSEMBLY

1. Assemble water slinger, outer bearing, spacer, and inner bearing to the pump shaft, making sure that the rear bearing with the retainer ring is positioned correctly with the retainer ring to the outside. These parts are assembled, Fig. 10-7, first with the slinger next to the shoulder on the shaft, concave side toward the impeller end, followed by the outer bearing (without retainer), spacer and inner bearing, abutting each other snugly. The seal sides of the bearings go toward the outer ends of the assembly, being distinguished by the seal side of the bearing protruding slightly beyond the outer race.

2. Place the drive shaft housing in a vise with jaw protectors.

3. Clean dirt and oil from support housing outboard bore and outer race of outboard bearing, and apply a thin coating of silicone rubber sealing compound to housing outboard bore.

4. Insert the shaft and bearing assembly, slinger end first, from the drive gear end of the housing. Using a rawhide mallet, lightly tap the assembly until it aligns with and enters the first bearing bore and continue tapping the assembly until it is properly seated in the housing.

5. Apply the bearing retainer and snap ring back of the rear bearing.

6. Place key in shaft and assemble drive gear to shaft, using a rawhide mallet. Check shaft key and keyway fit. Check that pump shaft diameter to gear bore fit is within the maximum limit. Inspect gear nut insert for any signs of disintegration. Nuts may be reused if fiber collar drag is 10.4 N-m (92 in-lbs). Gear nut W'44) torque is 359 N-m (265 ft-lbs).

7. Replace seal assembly as previously described.

INSTALLING IMPELLER

1. Fig. 10-12 shows the impeller installer being used to assemble the impeller to the drive shaft housing. The threaded bushing is screwed on pump shaft threads and then by turning outer portion of installer tool, the impeller is pressed into position. Care must be taken to start the impeller straight on the shaft and to see that the key and keyway are aligned. Before the impeller is brought all the way down, check the underside to see that the seal spring is in the spring slot under the impeller and then finish the impeller application.

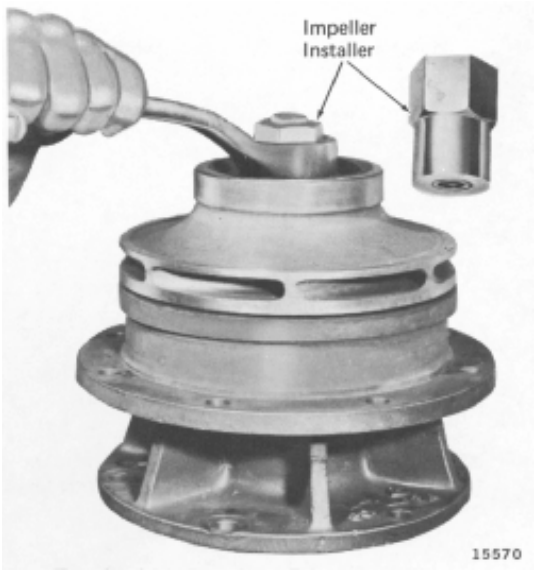


Fig. 10-12 - Installing Pump Impeller

2. Check the insert in the impeller shaft nut to see that it is free from tears and disintegration. Nuts may be reused if the fiber drag is 3.6 N-m (32 in-lbs). Apply the impeller retaining washer and nut. Torque value of the impeller nut is 108 N-m (80 ft-lbs).

INSTALLING IMPELLER HOUSING

1. Check that drilled drain passage is free of obstruction.

2. Determine whether the pump is to be used on the right or left bank of the engine since the impeller housing is positioned differently in each case.

3. An arrow is cast at the bottom of the pump shaft housing and the impeller housing has a letter "R" and "L". For a right bank pump, assemble the impeller housing so that "R" is opposite the arrow on the shaft housing or for a left bank pump, the "L" is opposite the arrow, as shown in Fig. 10-13.

4. Install housing in the correct position, using new gasket between the impeller and shaft housing. Apply housing nuts to studs and tighten to 88 N-m (65 ft-lbs).

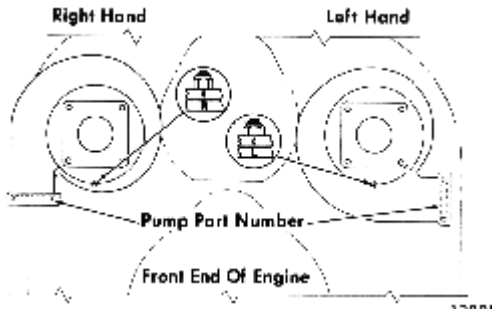


Fig. 10-13 - Pump Housing Positioning

INSTALLING PUMP

1. The pumps are installed in the position shown in Fig. 10-13 for the right and left bank. Torque value for the pump to accessory cover mounting bolts is 88 N-m (65 ft-lbs).

2. The part number of the pump is located on a plate attached to the pump discharge flange, as shown in Fig. 10-13.

   It should also be noted on pump installation, that the water inlet elbow is the proper one as listed in the parts book for the engine installation.

3. When installing a water pump, care should be taken with the application of the water inlet connection. This connection consists of a sleeve, synthetic rubber seals, seal retainers, and bolted clamps.

SERVICE DATA
COOLING SYSTEM

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.

Pump drive gear backlash -		
New		0.20-0.41 mm (.008"-.016")
Max.		0.76 mm (.030")
Bearing bores in support housing may be oversize or bearing outer diameter undersize. The limits governing the fit are:	Interference - Max.	0.002 mm (.0001")
	Clearance - Max.	0.051 mm (.0020")
Pump shaft bearing mounting diameters to bearing bores. No wear allowed. The limits governing the fit are:	Interference - Max.	0.023 mm (.0009')
	Clearance - Max.	0.002 mm (.0001 ")
Pump shaft drive gear mounting diameter to gear bore. The limits governing the fit are:	Interference - Max.	0.013 mm (.0005')
	Clearance - Max.	0.02 mm (.001")
Pump shaft impeller mounting diameter to impeller bore. The limits governing the fit are:	Interference - Max.	0.064 mm (.0025")
	Interference - Min.	0.013 mm (.0005")
Stationary bushing seal seat squareness with drive shaft - T.I.R. Max.		0.025 mm (.001")
Maximum depression allowed across aftercooler core (engine at full speed)		254 mm (10") H_2O

EQUIPMENT LIST

	Part No.
Impeller installer	8052959
Hydraulic jack (10 ton)	8263531
Water pump impeller puller	8354367
Silicone rubber sealing compound (5 oz)	8453256
Adapter	9312770
Pressure plate	9312771
Aftercooler lifting tool	File 690