Section 2
Maintenance, Troubleshooting, Removal and Installation

2-1. MAINTENANCE

2-2. GENERAL The periodic maintenance required for the Velvet Drive ® Series 5000 marine transmission is given in Table 2-1. Follow this schedule to ensure trouble-free operation and long service life.

2-3. LUBRICATION SCHEDULE. Refer to Table 2-1.

CAUTION: Temperatures in excess of 190°F (88°C) will break down the transmission fluid. If there are signs of burnt fluid or there are other reasons to believe that the transmission has overheated, change the fluid immediately.

2-4. APPROVED TRANSMISSION FLUID. General Motors Dexron IIE or Dexron III fluids are recommended, but any of the following automatic transmission fluids are suitable for use in the 5000 transmission. However, do not mix different brands or types of transmission fluid. Approved specifications are:

1. General Motors Dexron IIE or Dexron III
2. Ford Mercon
3. Detroit Diesel Allison C4
4. Caterpillar TO-4
5. Daimler-Benz 236.6

2-5. CHECKING TRANSMISSION FLUID LEVEL. The transmission should be at operating temperature [Do not exceed 190°F (88°C) max] to get an accurate fluid level reading. The fluid will expand when heated and affect the level in the transmission. Any additions to the boat that will change the installed angle of the transmission at rest may require an oil level adjustment.

WARNING: Hot transmission fluid can cause burns.

WARNING: Do not enter the engine compartment with the engine running.

CAUTION: Transmission fluid may drain back into the transmission from the cooler and connecting lines after engine shutdown. Fluid level must be checked immediately after engine shutdown. Otherwise, the dipstick reading may not be accurate and transmission could be operated with insufficient fluid.

2-6. Warm Fluid Level Check. With the engine at operating temperature, place the control lever in neutral and shut down the engine. Remove the dipstick (1) by holding the base and turning the T-handle counter clockwise (see figure 2-1) and wipe it clean. Insert the clean dipstick fully into the transmission, withdraw, and read the fluid level. Add or remove fluid as necessary to bring the fluid level to the full mark on the dipstick. Replace dipstick (1) and tighten by holding the base and turning the T-handle securely clockwise.

2-7. Cold Fluid Level Check. For ease of checking the fluid level prior to start-up, a cold fluid level mark can be made on the dipstick. First, make the warm fluid level check as described above and adjust the fluid level to the dipstick full mark. Shut down the engine and allow the transmission to cool overnight. With the transmission cold, check the fluid level and put a new cold full mark on the dipstick.

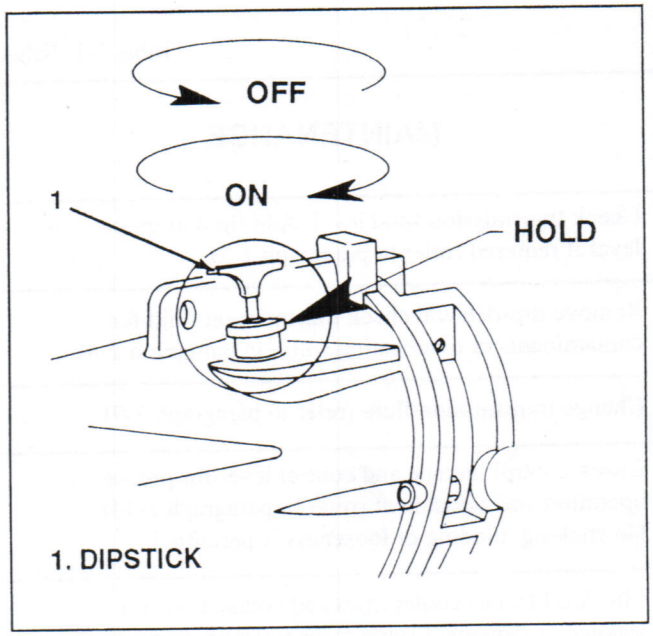


Figure 2-1. Dipstick Removal

WARNING: Frequent fluid loss indicates a system leak, even if there is no sign of transmission fluid in the bilge. As example, a defective cooler can allow transmission fluid to enter the engine's cooling system or to be returned overboard with the cooling water.

2-8. CHECKING TRANSMISSION FLUID CONDITION. Whenever the transmission fluid level is checked or any time that there is evidence of transmission overheating, check the condition of the fluid. Remove the dipstick and check for evidence of water or other contaminants. Look for evidence of overheated fluid. The recommended Dexron fluid is normally bright red but will tum dark brown if overheated. Other acceptable fluids (refer to paragraph 2-4) are different in color but all will have a distinctive "burnt" smell if overheated. If there is any evidence of contaminated or overheated fluid, determine and correct the cause and replace the fluid (refer to paragraph 2-9)

2-9. CHANGING TRANSMISSION FLUID. A seasonal change of the transmission fluid is required for all pleasure boats. Work boats require transmission fluid change every 1000 hours. In addition, the transmission fluid must be changed any time it becomes overheated, contaminated, changes color, or becomes rancid smelling.

WARNING: Do not use gasoline or any other volatile or highly combustible liquid as a cleaning solvent when changing the transmission fluid.

CAUTION: Do not, under any circumstances, start the engine with a cooler line disconnected or plugged.

1. Place a suitable container near the oil (fluid) cooler return port (103) (see figure 2-2).

2. Remove both cooler lines from the transmission. Be careful to label them for proper return. Drain all fluid from the return line into the container, using moderate air pressure to empty lines. Reconnect the cooler return line and torque fittings to 25-35 Ib-ft (34-47 Nm).

3. Remove the dipstick (1) as described in paragraph 2-6.

4. Place a suitable container under the transmission and remove the drain plug (2). Drain all fluid from the transmission and install the drain plug. Torque plug to 20-45 lb-ft (27-34 Nm)

5. Fill the transmission with the proper type (refer to paragraph 2-4) and quantity (determined by dipstick check) of transmission fluid.

6. Replace dipstick and check fluid level (refer to paragraph 2-5).

Table 2-1. Scheduled Maintenance.

MAINTENANCE	INTERVAL		
	WEEKLY	MONTHLY OR 100 HR	ANNUALLY OR 1000 HR
Check transmission fluid level. Add fluid to proper level if required (refer to paragraph 2-5).	X		
Remove dipsdck and check transmission fluid for contaminants or overheating (refer to paragraph 2-8).	X		
Change transmission fluid (refer to paragraph 2-9).			X
Check control linkage and control lever for proper operation and adjustment (refer to paragraph 2-14). No sticking, binding or looseness is permitted.		X	
Check oil (fluid) cooler lines and connections for leakage or damage. Connections must be tight.	X	X	X
Check transmission for signs of fluid leakage (refer to paragraph 2-10).		X	X
Check that transmission cover and bell housing mounting bolts are tight. Torque to specifications (refer to table 5-1).			X

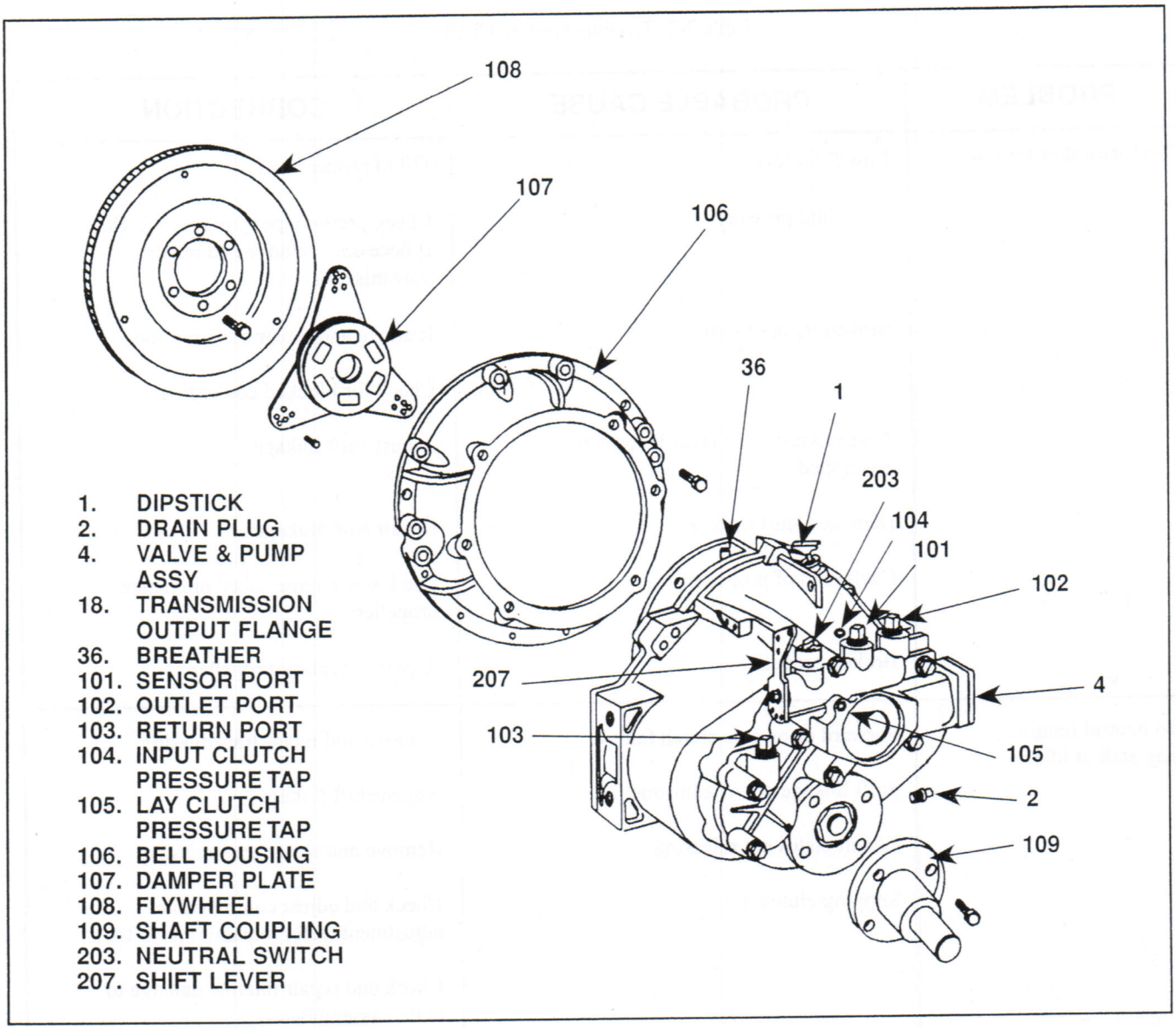


Figure 2-2. Transmission Installation

2-10. LEAKAGE CHECK. Since it is important to determine the source of a leak, a leakage check should be made before the transmission is removed from the boat. Dexron fluid leakage will show a red path leading back to the source. Fluid leaking from the valve and pump assembly (4) may be remedied without removing the transmission from the boat (refer to paragraph 2-19). Fluid leaking from the bottom of the bell housing (106) usually indicates a worn or damaged front transmission seal or engine rear seal. Sometimes leakage can be stopped by retorquing transmission bolts to specifications (except those secured with Loctite, refer to Table 5-1). If removal of the transmission is anticipated make note of tell-tale leakage path for future remedy.

2-11. TROUBLESHOOTING

2-12. GENERAL. In the event of operating difficulty, immediately note and record the symptoms and then shut down the transmission (engine) to prevent possible damage. Proper trouble diagnosis is the most essential part of repair. Without it, unnecessary repairs may be made without correcting the real problem. In some cases, as noted in the preceding paragraphs, useful diagnostic information can be obtained with the transmission installed in the boat. Other times it may be necessary to remove and disassemble, or partially disassemble, the transmission to accurately pinpoint the source of trouble. Specific inspection procedures for individual parts of the transmission are provided in Section 4.

Table 2-2. Troubleshooting Chart

PROBLEM	PROBABLE CAUSE	CORRECTION
No forward or reverse	Low fluid level	Fill to proper level
	Low fluid pressure	Check pressure per paragraph 2-18. If necessary remove and repair transmission
	Broken input or output shaft	Remove and repair transmission
		Check for blocked cooler line
	Transmission shift lever incorrectly positioned	Adjust shift linkage
	Damaged shift linkage	Repair shift linkage
	Cavitation of propeller	Use lower engine speed or change propeller
	Broken propeller	Repair or replace propeller
No neutral (engine may stall at idle)	Forward or reverse clutch failure	Remove and repair transmission
	Shift linkage out of adjustment	Adjust shift linkage
	Clutch plates not releasing	Remove and repair transmission
	Slipping clutches	Check and adjust control cable adjustment (refer to paragraph 2-14)
		Check and repair internal damage to clutch assemblies
Transmission overheats	Cooler oil or water flow restricted	Reverse flush cooler and connecting lines. Replace components that cannot be cleaned out.
	Cooler size too small for application	Install larger cooler
	Cooler hose size too restrictive	Install larger ID cooler hoses and fittings
	Low fluid level	Fill to proper level

Table 2-2. Troubleshooting Chart (Cont)

PROBLEM	PROBABLE CAUSE	CORRECTION
Overheated ("burned") fluid	Refer to "Transmission Overheats" above Repeated overheating	Take corrective action as specified for "Transmission Overheats" plus replace transmission fluid. Remove, disassemble and inspect transmission
Knocking noise that diminishes when RPM increases	Torsional vibration from improper or damaged damper plate (refer to paragraph 2-17)	Replace damper plate with one of correct design for the application
Other noise that can be isolated to transmission	Internal damage to transmission	Identify noise by type (squeal, grind, frequency, etc.) to aid in finding cause, remove, disassemble and inspect transmission

2-13. TROUBLESHOOTING CHART. Table 2-2 lists troubles which may be encountered along with possible causes and corrections.

2-14. CONTROL CABLE CHECK AND ADJUSTMENT. Check control cables for sticking or binding and for lost motion. Each cable must be free to move in its housing for its full length without binding. Any cable that sticks must be replaced. It may be possible to compensate for some lost motion by adjusting the bridge control head.

In the following instructions note that:
1. When a right-hand propeller is used, moving the transmission shift lever away from the engine will result in forward boat movement.
2. When a left-hand propeller is used, moving the transmission shift lever toward the engine will result in forward boat movement.

2-15. With the engine shut down, make cable adjustment as follows (see figure 2-3):

NOTE: Before the following steps, determine which hole the control cable is connected to, A, B, or C. The center hole is the one most commonly used. Stop to stop travel of the center hole (A, figure 2-3) is approximately 2-3/4 in. (70MM). Stop to stop travel for the outer hole (B) is 3 in. (76MM). Stop to stop travel for the inner hole (C:) is approximatley 2-3/32in.(53MM).

1. Disconnect control cable from transmission shift lever (207).
2. Place bridge control lever (111) in central, neutral position.
3. Move transmission shift lever (207) to its central neutral position. Make sure lever detent ball is engaged.
4. Adjust cable ball socket (112) to align with proper hole in transmission shift lever (207). Once established, this setting should not need to be altered.

NOTE: In the following step, it may be necessary to back off the stops in the bridge control head. Refer to the bridge control head manual for instructions.

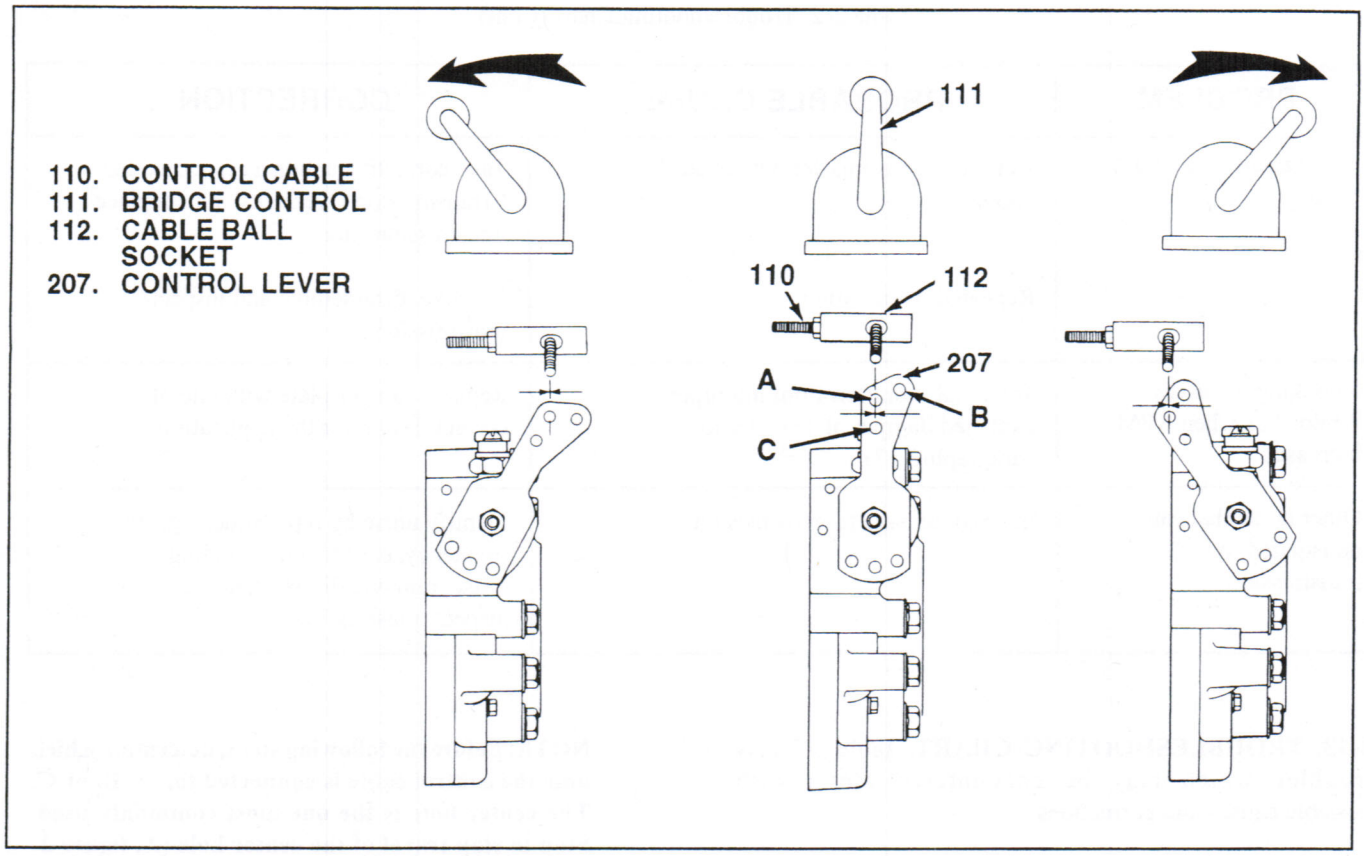


Figure 2-3. Control Cable Adjustment

5. Move bridge control lever (111) to its full forward stop position.

6. Position transmission shift lever (207) in its corresponding forward position, making sure detent ball is engaged.

7. Check that cable ball socket (112) aligns with same hole in transmission shift lever as used in step 4. If not, adjust bridge control.

8. Move bridge control lever (111) to its full reverse stop position and repeat steps 6 and 7.

9. Connect control cable to transmission shift lever (207). Move the bridge control lever (111) into each position and check that transmission shift lever moves into its proper detent, for each position.

NOTE: It may be necessary to readjust bridge control head slightly to get proper transmission shift lever positioning. If adjustment is not possible, replacement of worn cable may be required. Readjust control head stops as specified by control head manufacturer.

NOTE: For parallel connected stations, steps 1 through 9 above must first be performed independently. Then, both stations shall be connected together to ensure that each will function properly with the added resistance of the other. If reduced cable movement results, one or both cables may require replacement.

NOTE: If the two stations are connected in series (two stations connected together with one cable attached to the transmission) refer to the control head manufacturer's instructions.

2-16. PROPELLER SHAFT ALIGNMENT CHECK (see figure 2-4) The propeller shaft alignment must be checked whenever any of the following has taken place:

- the boat has been removed and replaced in the water.
- the engine and/or transmission is removed, replaced or repositioned on its bed.
- the propeller has hit a foreign object while under way.
- the output shaft seal and/or bearing has a history of failure.

CAUTION: It is possible for the side loading described in following step 1 to exist and still have the flange and coupling faces aligned as described in step 2. Flange and coupling must meet requirements of both steps. Otherwise seal leakage, bearing failure or other misalignment failures may result.

1. With boat in water, remove coupling nuts and bolts and slowly separate shaft coupling (109) from transmission output flange (18). As coupling leaves flange locating boss, check that there is no sudden radial (side to side or up or down) movement. Check that no side loading is required to remate the coupling with the flange boss.

2. With coupling (109) in flange (18) locating boss, draw flanges together using hand pressure only. Using suitable feeler gauge (114), check the clearances between the flanges at four locations, 90 degrees apart. (see figure 2-4) Clearance measurements must not vary from each other by more that 0.003 in. (.076 MM).

3. If alignment conditions of both preceding steps 1 and 2 are not met, adjustment is required. This adjustment shall be done only at the engine and transmission mounts and then only by a qualified marine mechanic. Do not pry against the transmission output flange or propeller shaft flange to attempt alignment.

4. When alignment is satisfactory, install coupling bolts and nuts and torque to OEM specifications.

2-17. TORSIONAL VIBRATION. The delivery of power from a piston engine is not smooth but rather comes in pulses. The engine flywheel uses inertia to smooth out some but not all pulsation. That remaining pulsation is called torsional vibration. In marine applications a damper plate (107, figure 2-2) is used to absorb the torsional vibration by compressing and relaxing a system of springs. The damper must be selected carefully. If its springs are inadequate for the application, damage to the transmission and damper plate itself will result. Proper damper selection is the responsibility of the boat manufacturer, or whoever matches the engine and transmission to the application—not Borg Warner. Borg Warner is not responsible for torsional vibration or any resulting damage to the transmission or other power train components.

2-18. CONTROL VALVE AND PUMP ASSEMBLY PRESSURE TEST. Perform the following test to determine if the control valve and pump assembly is functioning properly (see figure 2-5):

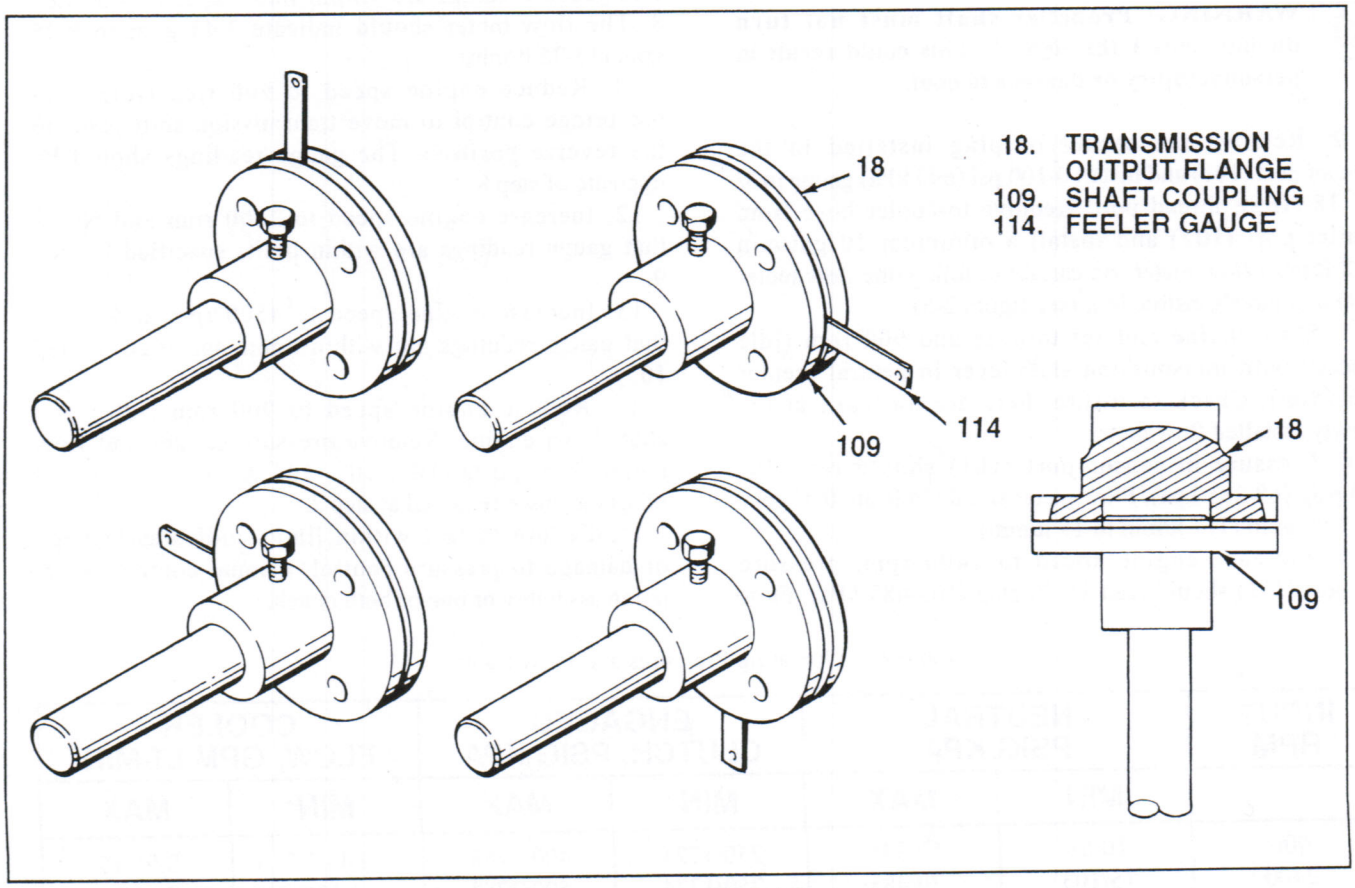
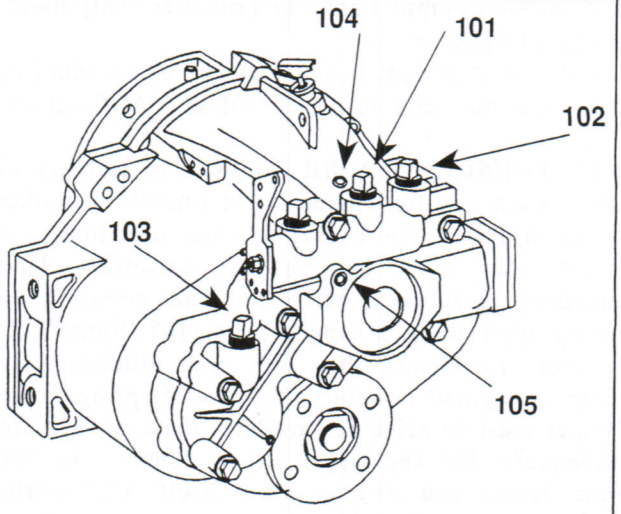


Figure 2-4. Propeller Shaft Alignment



101. MAIN SERVICE PORT
102. OUTLET PORT TO COOLER
103. RETURN PORT FROM COOLER
104. INPUT SERVICE PORT
105. LAY SERVICE PORT

Figure 2-5. Service Port Locations

1. Check fluid level as described in paragraph 2-5 and adjust level as required. Disconnect the propeller shaft (109) from the transmission output flange (18) and separate the flanges completely.

WARNING: Propeller shaft must not turn during steps 1 through 15. This could result in personal injury or damage to boat.

2. Remove the sensor or plug installed in the sensor port (101) and install 0-100 psi (690 kPa) gauge in 3/8- 18 NPSF thread port. Remove to-cooler hose from outlet port (102) and install a minimum 10 gal/min (38 lt/min) flow meter. Be careful to follow the flow meter manufacturer's instruction. (see figure 2-5)

3. Start engine and set throttle and 900 rpm (idle speed) with transmission shift lever in neutral (center position). Check to insure there are no leaks at the newly installed flow meter.

4. Pressure in sensor port (101) should read 10-50 psig (68-345 kpa). Flow meter should indicate 0.45gpm to 3.96 gpm (117 lt/min to 15 lt/min).

5. Increase engine speed to 2400 rpm, pressure in port (101) should read 15-70 psig (103-483 kPa). Flow meter should indicate 2.11 gpm to 7.40 gpm (8 lt/min to 28 lt/min).

6. Shut down engine and remove 0-100 psi (690 kPa) gauge and install sensor or plug removed in step 2. Remove plugs from input clutch pressure tap (104) and lay clutch pressure tap (105) and install 0-500 psi (3500 kPa) pressure gauges in the 1/8 in. NPT ports.

7. Start engine and set at 900 rpm (idle speed).

8. Move the bridge control to its full forward position. If the shift lever on the transmission has moved away from the engine, port (104) should have 250-400 psig (1724-2758 kPa). If the transmission shift lever has moved toward the engine, port (105) should have 250-400 psig (1724-2758 kPa). The flow meter should indicate 0.45 gpm to 3.96 gpm (1.7-15 lt/min) in both steps 7 and 8.

NOTE: In step 8 if the transmission shift lever moved away from the engine, the propeller is right handed. If the shift lever moved toward the engine, the propeller is left handed.

9. Increase engine speed to 2400 rpm and check that gauge readings are within limits specified in step 8. The flow meter should indicate 2.11 gpm to 7.40 gpm (8-28 lt/min).

10. Increase engine speed to 4500 rpm and check that gauge readings are within limits specified in step 8. The flow meter should indicate 3.43 gpm to 9.25 gpm (13-35 lt/min).

11. Reduce engine speed to 900 rpm (idle) and use bridge control to move transmission shift lever to the reverse position. The gauge readings should be opposite of step 8.

12. Increase engine speed to 2400 rpm and check that gauge readings are within limits specified in step 9.

13. Increase engine speed to 4500 rpm and check that gauge readings are within limits specified in step 10.

14. Reduce engine speed to 900 rpm (idle) and shut down engine. Remove pressure gauges and flow meter from ports (101, 102, 104 & 105) and install plugs or sensor removed at step 2.

15. Failure to test within limits indicates leakage or damage to pressure control, manual control valve, pump assembly or one or both clutches.

Table 2-3. Operating Pressures and Flow Rates

INPUT RPM	NEUTRAL PSIG/KPA		ENGAGED CLUTCH, PSIG\KPA		COOLER FLOW, GPM/LT-MIN	
	MIN	MAX	MIN	MAX	MIN	MAX
900	10/68	50/345	250/1724	400/2758	0.45/1.7	3.96/15
2400	15/103	70/483	250/1724	400/2758	2.11/8	7.40/28
4500	--	--	250/1724	400/2758	3.43/13	9.25/35

2-19. VALVE AND PUMP ASSEMBLY REPLACEMENT WITH TRANSMISSION MOUNTED ON ENGINE. If trouble is isolated to the control valve and pump assembly and there is no other reason to remove the transmission from the boat, it is possible to replace the valve and pump assembly with the transmission installed in the boat. However, when removing the valve and pump assembly (see figure 3-1), extreme care must be taken to capture and tag the exact number of shims (6) used at each location. If shims drop out or become lost or intermixed for any other reason, abandon this replacement procedure, remove the transmission from the boat and proceed as specified in Sections 3 through 5 in this manual.

CAUTION: Improper shimming of input or lay shaft bearings will result in transmission damage. If there is any doubt as to shim thickness at either location, remove transmission from boat so that it can be shimmed properly.

2-20. VALVE AND PUMP ASSEMBLY REMOVAL (see figure 3-1) Remove valve and pump assembly as follows:

1. Withdraw valve and pump assembly (4) with extreme care so as not to dislodge any shims (6). If any shims stick to valve and pump assembly rather than being retained in case (46), remove, identify and save these just as soon as clearance permits.

2. Save and record for possible future identification all shims (6) and tag as "INPUT" or "LAY" coming from input shaft assembly (28) or lay shaft assembly (29).

2-21. VALVE AND PUMP ASSEMBLY INSTALLATION. Install valve and pump assembly as follows:

1. If the original valve and pump assembly (4) are to be reinstalled, return all shims to their original positions.

2. If pump assembly (2O2) is replaced, determine shim thickness for input shaft (28) bearing as follows:

a. Measure and record dimension E, figure 2-6 on both the new and old pumps.

b. If dimension E is greater on the new pump, subtract the difference from the shims removed from the input shaft.

c. If dimension E is less than the new pump, add the difference to the shims removed from the input shaft.

NOTE: The shims returned to the lay shaft must be the same as those removed.

3. Install valve and pump assembly (4) with extreme care so as not to dislodge any shims (6). If any shims become dislodged and its location cannot be identified positively, remove all shims and assemble shim stacks for each location according to recorded data. Use petroleum jelly or cup grease to hold shims in place until assembled.

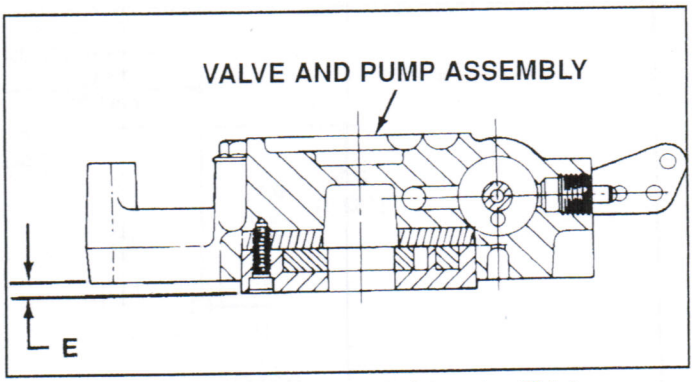


Figure 2-6. Determine Input Shaft Bearing Thickness

2-22. TRANSMISSION REMOVAL AND INSTALLATION

2-23. REMOVAL OF TRANSMISSION. Refer to the OEM manual for specific instructions regarding enclosures, mounts, supports, shift linkage and other components related to the transmission. A suitable hoist or other means for completely supporting the transmission will be required. Proceed as follows (see figures 2-2 and 2-7):

1. Disconnect negative battery terminal.

2. Disconnect electrical connectors from neutral switch assembly (203) and sensor in port (101) (if used) on transmission.

3. Remove the cooler outlet and return lines from the transmission ports (102 and 103) tag each hose for proper identification. Drain all fluid from the lines into a suitable container.

4. Disconnect shift linkage from transmission shift lever (207).

5. Remove coupling nuts and bolts and separate propeller shaft coupling (109) from the transmission output flange (18).

6. Remove rear mounts, raise and support engine.

7. Support transmission with hoist or by other suitable means through the lifting eye on the transmission case.

CAUTION: Make sure transmission is completely supported before removing hardware attaching transmission to flywheel housing. Do not allow transmission to "hang" on input shaft.

8. Remove all hardware attaching transmission to bell housing (106).

9. Move transmission straight back away from engine to completely disengage spline on input shaft.

10. Carefully lift out transmission.

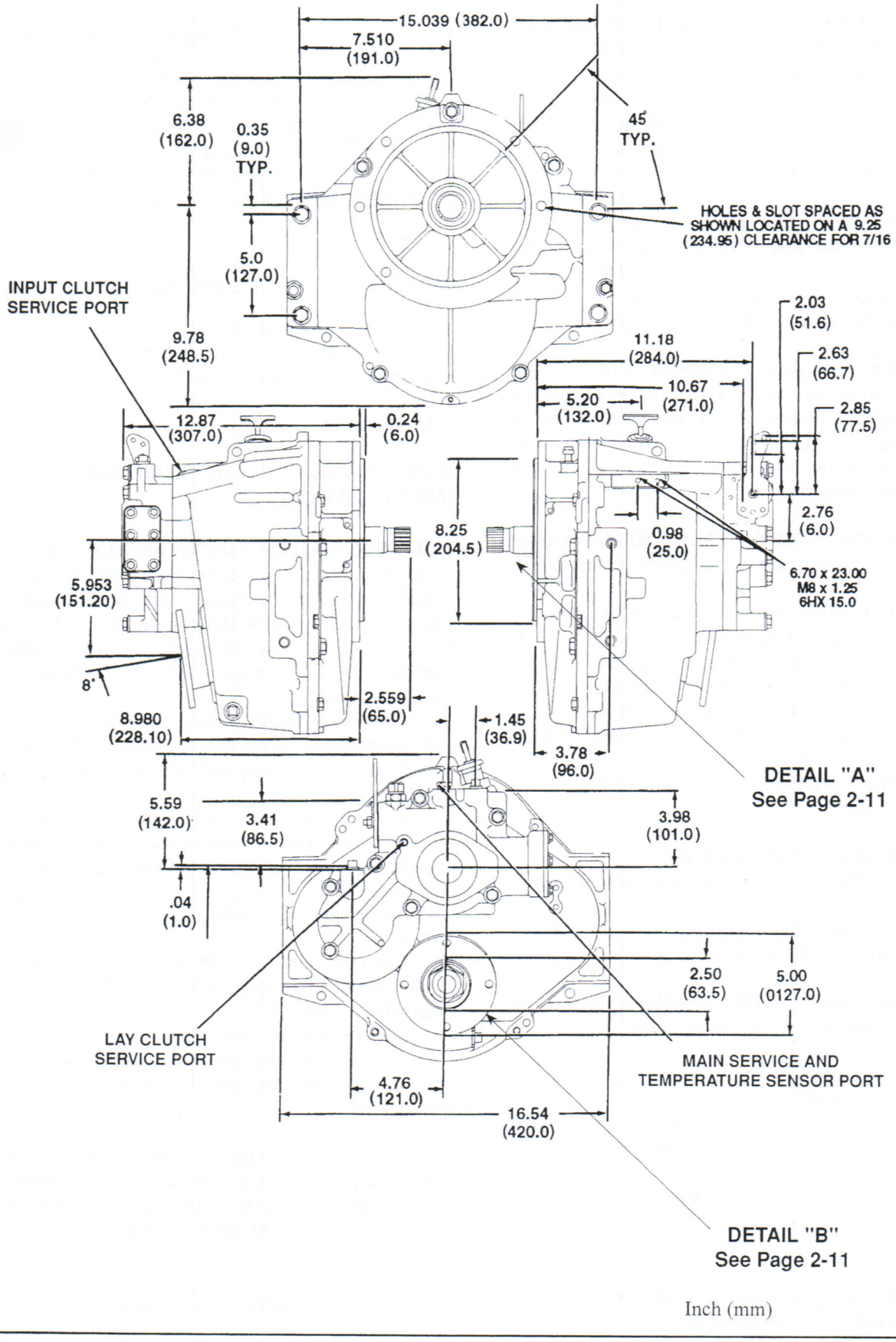
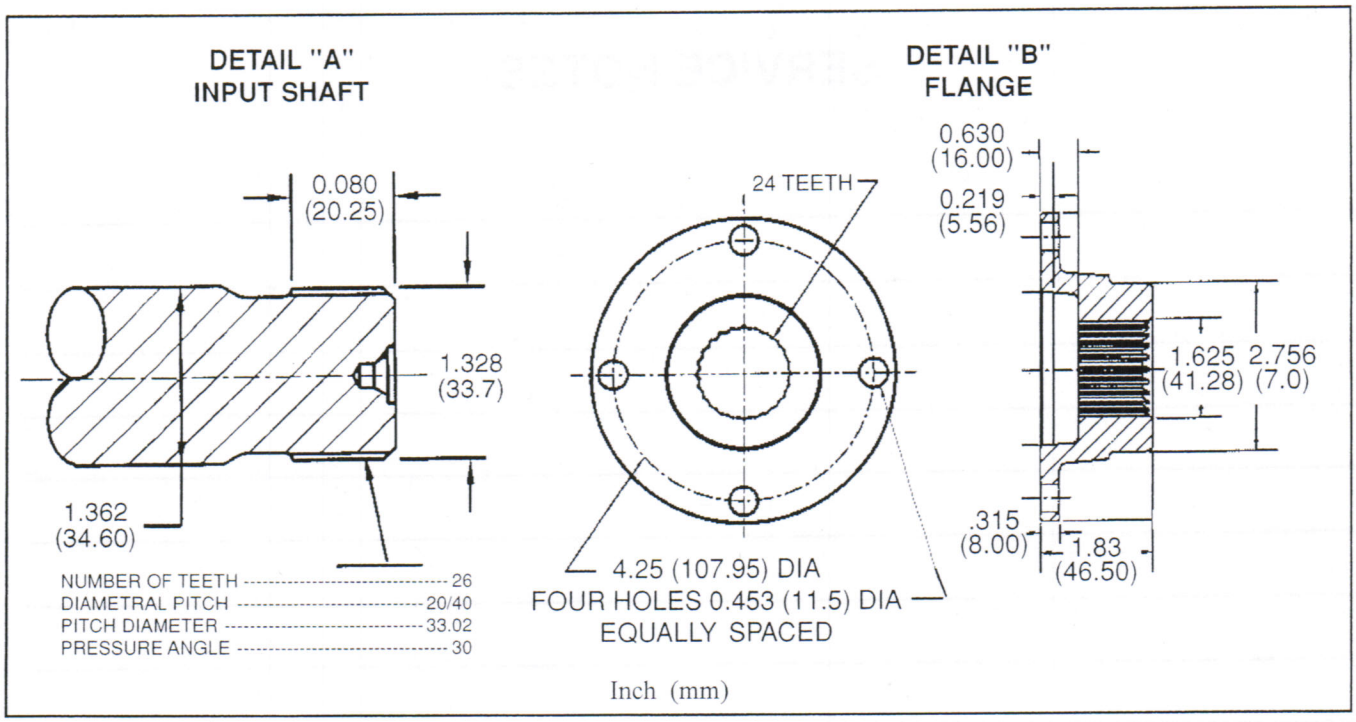


Figure 2-7. Transmission Installation Dimensions



Input Shaft Spline / Flange Dimensions

2-24. REPAIR/OVERHAUL OF TRANSMISSION. Refer to Sections 3 through 5 for disassembly, inspection, repair, parts replacement and assembly of the transmission.

2-25. INSTALLATION OF TRANSMISSION. Refer to the OEM manual for specific instructions regarding enclosures, mounts, supports, shift linkage and other components related to the transmission. Transmission installation dimensions are shown on figure 2-7. With transmission supported in a suitable manner, proceed as follows (see figure 2-2):

1. Apply a thin film of high temperature grease to spline on transmission input shaft.

2. Position transmission and align with engine. Use guide pins to align transmission during installation.

3. Carefully move transmission forward, engaging spline on input shaft. Install and torque hardware per OEM specifications. Remove hoist.

4. With the boat in the water, connect and align propeller shaft coupling (109) as specified in paragraph 2-16.

CAUTION: Improper shift linkage adjustment can cause premature clutch failure.

5. Connect shift linkage to transmission shift lever (207). The control lever at the bridge must agree with the shift lever on the transmission. Adjust the shift linkage if required (paragraph 2-14).

6. Connect the cooler outlet and return lines to the transmission ports (102 and 103). Torque fittings to OEM specifications.

7. Fill transmission with fluid as specified in paragraphs 2-4 and 2-9.

8. Connect electrical connectors to neutral safety switch (203) and sensor in port (101) (if used).

9. Connect negative battery terminal.