POWERHEAD

Section 4B - Cooling

Table of Contents

4B

Specifications

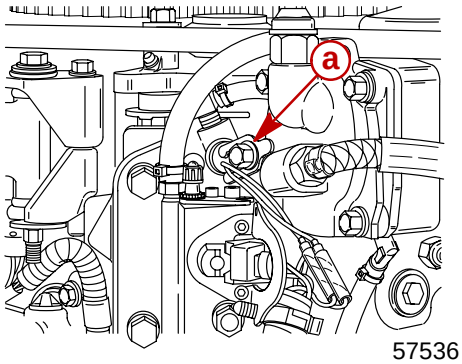
Water Pressure

Idle	1.0 – 3.0 PSI (6.8 – 20.5 kPa)
Poppet Valve Opening	4 – 9 PSI (27.4 – 61.6 kPa)
W.O.T.	12.0 PSI (82.1 kPa) Minimum

Thermostat . . . . . 143°F (61.7°C)

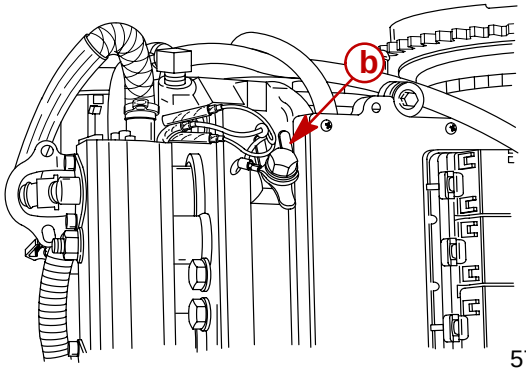
Temperature Sensor

Temperature Sensor(s)	
Between Black and each TAN/BLK wire.	No Continuity
Between each lead and ground	No Continuity



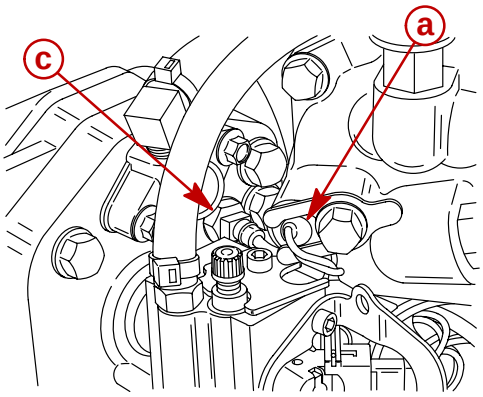
57536

MODEL 2000 PORT



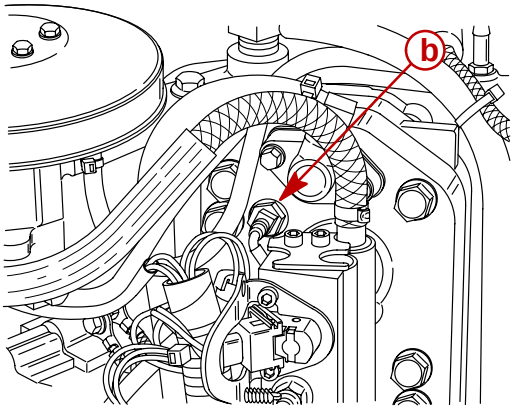
57682

MODEL 2000 STARBOARD



58442

MODEL 2001 PORT



MODEL 2001 STARBOARD

58441

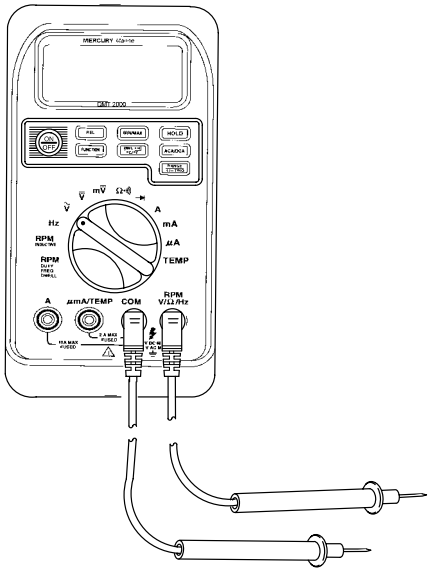
a - Air Compressor Temperature Sensor – Activates at 221°F (105°C) – Horn activation only

b - Starboard Cylinder Head Temperature Sensor – Activates at 221°F (105°C) – Horn Activation and Speed Reduction

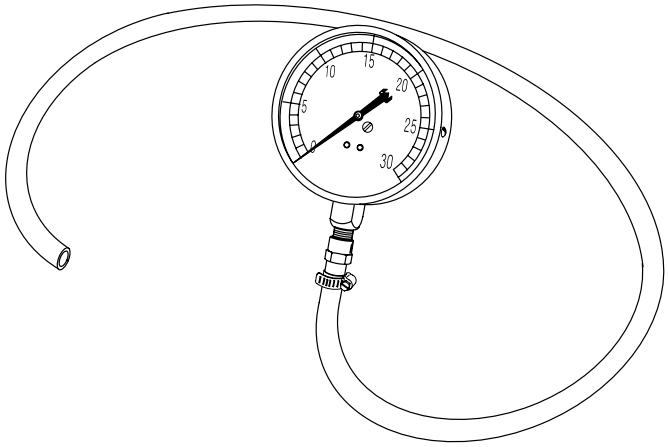
c - Port Cylinder Head Temperature Sensor – Activates at 221°F (105°C) – Horn Activation and Speed Reduction

Special Tools

1. DMT 2000 Digital Tachometer Multi-meter P/N 91-854009A1



2. Water Pressure Gauge 91-79250A2



56725

Temperature Sensor

NOTE: *Model Year 2000 – The air compressor temperature sensor and cylinder head temperature sensors are the same part number. The ECM has been programmed to activate a warning circuit at different temperatures depending upon sensor location.*

NOTE: *The Digital Diagnostic Terminal (DDT) can be used to monitor temperature readings from both temperature sensors.*

Model Year 2000 – Two (2) temperature sensors are used to provide cylinder head temperature information to the ECM. One sensor is mounted in the starboard cylinder head and one in the air compressor cylinder head.

Model Year 2001 – Three (3) temperature sensors are used to provide temperature information to the ECM. One sensor is mounted in each cylinder head and one sensor is mounted in the air compressor cylinder head.

The ECM uses this information to increase injector pulse width for cold starts and to retard timing in the event of an over-heat condition.

An ohms test of the temperature sensor would be as follows:

MODEL YEAR 2000 – Insert digital or analog ohmmeter test leads into both TAN/BLACK sensor leads. With engine at temperature (F°) indicated, ohm readings should be as indicated ±10%. There should be no continuity between BLACK and each TAN/BLACK lead and no continuity between each TAN/BLACK lead and ground.

MODEL YEAR 2001 – Disconnect temperature sensor harness and check continuity with digital or analog ohmmeter test leads between both connector pins. With engine at temperature (F°) indicated, ohm readings should be as indicated ±10%. There should be no continuity between each connector pin and ground.

MODEL YEAR 2000		
F	C	
257	125	34
248	120	38
239	115	44
230	110	51
221	105	59
212	100	68
203	95	79
194	90	92
185	85	107
176	80	126
167	75	148
158	70	175
149	65	208
140	60	248
131	55	298
122	50	360
113	45	436
104	40	532
95	35	653
86	30	805
77	25	1000
68	20	1250
59	15	1573
50	10	1993
41	5	2546
32	0	3277
14	–10	5579
5	–15	7372

MODEL YEAR 2001		
F	C	
257	125	340
248	120	390
239	115	450
230	110	517
221	105	592
212	100	680
203	95	787
194	90	915
185	85	1070
176	80	1255
167	75	1480
158	70	1752
149	65	2083
140	60	2488
131	55	2986
122	50	3603
113	45	4370
104	40	5327
95	35	6530
86	30	8056
77	25	10000
68	20	12493
59	15	15714
50	10	19903
41	5	25396
32	0	32654
14	–10	55319
5	–15	72940

2.5 Liter Optimax/DFI Water Flow

Description

Cooling water enters the cooling system through the lower unit water inlets. The pump assembly forces water through the water tube and exhaust adapter plate passages filling the power head central water chamber (located behind the exhaust cavity). Water enters the exhaust cover cavity through 2 holes near the top of the exhaust cover.

Water exits the exhaust cover cavity through 4 slots (2 each side) filling the water passages around the cylinders. Water flows around each bank of cylinders to the top of the cylinder block.

Water flow exiting the cylinder block is controlled by the thermostats (1 in each cylinder head) and the poppet valve (located at the bottom starboard side of powerhead). At low RPM (below 1500 RPM), the thermostats control water flow depending upon engine temperature. When the thermostats are open, water passes through the cylinder heads and exits to the drive shaft housing. At higher RPM (above 1500 RPM) the poppet valve will control the water flow.

Water that passes through the poppet valve enters water passages in the adaptor plates. Water passes through the adaptor plates into the driveshaft housing.

Water dumped into the drive shaft housing builds up a wall of water around the exhaust tube. This performs 2 functions:

- Helps silence the exhaust
- Prevents air from being drawn into the pump

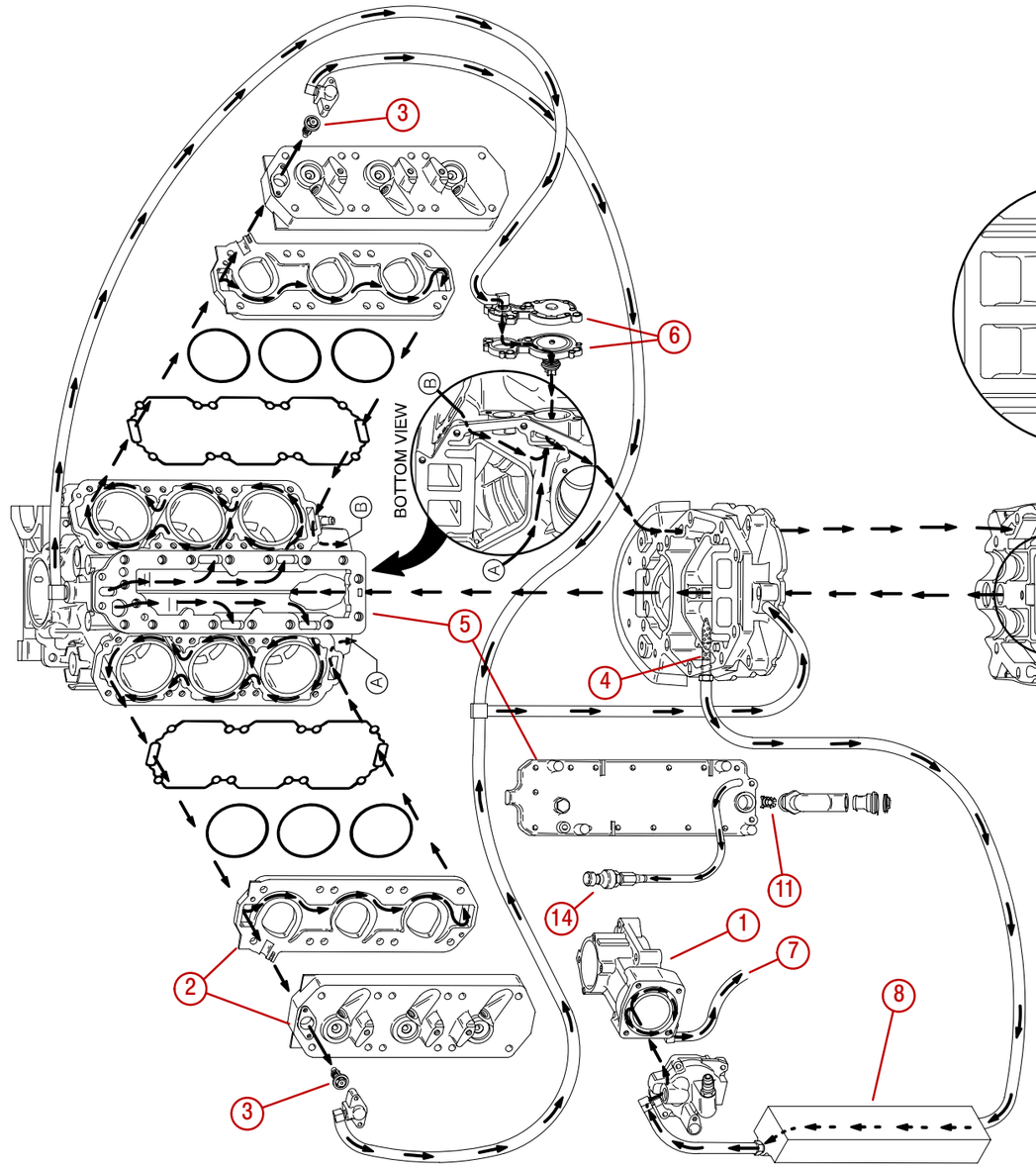
Water exits the engine in 3 locations:

- Excess water from the wall of water exits around anodes on the gear housing.
- Water that passes through the air compressor exits out the tell tail.
- Water exits through two 1/8 in. (3.175 mm) holes in the lower adaptor plate into the exhaust.

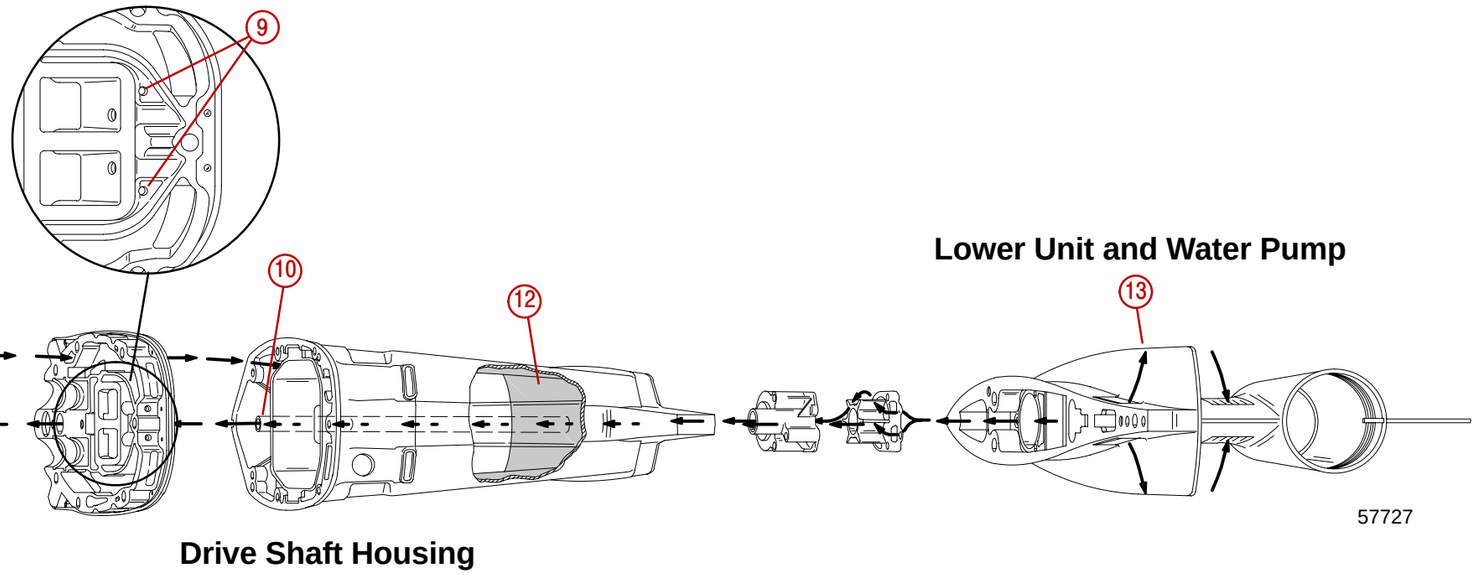
To allow complete passage filling and to prevent steam pockets, all cooling passages are interconnected. Small passages are incorporated to allow the cooling system to drain.

Notes:

Water Flow Diagram



Cylinder Block and Adaptor Plate



Drive Shaft Housing

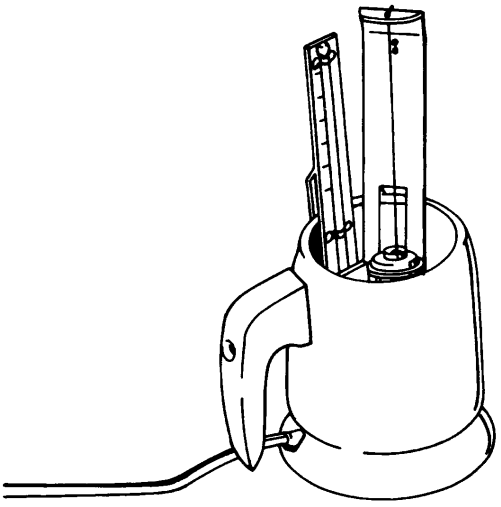
1 - Air Compressor
2 - Cylinder Head Cover – Removed from head for illustration, normally part of head casting
3 - Thermostats (2) 143° F (61.7° C) – If stuck closed, engine will overheat at idle.
4 - Strainer Screen for air compressor and fuel rail water supply – If restricted, compressor will overheat and tell-tale will be weak.
5 - Exhaust Divider Plate – Separated for illustration
6 - Poppet Valve – Controls water flow at high RPM.
Note: If poppet valve is stuck open at low RPM, the engine will not reach proper operating temperature (run cold) and will run rough at idle.
7 - Water Outlet from Air Compressor – Connects to tell-tale outlet on bottom cowl.
8 - Port Fuel Rail – Fuel Cooler is built into Port Fuel Rail.
9 - Water Dump Holes Exhaust Cooling (2 each) 1/8 in. (3.175 mm) – If holes are plugged, tuner pipe will melt and bearing carrier prop shaft seals will be damaged.
10- Water Tube
11- Check Valve for powerhead flush.
12- Wall of Water – If water level height is insufficient, water pump may draw in air resulting in an overheated engine.
13- Excess water from wall of water around exhaust bucket exits around anodes.
14- Block Water Pressure Sensor

Troubleshooting

Thermostat Test

1. Inspect thermostat covers and cylinder head covers (thermostat opening) for cracks and corrosion damage that could cause leakage. Replace parts as necessary.
2. Remove and discard gasket from each thermostat.
3. Wash thermostats with clean water.
4. Using a thermostat tester, similar to the one shown, test each thermostat as follows:
   a. Open thermostat valve, then insert a thread between valve and thermostat body. Allow valve to close against thread.
   b. Suspend thermostat (from thread) and thermometer inside tester so that neither touches the container. Bottom of thermometer must be even with bottom of thermostat to obtain correct temperature of thermostat opening.
   c. Fill thermostat tester with water to cover thermostat.
   d. Plug tester into electrical outlet.
   e. Observe temperature at which thermostat begins to open. (Thermostat will drop off thread, that was installed in Step “a”, when it starts to open.) Thermostat must begin to open when temperature reaches 140°-145° F (60°-63° C).
   f. Continue to heat water until thermostat is completely open.
   g. Unplug thermostat tester.
   h. Replace thermostat, if it fails to open at the specified temperature, or if it does not fully open.

NOTE: *BE SURE that water in thermostat tester is allowed to cool sufficiently [below 110° F (43.3° C)] before testing the other thermostat.*



51087

IMPORTANT: DO NOT operate engine without thermostats installed.

Water Pressure Check

Water pressure may be checked by one of three methods;

- Use a Digital Diagnostic Terminal (DDT) [91-823686A2]
- On engines equipped with Omega gauges, water pressure is an available readout.
- On engines not equipped with Omega gauges, a water pressure line is provided that exits at the front of the lower cowl. A dash style gauge may be connected to this line to register water pressure.

⚠ WARNING

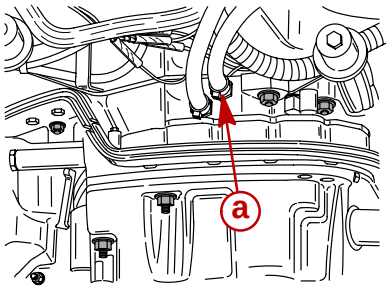
Shut off engine and refer to troubleshooting chart if water pressure is not within specification. DO NOT exceed 3000 RPM in neutral.

Idle	1.0 – 3.0 PSI (6.8 – 20.5 kPa)
Poppet Valve Opening	4 – 9 PSI (27.4 – 61.6 kPa)
W.O.T.	12.0 PSI (82.1 kPa) Minimum

Cooling Water Strainer

The cooling water strainer filters cooling water flowing to the port fuel rail and air compressor.

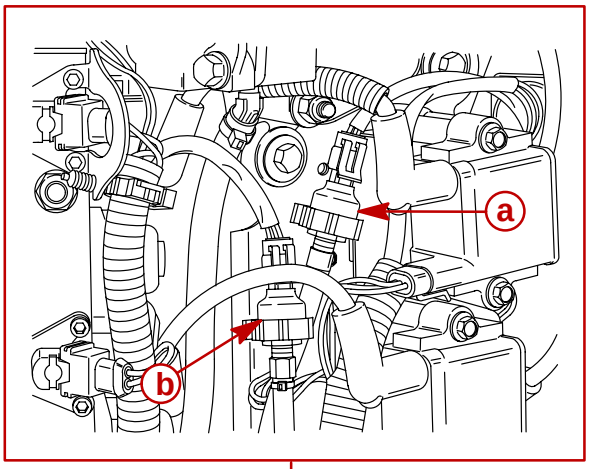
1. Remove bottom cowl. Disconnect water hose from the strainer plug.
2. Remove and clean strainer.
3. Apply Loctite Pipe Sealant w/Teflon (92-88504) to strainer threads and reinstall strainer. Reconnect water hose and secure with sta-strap.



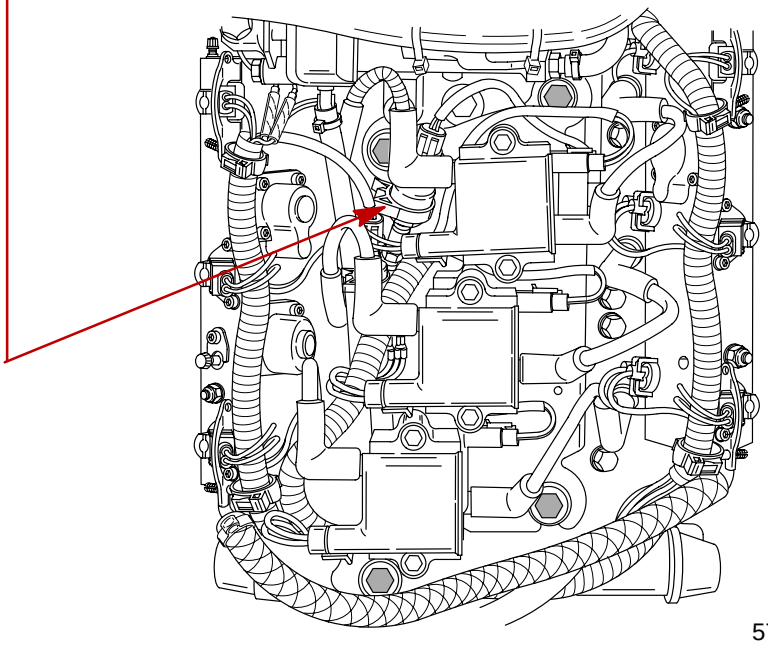
57543

a - Water Strainer

Water Pressure Sensor



57535



57532

a - Water Pressure Sensor (TAN housing)
b - Speedometer Pressure Sensor (Optional) (BLACK housing)

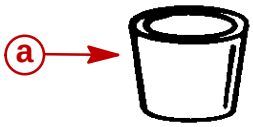
The water pressure sensor is monitored by the ECM at 1200 rpm and above on Model Year 2000 engines and at 2750 rpm and above on Model Year 2001 engines. Should the low water pressure continue for more than 5 seconds, a speed reduction circuit* within the ECM will be activated.

*The Guardian System will limit rpm if temperatures are high regardless of system pressure.

Water Pressure Low for more than 2 seconds	Warning horn activated Warning light illuminated (If Equipped)
Water Pressure Low for more than 5 seconds	Warning horn activated Warning light illuminated (If Equipped) Maximum engine rpm limited

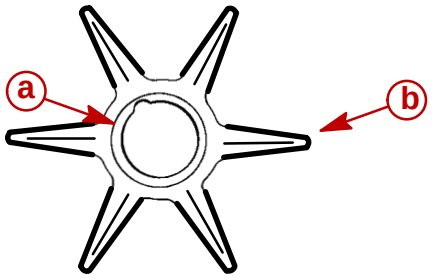
Water Pump Cleaning and Inspection

1. Inspect the water tube coupling for wear or damage. If necessary replace..



a - Water Tube Coupling

2. Inspect the water pump impeller for wear on the end, top and bottom of the impeller blades. Replace the impeller if this condition is found.
3. Inspect for proper bonding between the hub and the impeller. Replace the impeller if improper bonding is found.

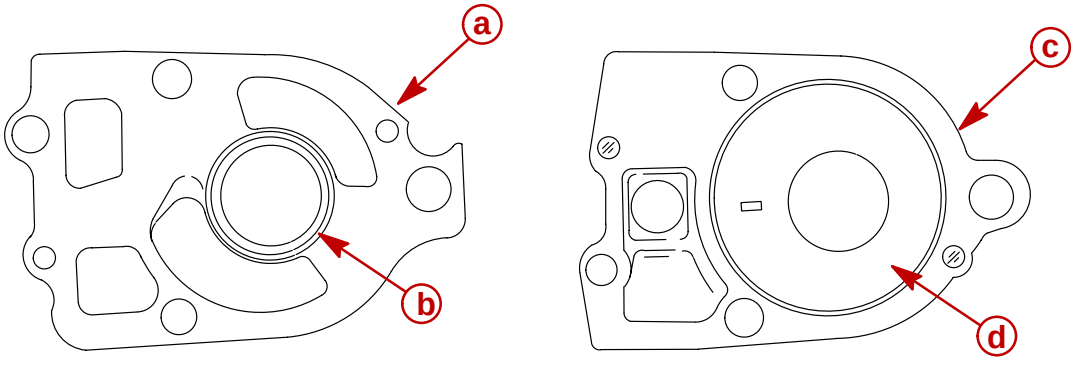


a - Hub
b - Impeller

4. Inspect the impeller blades to see if they are cracked, burnt, hard or deformed. Replace the impeller if the blades are in this condition.

IMPORTANT: The circular groove formed by the impeller sealing bead should be disregarded when inspecting cover and plate. The depth of the groove will not affect water pump output.

5. Replace cover if plastic is melted from excessive heat (lack of water). Replace stainless insert and/or face plate if grooves (other than impeller sealing bead groove) are more than 0.010 in. (0.254 mm) deep.



57408

a - Water Pump Face Plate
b - Sealing Groove (disregard)
c - Water Pump Cover
d - Stainless Insert [discard if grooves exceed 0.010 in. (0.254 mm)]

IMPORTANT: It is recommended that all seals and gaskets be replaced (as a normal repair procedure) to assure effective repair.

IMPORTANT: It is recommended that the water pump impeller be replaced whenever the gearcase is removed for maintenance. However, if it is necessary to re-use the impeller, DO NOT install in reverse to original rotation as premature impeller failure will occur.

Problem Diagnosis

NOTE: *The Guardian System will limit power if temperatures are high regardless of system pressures.*

Condition	Recommended Range	Possible Cause
Pressure below specification @ idle	1.0 – 3.0 PSI (6.8 – 20.5 kPa)	•Poppet valve spring defective (weak, broken, missing) •Defective poppet valve seal •Thermostat stuck open •Severe internal leak •Low output water pump •Inlet restriction •Strainer screen for air compressor water supply is restricted
Pressure above 5 psi (34.2kPa) @ idle	1.0 – 3.0 PSI (6.8 – 20.5 kPa)	•Plugged poppet by-pass passage or tell-tale
Pressure does not drop between 1000 – 2500 RPM indicating poppet valve has opened	4 – 9 PSI (27.4 – 61.6 kPa) between 1000 – 2200 RPM	•Wrong poppet valve spring •Low output water pump •Inlet restriction •Poppet valve vent hole plugged or restricted •Severe internal leak •Defective poppet valve seal
Poppet valve flutter/water pressure drop does not stabilize prior to 2500 RPM	4 – 9 PSI (27.4 – 61.6 kPa) between 1000 – 2200 RPM	•Wrong poppet valve spring •Low output water pump •Inlet restriction •Broken diaphragm in poppet valve •Severe internal leak •Defective poppet valve seal
Pressure is below minimum specification @ W.O.T.	12 PSI (54.9 – 68.5kPa)	•Inlet restriction •Engine mounted too high on transom •Engine trimmed out too far •Configuration of boat bottom interfering with adequate flow of water to coolant inlets •Severe internal leak •Low output water pump •Plugged strainer screen for port fuel rail and air compressor water supply
Pressure higher than normal @ W.O.T., but engine still indicates overheat condition	Maximum pressure – 23 PSI (157.4 kPa)	•Outlet water passages restricted. •Steam pocket has formed at top of powerhead due to lack of cooling water