MERCURY®

15/20 EFI FourStroke

SERVICE MANUAL

Notice to Users of This Manual

Throughout this publication, safety alerts labeled WARNING and CAUTION (accompanied by the international hazard symbol ⚠) are used to alert the mechanic to special instructions concerning a particular service or operation that may be hazardous if performed incorrectly or carelessly. Observe these alerts carefully.

These safety alerts alone cannot eliminate the hazards that they signal. Strict compliance to these special instructions when performing the service, plus common sense operation, are major accident prevention measures.

⚠ WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

Additional alerts provide information that requires special attention:

NOTICE

Indicates a situation which, if not avoided, could result in engine or major component failure.

IMPORTANT: Indicates information essential to the successful completion of the task.

NOTE: *Indicates information that helps in the understanding of a particular step or action.*

This manual has been written and published by the Mercury Marine Service Department to aid our dealers' mechanics and company service personnel when servicing the products described herein. It is assumed that these personnel are familiar with marine product servicing procedures. Furthermore, it is assumed that they have been trained in the recommended service procedures of Mercury Marine power products, including the use of mechanics' common hand tools and the special Mercury Marine tools or recommended tools from other suppliers.

We could not possibly know of and advise the marine trade of all conceivable procedures and of the possible hazards and results of each method. Therefore, anyone who uses a service procedure or tool that is not recommended by the manufacturer must first completely satisfy himself that neither his nor the product's safety will be endangered.

All information, illustrations, and specifications contained in this manual are based on the latest product information available at the time of publication. As required, revisions to this manual will be sent to all dealers contracted by us to sell or service these products. We reserve the right to make changes to this manual without prior notification.

Refer to dealer service bulletins, operation, maintenance and warranty manuals, and installation manuals for other pertinent information concerning the products described in this manual.

Precautions

While working on the product, keep in mind that the electrical and ignition systems are capable of violent and damaging short circuits or severe electrical shocks. When performing any work where electrical terminals could possibly be grounded or touched by the mechanic, the battery cables should be disconnected at the battery.

Any time the intake or exhaust openings are exposed during service they should be covered to protect against accidental entrance of foreign material into the cylinders, which could cause extensive internal damage when the engine is started.

During any maintenance procedure, replacement fasteners must have the same measurements and strength as those removed. Numbers on the heads of the metric bolts and on the surfaces of metric nuts indicate their strength. American bolts use radial lines for this purpose, while most American nuts do not have strength markings. Mismatched or incorrect fasteners can result in damage or malfunction, or possibly personal injury. Therefore, fasteners removed should be saved for reuse in the same locations whenever possible. Where the fasteners are not satisfactory for reuse, care should be taken to select a replacement that matches the original.

Personnel should not work on or under an engine that is suspended. Engines should be attached to workstands, or lowered to the ground as soon as possible.

Replacement Parts

Use of parts other than the recommended service replacement parts will void the warranty on those parts that are damaged as a result.

⚠ WARNING

Avoid fire or explosion hazard. Electrical, ignition, and fuel system components on Mercury Marine products comply with federal and international standards to minimize risk of fire or explosion. Do not use replacement electrical or fuel system components that do not comply with these standards. When servicing the electrical and fuel systems, properly install and tighten all components.

Cleanliness and Care of Product

A Mercury Marine power product is a combination of many machined, honed, polished, and lapped surfaces with tight tolerances. When any product component is serviced, care and cleanliness are important. Proper cleaning and protection of machined surfaces and friction areas is an implied part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Whenever components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

Copyright and Trademark Information

Manual Outline

Important Information

Section 1A - Specifications

Table of Contents

Model Specifications

Parameter		Specification
Weight	MH	46.7 kg (103 lb)
	MRC	44 kg (97 lb)
	MLH	48.5 kg (107 lb)
	EH	50.3 kg (111 lb)
	ELH	51.7 kg (114 lb)
	E	47.6 kg (105 lb)
	EL	49 kg (108 lb)
	EPT	52.6 kg (116 lb)
	ELPT	54 kg (119 lb)
	ELHPT	57.6 kg (127 lb)
	ProKicker EXLPT	55.3 kg (122 lb)
	ProKicker EXLHPT	59 kg (130 lb)
Engine idle speed		900–1000 RPM
Recommended RPM range at WOT	SeaPro models	4500–5500 RPM
	15/20 JCI models	5400–6100 RPM
	All other (10/15/20 hp)	5700–6200 RPM
Bore x stroke		61.0 mm x 57.0 mm (2.402 in. x 2.244 in.)
Compression ratio		10.0:1
Starting system		Manual/electric
Tilt range	Manual Tilt	4°–76°
	Power Tilt	4°–75°
Transom height	Short	41.3 cm (16.3 in.)
	Long (L)	56.2 cm (22.1 in.)
	Extra long (XL)	68.9 cm (27.1 in.)

Ignition Specifications at 20 °C (68 °F)

Parameter		Specification
Ignition type		Computer-controlled capacitor discharge ignition (CDI)
Spark plug		NGK DCPR6E
Spark plug gap		0.9 mm (0.035 in.)
Ignition timing at idle		5° ± 5° BTDC
Ignition timing at WOT		28° BTDC
RPM overspeed	SeaPro models	5800 RPM
	15/20 JCI models	6300 RPM
	All other (10/15/20 hp)	6500 RPM
ECM RPM limiter (Guardian)		2800 RPM
Overtemperature		85 °C (185 °F)
Low oil pressure (over 10 seconds)		26.3 kPa (3.8 psi)
Crankshaft position sensor		148–222 Ω
Ignition coil	Primary	0.26–0.35 Ω
	Secondary (with plug wires and caps)	16.8–20.2 kΩ
	Spark plug lead (without spark plug cap)	3.0–7.5 kΩ

Charging and Starting Specifications

Parameter		Specification
Alternator type		Single phase
Alternator charge coil resistance		0.17–0.25 Ω
Alternator output at 900 RPM		4.6 A
Alternator output at 5000 RPM		11.5 A
Starter	Type	Bendix®
	Output	0.6 kW at 12 V
	Brush length	14.0 mm (0.551 in.)
	Brush length (service limit)	11.0 mm (0.433 in.)
	Commutator undercut	0.95–1.05 mm (0.037–0.041 in.)
	Commutator diameter	28.3 mm (1.114 in.)
	Commutator diameter (service limit)	27.8 mm (1.095 in.)
Fuse capacity	Voltage regulator output	20 A
	Starting control circuit	15 A
Fuse type		Mini ATC
Battery requirements (minimum)	Above 0 °C (32 °F)	465 MCA, 350 CCA
	At or below 0 °C (32 °F)	800 MCA, 650 CCA
Voltage control		Shunt/ground voltage regulator

Fuel System Specifications

Parameter	Specification
Fuel system	Computer-controlled split-sequential multiport electronic fuel injection
Fuel type	Automotive unleaded with a minimum pump posted octane rating of 87 (R+M)/2 (90 RON); up to 10% ethanol
Fuel pump type	Mechanical plunger (diaphragm) + Electric high pressure
Fuel pump pressure (mechanical)	30 kPa ± 20 kPa (4.3 psi ± 2.9 psi)
Fuel pump pressure (electric)	256 kPa ± 25 kPa (37.1 psi ± 3.6 kPa)

Cylinder Block/Crankcase Specifications

Parameter	Specification
Number of cylinders	2
Displacement	333 cc (20.3 cid)
Standard bore	61.00 mm (2.4016 in.)
Standard bore (service limit)	61.06 mm (2.4039 in.)
Cylinder bore maximum taper (service limit)	0.08 mm (0.0032 in.)
Cylinder bore maximum out of round (service limit)	0.06 mm (0.0023 in.)
Crankshaft main bearing journal	33.992 mm (1.3382 in.)
Crankshaft main bearing journal (service limit)	33.972 mm (1.3374 in.)
Crankshaft pin journal	28.972–28.985 mm (1.1406–1.1411 in.)
Crankshaft pin journal (service limit)	28.970 mm (1.1405 in.)
Crankshaft end play	0.1–0.2 mm (0.004–0.008 in.)
Crankshaft runout	0.030 mm (0.00118 in.)
Crankshaft runout (service limit)	0.03 mm (0.001 in.)
Crankshaft main bearing oil clearance	0.012–0.044 mm (0.0005–0.0017 in.)
Crankshaft main bearing oil clearance (service limit)	0.06 mm (0.002 in.)
Crankshaft pin bearing oil clearance	0.015–0.041 mm (0.0006–0.0016 in.)
Crankshaft pin bearing/connecting rod oil clearance (service limit)	0.060 mm (0.002 in.)

Parameter	Specification
Connecting rod wrist pin bore diameter	16.010–16.021 mm (0.6303–0.6307 in.)
Connecting rod wrist pin bore diameter (service limit)	16.025 mm (0.6309 in.)
Connecting rod crankshaft pin diameter	29.000–29.013 mm (1.1417–1.1422 in.)
Connecting rod crankshaft pin diameter (service limit)	28.038 mm (1.1432 in.)
Connecting rod side clearance	0.1–0.25 mm (0.004–0.01 in.)
Connecting rod side clearance (service limit)	0.6 mm (0.0236 in.)

Piston Specifications

Parameter	Specification
Piston skirt standard diameter	60.96 mm (2.40 in.)
Piston skirt standard diameter (service limit)	60.90 mm (2.3976 in.)
Piston to bore clearance	0.020–0.055 mm (0.0008–0.0022 in.)
Wrist pin diameter	15.996–16.000 mm (0.6298–0.6299 in.)
Wrist pin diameter (service limit)	15.993 mm (0.6296 in.)
Top ring side clearance	0.03–0.08 mm (0.0012–0.0031 in.)
Top ring side clearance (service limit)	0.1 mm (0.004 in.)
Second ring side clearance	0.02–0.06 mm (0.0008–0.0024 in.)
Second ring side clearance (service limit)	0.09 mm (0.0035 in.)
Oil ring side clearance	0.03–0.13 mm (0.0012–0.0051 in.)
Oil ring side clearance (service limit)	0.15 mm (0.0059 in.)
Top ring end gap	0.15–0.30 mm (0.0059–0.0118 in.)
Top ring end gap (service limit)	0.5 mm (0.02 in.)
Second ring end gap	0.35–0.50 mm (0.0138–0.0197 in.)
Second ring end gap (service limit)	0.7 mm (0.028 in.)
Oil ring end gap	0.2–0.7 mm (0.008–0.028 in.)

Cylinder Head Specifications

Parameter		Specification
Maximum deck warp		0.1 mm (0.004 in.)
Number of valves		4
Number of valves per cylinder		2
Number of camshafts		1
Camshaft journal outside diameter	Pulley side	17.98 mm (0.708 in.)
	Pulley side (service limit)	17.95 mm (0.707 in.)
	Oil pump side	15.97 mm (0.629 in.)
	Oil pump side (service limit)	15.95 mm (0.628 in.)
Cam lobe height	Intake	23.63 mm (0.9303 in.)
	Exhaust	23.80 mm (0.9370 in.)
	Intake and exhaust (service limit)	23.50 mm (0.9252 in.)
Valve clearance	Intake	0.13–0.17 mm (0.005–0.007 in.)
	Exhaust	0.18–0.22 mm (0.007–0.008 in.)
Valve seat angles		30°, 45°, 60°
Valve spring free length		32.85 mm (1.293 in.)
Valve spring free length (service limit)		31.50 mm (1.240 in.)
Valve spring tilt limit		1.1 mm (0.043 in.)

Parameter		Specification
Valve stem diameter	Intake	5.48 mm (0.216 in.)
	Intake (service limit)	5.46 mm (0.215 in.)
	Exhaust	5.46 mm (0.215 in.)
	Exhaust (service limit)	5.44 mm (0.214 in.)
Cylindricity (maximum)		0.01 mm (0.0004 in.)
Valve face width (intake and exhaust)		1.0 mm (0.04 in.)
Valve face width (service limit)		2.0 mm (0.08 in.)
Valve margin thickness	Intake	0.55 mm (0.0217 in.)
	Exhaust	1.00 mm (0.0394 in.)
Valve seat width		1.0 mm (0.04 in.)
Valve guide bore	Intake and exhaust	5.51 mm (0.217 in.)
	Intake valve guide bore (service limit)	5.55 mm (0.218 in.)
	Exhaust valve guide bore (service limit)	5.57 mm (0.219 in.)
Valve stem to valve guide clearance	Intake	0.008–0.04 mm (0.0003–0.0016 in.)
	Intake (service limit)	0.07 mm (0.0028 in.)
	Exhaust	0.025–0.057 mm (0.001–0.0022 in.)
	Exhaust (service limit)	0.1 mm (0.004 in.)
Rocker arm shaft outside diameter		12.99 mm (0.511 in.)
Rocker arm shaft outside diameter (service limit)		12.94 mm (0.509 in.)
Rocker arm inside diameter		13.01 mm (0.512 in.)
Rocker arm inside diameter (service limit)		13.05 mm (0.514 in.)
Rocker arm shaft clearance		0.006–0.035 mm (0.00023–0.0014 in.)
Cylinder head upper camshaft bearing inside diameter		17.975–17.990 mm (0.7077–0.7083 in.)
Oil pump camshaft bearing inside diameter		15.965–15.980 mm (0.6285–0.6291 in.)
Valve stem seal color	Intake	Black
	Exhaust	Green

Oil System Specifications

Parameter		Specification
Oil pump type		Trochoid
Oil type	All temperatures	FC-W® 10W-30
	Alternate viscosity above 4 °C (40 °F)	FC-W® 25W-40
Oil capacity		1.0 L (1.1 U.S. qt)
Engine oil pressure at 75 °C (167 °F)	At 950 RPM	50 kPa (7.3 psi) or greater
	At 5000 RPM	100 kPa (14.5 psi) or greater
Oil pump housing inside diameter (service limit)		29.15 mm (1.148 in.)
Outer rotor to oil pump housing inside diameter clearance (service limit)		0.18 mm (0.007 in.)
Outer rotor height (service limit)		14.96 mm (0.589 in.)
Rotor to oil pump cover clearance (service limit)		0.11 mm (0.004 in.)
Inner rotor to outer rotor clearance (service limit)		0.13 mm (0.005 in.)

Cooling System Specifications

Parameter		Specification
Thermostat	Start to open temperature	50–54 °C (122–129 °F)
	Full open temperature	60–64 °C (140–147 °F)
	Valve lift	4.0 mm (0.157 in.)
Water pressure at idle		9–18 kPa (1.3–2.6 psi)
Water pressure at WOT		59–118 kPa (8.6–17.2 psi)

Power Tilt Specifications

Parameter	Specification
System fluid	Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) (Type Dexron III)
Electric motor - Maximum current draw	35 A

Gearcase Specifications

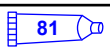
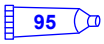
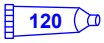
Parameter	Specification
Gear ratio	2.15:1
Gearcase capacity	460 ml (15.6 fl oz)
Gear lubricant type	Premium Gear Lubricant or GL5 SAE 80W-90
Pinion teeth	13
Pinion height	Floating
Clutch	Dog type (forward–neutral–reverse)
Forward, reverse teeth	28
Forward gear backlash	0.8–1.5 mm (0.030–0.059 in.)

Important Information

Section 1B - Maintenance

Table of Contents

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Quickleen Engine & Fuel System Cleaner	Fuel tank	8M0047931
	Extreme Grease	Driveshaft splines Propeller shaft Swivel bracket, transom clamp screws, tilt tube, propeller shaft, steering cable grease	8M0071842
 81	Anti-Seize Compound	Spark plug threads	92-898101389
 95	2-4-C with PTFE	Throttle cable barrels and the shift cable rod end Propeller shaft Swivel bracket, transom clamp screws, tilt tube, throttle/shift cables, steering cable grease fitting	92-802859A 1
 120	Corrosion Guard	External metal surfaces (except corrosion control anodes)	92-802878 55

Cleaning Care

Do Not Use Caustic Cleaning Chemicals

IMPORTANT: Do not use caustic cleaning chemicals on the outboard power package. Some cleaning products contain strong caustic agents such as hull cleaners with hydrochloric acid. These cleaners can degrade some of the components they come in contact with including critical steering fasteners.

Damage to steering fasteners may not be obvious during visual inspection and this damage may lead to catastrophic failure. Some caustic cleaning chemicals may cause or accelerate corrosion. Exercise caution when using cleaning chemicals around the engine and follow the recommendations on the packaging of the cleaning product.

Cleaning Care for Top and Bottom Cowls

IMPORTANT: Dry wiping (wiping the plastic surface when it is dry) will result in minor surface scratches. Always wet the surface before cleaning. Do not use detergents containing hydrochloric acid. Follow the cleaning and waxing procedure.

Cleaning and Waxing Procedure

1. Before washing, rinse the cowls with clean water to remove dirt and dust that may scratch the surface.
2. Wash the cowls with clean water and a mild nonabrasive soap. Use a soft clean cloth when washing.
3. Dry thoroughly with a soft clean cloth.
4. Wax the surface using a nonabrasive automotive polish (polish designed for clear coat finishes). Remove the applied wax by hand using a clean soft cloth.
5. To remove minor scratches, use Mercury Marine Cowl Finishing Compound (92-859026K 1).

Inspection and Maintenance Schedule

Before Each Use

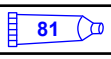
Refer to the Owner's Manual for a list of checks and inspections that the owner should perform before each use.

After Each Use

Refer to the Owner's Manual for a list of procedures that the owner should perform after each use.

Every 100 Hours of Use or Once Yearly, Whichever Occurs First

- Change the engine oil and replace the oil filter. The oil should be changed more often when the engine is operated under adverse conditions, such as extended trolling. Refer to **Engine Oil**.
- Check the water-separating fuel filter for contaminants. Replace filter if required. Refer to **Fuel System**.
- Remove the propeller and lubricate the propeller shaft. Refer to **Propeller Replacement**.
- Check the corrosion control anodes. Check more frequently when used in saltwater. Refer to **Corrosion Control Anodes**.
- Drain and replace the gearcase lubricant. Refer to **Gearcase Lubrication**.
- Inspect the battery. Refer to **Battery Inspection**.
- Saltwater use: Remove and inspect the spark plugs for corrosion, and replace as necessary. Apply Anti-Seize Compound only to the threads of the spark plug prior to installation. Refer to **Spark Plug Inspection and Replacement**.

Tube Ref No.	Description	Where Used	Part No.
	Anti-Seize Compound	Spark plug threads	92-898101389

- Add Quickleen to the fuel tank.

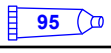
Tube Ref No.	Description	Where Used	Part No.
	Quickleen Engine & Fuel System Cleaner	Fuel tank	8M0047931

- Check the cowl seals to ensure that the seals are intact and not damaged.
- Check that the idle relief muffler is in place, if equipped.
- Inspect the thermostat for corrosion or a broken spring. Verify the thermostat closes completely at room temperature.
- Check the mounting fasteners that secure the outboard to the boat transom. Tighten the fasteners to the specified torque. Refer to **Section 1D - Installing Outboard on Transom**.
- Check the tightness of screws, nuts, and other fasteners.
- Check for loose hose clamps and rubber boots on the air intake assembly.
- Lubricate the driveshaft splines with Extreme Grease.

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Driveshaft splines	8M0071842

Every 300 Hours of Use or Three Years

- Tiller handle models: Lubricate the throttle cable barrels and the shift cable rod end with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
	2-4-C with PTFE	Throttle cable barrels and the shift cable rod end	92-802859A 1

- Verify the throttle and shift cables are properly adjusted.
- Lubricate all lubrication points. Lubricate more frequently when used in saltwater. Refer to **Lubrication Points**.
- Replace the spark plugs. Refer to **Spark Plug Inspection and Replacement**.
- Check the remote control cable adjustment, if applicable.
- Inspect the timing belt.
- Lubricate the splines on the upper driveshaft.
- Inspect the wiring and connectors.
- Replace the water pump impeller.

  NOTE: *Replace the water pump impeller more often, if overheating occurs or reduced water pressure is noted.*

Before Periods of Storage

Refer to **Storage Preparation**.

Battery Inspection

The battery should be inspected at periodic intervals to ensure proper engine starting capability.

IMPORTANT: Read the safety and maintenance instructions which accompany your battery.

1. Turn off the engine before servicing the battery.
2. Ensure the battery is secure against movement.
3. Battery cable terminals should be clean, tight, and correctly installed. Positive to positive and negative to negative.
4. Ensure the battery is equipped with a nonconductive shield to prevent accidental shorting of battery terminals.

Flushing the Cooling System

⚠ WARNING

Rotating propellers can cause serious injury or death. Never operate the boat out of the water with a propeller installed. Before installing or removing a propeller, place the drive unit in neutral and engage the lanyard stop switch to prevent the engine from starting. Place a block of wood between the propeller blade and the anti-ventilation plate.

Flush the internal water passages of the outboard with fresh water after each use in salt, polluted, or muddy water. This will help prevent a buildup of deposits from clogging the internal water passages.

IMPORTANT: The engine must be run during flushing in order to open the thermostat and circulate water through the water passages.

1. Remove the propeller. Refer to **Propeller Replacement**.
2. Remove the plug from the flush fitting, and attach a water hose. Turn on the water to half of the maximum flow.

Flush fitting

3. Start the engine and run it at idle speed in neutral shift position.

   IMPORTANT: Do not run the engine above idle while flushing.
4. Check for a steady stream of water flowing out of the water pump indicator hole. Continue flushing the outboard for 3–5 minutes, carefully monitoring the water supply at all times.
5. Stop the engine, turn off the water, and remove the water hose.
6. Install the plug into the flush fitting.
7. Install the propeller.

Fuel System

Fuel System Precautions

⚠ WARNING

Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for leaks before attempting to start the engine, and wipe up any spilled fuel immediately.

Before servicing any part of the fuel system, stop the engine and disconnect the battery. Drain the fuel system completely. Use an approved container to collect and store fuel. Wipe up any spillage immediately. Material used to contain spillage must be disposed of in an approved receptacle. Any fuel system service must be performed in a well ventilated area. Inspect any completed service work for sign of fuel leakage.

Fuel Line Inspection

Visually inspect the fuel line and primer bulb for cracks, swelling, leaks, hardness, or other signs of deterioration or damage. If any of these conditions are found, the fuel line or primer bulb must be replaced.

VST Vent and Cooling Hose Inspection

Visually inspect the fuel vapor vent hoses (between the vapor separator tank and the vent tank) and the vapor separator tank (VST) cooling hoses for cracks, swelling, leaks, hardness, or other signs of deterioration or damage. If any of these conditions are found, the hoses must be replaced.

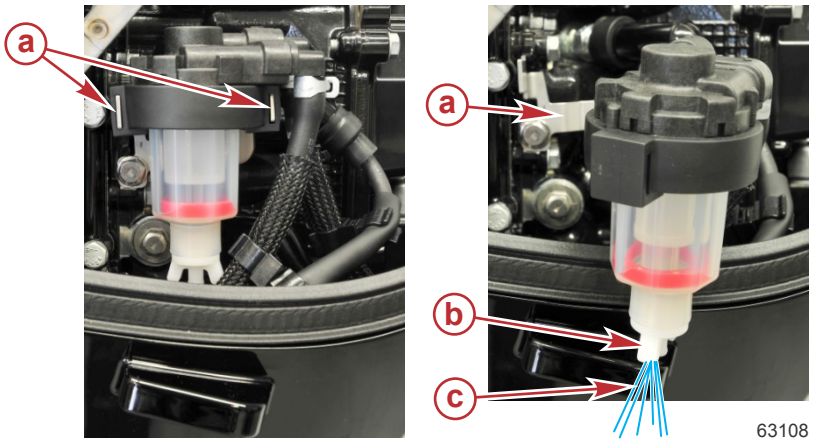
Draining Water from the Fuel Filter

Check the fuel filter for water accumulation or sediment. If water is in the fuel, drain the water. If the filter appears to be contaminated, remove and replace.

1. Read **Fuel System Precautions**, preceding.
2. Inspect the water-separating fuel filter. If water is present, the red ring inside the filter assembly should float at the water level.

3. Pull the filter assembly—including the rubber mount—off of the mounting bracket on the engine, and swing the assembly over the edge of the engine.
4. Loosen the drain valve until liquid flows out of the bottom. Empty the filter bowl's contents into an approved container. To protect the environment, immediately clean up spilled fluids and dispose of according to local laws and regulations.

   NOTE: *A drain hose can be temporarily installed onto the center drain port of the drain fitting to assist emptying the contents into an approved container.*



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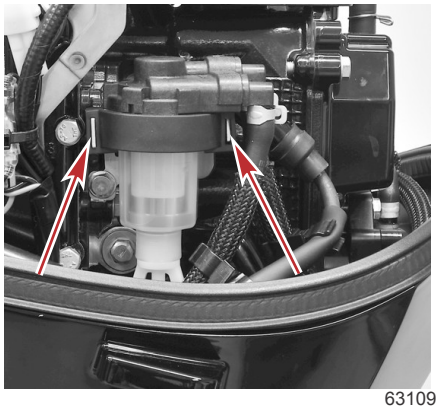
a - Mounting bracket
b - Drain valve
c - Empty contents into an approved container

Fuel Filter Replacement

Filter Removal

1. Pull the filter assembly—including the rubber mount—off of the mounting bracket on the engine, and swing the assembly over the edge of the engine cowl.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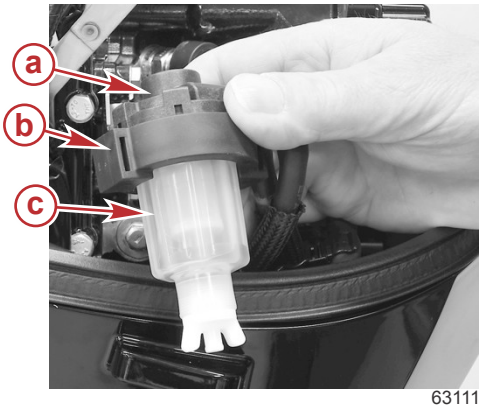
Filter assembly mounting bracket

2. Pull the rubber mount downward, to remove it from the filter assembly.
3. Remove the sight bowl from the filter housing.



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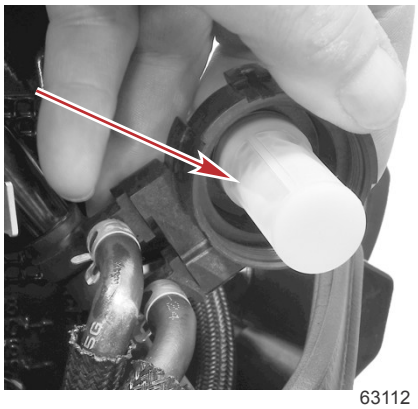
a - Filter housing
b - Rubber mount
c - Sight bowl

4. Pull the filter element off the filter housing.

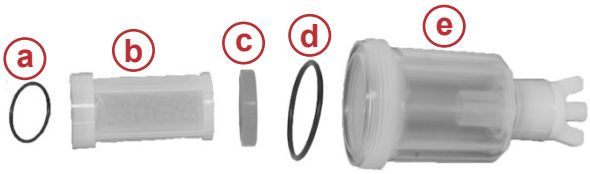
IMPORTANT: The filter is secured and sealed to the filter housing with an O-ring. The O-ring may remain on the filter housing. The O-ring should be removed before installing the fuel filter.



63112

Fuel filter

Filter Installation



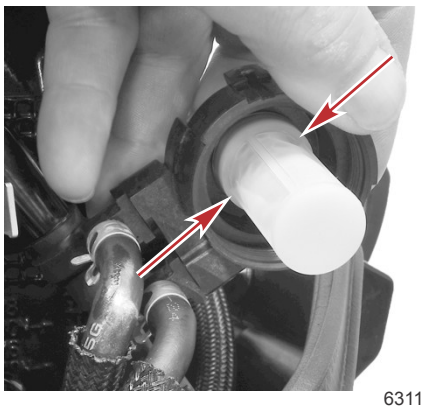
63113

- **a -** Fuel filter O-ring seal
- **b -** Fuel filter
- **c -** Red ring
- **d -** Sight bowl O-ring seal
- **e -** Sight bowl

1. Install the fuel filter O-ring seal into the fuel filter. Verify the O-ring does not have any folds or kinks.

63114

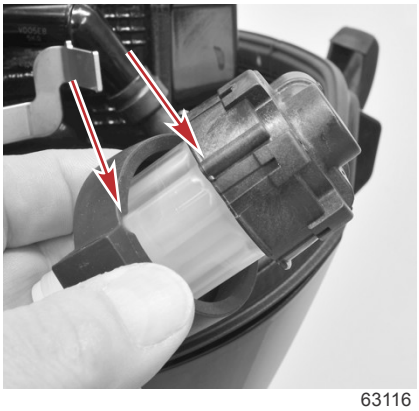
2. Lubricate the O-ring with clean engine oil.
3. Push the fuel filter element onto the filter housing. Verify the filter is completely installed by pushing on the filter in the locations shown in the following illustration.



63115

4. Install the sight bowl O-ring seal onto the sight bowl and place the red ring into the sight bowl.

5. Install the sight bowl onto the filter housing hand-tight.
6. Verify the rubber mount is properly aligned with the filter housing and install the rubber mount.



63116

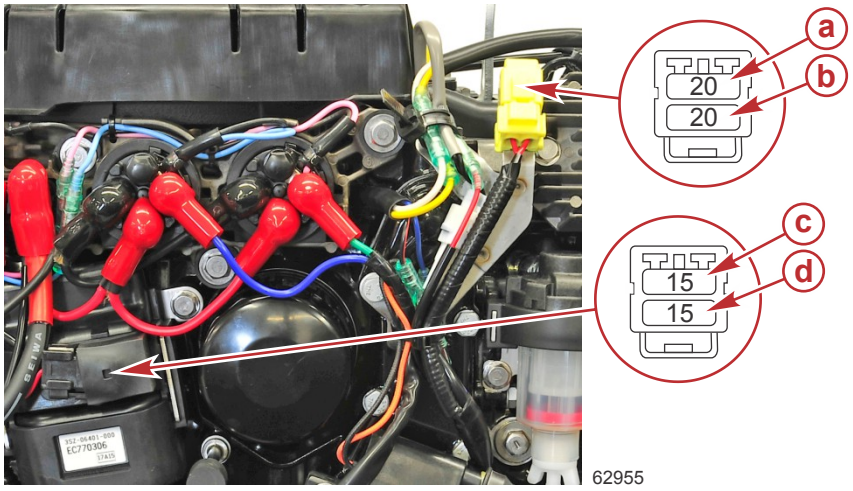
Rubber mount properly aligned

7. Install the filter assembly onto the mounting bracket.
8. Connect the fuel line to the engine and prime the engine fuel system. Inspect the fuel filter area for fuel leaks. Repair as needed.

Fuse Replacement - Electric Start Models

IMPORTANT: Both fuse housings have a space for a spare fuse. Always carry spare fuses.

The voltage regulator circuit and the electric starting circuit are protected from overload by 20-amp and 15-amp fuses, respectively. If a fuse opens, try to locate and correct the cause of the overload. If the cause is not found, the fuse may open again.

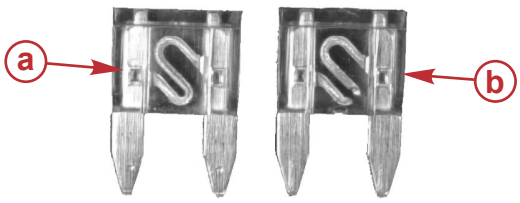


62955

- **a -** Voltage regulator circuit - 20-amp fuse
- **b -** Spare 20-amp fuse
- **c -** Electric starting circuit - 15-amp fuse
- **d -** Spare 15-amp fuse

To access the 15-amp fuse, remove the fuse block from the pocket on the ECM rubber mount. Then remove the cap from the fuse block.

Remove the fuse and examine the silver colored band inside the fuse. If the band is broken, replace the fuse. Replace the fuse with a new fuse of the same rating.



28619

Identifying an open fuse

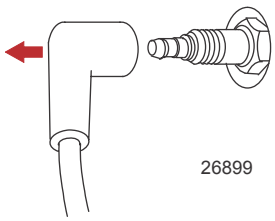
- **a -** Good fuse
- **b -** Open (blown) fuse

Spark Plug Inspection and Replacement

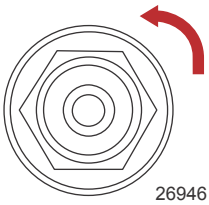
⚠ WARNING

Damaged spark plug boots may emit sparks that can ignite fuel vapors under the engine cowl, resulting in serious injury or death from a fire or explosion. To avoid damaging the spark plug boots, do not use any sharp object or metal tool to remove the spark plug boots.

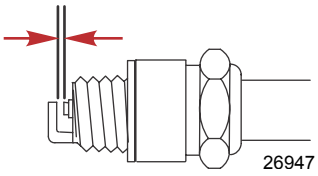
1. Remove the spark plug boots. Twist the rubber boots slightly and pull off.



2. Remove the spark plugs for inspection. Replace the spark plug if the electrode is worn or the insulator is rough, cracked, broken, blistered, or fouled.



3. Set the spark plug gap to specification.



Spark Plug	
Spark plug gap	0.9 mm (0.035 in.)

4. Before installing the spark plugs, clean off any dirt on the spark plug seats. Install the spark plugs finger-tight and then tighten to the specified torque.

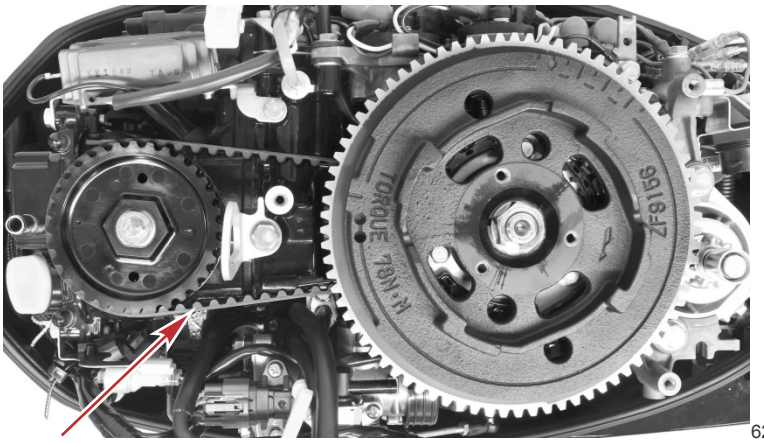
Description	Nm	lb-in.	lb-ft
Spark plug	18.0	159.3	–

Timing Belt Inspection

Inspect the timing belt. Replace the belt if any of the following conditions are found:

- Cracks in the back of the belt or in the base of the belt teeth
- Excessive wear at the roots of the cogs
- Rubber portion swollen by oil
- Belt surfaces roughened

- Signs of wear on edges or outer surfaces of belt



62878

Engine Oil

Changing the Oil Filter

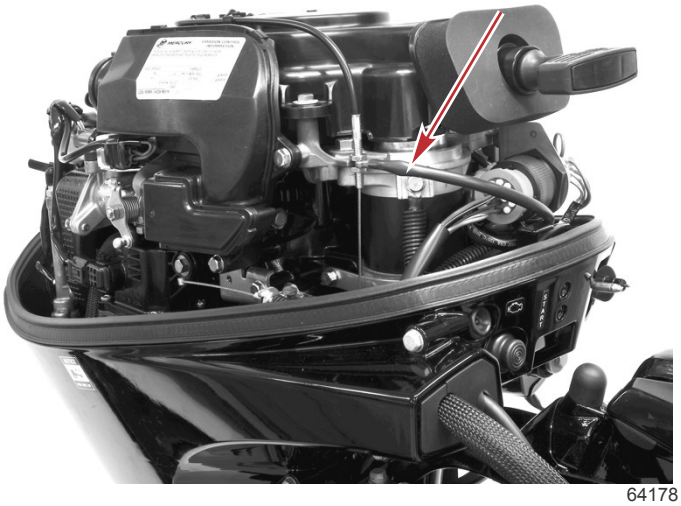

62880

Oil filter

1. Position the engine for a full starboard turn.

   NOTE: *For models with kicker straps, temporarily disconnect one end of the port kicker strap. This will allow the engine to be rotated when the engine is in the full tilt position.*

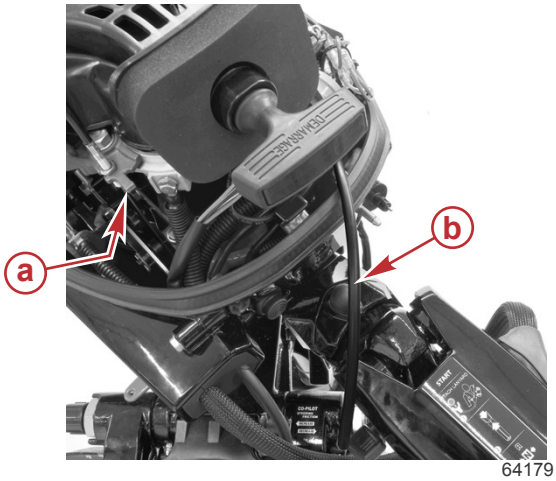
2. Remove the top cowl and remove the oil filter drain hose from it's storage location on the front of the engine.



64178

Oil filter drain hose

3. Tilt the engine up and lock the outboard in the full tilt position. Allow a few minutes for the oil in the filter to drain into the engine.
4. Route the oil filter drain hose into an approved container.



64179

a - Drain hose storage location
b - Drain hose

5. Remove the oil filter by turning the filter counterclockwise. If necessary, carefully move wires temporarily out of the way, to gain clearance for the oil filter wrench.
6. Wipe up any spilled oil.
7. Clean the mounting base. Apply a film of clean oil to the filter gasket. Do not use grease. Install the new filter. When the gasket contacts the base, tighten the filter an additional 3/4 to 1 turn.
8. If any components were moved or removed to gain access to the oil filter, restore them to their original positions or install them accordingly.

Draining the Engine Oil

1. Lock the outboard in the full tilt up position.
2. Position the outboard so the drain hole is facing downward.
3. Remove the drain plug and drain the engine oil into an appropriate container.

   IMPORTANT: Do not use a crankcase oil pump when changing the oil or engine damage may occur.
4. After the initial oil has been drained, temporarily install the drain plug. Disengage the tilt lock and lower the outboard. Wait a minute to allow the remaining oil that was trapped in the engine to return to the drain. Return the outboard to the full tilt position and drain the remaining oil.

5. Inspect the drain plug seal and replace it if damaged. Lubricate the seal on the drain plug with oil and install. Tighten to the specified torque.


63034

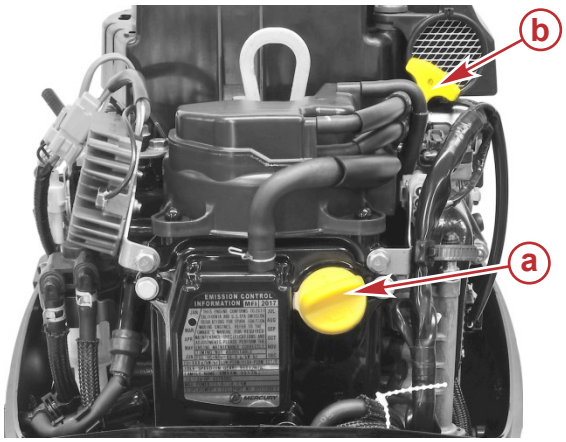

4537

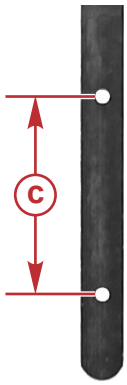
Description	Nm	lb-in.	lb-ft
Drain plug	24.0	–	17.7

Filling the Crankcase with Oil

IMPORTANT: Do not try to fill the oil level to the top of the operating range (upper hole). The oil level is correct as long as it appears in the operating range between the upper and lower hole.

1. Position the outboard in a level operating position.
2. Remove the oil fill cap and add the recommended oil to the midpoint of the oil level operating range. Adding approximately 1.0 liter (1.1 U.S. quart) of oil to an empty crankcase will bring the oil level to the midpoint of the oil level range. Reinstall the oil fill cap.





a - Oil fill cap
b - Dipstick
c - Oil level operating range

62881

3. With cooling water properly supplied, idle the engine for five minutes and check for leaks. Stop the engine and check the oil level on the dipstick. Add oil if necessary.

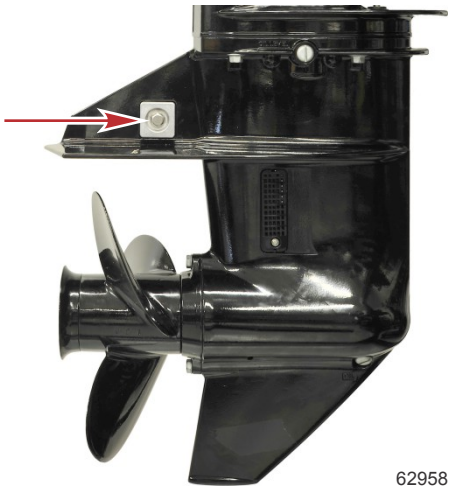
Corrosion Control Anodes

Your outboard has four corrosion control anodes. An anode helps protect the outboard against galvanic corrosion by sacrificing its metal to be slowly corroded instead of the outboard metals.

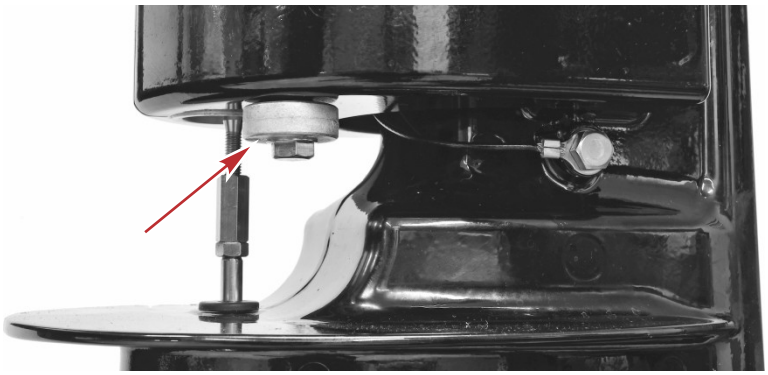
The anodes require periodic inspection, especially in saltwater, which will accelerate the erosion. To maintain this corrosion protection, always replace an anode before it is completely eroded. Never paint or apply a protective coating to an anode, as this will reduce the effectiveness of the anode.

The anodes are located as follows:

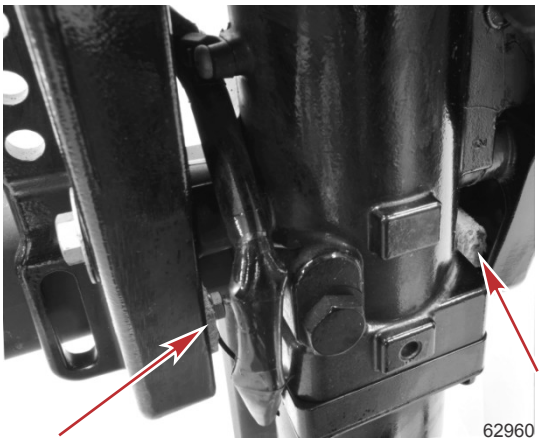
- One anode is mounted on the starboard side of the midsection, just above the anti-ventilation plate. A screw and nut secure the anode to the midsection.


62958

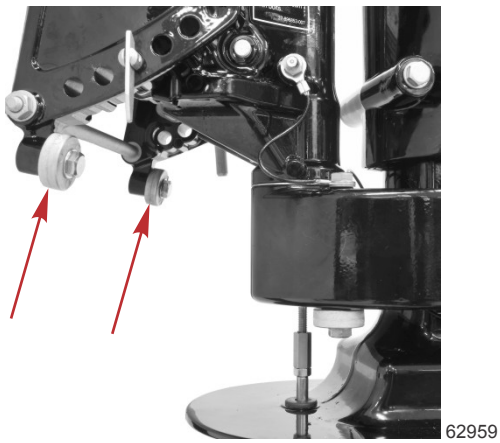
- One anode is located on the underside of the lower engine mount. A screw secures it to the mount.


63263

- Two anodes are located near the bottom of the transom brackets. On power tilt models, the anodes are on the inside faces of the brackets. On manual tilt models, the anodes are secured to the rear face of the brackets. The anodes on both models are secured to the brackets with screws.


62960

Power tilt model


62959

Manual tilt model

When installing an anode, be certain to tighten the fasteners to the specified torque.

Description	Nm	lb-in.	lb-ft
Anode fasteners	6.0	53.1	–

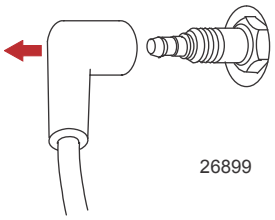
Propeller Replacement

⚠ WARNING

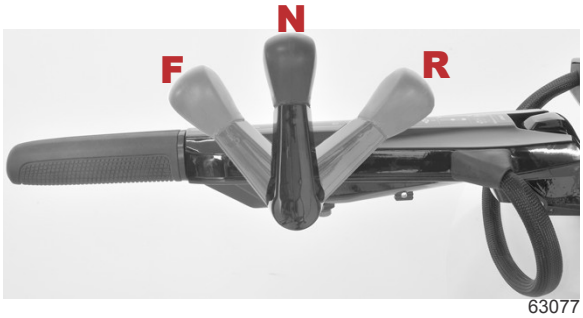
Rotating propellers can cause serious injury or death. Never operate the boat out of the water with a propeller installed. Before installing or removing a propeller, place the drive unit in neutral and engage the lanyard stop switch to prevent the engine from starting. Place a block of wood between the propeller blade and the anti-ventilation plate.

Removal

1. Remove the spark plug leads to prevent the engine from starting.



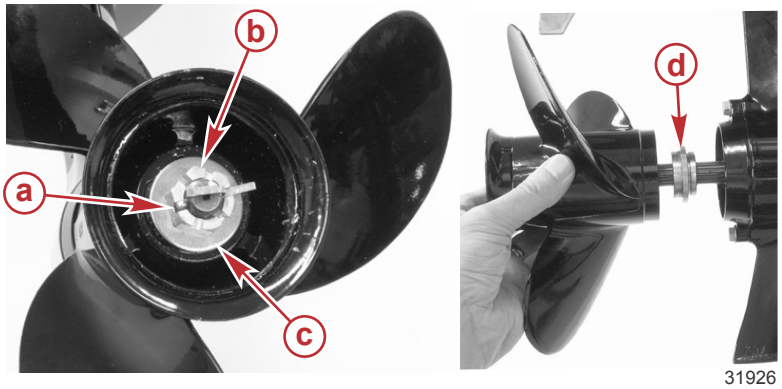
2. Shift the outboard into neutral (N).



Tiller handle models

Remote control models

3. Straighten the cotter pin and pull it out using a pair of pliers.
4. Place a block of wood between the gearcase and the propeller to prevent rotation, and remove the propeller nut.
5. Pull the propeller straight off the shaft.



a - Cotter pin
b - Nut
c - Rear thrust washer
d - Front thrust hub

IMPORTANT: To prevent the propeller hub from corroding and seizing to the propeller shaft (especially in saltwater), always apply the recommended lubricant to the entire propeller shaft at the recommended maintenance intervals and also each time the propeller is removed.

Installation

1. Apply Extreme Grease or 2-4-C with PTFE to the propeller shaft.

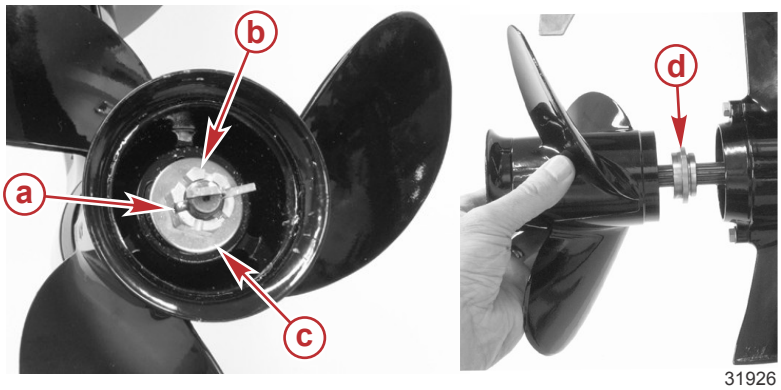
Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Propeller shaft	8M0071842
95	2-4-C with PTFE	Propeller shaft	92-802859A 1

2. Install the front thrust hub onto the shaft so that the larger diameter end is facing the propeller.
3. Install the propeller, rear thrust washer, and propeller nut onto the shaft.
4. Place a block of wood between the gearcase and the propeller to prevent rotation, and tighten the propeller nut to the specified torque.

Description	Nm	lb-in.	lb-ft
Propeller nut	12	106	–

NOTE: *If the propeller nut does not align with the propeller shaft hole after tightening, tighten the nut further to align with the hole.*

5. Align the propeller nut with the propeller shaft hole. Insert a new cotter pin in the hole and bend the ends.



a - Cotter pin
b - Propeller nut
c - Rear thrust washer
d - Front thrust hub - Larger diameter end towards propeller

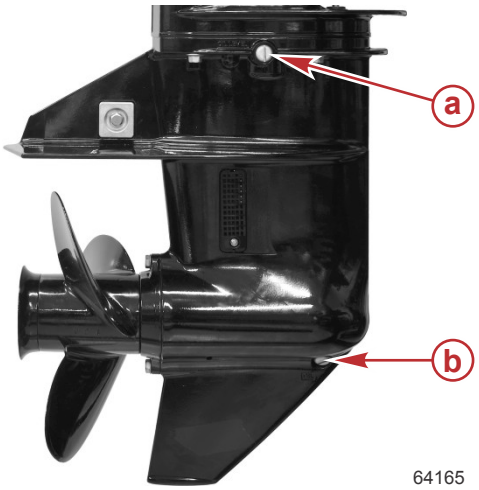
Gearcase Lubrication

Draining and Inspecting Gear Housing Lubricant

⚠ WARNING

Rotating propellers can cause serious injury or death. Never operate the boat out of the water with a propeller installed. Before installing or removing a propeller, place the drive unit in neutral and engage the lanyard stop switch to prevent the engine from starting. Place a block of wood between the propeller blade and the anti-ventilation plate.

1. Position a clean drain pan under the gear housing and remove the fill and vent screws with gaskets from the gear housing.



64165

a - Vent screw
b - Fill screw

2. Inspect the gear lubricant for metal particles. Presence of a small amount of fine metal particles resembling powder indicates normal wear. Presence of larger particles or a large quantity of fine particles indicates a need for gear housing disassembly and component inspection.
3. Note the color of the gear lubricant. White or cream color indicates the presence of water in the lubricant. Check the drain pan for water separation from the lubricant. Presence of water in the gear lubricant indicates the need for disassembly and inspection of oil seals, seal surfaces, O-rings, and gear housing components. Pressure check the gearcase prior to disassembly.

   NOTE: *When draining the gearcase for the first time, lubricant may appear cream colored due to the mixing of assembly lubricant and gear lubricant. This is not an indication of water intrusion. If, during subsequent draining of the gearcase, lubricant appears cream colored or milky, water may be present. The gearcase should be disassembled and all gaskets, seals, and O-rings replaced. Inspect all components for water damage.*

   NOTE: *Gear lubricant drained from a recently run gearcase will be a light chocolate brown in color due to agitation/aeration. Oil that is stabilized will be a clear yellow brown in color.*

Gearcase Lubricant Capacity

Approximately 460 ml (15.6 fl oz).

Gearcase Lubricant Recommendation

Mercury or Quicksilver Premium or High Performance Gear Lubricant.

Filling the Gearcase

1. Place the outboard in a vertical operating position or in the full tilt position.
2. Remove the vent plug from the vent hole.
3. Place the lubricant tube into the fill hole and add lubricant until it appears at the vent hole.

62882

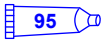
IMPORTANT: Replace the sealing washers with new sealing washers.

4. Stop adding lubricant. Install the vent plug and sealing washer before removing the lubricant tube.

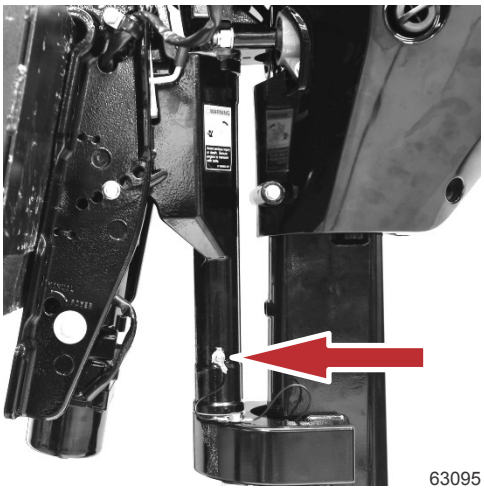
5. Remove the lubricant tube and install the cleaned fill/drain plug and new sealing washer.

Lubrication Points

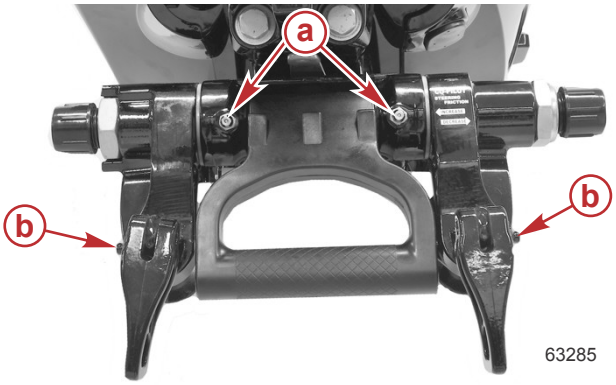
1. Lubricate the following with 2-4-C with PTFE or Extreme Grease.

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Swivel bracket, transom clamp screws, tilt tube, propeller shaft, steering cable grease	8M0071842
	2-4-C with PTFE	Swivel bracket, transom clamp screws, tilt tube, throttle/shift cables, steering cable grease fitting	92-802859A 1

- Swivel bracket lubrication fitting.

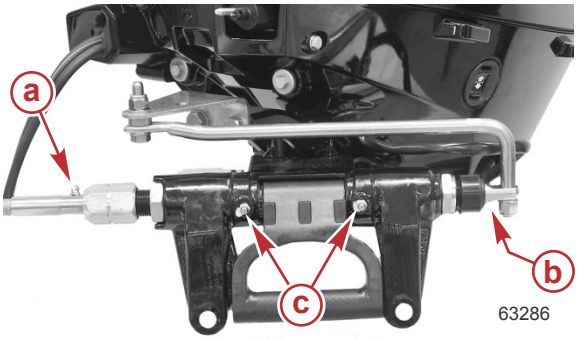


- Tilt tube lubrication fittings.
- Transom clamp screws lubrication fittings.



a - Tilt tube lubrication fittings
b - Transom clamp screws lubrication fittings

- Steering cable lubrication fitting (if equipped) - Steer the outboard to fully retract the steering cable end into the outboard tilt tube. Lubricate the steering cable through the fitting.

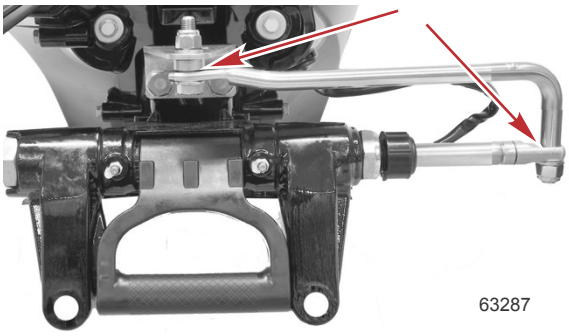


a - Steering cable lubrication fitting
b - Steering cable end
c - Tilt tube lubrication fittings

⚠ WARNING

Incorrect cable lubrication can cause hydraulic lock, leading to serious injury or death from loss of boat control. Completely retract the end of the steering cable before applying lubricant.

2. Lubricate the following with lightweight oil.
   - Steering link rod pivot points - Lubricate points.



3. Lubricate the following with Extreme Grease or 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Propeller shaft	8M0071842
95	2-4-C with PTFE	Propeller shaft	92-802859A 1

   - Propeller shaft - Refer to **Propeller Replacement** for removal and installation of the propeller. Coat the entire propeller shaft with lubricant to prevent the propeller hub from corroding to the shaft.

Storage Preparation

The major consideration in preparing your outboard for storage is to protect it from rust, corrosion, and damage caused by freezing of trapped water. Follow these storage procedures to prepare your outboard for out-of-season storage or prolonged storage (two months or longer).

Fuel System Storage Preparation

NOTICE

Without sufficient cooling water, the engine, the water pump, and other components will overheat and suffer damage. Provide a sufficient supply of water to the water inlets during operation.

IMPORTANT: Gasoline containing alcohol (ethanol or methanol) can cause the formation of acid during storage and can damage the fuel system. If the gasoline being used contains alcohol, it is advisable to drain as much of the remaining gasoline as possible from the fuel tank, remote fuel line, and engine fuel system.

Fill the fuel tank and engine fuel system with treated (stabilized) fuel to help prevent formation of varnish and gum. Proceed with the following instructions.

- Portable fuel tank - Pour the required amount of gasoline stabilizer (follow the instructions on the container) into the fuel tank. Tip the fuel tank back and forth to mix the stabilizer with the fuel.
- Permanently installed fuel tank - Pour the required amount of gasoline stabilizer (follow the instructions on the container) into a separate container and mix with approximately 1 liter (1 U.S. quart) of gasoline. Pour this mixture into the fuel tank.
- Place the outboard in water or a water hose to the flush fitting for circulating cooling water. Run the engine for ten minutes to fill the engine fuel system.

Protecting External Outboard Components

- Lubricate all outboard components listed in the **Inspection and Maintenance Schedule**, preceding.
- Touch-up any paint nicks.
- Spray Quicksilver or Mercury Precision Lubricants Corrosion Guard on external metal surfaces (except corrosion control anodes).

Tube Ref No.	Description	Where Used	Part No.
120	Corrosion Guard	External metal surfaces (except corrosion control anodes)	92-802878 55

Protecting Internal Engine Components

- Remove the spark plugs and add approximately 30 ml (1 oz) of engine oil or inject a five second spray of storage seal inside of each cylinder.
- Rotate the flywheel manually several times to distribute the oil in the cylinders. Install spark plugs.
- Change the engine oil.

Gearcase

- Drain and refill the gearcase lubricant (refer to **Gearcase Lubrication**).

Positioning Outboard for Storage

NOTICE

Storing the outboard in a tilted position can damage the outboard. Water trapped in the cooling passages or rain water collected in the propeller exhaust outlet in the gearcase can freeze. Store the outboard in the full down position.

- Store the outboard in an upright position, horizontal with the front of the engine facing up (tiller handle facing up), or on the port side.

63254

Upright position

- The port side lower cowl has two bumpers to help reduce damage to the cowl when the engine is stored in the laying down position. Storing the engine on the port side will prevent oil from draining out of the crankcase into the cylinders or crankcase ventilation system. There are bumpers on the aft side of the top cowl also.

63255

Notes:

Important Information

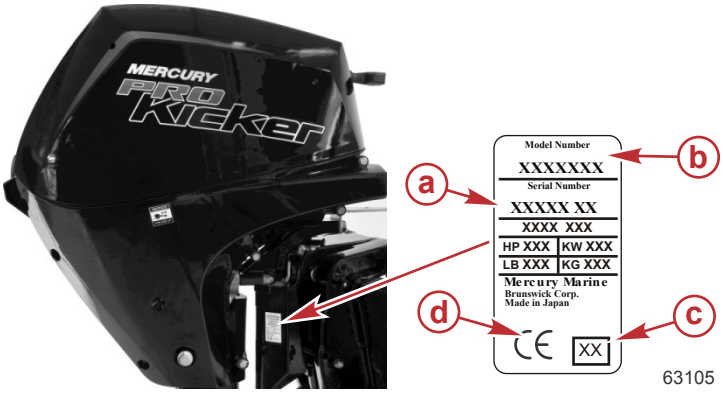
Section 1C - General Information

1
C

Table of Contents

Recording Serial Number

It is important to record this number for future reference. The serial number is located on the outboard as shown.



- **a -** Serial number
- **b -** Model designation
- **c -** Year manufactured
- **d -** Certified Europe Insignia (as applicable)

Model Year Production Code

The serial number decal lists the year of manufacture as an alpha code. This code can be deciphered into a corresponding number utilizing the following table.

Serial number decal alpha code

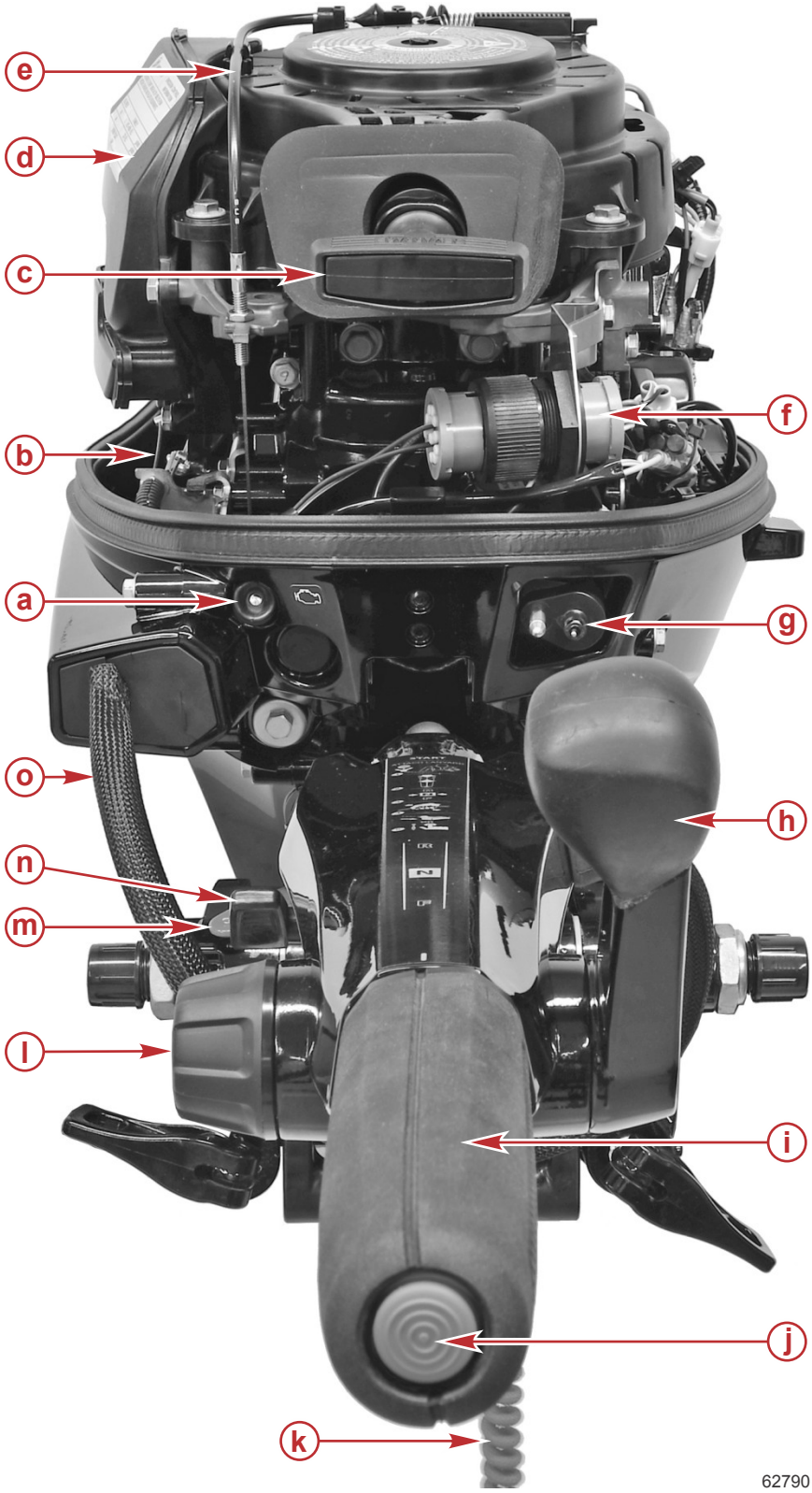
Model Year Manufactured Code										
Alpha Production Code	A	B	C	D	E	F	G	H	K	X
Corresponding Number	1	2	3	4	5	6	7	8	9	0

Examples:

- XX = 2000
- HK = 2089
- AG = 2017

Engine Component Identification - Manual Start Model

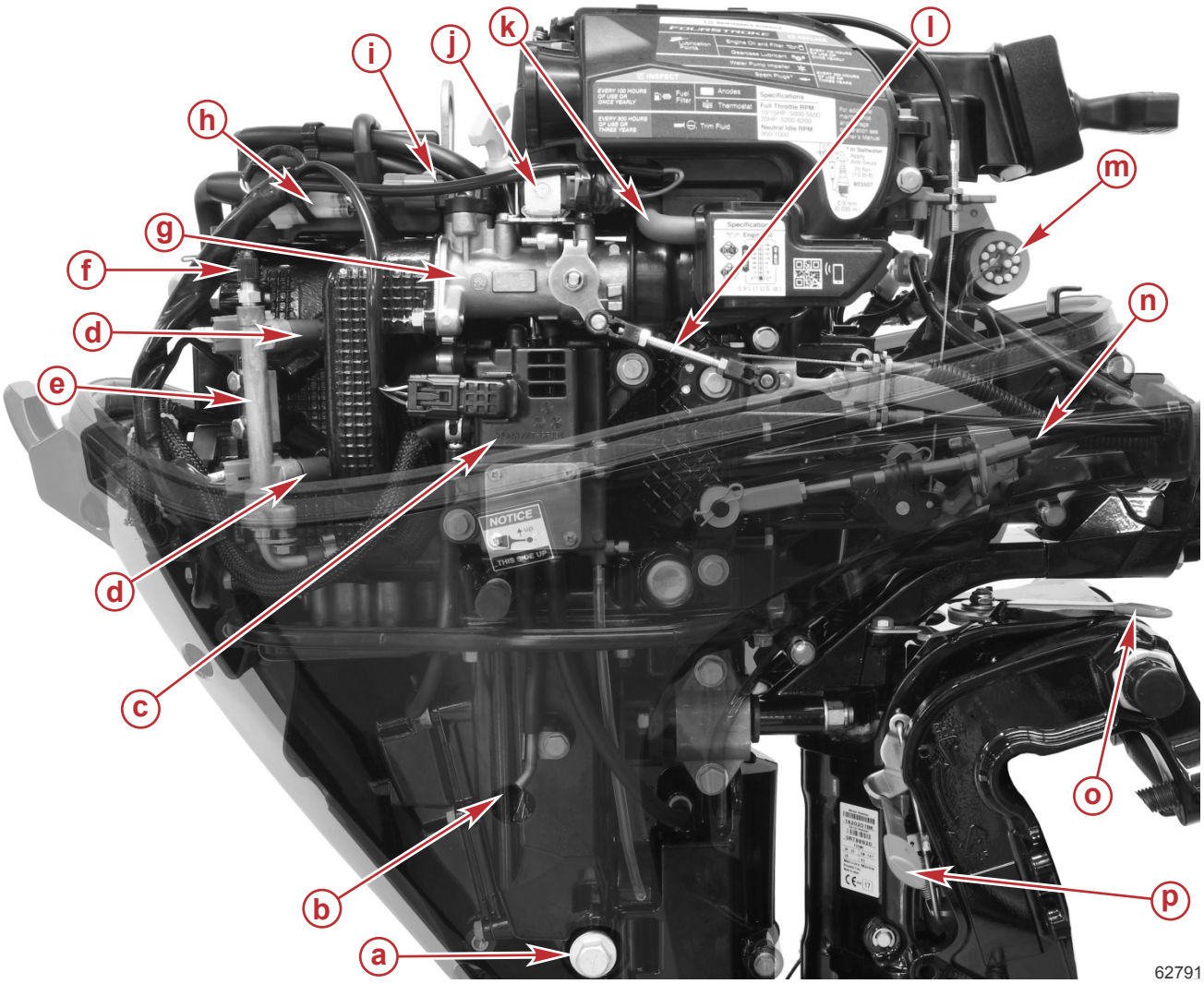
15/20 FourStroke EFI Manual Start Front View



Tiller model shown

- **a -** Warning light
- **b -** Throttle cable (one of two)
- **c -** Recoil handle
- **d -** Air box
- **e -** Recoil interlock cable
- **f -** Engine harness 14-pin connector
- **g -** Fuel line connector
- **h -** Shift lever
- **i -** Throttle control
- **j -** Stop (engine off) button
- **k -** Lanyard
- **l -** Throttle friction knob
- **m -** Copilot handle
- **n -** Tiller handle tilt lock lever
- **o -** Control cable from tiller handle

15/20 FourStroke EFI Manual Start Starboard View

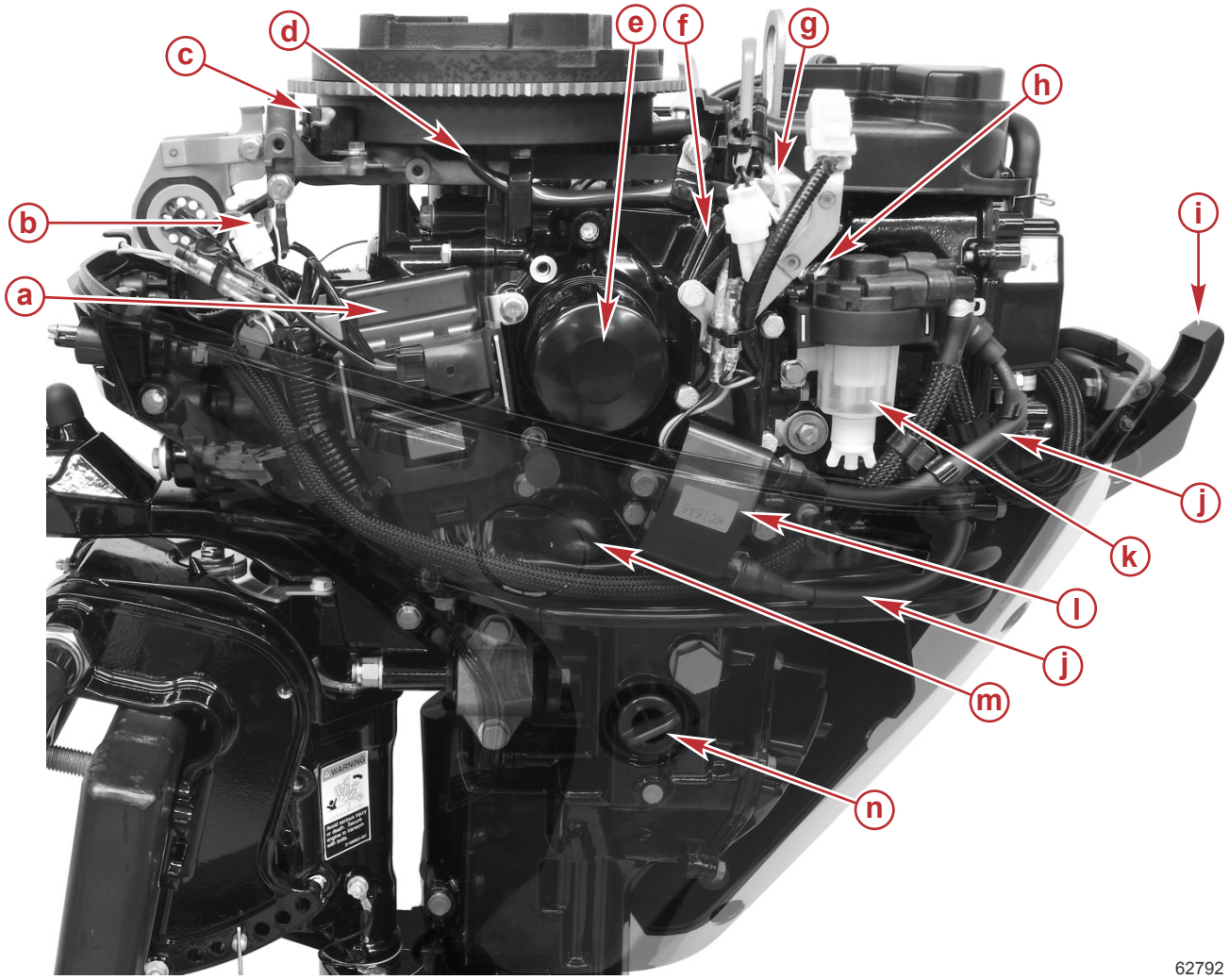


Tiller model shown, remote control model similar

- **a -** Oil drain screw
- **b -** Water pump indicator
- **c -** Vapor separator tank (VST) assembly
- **d -** Fuel injector (2)
- **e -** Fuel rail
- **f -** Fuel rail service port with cap
- **g -** Throttle body
- **h -** Throttle position sensor (TPS) connector

  NOTE: *The TPS is behind (on the port side of) the throttle body.*
- **i -** Temperature and manifold absolute pressure (TMAP) sensor
- **j -** Idle air control (IAC) valve
- **k -** Throttle bypass (to IAC valve)
- **l -** Throttle link
- **m -** 14-pin connector from operator controls
- **n -** Shift cable
- **o -** Copilot handle
- **p -** Tilt lock

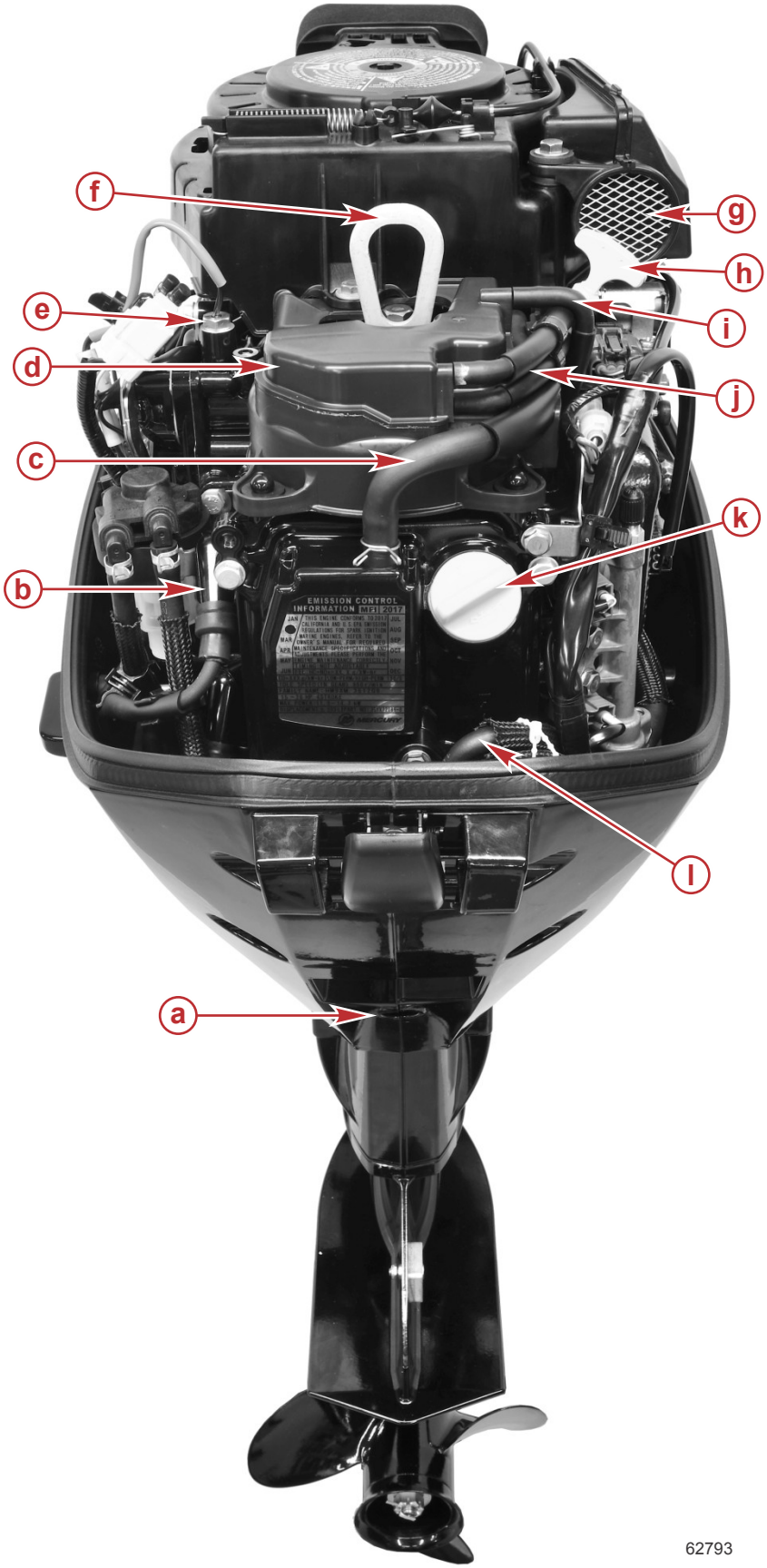
15/20 FourStroke EFI Manual Start Port View



Tiller model shown, with air box and recoil starter removed

- **a -** Engine control module (ECM)
- **b -** Diagnostic connector
- **c -** Crankshaft position sensor (CPS)
- **d -** Stator output wires
- **e -** Oil filter
- **f -** Thermostat housing
- **g -** Electrical bracket
- **h -** Spark plug (2)
- **i -** Cowl latch
- **j -** Spark plug wire (2)
- **k -** Fuel filter
- **l -** Ignition coil
- **m -** Oil pressure switch
- **n -** Flush connector

15/20 FourStroke EFI Manual Start Aft View

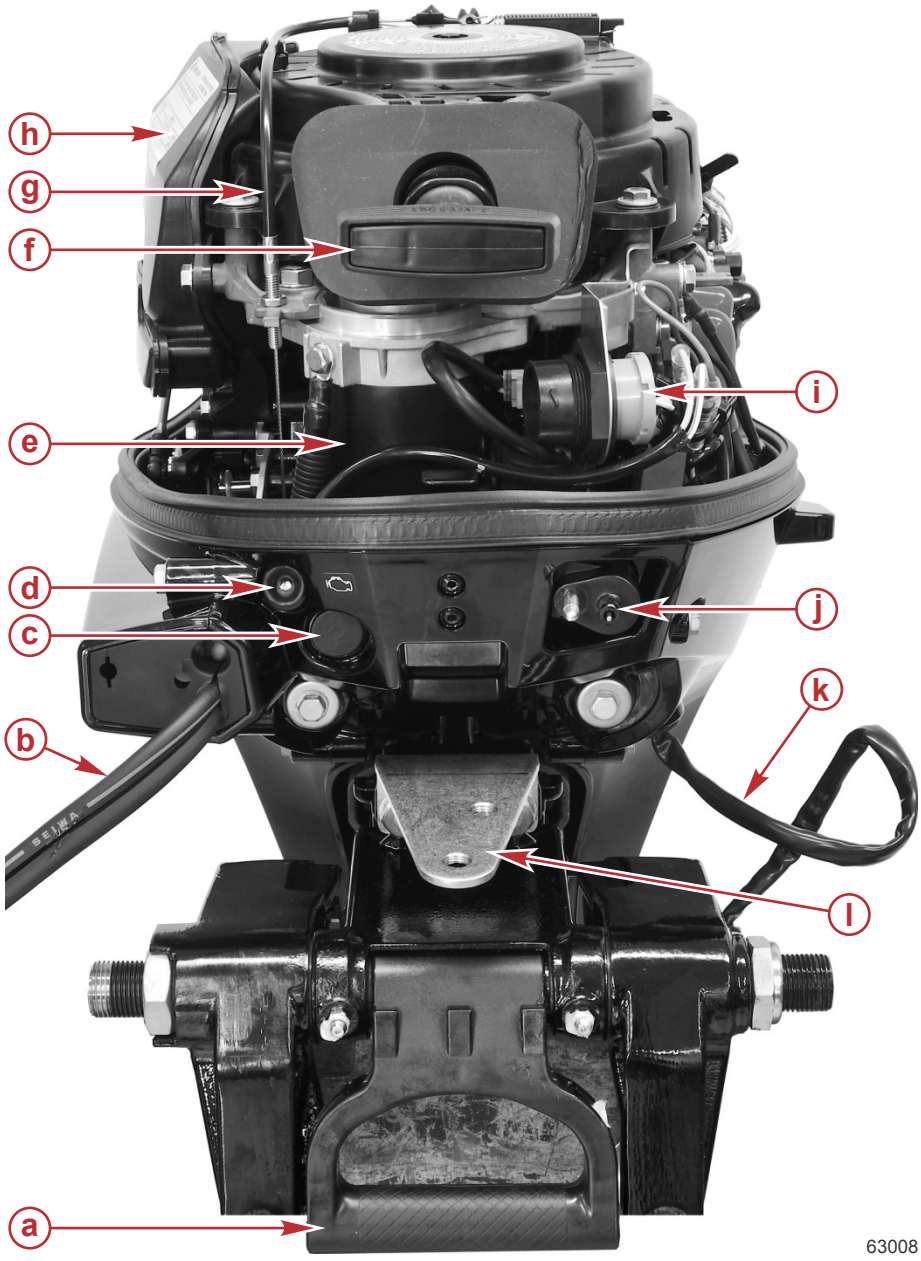


Tiller model shown

- **a -** Idle exhaust port
- **b -** Spark plug cap (2)
- **c -** Crankcase ventilation hose
- **d -** Camshaft gear cover/vent tank
- **e -** Engine coolant temperature (ECT) sensor
- **f -** Engine lifting eye
- **g -** Air intake
- **h -** Oil level dipstick
- **i -** Vent tank vent hose
- **j -** Vapor separator tank (VST) hoses (2)
- **k -** Oil fill cap
- **l -** Fuel hose from low-pressure fuel pump (behind driveshaft housing covers and cowl latch)

Engine Component Identification - Electric Start Model

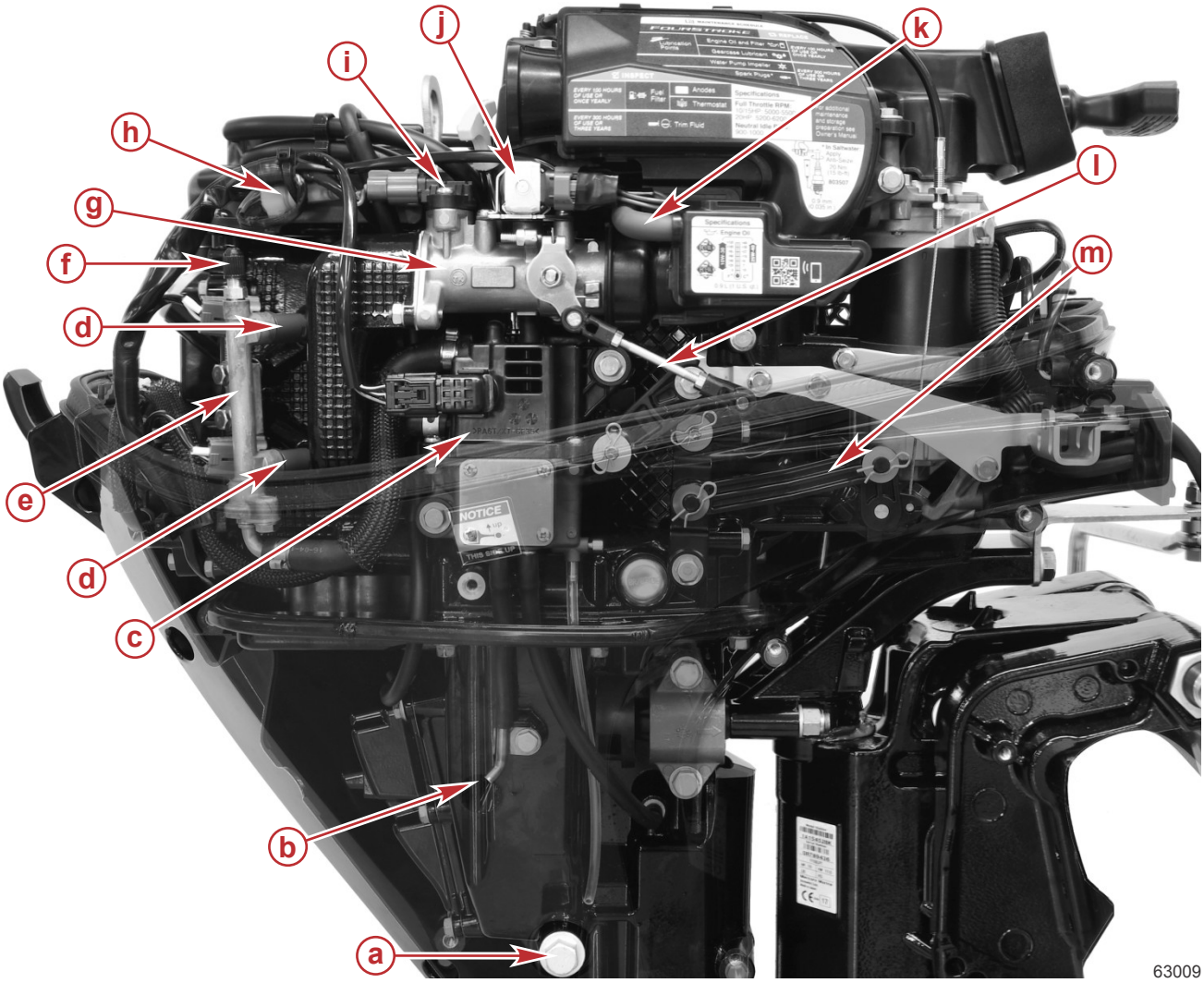
15/20 FourStroke EFI Electric Start Front View



Remote control (RC) model shown, with control cables and steering hardware removed

- **a -** Carry handle
- **b -** Battery cable
- **c -** Rubber plug (start push-button on electric start tiller models)
- **d -** Warning light
- **e -** Starter motor
- **f -** Recoil handle (for manual start)
- **g -** Recoil interlock cable
- **h -** Air box
- **i -** Engine harness 14-pin connector
- **j -** Fuel line connector
- **k -** Power tilt pump wires
- **l -** Steering bracket

15/20 FourStroke EFI Electric Start Starboard View

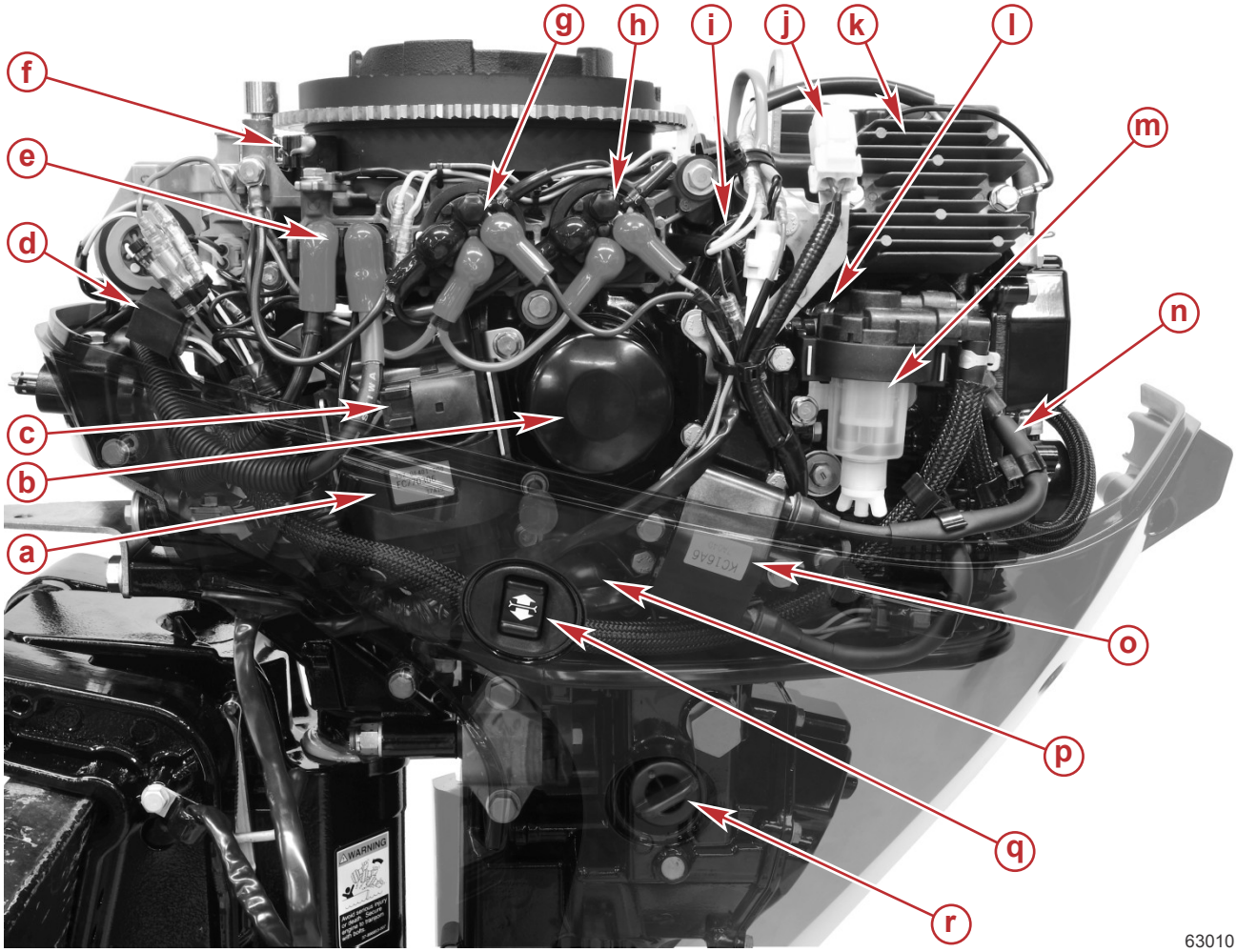


Remote control (RC) model shown

- **a -** Oil drain screw
- **b -** Water pump indicator hose
- **c -** Vapor separator tank (VST) assembly
- **d -** Fuel injector (2)
- **e -** Fuel rail
- **f -** Fuel rail service port with cap
- **g -** Throttle body
- **h -** Throttle position sensor (TPS) connector

  NOTE: *The TPS is behind (on the port side of) the throttle body.*
- **i -** Temperature and manifold absolute pressure (TMAP) sensor
- **j -** Idle air control (IAC)
- **k -** Throttle bypass (to IAC)
- **l -** Throttle link (shown with throttle cable removed)
- **m -** Shift linkage (shown with shift cable removed)

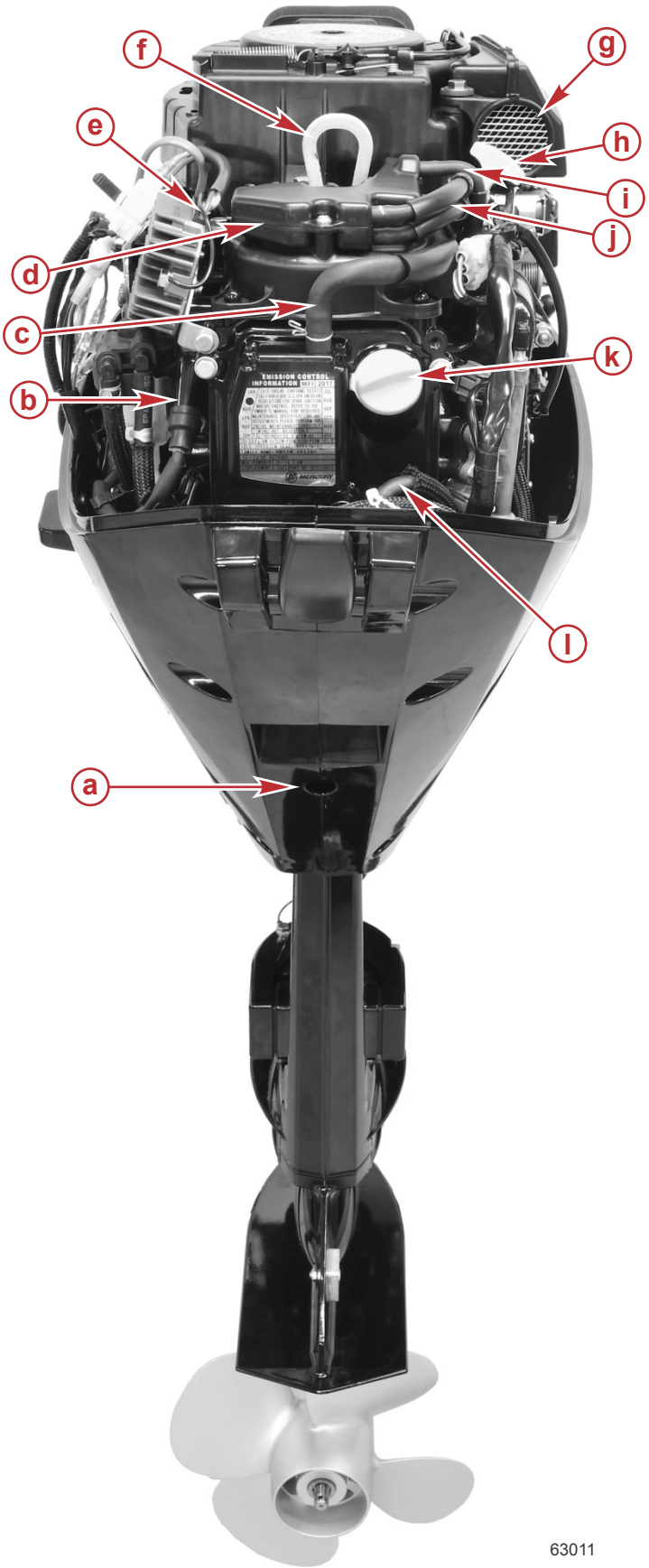
15/20 FourStroke EFI Electric Start Port View



Remote control (RC) model shown

- **a -** Engine control module (ECM)
- **b -** Oil filter
- **c -** 15-amp fuse housing
- **d -** Diagnostic connector
- **e -** Starter solenoid
- **f -** Crankshaft position sensor (CPS)
- **g -** Tilt up relay (power tilt models only)
- **h -** Tilt down relay (power tilt models only)
- **i -** Thermostat housing
- **j -** 20-amp fuse housing
- **k -** Voltage regulator/rectifier
- **l -** Spark plug (2)
- **m -** Fuel filter
- **n -** Spark plug wire (2)
- **o -** Ignition coil
- **p -** Oil pressure switch
- **q -** Cowl-mounted tilt switch (RC power tilt models only)
- **r -** Engine flush connector

15/20 FourStroke EFI Electric Start Aft View



Remote control (RC) model shown

- **a -** Idle exhaust port
- **b -** Spark plug cap (2)
- **c -** Crankcase ventilation hose
- **d -** Camshaft gear cover/vent tank
- **e -** Engine coolant temperature (ECT) sensor (behind voltage regulator/rectifier wires)
- **f -** Engine lifting eye
- **g -** Air intake
- **h -** Oil level dipstick
- **i -** Vent tank vent hose
- **j -** Vapor separation tank (VST) hoses
- **k -** Oil fill cap
- **l -** Fuel hose from fuel pump (behind cowl)

Following Complete Submersion

Engine Submerged while Running (Special Instructions)

When an engine is submerged while running, the possibility of internal engine damage is greatly increased. After the engine is recovered, remove the spark plugs. If the engine fails to turn over freely when turning the flywheel, the possibility of internal damage (bent connecting rod or bent crankshaft) exists. The powerhead must be disassembled for inspection.

Freshwater Submersion (Special Instructions)

1. Recover the engine as quickly as possible.
2. Place the engine at full tilt down.
3. Remove the cowling, including driveshaft housing covers.
4. Flush the exterior of the outboard with fresh water to remove mud, weeds, etc. Disassemble the powerhead if necessary to clean the components.

   IMPORTANT: Do not attempt to start the engine if sand has entered the powerhead.
5. Remove the spark plugs and get as much water as possible out of the powerhead. Most of the water inside the combustion chambers can be eliminated by rotating the flywheel while the engine is tilted all the way down.
6. Remove and clean the fuel rail, idle air control, throttle body, air box, vapor recovery tank, and vapor separator tank/fuel pump assembly.
7. Pour approximately one teaspoon of engine oil into each spark plug opening. Rotate the flywheel to distribute the oil.
8. Dry all wiring and electrical components using compressed air.
9. Change the engine oil.
10. Disassemble the starter motor, and dry all internal parts with compressed air. Be careful to not lose the brush springs.
11. Reinstall the spark plugs.
12. Reassemble the engine, and attempt to start the engine using a fresh fuel source.
    - Run the outboard for a short time, and check for the presence of water in the oil. If water is present, the oil will appear milky. Drain and replace the oil.
    - Run the engine for at least one hour to eliminate any water in the engine.
    - If the engine fails to start, determine if the cause is fuel related, electrical, or mechanical. Repair as required.

IMPORTANT: The engine should be run within two hours of recovery from the water, or serious internal damage will occur. If the engine is unable to start within two hours of recovery, disassemble the engine and clean all parts. Apply oil as soon as possible.

Saltwater Submersion (Special Instructions)

Due to the corrosive effect of saltwater on internal engine components, complete disassembly of the engine is necessary before any attempt is made to start the engine.

Fuel Requirements

IMPORTANT: Use of improper gasoline can damage your engine. Engine damage resulting from the use of improper gasoline is considered misuse of the engine and will not be covered under the limited warranty.

Fuel Ratings

Mercury outboard engines will operate satisfactorily with any major brand of unleaded gasoline that meets the following specifications:

USA and Canada - A posted pump octane rating of 87 (R+M)/2, minimum, for most models. Premium gasoline 91 (R+M)/2 octane is also acceptable for most models. **Do not** use leaded gasoline.

Outside USA and Canada - A posted pump octane rating of 91 RON, minimum, for most models. Premium gasoline (95 RON) is also acceptable for all models. **Do not** use leaded gasoline.

Using Reformulated (Oxygenated) Gasoline (USA Only)

Reformulated gasoline is required in certain areas of the USA and is acceptable for use in your Mercury Marine engine. The only oxygenate currently in use in the USA is alcohol (ethanol, methanol, or butanol).

Gasoline Containing Alcohol

Bu16 Butanol Fuel Blends

Fuel blends of up to 16.1% butanol (Bu16) that meet the published Mercury Marine fuel rating requirements are an acceptable substitute for unleaded gasoline. Contact your boat manufacturer for specific recommendations on your boat's fuel system components (fuel tanks, fuel lines, and fittings).

Methanol and Ethanol Fuel Blends

IMPORTANT: The fuel system components on your Mercury Marine engine will withstand up to 10% alcohol (methanol or ethanol) content in the gasoline. Your boat's fuel system may not be capable of withstanding the same percentage of alcohol. Contact your boat manufacturer for specific recommendations on your boat's fuel system components (fuel tanks, fuel lines, and fittings).

Be aware that gasoline containing methanol or ethanol may cause increased:

- Corrosion of metal parts
- Deterioration of rubber or plastic parts
- Fuel permeation through the rubber fuel lines
- Likelihood of phase separation (water and alcohol separating from the gasoline in the fuel tank)

⚠ WARNING

Fuel leakage is a fire or explosion hazard, which can cause serious injury or death. Periodically inspect all fuel system components for leaks, softening, hardening, swelling, or corrosion, particularly after storage. Any sign of leakage or deterioration requires replacement before further engine operation.

IMPORTANT: If you use gasoline that contains or might contain methanol or ethanol, you must increase the frequency of inspection for leaks and abnormalities.

IMPORTANT: When operating a Mercury Marine engine on gasoline containing methanol or ethanol, do not store the gasoline in the fuel tank for long periods. Cars normally consume these blended fuels before they can absorb enough moisture to cause trouble; boats often sit idle long enough for phase separation to take place. Internal corrosion may occur during storage if alcohol has washed protective oil films from internal components.

Low Permeation Fuel Hose Requirement

Required for outboards manufactured for sale, sold, or offered for sale in the United States.

- The Environmental Protection Agency (EPA) requires that any outboard manufactured after January 1, 2009, must use low permeation fuel hose for the primary fuel hose connecting the fuel tank to the outboard.
- Low permeation hose is USCG Type B1-15 or Type A1-15, defined as not exceeding 15 g/m²/24 h with CE 10 fuel at 23 °C as specified in SAE J 1527 - marine fuel hose.

EPA Pressurized Portable Fuel Tank Requirements

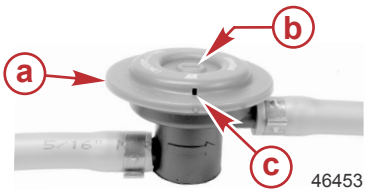
The Environmental Protection Agency (EPA) requires portable fuel systems that are produced after January 1, 2011, for use with outboard engines to remain fully sealed (pressurized) up to 34.4 kPa (5.0 psi). These tanks may contain the following:

- An air inlet that opens to allow air to enter as the fuel is drawn out of the tank.
- An air outlet that opens (vents) to the atmosphere if pressure exceeds 34.4 kPa (5.0 psi).

Fuel Demand Valve (FDV) Requirement

Whenever a pressurized fuel tank is used, a fuel demand valve is required to be installed in the fuel hose between the fuel tank and primer bulb. The fuel demand valve prevents pressurized fuel from entering the engine and causing a fuel system overflow or possible fuel spillage.

The fuel demand valve has a manual release. The manual release can be used (pushed in) to open (bypass) the valve in case of a fuel blockage in the valve.



a - Fuel demand valve - installed in the fuel hose between the fuel tank and primer bulb
b - Manual release
c - Vent/water drain holes

Painting Procedures

Propeller Painting Procedure

⚠ WARNING

Continuous exposure to airborne particles such as chemical vapors, dust, or spray can cause serious injury or death. Ensure that the work area is properly ventilated and wear protective eyewear, clothing, and respirators.

1. Sand the entire area to be painted with 3M™ 120 Regalite™ Polycut™ or coarse Scotch-Brite™ disc or belts.
2. Feather the edges of all broken paint edges. Try not to sand through the primer.
3. Clean the surface to be painted using PPG DX330 Wax and Grease Remover or equivalent (xylene or M.E.K.).
4. If bare metal has been exposed, use Mercury Light Gray Primer.
5. Allow a minimum of one hour dry time and no more than one week before applying the finish coat.
6. Apply the finish coat using Mercury EDP Propeller Black Paint.

Gearcase and Lower Housing Refinishing

⚠ WARNING

Some cleaners and solvents are flammable. Improper use can result in serious injury or death from fire or explosion. Do not use flammable cleaners on energized equipment, use in a well-ventilated area, and keep away from open flames or sources of ignition.

⚠ WARNING

Continuous exposure to airborne particles such as chemical vapors, dust, or spray can cause serious injury or death. Ensure that the work area is properly ventilated and wear protective eyewear, clothing, and respirators.

1. Clean the component to remove all oils, wax, grease, salts, and other marine build-up with an appropriate marine cleaner. Wipe the part with a solvent type wax remover, grease remover, or naphtha.
2. If this is a spot repair:
   a. Sand the affected area with 180 or 220 grit to remove blisters and coarse pitting, if present.
   b. Finish and feather into the surrounding paint with 320 grit either by hand or using dual-action (DA) equipment. The original primer should not be sanded through, if it can be avoided.
   c. Scuff the entire component with a medium (maroon) Scotch-Brite™ pad by hand.
3. If refinishing the entire component:
   - Media blasting using either a plastic type or soda type media is allowable, provided proper precautions are taken to prevent grit from entering any mechanisms.
   - Complete disassembly and masking prior to media blasting is suggested, with glass media being acceptable in this case.
4. Treat areas of bare aluminum with Alumiprep® 33, PPG DX-533, or Metalprep 79. Rinse the area with clean water and blow dry with clean compressed air.
5. When they are dry, treat the bare aluminum areas with Alodine® 1201™ or PPG DX-503. Rinse again with clean water and blow dry with clean compressed air. Masking, if needed, is to be done after this final rinse process, paying special attention to the masking of anode and ground contact areas.
6. Complete a final wipe with a wax and grease remover or naphtha. Lightly remove dust with a tack rag.
7. Prime the bare aluminum areas with Stits EP-420 (green) epoxy primer, mixed with Stits EP-430 catalyst and Stits E-500 reducer, per the manufacturer's mixing and application directions. PTI PT-573 or Randolph Rand-O-Plate are acceptable substitutes. Apply two medium wet coats, allowing 20 minutes between. If the topcoat color is Verado Silver, PPG Omni™ MP170 gray epoxy should be applied as a second (intermediate) primer for color match and scratch hiding on gearcases.
8. After it has cured for 24 hours, the primer may be scuffed lightly with a medium (maroon) Scotch-Brite™ pad to feather the edge of the spray into surrounding paint and to promote adhesion. Do not penetrate the primer. Wait no more than four days before topcoating.
9. Topcoat with Stits Aerothane color code 215 for Mercury Phantom Black. Use Stits Catalyst U-865 and UE-820 Urethane Reducer per manufacturer's mixing and application directions. PPG Omni™ MTK9300 is an acceptable substitute. Apply two medium wet coats, allowing 15 minutes between. Allow to cure for 24 hours before handling.

   NOTE: *Other PPG topcoat colors are: DU34334 Mariner Silver, DU35466 Force Charcoal, and DU33414M Sea Ray White. Use PPG DU5 catalyst and reduce per manufacturer's current technical information.*

Cowl Refinishing

⚠ WARNING

Some cleaners and solvents are flammable. Improper use can result in serious injury or death from fire or explosion. Do not use flammable cleaners on energized equipment, use in a well-ventilated area, and keep away from open flames or sources of ignition.

⚠ WARNING

Continuous exposure to airborne particles such as chemical vapors, dust, or spray can cause serious injury or death. Ensure that the work area is properly ventilated and wear protective eyewear, clothing, and respirators.

1. Wash and degrease the cowl with a water-based cleaning solution. Simple Green® Aircraft & Precision Cleaner or Stewart Systems EkoClean are suggested at a 10:1 mix ratio with clean water. Rinse with clean water.
2. Use an orbital dual-action (DA) sander at low speed with an 80–100 grit disc to sand around any damaged areas. Low speed is used to prevent melting of the cowl substrate and causing adhesion issues. Wipe with the same cleaner used to wash the cowl, followed by a clean water wipe. Blow dry with compressed air.
3. Apply two light coats of Klean-Strip® Bulldog® Adhesion Promoter to areas that were sanded to the base cowl material. Omni™ MP178 Plastic Primer or equivalent is a suitable alternative.
4. Repair dings and scratches with Evercoat Poly-Flex™ following manufacturer instructions. An equivalent filler designed for flexible automotive components may be substituted. Sand to contour with a 180 grit disc, using an orbital DA sander, and finish with a 320 grit disc to feather into the surrounding paint. If the entire cowl is to be refinished, scuff all surfaces with either 320 grit or a maroon Scotch-Brite™ pad, feathering in all minor chips and scratches.
5. Wipe down the cowl with the same cleaner used to wash and degrease the cowl, followed by a water wipe. Blow dry with clean compressed air.
6. Prime all areas to be painted with Omni™ MP281 or MP282, mixing and using per manufacturer instructions. For top quality cowl work, complete refinishing is suggested in place of spot repairs. If the topcoat color is white, PPG Omni™ MP170 gray epoxy should be applied as a second (intermediate) primer for color match and scratch hiding on cowls.
7. Lightly sand the primer with 320 grit using an orbital DA sander or by hand to a uniform surface. Wipe down and blow dry as in previous steps. If there are no imperfections, a maroon Scotch-Brite™ pad may be used instead.
8. Base coat with either Omni™ MBC9300 (Phantom Black), Delfleet® 938661 (Warm Fusion White), Delfleet® 938662 (Cold Fusion White), PPG DU34334 (Mariner Silver), PPG DU35466 (Force Charcoal) using the manufacturer's mixing and use guideline.
9. Topcoat with PPG Omni™ MC161 clear or equivalent, using the manufacturer's mixing and use guidelines. Use two full wet coats of a high quality clear coat for long term durability.
10. If a top quality finish is required, or if errors in the clear coat need to be corrected, cut and buff the clear coat using a reputable automotive-type system, appropriate for the clear coat material.
11. Follow paint manufacturer's guidelines for cure times before machine finishing, waxing, or applying decals.

Emissions

Exhaust Emission Standards

Through the Environmental Protection Agency (EPA), the federal government has established exhaust emissions standards for all new marine engines sold in the U.S.

What Are Emissions?

Emissions are what comes out of the exhaust system in the exhaust gas when the engine is running. They are formed as a result of the process of combustion or incomplete combustion. To understand exhaust gas emissions, remember that both air and fuel are made of several elements. Air contains oxygen and nitrogen among other elements; gasoline contains mainly hydrogen and carbon. These four elements combine chemically during combustion. If combustion were complete, the mixture of air and gasoline would result in these emissions: water, carbon dioxide and nitrogen, which are not harmful to the environment. But combustion is not usually complete. Also, potentially harmful gases can be formed during and after combustion.

All marine engines must reduce the emission of certain pollutants, or potentially harmful gases, in the exhaust to conform with levels legislated by the EPA. Emissions standards become more stringent each year. Standards are set primarily with regard to three emissions: hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx).

Hydrocarbons – HC

Gasoline is a hydrocarbon fuel. The two elements of hydrogen and carbon are burned during combustion in combination with oxygen. But they are not totally consumed. Some pass through the combustion chamber and exit the exhaust system as unburned gases known as hydrocarbons.

Carbon Monoxide – CO

Carbon is one of the elements that make up the fuel burned in the engine along with oxygen during the combustion process. If the carbon in the gasoline could combine with enough oxygen (one carbon atom with two oxygen atoms), it would come out of the engine in the form of carbon dioxide (CO_2). CO_2 is a harmless gas. But carbon often combines with insufficient oxygen (one carbon atom with one oxygen atom). This forms carbon monoxide, CO. Carbon monoxide is the product of incomplete combustion and is a dangerous, potentially lethal gas.

Oxides of Nitrogen – NOx

NOx is a slightly different by-product of combustion. Nitrogen is one of the elements that makes up the air going into the engine. Under extremely high temperatures it combines with oxygen to form oxides of nitrogen (NOx). This happens in the engine's combustion chambers when temperatures are too high. NOx itself is not harmful, but when exposed to sunlight it combines with unburned hydrocarbons to create the visible air pollutant known as smog. Smog is a serious problem in California as well as many other heavily populated areas of the United States.

Controlling Emissions

There are two principle methods of reducing emissions from a marine engine. The first method is to control the air/fuel ratio that goes into the combustion chamber. The second is to control the time when this air/fuel mixture enters the combustion chamber. Timing is important, to prevent any unburned mixture from escaping out of the exhaust port.

Stoichiometric (14.7:1) Air/Fuel Ratio

In the search to control pollutants and reduce exhaust emissions, engineers have discovered that they can be reduced effectively if a gasoline engine operates at an air/fuel ratio of 14.7:1. The technical term for this ideal ratio is stoichiometric. An air/fuel ratio of 14.7:1 provides the best control of all three elements in the exhaust under almost all conditions. The HC and CO content of the exhaust gas is influenced significantly by the air/fuel ratio. At an air/fuel ratio leaner than 14.7:1, HC and CO levels are low, but with a ratio richer than 14.7:1 they rise rapidly. It would seem that controlling HC and CO by themselves might not be such a difficult task; the air/fuel ratio only needs to be kept leaner than 14.7:1. However, there is also NOx to consider.

As the air/fuel ratio becomes leaner, combustion temperatures increase. Higher combustion temperatures raise the NOx content of the exhaust. But, enrichening the air/fuel ratio to decrease combustion temperatures and reduce NOx also increases HC and CO, as well as lowering fuel economy. So the solution to controlling NOx - as well as HC and CO - is to keep the air/fuel ratio as close to 14.7:1 as possible.

Emissions Information

Manufacturer's Responsibility

Beginning with 1998 model year engines, manufacturers of all marine propulsion engines must determine the exhaust emission levels for each engine horsepower family and certify these engines with the United States Environmental Protection Agency (EPA). A certification decal/emissions control information label, showing emission levels and engine specifications directly related to emissions, **must** be placed on each engine at the time of manufacture.

Dealer Responsibility

When performing service on all 1998 and newer outboards that carry a certification, attention must be given to any adjustments that are made that affect emission levels.

Adjustments must be kept within published factory specifications.

Replacement or repair of any emission related component must be executed in a manner that maintains emission levels within the prescribed certification standards.

Dealers are **not** to modify the engine in any manner that would alter the horsepower or allow emission levels to exceed their predetermined factory specifications.

Exceptions include manufacturer's prescribed changes, such as that for altitude adjustments.

Owner Responsibility

The owner/operator is required to have engine maintenance performed to maintain emission levels within prescribed certification standards.

The owner/operator is **not** to modify the engine in any manner that would alter the horsepower or allow emission levels to exceed their predetermined factory specifications.

Exceptions

- Carburetor jets may be changed for high altitude use in accordance with factory recommendations.
- Single engine exceptions may be allowed with permission from the EPA for racing and testing.

EPA Emission Regulations

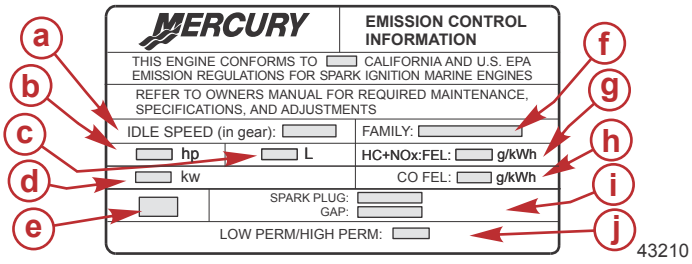
All new 1998 and newer outboards manufactured by Mercury Marine for operation in the USA, are certified to the United States Environmental Protection Agency as conforming to the requirements of the regulations for the control of air pollution from new outboard motors. This certification is contingent on certain adjustments being set to factory standards. For this reason, the factory procedure for servicing the product must be strictly followed and, whenever practicable, returned to the original intent of the design.

The responsibilities listed above are general and in no way a complete listing of the rules and regulations pertaining to the EPA laws on exhaust emissions for marine products. For more detailed information on this subject, you may contact the following location:

EPA INTERNET WEB SITE: http://www.epa.gov/otaq/marinesi.htm

Manufacturer's Certification Label

The certification label must be placed on each engine at the time of manufacture and must be replaced in the same location if damaged or removed. Shown below is a typical certification label and is not representative of any one model. Label shown below is not to scale.



- **a -** Idle speed
- **b -** Engine horsepower
- **c -** Piston displacement
- **d -** Engine power in kilowatts
- **e -** Date of manufacture
- **f -** US EPA engine family name
- **g -** Regulated emissions limit for the engine family
- **h -** Regulated emissions limit for the engine family
- **i -** Recommended spark plug and gap
- **j -** Percent of fuel line permeation

Service Replacement Certification Label

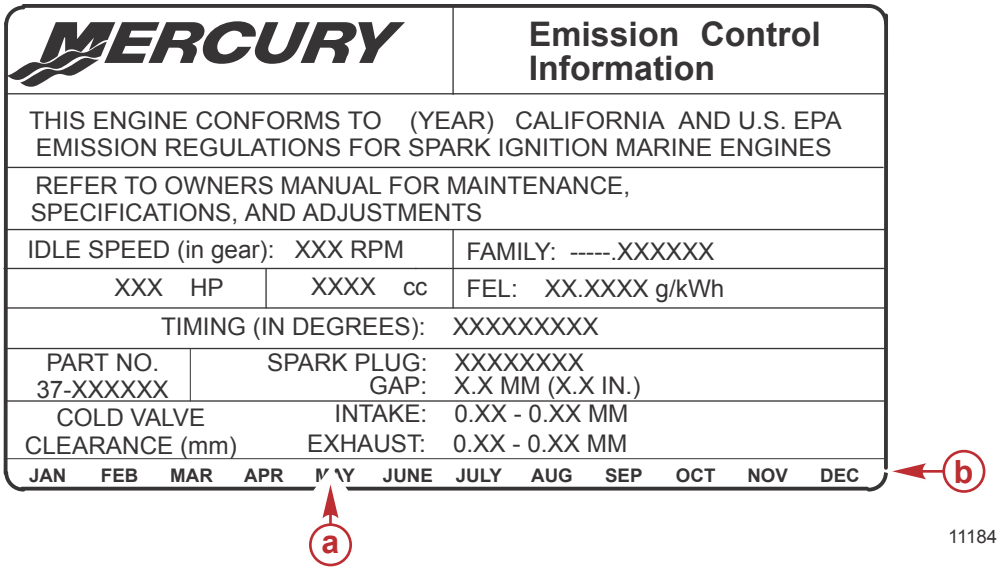
IMPORTANT: By federal law, it is required that all 1998 and newer Mercury Marine outboards have a visible and legible emission certification label. If this label is missing or damaged, contact Mercury Marine Service for a replacement.

Removal

Remove all remaining pieces of the damaged or illegible label. Do not install new label over the old label. Use a suitable solvent to remove any traces of the old label adhesive from the display location.

Date Code Identification

Cut and remove a **"V"** notch through the month of engine manufacture before installing the new label. The month of manufacture can be found on the old label. If the label is missing or the date code illegible, contact Mercury Marine Technical Service for assistance.



- **a -** "V" notch
- **b -** Month of manufacture

Installation

Install the label on a clean surface in the original factory location.

Shipping of Hazardous Material (HazMat) and Engine/Components Containing Hazardous Material

Outboard Service Bulletin 2008-07

There are a number of United States regulations regarding the shipment of hazardous material. These regulations apply not only to shipments within the United States, but to import and export shipments as well. It is important to comply with all of these regulations. This bulletin is intended to provide you with some basic information about some of these regulations, and provide you with information about resources from which you can obtain additional information. It is also intended to draw your attention to the importance of proper packaging, labeling, and shipping of hazardous material; as well as any engine or engine component that contains hazardous material like gasoline or other fluids such as crankcase oil, gearcase oil, and hydraulic fluid. There are also requirements for training personnel that deal with the shipment of hazardous material. This bulletin is intended to draw your attention to some of the shipping regulations that we are aware of that might apply to your business, it is not a complete review of all of the laws and regulations that apply to the shipment of hazardous materials. Please do not treat it as such.

NOTE: *You, as the shipper of record, are responsible for classification, packaging, hazard communication, incident reporting, handling, and transportation of hazardous materials.*

Overview of Regulations

The Hazardous Materials Regulations (HMR) specify requirements for the safe transportation of hazardous materials in commerce by rail car, aircraft, vessel, and motor vehicle. These comprehensive regulations govern transportation-related activities. In general, the HMR prescribe requirements for classification, packaging, hazard communication, incident reporting, handling, and transportation of hazardous materials. The HMR are enforced by Pipeline Hazardous Material Safety Administration (PHMSA), Department of Transportation (DOT), Federal Aviation Administration (FAA), Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), and the United States Coast Guard (USCG).

Overview of Training Requirements

Current U.S. Department of Transportation (DOT) regulations require initial training (and recurrent training) of all employees who perform work functions covered by the Hazardous Materials Regulations. Any employee who works in a shipping, receiving, or material handling area; or who may be involved in preparing or transporting hazardous materials, is required to have training. Hazardous materials transportation training is available from ShipMate, Inc. The training modules on CD-ROM or online contain an interactive training program which satisfies the DOT requirement for general awareness, general safety, and HazMat security training. A comprehensive exam is offered and Certificates of Completion are generated upon successful completion of the program. The CD-ROM and online Web-Based Training may be purchased from ShipMate, Inc. This also includes an electronic version of the 49 CFR Hazardous Materials Regulations, the current Emergency Response Guidebook, and full access to ShipMate's technical staff to assist you in properly preparing hazardous materials for transport. ShipMate, Inc. may be reached at 1-310-370-3600 or on the web at http://www.shipmate.com.

NOTE: *The DOT training program does* ***NOT*** *include a test of any type and contains a lot of material which is not relevant (e.g. cargo tanks). In addition, you would have to purchase the 49 CFR and the Emergency Response Guidebook separately. Further, the DOT program provides no support – technical or otherwise. For further information, view the DOT website at http://www.dot.gov.*

Shipping of Complete Engines and Major Assemblies

Complete engines cannot be transported without going through additional preparation first. Electronic fuel injection (EFI) and direct fuel injection (DFI) engines must have the fuel system drained of fuel, not run dry because of possible damage to electric fuel pumps. Carbureted engines must be completely run dry and have stalled due to lack of fuel. All engines must have any remaining fluids/oils drained (including engine and gearcase oil) and hydraulic fluids (including power trim fluid) and disconnected fluid pipes that previously contained fluid must be sealed with leakproof caps that are positively retained. Major assemblies such as gearcases, dressed powerheads, or other components containing any fluids must be also drained prior to shipping.

More Information on Hazardous Material

More information on hazardous material, regulations, packaging, training, etc. can be found by going to the ShipMate website: http://www.shipmate.com or by calling:

ShipMate Inc.	
Telephone	+ 1 (310) 370-3600
Fax	+ 1 (310) 370-5700
E-mail	shipmate@shipmate.com

Notes:

Important Information

Section 1D - Outboard Installation

Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Steering cable end	92-802859A 1

Start in Gear Protection

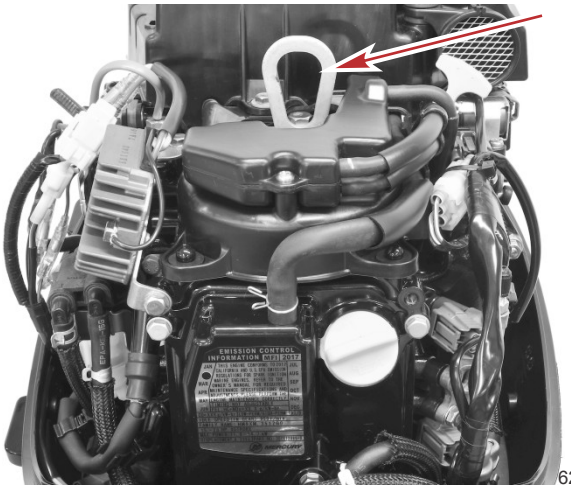
⚠ WARNING

Starting the engine with the drive in gear can cause serious injury or death. Never operate a boat that does not have a neutral-safety-protection device.

The remote control connected to the outboard must be equipped with a start in neutral only protection device. This prevents the engine from starting in gear.

Lifting the Outboard

Use the lifting eye on the engine.

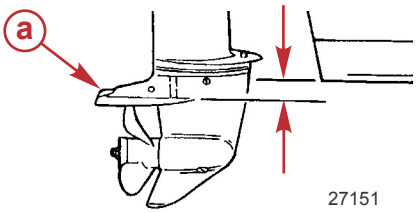


62883

Installing Outboard

Boat Transom Height Requirement

Measure the transom height of your boat. The boat bottom should be aligned or be within 25 mm (1 in.) above the antiventilation plate of the outboard.



27151

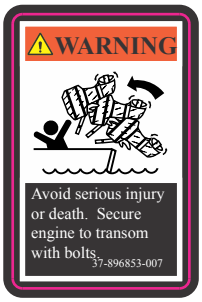
a - Antiventilation plate

Installing Outboard on Transom

⚠ WARNING

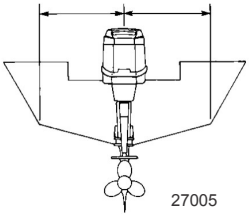
Failure to correctly fasten the outboard could result in the outboard propelling off the boat transom resulting in property damage, serious injury, or death. Before operation, the outboard must be correctly installed with the required mounting hardware.

This product must be secured to the transom with the required mounting hardware. If the outboard strikes an underwater object, the required mounting hardware prevents the outboard from propelling off the transom. A decal on the swivel bracket reminds the installer of the potential hazard.

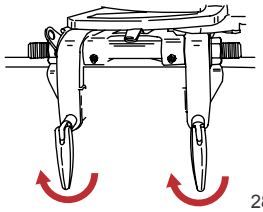


52375

1. Place the outboard on the centerline of the transom.

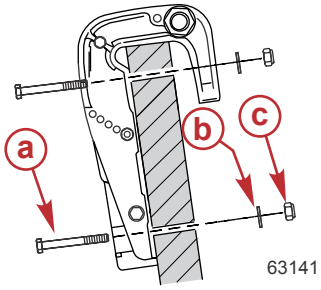

27005

2. Tighten the transom bracket clamp screws to the specified torque.

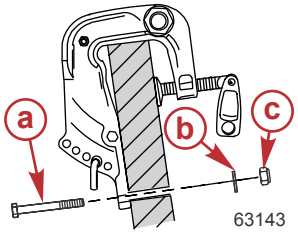

28501

Description	Nm	lb-in.	lb-ft
Transom bracket clamp screws	13.5	120	–

3. To prevent a loss of the outboard, secure the outboard to the transom with the supplied mounting hardware. Use a 7.9 mm (5/16 in.) drill bit to bore the holes into the transom. Use the transom bracket mounting holes for the alignment guide. Secure the bolts with flat washers and locknuts. Apply marine waterproofing sealer in the holes and around the bolts to make the installation water tight. Tighten the bolts to the specified torque.



63141



63143

Power tilt models **Manual tilt models**

a - Power tilt models have four bolts, manual tilt models have two bolts

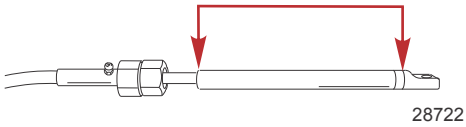
b - Power tilt models have four washers, manual tilt models have two washers

c - Power tilt models have four nuts, manual tilt models have two nuts

Description	Nm	lb-in.	lb-ft
Transom bracket mounting bolts—all models	13.5	120	–

Steering Cable Installation

1. Lubricate the entire cable end with Mercury or Quicksilver 2-4-C with PTFE.



Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Steering cable end	92-802859A 1

2. Insert the steering cable into the tilt tube.
3. Tighten the steering cable nut to the specified torque.
4. Thread the steering cable seal onto the end of the tilt tube.

a - Steering cable nut
b - Steering cable seal

Description	Nm	lb-in.	lb-ft
Steering cable nut	47.5	–	35

Steering Link Rod Fasteners

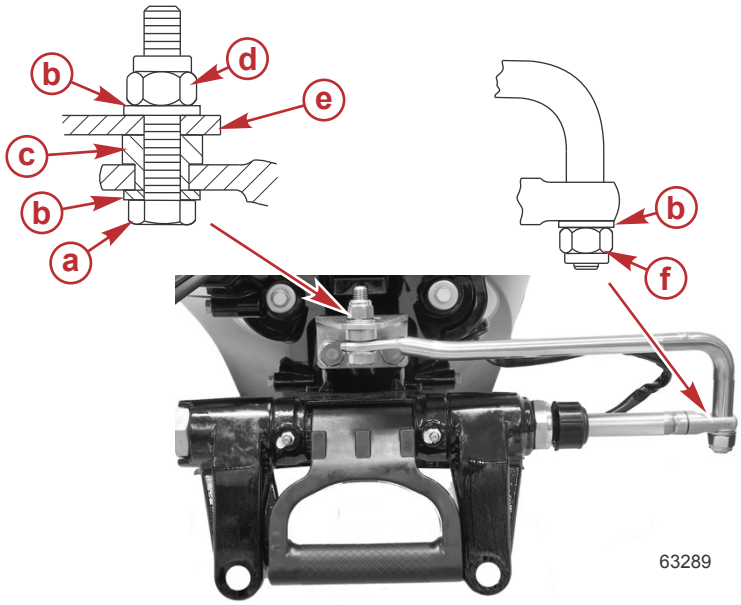
IMPORTANT: The steering link rod that connects the steering cable to the engine must be fastened using the steering link rod fastening hardware supplied with the engine. Never replace the locknuts with common nonlocking nuts; they will work loose and vibrate off, allowing the link rod to disengage from the steering cable.

⚠ WARNING

Improper fasteners or improper installation procedures can result in loosening or disengagement of the steering link rod. This can cause a sudden, unexpected loss of boat control, resulting in serious injury or death due to occupants being thrown within or out of the boat. Always use required components and follow instructions and torque procedures.

Assemble the steering link rod to the steering cable with a flat washer and nylon insert locknut. Tighten the locknut until it seats, then back nut off 1/4 turn.

Assemble the steering link rod to the engine with bolt, locknut, spacer, and flat washers. Tighten the locknut to the specified torque.



- **a -** Bolt
- **b -** Flat washer
- **c -** Spacer
- **d -** Nylon insert locknut
- **e -** Steering bracket
- **f -** Nylon insert locknut - tighten until it seats, then back off 1/4 turn

Description	Nm	lb-in.	lb-ft
Nylon insert locknut "d"	27	–	20
Nylon insert locknut "f"	Tighten until it seats, then back off 1/4 turn		

Remote Wiring Harness and Control Cable Installation

Remote Wiring Harness Connection

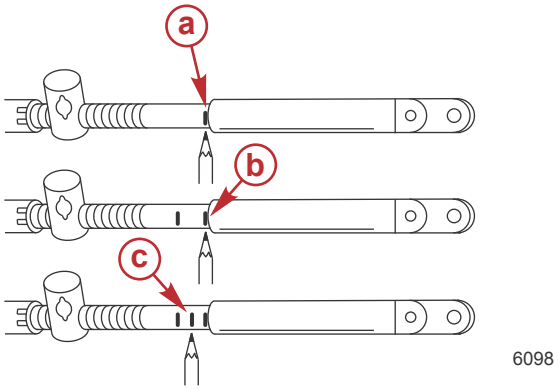
1. Remove the starboard side driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.
2. Connect the 14-pin connector to the engine harness.
3. Route the remote wiring harness through the rubber grommet.

Shift Cable Installation

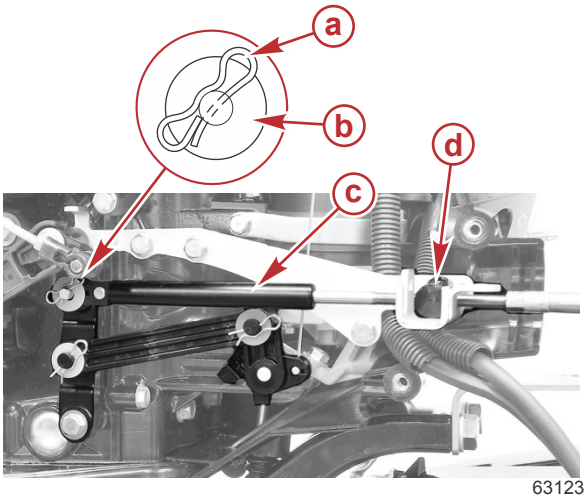
Install the cables into the remote control following the instructions provided with the remote control.

NOTE: *The shift cable is the first cable to move when moving the control box out of neutral.*

1. Locate the center point of the slack or lost motion that exists in the shift cable as follows:
   a. Move the remote control handle from neutral into forward and advance the handle to full speed position. Slowly return the handle back to neutral. Place a mark (a) on the cable next to the end guide.
   b. Move the remote control handle from neutral into reverse and advance the handle to full speed position. Slowly return the handle back to neutral. Place a mark (b) on the cable next to the end guide.
   c. Make a center mark (c), midway between marks (a and b). Align the end guide with this center mark when installing the cable to the engine.



2. Position the remote control handle into neutral.
3. Attach the shift cable to the shift lever with a washer and bow-tie retainer.
4. Adjust the cable barrel so the center mark on the cable is aligned with the end guide when the cable barrel is placed in the barrel receptacle.



63123

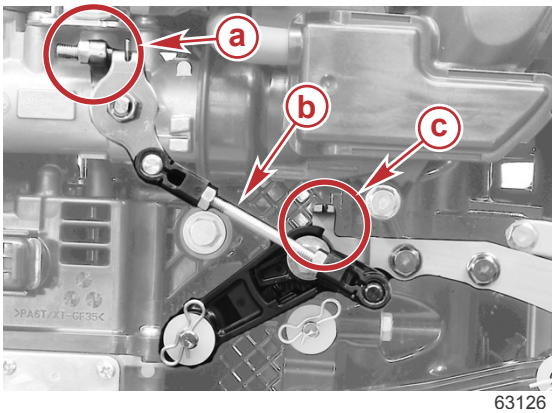
a - Bow-tie retainer
b - Flat washer
c - Shift cable
d - Cable barrel

5. Check shift cable adjustments as follows:
   a. Shift the remote control into forward. The propeller shaft should be locked in gear. If not, adjust the barrel closer to the cable guide.
   b. Shift the remote control into reverse while turning the propeller. The propeller shaft should be locked in gear. If not, adjust the barrel away from the cable guide.
   c. Shift the remote control back to neutral. The propeller shaft should turn freely without drag. If not, adjust the barrel closer to the cable guide. Repeat steps a through c.

Throttle Cable Installation

Install the cables into the remote control following the instructions provided with the remote control.

1. Verify the throttle actuator timing mark is aligned with the timing mark on the bracket. Adjust the throttle link if necessary to achieve proper alignment.

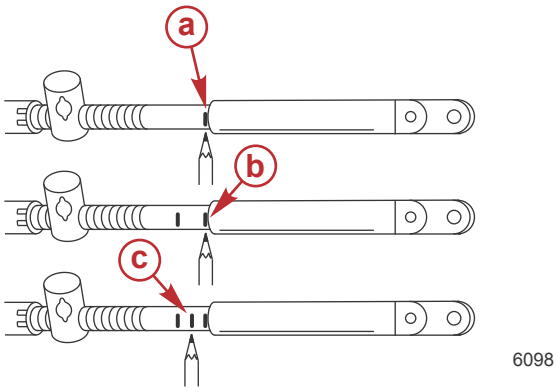


63126

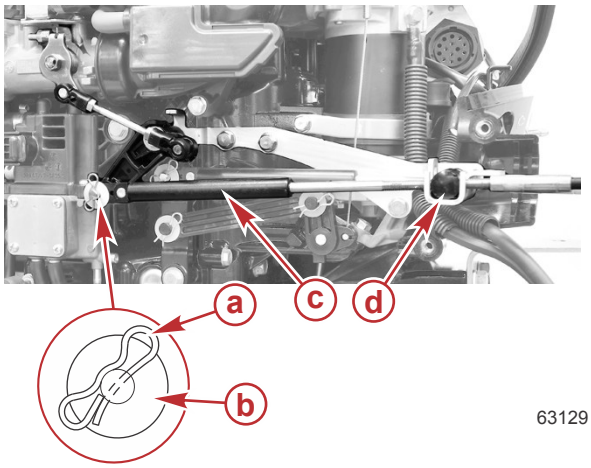
a - Throttle against stop
b - Throttle link
c - Timing marks aligned

2. Locate the center point of the slack or lost motion that exists in the throttle cable as follows:
   a. Move the remote control handle from neutral into forward and advance the handle to full speed position. Slowly return the handle back to neutral. Place a mark (a) on the cable next to the end guide.
   b. Move the remote control handle from neutral into reverse and advance the handle to full speed position. Slowly return the handle back to neutral. Place a mark (b) on the cable next to the end guide.

c. Make a center mark (c), midway between marks (a and b). Align the end guide with this center mark when installing the cable onto the engine.

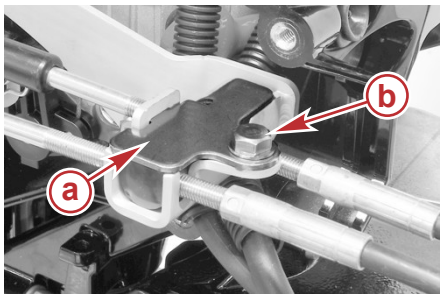


3. Attach the throttle cable end guide to the throttle lever with a washer and bow-tie retainer.
4. Adjust the cable barrel so the installed throttle cable will maintain alignment.
5. Position the throttle cable into the barrel receptacle.



a - Bow-tie retainer
b - Flat washer
c - Throttle cable
d - Cable barrel

6. Install the cable barrel retainer and secure with the screw. Tighten the screw to the specified torque.



a - Cable barrel retainer
b - Screw

Description	Nm	lb-in.	lb-ft
Screw	6	53	–

Battery Installation

NOTE: *Outboards with battery charging capabilities must not be operated with the battery cables disconnected from the battery. Damage to the charging system may result.*

Mounting Battery

Follow the battery manufacturer's instructions carefully. Mount the battery in the boat so it is secured against movement, preferably in a battery box. Ensure the battery is equipped with a nonconductive shield to prevent accidental shorting of the battery terminals. Electric starting outboards must have the battery cables connected to a battery whenever the engine is running, even if started manually, as damage to the charging system could result.

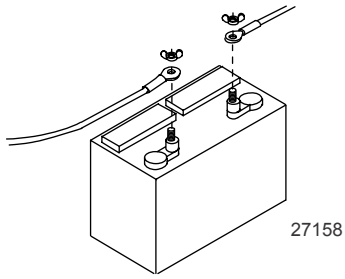
Battery Connections

Connecting Outboard Battery Cables

First, connect the red battery cable to the (+) positive battery terminal and then connect the black battery cable to the (–) negative battery terminal.

Disconnecting Outboard Battery Cables

First, disconnect the black battery cable from the (–) negative terminal and then disconnect the red battery cable from the (+) positive terminal.



Important Information

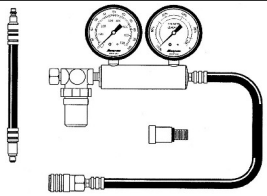
Section 1E - General Troubleshooting

Table of Contents

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	All ring terminal connections	92- 25711 3

Special Tools

Cylinder Leakage Tester	Snap-On EEPV309A
 11604	Aids in checking cylinder leakdown.

CDS G3 Diagnostic Tool Kit	8M0114141
 60575	Interfaces CDS G3 software to SmartCraft network. NOTE: This kit includes download instructions and a license key.

CDS G3 Cable Kit	8M0137534
 65167	Allows the use of the CDS G3 diagnostic tool on small EFI Fourstroke outboard engines.

Conditions Affecting Performance

Bottom of Boat

For maximum speed, a boat bottom should be nearly a flat plane where it contacts the water and particularly straight and smooth in fore and aft direction.

- **Hook:** Exists when bottom is concave in fore and aft direction when viewed from the side. When boat is planing, hook causes more lift on bottom near transom and allows bow to drop, thus greatly increasing wetted surface and reducing boat speed. Hook frequently is caused by supporting boat too far ahead of transom while hauling on a trailer or during storage.
- **Rocker:** The reverse of hook and much less common. Rocker exists if bottom is convex in fore and aft direction when viewed from the side, and boat has strong tendency to porpoise.
- **Surface roughness:** Moss, barnacles, etc., on boat or corrosion of outboard's gear housing increase skin friction and cause speed loss. Clean surfaces when necessary.

Cavitation

Cavitation occurs when water flow cannot follow the contour of a fast-moving underwater object, such as a gear housing or a propeller. Cavitation increases propeller speed while reducing boat speed. Cavitation can seriously erode the surface of the gear housing or the propeller. Common causes of cavitation are:

- Weeds or other debris snagged on the propeller
- Bent propeller blade
- Raised burrs or sharp edges on the propeller

Detonation

Detonation in a 4-cycle engine resembles the pinging heard in an automobile engine. It can be otherwise described as a tin-like rattling or plinking sound.

Detonation is the explosion of the unburned fuel/air charge after the spark plug has fired. Detonation creates severe shock waves in the engine. These shock waves often find or create a weakness: the dome of a piston, cylinder head or gasket, piston rings or piston ring lands, piston pin, and roller bearings.

A few of the most common causes of detonation in a marine 4-cycle application are as follows:

- Over-advanced ignition timing
- Use of low octane gasoline
- Propeller pitch too high: engine RPM below recommended maximum range
- Lean fuel mixture at, or near, wide-open throttle
- Spark plugs: heat range too hot, incorrect reach, cross-firing
- Deteriorated or inadequate engine cooling system
- Combustion chamber deposits: result in higher compression ratio

Detonation usually can be prevented if:

- The engine is correctly set up
- Regular maintenance is scheduled

Elevation, Weather, and Climate

Elevation, weather, and climate changes affect engine performance because an engine's power depends upon the density of the air that it consumes. Air density, in turn, is dependent upon the ambient air temperature, the barometric pressure, and the humidity (water vapor) content. Loss of performance can therefore be caused by:

- Higher elevations
- Higher temperatures
- Low barometric pressures
- High humidity

For optimum engine performance under changing conditions, it is essential that the engine be propped to allow the engine to operate at or near the top end of the specified maximum RPM range with a normal boat load during your normal boating weather conditions. In most cases, recommended RPM can be achieved by changing to a lower pitch propeller.

Propeller Selection

IMPORTANT: The engines covered in this manual are equipped with an RPM rev-limiter that is set to an upper RPM limit. This limit, which is slightly above the normal operating range of the engine, helps prevent damage from excessive engine RPM. Once the RPM returns to the recommended operating RPM range, normal engine operation resumes.

The boat manufacturer and the selling dealer are responsible for equipping the power package with the correct propeller. Refer to Mercury Marine's web page https://www.mercurymarine.com/en/us/propellers/selector/#/step-one.

Select a propeller that will allow the engine power package to operate at or near the top end of the recommended WOT operating RPM range with a normal load.

If full-throttle operation is below the recommended range, the propeller must be changed to prevent loss of performance and possible engine damage. On the other hand, operating an engine above the recommended operating RPM range will cause higher than normal wear and damage.

After initial propeller selection, the following common problems may require that the propeller be changed to a lower pitch.

- Warmer weather and greater humidity cause a loss of RPM.
- Operating in a higher elevation causes a loss of RPM.
- Operating with a dirty boat bottom causes a loss of RPM.
- Operating with increased load (additional passengers, pulling skiers) causes a loss of RPM.

For better acceleration, such as is needed for waterskiing, use the next lower pitch propeller. When not pulling skiers, do not operate at full throttle when using the lower pitch propeller.

Water Absorption

It is imperative that all through-the-hull fasteners be coated with a quality marine sealer at time of installation. Water intrusion into the transom core and/or inner hull will result in additional boat weight (reduced boat performance), hull decay, and eventual structural failure.

Weight Distribution (Passengers and Gear) Inside the Boat

Shifting weight to rear (stern):

- Generally increases speed and engine RPM
- Causes bow to bounce in choppy water
- Increases danger of following wave splashing into the boat when coming off plane
- At extremes, can cause the boat to porpoise

Shifting weight to front (bow):

- Improves ease of planing
- Improves rough water ride
- At extremes, can cause the boat to veer back and forth (bow steer)

Compression Check

1. Remove spark plugs.
2. Install compression gauge in spark plug hole.
3. Hold throttle plate at WOT.
4. Pull on the recoil rope or crank the engine over until the compression reading peaks on the gauge. Record the reading.
5. Check and record compression of each cylinder. The highest and lowest reading recorded should not differ by more than 15%. A reading below 827.4 kPa (120 psi) might indicate a total engine wear problem. **The following chart, is not a representation of compression values specific to the engine that is actually tested. It is only an example.**

Compression Test Differences		
Condition	**Maximum Reading**	**Minimum Reading**
Good	1241 kPa (180 psi)	1062 kPa (154 psi)
Bad	1172 kPa (170 psi)	972.2 kPa (141 psi)

6. To find the maximum allowable minimum compression reading difference, use this formula; highest compression reading x 0.85 = the lowest allowable difference. 1241 kPa x 0.85 = 1054.85 kPa (180 x 0.85 = 153 psi).
7. Compression check is important because an engine with low or uneven compression cannot be tuned successfully to give peak performance. It is essential, therefore, that improper compression be corrected before proceeding with an engine tune-up.
8. Cylinder scoring: If powerhead shows any indication of overheating, such as discolored or scorched paint, visually inspect cylinders for scoring or other damage as outlined in **Section 4 - Powerhead.**

Cylinder Leakage Test

Testing for the amount of cylinder leakage, along with compression testing, can help the mechanic pinpoint the source of a mechanical failure by gauging the amount of leakage in an engine cylinder.

NOTE: *Refer to the manufacturer's instruction procedures included with the tester.*

NOTE: *The spark plug hole is 12 mm in diameter. Use Snap-On adapter with valve core removed.*

Cylinder Leakage Tester	Snap-On EEPV309A

Analysis

Due to standard engine tolerances and engine wear, no cylinder will maintain 0% leakage. It is important the cylinders have a somewhat consistent reading between them. Differences of 15 to 30% indicate excessive leakage. Larger engines tend to have a greater percentage of cylinder leakage than smaller engines.

If excessive leakage is present, first check if the piston is at top dead center of its compression stroke. Leakage will naturally occur if the exhaust or intake valve is open.

To determine the cause of high percentage leak, locate the source of the air leak. Listen for air escaping through the throttle body, adjacent spark plug holes, exhaust pipe, or the crankcase oil fill plug. Use the following table to aid in locating the source of cylinder leakage.

Air Escaping From:	Indicates Possible Defective:
Throttle body	Intake valve
Exhaust system	Exhaust valve
Crankcase oil fill plug	Piston or rings
Adjacent cylinders	Head gasket

Guardian Protection System

The Guardian Protection System monitors critical engine functions and will reduce engine power accordingly in an attempt to keep the engine running within safe operating parameters.

IMPORTANT: The Guardian Protection System cannot guarantee that powerhead damage will not occur when adverse operating conditions are encountered. The Guardian Protection System is designed to 1) warn the boat operator that the engine is operating under adverse conditions and 2) reduce power by limiting maximum RPM in an attempt to avoid or reduce the possibility of engine damage. The boat operator is ultimately responsible for proper engine operation.

Warning System

Warning Horn Location

A warning horn is located near the front of the engine, under the cowl. On remote control models, an additional warning horn is located inside the remote control or connected to the ignition key switch.

Warning Light Location

The warning light is located on the front of the engine, just below the top cowl. It will turn on or flash to alert the operator to the warning system situations listed in **Warning System Operation**.

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Warning System Operation

Overview

The warning system is designed to alert the operator of problems with the engine's operation. The following chart provides a brief overview of the system operation in certain situations.

Function	Warning Horn	Warning Lamp	Description	Rev Limit
Start up	One second		System test	None
No fault	None		System normal	None
Overheat	Continuous for six seconds	On	Engine overheat	2800 RPM
Low oil pressure			Low oil pressure	
Sensor error	Six beeps no repeats	Six flashes repeats every five minutes	Engine sensor fault	
Overspeed (20 hp models)	None		Engine speed too high	6300 RPM*
Overspeed (10/15 hp models)	None		Engine speed too high	5600 RPM*
Restrictor (10/15 hp models only)	Six beeps no repeats	Six flashes repeats every five minutes	Restrictor missing	2800 RPM

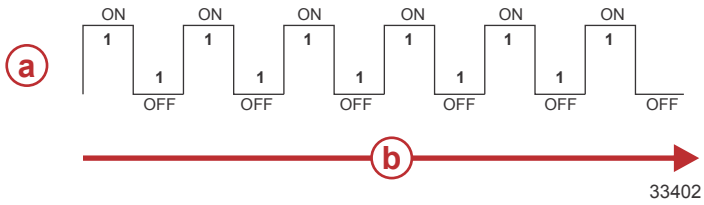
**Engine misfire may be noticed.*

Warning System States

The warning system, comprised of horn and light, serves to alert the operator to most engine system faults. There are two warning states:

- Caution
- Critical

If a caution state is detected, the warning system will sound the horn for six one-second intervals, and then remain silent. The warning light will flash six times, in sync with the horn, and then will repeat every five minutes.

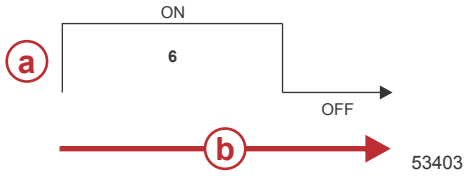


Caution state sequence

a - Horn and light (on or off); light repeats every five minutes

b - Time (in seconds)

If a critical state is detected, the warning system sounds the horn for six seconds and then turns off. The warning light will turn on and remain lit as long as the fault is active.



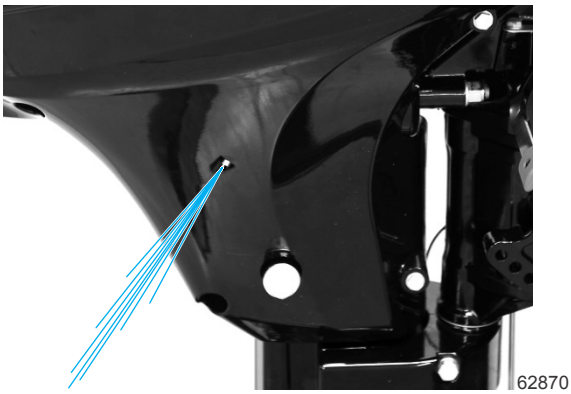
Critical state horn sequence

a - Horn (on or off); light remains lit

b - Time (in seconds)

Engine Overheat

If the engine overheats, immediately reduce throttle speed to idle. Shift the outboard into neutral and check for a steady stream of water coming out of the water pump indicator hole.



If no water is coming out of the water pump indicator hole, or flow is intermittent, stop the engine and check the cooling water intake holes for obstruction. If no obstruction is found, there may be a blockage in the cooling system or a water pump problem. Operating the engine while overheated will cause engine damage.

If a steady flow of water is coming out of the water pump indicator hole and the engine continues to overheat, service is required. Operating an overheated engine will cause engine damage.

NOTE: *Should overheating occur and you are stranded, stop the engine and allow it to cool down. This will usually allow some additional low speed (idle) running time before the engine starts to overheat again.*

Low Oil Pressure

The warning system will be activated if the oil pressure drops too low. First, stop the engine and check the oil level. Add oil if necessary. If the oil level is within the operating range and the warning horn continues to sound, service is required. Engine speed will be limited to 2800 RPM, however, you should not continue to run the engine.

Engine Overspeed Limiter

Some causes of engine overspeed are as follows:

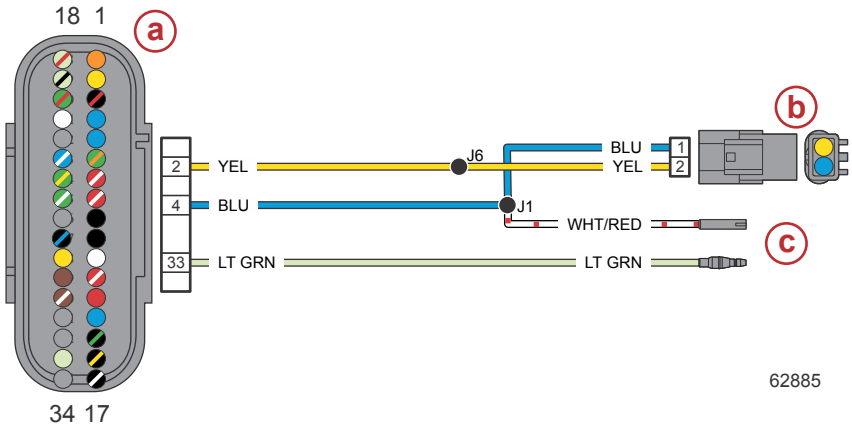
- Propeller ventilation
- A propeller that has an incorrect pitch or diameter
- Propeller hub slippage
- Outboard mounted too high on the transom
- Tilting the outboard out beyond a vertical position
- Cavitation of the propeller due to rough water or obstruction in the boat hull

When the engine overspeed limiter is activated, the engine timing will be momentarily retarded to decrease the engine speed. Excessive overspeed will result in the momentary removal of ignition to prevent operation above the RPM limit.

Wire Color Code Abbreviations

Wire Color Abbreviations				
BLK	Black		BLU	Blue
BRN	Brown		GRA	Gray
GRN	Green		ORN	Orange
PNK	Pink		PPL	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT	Light		DK	Dark

Warning System Wiring Diagram



a - Engine control module (ECM)
b - Warning horn
c - Warning light

Troubleshooting without a Computer Diagnostic System (CDS)

Troubleshooting without a computer diagnostic system (CDS) is limited to checking resistance on some of the sensors.

Typical failures usually do not involve the ECM. Connectors, setup, or mechanical wear are most likely at fault.

- Verify the ignition coils are securely connected to the spark plugs.
- The engine may not run or may not run above idle with the wrong spark plugs installed.
- Swap ignition coils to see if the problem follows the coil or stays with the particular cylinder.

IMPORTANT: Disconnecting a sensor while the engine is running may result in a fault recording in the ECM Fault History. Use the CDS to view the ECM fault history when troubleshooting/repair is completed.

- If all cylinders exhibit similar symptoms, the problem is with a sensor or harness input to the ECM.
- If a problem is speed related or intermittent, it is probably connector or contact related. Inspect connectors for corrosion, loose wires, or pins pushed back into the connector. Verify the connectors are properly seated.
- Inspect the harness for damage: pinched or cut wires and chafing.
- Secure the grounds and all connections involving ring terminals. Apply Liquid Neoprene to all ring terminal connections.

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	All ring terminal connections	92- 25711 3

- Inspect the fuel pump electrical connector for corrosion, loose wires, or pins pushed back into connector.
- Check the fuel pump pressure.

Troubleshooting with CDS G3

The ECM is designed such that if a sensor fails, the ECM will prevent the engine from going into an overly rich condition. This means that disconnecting a sensor for troubleshooting purposes may have no noticeable effect, presenting the technician with a difficult diagnostic challenge. To meet this challenge, Mercury Marine has developed the CDS G3 diagnostic tool.

About CDS G3

CDS G3 is a standalone program that provides diagnostic support for select Mercury engines and engine control systems. CDS G3 also supports all configuration functions necessary for preparing these systems for delivery. CDS G3 provides a clean, easy-to-navigate interface.

This manual assumes that you have successfully installed CDS G3 on your computer and have updated it to the most current version. For installation instructions, refer to the user manual loaded onto the computer diagnostic system laptop (in the Windows® **Start** menu > All Programs > Mercury Marine > User Manual).

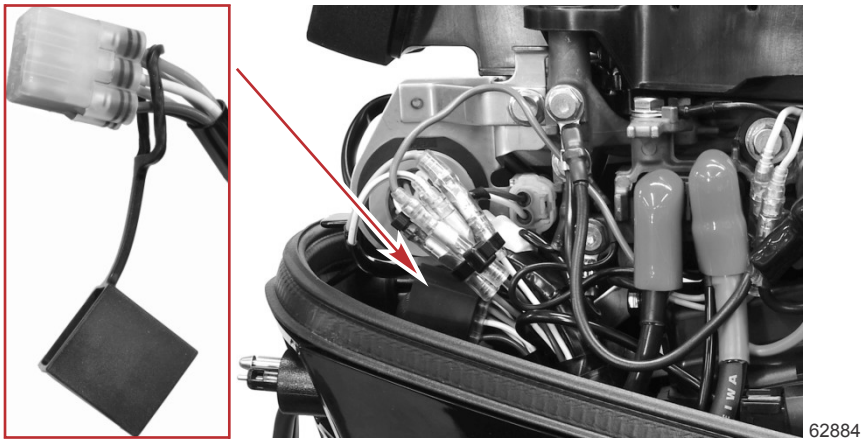
Connecting CDS G3

CDS G3 Diagnostic Tool Kit	8M0114141

1. Insert the CDS G3 SmartCraft diagnostic interface USB connector into a USB port on your computer.
2. Connect the SmartCraft cable to the serial adapter cable from the CDS G3 cable kit.

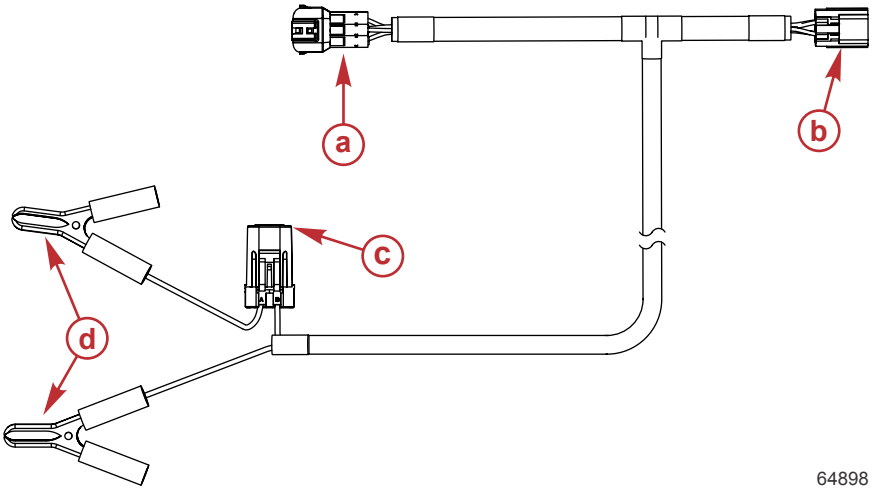
CDS G3 Cable Kit	8M0137534

3. Connect the serial adapter cable to the diagnostic adapter harness.
4. Connect the diagnostic adapter harness to the ECM diagnostic connector on the engine.



ECM diagnostic connector (location approximate)

5. Connect the red and black clips on the diagnostic adapter harness to the positive and negative battery terminals, respectively.



Diagnostic adapter harness

- **a -** To serial adapter cable
- **b -** To ECM diagnostic connector
- **c -** 5-amp fuse (in positive cable)
- **d -** To 12 V battery

NOTE: *For manual start models, use a shop battery or other suitable 12 volt battery.*

Using CDS G3

CDS G3 will monitor sensors and ECM data, including status switches. The ECM program can help diagnose intermittent engine problems. It can record the state of the engine sensors and switches for a period of up to 10 minutes, which can then be played back and analyzed.

When using CDS G3 for troubleshooting, follow the driven troubleshooting menu for the complete diagnostic troubleshooting procedures.

Accessing ECM Information with CDS G3

CDS G3 Diagnostic Tool Kit	8M0114141

CDS G3 Cable Kit	8M0137534

- CDS G3 requires the technician to select the specific engine to which it is connected. Accurate engine identification is important, because in many cases, the available testing options depend on the engine identified.
- The diagnostic cable connection supplies power to the ECM.
- Fault codes can be displayed active or historic. **View Faults** displays the code number, description, and the source of the faults. **Freeze Frame** displays a fault number and text that corresponds to the exact moment in the engine's run history that the fault was set.

CDS G3 Screens (10/15/20 EFI)

CDS G3 Live Data Screen

STARBOARD ENGINE — Engine | Meters | Graph | 0

	SENSOR NAME	VALUE (a)		DESCRIPTION
☐	Fuel Flow	---gal/h		Fuel consumption
☐	Engine Speed	---r/min		Engine speed
☐	Throttle Position	---°		Throttle position
☐	Manifold Pressure	---psi		Manifold pressure
☐	Atmospheric Pressure	---psi		Atmospheric pressure
☐	Engine Temperature	---°F (b)		Sea Water/Engine Temperature
☐	IAC Duty Cycle	---%		IAC On Duty
☐	Engine Operating Hour	---h		Engine Operating Hour
☐	Target Idle Speed	---r/min		Target Idle Speed
☐	Engine Control state	---		Engine Control state
☐	Ignition timing	---°BTDC		Ignition timing
☐	Lanyard State	---		Lanyard State
☐	Oil pressure switch state	---		Oil pressure switch state
☐	Injector pulse width	Data 1	Data 2	Injector pulse width
		---	---	

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CDS G3 Live Data screen for 10/15/20 EFI FourStroke

a - Units of measure are configurable, U.S. units shown

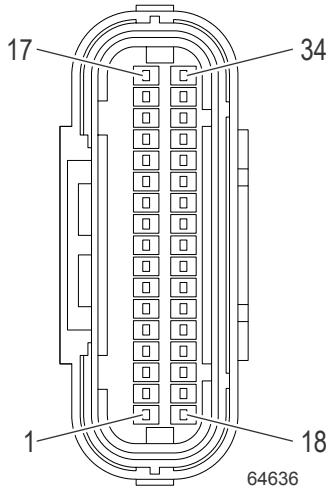
b - Default temperature reading is 25 °C (77 °F)

CDS G3 Diagnostics Screen

Use the **Diagnostics** screen to confirm proper operation of various system components. To perform one of the listed diagnostics, click the appropriate button, and follow the on-screen instructions.

64646

Engine Control Module Pinout

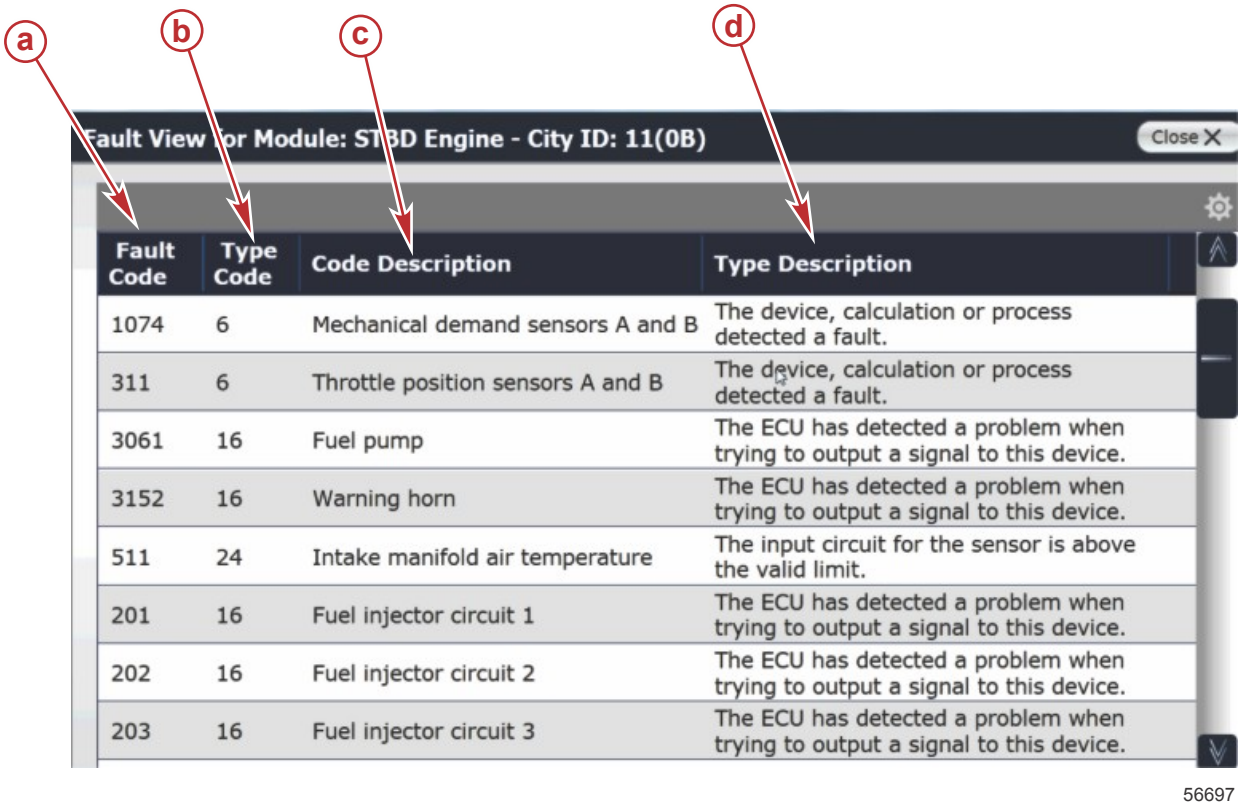
Connector	Pin	Wire Color	Function
	1	Orange	Ignition coil
	2	Yellow	Warning horn
	3	Black/red	Stator coil H
	4	Blue	12 VDC
	5	Blue	Stator coil L
	6	Green/orange	MAP sensor
	7	Red/white	Sensor power 5 VDC
	8	Red/white	CPS (signal)
	9	Black	CPS (ground)
	10	Black	Ground
	11	White	Diagnostics (Rx)
	12	Red/white	Communication power 5 VDC
	13	Red	Battery input (diagnostics)
	14	Blue	Boot mode
	15	Black/green	VST W
	16	Black/yellow	VST V
	17	Black/white	VST U
	18	Light green/red	Injector 1
	19	Light green/black	Injector 2
	20	Green/red	IAC valve
	21	Gray	Tachometer
	22	N/A	Not used
	23	Blue/white	TPS
	24	Green/yellow	ECT sensor power
	25	Green/white	MAT sensor
	26	N/A	Not used
	27	Black/blue	Sensor ground
	28	Yellow	Diagnostics (Tx)
	29	Brown	Stop switch
	30	Brown/white	Oil pressure switch power supply
	31	N/A	Not used
	32	N/A	Not used
	33	Light green	LED
	34	N/A	Not used

Fault Codes

Mercury Universal Fault Codes

Mercury universal fault codes help ensure uniformity in fault reporting in control modules. It also ensures that boat operators receive consistent information and instruction, such as **Service Engine Soon**, **Reduce Engine Speed**, and others in response to specific faults.

For CDS G3 users this means that instead of seeing a fault such as INJ1_OutputFault, the fault will now appear as **201 (Fuel injector circuit 1), 16 (The ECU has detected a problem when trying to output a signal to this device.).**



Fault Code	Type Code	Code Description	Type Description
1074	6	Mechanical demand sensors A and B	The device, calculation or process detected a fault.
311	6	Throttle position sensors A and B	The device, calculation or process detected a fault.
3061	16	Fuel pump	The ECU has detected a problem when trying to output a signal to this device.
3152	16	Warning horn	The ECU has detected a problem when trying to output a signal to this device.
511	24	Intake manifold air temperature	The input circuit for the sensor is above the valid limit.
201	16	Fuel injector circuit 1	The ECU has detected a problem when trying to output a signal to this device.
202	16	Fuel injector circuit 2	The ECU has detected a problem when trying to output a signal to this device.
203	16	Fuel injector circuit 3	The ECU has detected a problem when trying to output a signal to this device.

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An active fault list example (actual screen appearance may vary)

a - Fault code (the affected component)
b - Fault type code (how it was affected)
c - Code description
d - Fault code type description

In the last line of this example, component **203**, **Fuel injector circuit 3**, had a fault type **16**, meaning that the ECM/PCM is unable to output a signal to the device. This could indicate a faulty fuel injector, or in this case, where the same fault is affecting multiple injector and other components, likely indicates a more widespread fault, such as an unplugged harness, issues with a power supply, or some other systemic issue.

Mercury Universal Fault Code Table (10/15/20)

Refer to the following table for an explanation of faults and possible solutions when using the CDS G3 diagnostic interface tool.

Fault Code	Type Code	Code Description	Type Description	Possible Root Cause
0	0	Fault system	The system has no active faults.	–
101	16	Ignition circuit 1	The ECU has detected a problem when trying to output a signal to this device.	Ignition coil, wire harness, or ECM failure
201	1	Fuel injector circuit 1	The output signal from the ECU to the device is open circuit or has too much resistance.	Faulty fuel injector
202	1	Fuel injector circuit 2	The output signal from the ECU to the device is open circuit or has too much resistance.	Faulty fuel injector
300	12	Throttle position sensor group	The device is disabled due to conditions present.	Faulty throttle position sensor
407	15	Manifold pressure sensor barometer reading	The diagnostic performed at key on has failed.	Faulty TMAP sensor

Fault Code	Type Code	Code Description	Type Description	Possible Root Cause
511	13	Intake manifold air temperature	Lost communication with device.	Faulty TMAP sensor
541	22	Seawater temperature	Relative to a specified threshold, the value is too high.	Faulty ECT sensor
621	5	System voltage	The signal received is valid but is lower than the expected range.	Faulty stator coil or associated wiring
3061	2	Fuel pump	The output signal from the ECU to the device is short circuit or has too little resistance.	Contamination in the electric fuel pumps or failure of the pumps
3160	11	Idle air control system	Too little fuel is detected relative to the amount of air.	Faulty IAC valve

Descriptive Fault List (10/15/20)

Fault Name	Warning Type*	Power Limit	UFC	Possible Root Cause
Coolant temp high	Critical	2800 RPM	–	Water pump; debris in the system
ETC sensor open	Caution	None	541-22	Wiring issue; bad component
ETC sensor short	Caution	None	541-22	Wiring issue; bad component
Fuel injector #1 output	Caution	None	201-1	Wiring issue; bad component
Fuel injector #2 output	Caution	None	202-1	Wiring issue; bad component
Fuel pump output	Caution	None	3061-2	Contamination in the electric fuel pump or failure of the pump
IAC output	Caution	None	3160-11	Wiring issue; bad component
Ignition coil #1 output	Caution	None	101-16	Ignition coil, wire harness, or ECM failure
MAP sensor open	Caution	None	407-15	Wiring issue; bad component
MAP sensor short	Caution	None	407-15	Wiring issue; bad component
MAT sensor open	Caution	None	511-13	Wiring issue; bad component
MAT sensor short	Caution	None	511-13	Wiring issue; bad component
MAT temp high	Caution	None	–	Wiring issue; bad component
Oil pressure low	Critical	2800 RPM	–	Oil level low; bad sensor
Restrictor missing	Caution	2800 RPM	–	Restrictor missing
System voltage (stator coil 1)	Caution	None	621-5	Wiring issue; defective stator
TPS open	Caution	None	300-12	Wiring issue; bad component
TPS short - 5 V	Caution	None	300-12	Wiring issue; bad component
TPS short - ground	Caution	None	300-12	Wiring issue; bad component

NOTE: **Refer to **Warning System Operation** for descriptions of the two types (states) of warnings.*

Notes:

Electrical

Section 2A - Ignition

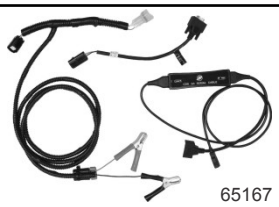
Table of Contents

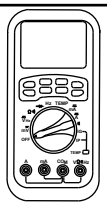
Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
6	Dielectric Grease	Oil pressure switch electrical connection	92-823506 1
9	Loctite® 567 PST Pipe Sealant	Threads of the oil pressure switch	92-809822

Special Tools

CDS G3 Diagnostic Tool Kit	8M0114141
 60575	Interfaces CDS G3 software to SmartCraft network. NOTE: This kit includes download instructions and a license key.

CDS G3 Cable Kit	8M0137534
 65167	Allows the use of the CDS G3 diagnostic tool on small EFI Fourstroke outboard engines.

DMT 2004 Digital Multimeter	91-892647A01
 4516	Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments.

Flywheel Holding Tool	91- 52344
 4738	Holds and/or turns the flywheel while making engine repairs, also used to torque the flywheel or the engine coupler.

Ignition Specifications at 20 °C (68 °F)

Parameter		Specification
Ignition type		Computer-controlled capacitor discharge ignition (CDI)
Spark plug		NGK DCPR6E
Spark plug gap		0.9 mm (0.035 in.)
Ignition timing at idle		5° ± 5° BTDC
Ignition timing at WOT		28° BTDC
RPM overspeed	SeaPro models	5800 RPM
	15/20 JCI models	6300 RPM
	All other (10/15/20 hp)	6500 RPM

Parameter		Specification
ECM RPM limiter (Guardian)		2800 RPM
Overtemperature		85 °C (185 °F)
Low oil pressure (over 10 seconds)		26.3 kPa (3.8 psi)
Crankshaft position sensor		148–222 Ω
Ignition coil	Primary	0.26–0.35 Ω
	Secondary (with plug wires and caps)	16.8–20.2 kΩ
	Spark plug lead (without spark plug cap)	3.0–7.5 kΩ

Ignition Theory of Operation

The ignition system uses a microcomputer-controlled capacitor discharge ignition (CDI) system. This system provides quick voltage build-up and the strong spark required for high power and high performance engines.

This is a stator-powered, synchronous multiport fuel injection outboard. No battery voltage source is required for the engine operations. The flywheel must be rotating at a minimum of 250 RPM to generate the 5 VDC required to energize the engine control module (ECM) and maintain an active warning system.

As the flywheel rotates, the stator produces alternating current, which is rectified by the ECM for the ignition and fuel delivery systems. When the ignition driver is off, a capacitor inside the ECM stores the DC voltage. When the capacitor is charged to its potential, an applied gate signal allows the charge to dissipate through the primary winding of the ignition coils.

A timing key cast into the flywheel rotates past the crankshaft position sensor (CPS), collapsing a magnetic field, sending a signal to the ECM to indicate crankshaft position and engine speed. The ECM uses this data to calculate the gate signal for dissipating the capacitor charge.

The ECM also obtains information from the engine coolant temperature (ECT) sensor, manifold absolute pressure (MAP) sensor, and manifold air temperature (MAT) sensor to formulate the correct ignition timing. The output from an oil pressure switch indirectly affects ignition timing, as the ECM will limit engine speed, if the oil pressure is too low.

General Troubleshooting

For general troubleshooting information, including connecting and using the CDS G3 diagnostic tool, refer to **Section 1E - General Troubleshooting**.

Engine Control Module (ECM)

This engine control module (ECM) is powered by the stator, and does not require a 12-volt battery to function. As the flywheel is rotated by the recoil rope or electric starter, the stator begins to generate voltage to energize the ECM. The ECM rectifies the applied voltage to keep itself powered as well as to supply voltage to the various sensors, ignition coils, and high-pressure fuel pump. The ECM does not supply power for the optional electric start or power tilt circuits.

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The ECM receives information from the engine sensors. It uses this data to calculate ignition timing, fuel injection timing, and fuel injection pulse width (duration). The ECM then sends signals to the actuators to turn them on or off according to the values calculated for optimum performance.

The ECM will generate a warning horn and warning light if the coolant temperature exceeds its upper limit, the oil pressure switch indicates low pressure, or a sensor's value is outside of its parameters.

The ECM stores past running information and failure codes. Engine operating information and stored running history can be monitored and reviewed using CDS G3. An adapter harness connects the CDS G3 computer to the ECM diagnostic port.

CDS G3 Diagnostic Tool Kit	8M0114141
CDS G3 Cable Kit	8M0137534

ECM Systems Control Matrix

ECM Control Item	Description
Ignition timing	Controls the optimum ignition timing according to the current operating conditions
Fuel injection	Controls the fuel injection pulse width (duration) for optimum efficiency according to current operating condition
Idle air control (IAC)	Stabilizes the engine RPM when idling and during quick engine RPM deceleration by managing the duty cycle driving the IAC in order to control bypass air entering the intake manifold
Tachometer	Sends out six tachometer pulses per engine revolution (12 pole)
Warning horn and light	Refer to **Section 1E - Warning System Operation**
Fault and running data memory	• Engine running time • Over temperature and time of occurrence • Engine Guardian (overspeed, and speed reduction to 2800 RPM or less) • Sensor failures

Troubleshooting

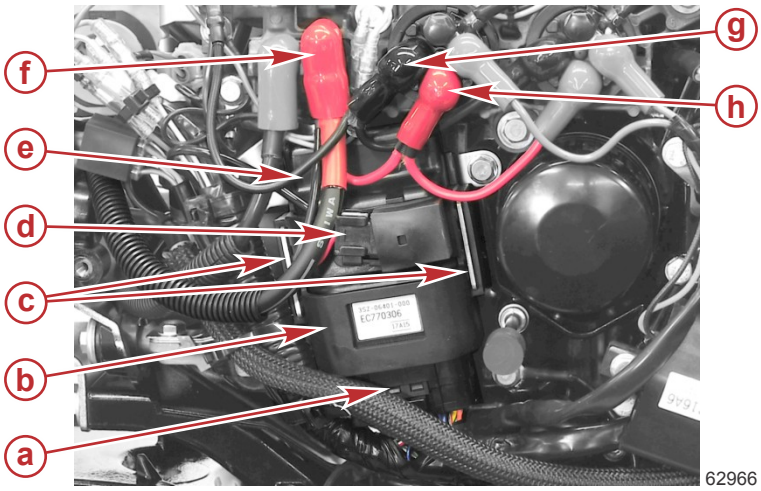
The ECM is a highly reliable component, and is rarely the source of a running issue. However, if the ECM should completely fail, the engine will not operate.

For troubleshooting, refer to:

- **Section 1E - Accessing ECM Information with CDS G3**
- The appropriate engine wiring diagram in **Section 9A - Color Diagrams**

Removal

1. For models with electric start, disconnect the battery, and remove the positive battery cable from the starter solenoid.
2. For models with power tilt, remove the positive and negative wires from the tilt up relay.
3. Remove the 15-amp fuse block from its holder on the front of the ECM rubber mount.
4. Slide the ECM and rubber mount off of the ECM bracket.
5. Disconnect the ECM from the engine harness.



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Power tilt model shown, others similar

- **a -** Engine harness connector
- **b -** Rubber mount
- **c -** ECM bracket
- **d -** 15-amp fuse block
- **e -** ECM
- **f -** Positive battery cable (models with electric start only)
- **g -** Negative wire connection at the tilt up relay (models with power tilt only)
- **h -** Positive wire connection at the tilt up relay (models with power tilt only)

6. Remove the ECM from its rubber mount.

Installation

1. Slide the ECM rubber mount over the ECM.
2. Connect the ECM to the engine harness.
3. Slide the ECM and mount onto the ECM bracket. Ensure that the metal bracket protrudes through the rubber mount on either side.
4. Insert the 15-amp fuse block into its holder on the front of the ECM rubber mount.
5. For models with power tilt, connect the positive and negative wires to the tilt up relay.
6. For models with electric start, connect the positive battery cable to the starter solenoid.

Wire Color Code Abbreviations

Wire Color Abbreviations				
BLK	Black		BLU	Blue
BRN	Brown		GRA	Gray
GRN	Green		ORN	Orange
PNK	Pink		PPL	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT	Light		DK	Dark

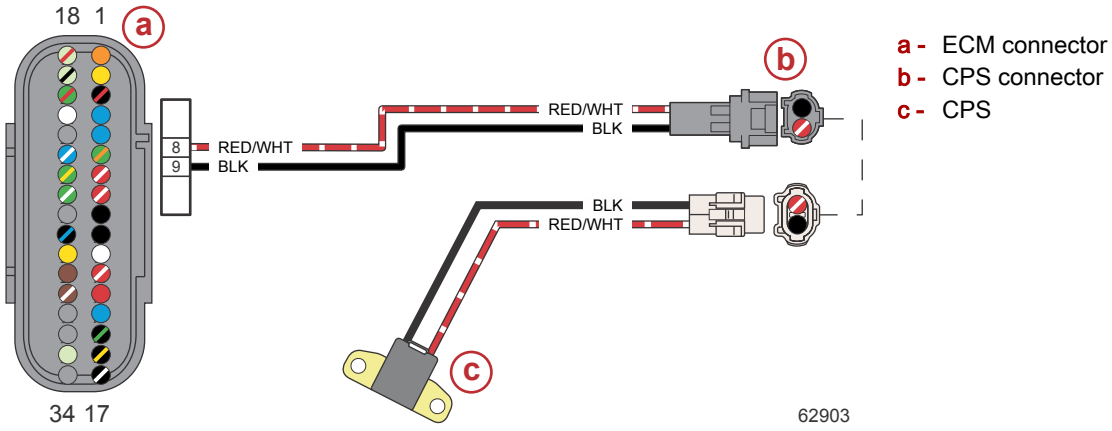
Sensors

Crankshaft Position Sensor

The crankshaft position sensor (CPS) is a hall effect switch, which senses the collapse of a magnetic field. The CPS is located at the top of the cylinder block, next to the flywheel.

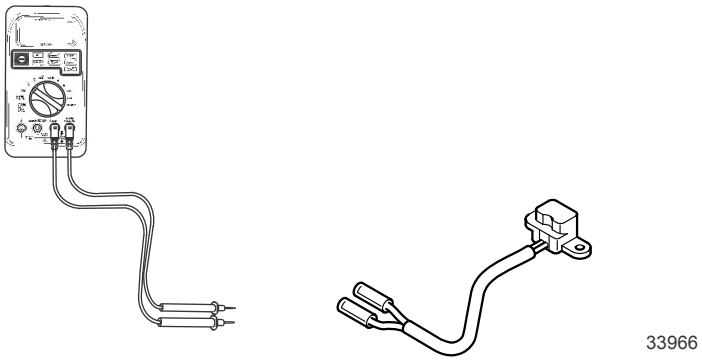
There is a timing key (indentation) in the flywheel casting, below the ring gear, and when the key passes the CPS, the CPS generates an electric pulse. This pulse is sent to the engine control module (ECM). The timing and frequency of the pulse allows the ECM to regulate ignition and fuel injector timing. If the CPS fails, the engine will run rough or stop running.

Wiring Diagram



Crankshaft Position Sensor Test

With the engine not running, disconnect the CPS from the engine harness, and measure the sensor's resistance with a DMT 2004 Digital Multimeter, or equivalent.

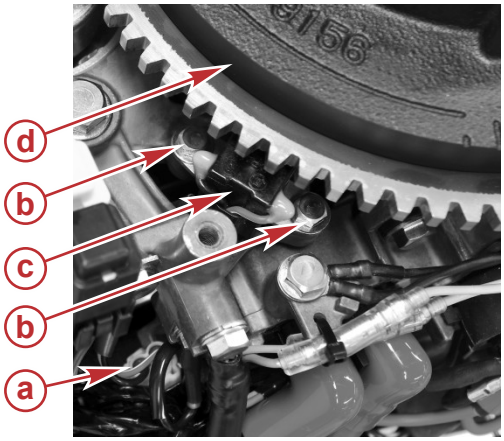


DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading
Red	Black		
Red/white	Black	Ω	148–222 Ω

CPS Removal

1. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
2. Disconnect the CPS from the engine harness at the 2-pin connector.
3. Remove the two screws that secure the CPS, and remove the CPS.



a - CPS 2-pin connector
b - Screw (2)
c - CPS
d - Flywheel

CPS Installation

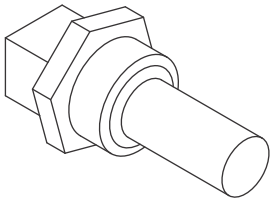
1. Secure the CPS to the engine with two screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
CPS screws	3.0	26.6	–

2. Connect the CPS to the engine harness at the 2-pin connector.
3. Install the air box and recoil starter assembly.
   - It is easiest to install the recoil starter and air box together.
   - Refer to **Section 8A - Recoil Starter** and **Section 3C - Air Box Installation**.

Engine Coolant Temperature (ECT) Sensor

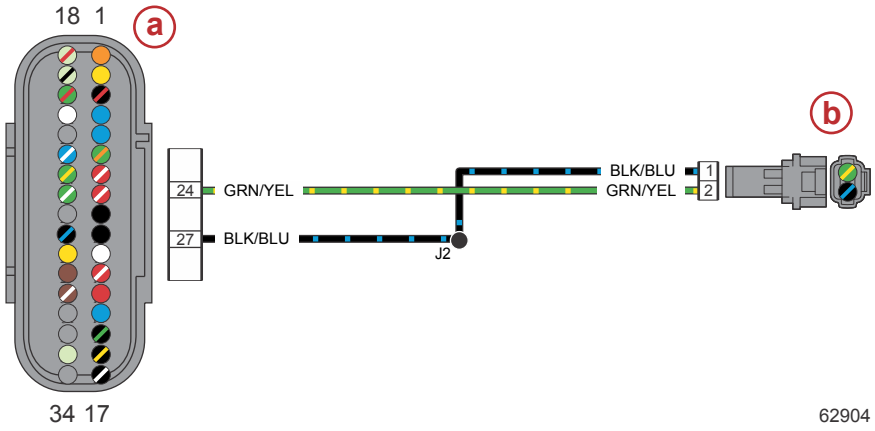
The engine coolant temperature sensor is located at the top of the cylinder block. The ECT sensor monitors the temperature of the cooling water that has passed through the engine as controlled by the thermostat. The ECM uses the data from the ECT sensor in its calculations for the amount of fuel to inject into the combustion chamber to achieve optimum fuel economy, based on the engines RPM.



21113

In the event of an overtemperature exceeding 85 °C (185 °F), the ECM will limit engine power, generate a failure code, and complete the circuit for the warning horn and warning light, informing the operator of potential engine damage.

ECT Wiring Diagram

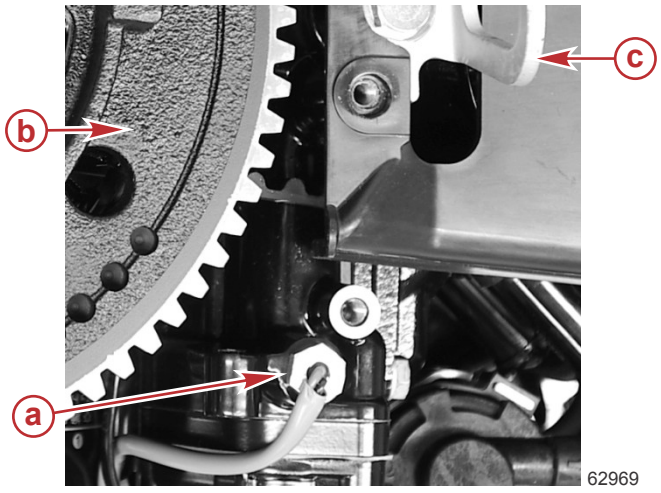


62904

a - ECM connector
b - ECT connector

ECT Sensor Removal

1. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
2. Release the reusable cable tie that secures the sensor lead to the electrical bracket.
3. Disconnect the ECT 2-pin connector from the engine harness.
4. Use an appropriate wrench to remove the ECT sensor from the engine.



62969

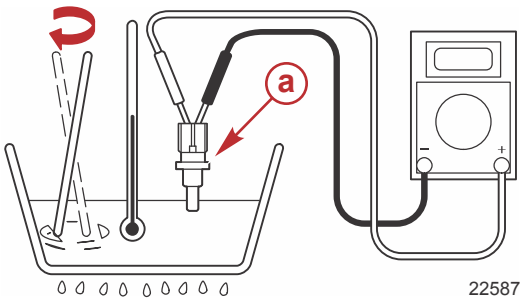
a - ECT sensor
b - Flywheel
c - Engine lifting eye

ECT Sensor Test

1. Place the ECT sensor in a container filled with water.
2. Place a thermometer in the water, and slowly heat the water.

3. Measure the resistance when the specified temperature is reached. If out of specification, replace the sensor.

DMT 2004 Digital Multimeter	91-892647A01

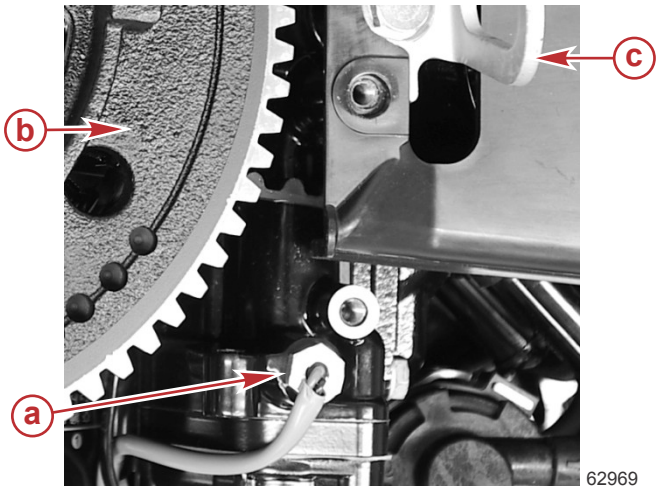


a - Engine coolant temperature sensor

Meter Test Leads		Meter Scale	Temperature	Reading
Red	Black			
Black/blue	Green/yellow	Auto	5 °C (41 °F)	4.24 kΩ–4.86 kΩ
			25 °C (77 °F)	1.90 kΩ–2.10 kΩ
			100 °C (212 °F)	166 Ω–204 Ω

ECT Sensor Installation

1. With a new O-ring in place, thread the ECT sensor into the engine.



a - ECT sensor
b - Flywheel
c - Engine lifting eye

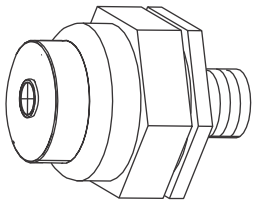
2. Tighten the sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
ECT sensor	4.0	35.4	–

3. Connect the ECT sensor 2-pin connector to the engine harness.
4. Use the reusable cable tie to secure the sensor lead and the other wires to the electrical bracket.
5. Install the air box and recoil starter assembly.
   - It is easiest to install the recoil starter and air box together.
   - Refer to **Section 8A - Recoil Starter** and **Section 3C - Air Box Installation**.

Oil Pressure Switch

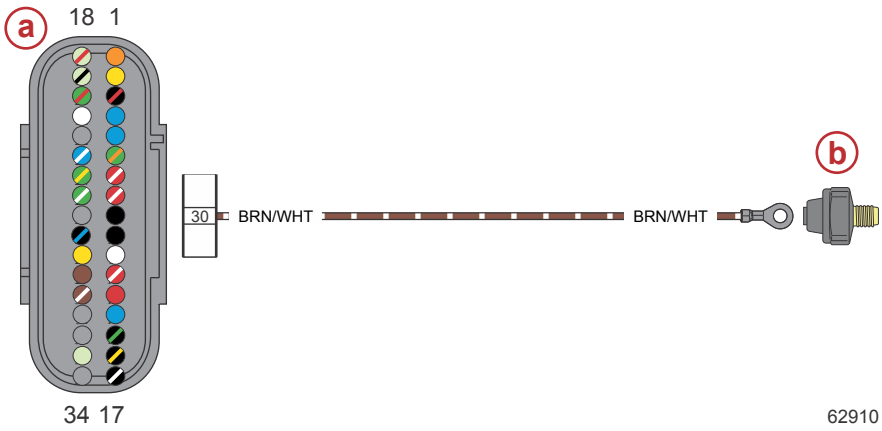
The oil pressure switch is located at the bottom port side of the powerhead. It is a pressure sensitive switch that will show either continuity or no continuity.



21122

If the engine oil pressure drops below 24.5 kPa (3.5 psi) for more that 0.5 seconds, the ECM will limit engine power, generate a failure code, and complete the circuit for the warning horn and warning light, informing the operator of potential engine damage. The warning system can be reset by stopping the engine.

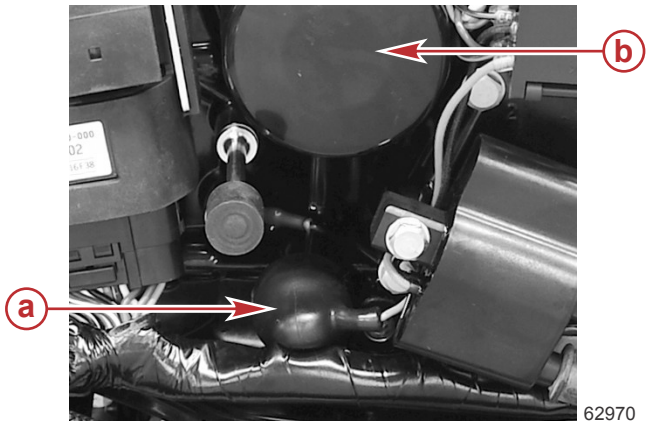
Wiring Diagram



a - ECM connector
b - Oil pressure switch

Removal

1. Remove the port side driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.
2. Slide the rubber boot off the oil pressure switch.
3. Remove the screw that secures the harness wire to the switch.
4. Remove the oil pressure switch from the cylinder block.



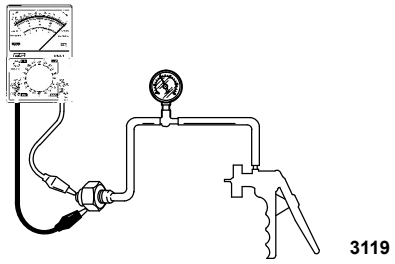
a - Oil pressure switch
b - Oil filter

Switch Testing

1. Connect the red lead of an ohmmeter to the terminal and the black lead to the oil pressure switch metal body.

DMT 2004 Digital Multimeter	91-892647A01

2. Using a controllable air pressure source, apply air pressure to the oil pressure switch. Check for continuity specifications.



Meter Test Leads		Meter Scale	Applied pressure	Reading
Red	Black			
Switch terminal	Switch body	Resistance Auto	24.5 kPa (3.55 psi) or higher	Open
			0 kPa (0 psi)	Continuity

Installation

1. Apply Loctite® 567 PST Pipe Sealant to the threads of the oil pressure switch.

Tube Ref No.	Description	Where Used	Part No.
9	Loctite® 567 PST Pipe Sealant	Threads of the oil pressure switch	92-809822

2. Thread the oil pressure switch into the cylinder block. Tighten the oil pressure switch to the specified torque.
3. Use a screw to attach the ring terminal connector (brown/white wire) from the engine harness to the oil pressure switch. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Oil pressure switch	8.0	70.8	–
Screw securing ring terminal to oil pressure switch	1.5	13.3	–

4. Coat the electrical connection with dielectric grease to prevent corrosion.

Tube Ref No.	Description	Where Used	Part No.
6	Dielectric Grease	Oil pressure switch electrical connection	92-823506 1

5. Slide the rubber boot over the switch.
6. Install the port side driveshaft housing cover (refer to **Section 5A - Driveshaft Housing Covers**). Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Driveshaft housing cover screws	6.0	53.1	–

Temperature and Manifold Absolute Pressure (TMAP) Sensor

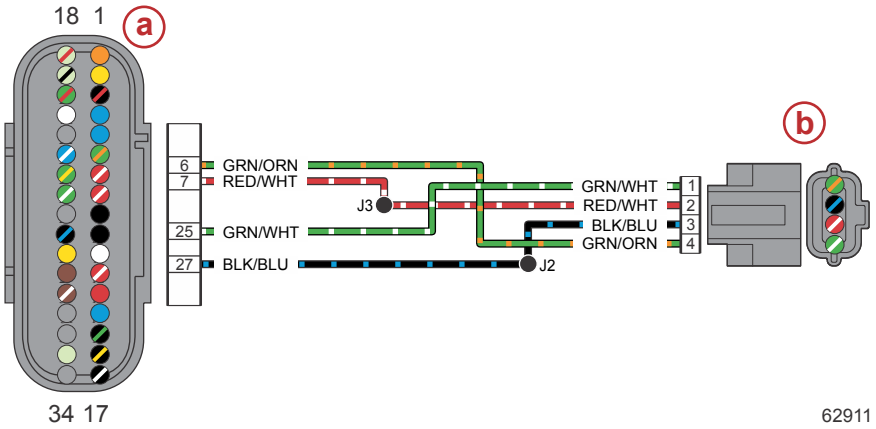
The manifold absolute pressure (MAP) sensor is a pressure transducer that measures the changes in intake manifold pressure caused by engine load and speed in order to calculate fuel and spark timing requirements.

Manifold absolute pressure is the opposite of manifold vacuum. That is, MAP is low when vacuum is high (such as closed throttle), and MAP is high when vacuum is low (such as at wide-open throttle).

The manifold air temperature (MAT) sensor measures the charge air temperature. This information is then conducted to the ECM for processing.

The temperature and manifold absolute pressure (TMAP) sensor combines the manifold absolute pressure sensor and manifold air temperature sensor into a single unit. The TMAP sensor is positioned in the throttle body, downstream of the throttle plate.

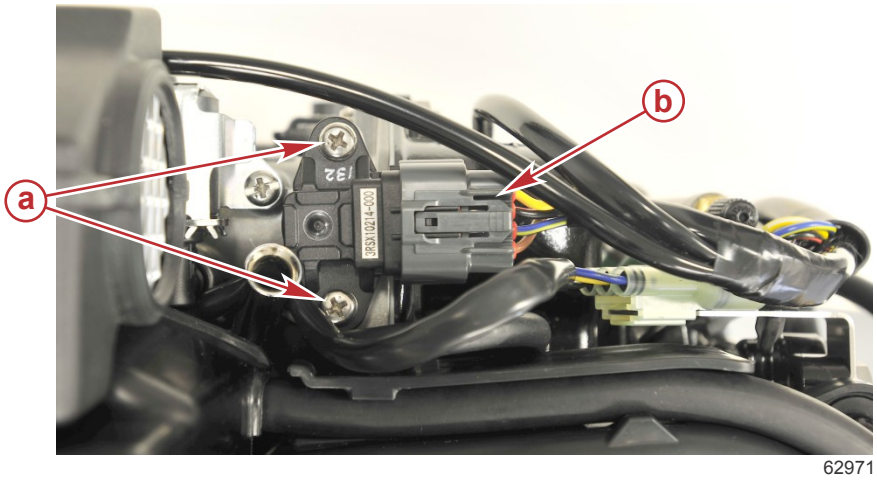
Wiring Diagram



a - ECM
b - TMAP

TMAP Removal

1. Disconnect the TMAP sensor from the engine harness.
2. Remove the two screws that secure the TMAP sensor to the throttle body.



Top view of TMAP sensor
a - Screws (2)
b - Engine harness connector

3. Remove the TMAP sensor and discard the O-ring seal.

TMAP Installation

1. Install a new O-ring onto the TMAP sensor.
2. Apply one drop of clean engine oil to the O-ring.
3. Install the TMAP sensor into the throttle body, and tighten the retaining screws to the specified torque.

Description	Nm	lb-in.	lb-ft
TMAP retaining screws	3.0	26.6	–

4. Connect the engine harness to the TMAP sensor.

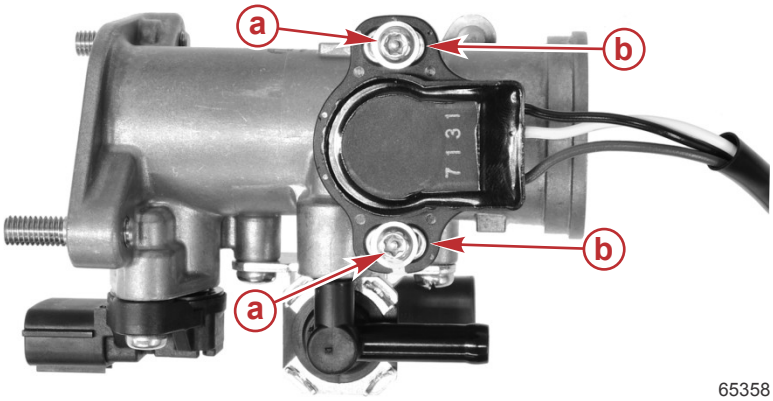
Throttle Position Sensor (TPS)

The throttle position sensor (TPS) is located on the throttle body and is in direct contact with the throttle shaft. The TPS transmits throttle angle information to the ECM, which regulates the fuel injector volume (pulse width) and ignition timing.

TPS Replacement

To replace the TPS:

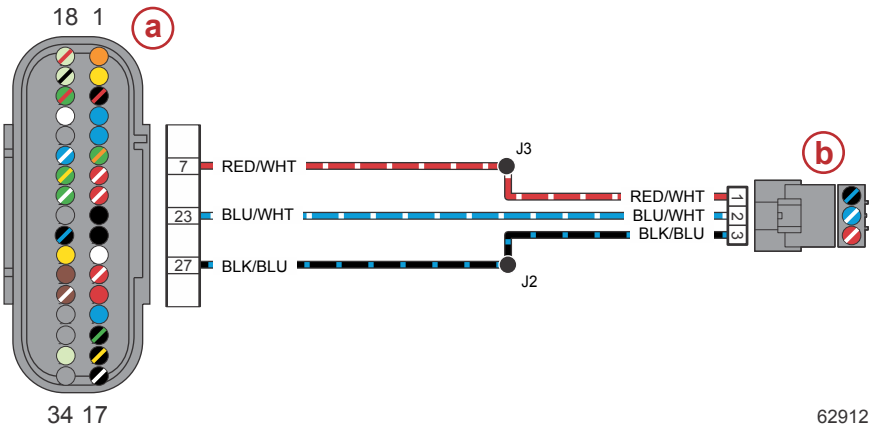
1. Remove the throttle body from the engine. Refer to **Section 3C - Throttle Body Removal**.
2. Remove the two Torx® screws that secure the TPS to the throttle body, and remove the TPS.
3. Attach the new TPS to the throttle body, and secure it with the two Torx® screws, positioned in the center of the two slots.



a - Torx® screw (2)
b - Slot (2)

4. Connect the TPS to the engine harness, and connect and launch CDS G3.
5. Navigate to the **Live Data** screen to view the **Throttle Position** value.
6. Adjust the position of the TPS until the value reads 0.6° ± 0.1°.
7. Tighten the two Torx® screws. Confirm that the TPS value did not change.
8. Disconnect CDS G3.
9. Install the throttle body onto the engine. Refer to **Section 3C - Throttle Body Installation**.

Wiring Diagram



a - ECM
b - TPS

Ignition Components

Flywheel

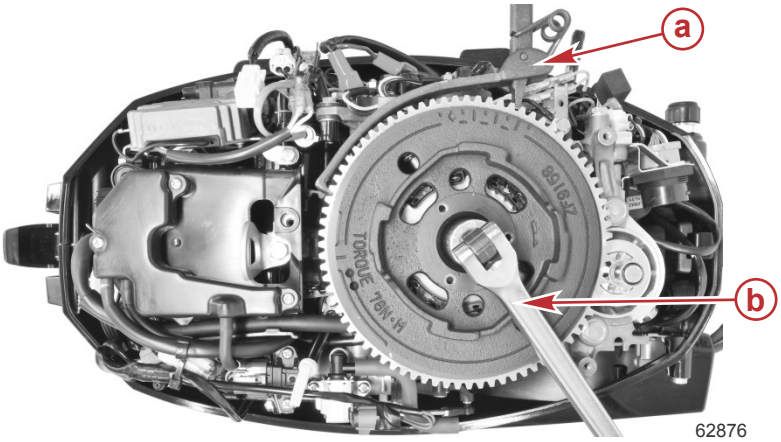
The flywheel is weighted and balanced to improve engine running characteristics. The flywheel is secured to the crankshaft with a washer and nut. The flywheel has a ring gear that is used with the optional starter motor to start the engine electrically. The top of the flywheel is cast with notches to engage the recoil starter, for manual starting.

Below the ring gear, the flywheel is cast with a timing key. As the timing key passes the crankshaft position sensor (CPS), the CPS generates an electrical pulse that is sent to the engine control module (ECM). The ECM calculates the speed and position of the crankshaft according to the frequency and timing of the pulses. The ECM then uses the speed and position information to regulate ignition and fuel injector timing.

The flywheel also has magnets on the inside circumference to generate voltage within the stator. Refer to **Stator**, for additional information.

Flywheel Removal

1. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
2. Disconnect the spark plug leads from the spark plugs.
3. Hold the flywheel with a flywheel holding tool, and remove the flywheel nut and washer.

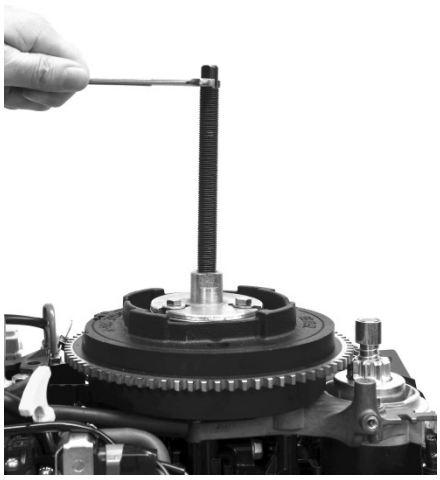


62876

a - Flywheel holding tool
b - Breaker bar and socket

Flywheel Holding Tool	91- 52344

4. Fasten a three-point flywheel puller onto the flywheel. Do not use a jaw type puller.
   NOTE: *Do not use heat or strike the flywheel.*
5. Loosen the flywheel using the puller.

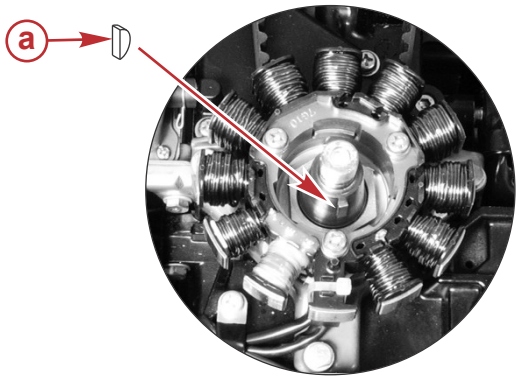


63875

6. Remove the flywheel and retain the flywheel key.

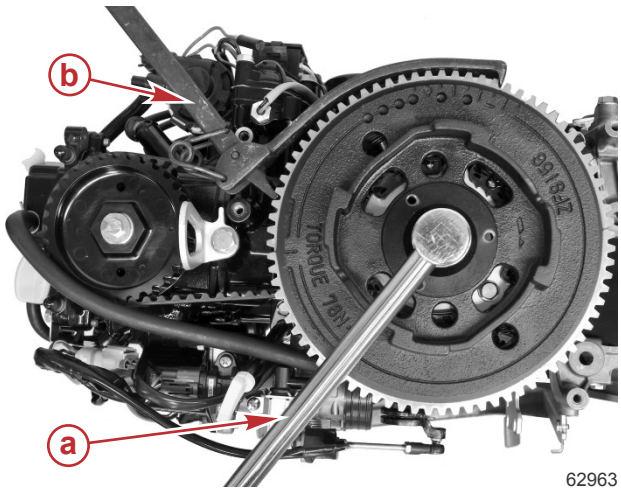
Flywheel Installation

1. Inspect the flywheel key. Replace if required. Place the flywheel key into the crankshaft keyway.



a - Flywheel key

2. Align the flywheel key with the flywheel slot.
3. Carefully install the flywheel.
4. While pushing down on the flywheel, rock the flywheel back and forth to ensure that the flywheel key has not fallen out of the crankshaft keyway.
5. Install the washer and flywheel nut.
6. Hold the flywheel with the flywheel holding tool, and tighten the nut to the specified torque.



a - Torque wrench
b - Flywheel holding tool

Flywheel Holding Tool	91- 52344

Description	Nm	lb-in.	lb-ft
Flywheel nut	78.0	–	57.5

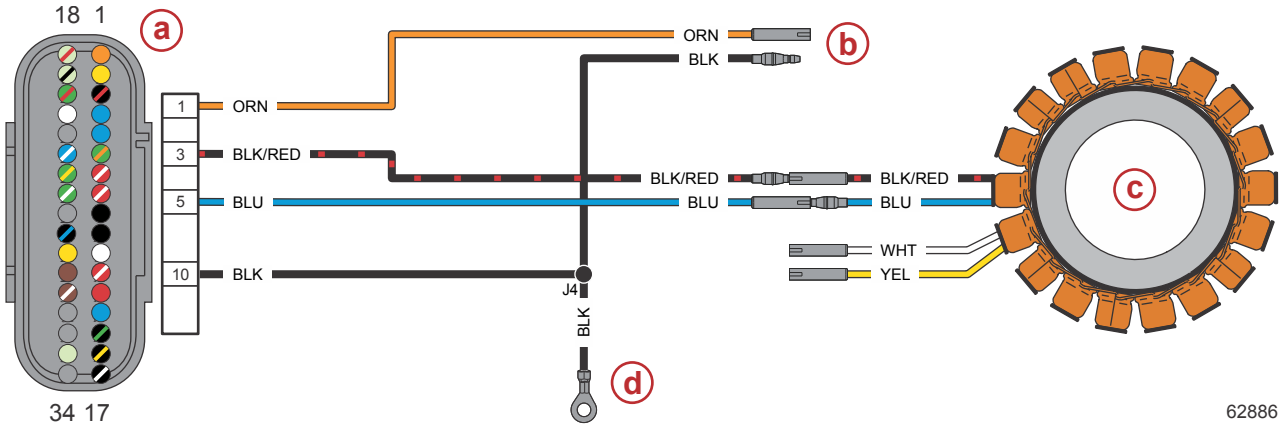
7. Connect the spark plug leads to the spark plugs.
8. Install the air box and recoil starter assembly.
   - It is easiest to install the recoil starter and air box together.
   - Refer to **Section 8A - Recoil Starter** and **Section 3C - Air Box Installation**.

Stator

The stator is located under the flywheel. It has two sets of windings. The first winding supplies AC voltage to the ECM. The ECM contains diodes that rectify the input voltage to keep itself powered and to supply power to the engine sensors, actuators, ignition coils, high-pressure fuel pump, and warning system.

The second winding generates the voltage required to maintain the battery on electric start models. This voltage is rectified external to the ECM. Refer to **Section 2B - Charging and Starting Systems**.

Ignition System Wiring Diagram



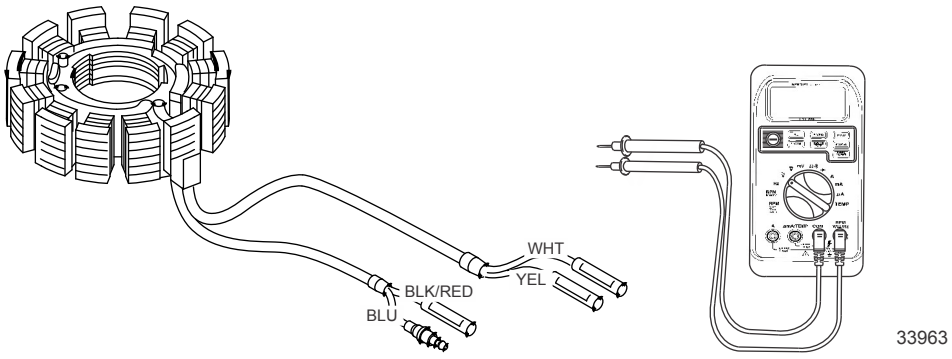
a - ECM
b - Ignition coil
c - Stator (white and yellow wires are not part of the ignition circuit)
d - Ground

Stator Resistance Test

IMPORTANT: Perform this test with the engine not running.

NOTE: *Readings may vary slightly due to temperature changes. The test readings listed were taken at 20 °C (68 °F).*

1. Ensure that the engine is not running, and disconnect the stator harness connectors.
2. Use the DMT 2004 Digital Multimeter to perform the following measurements. If the stator coil measurements are not within 10% of the values listed, replace the stator.



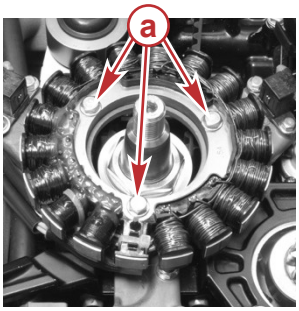
DMT 2004 Digital Multimeter	91-892647A01

Circuit	Meter Test Leads		Meter Scale	Reading
	Red	Black		
Ignition winding	Blue	Black/red	Ω	1.04–1.56 Ω
Battery charge winding	Yellow	White	Ω	0.17–0.25 Ω

Stator Removal

1. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
2. Remove the flywheel. Refer to **Flywheel Removal**.
3. Electric start models: Disconnect the white and yellow stator wires (bullet connectors) from the voltage regulator/rectifier.
4. Disconnect the blue and black/red stator wires (bullet connectors) from the engine harness.

5. Remove the three screws that secure the stator to the coil bracket. Remove the stator.

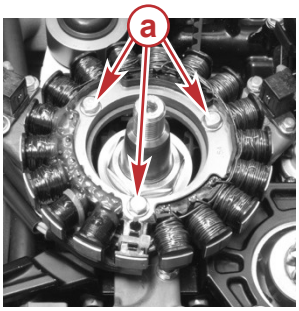


10117

a - Screws (3)

Stator Installation

1. Install the stator with the stator wires facing toward the front starboard side of the engine.
2. Secure the stator to the coil bracket with three screws. Tighten the screws to the specified torque.



10117

a - Screws (3)

Description	Nm	lb-in.	lb-ft
Stator screws	6.0	53.1	–

3. Connect the blue and black/red stator wires (bullet connectors) to the engine harness.
4. For electric start models, connect the white and yellow stator wires (bullet connectors) to the voltage regulator/rectifier.
5. Install the flywheel. Refer to **Flywheel Installation**. Be certain to tighten the flywheel nut to the specified torque.

Description	Nm	lb-in.	lb-ft
Flywheel nut	78.0	–	57.5

6. Install the air box and recoil starter assembly.
   - It is easiest to install the recoil starter and air box together.
   - Refer to **Section 8A - Recoil Starter** and **Section 3C - Air Box Installation**.

Timing Belt

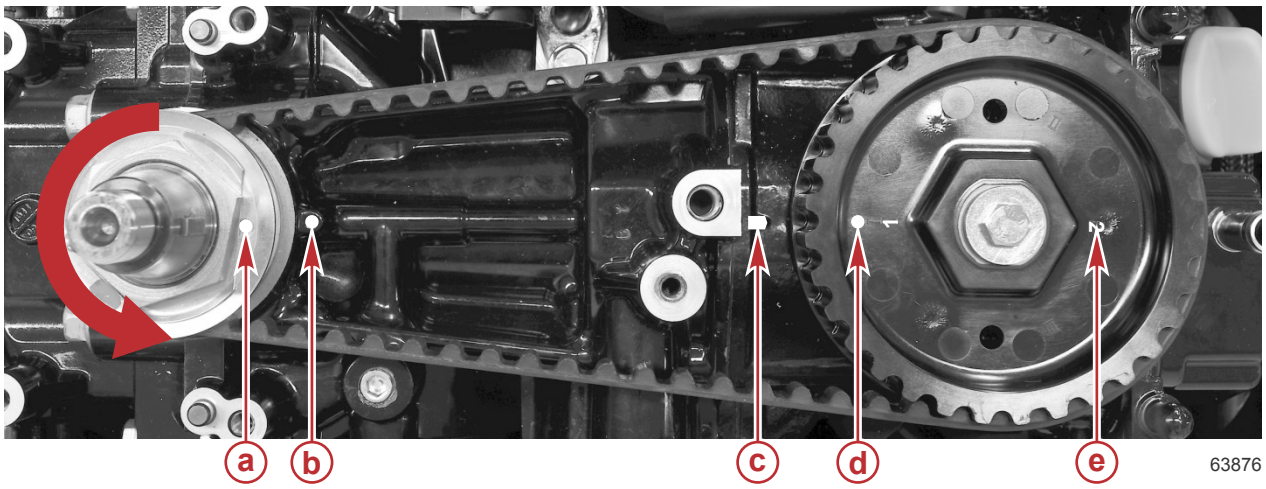
Timing Belt Removal

1. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
2. Remove the camshaft gear cover. Refer to **Section 3C - Camshaft Gear Cover/Vent Tank**.
3. Remove the flywheel. Refer to **Flywheel Removal**.
4. Remove the stator. Refer to **Stator Removal**.
5. Remove the timing belt.

   NOTE: *Use a flat-blade screwdriver or similar tool to work the timing belt through the opening in the starter bracket. Be careful to not damage the belt.*

Timing Belt Installation

1. Ensure that the timing marks on the crankshaft drive gear and the camshaft driven gear are still aligned with the corresponding marks on the engine.



Timing marks (shown with starter bracket removed, for clarity)

- **a -** Crankshaft drive gear timing mark
- **b -** Timing mark on the cylinder block for the crankshaft
- **c -** Timing mark on the cylinder block for the camshaft
- **d -** Timing mark for #1 cylinder
- **e -** Timing mark for #2 cylinder

2. Install the timing belt.
3. Install the stator. Refer to **Stator Installation**.
4. Install the flywheel. Refer to **Flywheel Installation**.
5. Install the camshaft gear cover. Refer to **Section 3C - Camshaft Gear Cover/Vent Tank**.
6. Install the air box and recoil starter assembly.
   - It is easiest to install the recoil starter and air box together.
   - Refer to **Section 8A - Recoil Starter** and **Section 3C - Air Box Installation**.

Ignition Coil

The primary side of the ignition coil receives voltage discharged from a capacitor located inside the ECM. The voltage is multiplied significantly by the coil so it can jump the spark plug gap while under compression. The ignition coil will produce a high voltage spark every revolution of the flywheel. The spark timing curve is controlled by the ECM.

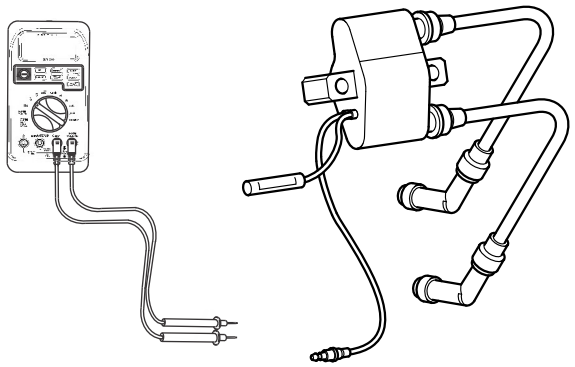
Ignition Coil Testing

NOTE: *The readings listed were taken at 20 °C (68 °F) with a digital ohmmeter. Due to the number of different manufacturers, meters available, and temperature variance; test results may vary.*

It is not necessary to remove the ignition coil from the powerhead for testing.

Primary Coil Resistance

Disconnect the coil leads from the engine harness, and measure the resistance of the primary coil with a DMT 2004 Digital Multimeter or equivalent.

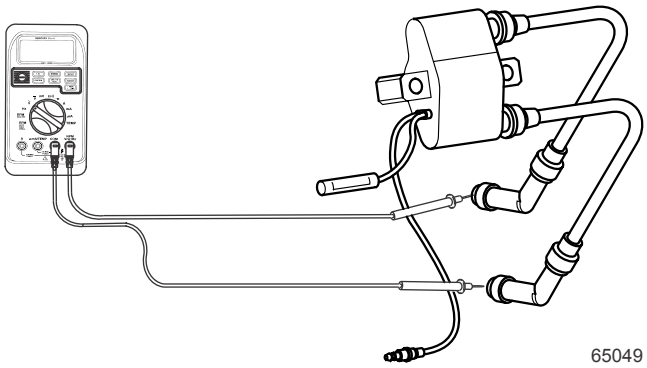


DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading
Red	Black		
Orange	Black	Ω	0.26–0.35 Ω

Secondary Coil Resistance

1. Remove the spark plug leads from the spark plugs.
2. Measure the resistance between the two high tension leads (spark plug boots).



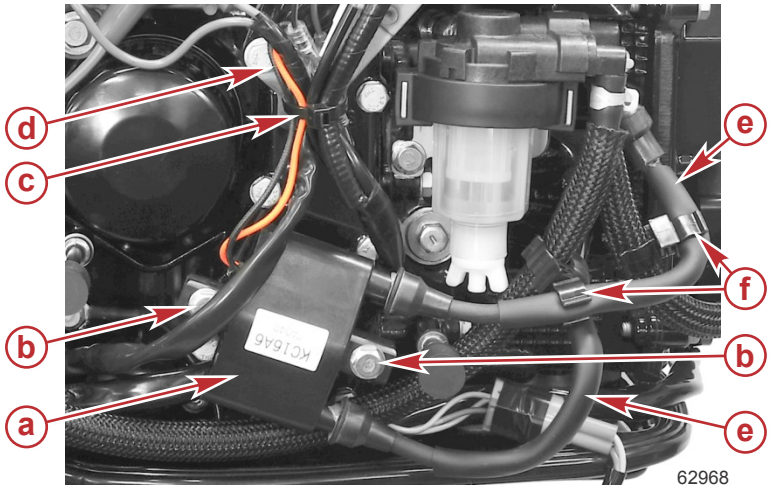
Meter Test Leads		Meter Scale	Reading
Red	Black		
High tension lead	High tension lead	Ω	16.8–20.2 kΩ

3. If the reading is other than specified, replace the ignition coil.

Removal

1. Remove the cable tie that secures the coil input wires.
2. Disconnect the bullet connectors for the orange and black coil input wires.
3. Remove the clips from the upper spark plug wire, and remove the spark plug wires from the spark plugs.
   NOTE: *It is easiest to remove the wire and boot as a unit from the plug.*

4. Remove the two screws that secure the ignition coil to the engine, and remove the coil.



a - Ignition coil
b - Screw (2)
c - Cable tie
d - Orange and black coil input wires
e - Spark plug wire (2)
f - Clip on upper spark plug wire (2)

Installation

1. Install the ignition coil onto the engine using two screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Ignition coil mounting screws	6.0	53.1	–

2. Attach the spark plug wires to the spark plugs. Be sure to connect the correct plug to the correct wire. Ensure that the plug wires are properly seated and that the upper plug wire is properly secured with clips.
3. Connect the orange and black coil input wires to the engine harness.
4. Secure the wires to the harness and bracket with a cable tie.

Notes:

Electrical

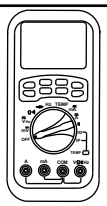
Section 2B - Charging and Starting Systems

Table of Contents

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
80	SAE® Engine Oil 30W	Starter end cap bushing	Obtain Locally
		Armature shaft	
		Starter armature shaft, and helix	

Special Tools

DMT 2004 Digital Multimeter	91-892647A01
 4516	Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments.

Charging and Starting Specifications

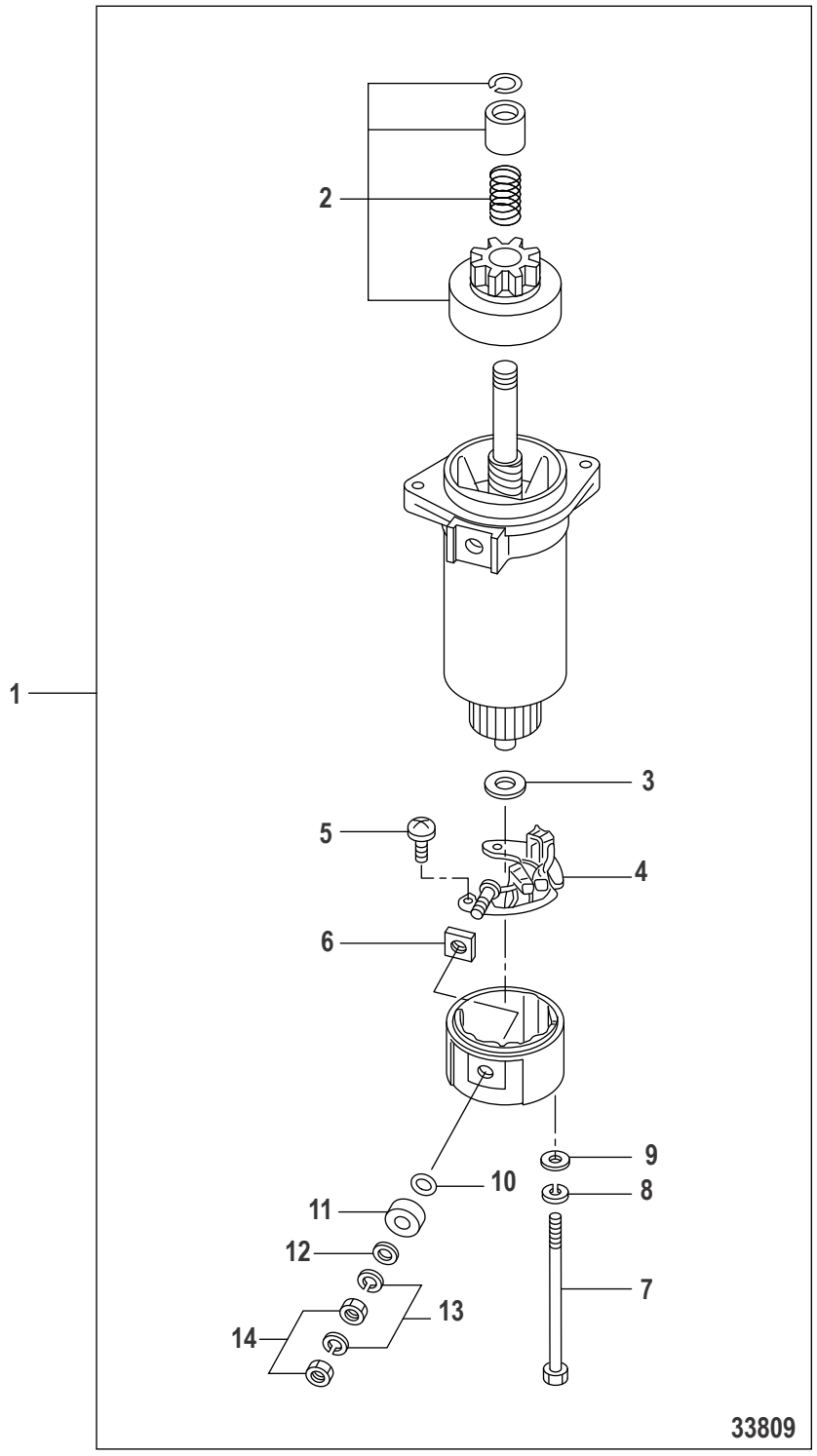
Parameter		Specification
Alternator type		Single phase
Alternator charge coil resistance		0.17–0.25 Ω
Alternator output at 900 RPM		4.6 A
Alternator output at 5000 RPM		11.5 A
Starter	Type	Bendix®
	Output	0.6 kW at 12 V
	Brush length	14.0 mm (0.551 in.)
	Brush length (service limit)	11.0 mm (0.433 in.)
	Commutator undercut	0.95–1.05 mm (0.037–0.041 in.)
	Commutator diameter	28.3 mm (1.114 in.)
	Commutator diameter (service limit)	27.8 mm (1.095 in.)
Fuse capacity	Voltage regulator output	20 A
	Starting control circuit	15 A
Fuse type		Mini ATC
Battery requirements (minimum)	Above 0 °C (32 °F)	465 MCA, 350 CCA
	At or below 0 °C (32 °F)	800 MCA, 650 CCA
Voltage control		Shunt/ground voltage regulator

General Troubleshooting

For general troubleshooting information, including connecting and using the CDS G3 diagnostic tool, refer to **Section 1E - General Troubleshooting**.

Notes:

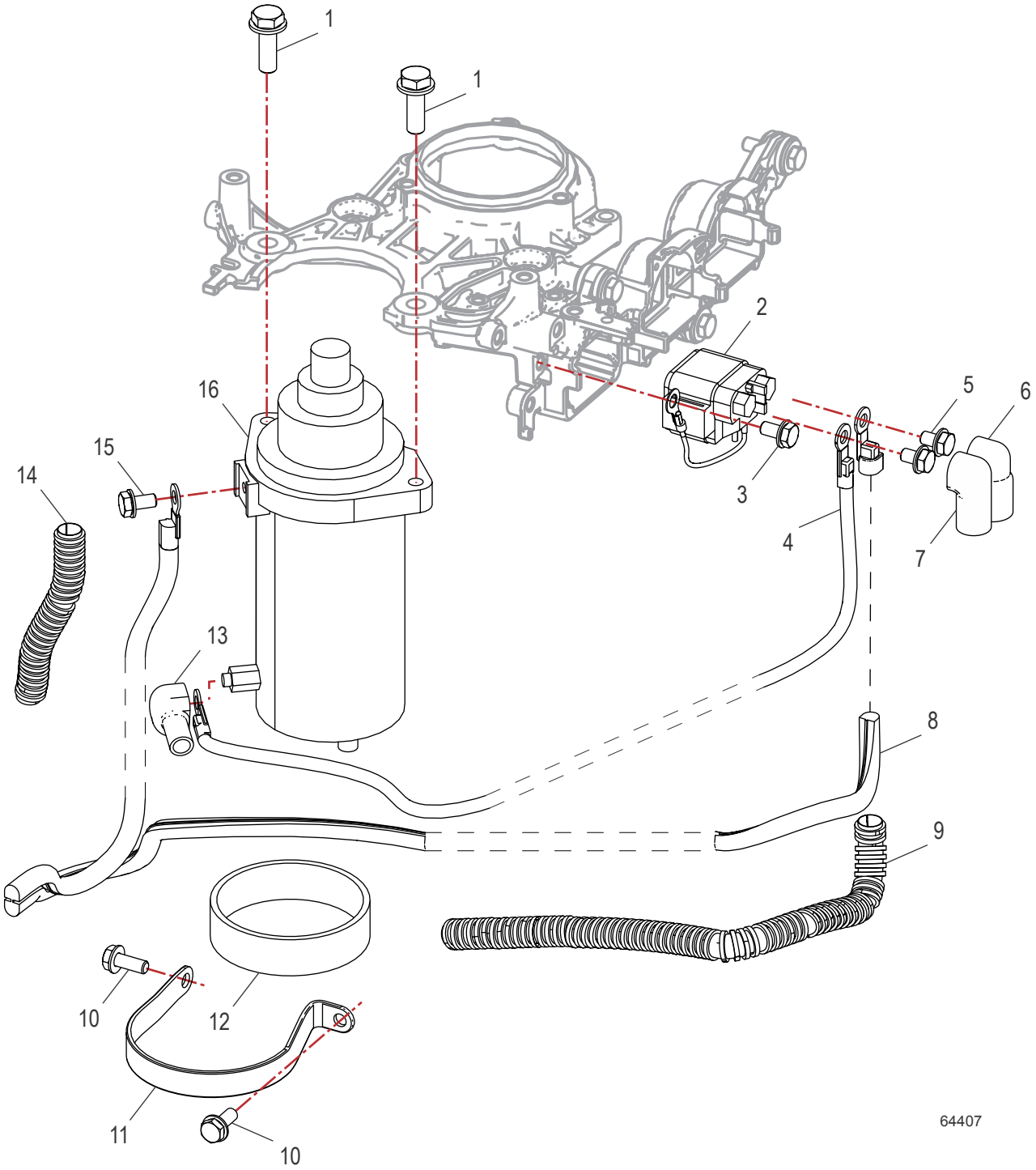
Starter Motor Components



Starter Motor Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Starter motor assembly			
2	1	Pinion assembly			
3	1	Washer			
4	1	Brush card			
5	2	Screw (M4 x 8)	1.5	13.3	–
6	1	Bushing			
7	2	Screw	6.0	53.1	–
8	2	Lockwasher			
9	2	Washer			
10	1	O-ring			
11	1	Bushing			
12	1	Washer			
13	2	Lockwasher (M6)			
14	2	Nut	4.0	35.4	–

Starter Motor and Solenoid Electrical Components



Starter Motor and Solenoid Electrical Components

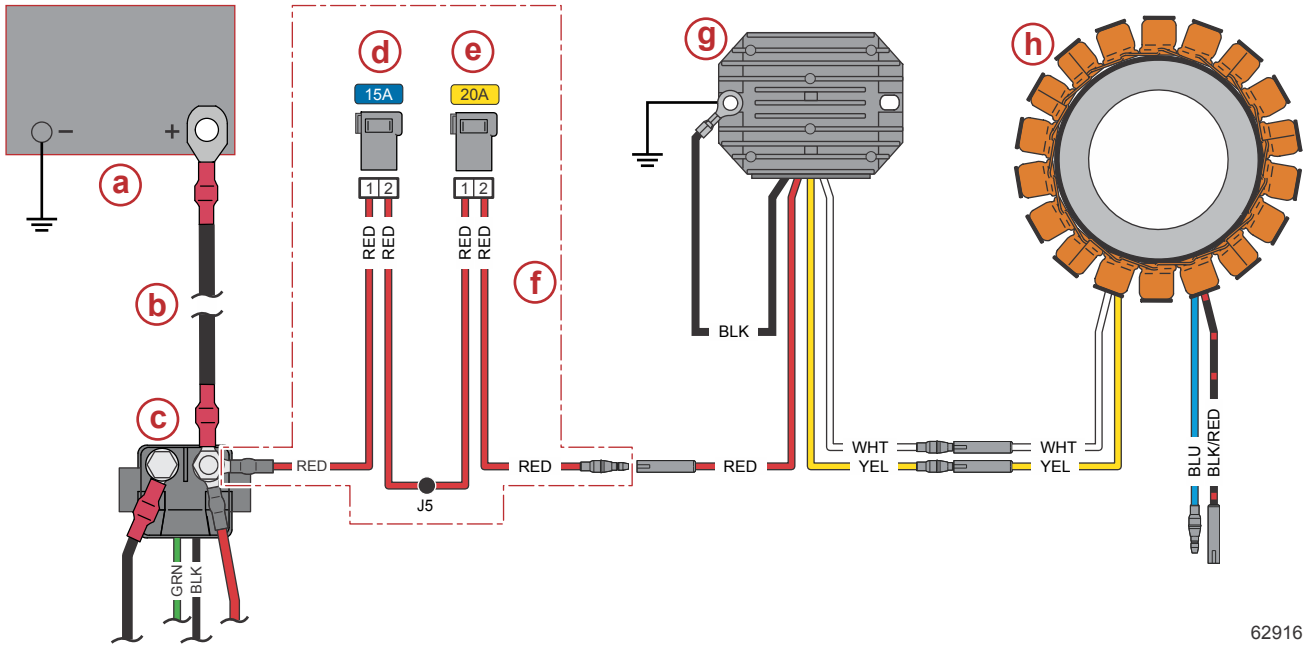
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Screw (M8 x 25)	13	115	–
2	1	Starter solenoid			
3	1	Screw	6.0	53.1	–
4	1	Starter cable			
5	2	Screw	6.0	53.1	–
6	1	Red terminal boot			
7	1	Red terminal boot			
8	1	Battery cable assembly			
9	1	Protective sleeve			
10	2	Screw	6.0	53.1	–
11	1	Starter motor bracket			
12	1	Rubber mount			
13	1	Red terminal boot			
14	1	Protective sleeve			
15	1	Screw	6.0	53.1	–
16	1	Starter motor			
–	1	Neutral switch (tiller)			
–	1	Start switch (tiller)			

Wire Color Code Abbreviations

Wire Color Abbreviations				
BLK	Black		BLU	Blue
BRN	Brown		GRA	Gray
GRN	Green		ORN	Orange
PNK	Pink		PPL	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT	Light		DK	Dark

Charging System

Charging System Wiring Diagram



- **a -** Battery
- **b -** Positive battery cable
- **c -** Starter solenoid
- **d -** 15-amp fuse
- **e -** 20-amp fuse
- **f -** Engine control module (ECM) harness
- **g -** Voltage rectifier/regulator
- **h -** Stator

Troubleshooting the Charging System

IMPORTANT: The charging system may be damaged by:

- **Reversed battery cables**
- **Running the engine with the battery cables disconnected and stator leads connected to the rectifier**
- **An open circuit, such as a broken wire or loose connection**

A fault in the battery charging system usually will cause the battery to become discharged. Check the battery electrolyte level, and charge the battery.

If the battery will not accept a satisfactory charge, replace the battery.

If the battery accepts a satisfactory charge, determine the cause of the charging system problem as follows.

- Check for correct battery polarity: red cable to positive (+) battery terminal. If polarity was incorrect, check for blown fuse and damaged rectifier. Refer to **Regulator/Rectifier Diode Test**.

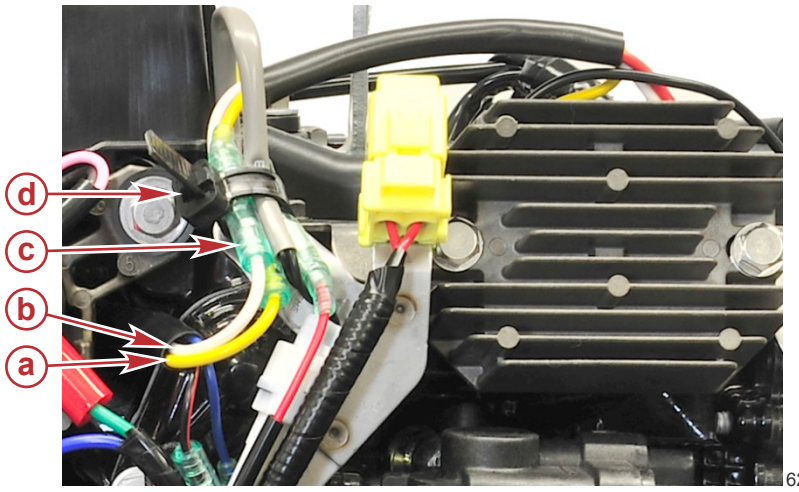
- Check for loose or corroded battery connections.
- Visually inspect the wiring between the stator and battery for cuts, chafing, loose, corroded, or disconnected connection.
- Excessive electrical load from too many accessories will cause battery to run down.

Testing the Stator Charge Windings

NOTE: *The test readings listed were taken at 20 °C (68 °F).*

NOTE: *The stator windings can be tested with the stator mounted to the engine.*

1. Release the reusable cable tie that secures the stator leads.
2. Disconnect the yellow and white stator leads at the bullet connectors.



a - Yellow stator wire
b - White stator wire
c - Bullet connectors
d - Reusable cable tie

3. Connect an ohmmeter to the yellow and white stator leads to perform the following test.

   NOTE: *When measuring the resistance of 10 ohms or less using a digital ohmmeter, if the correct measurement cannot be obtained, place the meter selector to a lower resistance range.*

DMT 2004 Digital Multimeter	91-892647A01

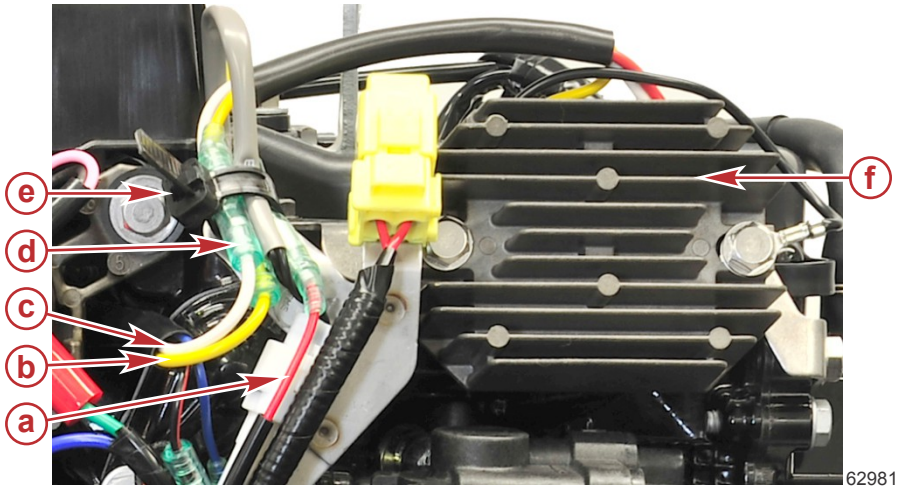
Meter Test Leads		Meter Scale	Reading
Red	Black		
White	Yellow	Ω	0.17–0.25 Ω

IMPORTANT: Be certain to secure the wires with the reusable cable tie, prior to placing the engine back into service.

Regulator/Rectifier Diode Test

IMPORTANT: When testing the regulator/rectifier diodes, use only a digital meter that has a diode inspection mode.

1. Release the reusable cable tie that secures the voltage regulator/rectifier leads.
2. Disconnect the yellow, white, and red voltage regulator/rectifier leads at the bullet connectors.



a - Red wire
b - Yellow wire
c - White wire
d - Bullet connectors
e - Reusable cable tie
f - Voltage regulator/rectifier

3. Connect the meter leads to the appropriate voltage regulator/rectifier leads to perform the following tests.

DMT 2004 Digital Multimeter	91-892647A01

NOTE: *Due to manufacturing differences, meter internal polarity may vary from manufacturer to manufacturer. As a result, the test readings may be a direct reversal of the readings specified. If so, reverse the meter leads and perform the test again.*

A slight variance from the listed specification does not necessarily indicate a defective component.

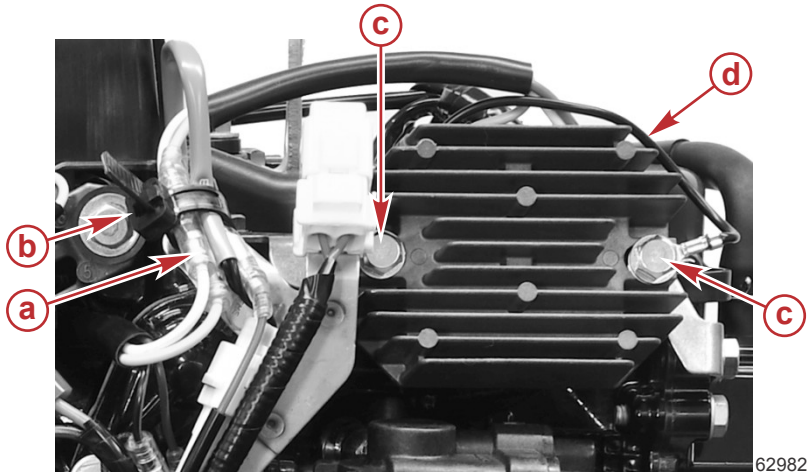
Meter Test Leads		Meter Scale	Reading
Black	**Red**		
White	Red	Diode	OUCH
	Yellow	Diode	1.3–2.2 Ω
	Ground	Diode	0.3–0.9 Ω
Yellow	Red	Diode	OUCH
	White	Diode	1.3–2.2 Ω
	Ground	Diode	0.3–0.9 Ω
Red	Yellow	Diode	0.3–0.9 Ω
	White	Diode	0.3–0.9 Ω
	Ground	Diode	0.7–1.3 Ω
Ground	White	Diode	1.2–1.8 Ω
	Yellow	Diode	1.1–1.8 Ω
	Red	Diode	OUCH

IMPORTANT: Be certain to secure the wires with the reusable cable tie, prior to placing the engine back into service.

Voltage Regulator/Rectifier Removal and Installation

Removal

1. Release the reusable cable tie that secures the voltage regulator/rectifier wires.
2. Disconnect the bullet connectors for the white, yellow, and red wires from the voltage regulator/rectifier.
3. Remove the two screws that secure the voltage regulator to the bracket, and remove the voltage regulator.



a - Bullet connectors
b - Reusable cable tie
c - Voltage regulator mounting screws (2)
d - Voltage regulator ground (black) wire

Installation

1. Attach the voltage regulator to its mounting bracket with two screws. Be certain to attach the ring terminal for the ground (black) wire with one of the screws.
2. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Voltage regulator mounting screws	6.0	53.1	–

3. Attach the three bullet connectors for the red, yellow, and white wires, to complete the electrical connections.
4. Secure the wires at the bullet connectors with the reusable cable tie.

Starting System

Starting System Description

The battery supplies energy to spin the starter motor. When the start button or key switch is activated, the starter solenoid is energized and completes the starting circuit between the battery and starter.

The neutral start switch opens the start circuit when the shift control lever is not in neutral. This prevents accidental starting when the engine is in gear.

NOTICE
Engaging the starter motor while the engine is operating can damage the starter motor or flywheel. Do not engage the starter motor continually for longer than 15 seconds. Do not engage the starter motor when the engine is operating.

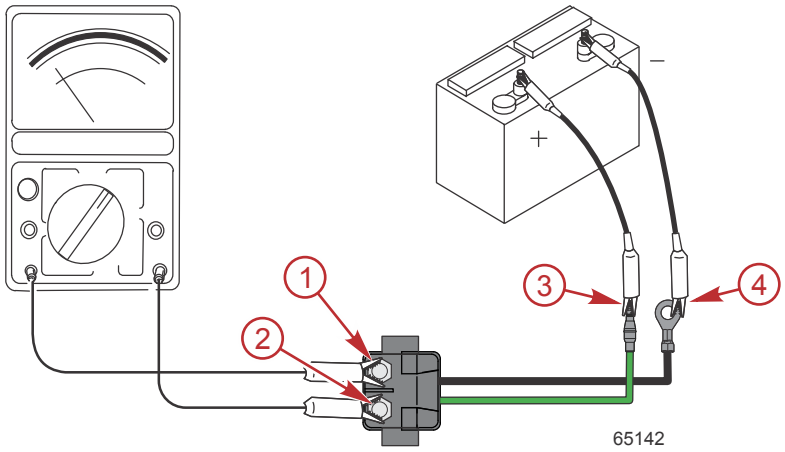
Starting System Components

The starting system consists of the following components.

- Battery
- Starter solenoid
- Neutral safety switch
- Starter motor
- Start button or key switch

Starter Solenoid Test

1. Disconnect all wires from the solenoid.
2. Connect an ohmmeter (R × 1 scale) between terminals 1 and 2.
3. Connect a 12-volt power supply between terminals 3 and 4.
   - The solenoid should click, and the meter should read 0 ohms (full continuity).
   - If the meter does not read 0 ohms (full continuity), replace the solenoid.



DMT 2004 Digital Multimeter	91-892647A01

Troubleshooting the Starting Circuit

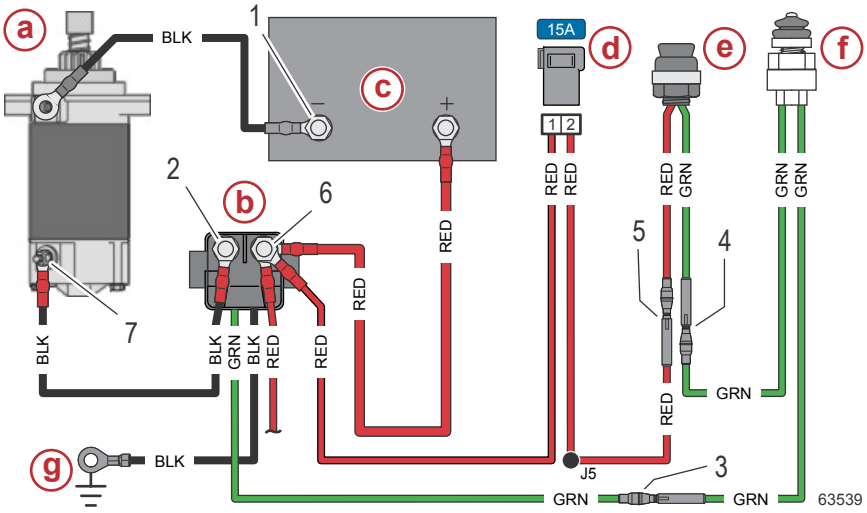
Before beginning the starting circuit troubleshooting flowchart, first check for the following conditions:

- Ensure that the battery is fully charged.
- Ensure that the control lever is in the neutral position.
- Ensure that the lanyard clip is on the E-stop switch.
- Check terminals for corrosion and loose connections.
- Check that the battery cables are connected to the correct polarity terminals: red (+), black (–)
- Check cables and wiring for frayed and worn insulation.
- Check the in-line fuse.

Starting System Wiring Diagrams

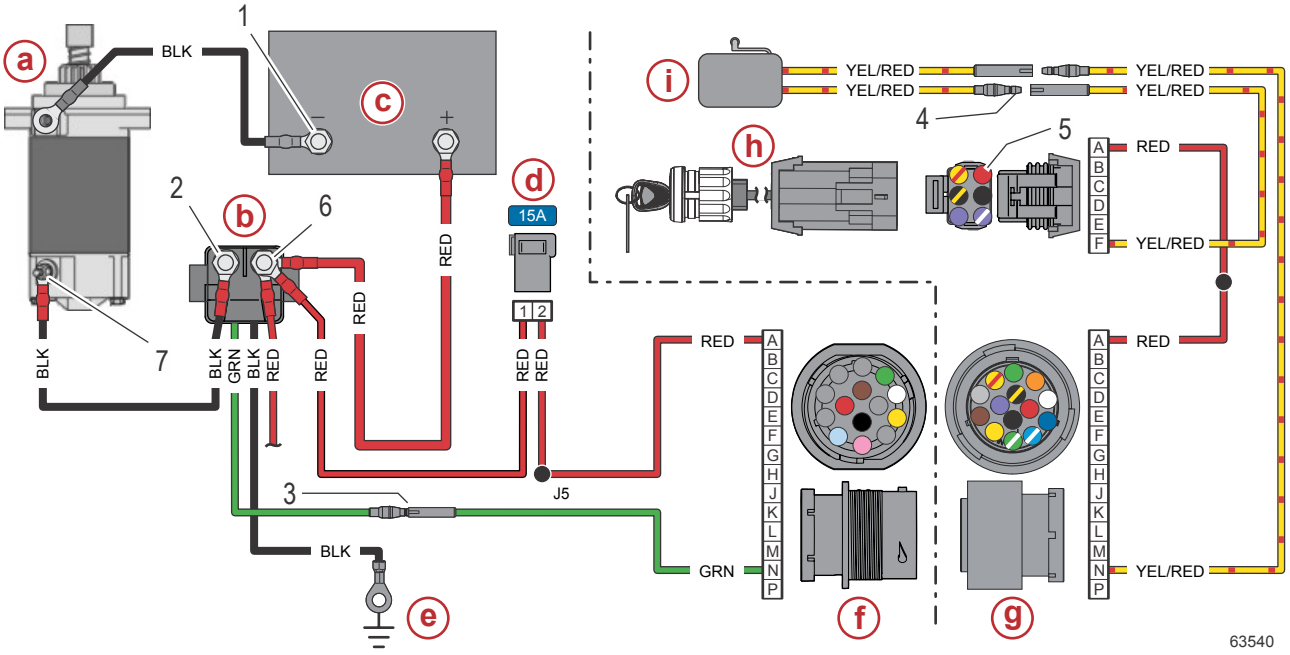
Use these wiring diagrams in conjunction with the **Starting System Troubleshooting Chart**, following. The numbers indicate test points identified in the troubleshooting chart.

Tiller Handle Models



- **a -** Starter motor
- **b -** Starter solenoid (disconnect at TP2 for tests 2 through 6)
- **c -** Battery
- **d -** 15-amp fuse
- **e -** Cowl-mounted start button
- **f -** Neutral safety switch
- **g -** Chassis ground

Remote Control Models



Typical

- **a -** Starter motor
- **b -** Starter solenoid (disconnect at TP2 for tests 2 through 6)
- **c -** Battery
- **d -** 15-amp fuse
- **e -** Chassis ground
- **f -** Engine harness 14-pin connector
- **g -** Remote control harness 14-pin connector
- **h -** Key switch
- **i -** Neutral start switch

Starting System Troubleshooting Chart

Location of test points (TP) called out in the chart are numbered in the preceding diagrams.

DMT 2004 Digital Multimeter	91-892647A01

Starter Does Not Work		
Test Number	**Procedure**	**Reading: Action**
Test 1	Test the ground connection: Connect the leads of an ohmmeter (R x 1 scale) between the negative (–) battery post (TP1) and a common powerhead ground.	**Continuity:** The ground connection is good. Proceed to Test 2.
		No continuity: There is an open circuit in the negative (–) battery cable between the negative (–) battery post and the starter motor. • Check the cable for loose or corroded connections. • Test the cable for continuity.
–	**IMPORTANT: Disconnect the positive starter motor cable from the starter solenoid at test point 2 (TP2) before performing tests 2 through 6, to prevent unexpected engine cranking.**	
Test 2	Identify the circuit with the trouble: 1. Ensure that the shift lever is in neutral. 2. Change the meter to read DC voltage. 3. Connect the voltmeter between engine ground and TP2. 4. Turn the ignition key to "START" or push in the start button.	**Battery voltage:** The trouble is in the starter motor circuit. Proceed to Test 7.
		No voltage: The trouble is in the control circuit. Proceed to Test 3.
Test 3	Test the starter solenoid: 1. Connect a voltmeter between engine ground and TP3. 2. Turn the ignition key to "START" or push in the start button.	**Battery voltage:** Check the starter solenoid coil wiring. If it is okay, then the starter solenoid is defective.
		No voltage: Proceed to Test 4.
Test 4	Test the neutral start switch: 1. Connect a voltmeter between engine ground and TP4. 2. Turn the ignition key to "START" or push in the start button.	**Battery voltage:** Neutral start switch is open, or a wire is open between the switch and TP3.
		No voltage: Proceed to Test 5.
Test 5	Test the ignition key or start button: 1. Connect a voltmeter between engine ground and TP5. 2. Turn the ignition key to "START" or push in the start button.	**Battery voltage:** Defective ignition key or start button, or a wire is open between the switch and TP4.
		No voltage: Proceed to Test 6.
Test 6	Test the circuit between TP5 and TP6: 1. Connect a voltmeter between engine ground and TP6. 2. Turn the ignition key to "START" or push in the start button.	**Battery voltage:** • Check the 15-amp fuse. • Check for an open between TP5 and TP6.
		No voltage: Check the positive (+) battery cable between the battery and TP6.
–	**IMPORTANT: Reconnect the positive starter motor cable to the starter solenoid at TP2 before performing Test 7.**	
Test 7	Test the starter motor circuit: 1. Connect a voltmeter between engine ground and TP7. 2. Turn the ignition key to "START" or push in the start button.	**Battery voltage:** Check the starter for a corroded ground. If OK, check the starter motor.
		No voltage: Check the positive starter cable for poor connection or open circuit.

Starter Motor

Starter Motor Current Draw

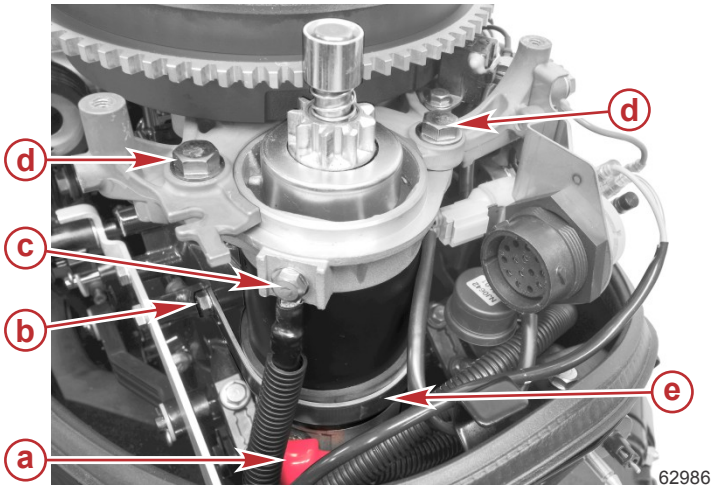
IMPORTANT: The starter motor current draw test must be performed with a fully charged battery.

Condition	Current Draw
No load test	13 A
Normal operation (cranking)	45–50 A

Starter Motor Removal

1. Disconnect the battery cables from the battery.
2. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
3. Move the rubber boot out of the way, and remove the positive lead from the starter.
4. Remove the negative lead from the starter.

   IMPORTANT: The port side screw that secures the starter motor isolation bracket is not easily accessible. Disconnect or remove components as necessary to access this screw. Removing only the starboard side screw and bending the bracket is NOT recommended, as this may weaken the bracket.
5. Remove the two screws that secure the starter motor isolation bracket to the engine.
6. Remove the two starter motor mounting screws.
7. Lift the starter motor and isolation bracket out and away from the engine.



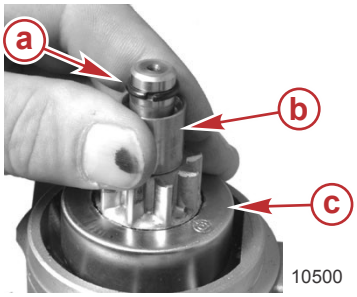
Some items shown removed for clarity

- **a -** Positive lead and rubber boot
- **b -** Isolation bracket screw (2)

  NOTE: *The port side screw is not shown in this view.*
- **c -** Negative lead connection point
- **d -** Starter motor mounting screws (2)
- **e -** Starter motor isolation bracket

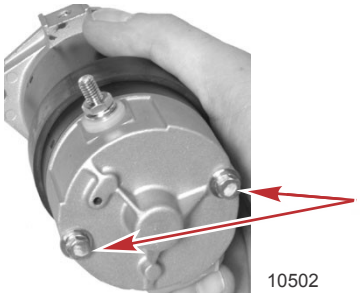
Starter Motor Disassembly

1. Push the pinion stopper down and remove the circlip.
2. Remove the pinion stopper, bendix spring, and bendix.



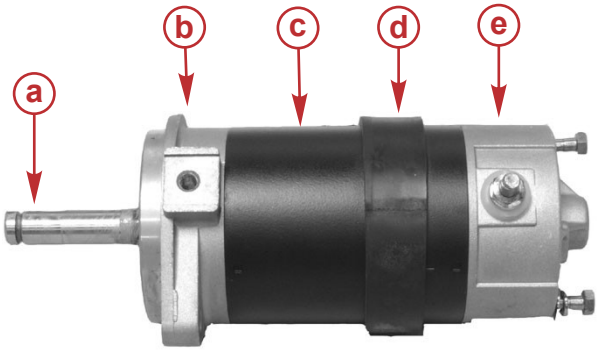
- **a -** Circlip
- **b -** Pinion stopper
- **c -** Bendix

3. Remove two bolts on the bottom of the starter holding it together.



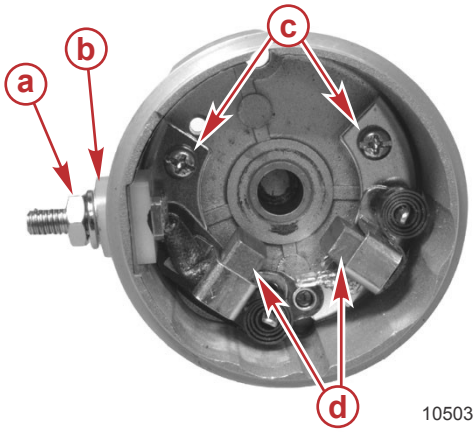
4. Remove the top end cap. Do not lose any armature shims.
5. Remove the field frame.

6. Remove the armature from the bottom end cap. Do not lose the thrust washer on end of armature.



a - Armature
b - Top end cap
c - Field frame
d - Starter motor support insulator
e - Bottom end cap

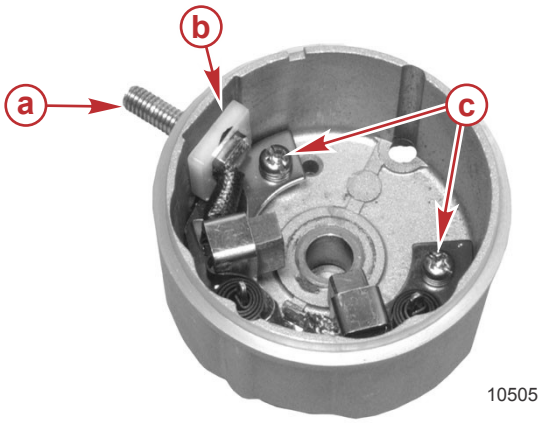
7. Remove the nut securing the power stud to the end cap insulator.
8. Remove the two screws securing the brush card to the end cap. Remove the brush card.



a - Nut securing power stud to insulator
b - End cap insulator
c - Screw securing brush card
d - Brushes

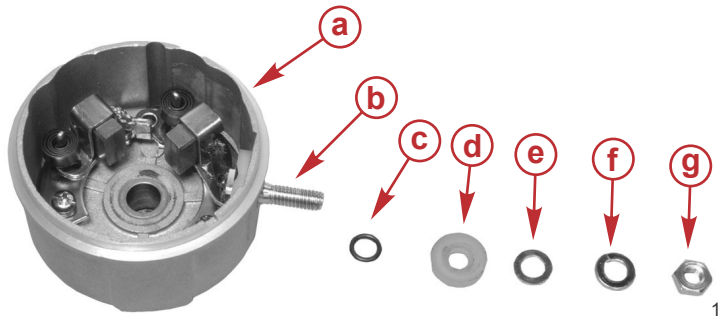
Starter Motor Reassembly

1. Install the power stud insulator onto the power stud.
2. Insert the power stud through the end cap.
3. Install the two brush card screws. Do not tighten the brush card screws.



a - Power stud
b - Power stud insulator
c - Brush card screw (2)

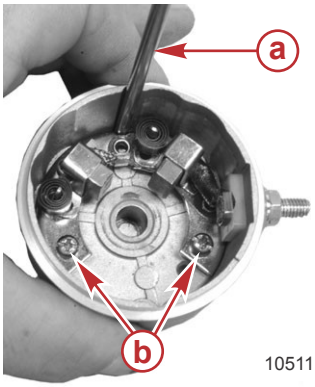
4. Assemble the power stud O-ring, insulator, washer, lockwasher, and nut onto the power stud. Tighten the nut to the specified torque.



a - End cap
b - Power stud
c - Power stud O-ring
d - Insulator
e - Washer
f - Lockwasher
g - Power stud nut

Description	Nm	lb-in.	lb-ft
Power stud nut	4.0	35.4	–

5. Insert a starter assembly screw through the end cap to ensure the brush card alignment.
6. Tighten the brush card screws to the specified torque. Remove the screw from the end cap.



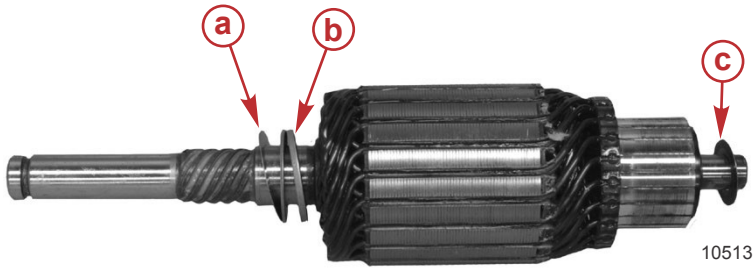
a - Starter assembly screw
b - Brush card screw

Description	Nm	lb-in.	lb-ft
Brush card screw (2)	1.5	13.3	–

7. Install the top thrust washer and shims onto the armature.

IMPORTANT: The thrust washer must be installed first onto the armature. The shims must be between the end cap and the thrust washer.

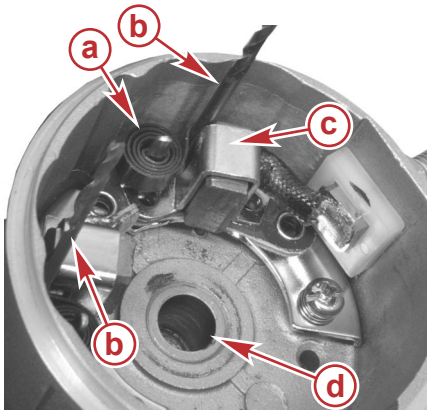
8. Install the bottom thrust washer onto the commutator end of the armature.



a - Top end cap shims
b - Top thrust washer
c - Bottom thrust washer

9. Push the brush in and insert a 2.6 mm (0.093 in.) drill bit between the brush spring and the brush card. This will hold the spring and brush for the insertion of the armature into the end cap.

10. Lubricate the end cap bushing with a drop of SAE® Engine Oil 30W.

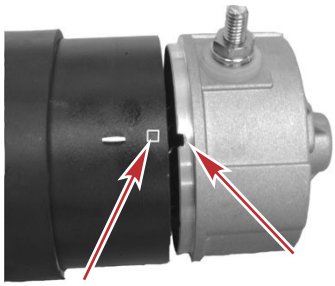


10520

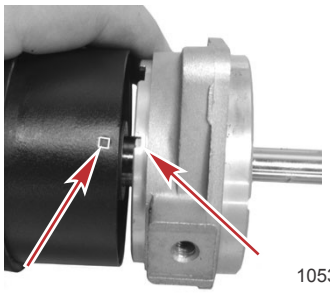
a - Brush spring
b - Drill bit
c - Brush card
d - End cap bushing

Tube Ref No.	Description	Where Used	Part No.
80	SAE® Engine Oil 30W	Starter end cap bushing	Obtain Locally

11. Insert the armature into the end cap. Ensure the armature is seated in end cap.
12. Remove the two drill bits to engage the brushes to the commutator.
13. Install the field frame to the end cap. Ensure the locating key of the field frame and the end cap are aligned.


10537

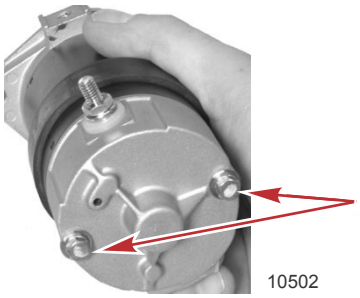
14. Lubricate the armature shaft with SAE Engine Oil 30W and install the top end cap. Ensure the locating keys are in alignment.


10539

Tube Ref No.	Description	Where Used	Part No.
80	SAE® Engine Oil 30W	Armature shaft	Obtain Locally

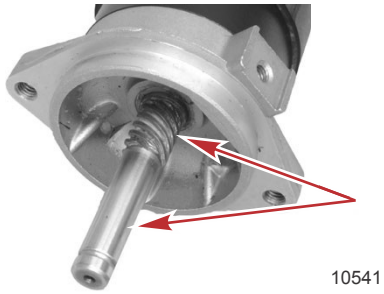
15. Ensure the lockwasher and washer are installed onto the starter assembly screws.

16. Install two starter assembly screws. Tighten the screws to the specified torque.



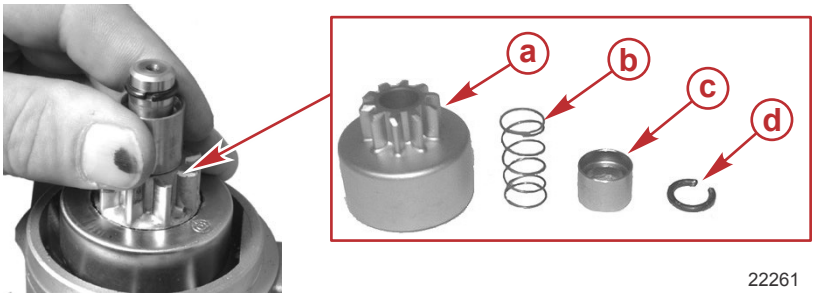
Description	Nm	lb-in.	lb-ft
Starter assembly screw	6.0	53.1	–

17. Lubricate the armature shaft and helix with SAE Engine Oil 30W.



Tube Ref No.	Description	Where Used	Part No.
80	SAE® Engine Oil 30W	Starter armature shaft, and helix	Obtain Locally

18. Install the starter bendix, bendix spring, and pinion stopper. Secure the starter bendix assembly with a circlip. Push the pinion stopper up to capture the circlip.



a - Bendix
b - Bendix spring
c - Pinion stopper
d - Circlip

Starter Motor Installation

1. Ensure that the rubber isolator is around the body of the starter motor. Position the isolator bracket over the isolator, and move the starter motor and isolator bracket into place.
2. Attach the starter motor to the engine with two mounting screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Starter motor mounting screws (2)	13	115	–

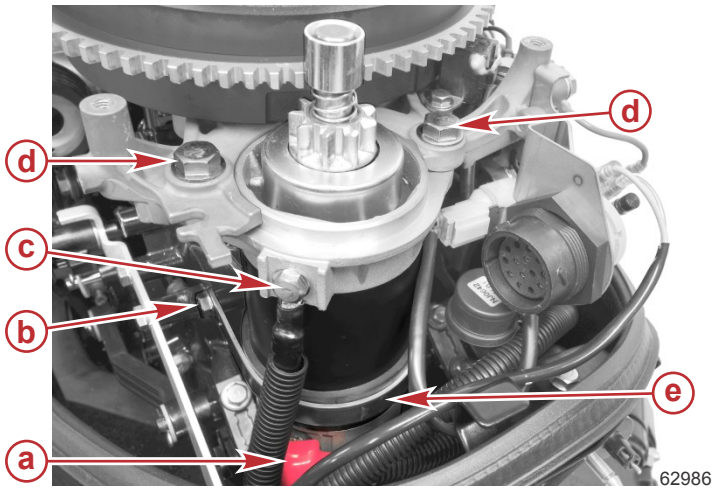
3. Attach the isolator bracket to the engine with two screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Starter motor isolator bracket screws	6.0	53.1	–

4. Connect any connectors and install any components removed to access the port side isolator bracket screw.
5. Attach the positive cable to the starter motor, using a lockwasher and nut. Tighten the nut to the specified torque.
6. Attach the negative cable to the starter motor, using a lockwasher and nut. Tighten the nut to the specified torque.

Description	Nm	lb-in.	lb-ft
Starter motor cable nuts (2)	4.0	35.4	–

7. Cover the positive electrical connection with the red rubber boot.



Some items shown removed for clarity

- **a -** Positive cable with rubber boot covering the connection
- **b -** Isolator bracket screw (2)

  NOTE: *The port side isolator bracket screw is not shown in this view.*
- **c -** Negative cable connection point
- **d -** Starter motor mounting screws (2)
- **e -** Starter motor isolator bracket, positioned around rubber isolator

8. Install the air box and recoil starter assembly.
   - It is easiest to install the recoil starter and air box together.
   - Refer to **Section 8A - Recoil Starter** and **Section 3C - Air Box Installation**.
9. Connect the battery cables to the battery, positive connection first.

Notes:

Fuel System

Section 3A - Fuel System Operation

Table of Contents

Theory of Operation

Air Induction System

The air induction system consists of an intake manifold with an intake runner to each cylinder for a smooth air flow to the combustion chamber. Each runner has a single fuel injector controlled by the ECM. The fuel injector has several very small holes in the fuel injector nozzle tip, to help atomize the fuel when injected into the runner as the cylinder intake valve opens.

A single throttle body/shutter with an attached throttle position sensor (TPS), along with the idle air control (IAC) valve, manages the amount of air entering the induction system. A combined manifold air temperature (MAT) and manifold absolute pressure (MAP) sensor send manifold temperature and pressure information to the ECM to regulate the fuel injector pulse width and to modulate the IAC duty cycle.

Fuel System

The fuel system consists of:

- A fuel line connector
- A water-separating fuel filter
- A low-pressure mechanical fuel pump
- A pulse-width modulated (PWM) high-pressure electric fuel pump with integral fuel filter
- A fuel pressure relief valve
- A water-cooled vapor separator tank (VST)
- Two fuel injectors

The low-pressure mechanical fuel pump draws fuel from the fuel tank through the fuel line connector and fuel filter. The fuel is then delivered to the high-pressure fuel pump inside the VST. The high-pressure fuel pump then supplies fuel to the injectors in the fuel rail.

Fuel rail pressure is regulated both via pulse-width modulation of the high-pressure pump and by fuel recirculation through the pressure relief valve inside the VST.

Each fuel injector sprays fuel into the intake manifold as the corresponding intake valve opens.

Fuel Pump

The fuel pump is a mechanically driven diaphragm pump that is driven off of the camshaft via a rocker arm. The pump base insulates the fuel pump from the heat of the cylinder head/valve cover.

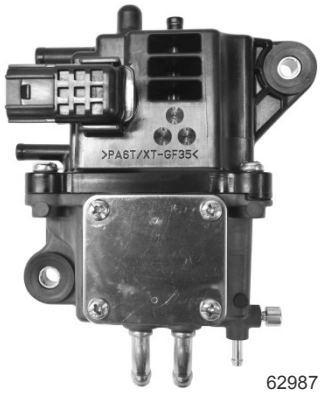
21124

Vapor Separator Tank

The vapor separator tank (VST) maintains a liquid fuel supply for the high-pressure fuel pump and delivers pressurized fuel to the fuel injectors at a regulated pressure. Fuel delivered from the mechanical low-pressure fuel pump enters at the top of the vapor separator and passes through a needle/float assembly that controls the fuel level with the VST. The high-pressure pump inlet is submerged below the fuel level and draws fuel in through an attached fuel filter.

The high-pressure fuel pump is pulse-width modulated by the ECM to deliver fuel flow in excess of the fuel volume injected in the intake manifold by the fuel injectors. The excess fuel recirculates through the pressure relief valve within the VST.

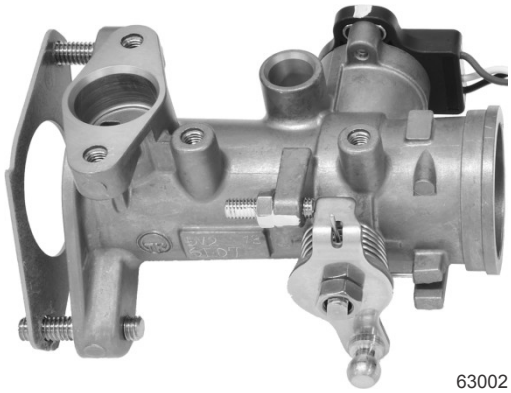
A fuel cooler is integrated within the lower housing of the VST.



62987

Throttle Body

The throttle body is connected to the intake manifold. It controls the amount of air that is allowed into the intake manifold. The throttle body affects the manifold absolute pressure (MAP). When the throttle body valve is closed (idle), the air pressure inside the intake manifold is in a vacuum state. When the throttle body valve opens, the vacuum condition of the intake manifold drops proportionally to the position of the throttle body valve. At wide-open throttle (WOT), the condition of the air inside the intake manifold continues to be in a vacuum state, but is significantly less of a vacuum than when at an idle position. These changes of the vacuum inside the intake manifold affect the MAP sensor reading, allowing the ECM to adjust the fuel injection quantity and the ignition timing.



63002

Engine Control Module (ECM)

Overview

The ECM takes inputs from sensors and controls the actuators. The ECM also rectifies voltage from the stator, to supply power to the various electrical components used on the engine, excluding the optional electric starting, charging, and power tilt components.

The ECM is itself powered by voltage from the stator, and does not require a battery. For diagnostics, a special adapter cable supplies the required power.

The ECM is a highly reliable component, and is rarely the source of a running issue. However, if the ECM should completely fail, the engine will not operate.

ECM and Fuel Injection

The ECM receives inputs from the crankshaft position sensor (CPS), engine coolant temperature (ECT) sensor, temperature and manifold absolute pressure (TMAP) sensor, and the throttle position sensor (TPS). It uses the data from these sensors to control the fuel injectors and the idle air control (IAC) valve:

Fuel injection: Controls the fuel injection pulse-width (duration) for optimum efficiency according to current operating condition

Idle air control: Stabilizes the engine RPM when idling and during quick engine RPM deceleration by managing the duty cycle driving the IAC in order to control bypass air entering the intake manifold

Troubleshooting

For troubleshooting information, refer to:

- **Section 1E - Accessing ECM Information with CDS G3**
- The appropriate engine wiring diagram in **Section 9A - Color Diagrams**

Additional Information

For additional information on the ECM, including removal and installation procedures, refer to **Section 2A - Engine Control Module (ECM)**.

Sensors

This engine uses sensors to monitor various aspects of engine operation. The data from these sensors are vital to controlling optimum fuel efficiency, horsepower, and emissions. The engine control module (ECM) uses sensor data to manage the fuel system, ignition system, and operator warning system.

The following brief descriptions are of each sensor that contributes to fuel system operation. For additional details, including service procedures and troubleshooting information, refer to **Section 2A - Sensors**.

Crankshaft Position Sensor (CPS)

The crankshaft position sensor (CPS) is a hall effect switch. It is located at the top of the cylinder block, next to the flywheel. The CPS generates a pulse for each revolution of the crankshaft. Each pulse is sent to the ECM. The timing and frequency of the pulse allows the ECM to regulate ignition and fuel injector timing.

If the CPS fails, the engine will run rough or stop running.

Engine Coolant Temperature (ECT) Sensor

The engine coolant temperature sensor is located on the top of the cylinder block. It monitors the temperature of the engine coolant. The ECM uses this data in the calculations for setting the fuel delivery volume.

If the sensor indicates an overtemperature condition, the ECM issues a warning to the operator via the warning buzzer and warning light for the duration of the overtemperature state.

If the sensor fails or becomes disconnected, engine speed will be limited to 2800 RPM.

Temperature and Manifold Absolute Pressure (TMAP) Sensor

This sensor unit combines two sensors in one housing. The two sensors are the manifold air temperature (MAT) sensor and the manifold absolute pressure (MAP) sensor.

The MAT sensor is a thermistor that monitors the temperature of the intake air as it exits the throttle body and enters the intake manifold. The ECM sets the fuel injection volume to allow the engine to run at optimum efficiency, based in part on the MAT data.

The MAP sensor monitors the air pressure of the intake air as it exits the throttle body and enters the intake manifold. The ECM compares the current manifold absolute pressure to the ambient atmospheric pressure (measured at start-up), and then makes adjustments to the fuel injection volume, based in part on this MAP data.

If the sensor unit fails or becomes disconnected, engine speed will be limited to 2800 RPM.

Throttle Position Sensor (TPS)

The throttle position sensor (TPS) is located on the throttle body and is in direct contact with the throttle shaft. The TPS transmits throttle angle information to the ECM, which regulates the fuel injector volume (pulse width) and ignition timing.

Should the sensor fail, a warning horn will sound and the engine RPM will be reduced by the ECM.

Actuators

Function of Actuators

Actuators receive output signals from the ECM, and perform functions which control air-fuel ratios, spark advance, and idle RPM. The actuators maintain optimal fuel economy as a direct relation to the engine horsepower.

Idle Air Control (IAC)

The idle air control (IAC) valve, sometimes referred to as the idle speed control valve (ISCV), is an electrically operated spring-loaded solenoid valve that controls the amount of air bypassing the closed throttle shutter. Signals from the ECM regulate the duty cycle for which the IAC valve remains open or closed. The IAC valve controls three operating functions:

- Provides additional intake air for the engine during start-up, and allows increased idle RPM during engine warm-up.
- Controls idle speed according to the varying engine loads and running conditions.

- Functions as an electronic dashpot by providing additional bypass air as the throttle quickly closes during a rapid deceleration, preventing engine stalling.


62991

Fuel Injector

The fuel injector is an electrically-operated, spring-loaded solenoid that delivers a metered amount of fuel into the intake manifold runner, just ahead of the intake valve. The injectors are electrically charged by the ECM through the stator assembly when the flywheel starts to rotate. The ECM controls the injection by completing the ground circuit, lifting the solenoid, which allows high-pressure fuel to flow through the fuel injector. The ECM then opens the ground circuit, allowing the spring to close the injector and stop the fuel flow.

An injector filter screen is located on the fuel inlet side of the injector. The filter screen is not replaceable, but can be cleaned of debris.


21100

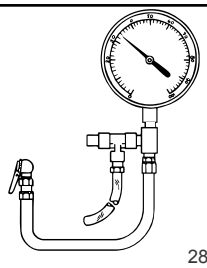
Notes:

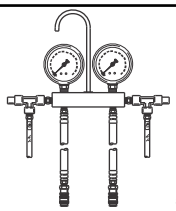
Fuel System

Section 3B - Troubleshooting and Diagnostics

Table of Contents

Special Tools

Fuel Pressure Gauge Kit	91-881833A03
 2807	Tests the fuel pump pressure; can be used to relieve fuel pressure.

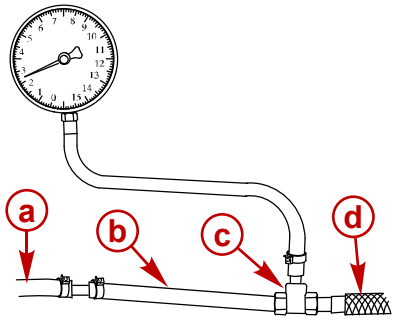
Dual Fuel/Air Pressure Gauge Kit	91-881834A 1
 5822	Tests fuel and air pressure; the dual gauges allow the viewing of both pressures simultaneously.

General Troubleshooting

For general troubleshooting information, including connecting and using the CDS G3 diagnostic tool, refer to **Section 1E - General Troubleshooting**.

Testing Fuel System Inlet Vacuum

1. Separate the engine fuel line and the boat fuel line.
2. Install a T-fitting on the boat fuel line.
3. Install a clear fuel line on the opposite side of the T-fitting.
4. Connect the clear fuel line to the engine fuel line.
5. Install a fuel vacuum gauge (obtain locally) on the T-fitting.
6. Clamp all fuel line connections securely to prevent vacuum leaks.
7. Start the engine.
8. Monitor the clear fuel line for air bubbles.
9. At maximum fuel flow (wide-open throttle operation), the vacuum gauge reading should not exceed the listed specification.



4439

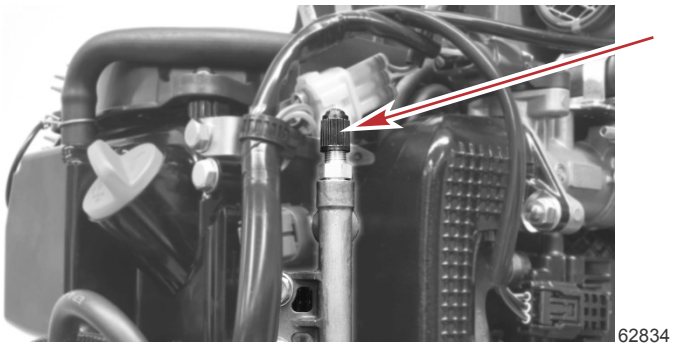
- **a -** Engine fuel line
- **b -** Clear fuel line
- **c -** T-fitting
- **d -** Boat fuel line

Fuel System Inlet Vacuum	
Maximum	8.5 kPa (2.5 in. Hg)

Fuel Pressure Test

1. Install a fuel pressure gauge onto the fuel rail service port.

2. Start the engine. The fuel pressure should be within specification.



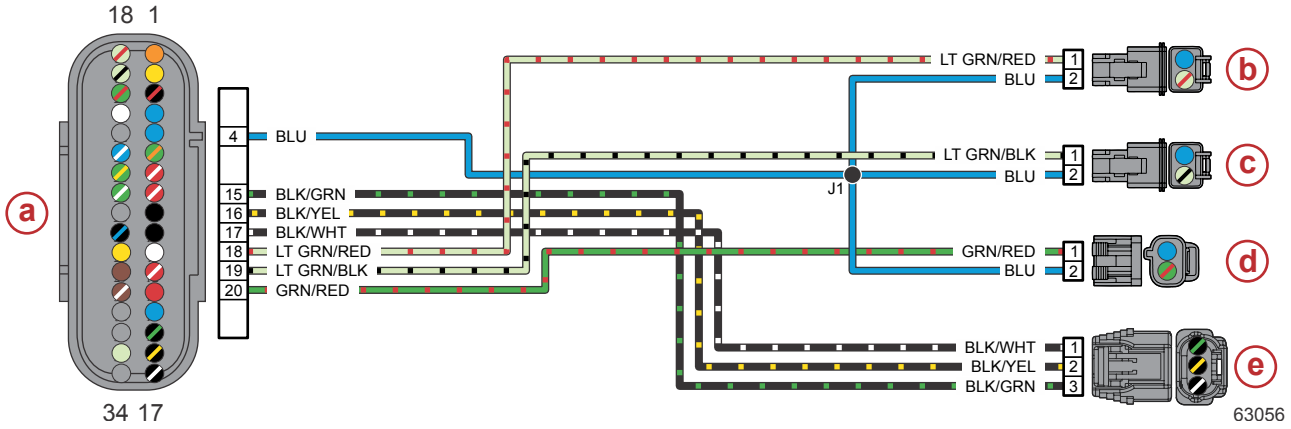
Fuel Pressure Specification	
All operating conditions	256 ± 25 kPa (37.1 ± 3.6 psi)

Fuel Pressure Gauge Kit	91-881833A03
Dual Fuel/Air Pressure Gauge Kit	91-881834A 1

Wire Color Code Abbreviations

Wire Color Abbreviations				
BLK	Black		BLU	Blue
BRN	Brown		GRA	Gray
GRN	Green		ORN	Orange
PNK	Pink		PPL	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT	Light		DK	Dark

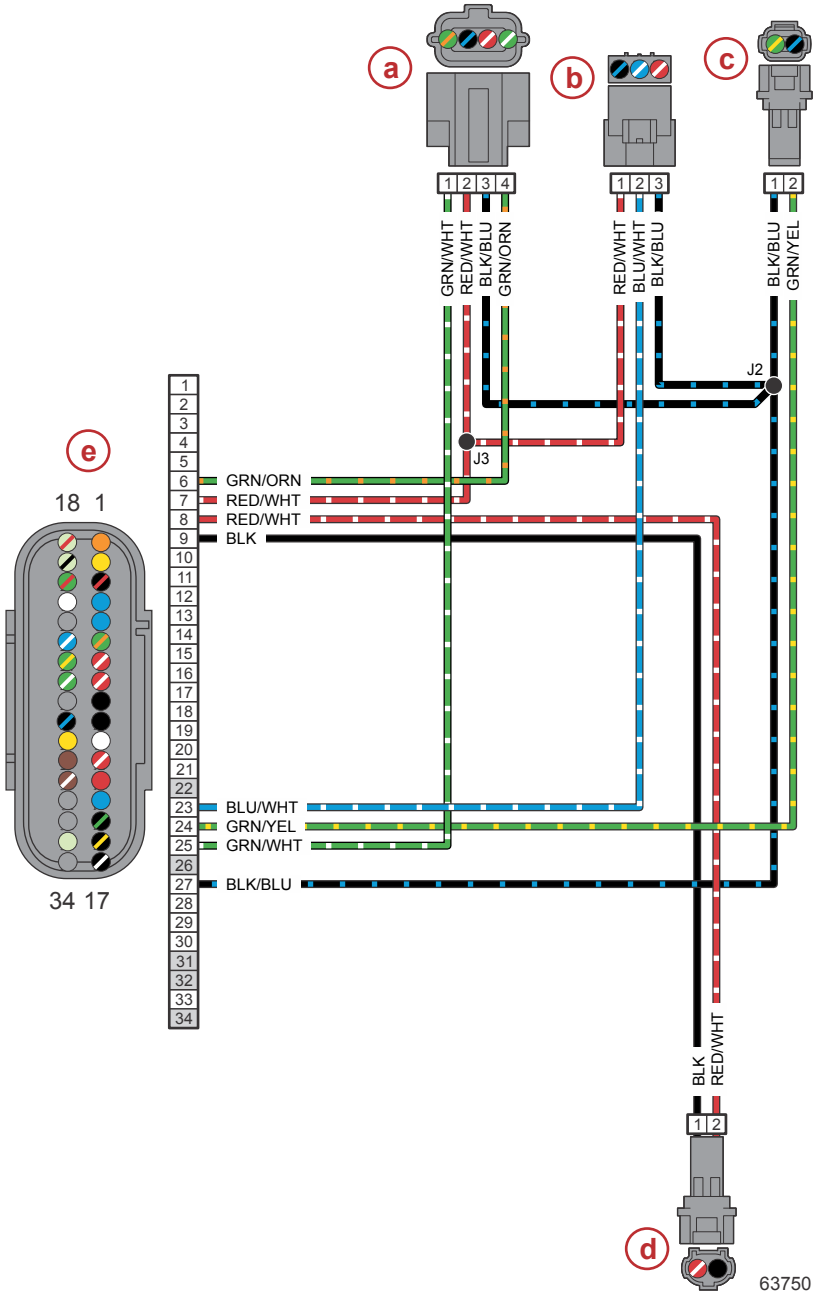
Fuel System Wiring Diagram



15/20 EFI fuel system wiring diagram

- **a -** Engine control module
- **b -** Fuel injector #1
- **c -** Fuel injector #2
- **d -** Idle air control valve
- **e -** High-pressure fuel pump

Sensor Wiring Diagram



15/20 EFI sensor wiring diagram

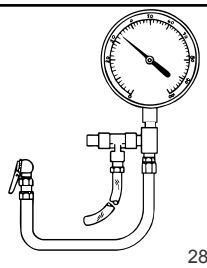
- **a -** Temperature and manifold absolute pressure (TMAP) sensor
- **b -** Throttle position sensor (TPS)
- **c -** Engine coolant temperature (ECT) sensor
- **d -** Crankshaft position sensor (CPS)
- **e -** Engine control module (ECM)

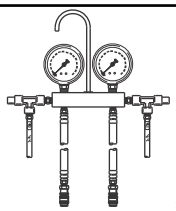
Fuel System

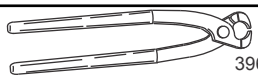
Section 3C - Service Procedures

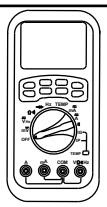
Table of Contents

Special Tools

Fuel Pressure Gauge Kit	91-881833A03
 2807	Tests the fuel pump pressure; can be used to relieve fuel pressure.

Dual Fuel/Air Pressure Gauge Kit	91-881834A 1
 5822	Tests fuel and air pressure; the dual gauges allow the viewing of both pressures simultaneously.

Clamp Tool	91-803146T
 39648	Used to clamp high-pressure (Oetiker®) hose clamps. Part of Clamp Tool Kit (91-803146A04).

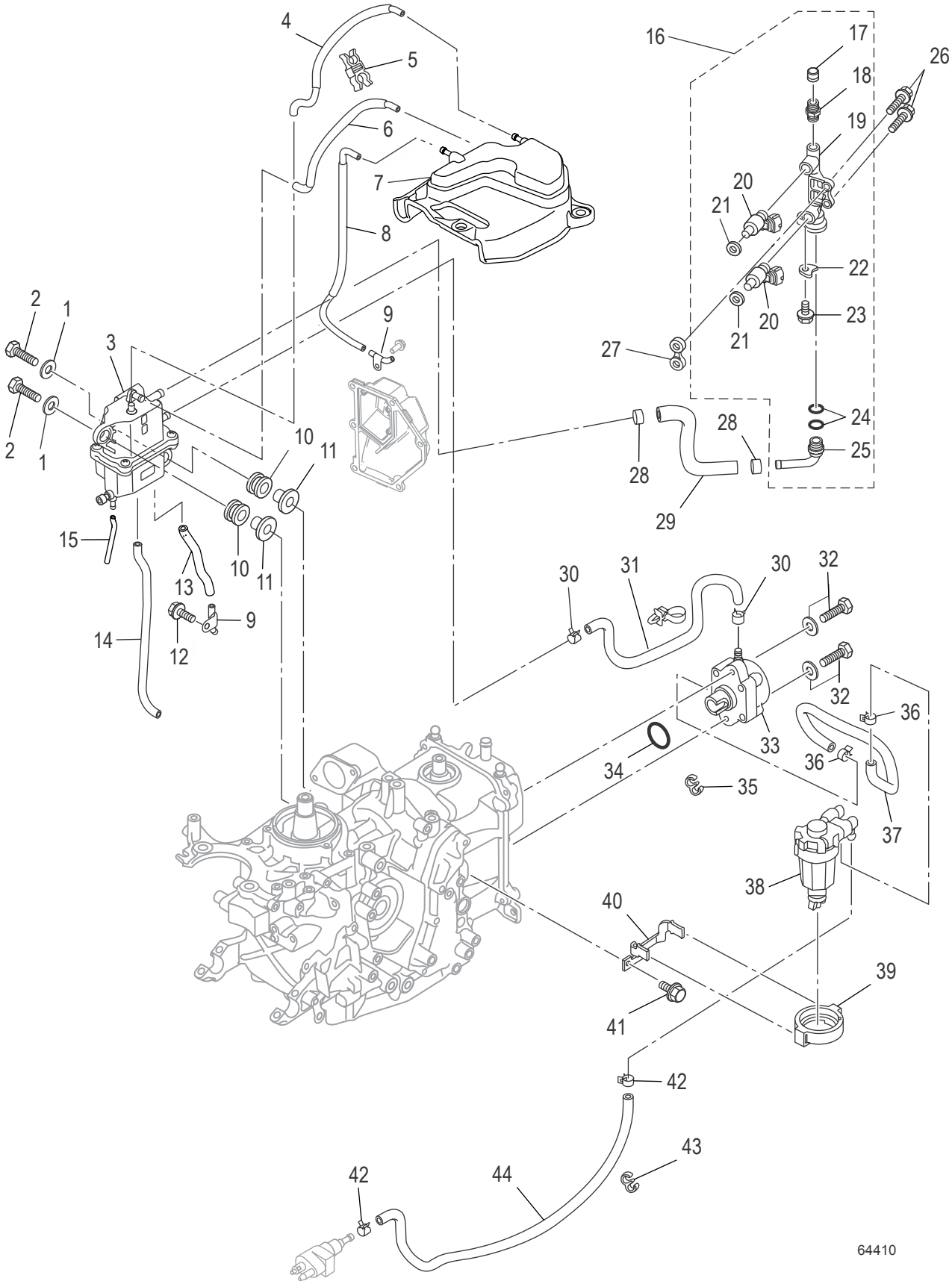
DMT 2004 Digital Multimeter	91-892647A01
 **4516**	Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments.

Fuel System Specifications

Parameter	Specification
Fuel system	Computer-controlled split-sequential multiport electronic fuel injection
Fuel type	Automotive unleaded with a minimum pump posted octane rating of 87 (R+M)/2 (90 RON); up to 10% ethanol
Fuel pump type	Mechanical plunger (diaphragm) + Electric high pressure
Fuel pump pressure (mechanical)	30 kPa ± 20 kPa (4.3 psi ± 2.9 psi)
Fuel pump pressure (electric)	256 kPa ± 25 kPa (37.1 psi ± 3.6 kPa)

Notes:

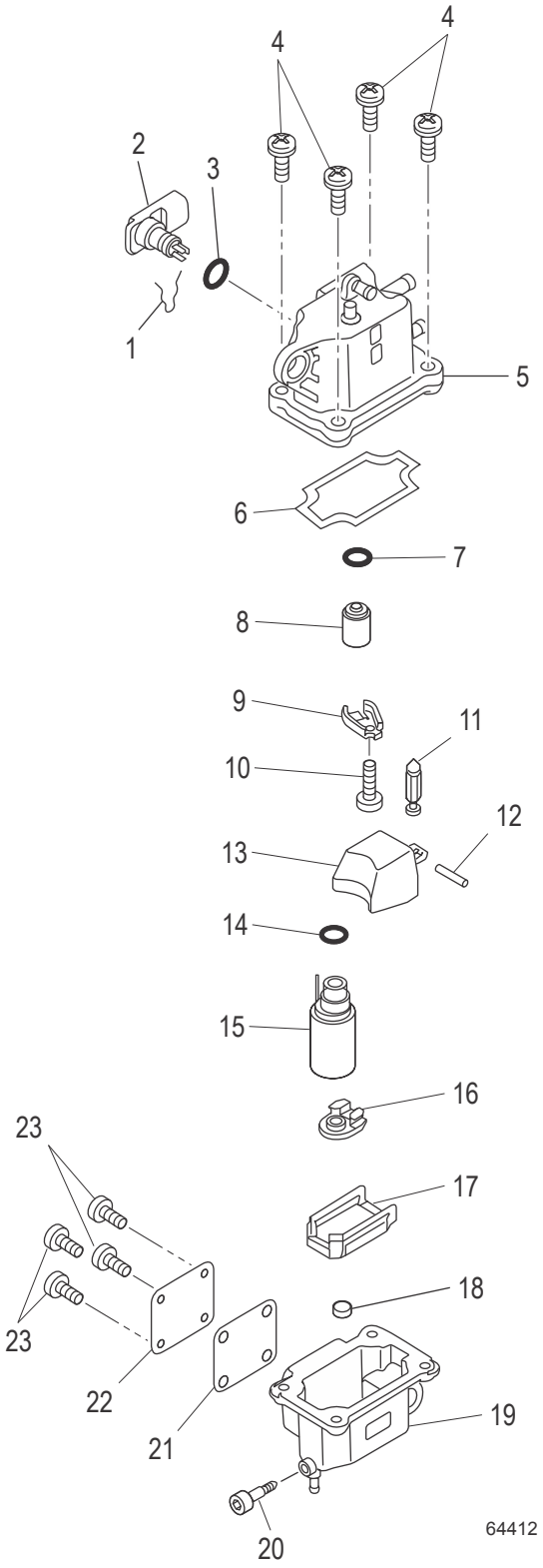
Fuel System Components



Fuel System Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Washer			
2	2	Screw	6.0	53.1	–
3	1	Vapor separator tank			
4	1	Vent hose			
5	1	Clamp			
6	1	Vent hose			
7	1	Vapor recovery tank			
8	2	Vent hose			
9	2	Fitting			
10	2	Rubber mount			
11	2	Collar			
12	1	Screw	6.0	53.1	–
13	1	Cooling hose			
14	1	Water hose			
15	1	VST drain hose			
16	1	Fuel rail assembly			
17	1	Cap			
18	1	Valve assembly (not a service item)			
19	1	Fuel rail			
20	2	Fuel injector assembly			
21	2	Seal ring			
22	1	Holding plate			
23	1	Screw	6.0	53.1	–
24	2	O-ring			
25	1	Fuel inlet tube			
26	2	Screw	6.0	53.1	–
27	1	Insulator			
28	2	Clamp			
29	1	Fuel hose			
30	2	Hose clamp			
31	1	Fuel hose			
32	2	Screw with washer	6.0	53.1	–
33	1	Fuel pump assembly			
34	1	O-ring			
35	1	Clamp			
36	2	Hose clamp			
37	1	Fuel hose			
38	1	Fuel filter assembly			
39	1	Fuel filter holder			
40	1	Bracket			
41	1	Screw	6.0	53.1	–
42	2	Hose clamp			
43	1	Clamp			
44	1	Fuel hose			

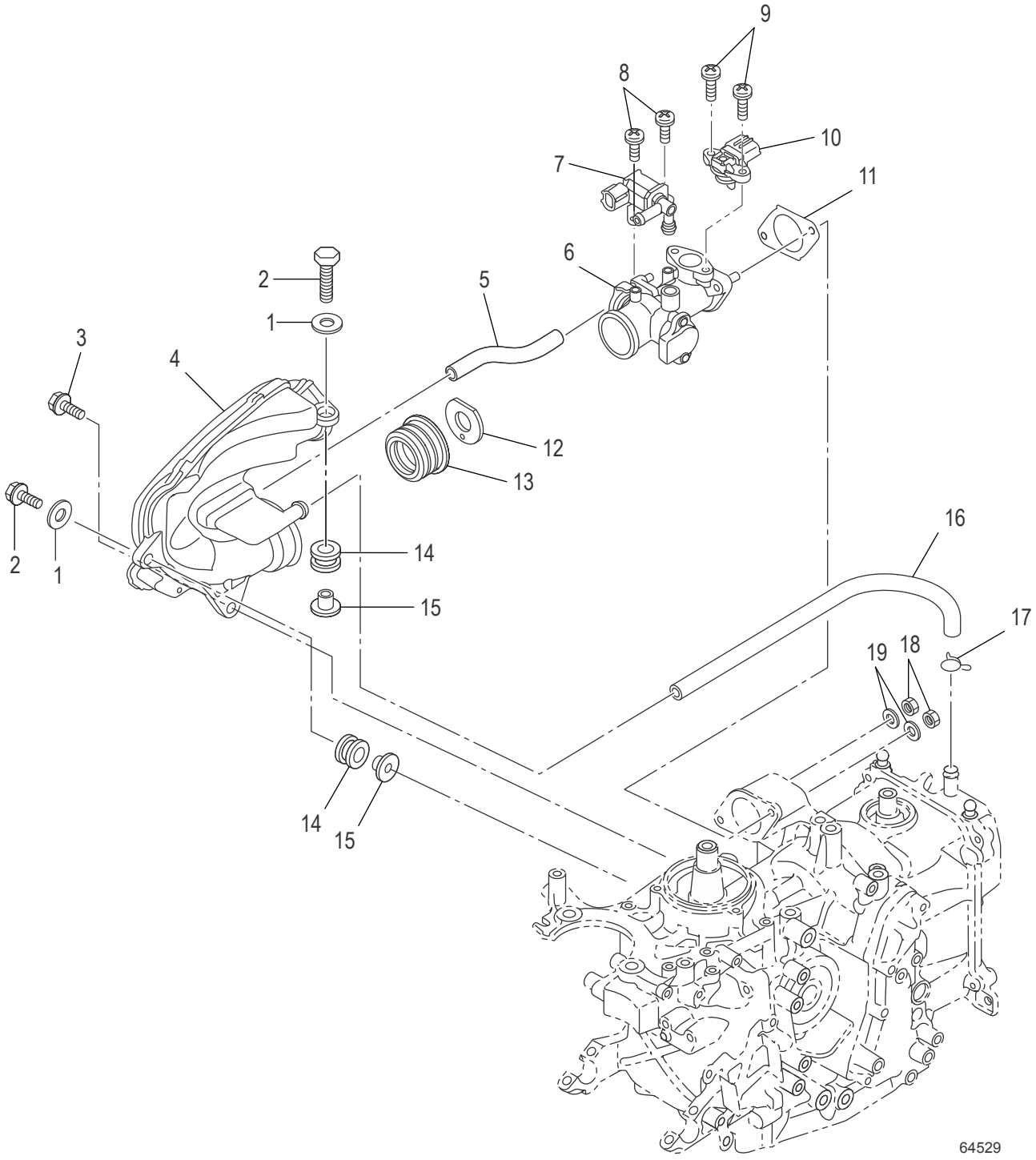
Vapor Separator Tank Components



Vapor Separator Tank Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Clip			
2	1	VST connector			
3	1	O-ring			
4	4	Screw	3.0	26.6	–
5	1	VST cover			
6	1	Gasket			
7	1	O-ring			
8	1	Fuel regulator			
9	1	Holder			
10	1	Screw	2.0	17.7	–
11	1	Float valve assembly			
12	1	Float arm pin			
13	1	Float			
14	1	O-ring			
15	1	Fuel pump			
16	1	Filter holder			
17	1	Filter			
18	1	Grommet			
19	1	VST lower housing			
20	1	Drain screw			
21	1	Seal			
22	1	Cover			
23	4	Screw	2.0	17.7	–

Air Intake Components



Air Intake Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Washer			
2	2	Screw	6.0	53.1	–
3	1	Screw	6.0	53.1	–
4	1	Air box			
5	1	Hose			
6	1	Throttle body assembly			
7	1	Idle air control valve			
8	2	Screw	3.0	26.6	–
9	2	Screw	3.0	26.6	–
10	1	TMAP sensor			
11	1	Gasket			
12	1	Restrictor (10/15 hp models only)			
13	1	Gasket			
14	2	Rubber mount			
15	2	Collar			
16	1	Breather hose			
17	1	Hose clamp			
18	2	Nut	6.0	53.1	–
19	2	Washer			

Fuel Lift Pump

Fuel Lift Pump Removal

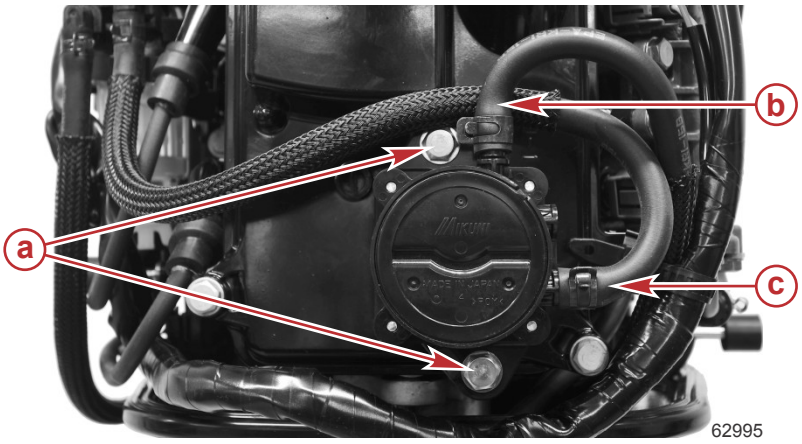
⚠ WARNING

Performing service or maintenance without first disconnecting the battery can cause product damage, personal injury, or death due to fire, explosion, electrical shock, or unexpected engine starting. Always disconnect the battery cables from the battery before maintaining, servicing, installing, or removing engine or drive components.

⚠ WARNING

Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for leaks before attempting to start the engine, and wipe up any spilled fuel immediately.

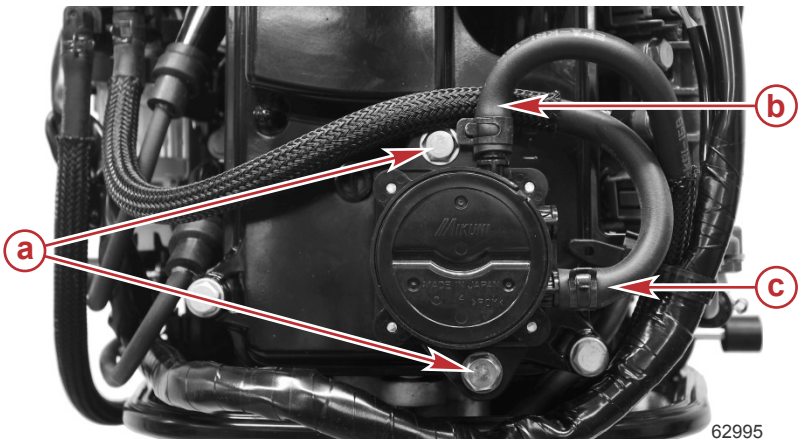
1. Remove the driveshaft housing covers. Refer to **Section 5A - Driveshaft Housing Covers**.
2. Remove the two screws securing the fuel pump to the cylinder head cover.
3. Pull the fuel pump assembly from the cylinder head cover.
4. Remove the fuel in and fuel out hoses from the fuel pump. Be certain to capture and dispose of any excess fuel according to local regulations.



a - Fuel pump screws (2)
b - Fuel out hose
c - Fuel in hose

Fuel Lift Pump Installation

1. Attach the fuel in and fuel out hoses to the fuel pump assembly. Secure the fuel in and fuel out hoses with spring clamps.
2. Install the fuel pump assembly with the hoses attached into the cylinder head cover.
3. Secure the fuel pump assembly to the cylinder head cover with two screws. Tighten the screws to the specified torque.



a - Fuel pump screws (2)
b - Fuel out hose
c - Fuel in hose

Description	Nm	lb-in.	lb-ft
Fuel pump screws (2)	6.0	53.1	–

4. Install the driveshaft housing covers. Refer to **Section 5A - Driveshaft Housing Covers**. Be certain to tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Driveshaft housing cover screws (11)	6.0	53.1	–

Vapor Separator Tank (VST)

VST Removal

⚠ WARNING

Performing service or maintenance without first disconnecting the battery can cause product damage, personal injury, or death due to fire, explosion, electrical shock, or unexpected engine starting. Always disconnect the battery cables from the battery before maintaining, servicing, installing, or removing engine or drive components.

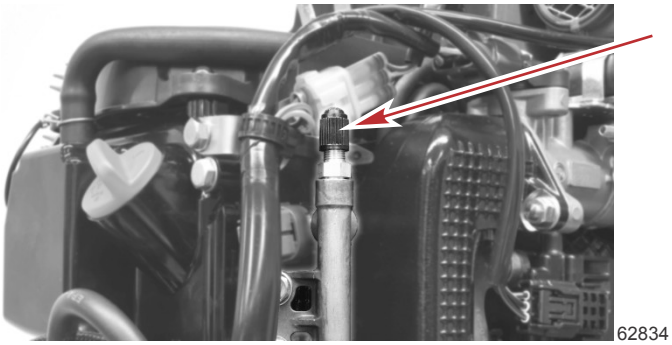
⚠ WARNING

Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for leaks before attempting to start the engine, and wipe up any spilled fuel immediately.

⚠ CAUTION

Failure to release pressure from the fuel system will result in fuel spraying out, which can cause a fire or explosion. Allow the engine to cool completely and release all fuel pressure before servicing any part of the fuel system. Always protect eyes and skin from pressurized fuel and vapors.

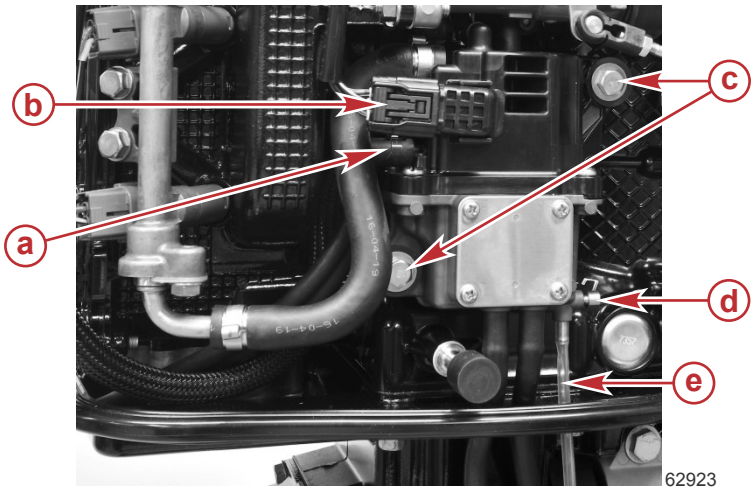
1. For electric start models: Disconnect the battery cables from the battery, starting with the negative cable.
2. Install a fuel pressure gauge onto the fuel rail service port and release any pressurized fuel into an appropriate container.


62834

Fuel Pressure Gauge Kit	91-881833A03
Dual Fuel/Air Pressure Gauge Kit	91-881834A 1

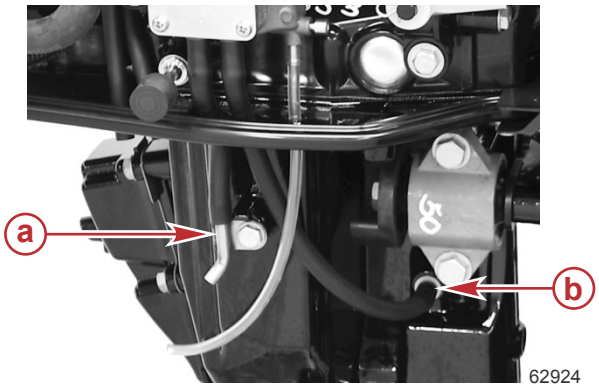
3. Remove the starboard driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.
4. Using an appropriate container to capture the fuel, open the VST drain screw and allow the VST to drain completely.
5. Disconnect the high-pressure fuel pump wire harness connector.
6. Remove the two screws securing the VST to the cylinder block, and pull the assembly away from the engine.

7. Remove the hose clamp securing the low-pressure fuel supply hose to the assembly.



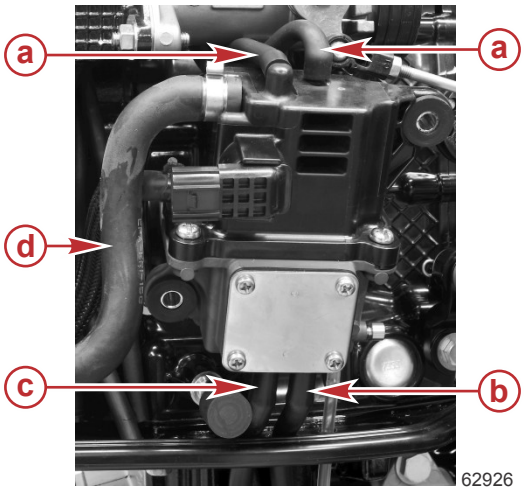
- **a -** Hose clamp securing the low-pressure fuel supply hose
- **b -** High-pressure fuel pump wire harness connector
- **c -** Screws (2)
- **d -** VST drain screw
- **e -** VST drain hose

8. Disconnect the fuel cooler water supply and water pump indicator hoses from the fittings located in the driveshaft housing.



- **a -** Water pump indicator hose fitting
- **b -** Fuel cooler water supply hose fitting

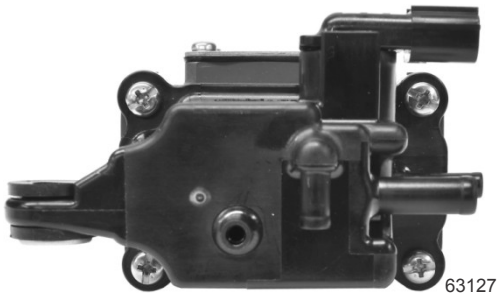
9. Remove the Oetiker® clamp securing the high-pressure fuel hose to the VST, and remove the fuel hose from the VST.
10. Remove the two vent hoses from the top of the VST assembly.
11. Pull the entire assembly away from the engine, carefully pulling the two fuel cooler water hoses through the holes in the midplate.



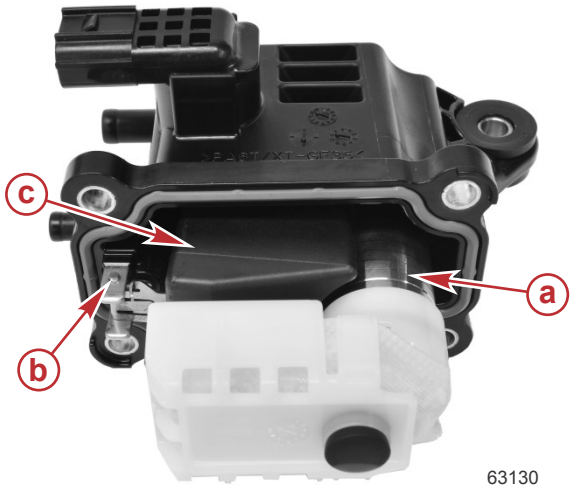
- **a -** VST vent hoses
- **b -** Fuel cooler water supply hose
- **c -** Fuel cooler drain hose (water pump indicator hose)
- **d -** High-pressure fuel hose (to fuel rail)

VST Disassembly

1. Remove the four screws that secure the two halves of the VST assembly. Be careful to not spill any fuel that may remain in the tank. Empty any fuel into an appropriate container and dispose of it according to local regulations.


63127

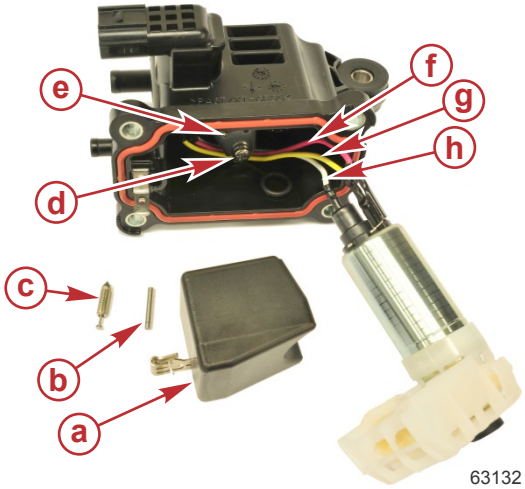
2. Gently pull on the high-pressure fuel pump to remove it from the cover.
3. Remove the float pin from the assembly. The float and the fuel inlet needle will come free.



63130

- **a -** High-pressure fuel pump
- **b -** Float pin
- **c -** Float

4. Disconnect the red, yellow, and white wires from the fuel pump.
5. Loosen the screw and remove the screw and clamp that secure the check valve in place.

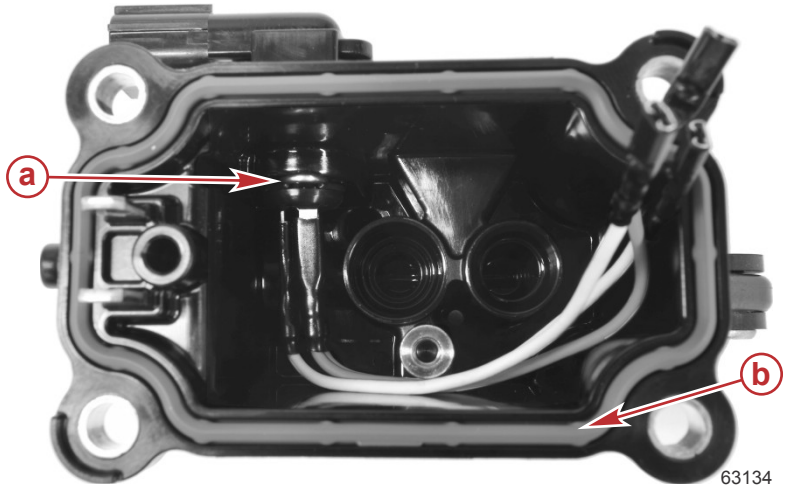


63132

- **a -** Float
- **b -** Float pin
- **c -** Fuel inlet needle
- **d -** Screw
- **e -** Clamp
- **f -** Red fuel pump wire
- **g -** Yellow fuel pump wire
- **h -** White fuel pump wire

6. Remove the check valve and O-ring.
7. Remove the clip that secures the fuel pump electrical connector, and remove the connector and O-ring from the cover.

8. Remove the seal from the cover, and discard.

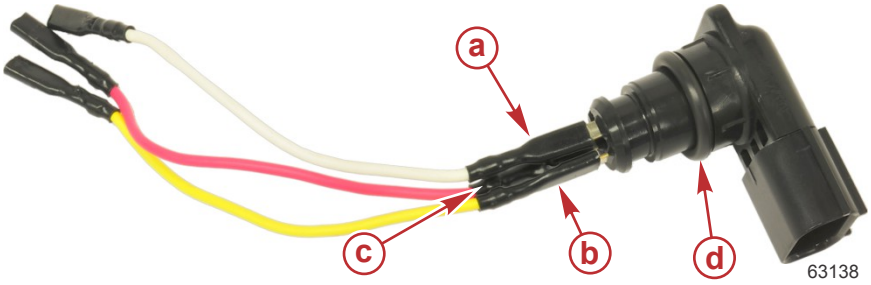


a - Clip
b - Seal

VST Reassembly

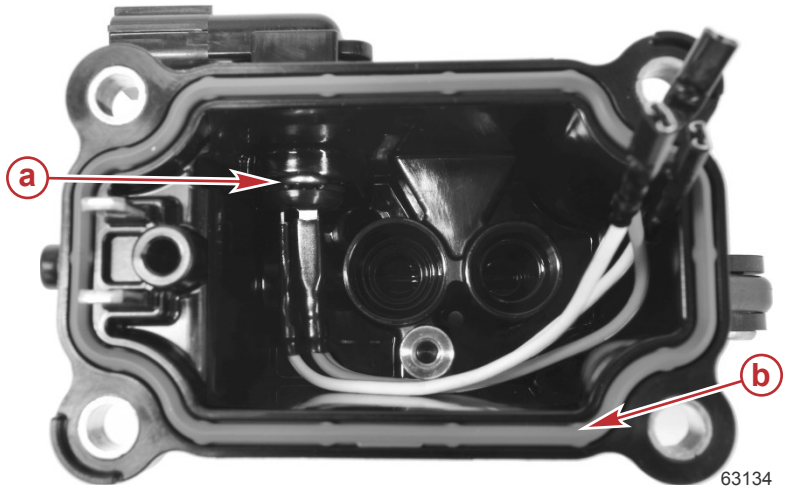
1. Ensure that the O-ring is in place on the fuel pump electrical connector, feed the red, yellow, and white wires through the opening on the top of the VST cover, and firmly seat the connector in position.

   NOTE: *When viewing the electrical connector from the terminal side, the clockwise order of the wires should be white, yellow, and red.*



Fuel pump electrical connector
a - Spade connector for white wire
b - Spade connector for yellow wire
c - Spade connector for red wire
d - O-ring

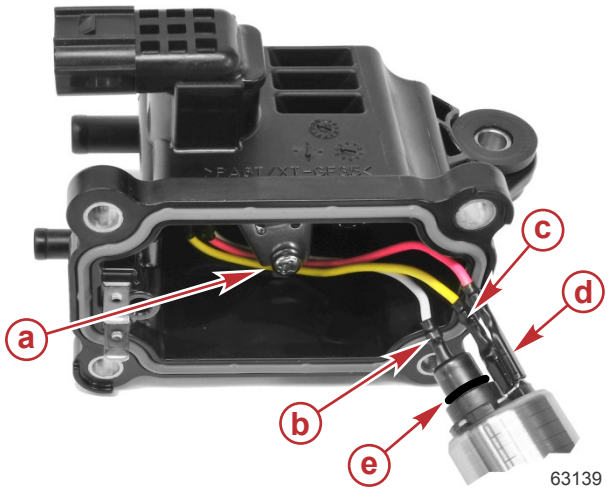
2. Secure the connector with the clip.
3. Place a new seal in the bottom of the VST cover.



a - Clip
b - Seal

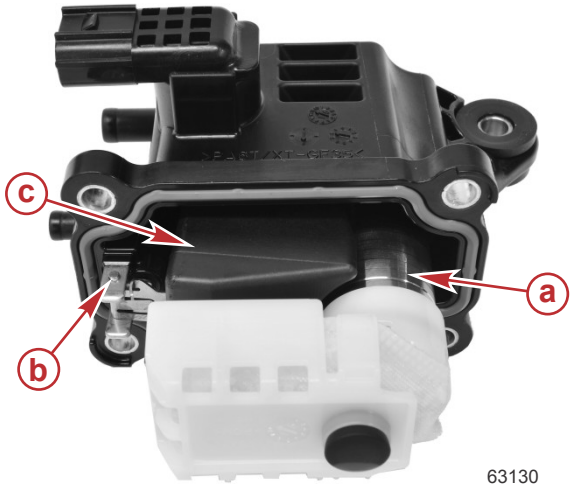
4. Place a new O-ring onto the check valve, and insert the check valve into the VST cover.
5. Ensure that the fuel pump wires route outside of the screw boss, and secure the check valve with the clamp and screw.
6. Attach the white, yellow, and red wires to the fuel pump.

NOTE: *When viewing the fuel pump electrical terminals from the top, the clockwise order of connection is white, yellow, and red.*



- **a -** Wires routed outside of screw boss
- **b -** White wire spade terminal
- **c -** Yellow wire spade terminal
- **d -** Red wire spade terminal
- **e -** O-ring

7. Insert the fuel inlet needle into the VST cover, place the float in position, and secure it with the float pin.
8. Ensure that the O-ring is in position on the fuel pump, and press it into position in the VST cover.



- **a -** High-pressure fuel pump
- **b -** Float pin
- **c -** Float

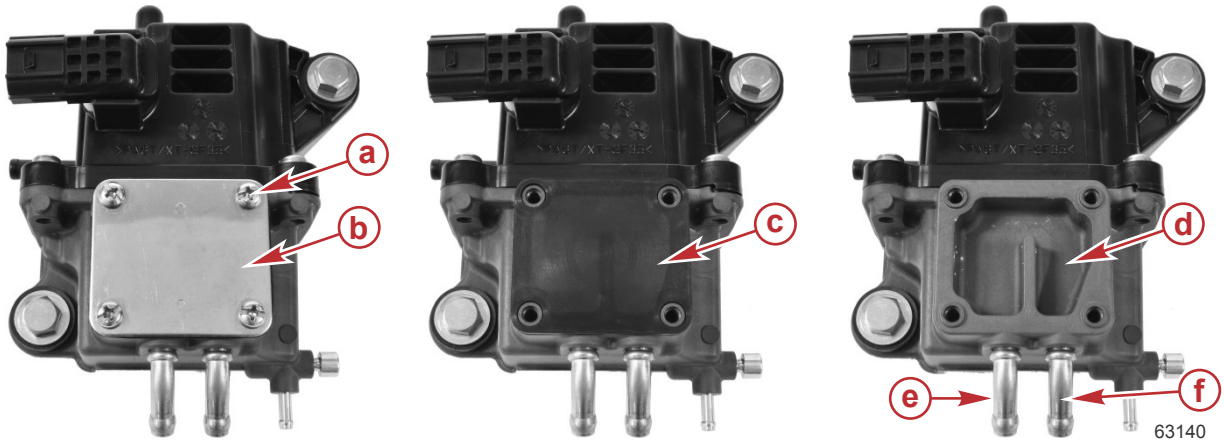
9. Assemble the two halves of the VST assembly, and secure with four screws.

Fuel Cooler

To remove the cover on the VST's fuel cooler chamber:

1. Remove four screws and remove the fuel cooler cover.

2. Remove the seal.

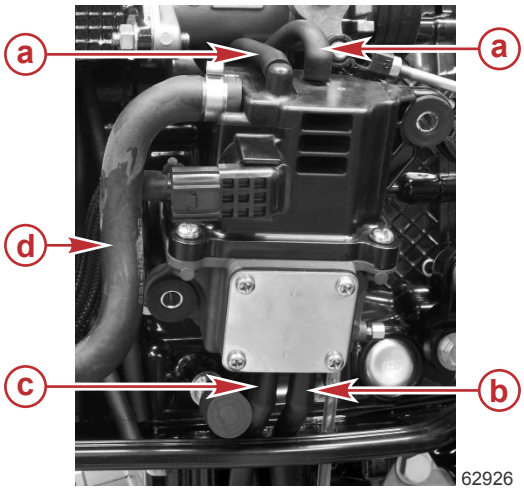


a - Screw (4)
b - Fuel cooler cover
c - Seal
d - Cooling water chamber
e - Water outlet (water pump indicator hose)
f - Water inlet

VST Installation

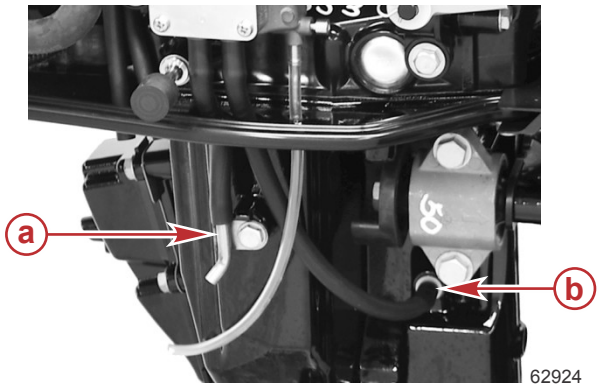
1. Feed the water pump indicator hose and the fuel cooler supply hose through their respective holes in the midplate.
2. Attach the two vent hoses to the top of the VST assembly.
3. Connect the high-pressure fuel hose to the VST with a new Oetiker® clamp.

Clamp Tool	91-803146T



a - VST vent hoses
b - Fuel cooler water supply hose
c - Fuel cooler drain hose (water pump indicator hose)
d - High-pressure fuel hose (to fuel rail)

4. Connect the fuel cooler water supply and water pump indicator hoses to the fittings located in the driveshaft housing.

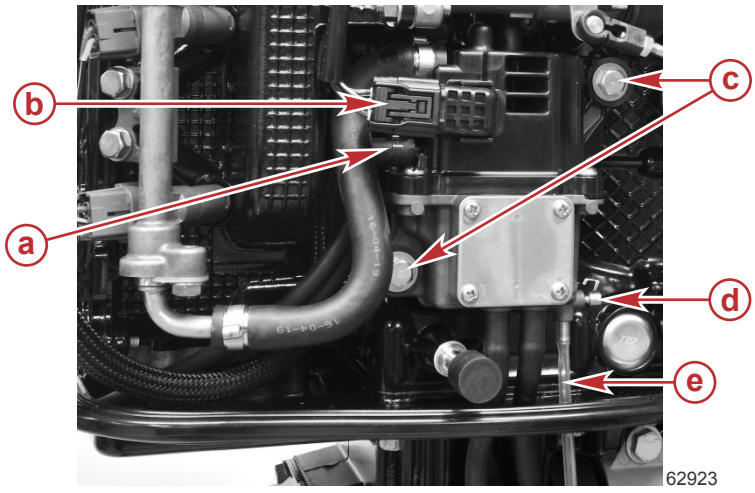


a - Water pump indicator hose fitting
b - Fuel cooler water supply hose fitting

5. Attach the low-pressure fuel supply hose to the VST assembly, and secure it with a hose clamp.
6. Attach the VST assembly to the cylinder block with two screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
VST mounting screws	6.0	53.1	–

7. Connect the high-pressure fuel pump electrical connector to the engine harness.
8. Ensure that the VST drain hose is routed through the midplate, and attach the hose to the drain fitting.



a - Hose clamp securing the low-pressure fuel supply hose
b - High-pressure fuel pump electrical connector
c - Screws (2)
d - VST drain screw
e - VST drain hose

9. Install the starboard driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.

Camshaft Gear Cover/Vent Tank

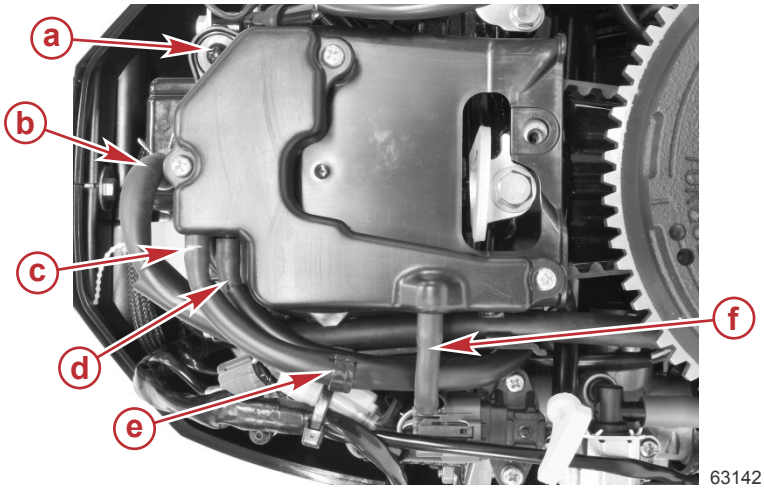
The camshaft gear cover assembly incorporates a secondary vent tank for the vapor separator tank (VST).

NOTE: *The following procedures assume that the air box and recoil starter assembly have been removed. For details on those procedures, refer to* ***Air Box*** *and* ***Section 8A - Recoil Starter****.*

Removal

1. Remove the vent hose from the cover assembly.
2. Remove the two vapor separator (VST) tank hoses from the cover assembly.
3. Remove the crankcase breather hose.

4. Lift the cover assembly to remove it from the two pins that secure it to the engine.



a - Pin (2)
b - Crankcase breather hose
c - VST hose with white mark
d - VST hose without white mark
e - Clip
f - Vent hose

Installation

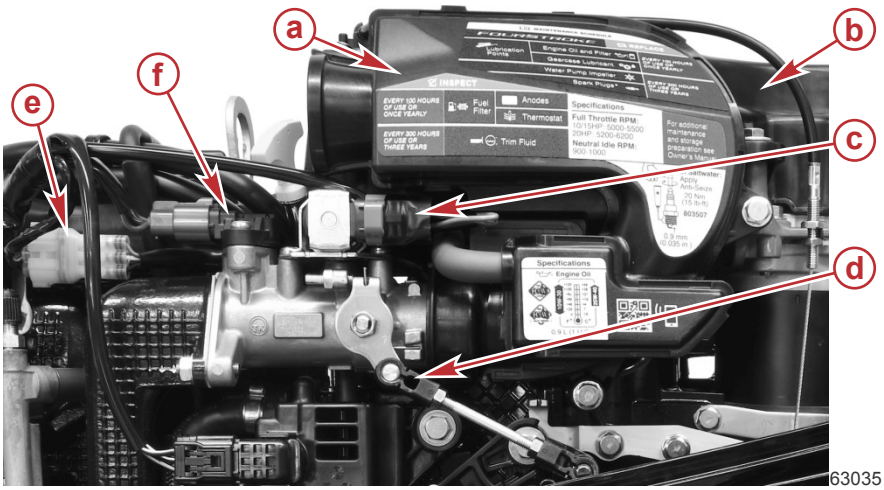
1. Position the cover assembly onto the engine. Ensure that the grommets do not become dislodged from the cover assembly.
2. Route the crankcase breather hose across the tray and secure it to the valve cover with a spring clamp.

   NOTE: *It may be easier to connect the crankcase hose to the air box if you route the hose, but do not connect it. Be certain, however, to complete the connection at the valve cover prior to placing the engine back into service.*
3. Attach the two hoses from the vapor separator tank. The hose with the white mark attaches to the upper fitting.
4. Attach the vent hose.

Throttle Body

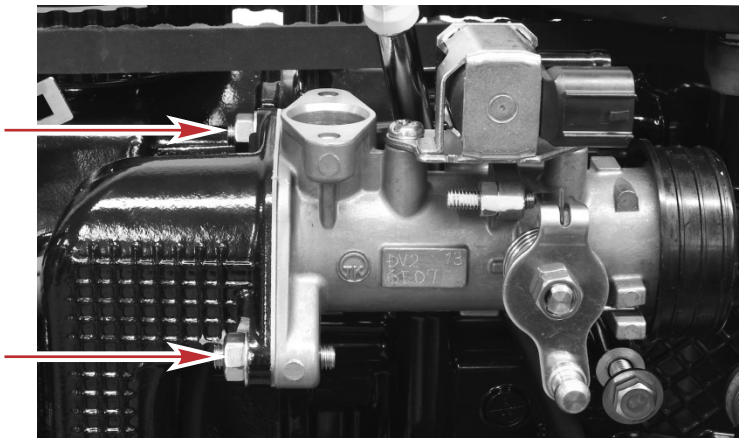
Throttle Body Removal

1. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Air Box Removal** and **Section 8A - Recoil Starter**.
2. Disconnect the idle air control (IAC) valve from the engine harness.
3. Remove the throttle link from the throttle cam.
4. Disconnect the throttle position sensor (TPS) from the engine harness.
5. Remove the temperature and manifold absolute pressure (TMAP) sensor. Refer to **Section 2A - Temperature and Manifold Absolute Pressure (TMAP) Sensor**.

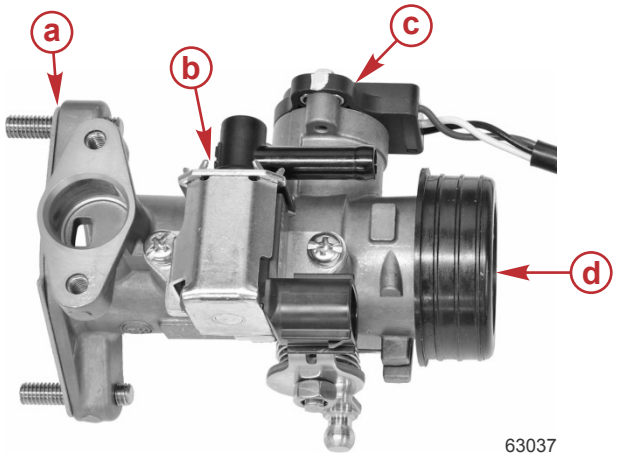


a - Air box
b - Recoil starter assembly
c - IAC valve harness connector
d - Throttle link
e - TPS harness connector
f - TMAP sensor

6. Remove the two nuts securing the throttle assembly to the intake manifold, and remove the throttle body assembly from the intake manifold.


63036

7. Remove the grommet from the throttle body assembly.
8. Remove the idle air control (IAC) valve from the throttle body assembly.
9. Remove the gasket.



63037

a - Gasket
b - IAC valve
c - Throttle position sensor (TPS)
d - Grommet

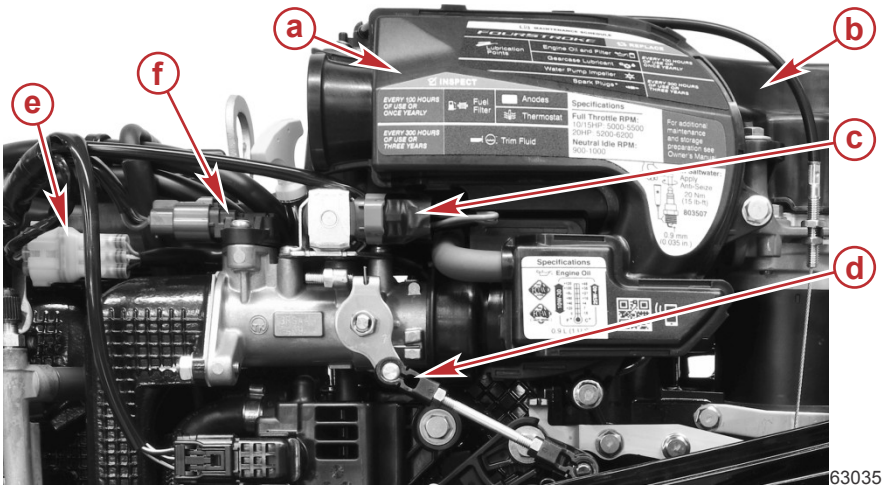
Throttle Body Installation

1. Install a gasket onto the throttle body studs.
2. Install the throttle body onto the intake manifold, and secure with two nuts. Tighten the nuts to the specified torque.

Description	Nm	lb-in.	lb-ft
Nuts securing the throttle body	6.0	53.1	–

3. Install the grommet onto the throttle body.
4. Install the idle air control (IAC) valve onto the throttle body. Refer to **IAC Installation**.
5. Connect the throttle link to the throttle cam.
6. Install the temperature and manifold absolute pressure (TMAP) sensor. Refer to **Section 2A - Temperature and Manifold Absolute Pressure (TMAP) Sensor**.
7. Connect the throttle position sensor (TPS) to the engine harness.
8. Install the recoil starter and air box.
   - It is easiest to install the recoil starter and air box together.

- Refer to **Section 8A - Recoil Starter** and **Air Box Installation**.



a - Air box
b - Recoil starter assembly
c - IAC valve harness connector
d - Throttle link
e - TPS harness connector

Fuel Rail

Fuel Rail Removal

⚠ WARNING

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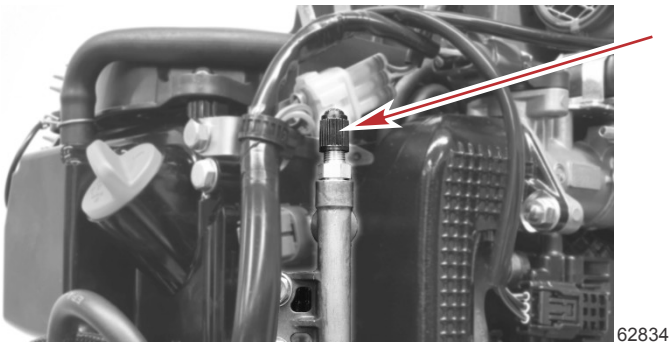
⚠ WARNING

Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for leaks before attempting to start the engine, and wipe up any spilled fuel immediately.

⚠ CAUTION

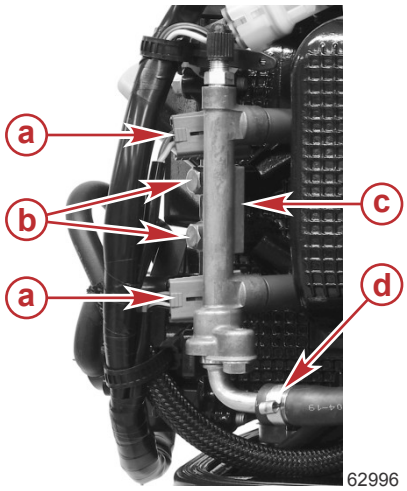
Failure to release pressure from the fuel system will result in fuel spraying out, which can cause a fire or explosion. Allow the engine to cool completely and release all fuel pressure before servicing any part of the fuel system. Always protect eyes and skin from pressurized fuel and vapors.

1. For electric start models, disconnect the battery cables from the battery. Always disconnect the negative battery cable first, and then the positive.
2. Install a fuel pressure gauge to the fuel rail service port and release the fuel into an appropriate container.



3. Disconnect the fuel injector harness connectors from the two fuel injectors.
4. Remove the two screws securing the fuel rail to the intake manifold. Do not lose the clamp securing the fuel rail to the intake manifold.
5. Pull the fuel rail assembly off the intake manifold.
6. Remove the Oetiker® clamp securing the fuel hose to the fuel rail inlet tube.

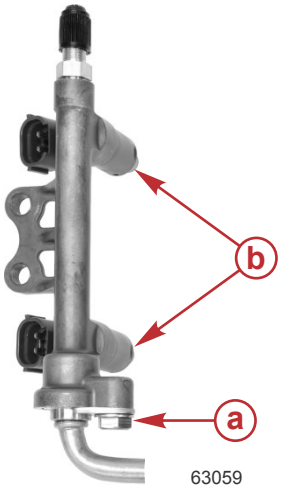
7. Remove the fuel hose from the fuel rail inlet tube. Clean up any spilled fuel after removing the fuel hose.



a - Fuel injector harness connectors
b - Fuel rail screws (2)
c - Clamp
d - Oetiker® clamp

Fuel Rail Disassembly

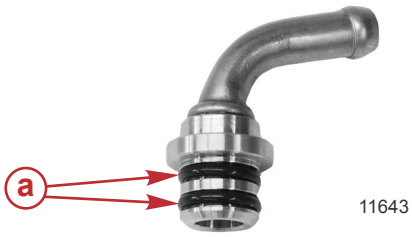
1. Remove the screw securing the fuel inlet tube to the fuel rail. Remove the fuel inlet tube.
2. Remove the fuel injectors from the fuel rail.



a - Screw securing the fuel inlet tube
b - Fuel injectors (2)

Fuel Rail Reassembly

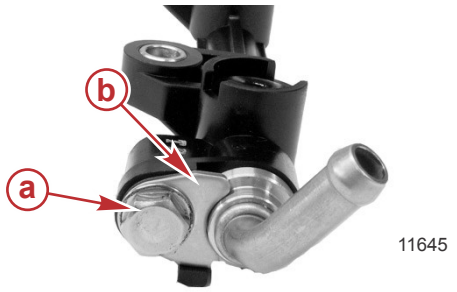
1. Wash the fuel rail with a solvent. Use compressed air to clean and dry the fuel rail.
2. Install new O-rings onto the fuel inlet tube.



a - O-rings (2)

3. Lubricate the fuel inlet tube O-rings with clean engine oil.
4. Install the fuel inlet tube onto the fuel rail.

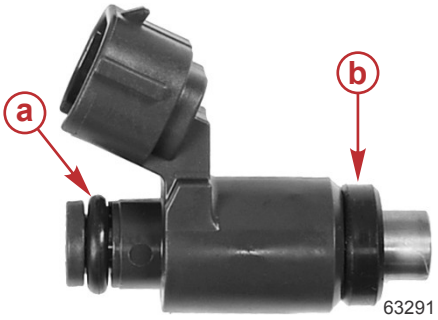
5. Secure the fuel inlet tube to the fuel rail with a clamp and screw. Tighten the screw to the specified torque.



a - Screw
b - Inlet tube clamp

Description	Nm	lb-in.	lb-ft
Screw	6.0	53.1	–

6. Inspect the fuel injector filter screen.
   NOTE: *The fuel injector filter screen is a nonserviceable component, but can be cleared of debris.*
7. Install new O-rings and seals onto the fuel injectors.



a - O-ring
b - Seal

8. Lubricate the fuel injector O-rings and seals with clean engine oil.
9. Install the fuel injectors into the fuel rail.

Fuel Rail Installation

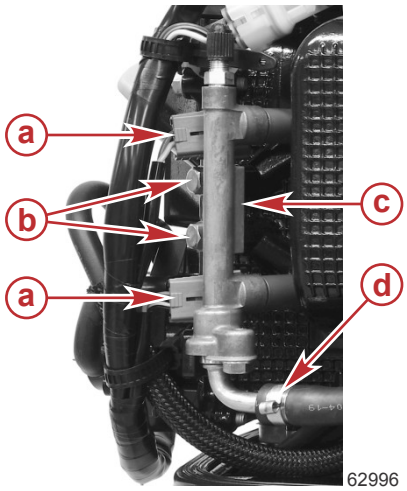
1. Install the fuel hose onto the fuel rail inlet tube. Ensure that an Oetiker® clamp is in position on the fuel hose.
2. Lubricate the fuel injector seals with a light oil.
3. Install the fuel rail assembly into the intake manifold.
4. Ensure that the spacer is in place, and secure the fuel rail to the intake manifold with two screws. Tighten the screws to the specified torque.

Description	Nm	lb–in.	lb–ft
Fuel rail screw	6.0	53.1	–

5. Crimp the Oetiker® clamp to secure the fuel hose.

Clamp Tool	91-803146T

6. Connect the fuel injector harness connectors to the fuel injectors.

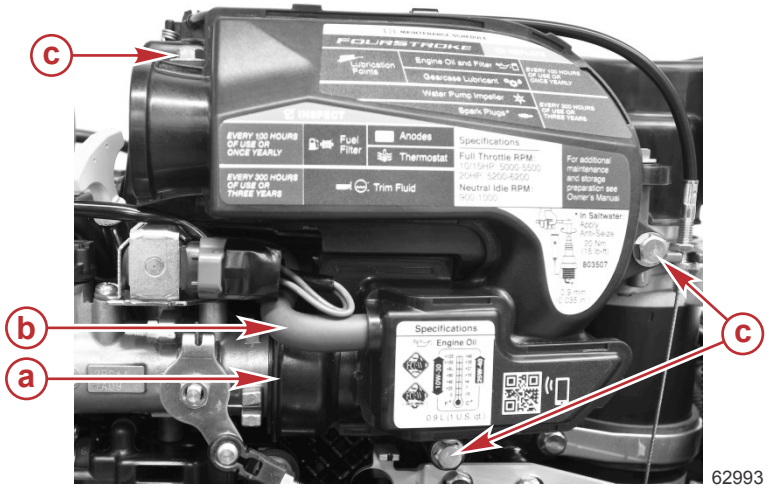


a - Fuel injector harness connectors
b - Fuel rail screws (2)
c - Spacer
d - Oetiker® clamp

Air Box

Air Box Removal

1. Remove the three screws that secure the air box to the engine.
2. Remove the recoil starter assembly. Refer to **Section 8A - Recoil Starter**.
3. Pull the air box off the end of the throttle body.
4. Disconnect the crankcase breather hose from the air box.
5. Disconnect the bypass hose.



a - End of throttle body
b - Bypass hose
c - Screws (3)

Air Box Installation

1. Disconnect the crankcase ventilation hose from the valve cover, and maneuver the hose to create enough slack to allow it to reach the air box. Attach the hose to the air box.
2. Ensure that the bypass hose is connected to the idle air control valve, and connect the hose to the air box.
3. Slide the air box over the end of the throttle body.
4. Install the recoil starter assembly. Refer to **Section 8A - Recoil Starter**.
5. Secure the air box to the engine with three screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Air box screws (3)	6.0	53.1	–

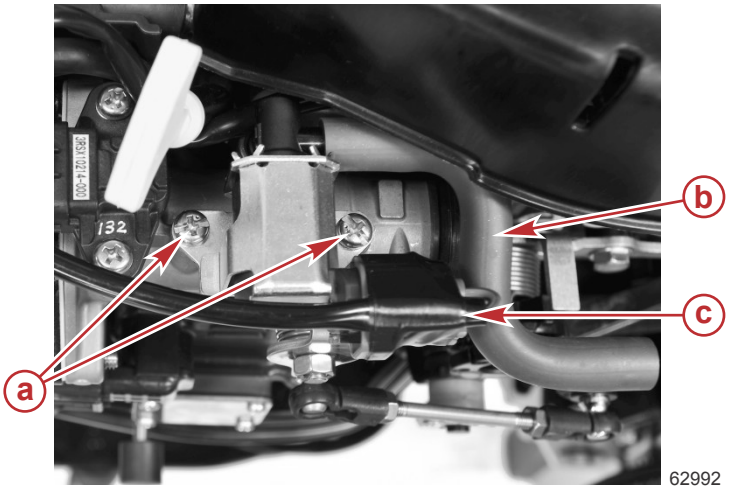
6. Attach the crankcase ventilation hose to the valve cover, and secure it with the spring clamp.

Idle Air Control (IAC)

The idle air control (IAC) is an electrically operated, spring-loaded solenoid valve that controls the amount of air bypassing the closed throttle shutter. Signals from the ECM regulate the duty cycle for which the IAC valve remains open. The duty cycle ranges from 0% to 100% open.

IAC Removal

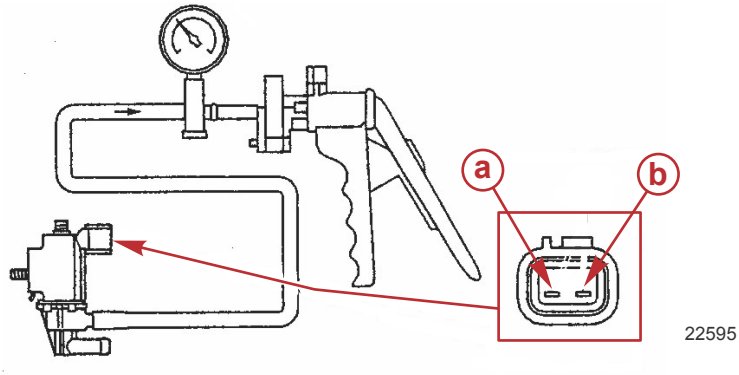
1. Remove the air box. Refer to **Air Box Removal**.
2. Remove the two screws that secure the IAC to the throttle body assembly, and remove the IAC.
3. Disconnect the IAC from the engine harness.
4. Remove the bypass hose from the IAC.



a - IAC mounting screws (2)
b - Bypass hose
c - Engine harness connector

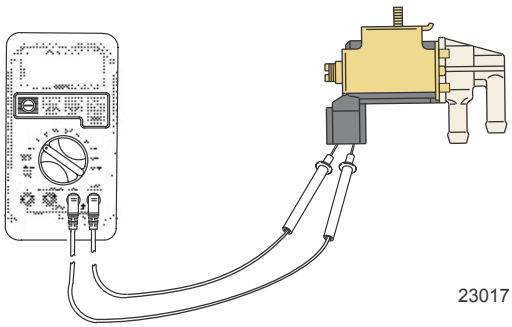
IAC Test

1. Apply 69 kPa (10 psi) vacuum to the top port of the IAC.
2. Ensure the IAC holds the vacuum.
3. Apply 12 volts to the terminals of the IAC.
4. If the vacuum is not released when 12 volts is applied to the IAC terminals, replace the IAC.



a - 12 volts positive
b - 12 volts negative

5. Connect the DMT 2004 Digital Multimeter tool to the terminal pins of the IAC.



DMT 2004 Digital Multimeter	91-892647A01

6. Measure the resistance of the IAC with the DMT 2004 Digital Multimeter tool. The IAC is not polarity sensitive.

NOTE: *The IAC resistance values are for reference only.*

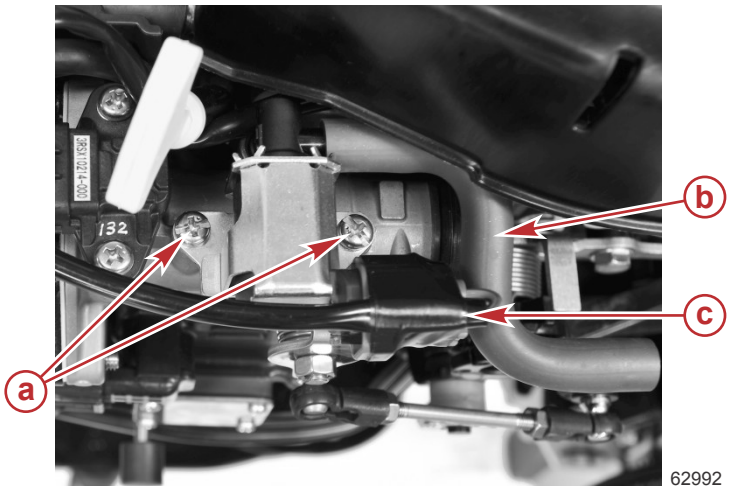
Meter Test Leads		Meter Scale	Reading
Red	Black		
Right terminal pin	Left terminal pin	Auto	21.0–27.0 Ω

IAC Installation

1. Apply clean engine oil to the O-ring on the IAC.
2. Insert the IAC into the throttle assembly, and attach with two screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
IAC mounting screws (2)	3.0	26.6	–

3. Attach the bypass hose to the IAC.
4. Connect the IAC to the engine harness.
5. Install the air box. Refer to **Air Box Installation**.
   - Be certain to attach the crankcase breather hose and the bypass hose to the air box.
   - Install the recoil starter assembly before tightening the top air box mounting screw.



a - IAC mounting screws (2)
b - Bypass hose
c - Engine harness connector

Notes:

Powerhead

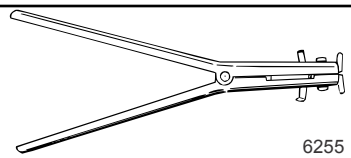
Section 4A - Cylinder Block/Crankcase

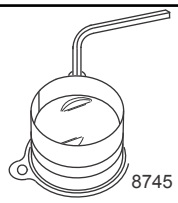
Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
9	Loctite® 567 PST Pipe Sealant	Oil pressure switch threads	92-809822
12	Loctite® Master Gasket Kit	Cylinder block and crankcase cover mating surfaces	92-12564 2
110	4-Stroke 10W-30 Outboard Oil	Piston pin	92-8M0078625
		Piston rings	
		Piston, piston rings, and cylinder bore	
		Crankshaft seal and main bearing area, crankshaft main and connecting rod journals, connecting rod bearing area, upper and lower oil crankshaft seal lips	
		Engine crankcase	

Special Tools

Piston Ring Expander	91- 24697
 6255	Expands piston rings for removal and installation.

Piston Ring Compressor	FT2997
 8745	Compresses the piston rings to ease piston installation

Cylinder Block/Crankcase Specifications

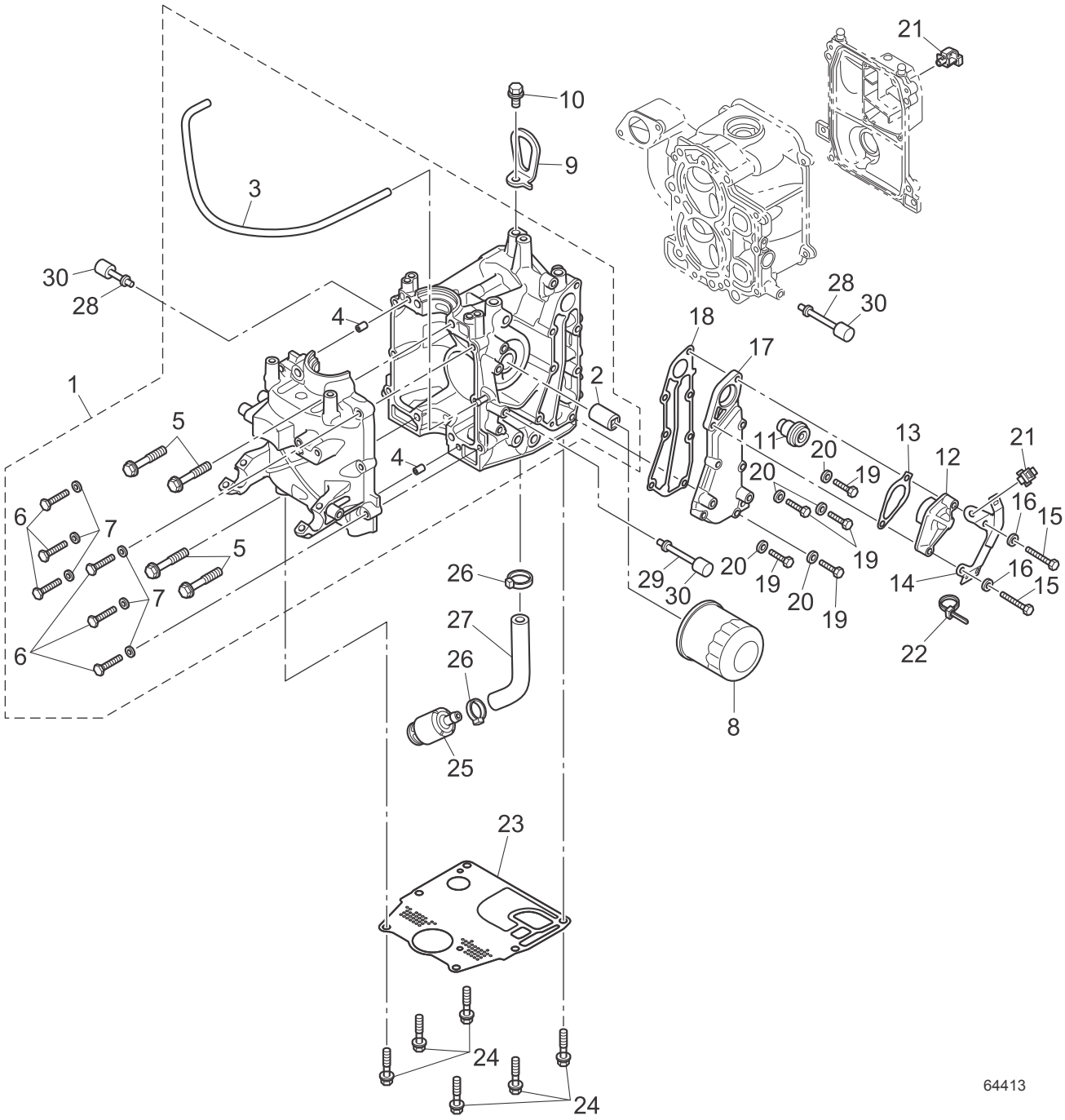
Parameter	Specification
Number of cylinders	2
Displacement	333 cc (20.3 cid)
Standard bore	61.00 mm (2.4016 in.)
Standard bore (service limit)	61.06 mm (2.4039 in.)
Cylinder bore maximum taper (service limit)	0.08 mm (0.0032 in.)
Cylinder bore maximum out of round (service limit)	0.06 mm (0.0023 in.)
Crankshaft main bearing journal	33.992 mm (1.3382 in.)
Crankshaft main bearing journal (service limit)	33.972 mm (1.3374 in.)
Crankshaft pin journal	28.972–28.985 mm (1.1406–1.1411 in.)
Crankshaft pin journal (service limit)	28.970 mm (1.1405 in.)
Crankshaft end play	0.1–0.2 mm (0.004–0.008 in.)
Crankshaft runout	0.030 mm (0.00118 in.)
Crankshaft runout (service limit)	0.03 mm (0.001 in.)
Crankshaft main bearing oil clearance	0.012–0.044 mm (0.0005–0.0017 in.)
Crankshaft main bearing oil clearance (service limit)	0.06 mm (0.002 in.)
Crankshaft pin bearing oil clearance	0.015–0.041 mm (0.0006–0.0016 in.)
Crankshaft pin bearing/connecting rod oil clearance (service limit)	0.060 mm (0.002 in.)
Connecting rod wrist pin bore diameter	16.010–16.021 mm (0.6303–0.6307 in.)
Connecting rod wrist pin bore diameter (service limit)	16.025 mm (0.6309 in.)

Parameter	Specification
Connecting rod crankshaft pin diameter	29.000–29.013 mm (1.1417–1.1422 in.)
Connecting rod crankshaft pin diameter (service limit)	28.038 mm (1.1432 in.)
Connecting rod side clearance	0.1–0.25 mm (0.004–0.01 in.)
Connecting rod side clearance (service limit)	0.6 mm (0.0236 in.)

Piston Specifications

Parameter	Specification
Piston skirt standard diameter	60.96 mm (2.40 in.)
Piston skirt standard diameter (service limit)	60.90 mm (2.3976 in.)
Piston to bore clearance	0.020–0.055 mm (0.0008–0.0022 in.)
Wrist pin diameter	15.996–16.000 mm (0.6298–0.6299 in.)
Wrist pin diameter (service limit)	15.993 mm (0.6296 in.)
Top ring side clearance	0.03–0.08 mm (0.0012–0.0031 in.)
Top ring side clearance (service limit)	0.1 mm (0.004 in.)
Second ring side clearance	0.02–0.06 mm (0.0008–0.0024 in.)
Second ring side clearance (service limit)	0.09 mm (0.0035 in.)
Oil ring side clearance	0.03–0.13 mm (0.0012–0.0051 in.)
Oil ring side clearance (service limit)	0.15 mm (0.0059 in.)
Top ring end gap	0.15–0.30 mm (0.0059–0.0118 in.)
Top ring end gap (service limit)	0.5 mm (0.02 in.)
Second ring end gap	0.35–0.50 mm (0.0138–0.0197 in.)
Second ring end gap (service limit)	0.7 mm (0.028 in.)
Oil ring end gap	0.2–0.7 mm (0.008–0.028 in.)

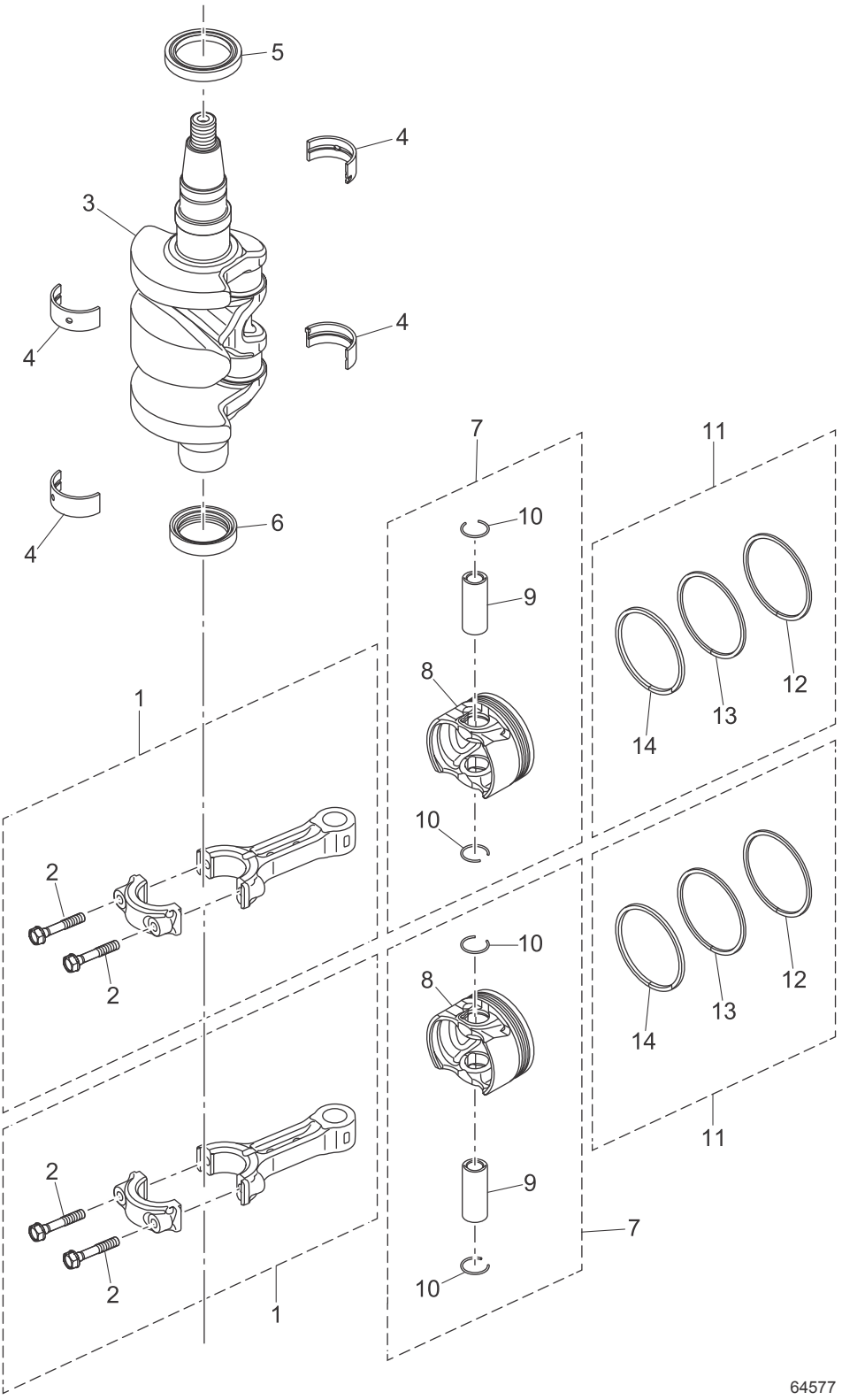
Cylinder Block and Crankcase Components



Cylinder Block and Crankcase Components

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	1	Cylinder block assembly				
2	1	Oil filter fitting		30	–	22.1
3	1	Hose				
4	2	Dowel pin				
5	4	Screw (M8 x 50)	First	10.0	88.5	–
			Final	23.5	–	17.3
6	6	Screw (M6 x 30)	First	6.0	53.1	–
			Final	11.5	101.8	–
7	6	Washer				
8	1	Oil filter		18.0	159.3	–
9	1	Lifting eye				
10	1	Screw		13.0	115	–
11	1	Thermostat				
12	1	Thermostat cover				
13	1	Thermostat gasket				
14	1	Bracket				
15	2	Screw		9.0	79.7	–
16	2	Washer				
17	1	Exhaust cover				
18	1	Exhaust cover gasket				
19	5	Screw	First	6.0	53.1	–
			Final	9.0	79.7	–
20	5	Washer				
21	2	Reusable cable tie				
22	1	Cable tie				
23	1	Oil pan gasket				
24	6	Screw (M8 x 35)	First	15.0	132.7	–
			Final	30.0	–	22.1
25	1	Oil strainer				
26	2	Cable tie				
27	1	Hose				
28	2	Cowl standoff		6.0	53.1	–
29	1	Cowl standoff		6.0	53.1	–
30	3	Rubber cowl support				

Crankshaft Components



Crankshaft Components

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	2	Connecting rod assembly				
2	2	Bolt	First	6.0	53.1	–
			Final	10.0	88.5	–
3	1	Crankshaft assembly				
4	1	Plain shaft bearing, blue (set of 2)				
	1	Plain shaft bearing, red (set of 2)				
5	1	Upper oil seal				
6	1	Lower oil seal				
7	2	Piston assembly				
8	1	Piston				
9	1	Piston pin				
10	2	Piston pin clip				
11	2	Piston ring kit				
12	1	Top piston ring				
13	1	Second piston ring				
14	1	Oil ring				

Powerhead Removal

⚠ WARNING

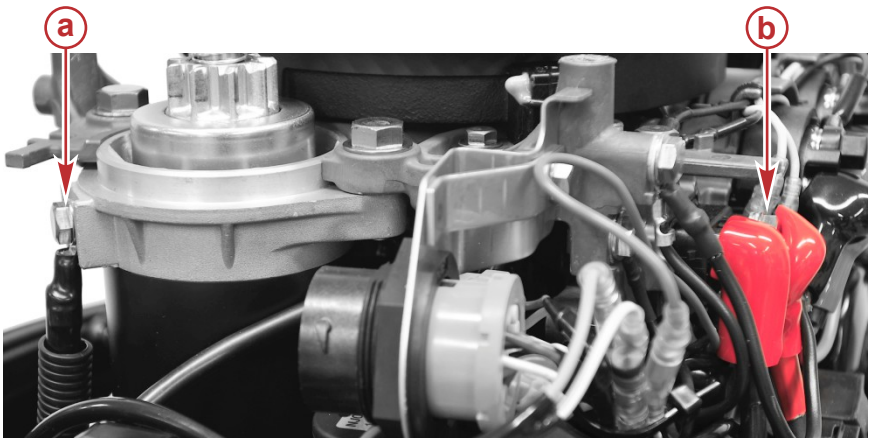
Performing service or maintenance without first disconnecting the battery can cause product damage, personal injury, or death due to fire, explosion, electrical shock, or unexpected engine starting. Always disconnect the battery cables from the battery before maintaining, servicing, installing, or removing engine or drive components.

⚠ WARNING

Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for leaks before attempting to start the engine, and wipe up any spilled fuel immediately.

IMPORTANT: The following procedure contains steps for an electric start, power tilt model. Some steps will not apply to other models.

1. Disconnect the battery, if applicable.
2. Completely remove the driveshaft housing covers. Refer to **Section 5A - Driveshaft Housing Covers**.
3. Remove the front cowl. Refer to **Section 5A - Front Cowl**.
4. Remove the remote control harness and cables when applicable.
5. Remove the following components from the top of the powerhead:
   a. Air box and recoil assembly. Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter Removal**.
      NOTE: *Also remove the neutral interlock cable.*
   b. Camshaft gear cover. Refer to **Section 3C - Camshaft Gear Cover/Vent Tank**.
   c. Flywheel. Refer to **Section 2A - Flywheel**.
   d. Stator. Refer to **Section 2A - Stator**.
6. For electric start models:
   a. Disconnect the battery cables from the starter motor and starter solenoid.

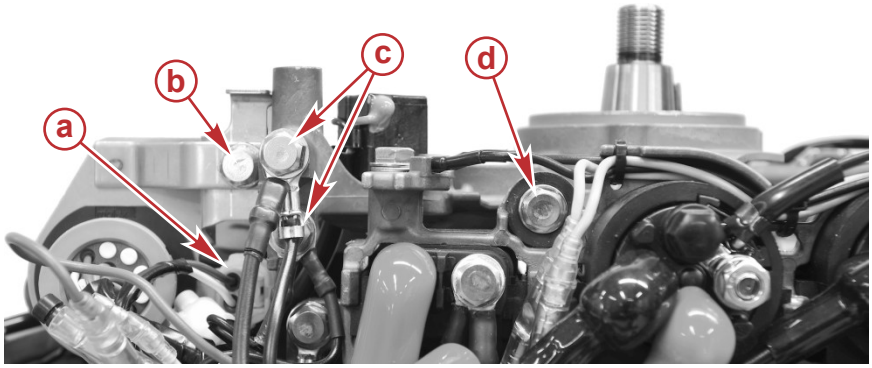


63065

a - Negative battery connection at starter motor
b - Positive battery connection at starter solenoid

   b. Remove the starter motor. Refer to **Section 2B - Starter Motor Removal**.
7. Remove the stator/starter bracket:
   a. Disconnect the crankshaft position sensor (CPS) from the engine harness.
   b. Remove the screw and washer that holds the 14-pin connector to the stator/starter bracket.
   c. Remove the two screws and washers that connect the ground terminals to the stator/starter bracket.

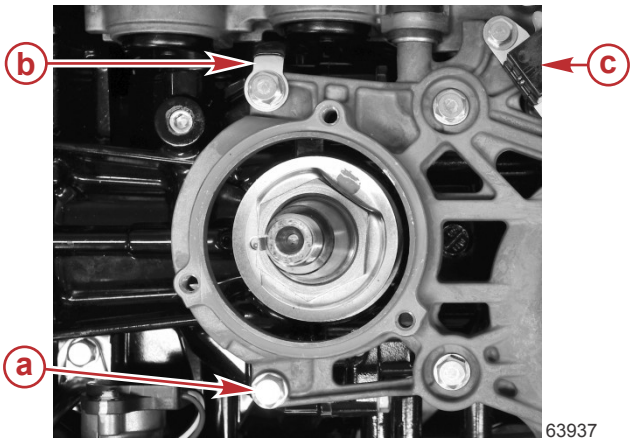
d. Remove the one screw and washer that secures the relay bracket to the stator/starter bracket.



63936

- **a -** CPS connector
- **b -** Screw and washer for 14-pin connector bracket
- **c -** Screws and washers for ground terminals (2 each)
- **d -** Screw and washer securing relay bracket to stator/starter bracket

e. Remove the four screws and washers that secure the stator/starter bracket to the powerhead, and remove the stator/starter bracket.



63937

- **a -** Screw and washer (4 each)
- **b -** J-clip (to secure stator leads)
- **c -** CPS

8. Remove the timing belt.
9. Remove the remaining throttle and shift linkage. Refer to **Section 7A - Throttle and Shift Linkage**.
10. Remove the fuel system components from the engine:
    a. Cut the cable tie securing the fuel inlet hose to the engine harness.
    b. Disconnect the inlet hose from the fuel filter, and remove the inlet hose from the engine.
    c. Disconnect the outlet hose from the fuel filter. Remove the fuel filter.

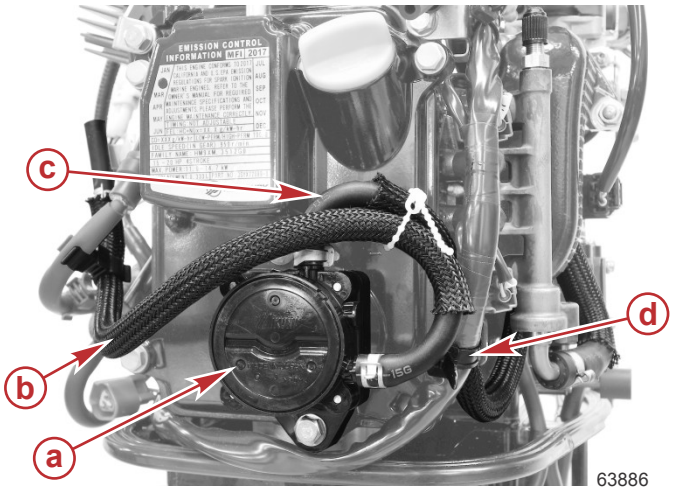
63877

Electric start, power tilt model shown, other models similar

- **a -** Cable tie
- **b -** Fuel inlet hose
- **c -** Fuel filter
- **d -** Fuel filter outlet hose

d. Remove one screw to remove the fuel filter bracket.
e. Remove the fuel hoses from the fuel pump.

f. Release the reusable cable tie.

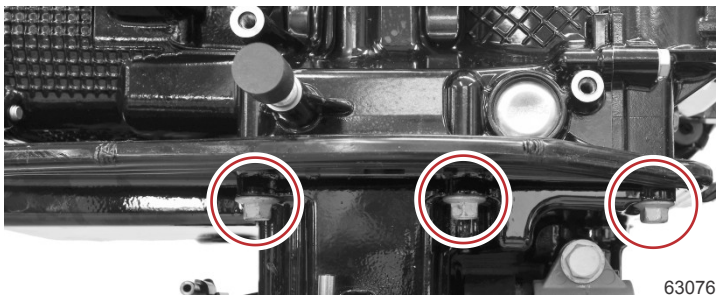


a - Fuel pump
b - Fuel pump inlet hose (from fuel filter)
c - Fuel pump outlet hose (to VST)
d - Reusable cable tie

g. Remove the vapor separator tank (VST). Refer to **Section 3C - VST Removal**.
NOTE: *It is not necessary to remove the high-pressure fuel hose that connects the VST to the fuel rail.*

h. Remove the fuel rail. Refer to **Section 3C - Fuel Rail Removal**.

11. Remove the six screws (three on each side) securing the powerhead to the driveshaft housing assembly.



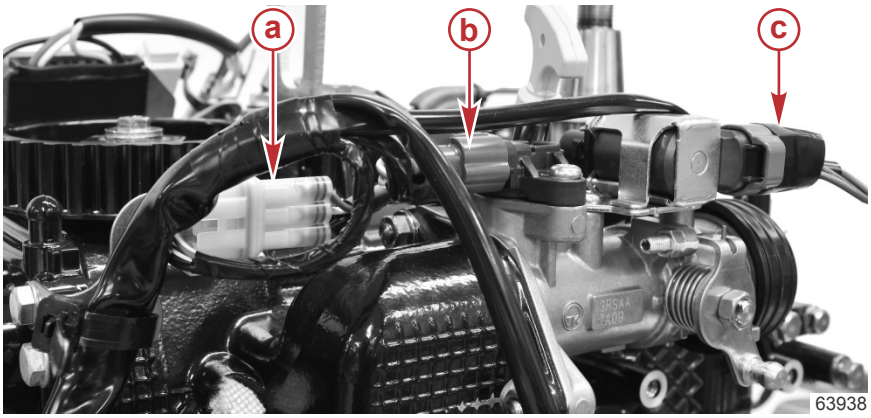
Powerhead screws (three on each side, starboard shown)

12. Lift the powerhead off of the driveshaft housing.
13. Install the powerhead onto an appropriate powerhead stand (obtain locally).

Cylinder Block Disassembly

Electrical Component Removal

1. Remove the powerhead. Refer to **Powerhead Removal**.
2. Disconnect the TPS, TMAP sensor, and IAC from the engine harness.



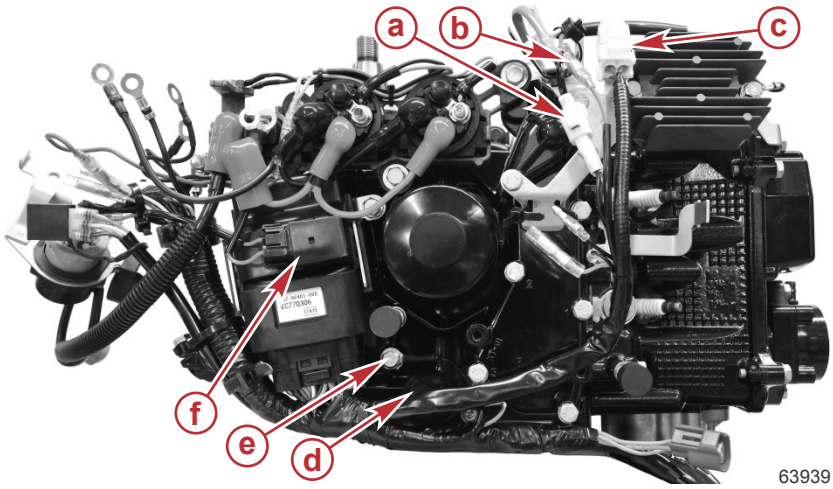
a - TPS connector
b - TMAP sensor connector
c - IAC connector

3. Remove the ignition coil. Refer to **Section 2A - Ignition Coil**.
4. Disconnect the red bullet connector for the voltage regulator/rectifier (electric start models) and the 2-pin connector for the ECT sensor.

5. Remove the yellow fuse housing from the electrical bracket and the black fuse housing from its pocket on the ECM.

   NOTE: *If you are servicing the cylinder head only, steps 6 through 11 may be skipped.*

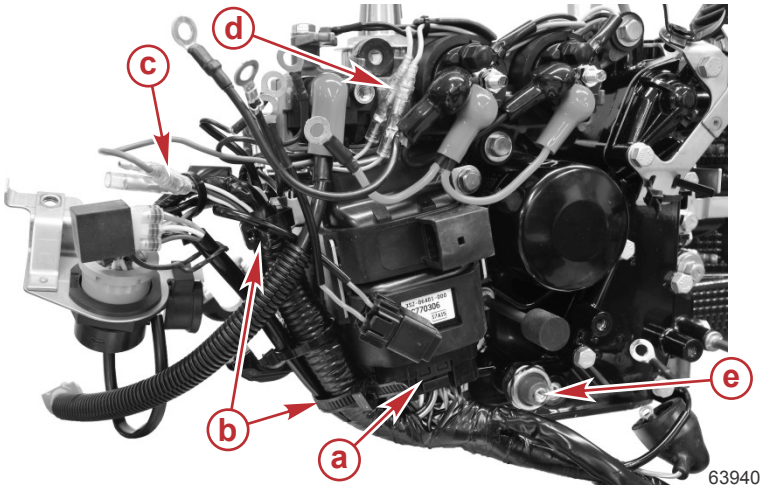
6. Remove the rubber boot from the oil pressure switch, and remove the single screw that secures the ring terminal to the switch.
7. Remove a single screw to remove the ground terminal from the engine block.



- **a -** 2-pin ECT sensor connector
- **b -** Voltage regulator/rectifier red bullet connector
- **c -** Yellow fuse housing
- **d -** Oil pressure switch (behind harness)
- **e -** Ground terminal
- **f -** Black fuse housing

8. Disconnect the ECM from the harness.
9. Power tilt models: Disconnect the pink, light blue, and green bullet connectors.
10. Release the reusable cable ties securing the engine harness, and remove the harness from the engine.

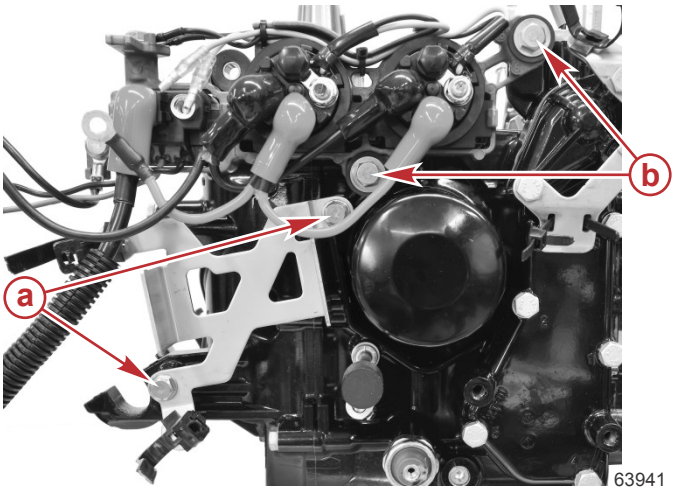
    IMPORTANT: Do not cut the reusable cable ties.



- **a -** ECM connector
- **b -** Reusable cable ties - do not cut
- **c -** Start solenoid green bullet connector
- **d -** Power tilt pink and light blue bullet connectors
- **e -** Oil pressure switch, rubber boot and ring terminal removed

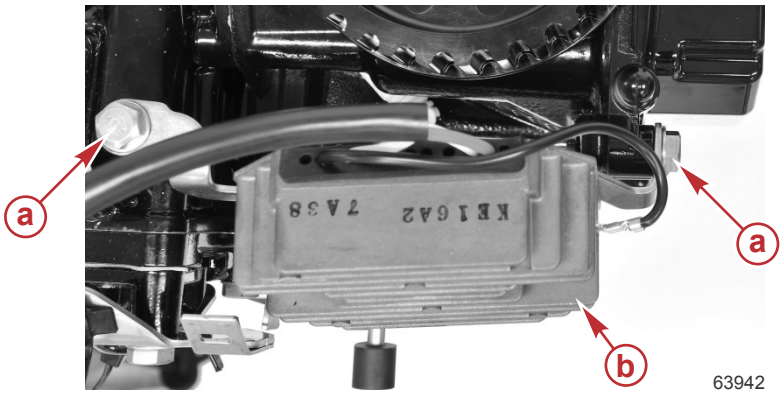
11. Remove the ECM from its bracket, and remove two screws to remove the bracket from the engine.

12. Power tilt models: Remove the two remaining screws to remove the tilt relay/start solenoid bracket from the engine.



a - ECM bracket screws (2)
b - Relay/solenoid bracket screws (2 + 1 previously removed)

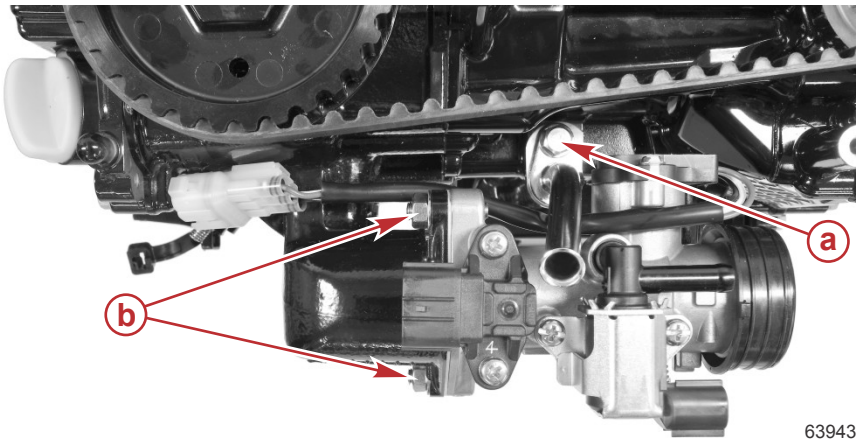
13. Electric start models: Remove two screws to remove the voltage regulator/rectifier and bracket from the engine.



a - Bracket screws (2)
b - Voltage regulator/rectifier

Throttle Body Removal

1. Remove two nuts to remove the throttle body.
2. Remove one screw to remove the dipstick extension tube.

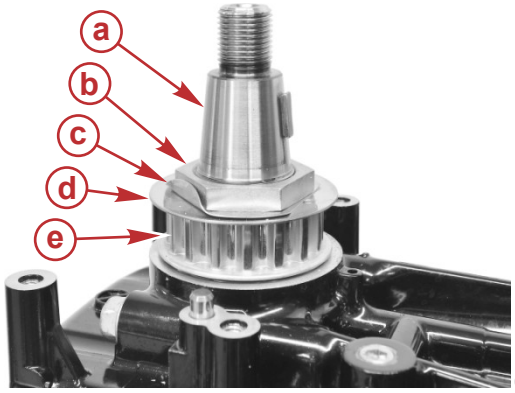


a - Dipstick extension tube screw
b - Throttle body nuts

Crankshaft Timing Gear Removal

1. Flatten the turned-up segment of the lockwasher.
2. Remove the crankshaft timing gear nut.

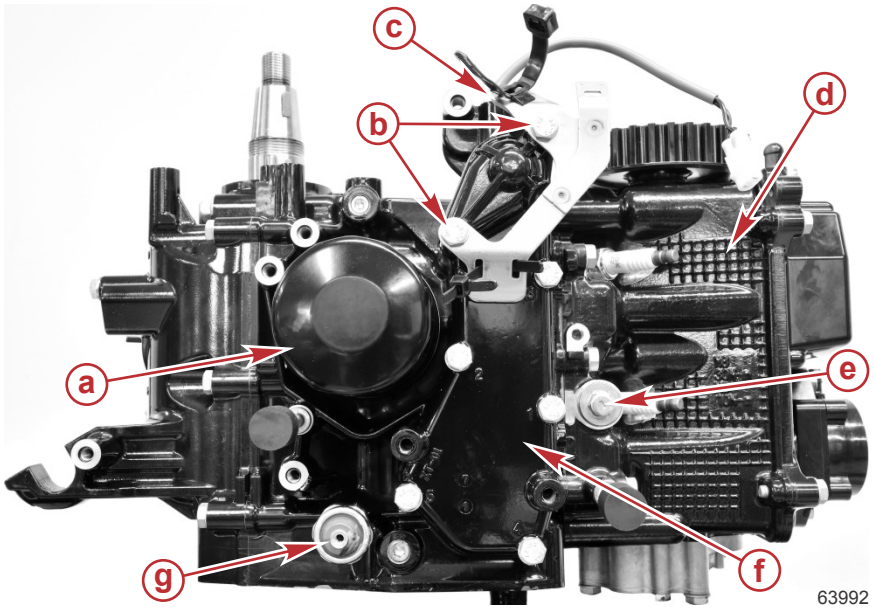
3. Remove the lockwasher, belt guide, timing gear, and timing gear key from the crankshaft.



- **a -** Crankshaft
- **b -** Nut
- **c -** Lockwasher
- **d -** Belt guide
- **e -** Timing gear

Thermostat and Exhaust Cover Removal

1. Remove the oil filter. Be certain to wipe up any spills, and dispose of oil, filter, and oil-soaked rags according to local regulations.
2. Remove the two screws securing the thermostat cover and electrical bracket.
3. Remove the engine coolant temperature sensor.
4. Remove and inspect the anode. Discard and replace, if it is corroded 50% or more.
5. Remove the five exhaust cover screws. Remove the exhaust cover.
6. Remove the oil pressure switch.

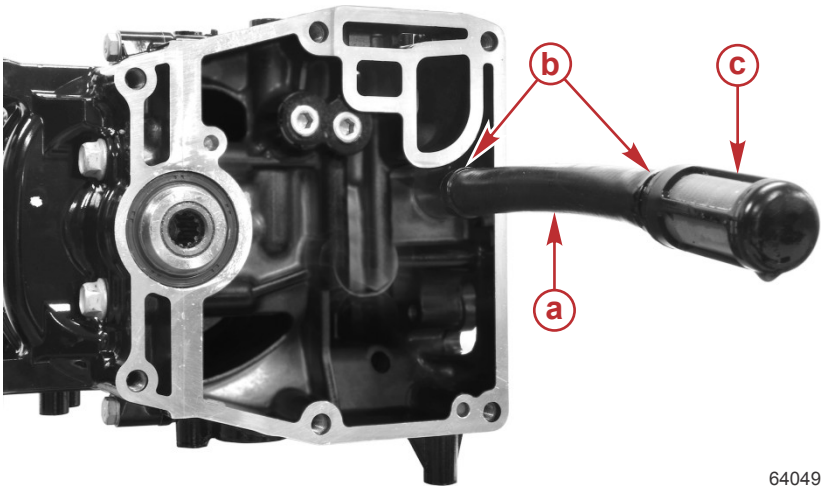


- **a -** Oil filter
- **b -** Thermostat cover/electrical bracket mounting screws
- **c -** Engine coolant temperature sensor
- **d -** Cylinder head assembly
- **e -** Anode
- **f -** Exhaust cover
- **g -** Oil pressure switch

7. Remove the cylinder head assembly. Refer to **Section 4B - Cylinder Head Removal**.
8. Inspect the water cooling passages in the block and the exhaust cover for debris.

Oil Strainer Removal

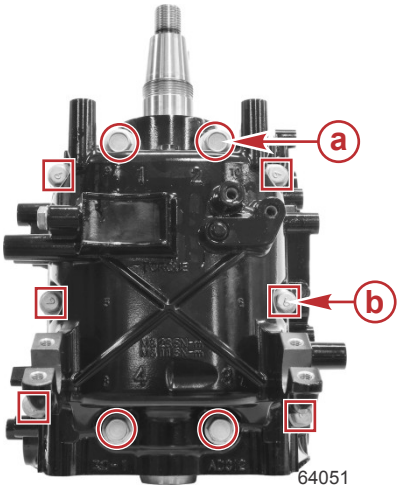
Remove the oil strainer and hose from the cylinder block.



a - Hose
b - Cable tie
c - Oil strainer

Crankcase and Crankshaft Removal

1. Remove the ten crankcase cover screws and remove the crankcase cover.

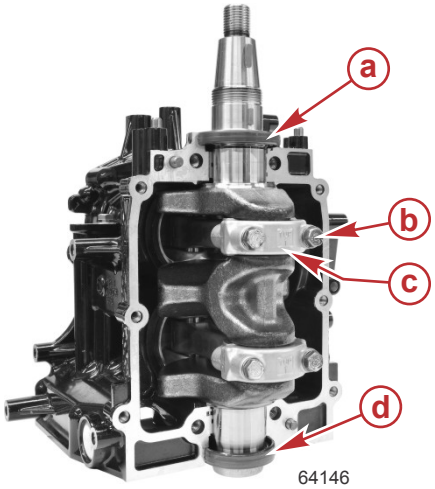


a - Screw (M8 x 50) (4)
b - Screw (M6 x 30) (6)

2. Remove the connecting rod cap screws.
3. Identify the connecting rod and cap position with indelible ink or paint. Do not use a scribe or punch for identification.

   IMPORTANT: Each connecting rod and cap are a matched set. Do not intermix the connecting rod caps with the connecting rods.
4. Remove the crankshaft.

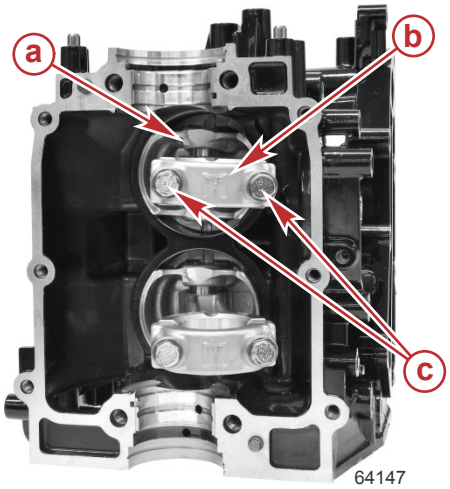
5. Remove the crankshaft seals.



64146

a - Upper crankshaft seal
b - Cap screw (4)
c - Connecting rod cap (2)
d - Lower crankshaft seal

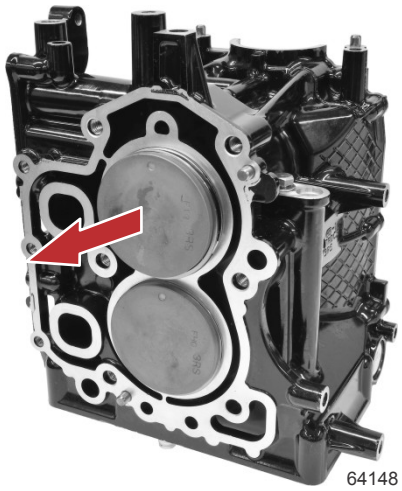
6. Mark the connecting rod cap screws with paint to identify them as used.
7. Install the connecting rod caps onto their respective connecting rods. Tighten the connecting rod cap screws finger-tight.



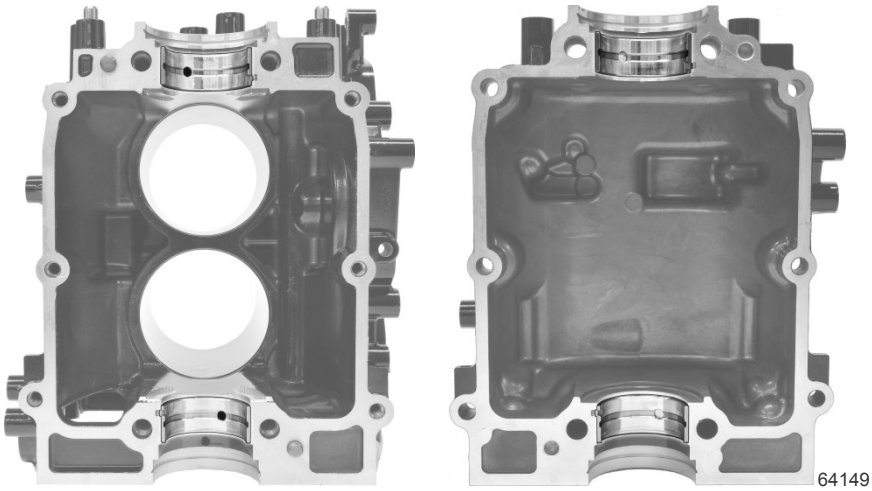
64147

a - Piston and connecting rod
b - Connecting rod cap
c - Cap screws

8. Push the connecting rod assembly out of the cylinder block.


64148

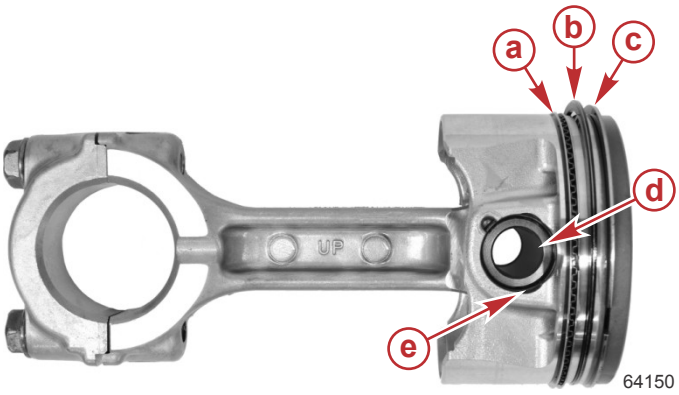
9. Remove the main bearings from the cylinder block and crankcase cover.



Piston Disassembly

IMPORTANT: Disassemble each piston separately to ensure the components will not be intermixed. After disassembly, place the components into a container that identifies the cylinder location.

1. Remove the piston pin clips, and piston pin. Separate the connecting rod from the piston.
2. Use a piston ring expander to remove the top ring and the second ring.
3. Use a piston ring expander to remove the oil ring top scraper, bottom scraper, and the oil control ring.



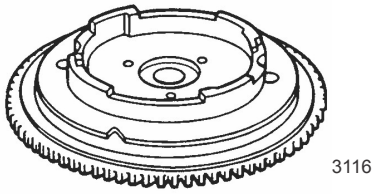
a - Oil rings
b - Second ring
c - Top ring
d - Piston pin
e - Piston pin clip (2)

Piston Ring Expander	91- 24697

Powerhead Cleaning, Inspection, and Repair

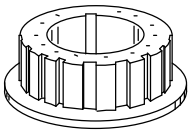
Flywheel

Inspect the flywheel keyway and teeth. Replace if damaged or worn.



Crankshaft Timing Gear

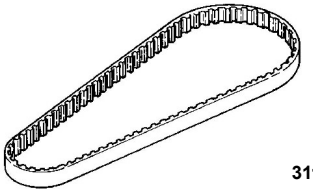
Inspect the crankshaft timing gear and key. Replace if damaged or worn.



3117

Timing Belt

Inspect the timing belt. Replace if worn, stretched, or damaged.



3118

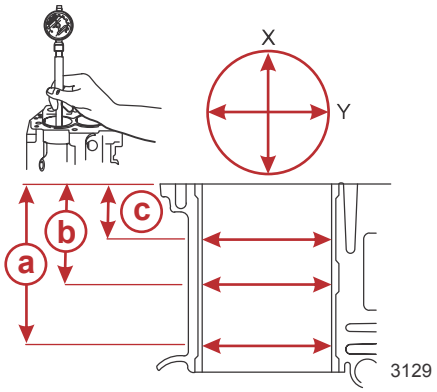
Anode

Replace the engine water jacket anode if partially consumed.

Measuring Cylinder Bore

Measure the cylinder walls for taper, out of round, or excessive ridge at the top of the ring travel. This should be done with a cylinder bore dial indicator or an inside micrometer. Carefully move the gauge up and down the cylinder bore to determine taper. Turn the gauge to different points around the cylinder wall to determine the out of round condition.

The measurement for cylinder taper should be taken at three depth locations: 15 mm (0.6 in.), 35 mm (1.4 in.), and 55 mm (2.2 in.).



3129

a - 55 mm (2.2 in.)
b - 35 mm (1.4 in.)
c - 15 mm (0.6 in.)

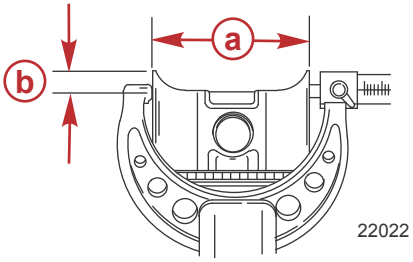
Cylinder Bore	
Cylinder bore (standard)	61.00 mm (2.4016 in.)
Cylinder bore (service limit)	61.06 mm (2.4039 in.)
Out of round (service limit)	0.06 mm (0.0023 in.)
Taper (service limit)	0.08 mm (0.0032 in.)

Piston Measurements

Inspect piston wall for wear or damage. Replace the piston if necessary.

Piston Diameter

1. Measure the piston at a point 9 mm (0.35 in.) from the bottom, 90° to the piston pin. Replace the piston if out of specification.



a - Piston diameter
b - Measure point 9 mm (0.35 in.)

Piston	
Diameter (standard)	60.96 mm (2.400 in.)
Diameter (service limit)	60.90 mm (2.3976 in.)

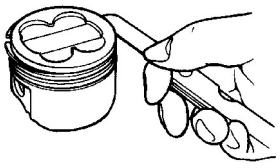
2. Measure the piston to cylinder clearance. If out of specification examine the piston and cylinder bore further to determine repair/replacement.

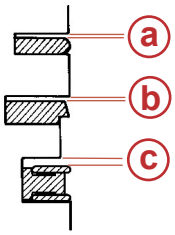
The minimum piston to cylinder wall clearance is defined by the formula: **Minimum cylinder bore measurement – Maximum piston diameter measurement = Piston to cylinder clearance.**

Piston to Cylinder Wall Clearance	
Minimum clearance	0.020–0.055 mm (0.0008–0.0022 in.)
Maximum clearance (service limit)	0.150 mm (0.0059 in.)

Piston Ring Side Clearance

Measure the piston ring side clearance. Replace the piston and rings if out of specification.





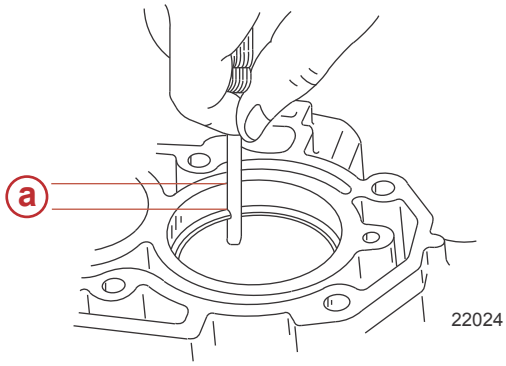
a - Top ring
b - Second ring
c - Oil ring

Piston Ring Side Clearance	
Top "a"	0.03–0.08 mm (0.0012–0.0031 in.)
Top "a" (service limit)	0.10 mm (0.004 in.)
Second "b"	0.02–0.06 mm (0.0008–0.0024 in.)
Second "b" (service limit)	0.09 mm (0.0035 in.)
Oil "c"	0.03–0.13 mm (0.0012–0.0051 in.)
Oil "c" (service limit)	0.15 mm (0.0059 in.)

Piston Ring End Gap

Measure the piston ring end gap clearance. Replace the piston rings as a set if out of specification.

NOTE: *The ring must be level for measurement. Push the ring 4 mm (0.157 in.) into the bore with the crown of a piston.*

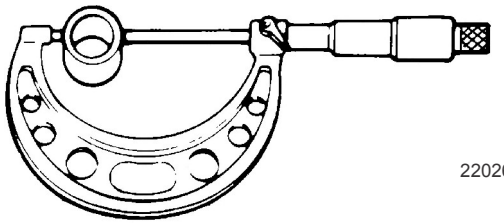


a - 4 mm (0.157 in.)

Piston Ring End Gap	
Top	0.15–0.30 mm (0.0059–0.0118 in.)
Top (service limit)	0.50 mm (0.020 in.)
Second	0.35–0.50 mm (0.0138–0.0197 in.)
Second (service limit)	0.70 mm (0.028 in.)
Oil	0.20–0.70 mm (0.008–0.028 in.)

Piston Wrist Pin

Measure the piston wrist pin diameter. Replace the piston wrist pin if out of specification.



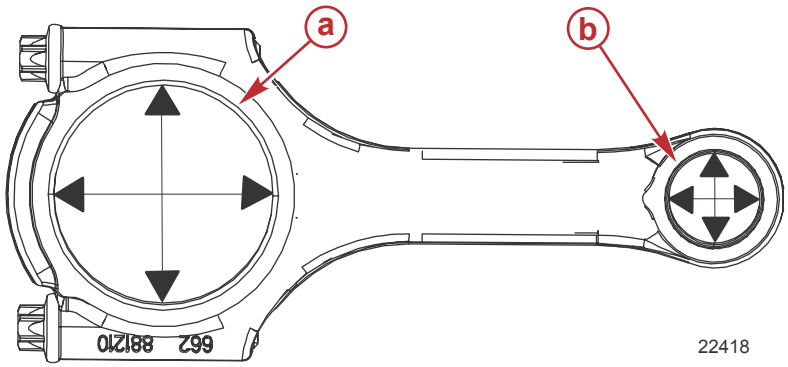
Piston Wrist Pin	
Diameter	15.996–16.000 mm (0.6298–0.6299 in.)
Diameter (service limit)	15.993 mm (0.6296 in.)

Connecting Rod Measurements

1. Ensure the connecting rod cap fits perfect. Tighten the connecting rod cap bolts to the specified torque.

Description	Nm	lb-in.	lb-ft
Connecting rod cap bolts	10.0	88.5	–

2. Measure the small (piston pin) and large (crankshaft pin journal) ends of the connecting rod.



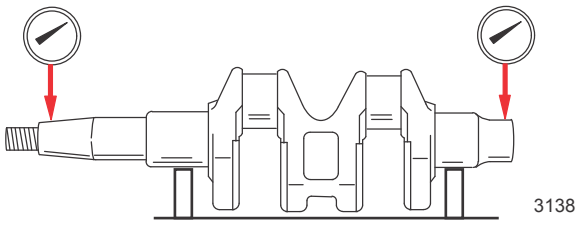
a - Crankshaft pin journal end
b - Piston pin end

Connecting Rod	
Crankshaft pin journal diameter	29.000–29.013 mm (1.1417–1.1422 in.)
Crankshaft pin journal diameter (service limit)	28.038 mm (1.1432 in.)
Piston pin bore diameter	16.010–16.021 mm (0.6303–0.6307 in.)
Piston pin bore diameter (service limit)	16.025 mm (0.6309 in.)

Crankshaft

Crankshaft Runout

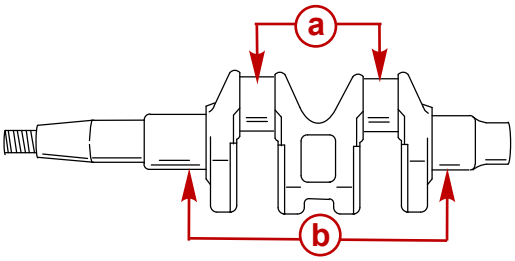
1. Thoroughly clean the crankshaft and inspect the bearing surfaces. Replace the crankshaft if the bearing surfaces are pitted, scored, or discolored.
2. Measure the crankshaft for runout. Replace the crankshaft if out of specification.



Crankshaft	
Runout	0.030 mm (0.00118 in.)

Crankshaft Bearing Journals

1. Measure the crankpin journals.
2. Measure the crankshaft main bearing journals.
3. Replace the crankshaft if journals are out of specification.



a - Crankshaft pin journals
b - Main bearing journals

Crankshaft Bearing Journal	
Crankshaft pin journal	28.972–28.985 mm (1.1406–1.1411 in.)
Crankshaft pin journal (service limit)	28.970 mm (1.1405 in.)
Main bearing journal	33.992 mm (1.3382 in.)
Main bearing journal (service limit)	33.972 mm (1.3374 in.)

Crankcase Main Bearings

Measure the crankshaft main bearing clearance as outlined in the following procedure. Replace the upper and lower bearings as a set if out of specification.

Main Bearing Oil Clearance	
Main bearing clearance	0.012–0.044 mm (0.0005–0.0017 in.)
Service limit	0.06 mm (0.002 in.)

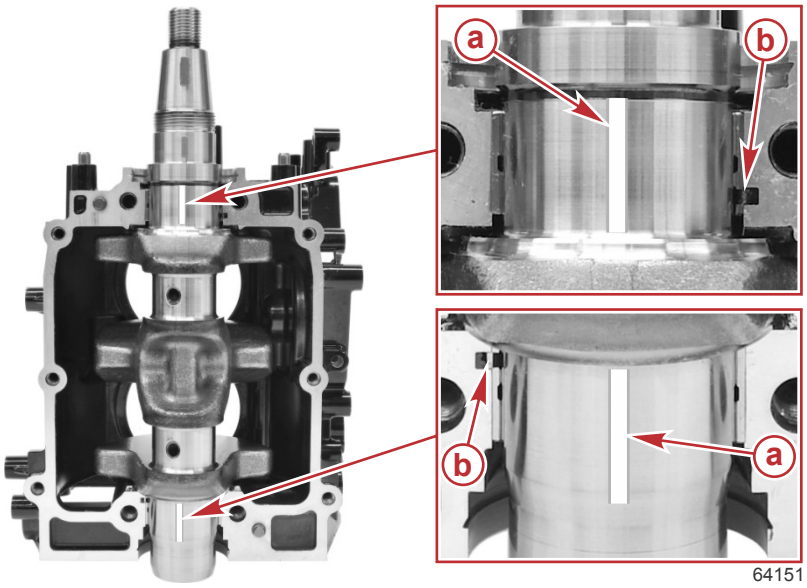
Crankshaft Main Bearing Clearance Measurement

IMPORTANT: Use new main bearings, do not reuse the removed main bearings.

1. Ensure that the mating surfaces on the crankcase cover and cylinder block are clear of debris.
2. Clean all the oil from the following areas:

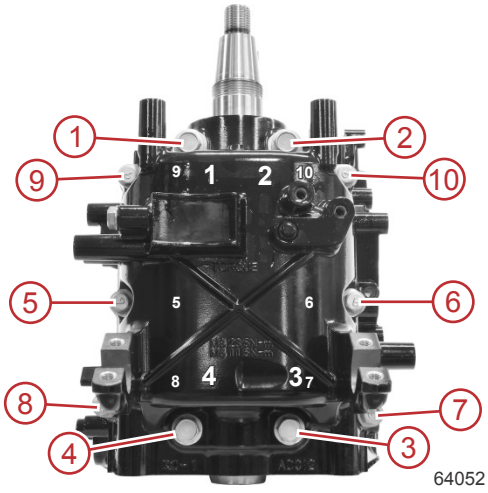
- Main bearing surfaces on the cylinder block and crankcase cover
- Main bearings
- Crankshaft bearing surfaces

3. Install the main bearing halves into the cylinder block.
   NOTE: *Align each bearing projection with the notch in the cylinder block.*
4. Install the crankshaft onto the cylinder block.
5. Place a piece of gauging plastic onto each of the crankshaft bearing surfaces.
   NOTE: *Do not put gauging plastic over the oil hole on the bearing surface of the crankshaft.*



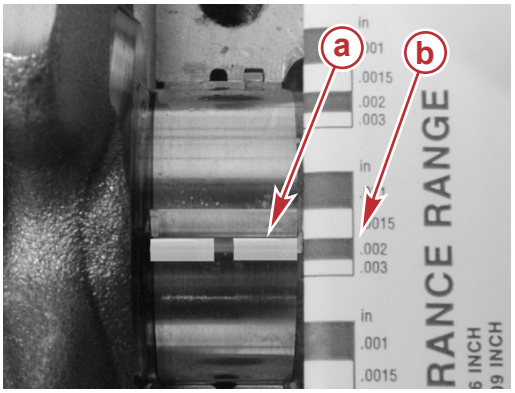
a - Gauging plastic
b - Bearing projection in the cylinder block notch

6. Install the bearing halves into the crankcase cover.
   NOTE: *Align each bearing projection with the notch in the crankcase cover.*
7. Install the crankcase cover onto the cylinder block.
8. Lightly lubricate the main bearing bolts and crankcase cover bolt threads with clean engine oil. Tighten the bolts to the specified torque in sequence in two steps.
   IMPORTANT: Do not move the crankshaft until the measurement process has been completed.



Description		Nm	lb-in.	lb-ft
Main bearing bolts (1–4) (M8 x 50)	**First**	10.0	88.5	–
	Final	23.5	–	17.3
Crankcase cover bolts (5–10) (M6 x 30)	**First**	6.0	53.1	–
	Final	11.5	101.8	–

9. Remove the bolts and the crankcase cover.
10. Measure the gauging plastic at its maximum compressed width.



11637

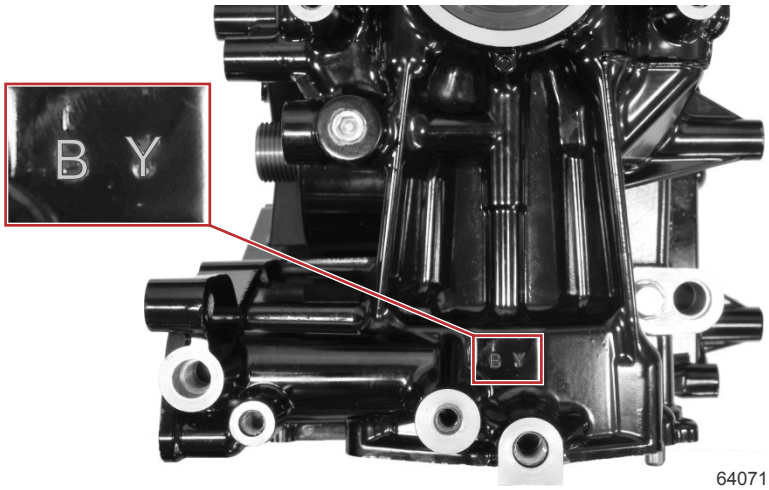
a - Compressed gauging plastic
b - Gauging plastic scale

11. If the oil clearance is out of specification limit, measure the inside diameter of the cylinder block and crankcase cover main bearing journals.

Selecting New Main Bearings

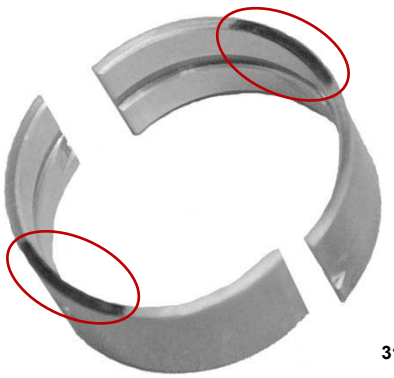
1. Locate the main bearing code on the cylinder block.
2. The journal size of the cylinder block is stamped with a code letter on the upper end of the cylinder block.

   NOTE: *The identification code for the upper main bearing is* ***A, B****.*
   The identification code for the lower main bearing is ***X, Y****.*



64071

3. Use the color coded main bearing that matches the main bearing code letters on the cylinder block.



3147

Bearing Code	Bearing Color	Bearing Size	Bearing Thickness
A, X	Blue	39.0–39.008 mm (1.5354–1.5357 in.)	1.488–1.494 mm (0.0586–0.0588 in.)
B, Y	Red	39.008–39.016 mm (1.5357–1.5361 in.)	1.494–1.500 mm 0.0588–0.0591 in.)

Connecting Rod Oil Clearance

Measure the connecting rod oil clearance using the measurement steps outlined following.

Connecting Rod	
Oil clearance	0.015–0.041 mm (0.0006–0.0016 in.)

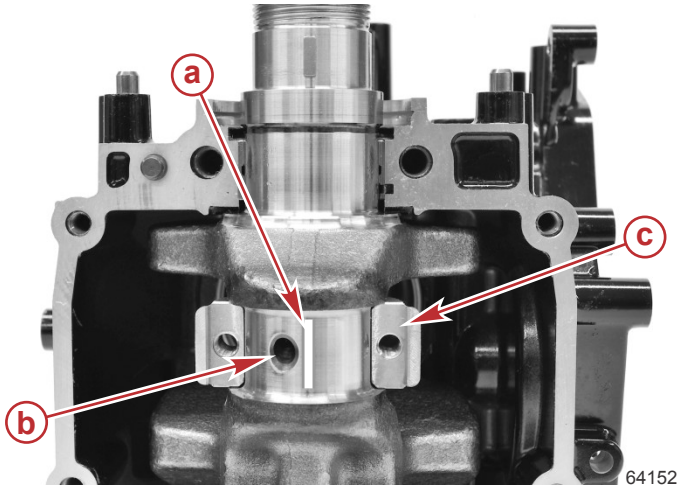
Connecting Rod Oil Clearance Measurement

IMPORTANT: Do not interchange connecting rod caps. Reinstall connecting rod caps in their original positions.

1. Clean all the oil from the connecting rod bearing surfaces and connecting rod journals on the crankshaft.
2. Install the connecting rod to the crankshaft.

   IMPORTANT: Install connecting rods in their original locations. Make sure that the "UP" mark on the connecting rod cap faces towards the flywheel end of the crankshaft.
3. Place a piece of gauging plastic on the crankpin journals.

   NOTE: *Do not put the gauging plastic over the oil hole in the bearing surface of the crankshaft.*



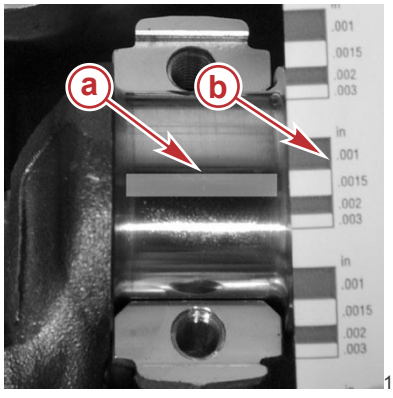
a - Gauging plastic
b - Crankshaft oil hole
c - Connecting rod

4. Install the connecting rod cap and tighten the connecting rod cap bolts to specification.

   IMPORTANT: Do not rotate the crankshaft while performing this measurement.

Description		Nm	lb-in.	lb-ft
Connecting rod cap bolt	**First**	6.0	53.1	–
	Final	10.0	88.5	–

5. Remove the connecting rod cap.
6. Measure the gauging plastic at its maximum compressed width.



a - Compressed gauging plastic
b - Gauging plastic scale

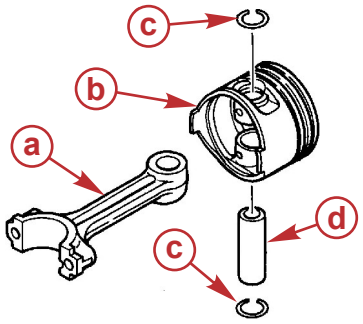
Connecting Rod	
Oil clearance	0.015–0.041 mm (0.0006–0.0016 in.)
Service limit	0.060 mm (0.002 in.)

7. If the oil clearance is out of specification limit, measure the diameter of the connecting rod and crankpin journal. Replace as needed.

Powerhead Assembly

Piston Assembly

1. Insert the connecting rod into the piston.
   IMPORTANT: Ensure that the "UP" indicators on the connecting rod and piston are facing the same direction.
2. Lubricate the piston pin with 4-Stroke 10W-30 Outboard Oil.
3. Install the piston pin, and secure it with new piston pin clips.



6366

a - Connecting rod
b - Piston
c - Piston pin clip (2)
d - Piston pin

Tube Ref No.	Description	Where Used	Part No.
110	4-Stroke 10W-30 Outboard Oil	Piston pin	92-8M0078625

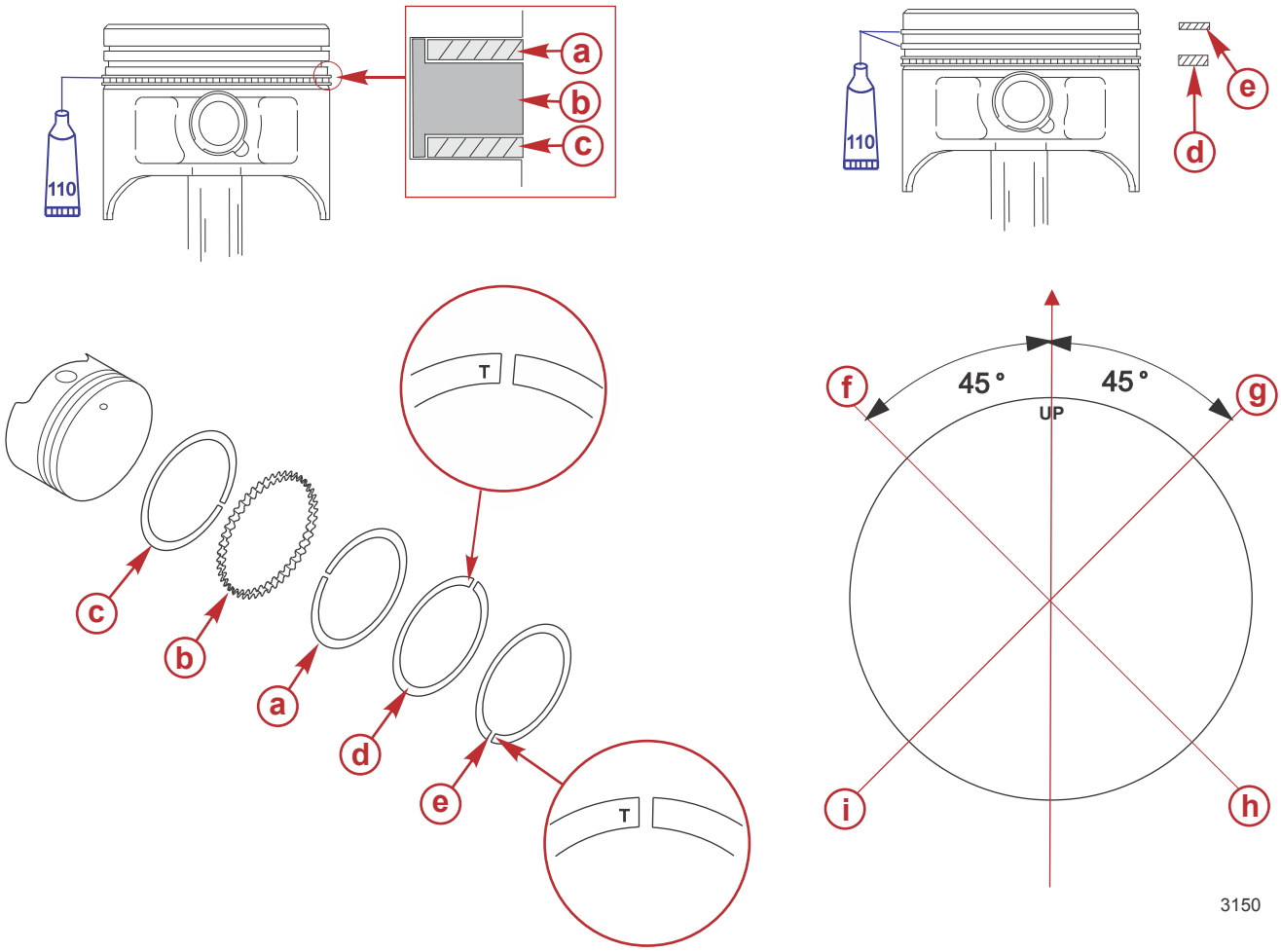
Piston Ring Installation

IMPORTANT: Use caution when installing piston rings, to avoid scratching the piston.

1. Use a piston ring expander to install the oil ring, second ring, and top ring.
   IMPORTANT: The "T" on the first and second ring must face the crown of the piston.

Piston Ring Expander	91- 24697

2. Lubricate the rings with 4-Stroke 10W-30 Outboard Oil, after the rings are installed on the piston.



a - Top oil control ring
b - Expander
c - Bottom oil control ring
d - Second ring
e - Top ring
f - End gap - Top ring
g - End gap - Bottom oil control ring
h - End gap - Second ring
i - End gap - Top oil control ring

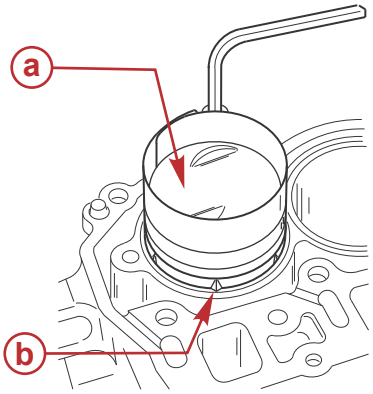
Tube Ref No.	Description	Where Used	Part No.
110	4-Stroke 10W-30 Outboard Oil	Piston rings	92-8M0078625

Piston Installation

IMPORTANT: The cylinder bores must be clean before installing the pistons. Clean the bore with a light honing as necessary. After honing, clean the cylinder bores with water and mild detergent. After cleaning, swab out the cylinder bores with engine oil and a clean cloth. Wipe the cylinder bore with a clean dry cloth.

1. Lubricate the piston, rings, and cylinder bores with 10W-30 4-Stroke Marine Engine Oil.
2. Use a piston ring compressor tool to compress the piston rings.
3. Using the piston ring compressor tool, install the piston/connecting rod assembly into the cylinder block.
4. Push down on the piston compressor tool to ensure that the tool is firmly seated against the block.

5. Ensure the **UP** mark on the top of the piston is towards the flywheel. Push the piston down into the cylinder bore until the rings have entered the cylinder.



21019

a - Piston
b - Ring compressor tool firmly seated against the cylinder block

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Piston, piston rings, and cylinder bore	92-8M0078625

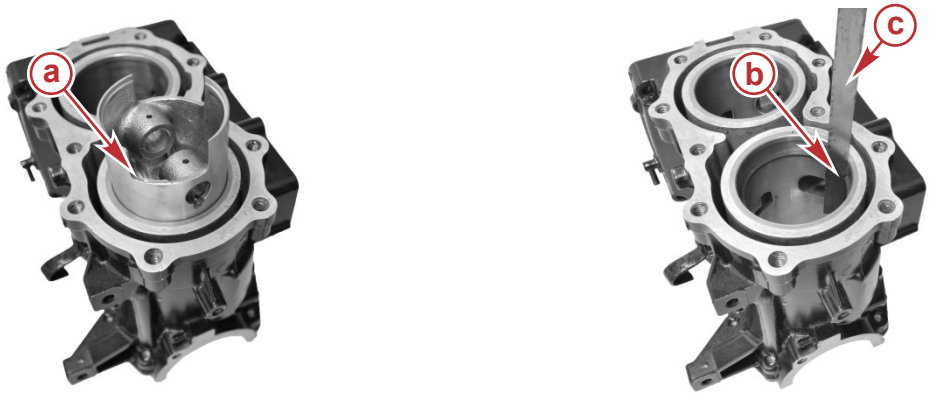
Piston Ring Compressor	FT2997

6. Repeat the procedure for the remaining cylinders.

Crankshaft Installation

1. Install the crankshaft main bearings into the cylinder block and crankcase cover.
2. Lubricate the following areas generously with 10W-30 4-Stroke Marine Engine Oil.
   - Crankshaft seal and main bearing area
   - Crankshaft main and connecting rod journals
   - Connecting rod bearing area
3. Lubricate the upper and lower oil crankshaft seal lips with 10W-30 4-Stroke Marine Engine Oil and install onto the crankshaft ends.

   NOTE: *Refer to the* ***Crankshaft Components*** *assembly view for correct installation direction of the crankshaft seals.*

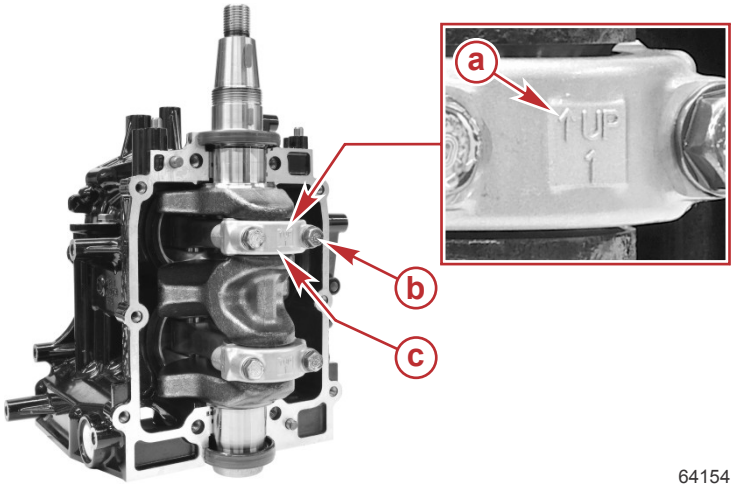


64153

a - Main bearings
b - Connecting rod
c - Lower crankshaft seal
d - Main bearing journal
e - Connecting rod journal
f - Upper crankshaft seal

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Crankshaft seal and main bearing area, crankshaft main and connecting rod journals, connecting rod bearing area, upper and lower oil crankshaft seal lips	92-8M0078625

4. Carefully place the crankshaft onto the cylinder block main bearings.
5. Ensure the crankshaft seals are parallel with the crankshaft and centered in the seal area of the cylinder block.
6. Attach the connecting rods to the crankshaft journals.
7. Ensure that the arrow on the connecting rod cap points up.
8. Install new connecting rod cap bolts.
9. Tighten the connecting rod cap bolts to the specified torque in two steps.

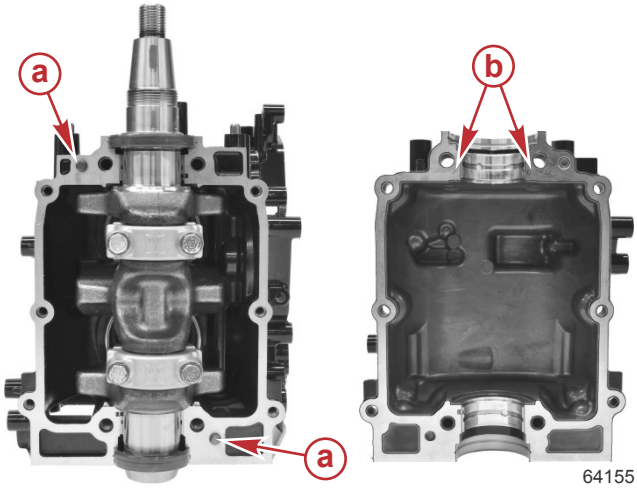


64154

a - "Up" arrow and text
b - Connecting rod cap bolt
c - Connecting rod cap

Description		Nm	lb-in.	lb-ft
Connecting rod cap bolt	**First**	6.0	53.1	–
	Final	10.0	88.5	–

10. Clean the cylinder block to crankcase mating surfaces of oil and debris.
11. Apply a continuous bead of Loctite® Master Gasket to the contact surface of the crankcase. Follow the instructions contained in the kit.
12. Ensure that the dowel pins are inserted into the cylinder block, and install the crankcase cover.



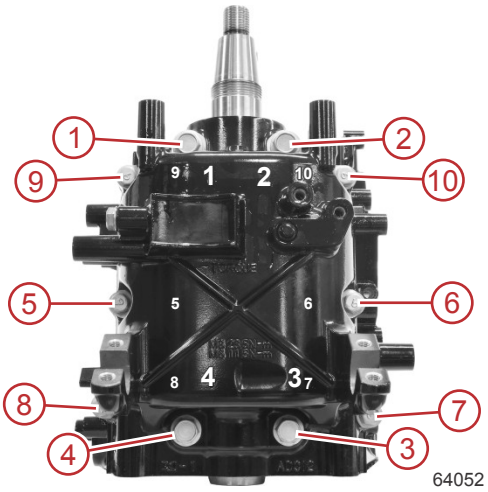
64155

a - Dowel pins (2)
b - Crankcase cover mating surface

Tube Ref No.	Description	Where Used	Part No.
12	Loctite® Master Gasket Kit	Cylinder block and crankcase cover mating surfaces	92-12564 2

13. Lubricate the main bearing and crankcase cover bolts with clean engine oil.

14. Tighten the bolts to the specified torque in sequence in two steps.



Description		Nm	lb-in.	lb-ft
Main bearing bolts (1–4) (M8 x 50)	**First**	10.0	88.5	–
	Final	23.5	–	17.3
Crankcase cover bolts (5–10) (M6 x 30)	**First**	6.0	53.1	–
	Final	11.5	101.8	–

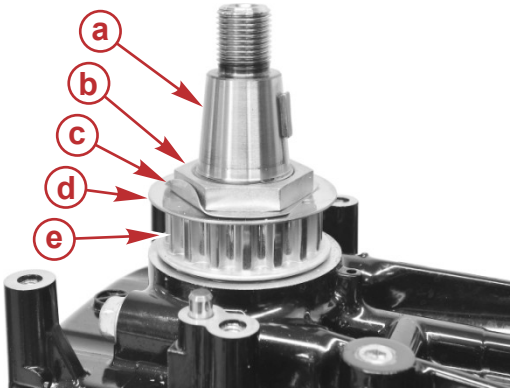
Crankshaft Timing Gear Installation

1. Install the timing gear key into the crankshaft.
2. Install the timing gear.
3. Install the belt guide with the dot side up.

   IMPORTANT: The belt guide outside edge is curved. Ensure the belt guide outside curved edge faces up toward the flywheel.
4. Install the lockwasher with the bent tang inserted into the keyway on the timing gear.
5. Install the timing gear nut.
6. Install the flywheel key. Tighten the timing gear nut to the specified torque.

Description	Nm	lb-in.	lb-ft
Timing gear nut	64.0	–	47.2

7. Bend the lockwasher against one flat on the nut.



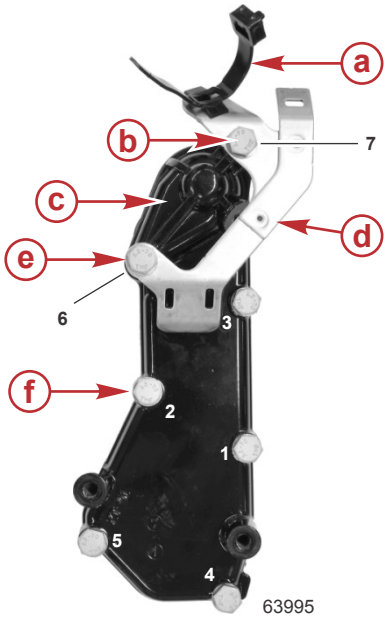
a - Crankshaft
b - Nut
c - Lockwasher
d - Belt guide
e - Timing gear

Thermostat, Exhaust Cover, and Anode Installation

1. Install the cylinder head. Refer to **Section 4B - Cylinder Head Installation**.

   NOTE: *Install the spark plugs as directed, but do not install the throttle body or removed electrical components at this time.*
2. Install a new exhaust cover gasket.
3. Install the exhaust cover, and start but do not tighten the five M6 x 25 screws.

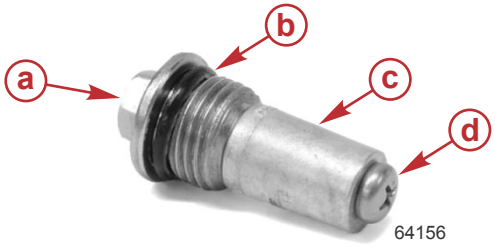
4. Install the thermostat, thermostat cover gasket, thermostat cover, and electrical bracket.
5. Tighten all seven screws (five M6 x 25 and two M6 x 50 screws) in the indicated sequence to the specified torque.



a - Reusable cable tie
b - Thermostat cover/electrical bracket screw (7th in tightening sequence)
c - Thermostat cover
d - Electrical bracket
e - Thermostat cover/electrical bracket screw (6th in tightening sequence)
f - Exhaust cover screws (1st through 5th in tightening sequence)

Description		Nm	lb-in.	lb-ft
Exhaust cover screws (M6 x 25) (5)	First	6.0	53.1	–
	Final	9.0	79.7	–
Thermostat cover screws (M6 x 50) (2)		9.0	79.7	–

6. Install a new anode onto the anode plug. Tighten the anode screw to the specified torque. Install a new O-ring onto the anode plug.

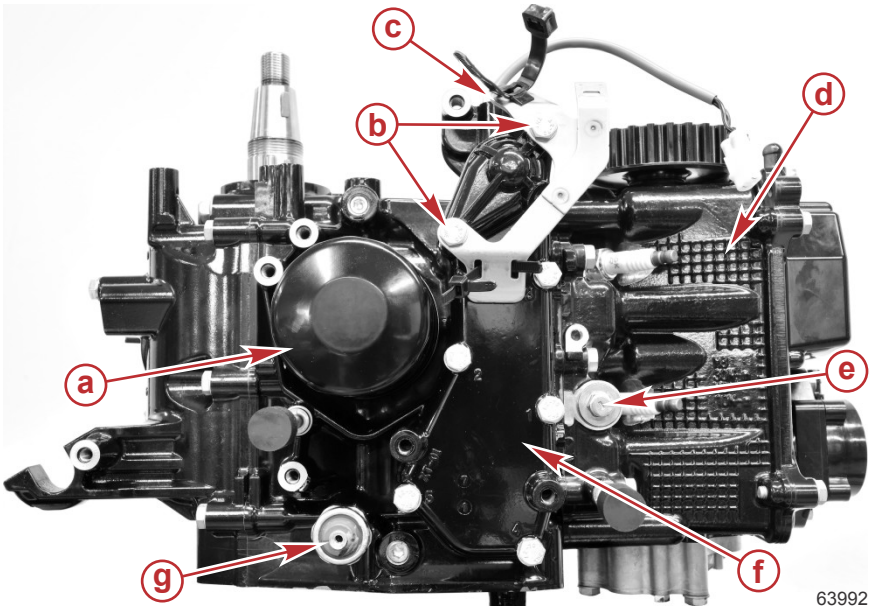


a - Anode plug
b - O-ring
c - Anode
d - Anode screw

7. Install the anode plug into the cylinder head. Tighten the anode plug to the specified torque.
8. Install the engine coolant temperature (ECT) sensor. Tighten the sensor to the specified torque.
9. Apply Loctite® 567 PST Pipe Sealant to the oil pressure switch threads. Install the oil pressure switch, and tighten it to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
9	Loctite® 567 PST Pipe Sealant	Oil pressure switch threads	92-809822

10. Lubricate the oil filter gasket with clean engine oil. Install the oil filter and tighten to the specified torque.

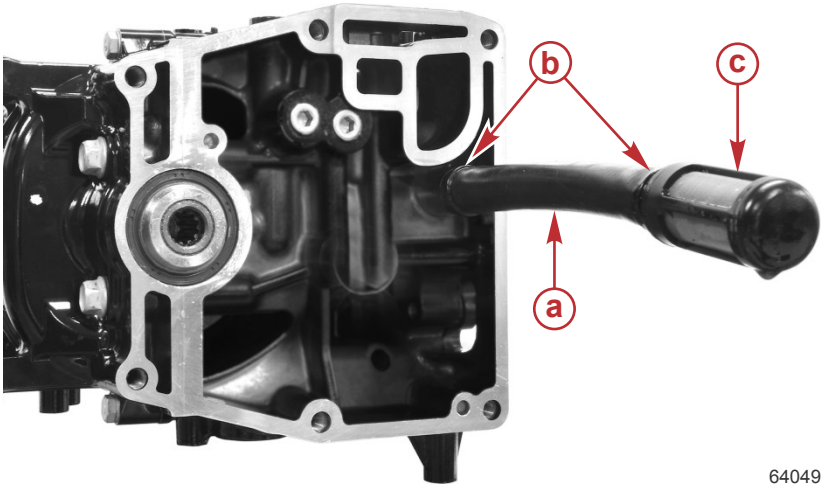


- **a -** Oil filter
- **b -** Thermostat cover/electrical bracket mounting screws
- **c -** Engine coolant temperature sensor
- **d -** Cylinder head assembly
- **e -** Anode
- **f -** Exhaust cover
- **g -** Oil pressure switch

Description	Nm	lb-in.	lb-ft
ECT sensor	4.0	35.4	–
Anode screw	2.0	17.7	–
Anode plug	18.0	159.3	–
Oil pressure switch	8.0	70.8	–
Oil filter	18.0	159.3	–

Oil Strainer Installation

1. Secure the hose and oil strainer to the cylinder block fitting.
2. Secure components with two cable ties.

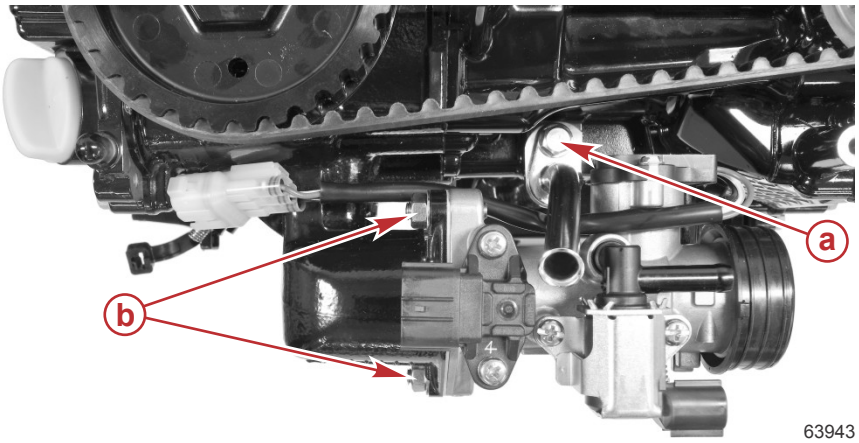


- **a -** Hose
- **b -** Cable tie
- **c -** Oil strainer

Throttle Body Installation

1. Ensure that an O-ring is on the dipstick tube extension. Lubricate the O-ring with clean engine oil.
2. Install the dipstick extension tube, and secure it with a single screw and washer. Tighten the screw to the specified torque.
3. Install a gasket onto the throttle body studs.

4. Install the throttle body, and secure it with two nuts and washers. Tighten the nuts to the specified torque.



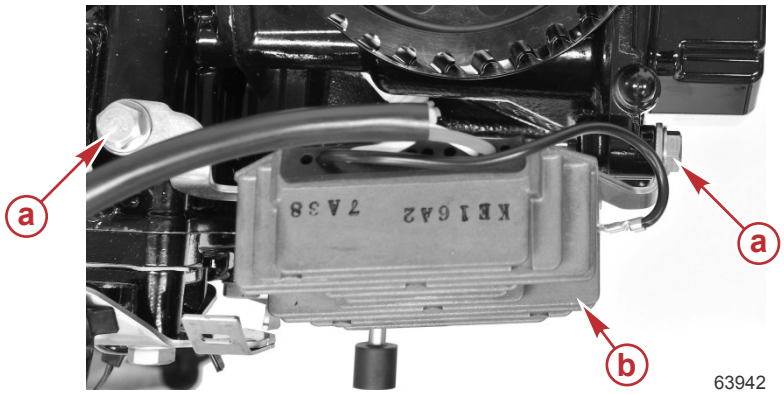
a - Dipstick extension tube screw
b - Throttle body nuts

Description	Nm	lb-in.	lb-ft
Dipstick extension tube screw	6.0	53.1	–
Throttle body nuts	6.0	53.1	–

Electrical Component Installation

IMPORTANT: This procedure assumes that all components are in the state as removed in Electrical Component Removal (for example, the voltage regulator/rectifier is installed on its mounting bracket). If any additional disassembly was performed, refer to the appropriate service procedure for reassembly.

1. Electric start models: Install the voltage regulator/rectifier and bracket, using two screws with washers. Tighten the screws to the specified torque.

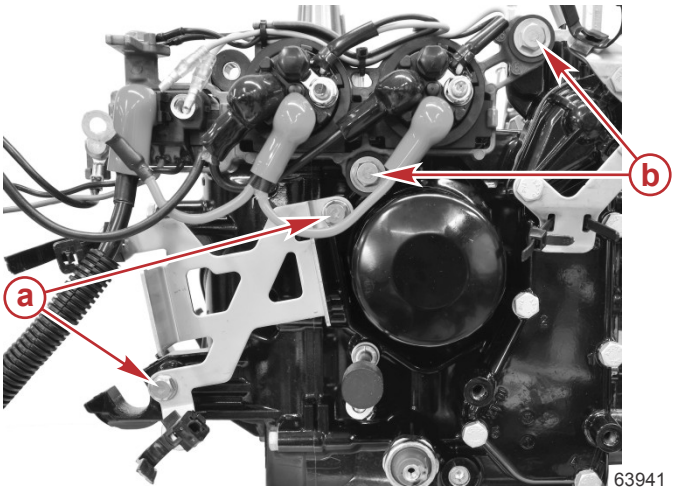


a - Bracket screws (2)
b - Voltage regulator/rectifier

Description	Nm	lb-in.	lb-ft
Voltage regulator/rectifier bracket screws	6.0	53.1	–

2. Power tilt models: Install the tilt relay/start solenoid bracket onto the engine, using two screws. Tighten the screws to the specified torque.

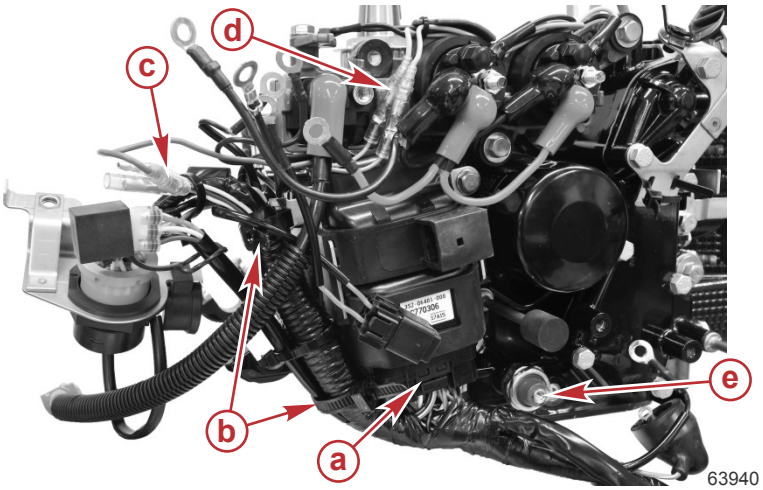
3. Install the ECM bracket, using two screws with washers. Tighten the screws to the specified torque.



a - ECM bracket screws (2)
b - Relay/solenoid bracket screws (2 + 1 to be installed later)

Description	Nm	lb-in.	lb-ft
Tilt relay/start solenoid bracket screws	6.0	53.1	–
ECM bracket screws	6.0	53.1	–

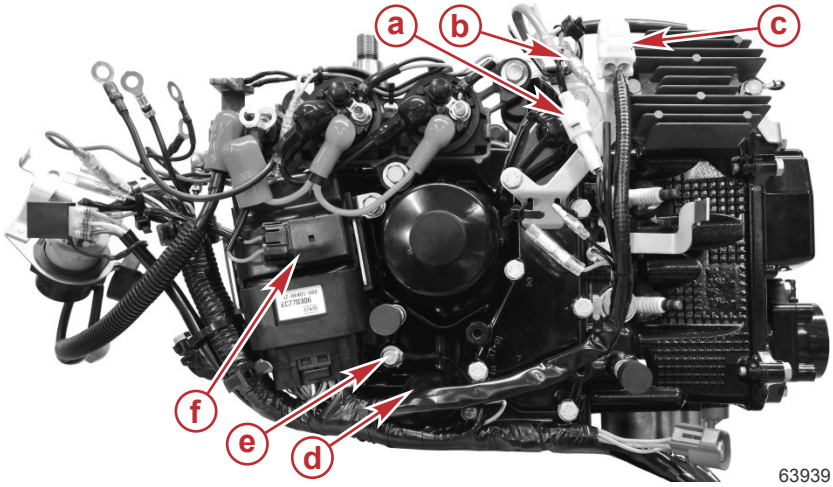
4. Install the ECM onto its bracket, and connect the ECM to the engine harness.
5. Secure the engine harness to the ECM bracket, using the two reusable cable ties.
6. Power tilt models: Connect the pink, light blue, and green bullet connectors from the tilt relays and start solenoid to the engine harness.



a - ECM connector
b - Reusable cable ties
c - Start solenoid green bullet connector
d - Power tilt pink and light blue bullet connectors
e - Oil pressure switch

7. Insert the black fuse housing into the pocket on the ECM rubber mount.
8. Connect the ground terminal to the engine block, using a single screw. Tighten the screw to the specified torque.
9. Connect the oil pressure switch ring terminal to the switch, using a single screw. Tighten the screw to the specified torque, and cover the switch with the rubber boot.
10. Slide the yellow fuse housing onto the thermostat cover electrical bracket.
11. Connect the engine harness 2-pin connector to the engine coolant temperature (ECT) sensor.

12. Electric start models: Connect the engine harness red bullet connector to the voltage regulator/rectifier.



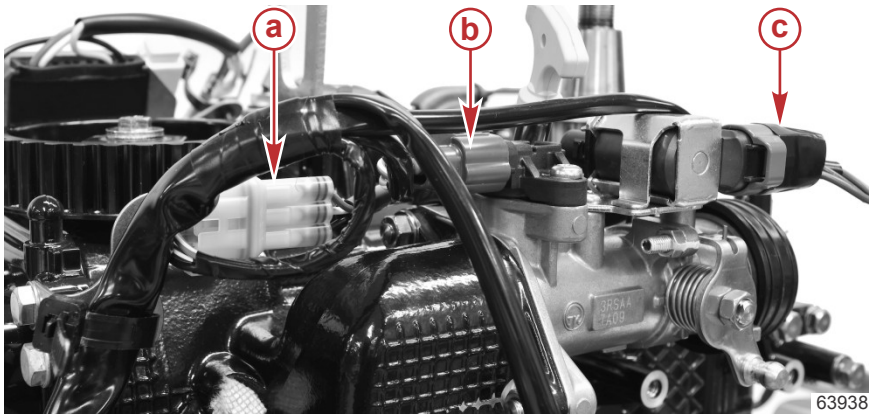
- **a -** 2-pin ECT sensor connector
- **b -** Voltage regulator/rectifier red bullet connector
- **c -** Yellow fuse housing
- **d -** Oil pressure switch with rubber boot installed (behind harness)
- **e -** Ground terminal
- **f -** Black fuse housing

Description	Nm	lb-in.	lb-ft
Ground terminal screw	6.0	53.1	–
Oil pressure switch screw	1.5	13.3	–

13. Install the ignition coil. Refer to **Section 2A - Ignition Coil.** Be certain to tighten the mounting screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Ignition coil mounting screw (M6 x 25) (2)	6.0	53.1	–

14. Connect the throttle position sensor (TPS), temperature and manifold absolute pressure (TMAP) sensor, and the idle air control (IAC) to the engine harness.



- **a -** TPS connector
- **b -** TMAP sensor connector
- **c -** IAC connector

IMPORTANT: Additional connections will be made after the powerhead is installed onto the driveshaft housing. Secure all loose items as necessary, for the powerhead installation.

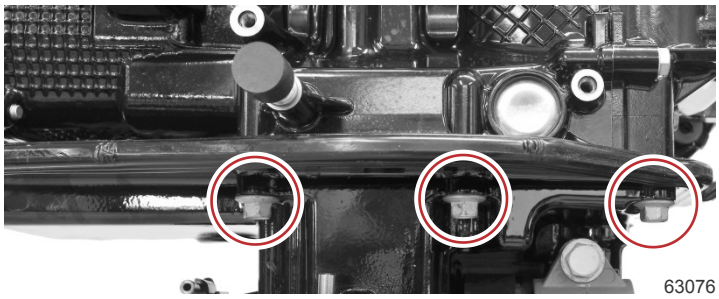
Powerhead Installation

IMPORTANT: This procedure assumes that all components are in the state as removed in Powerhead Removal (for example, the VST and fuel rail remain connected by the high-pressure fuel hose). If any additional disassembly was performed, refer to the appropriate service procedure for reassembly details.

This procedure contains steps for an electric start, power tilt model. Some steps will not apply to other models.

1. Attach the powerhead to the driveshaft housing:
   a. Ensure that the powerhead gasket, driveshaft seal, and rubber seal are in place on the driveshaft housing. Refer to **Section 5A - Driveshaft Housing Installation** for details.
   b. Install the powerhead onto the driveshaft and driveshaft housing.

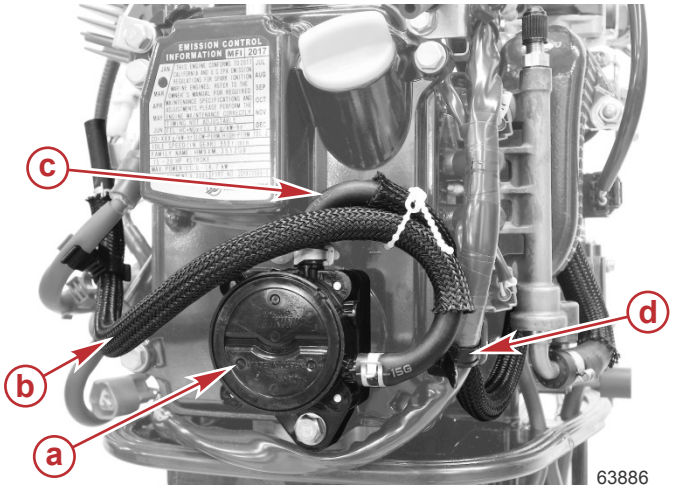
c. Install six screws to secure the powerhead to the driveshaft housing assembly. Tighten the screws to the specified torque in two stages.



Powerhead screws (three on each side, starboard shown)

Description		Nm	lb-in.	lb-ft
Powerhead screws (M8 x 35)	First	15.0	132.7	–
	Final	30.0	–	22.1

2. Install the fuel system components onto the engine:
   a. Install the vapor separator tank and the fuel rail. Refer to **Section 3C - VST Installation** and **Section 3C - Fuel Rail Installation**.
   b. Connect the fuel hoses to the fuel pump. Secure the connections with hose clamps.
   c. Secure the fuel outlet hose to the engine harness with the reusable cable tie.



a - Fuel pump
b - Fuel pump inlet hose (from fuel filter)
c - Fuel pump outlet hose (to VST)
d - Reusable cable tie

   d. Install the fuel filter bracket using one screw and washer. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Fuel filter bracket screw	6.0	53.1	–

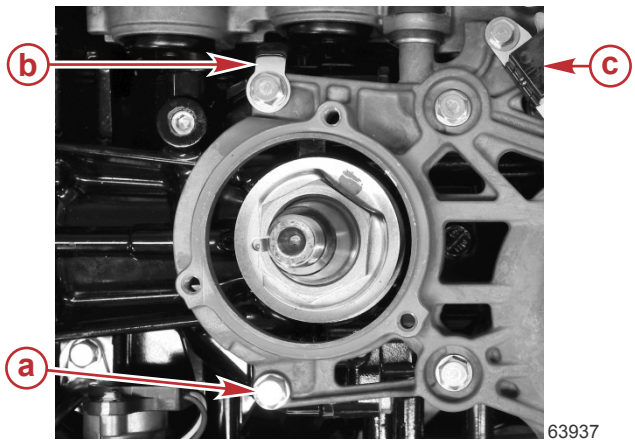
   e. Install the fuel filter onto the bracket.
   f. Connect the fuel filter outlet hose to the fuel filter. Secure the connection with a hose clamp, and secure the hose to the upper spark plug lead with a clip, as shown.

g. Connect the fuel inlet hose to the fuel filter. Secure the connection with a hose clamp. Route the hose to the front of the engine and attach it to the engine harness with a cable tie, as shown—do not tighten the cable tie. Secure the hose to the upper spark plug lead with a clip, as shown.

Electric start, power tilt model shown, other models similar

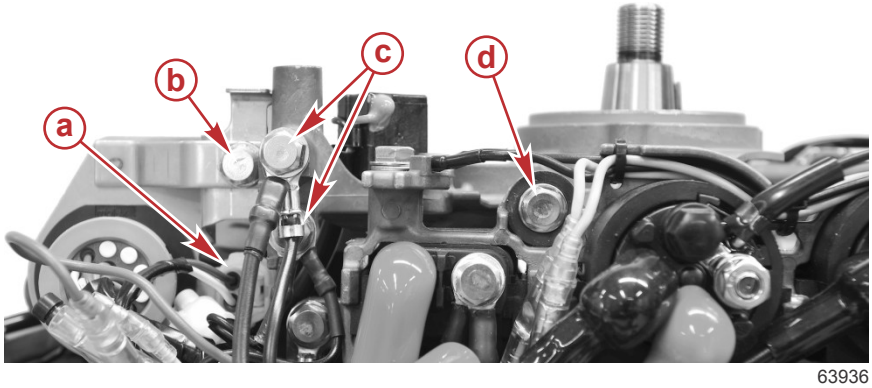
- **a -** Cable tie
- **b -** Fuel inlet hose
- **c -** Fuel filter
- **d -** Fuel filter outlet hose

3. Install the throttle and shift linkage. Refer to **Section 7A - Throttle and Shift Linkage**.
4. Install the stator/starter bracket:
   a. Secure the bracket to the top of the engine, using four screws with washers. Ensure that the J-clip for securing the stator leads is in place, as shown.



- **a -** Screw and washer (4 each)
- **b -** J-clip (to secure stator leads)
- **c -** Crankshaft position sensor

   b. Attach the relay/solenoid bracket to the side of the stator/starter bracket with one screw and washer. Tighten all five screws to the specified torque.
   c. Connect the four engine harness ground terminals to the stator/starter bracket, using two screws and washers. Tighten the screws to the specified torque.
   d. Install the 14-pin connector bracket onto the stator/starter bracket, using one screw and washer. Tighten the screw to the specified torque.
   e. Connect the crankshaft position sensor (CPS) to the engine harness.

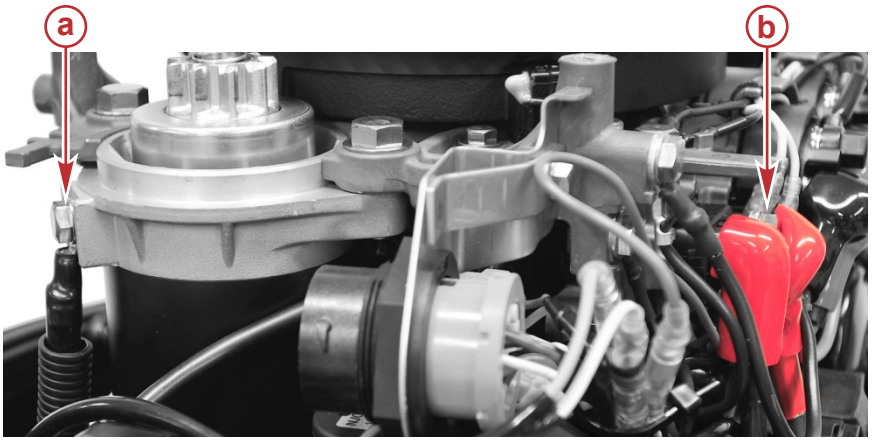


- **a -** CPS connector
- **b -** Screw and washer for the 14-pin connector bracket
- **c -** Screws and washers for ground terminals (2 each)
- **d -** Screw and washer securing relay bracket to stator/starter bracket

Description	Nm	lb-in.	lb-ft
Stator/starter bracket screws (5 - 4 top, 1 side)	6.0	53.1	–
Engine harness ground screws (2)	6.0	53.1	–
14-pin connector bracket screw	6.0	53.1	–

5. On electric start models:
   a. Install the starter motor. Refer to **Section 2B - Starter Motor Installation**.
   b. Connect the negative battery cable to the starter motor and the positive battery cable to the starter solenoid. Tighten the screws to the specified torque.

      NOTE: *Ensure that the fuse lead and tilt relay lead are also connected to the starter solenoid and that all three wires are routed through and covered by the red plastic boot.*



63065

a - Negative battery connection at the starter motor
b - Positive battery connection at the starter solenoid

Description	Nm	lb-in.	lb-ft
Negative battery cable screw (M6 x 12)	6.0	53.1	–
Positive battery cable screw (M6 x 10)	6.0	53.1	–

6. Install the following components on the top of the powerhead:
   a. Stator. Refer to **Section 2A - Stator**.
      - Route the stator wires under the J-clip and beneath the relay bracket.
      - Secure the harness wires to the electrical bracket with the reusable cable tie.
      - Pass a second cable tie through the two slots at the bottom of the electrical bracket and around the harness wires. Cinch the cable tie to secure the wires.
   b. Flywheel. Refer to **Section 2A - Flywheel**.
   c. Engine lifting eye. Tighten the screw to the specified torque.

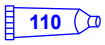
Description	Nm	lb-in.	lb-ft
Engine lifting eye screw	13	115	–

   d. Three cowl standoffs. Tighten the standoffs to the specified torque and cover them with rubber bumpers.

Description	Nm	lb-in.	lb-ft
Cowl standoffs (3)	6.0	53.1	–

   e. Camshaft gear cover. Refer to **Section 3C - Camshaft Gear Cover/Vent Tank**. Be certain to attach the three hoses to the proper ports on the vent tank.
   f. Air box and recoil assembly. Refer to **Section 8A - Recoil Starter Installation** and **Section 3C - Air Box Installation**.

      IMPORTANT: Be certain to install the neutral interlock cable onto the recoil starter assembly and to connect the crankcase breather hose to the valve cover.
7. Install the remote control harness and cables when applicable.
8. Install the front cowl. Refer to **Section 5A - Front Cowl**. Be certain to secure the fuel hose to the fitting in the front cowl.
9. Install the driveshaft housing covers. Refer to **Section 5A - Driveshaft Housing Covers**.
10. Add 10W-30 4-Stroke Marine Engine Oil to the crankcase to the recommended fluid level. Refer to **Section 1B - Filling the Crankcase with Oil**.

Tube Ref No.	Description	Where Used	Part No.
	10W-30 4-Stroke Marine Engine Oil	Engine crankcase	92-8M0078625

11. For electric start models, connect the battery cables to the battery.

Notes:

Powerhead

Section 4B - Cylinder Head

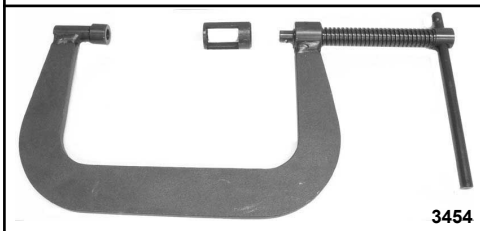
Table of Contents

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
51	Loctite® 222 Threadlocker	Camshaft gear screw threads	92-809818
110	4-Stroke 10W-30 Outboard Oil	Valve stems	92-8M0078625
		Rocker shaft components and camshaft lobes	

Special Tools

Lock-Ring Pliers	Snap-On SRP-4
 4799	Aids in the removal of lock rings.

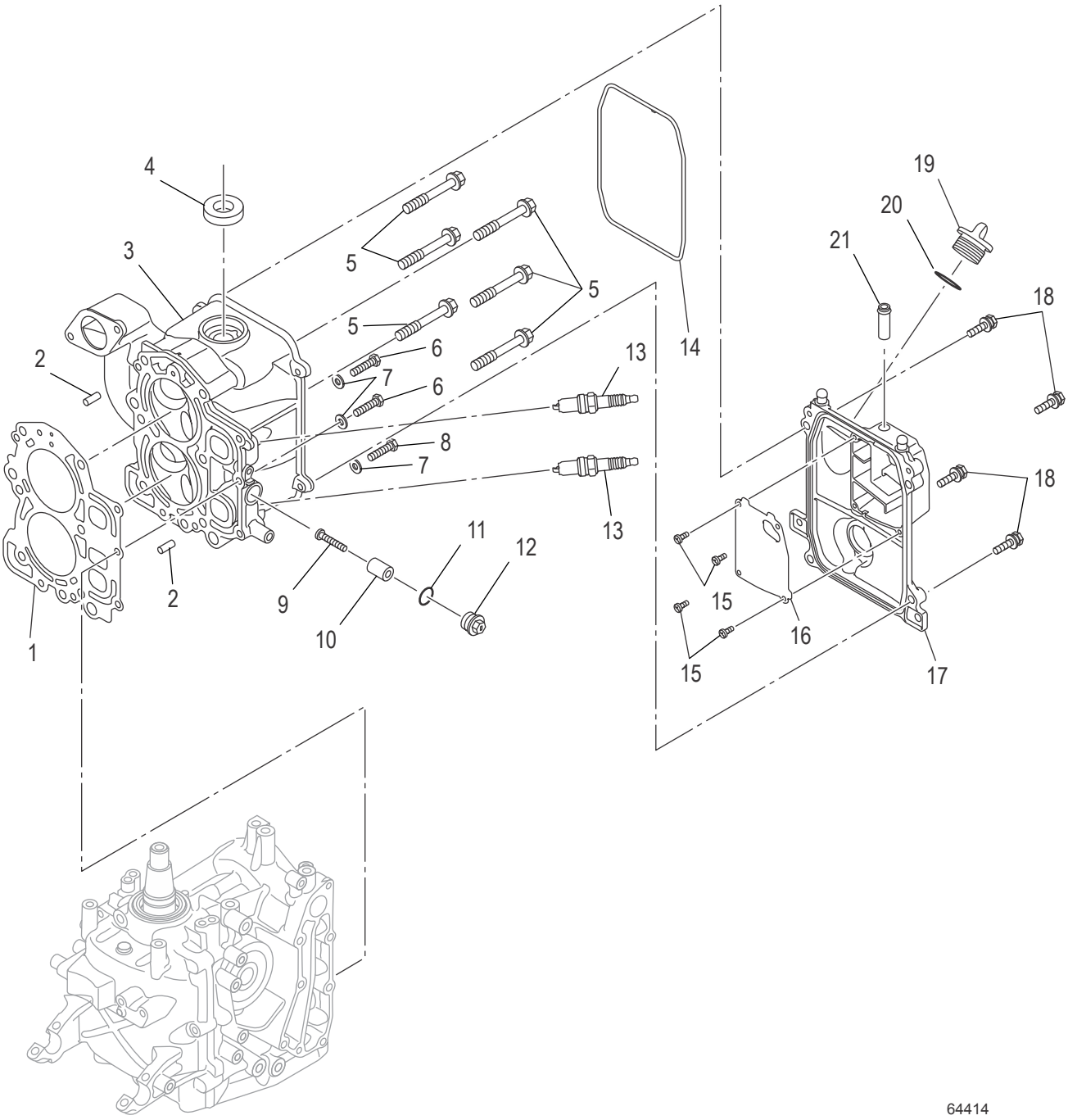
Valve Spring Compressor	91-809494A1
 3454	Removes and installs valve springs.

Cylinder Head Specifications

Parameter		Specification
Maximum deck warp		0.1 mm (0.004 in.)
Number of valves		4
Number of valves per cylinder		2
Number of camshafts		1
Camshaft journal outside diameter	Pulley side	17.98 mm (0.708 in.)
	Pulley side (service limit)	17.95 mm (0.707 in.)
	Oil pump side	15.97 mm (0.629 in.)
	Oil pump side (service limit)	15.95 mm (0.628 in.)
Cam lobe height	Intake	23.63 mm (0.9303 in.)
	Exhaust	23.80 mm (0.9370 in.)
	Intake and exhaust (service limit)	23.50 mm (0.9252 in.)
Valve clearance	Intake	0.13–0.17 mm (0.005–0.007 in.)
	Exhaust	0.18–0.22 mm (0.007–0.008 in.)
Valve seat angles		30°, 45°, 60°
Valve spring free length		32.85 mm (1.293 in.)
Valve spring free length (service limit)		31.50 mm (1.240 in.)
Valve spring tilt limit		1.1 mm (0.043 in.)
Valve stem diameter	Intake	5.48 mm (0.216 in.)
	Intake (service limit)	5.46 mm (0.215 in.)
	Exhaust	5.46 mm (0.215 in.)
	Exhaust (service limit)	5.44 mm (0.214 in.)
Cylindricity (maximum)		0.01 mm (0.0004 in.)

Parameter		Specification
Valve face width (intake and exhaust)		1.0 mm (0.04 in.)
Valve face width (service limit)		2.0 mm (0.08 in.)
Valve margin thickness	Intake	0.55 mm (0.0217 in.)
	Exhaust	1.00 mm (0.0394 in.)
Valve seat width		1.0 mm (0.04 in.)
Valve guide bore	Intake and exhaust	5.51 mm (0.217 in.)
	Intake valve guide bore (service limit)	5.55 mm (0.218 in.)
	Exhaust valve guide bore (service limit)	5.57 mm (0.219 in.)
Valve stem to valve guide clearance	Intake	0.008–0.04 mm (0.0003–0.0016 in.)
	Intake (service limit)	0.07 mm (0.0028 in.)
	Exhaust	0.025–0.057 mm (0.001–0.0022 in.)
	Exhaust (service limit)	0.1 mm (0.004 in.)
Rocker arm shaft outside diameter		12.99 mm (0.511 in.)
Rocker arm shaft outside diameter (service limit)		12.94 mm (0.509 in.)
Rocker arm inside diameter		13.01 mm (0.512 in.)
Rocker arm inside diameter (service limit)		13.05 mm (0.514 in.)
Rocker arm shaft clearance		0.006–0.035 mm (0.00023–0.0014 in.)
Cylinder head upper camshaft bearing inside diameter		17.975–17.990 mm (0.7077–0.7083 in.)
Oil pump camshaft bearing inside diameter		15.965–15.980 mm (0.6285–0.6291 in.)
Valve stem seal color	Intake	Black
	Exhaust	Green

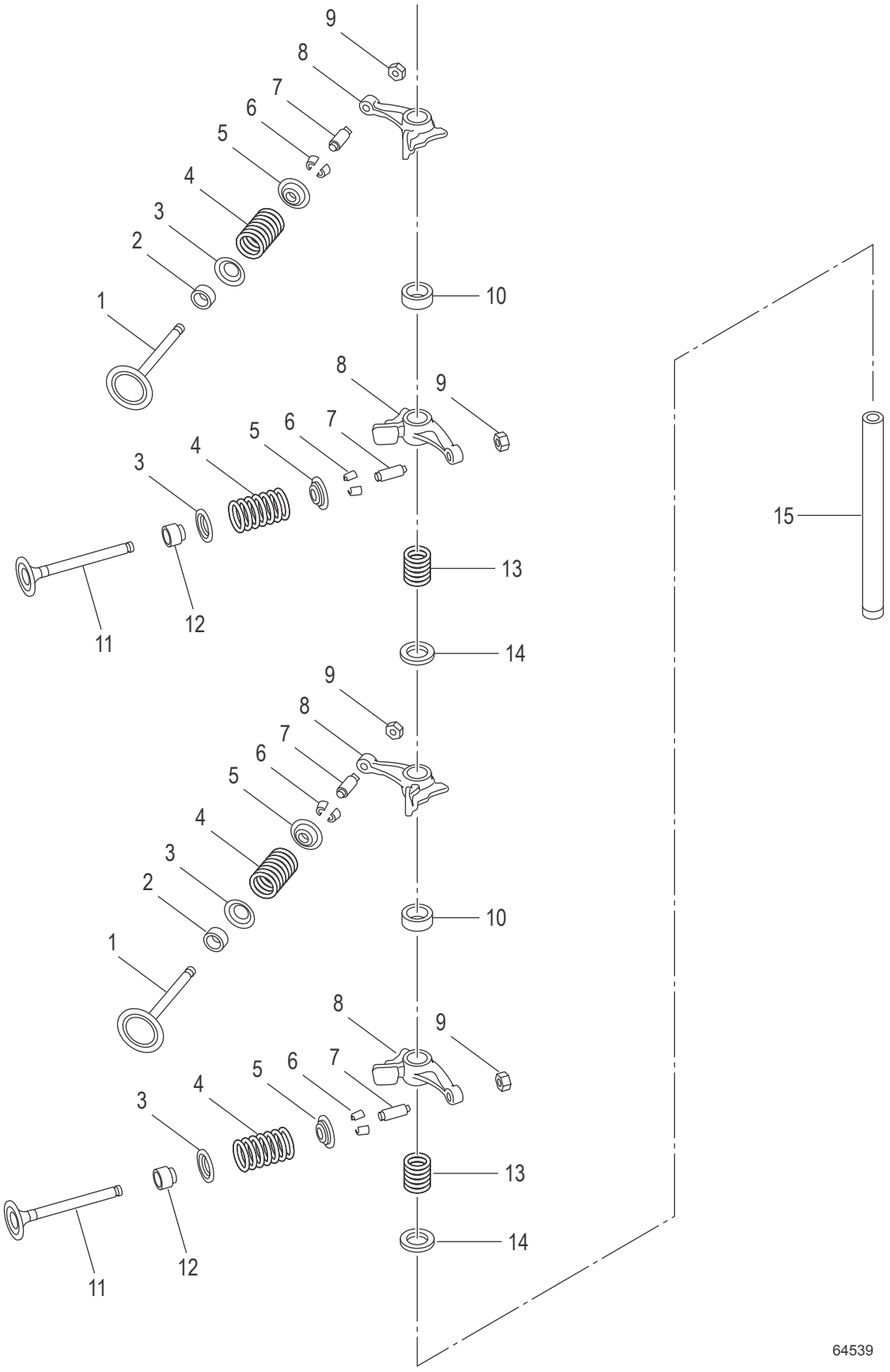
Cylinder Head Components



Cylinder Head Components

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	1	Cylinder head gasket				
2	2	Dowel pin				
3	1	Cylinder head				
4	1	Oil seal				
5	6	Screw (M8 x 60)	First	10.0	88.5	–
			Final	30.0	–	22.1
6	2	Screw (M6 x 25)	First	6.0	53.1	–
			Final	10.0	88.5	–
7	3	Washer				
8	1	Screw (M6 x 40)	First	6.0	53.1	–
			Final	10.0	88.5	–
9	1	Screw		2.0	17.7	–
10	1	Anode				
11	1	O-ring				
12	1	Anode plug		18.0	159.3	–
13	2	Spark plug		18.0	159.3	–
14	1	Cylinder head cover gasket				
15	4	Screw		1.5	13.3	–
16	1	Breather chamber cover				
17	1	Cylinder head cover				
18	4	Screw (M6 x 30)		6.0	53.1	–
19	1	Oil filler cap				
20	1	O-ring				
21	1	Nipple				

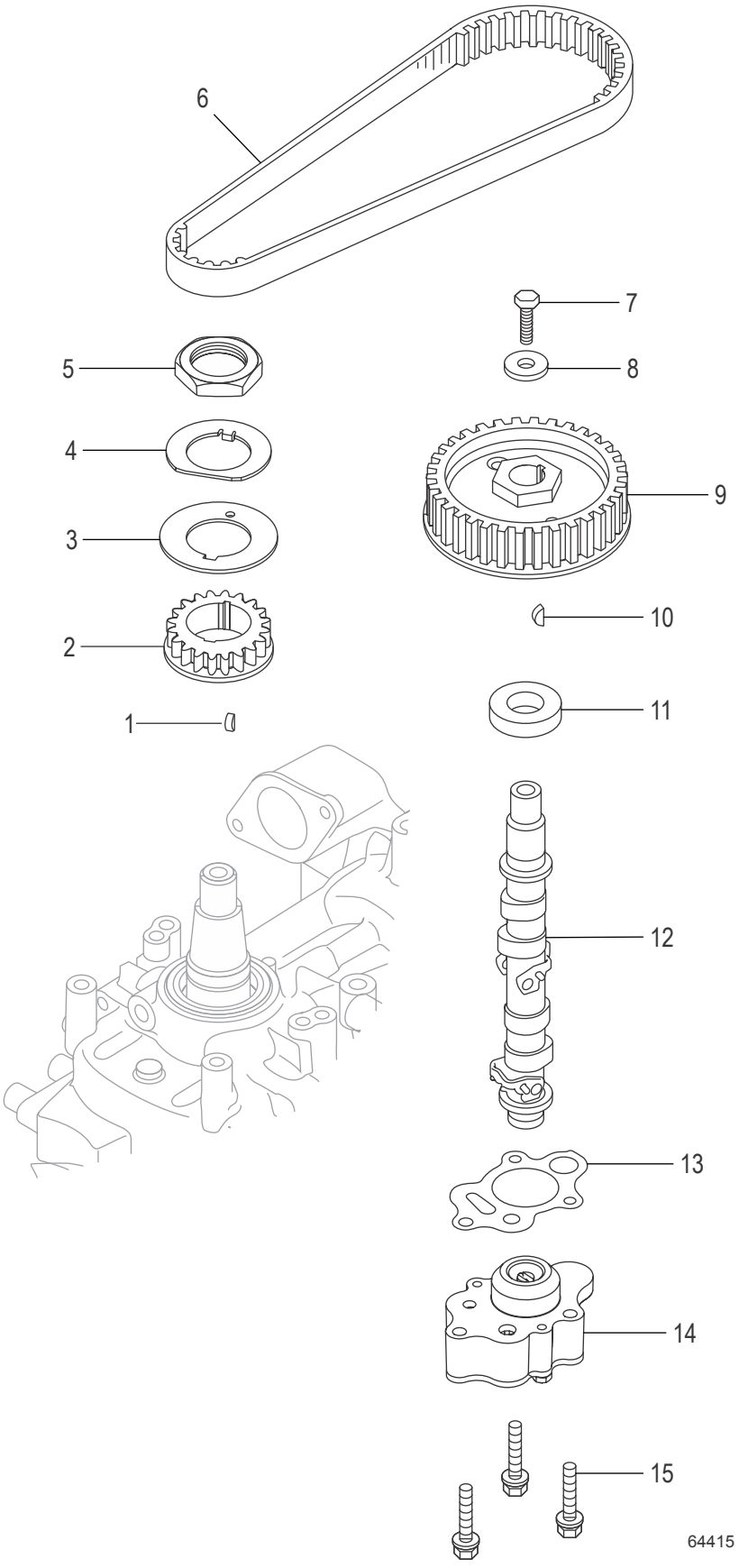
Intake/Exhaust Valve Components



Intake/Exhaust Valve Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Intake valve			
2	2	Intake valve stem seal			
3	4	Valve spring seat			
4	4	Valve spring			
5	4	Retainer			
6	8	Keeper			
7	4	Adjusting screw			
8	4	Rocker arm			
9	4	Locknut	7.0	62	–
10	2	Collar			
11	2	Exhaust valve			
12	2	Exhaust valve stem seal			
13	2	Rocker shaft spring			
14	2	Washer			
15	1	Rocker arm shaft			

Camshaft and Oil Pump Components



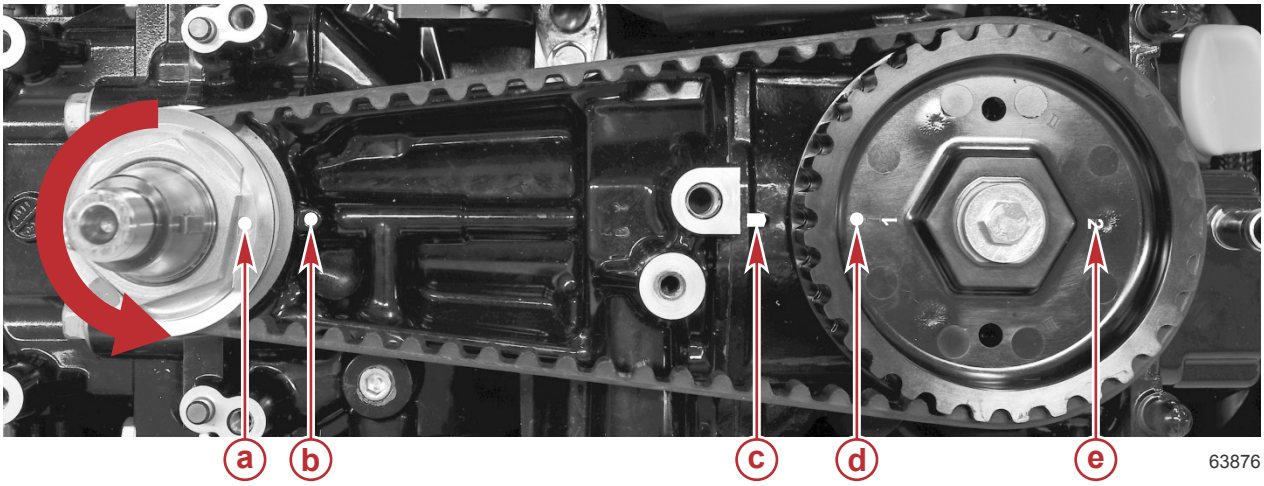
Camshaft and Oil Pump Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Key			
2	1	Drive gear			
3	1	Belt guide			
4	1	Lockwasher			
5	1	Nut	64.0	–	47.2
6	1	Timing belt			
7	1	Screw (M6 x 20)	11.5	101.8	–
8	1	Washer			
9	1	Driven gear			
10	1	Key			
11	1	Oil seal			
12	1	Camshaft assembly			
13	1	Oil pump gasket			
14	1	Oil pump assembly			
15	3	Screw (M6 x 35)	6.0	53.1	–

Valve Adjustments

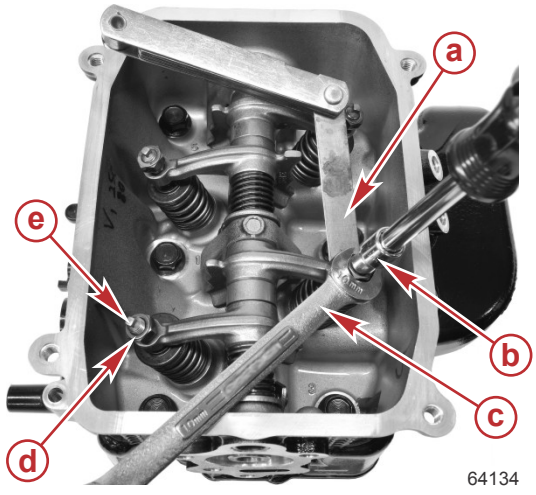
IMPORTANT: The timing belt and gears must be installed in the correct position or valve damage may occur.

1. Remove the following components:
   - Air box and recoil starter
     - It is easiest to remove and install these two items together.
     - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
   - Camshaft gear cover/vent tank. Refer to **Section 3C - Camshaft Gear Cover/Vent Tank**.
   - Disconnect the inlet and outlet fuel pump hoses. Refer to **Section 4A - Powerhead Removal**.
   - Cylinder head cover. Refer to **Cylinder Head Removal**.
   - Spark plugs.
2. Rotate the crankshaft until the timing marks on the crankshaft and camshaft are in proper alignment.



a - Crankshaft drive gear timing mark
b - Timing mark on the cylinder block for the crankshaft
c - Timing mark on the cylinder block for the camshaft
d - Timing mark for #1 cylinder
e - Timing mark for #2 cylinder

3. Measure valve clearance with a feeler gauge. Adjust if out of specification.



a - Feeler gauge
b - Square drive socket
c - Wrench
d - Locknut
e - Adjusting screw

Valve Clearance (Cold)	
Intake	0.13–0.17 mm (0.005–0.007 in.)
Exhaust	0.18–0.22 mm (0.007–0.008 in.)

4. Perform the following adjustment steps if out of specification:

- Turn the driven gear and align the dot on the driven gear with the timing mark on the cylinder block.
- Adjust the intake and exhaust valve clearance for #1 cylinder.
- Turn the crankshaft 360° and align the second dot on the driven gear with the timing mark on the cylinder block.
- Adjust the intake and exhaust valve clearance for #2 cylinder.
- Tighten the locknuts to the specified torque.

  IMPORTANT: When tightening locknuts, hold the adjusting screw with a square drive socket or adjustable wrench to prevent it from moving.

Description	Nm	lb-in.	lb-ft
Locknut	7.0	62	–

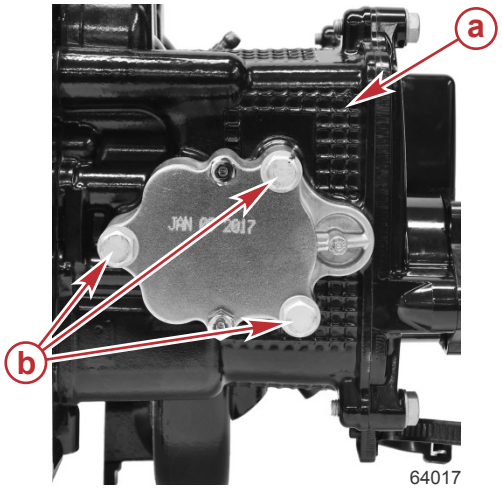
5. Install the following components:
   - Cylinder head cover. Refer to **Cylinder Head Installation**.
   - Connect inlet and outlet fuel pump hoses. Refer to **Section 4A - Powerhead Installation**.
   - Camshaft gear cover/vent tank. Refer to **Section 3C - Camshaft Gear Cover/Vent Tank**.
   - Air box and recoil starter.
     - It is easiest to install these two items together.
     - Refer to **Section 8A - Recoil Starter** and **Section 3C - Air Box Installation**.
   - Spark plugs.

Cylinder Head Removal

1. Remove the powerhead from the driveshaft housing. Refer to **Section 4A - Powerhead Removal**.

   IMPORTANT: The timing belt is removed during powerhead removal. Ensure that the engine timing is set correctly before removing the cylinder head, to avoid damaging any of the valves.
2. Remove the electrical components from the cylinder head. Refer to **Section 4A - Electrical Component Removal**.

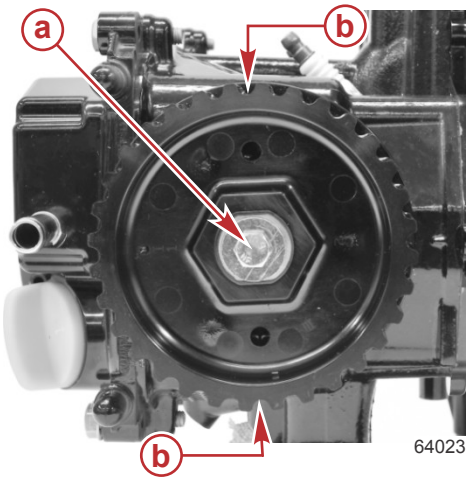
   NOTE: *To service only the cylinder head, it is not necessary to completely remove all electrical components from the powerhead. Refer to the note in the electrical component removal procedure.*
3. Remove the spark plugs.
4. Remove the throttle body from the cylinder head. Refer to **Section 4A - Throttle Body Removal**.
5. Remove the three screws holding the oil pump to the cylinder head.



a - Underside of cylinder head
b - Screws (3)

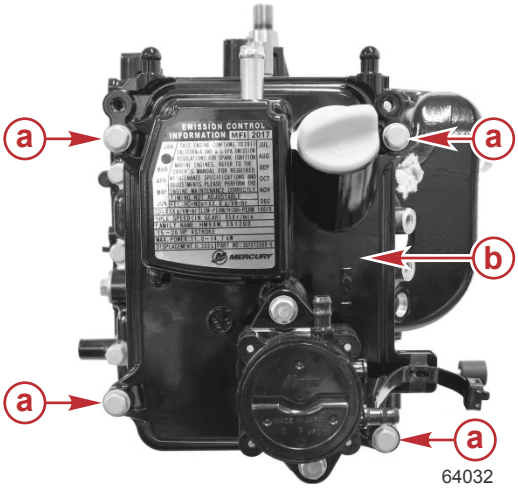
6. Remove the camshaft gear retaining screw.

7. Carefully pry on both sides of the camshaft gear to remove the gear from the camshaft.



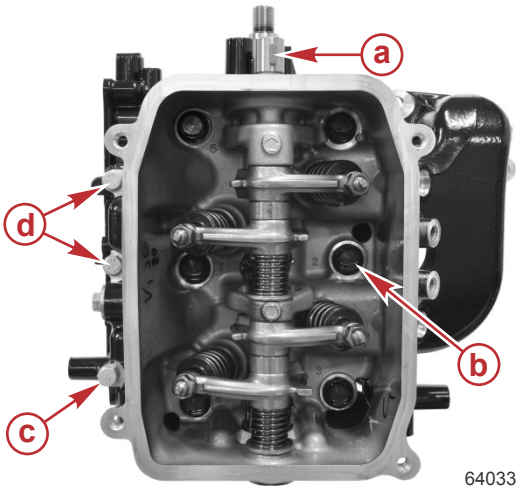
a - Camshaft gear retaining screw (M6 x 20) and washer
b - Camshaft gear pry points

8. Remove the four cylinder head cover screws.



a - Screw (M6 x 30) (4)
b - Cylinder head cover

9. Remove the camshaft key.
10. Remove the three cylinder head perimeter screws.
11. Remove the six cylinder head retaining screws.

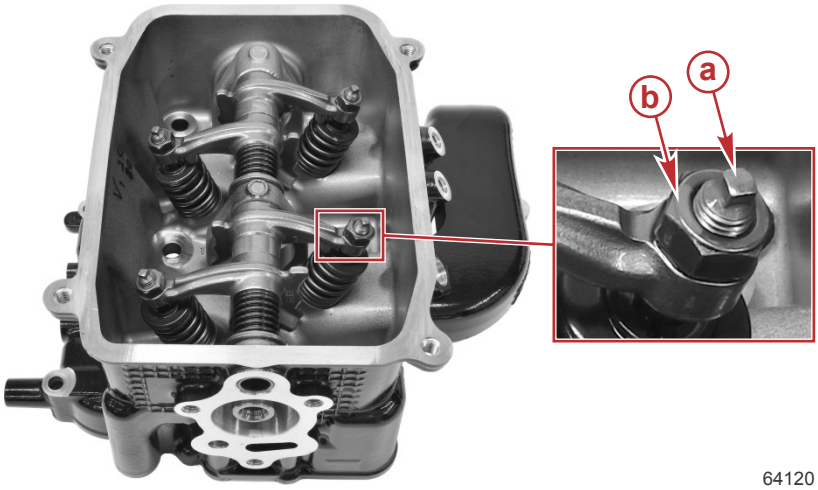


a - Camshaft key
b - Cylinder head retaining screw (M8 x 60) (6)
c - Perimeter screw (M6 x 40) and washer (1)
d - Perimeter screw (M6 x 25) and washer (2)

12. Remove the cylinder head.

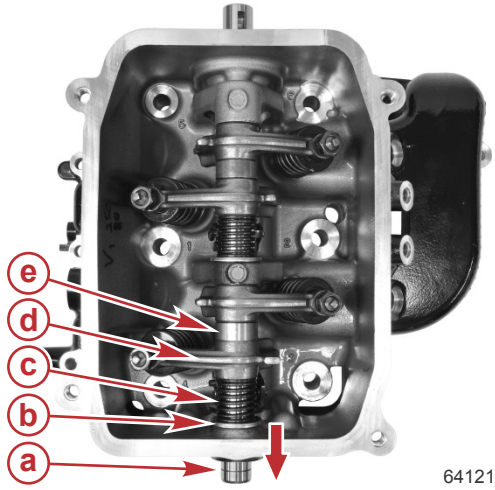
Cylinder Head Disassembly

1. Loosen all of the valve adjusting locknuts and screws. Turn the valve adjusting screws out several turns.



a - Adjusting screw
b - Locknut

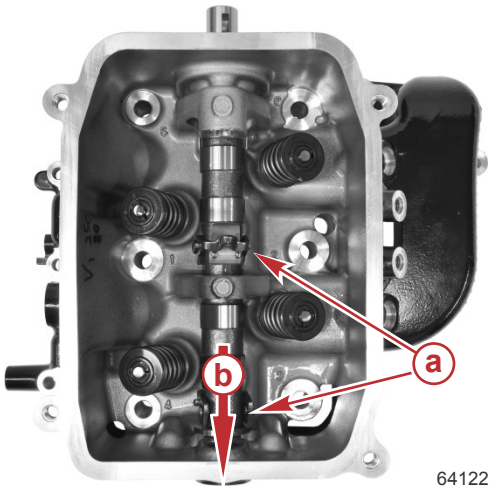
2. Use a lock-ring pliers to remove the rocker shaft.
3. Remove the springs, rocker arms, spacers, and washers.



a - Rocker shaft
b - Washer (2)
c - Spring (2)
d - Rocker arm (4)
e - Spacer (2)

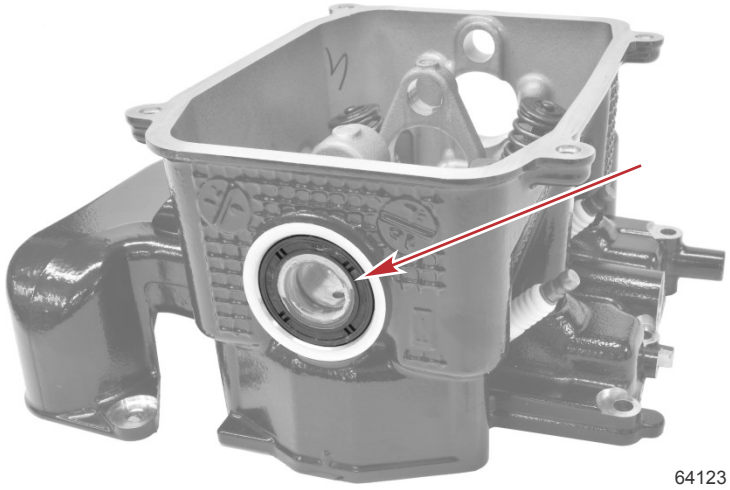
Lock-Ring Pliers	Snap-On SRP-4

4. Remove the camshaft. Be careful to not damage the decompression valves.

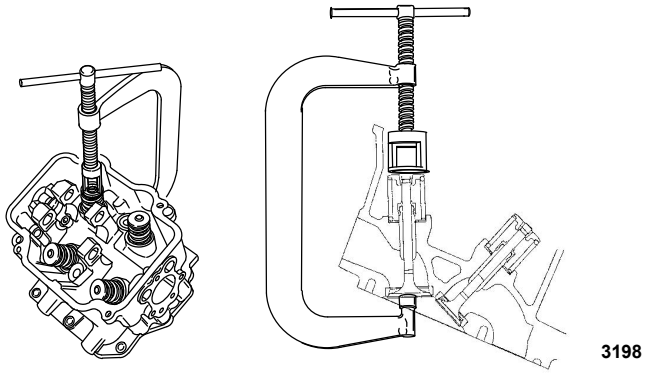


a - Decompression valves (2)
b - Remove the camshaft from the cylinder head

5. Remove the camshaft oil seal.

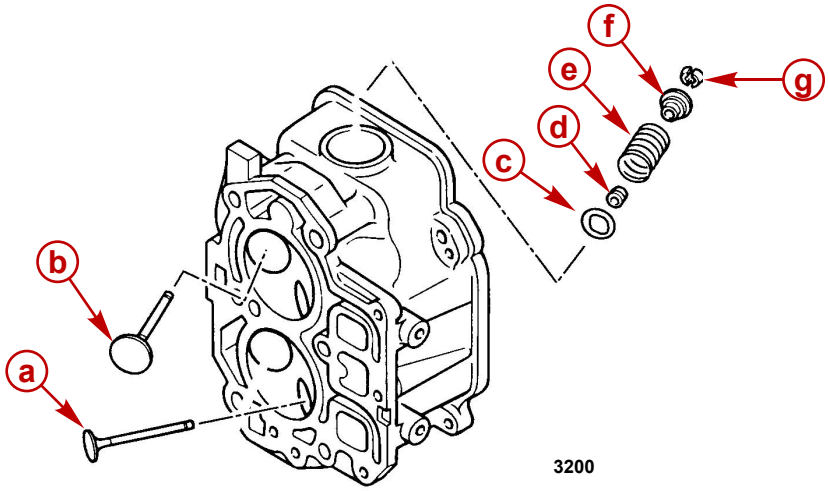


6. Compress the valve springs using a valve spring compressor.



Valve Spring Compressor	91-809494A1

7. Remove keepers, upper seats, springs, seals, lower seats, and intake/exhaust valves.
   NOTE: *Valve seals are not reusable.*

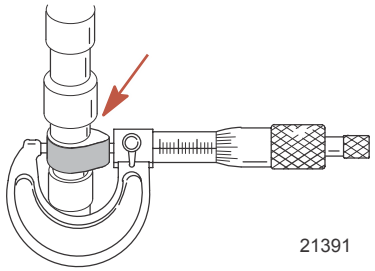


a - Exhaust valve
b - Intake valve
c - Valve seat
d - Valve seal
e - Valve spring
f - Retainer
g - Keepers

Cleaning and Inspection

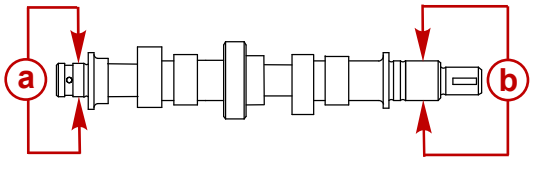
Camshaft

1. Measure the cam lobe at its maximum valve lift. Replace the cam if any of the cam lobe dimensions are out of specification.



Cam Lobe	
Intake	23.63 mm (0.9303 in.)
Exhaust	23.80 mm (0.9370 in.)

2. Measure the outer diameter of the upper and lower bearing journals. Replace the cam if the journal dimensions are out of specification.

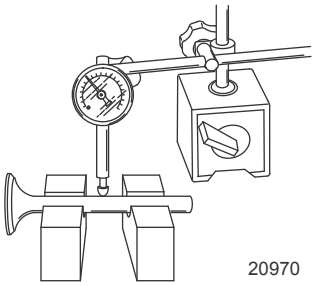


a - Lower bearing outside diameter
b - Upper bearing outside diameter

Cam Bearing Journal	
Lower bearing outside diameter	15.95–15.97 mm (0.628–0.629 in.)
Upper bearing outside diameter	17.95–17.98 mm (0.707–0.708 in.)

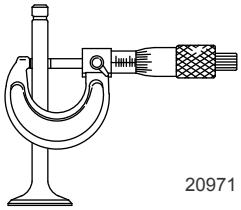
Valves

1. Inspect the valves for damage or warpage. Replace if necessary.
   a. Measure the valve stem cylindricity. Replace the valves if out of specification.



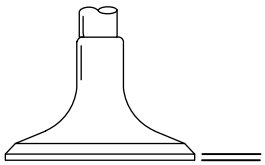
Cylindricity (Maximum)	
Intake and exhaust	0.01 mm (0.0004 in.)

2. Measure the valve stem outer diameter. Replace valves if out of specification.



Valve Stem Outside Diameter	
Intake	5.46–5.48 mm (0.215–0.216 in.)
Exhaust	5.44–5.46 mm (0.214–0.215 in.)

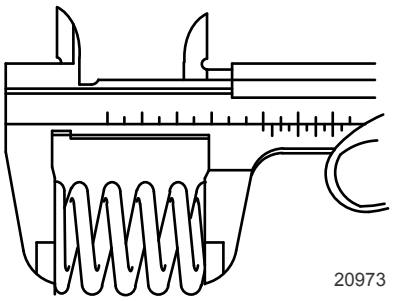
3. Measure the margin thickness of the valve. Replace the valve if out of specification.



Valve		
Margin thickness	Intake	0.55 mm (0.0217 in.)
	Exhaust	1.00 mm (0.0394 in.)

Valve Springs

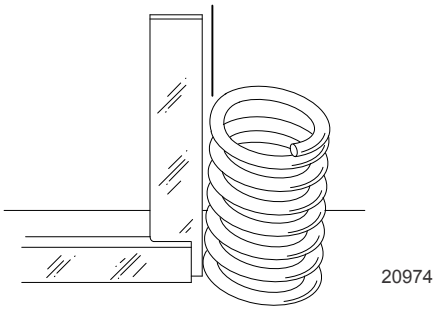
1. Check the free length of each valve spring. Replace the valve springs if they are out of specification.



Valve Spring	
Free length	31.50–32.85 mm (1.240–1.293 in.)

2. Measure the valve spring tilt. Replace the valve springs if they are out of specification.

   NOTE: *Check each spring on a flat surface using a square. Rotate the spring and check the space between the top coil and the square.*



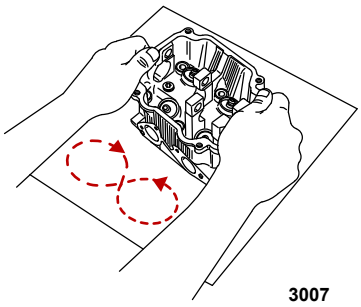
Valve Spring	
Tilt limit	1.1 mm (0.043 in.) maximum

Cylinder Head Resurfacing

NOTE: *The following procedure should only be attempted for minor scratches and minor warpage. Severe scratches or severe warpage cannot be corrected with resurfacing the head.*

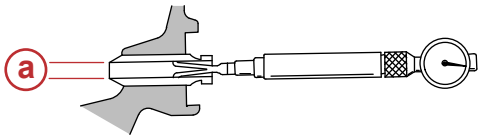
1. Place a sheet of 400–600 grit wet sandpaper on a flat surface.
2. Apply a light downward pressure on the head. Move the head in the pattern shown.
3. Rotate the head several times during the resurfacing procedure to avoid removing material from one side.

4. Thoroughly clean all sanding grit from the cylinder head.



Valve Guides

Measure the valve guide inner diameter. Replace the cylinder head if the valve guide inner diameter is out of specification.

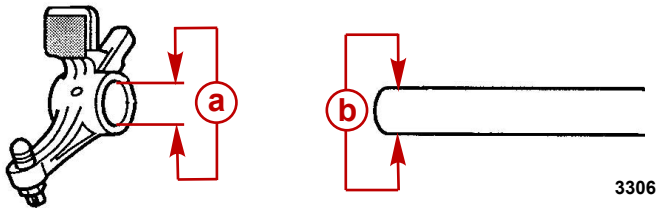


a - Valve guide inside diameter

Valve Guide Inside Diameter	
Intake	5.51–5.55 mm (0.217–0.218 in.)
Exhaust	5.51–5.57 mm (0.217–0.219 in.)

Rocker Arm and Rocker Arm Shaft Inspection

1. Measure the rocker arm inside diameter. Replace if out of specification.
2. Measure the rocker arm shaft outside diameter. Replace if out of specification.

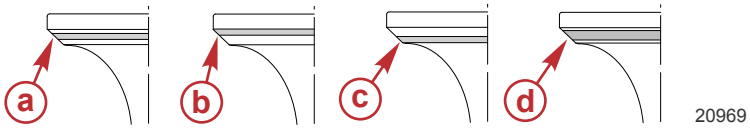


a - Rocker arm inside diameter
b - Rocker arm shaft outside diameter

Rocker Arm	
Rocker arm inside diameter	13.01–13.05 mm (0.5122- 0.514 in.)
Rocker arm shaft outside diameter	12.94–12.99 mm (0.5094–0.5114 in.)
Clearance	0.006–0.035 mm (0.0003–0.0014 in.)

Valve Seat Reconditioning

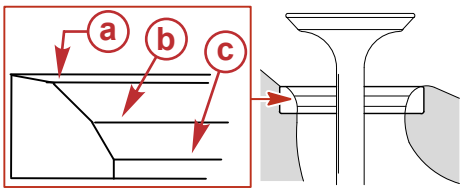
1. Clean the carbon deposits from the combustion chambers and valve seats. Check the valve seats for pitting.
2. Several different types of equipment are available for reseating valve seats. Follow the equipment manufacturers instructions.
3. Apply a thin even layer of mechanic's bluing dye (Dykem) onto the valve seat.
4. Insert the valve into the valve guide and lap the valve slowly on the valve seat.
5. Remove the valve and measure the valve seat contact pattern width. Resurface the valve seat if not in specification.



a - Correct valve seat contact width
b - Valve seat too high
c - Valve seat too low
d - Valve seat too wide

Valve Seat Contact Width	
Intake and exhaust valve	1.0–2.0 mm (0.0393–0.0787 in.)

6. To reface a valve seat, use a 30°, 45°, and 60° valve seat cutting tool.

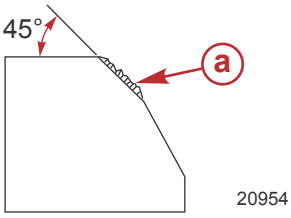


a - 30° angle
b - 45° angle
c - 60° angle

NOTE: *When twisting the cutter, keep an even downward pressure to prevent chatter marks.*

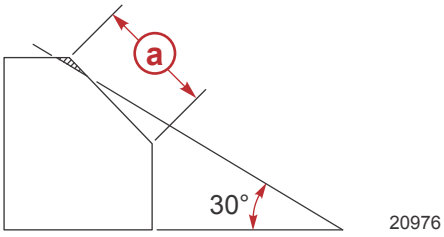
NOTE: *After refacing the valve seat or replacing the valve and valve guide, the valve seat and valve face should be lapped.*

7. Start with the 45° cutting tool to clean up any pitting or rough surface of the valve seat.



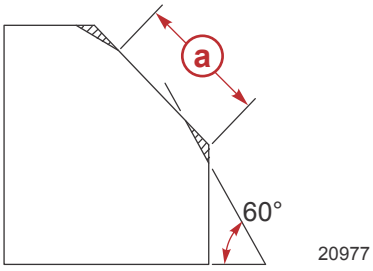
a - Rough surface of valve seat

8. Use the 30° cutting tool to adjust the contact width of the top edge of the valve seat.



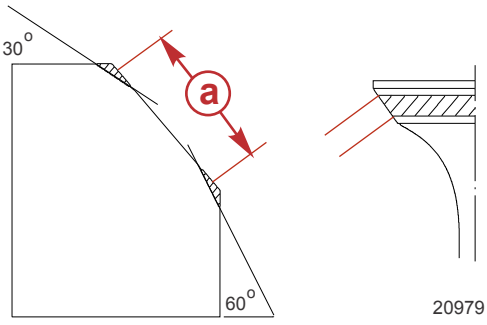
a - Previous contact width

9. Use the 60° cutting tool to adjust the contact width of the bottom edge of the valve seat.



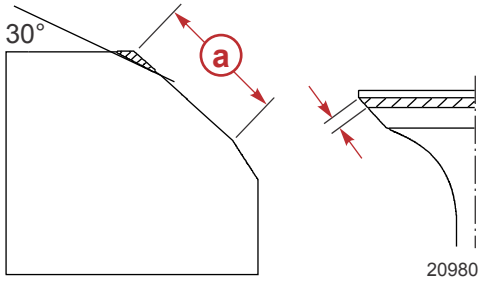
a - Previous contact width

10. If the valve seat contact area is too wide and situated in the center of the valve face, use the 30° cutting tool to cut the top edge of the valve seat and the 60° cutting tool to cut the bottom edge of the valve seat, to adjust its contact width.



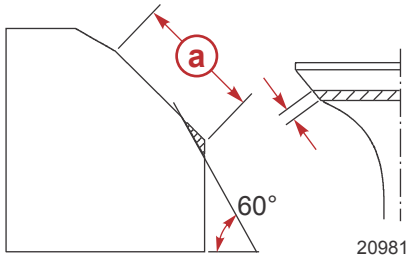
a - Previous contact width

11. If the valve seat contact area is too narrow and situated near the top of the valve face, use the 30° cutting tool to cut the top edge of the valve seat. If necessary, use the 45° cutting tool to center the area of contact and set its width.



a - Previous contact width

12. If the valve seat contact area is too narrow and situated near the bottom of the valve face, use the 60° cutting tool to cut the bottom edge of the valve seat. If necessary, use the 45° cutting tool to center the area of contact and set its width.

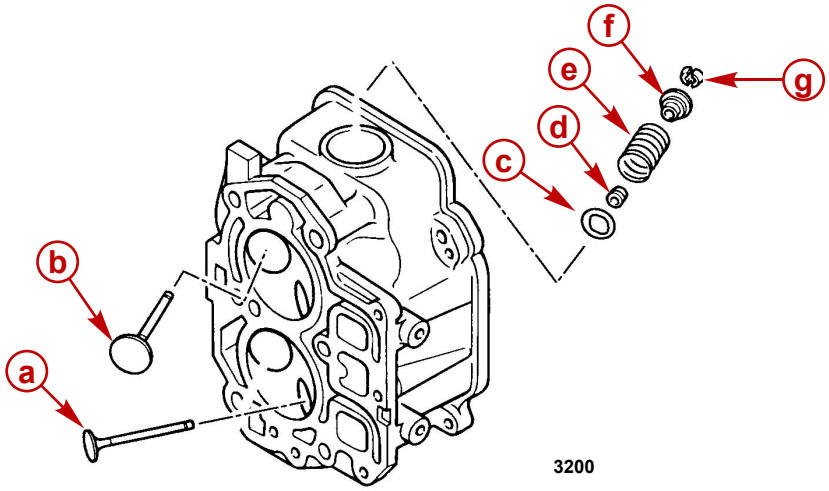


a - Previous contact width

Cylinder Head Assembly

IMPORTANT: Reassemble the valve train components in their original location.

1. Lubricate the valve stems with 4-Stroke 10W-30 Outboard Oil. Install the valves, springs, new seals, upper seats, and keepers.

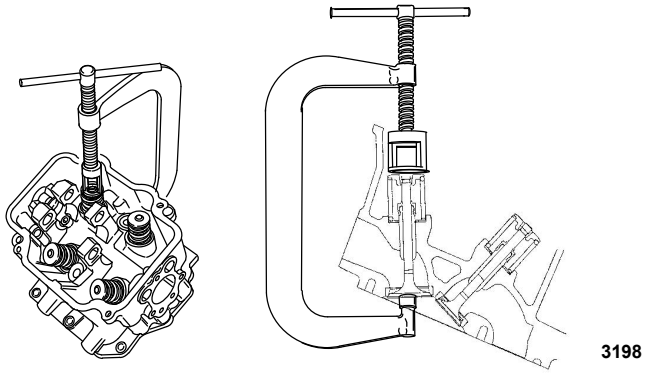


a - Exhaust valve
b - Intake valve
c - Valve seat
d - Valve seal
e - Valve spring
f - Retainer
g - Keepers

Tube Ref No.	Description	Where Used	Part No.
110	4-Stroke 10W-30 Outboard Oil	Valve stems	92-8M0078625

NOTE: *The green valve seal is for the exhaust and the black valve seal is for the intake.*

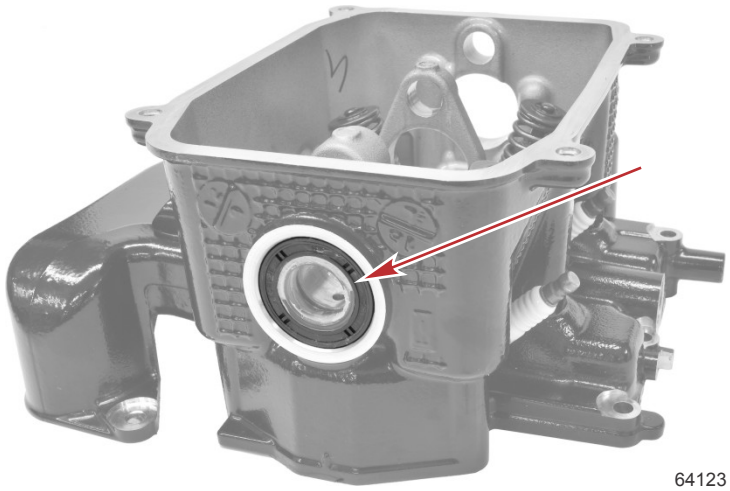
2. Compress the springs using a valve spring compressor. Insert the keepers and release the valve spring compressor.



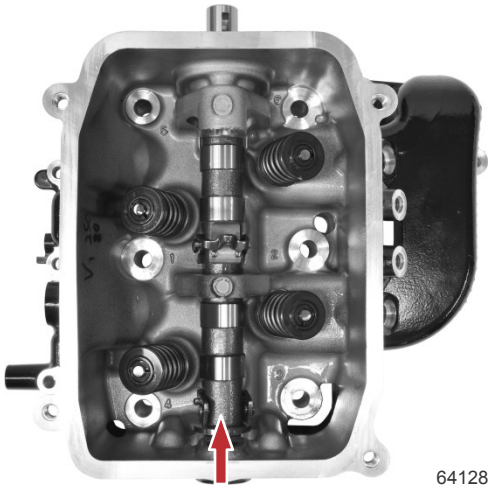
Valve Spring Compressor	91-809494A1

3. Install the camshaft oil seal.

NOTE: *Install the camshaft seal with the seal lip facing in.*

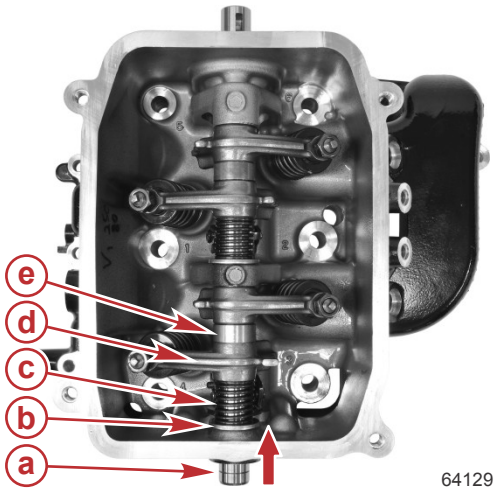


4. Lubricate the camshaft oil seal lip and the camshaft bearings with clean engine oil. Install the camshaft.



5. Lubricate the rocker shaft components and the camshaft lobes with 4-Stroke 10W-30 Outboard Oil.
6. Install the rocker shaft, washers, rocker arm shaft, spacer, springs, and rocker arms, as shown.

7. Insert the rocker shaft until it is fully seated in the cylinder head.

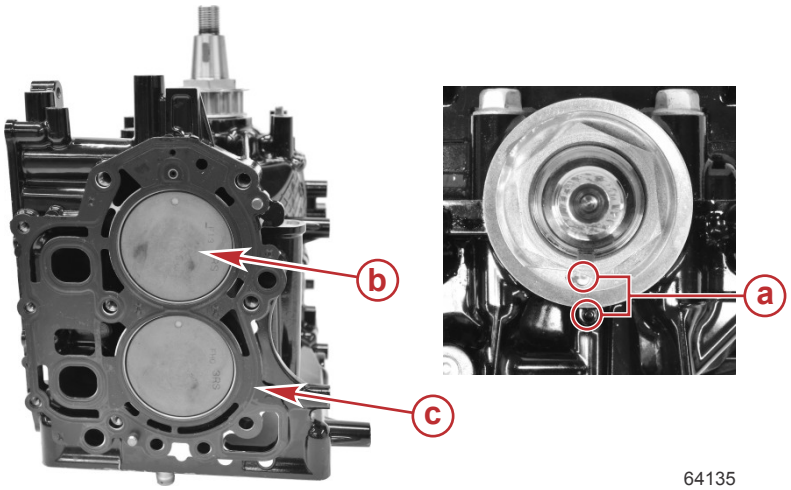


- **a -** Rocker shaft (1)
- **b -** Washer (2)
- **c -** Spring (2)
- **d -** Rocker arm (4)
- **e -** Spacer (2)

Tube Ref No.	Description	Where Used	Part No.
110	4-Stroke 10W-30 Outboard Oil	Rocker shaft components and camshaft lobes	92-8M0078625

Cylinder Head Installation

1. Rotate the crankshaft so the top pistons are at TDC and the drive gear on the crankshaft points to the timing mark on the cylinder block.
2. Install a new cylinder head gasket.

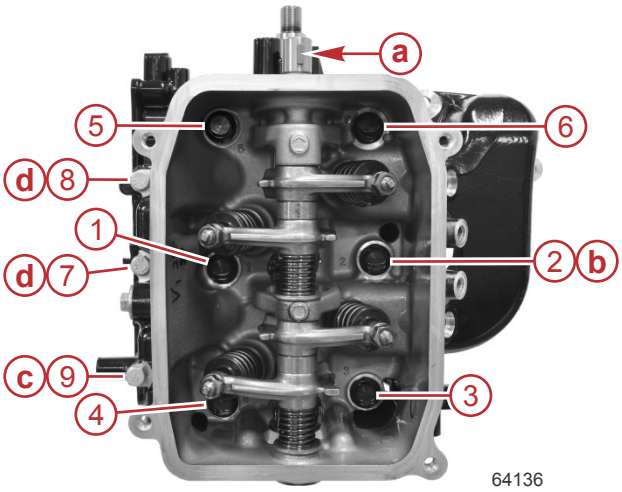


- **a -** Drive gear and cylinder timing marks aligned
- **b -** Pistons at TDC
- **c -** Cylinder head gasket

3. Rotate the camshaft so the valves are fully closed.
4. Lubricate the threads and head of the cylinder head screws and cylinder head perimeter screws with clean engine oil.
5. Install the cylinder head onto the cylinder block.

   IMPORTANT: Cylinder head screws must be tightened in two steps and in the sequence shown.
6. Tighten the cylinder head screws and the perimeter screw to the specified torque in sequence in two steps.

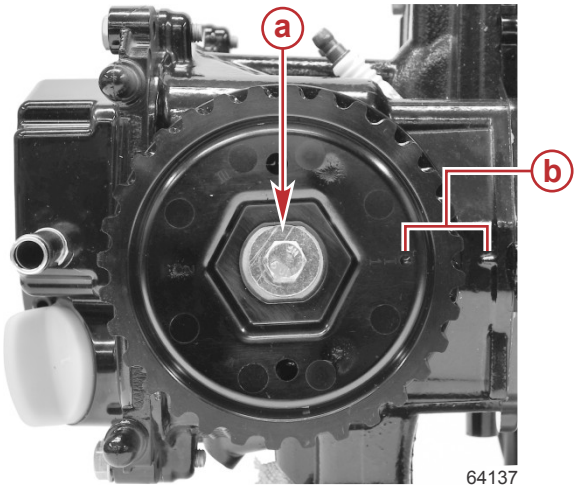
7. Install the key into the keyway on the camshaft.



a - Camshaft key
b - Cylinder head screw (M8 x 60) (6)
c - Perimeter screw (M6 x 40) and washer (1)
d - Perimeter screw (M6 x 25) and washer (2)

Description		Nm	lb-in.	lb-ft
Cylinder head screw (M8 x 60) (6)	**First**	10.0	88.5	–
	Final	30.0	–	22.1
Perimeter screw (M6) (3)	**First**	6.0	53.1	–
	Final	10.0	88.5	–

8. Slide the camshaft gear onto the camshaft, with the notch over the camshaft key. The timing mark on the camshaft gear for the #1 cylinder should be pointing to the timing mark on the cylinder head.
9. Apply Loctite® 222 Threadlocker to the threads of the camshaft gear screw. Install the screw and washer. Tighten the screw to the specified torque.



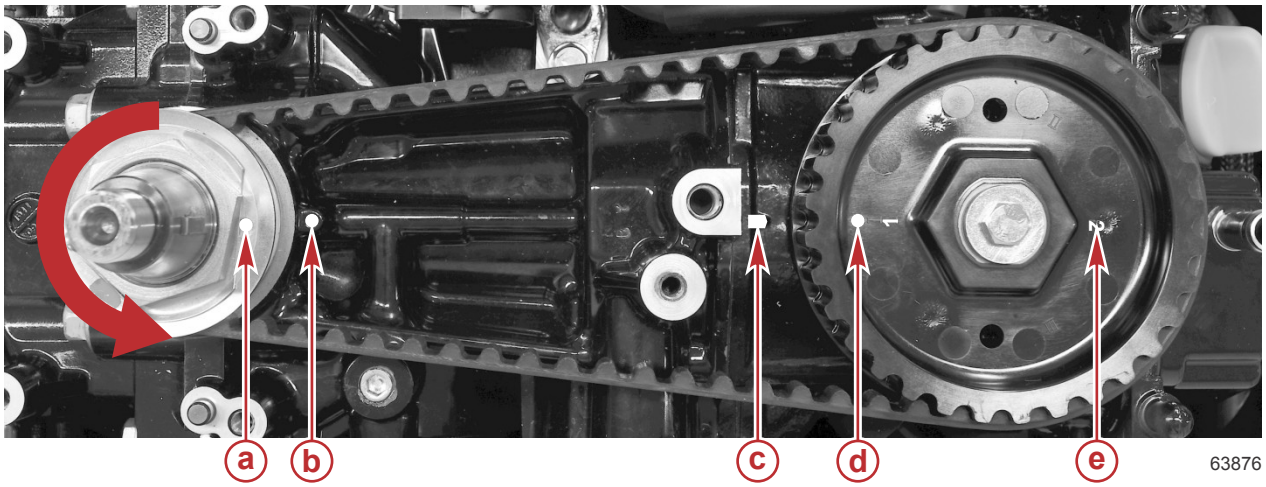
a - Camshaft gear screw (M6 x 20) and washer
b - Timing marks aligned

Tube Ref No.	Description	Where Used	Part No.
51	Loctite® 222 Threadlocker	Camshaft gear screw threads	92-809818

Description	Nm	lb-in.	lb-ft
Camshaft gear screw (M6 x 20)	11.5	101.8	–

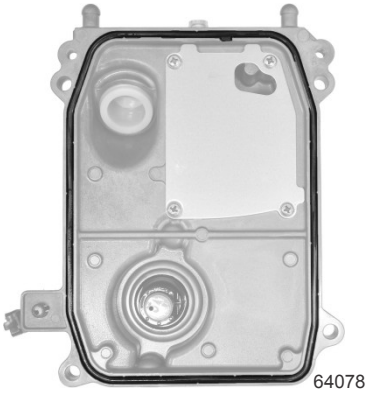
10. Install the oil pump. Refer to **Section 4C - Oil Pump Installation.**

11. Ensure that the timing marks on the crankshaft drive gear and the camshaft driven gear are still aligned with the corresponding marks on the engine.

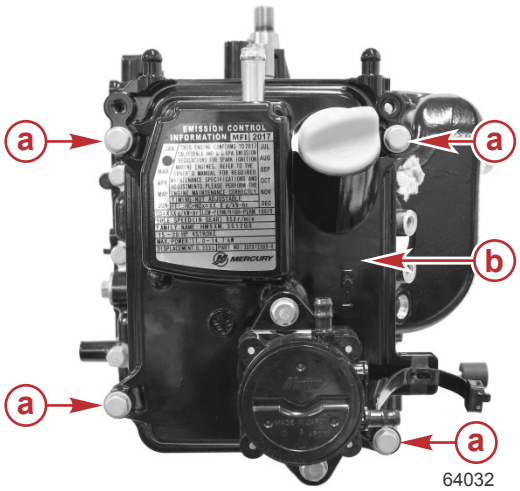


a - Crankshaft drive gear timing mark
b - Timing mark on the cylinder block for the crankshaft
c - Timing mark on the cylinder block for the camshaft
d - Timing mark for #1 cylinder
e - Timing mark for #2 cylinder

12. Install the timing belt.
13. Adjust the valve clearance. Refer to **Valve Adjustments**.
14. Install the gasket into the groove of the cylinder head cover.



15. Install the four cylinder head cover screws. Tighten the screws to the specified torque.



a - Screw (M6 x 30) (4)
b - Cylinder head cover

Description	Nm	lb-in.	lb-ft
Cylinder head cover screws (M6 x 30)	6.0	53.1	–

16. Install two spark plugs. Tighten them to the specified torque.

Description	Nm	lb-in.	lb-ft
Spark plugs	18.0	159.3	–

17. Install the following components:
    - Throttle body (refer to **Section 4A - Throttle Body Installation**)
    - Electrical components removed from the cylinder head (refer to **Section 4A - Electrical Component Installation**)
18. Install the powerhead onto the driveshaft housing. Refer to **Section 4A - Powerhead Installation**.

Powerhead

Section 4C - Oil Pump

Table of Contents

Lubricants, Sealants, Adhesives

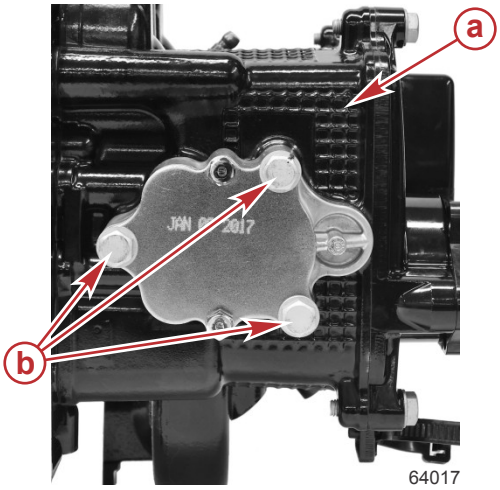
Tube Ref No.	Description	Where Used	Part No.
110	4-Stroke 10W-30 Outboard Oil	I.D. and O.D. of the mounting hub, oil pump inlet/outlet, cylinder head oil pump bore, camshaft	92-8M0078625

Oil System Specifications

Parameter		Specification
Oil pump type		Trochoid
Oil type	All temperatures	FC-W® 10W-30
	Alternate viscosity above 4 °C (40 °F)	FC-W® 25W-40
Oil capacity		1.0 L (1.1 U.S. qt)
Engine oil pressure at 75 °C (167 °F)	At 950 RPM	50 kPa (7.3 psi) or greater
	At 5000 RPM	100 kPa (14.5 psi) or greater
Oil pump housing inside diameter (service limit)		29.15 mm (1.148 in.)
Outer rotor to oil pump housing inside diameter clearance (service limit)		0.18 mm (0.007 in.)
Outer rotor height (service limit)		14.96 mm (0.589 in.)
Rotor to oil pump cover clearance (service limit)		0.11 mm (0.004 in.)
Inner rotor to outer rotor clearance (service limit)		0.13 mm (0.005 in.)

Oil Pump Removal

1. Remove the powerhead from the driveshaft housing. Refer to **Section 4A - Powerhead Removal**.
2. Remove the three screws securing the oil pump to the underside of the cylinder head.



a - Underside of cylinder head
b - Screws (3)

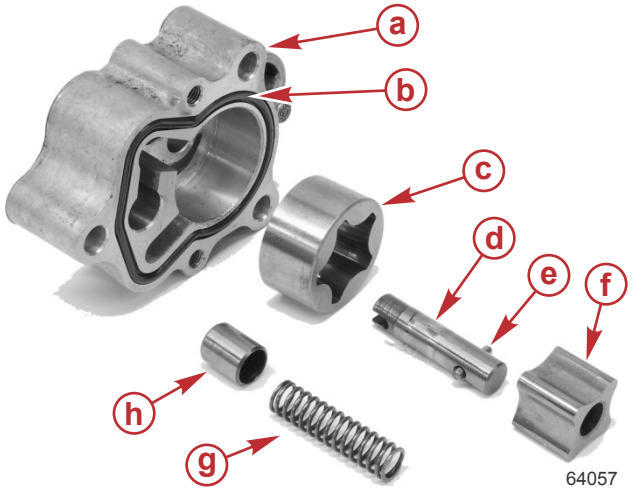
Oil Pump Disassembly

IMPORTANT: The pressure relief spring presses against the oil pump housing cover. Exercise care to not lose the spring, when removing the cover.

1. Remove the two screws securing the cover to the oil pump housing. Remove the cover.

2. Push the oil pump shaft out of the oil pump housing.
3. Remove the inner rotor and outer rotor from the oil pump housing.
4. Remove the pressure relief valve from its bore.

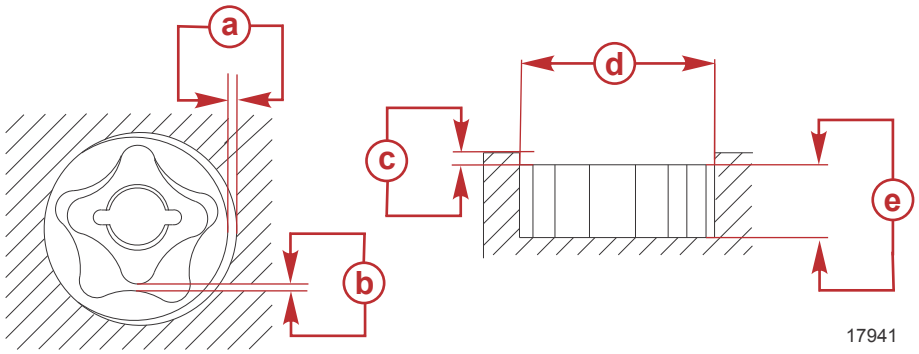
   NOTE: *Do not reuse the cover seal.*



- **a -** Oil pump housing
- **b -** Cover seal
- **c -** Outer rotor
- **d -** Shaft
- **e -** Drive pin
- **f -** Inner rotor
- **g -** Pressure relief spring
- **h -** Pressure relief valve

Oil Pump Inspection

1. Inspect oil pump components for pitting or scratches. Replace if necessary.
2. Using a feeler gauge, measure the following oil pump clearances. Replace if worn or out of specification.

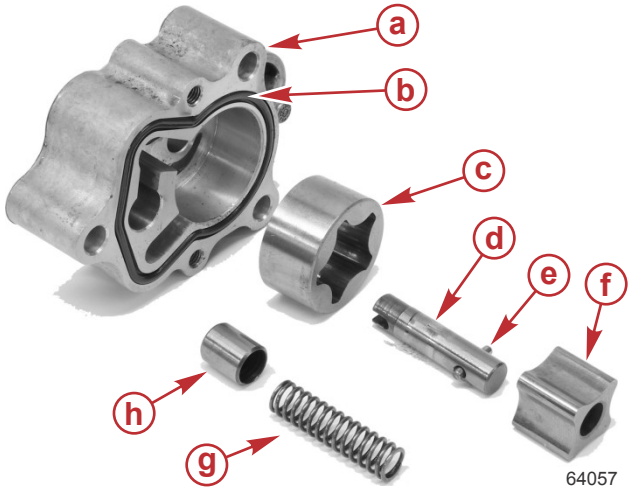


Ref	Measurement Location	Specification
a.	Outer rotor to pump housing (maximum)	0.18 mm (0.007 in.)
b.	Inner rotor to outer rotor (maximum)	0.13 mm (0.005 in.)
c.	Outer rotor to oil pump cover (maximum)	0.11 mm (0.004 in.)
d.	Oil pump housing inside diameter (maximum)	29.15 mm (1.148 in.)
e.	Outer rotor height (minimum)	14.96 mm (0.589 in.)

Oil Pump Assembly

1. Lubricate the oil pump components with clean engine oil.
2. Install the cover seal into the groove on the oil pump housing.
3. Install the outer rotor into the oil pump housing.
4. Install the inner rotor into the oil pump housing with the keyway facing towards the cover.
5. Install the drive pin into the shaft.
6. Install the shaft with the drive pin into the inner rotor. Ensure the drive pin engages with the inner rotor keyway.

7. Install the pressure relief valve and spring.



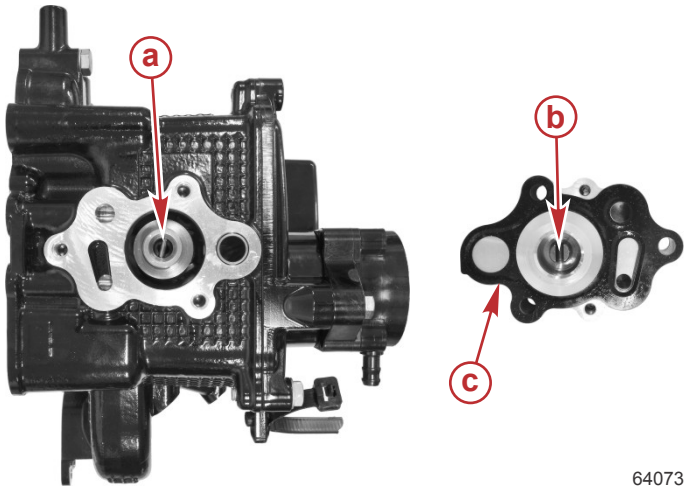
- **a -** Oil pump housing
- **b -** Cover seal
- **c -** Outer rotor
- **d -** Shaft
- **e -** Drive pin
- **f -** Inner rotor
- **g -** Pressure relief spring
- **h -** Pressure relief valve

8. Install the cover. Tighten the oil pump cover screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Cover screws	4.0	35.4	–

Oil Pump Installation

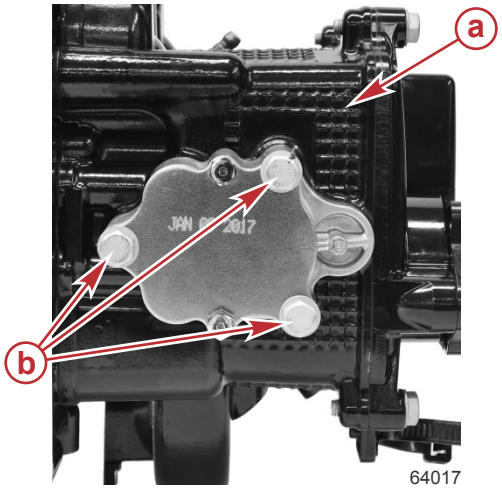
1. Lubricate the inside and outside diameter (I.D. and O.D.) of the mounting hub with 4-Stroke 10W-30 Outboard Oil.
2. Pour approximately 15 drops of 4-Stroke 10W-30 Outboard Oil into the inlet and outlet of the oil pump.
3. Lubricate the cylinder head oil pump bore and the camshaft with 4-Stroke 10W-30 Outboard Oil.
4. Place a new gasket on the oil pump.
5. Align the camshaft roll pin and the slot in the pump shaft.



- **a -** Camshaft roll pin
- **b -** Slot in pump shaft
- **c -** Oil pump gasket

Tube Ref No.	Description	Where Used	Part No.
110	4-Stroke 10W-30 Outboard Oil	I.D. and O.D. of the mounting hub, oil pump inlet/outlet, cylinder head oil pump bore, camshaft	92-8M0078625

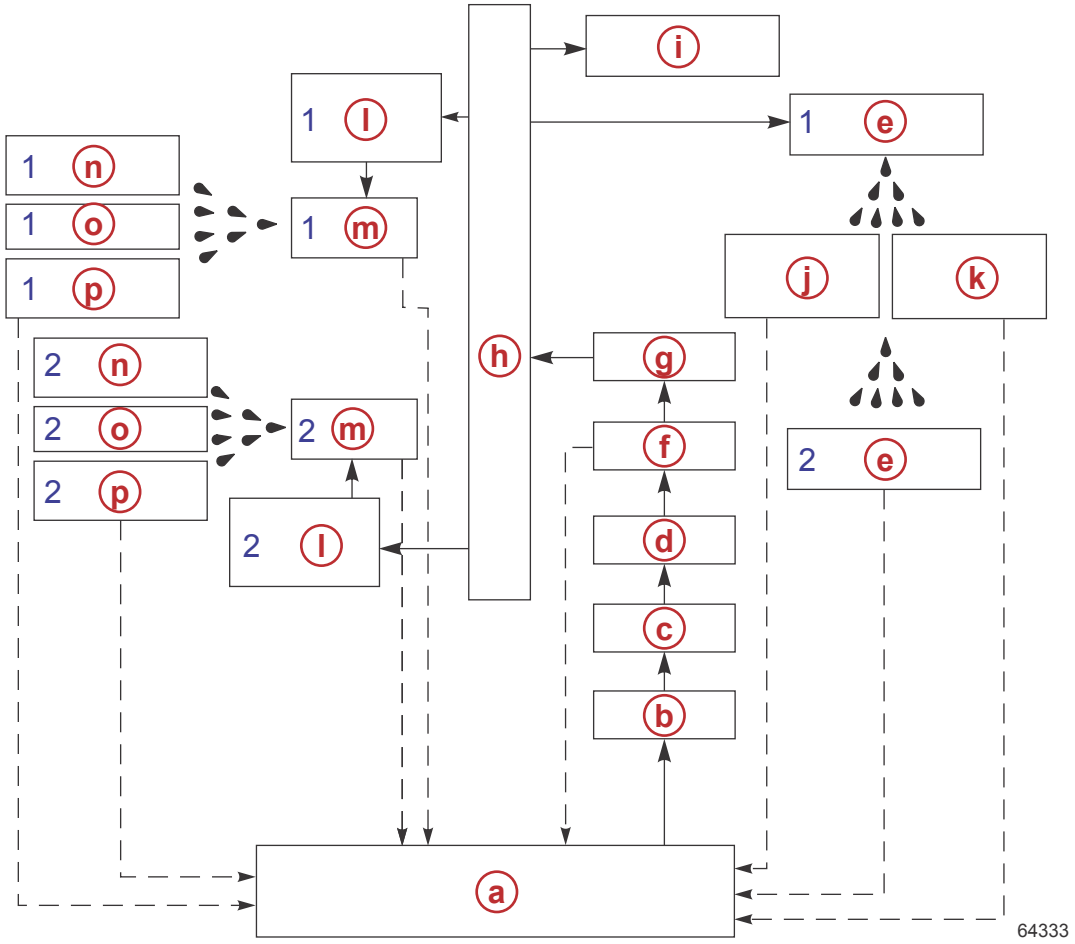
6. Fasten the oil pump to the cylinder head with three M6 x 35 screws. Tighten the screws to the specified torque.



a - Cylinder head
b - Screw (M6 x 35)

Description	Nm	lb-in.	lb-ft
Oil pump mounting screws	6.0	53.1	–

Oil Flow Diagram



a - Sump
b - Screen
c - Hose
d - Pump
e - Camshaft journal
f - Regulator valve
g - Filter
h - Main gallery
i - Oil pressure switch
j - Camshaft faces
k - Rocker arm shaft and valve
l - Crankshaft main bearing
m - Crankshaft rod journal
n - Cylinder wall
o - Piston
p - Piston pin

Powerhead

Section 4D - Cooling System

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D

Cooling System Specifications

Parameter		Specification
Thermostat	Start to open temperature	50–54 °C (122–129 °F)
	Full open temperature	60–64 °C (140–147 °F)
	Valve lift	4.0 mm (0.157 in.)
Water pressure at idle		9–18 kPa (1.3–2.6 psi)
Water pressure at WOT		59–118 kPa (8.6–17.2 psi)

Cooling System Description

Water enters the cooling system through the lower unit water inlets. The water pump, driven by the driveshaft, forces water through the water tube, through the driveshaft housing, and into the powerhead. After the powerhead is filled with water, a small steady stream of water exits the water pump indicator.

Water flow through the block is controlled by the thermostat. As the water temperature rises, the thermostat opens and allows water to pass by the thermostat, into the engine cooling jacket. The water then passes into the exhaust chamber area of the driveshaft housing, cooling the exhaust gasses, and on through the exhaust outlet of the propeller.

To allow complete passage filling and to prevent steam pockets, all cooling passages are interconnected. Small passages are incorporated into the cooling system, to allow the cooling system to drain while the outboard is in a normal operating position.

General Troubleshooting

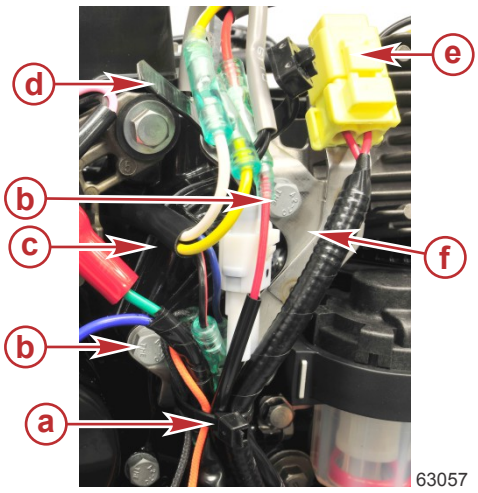
For general troubleshooting information, including connecting and using the CDS G3 diagnostic tool, refer to **Section 1E - General Troubleshooting**.

Thermostat

Thermostat/Electrical Bracket Removal

The thermostat housing and electrical bracket are both secured to the engine block with the same screws. They are removed and installed together.

1. Release the reusable cable tie at the top of the electrical bracket.
2. Clip the cable tie at the bottom of the electrical bracket.
3. Remove the two screws that secure the thermostat housing and electrical bracket to the engine block.



a - Cable tie
b - Screw (2)
c - Thermostat housing
d - Reusable cable tie - do not cut
e - Fuse housing
f - Electrical bracket

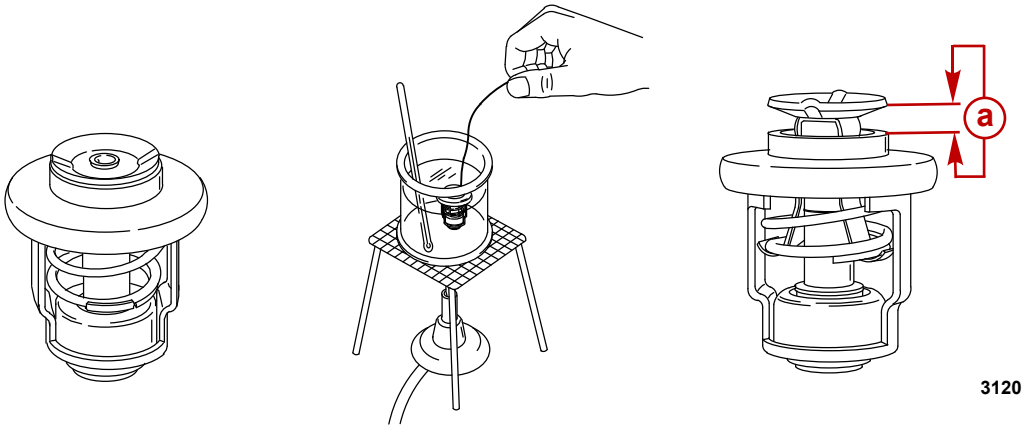
4. Remove the thermostat from the engine block.
5. Inspect the thermostat. Replace if damaged, seized, or corroded.

Testing the Thermostat

1. Tie a piece of thread or other nonconductive material onto the thermostat.
2. Suspend the thermostat in cold water.
3. Suspend a thermometer in the water.

   IMPORTANT: Do not allow the thermometer to contact the heating surface of the container. An inaccurate temperature reading may result.

4. Slowly heat the water while observing the thermostat and thermometer.
5. Measure the thermostat opening when the specified water temperature is achieved.



a - Minimum thermostat valve lift

Parameter	Specification
Start to open temperature	50–54 °C (122–129 °F)
Full open temperature	60–64 °C (140–147 °F)
Valve lift	4.0 mm (0.157 in.)

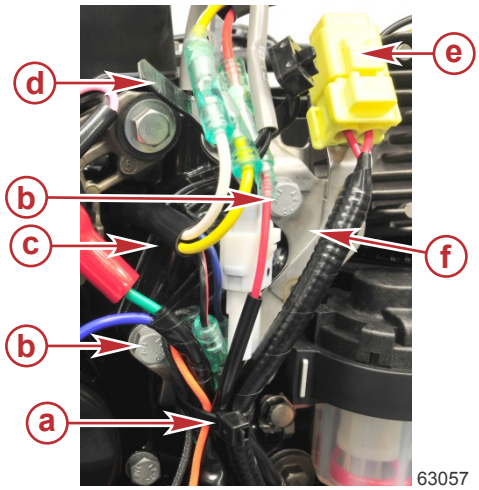
Thermostat/Electrical Bracket Installation

The thermostat housing and electrical bracket are secured to the engine with the same screws.

1. Install the thermostat into the engine block.
2. Ensure that the mating surfaces on the engine block and the thermostat housing are clean.
3. Thread a new cable tie through the two holes in the electrical bracket.
4. Attach the gasket, thermostat housing, and electrical bracket to the engine block with two screws. Tighten the screws to the specified torque.

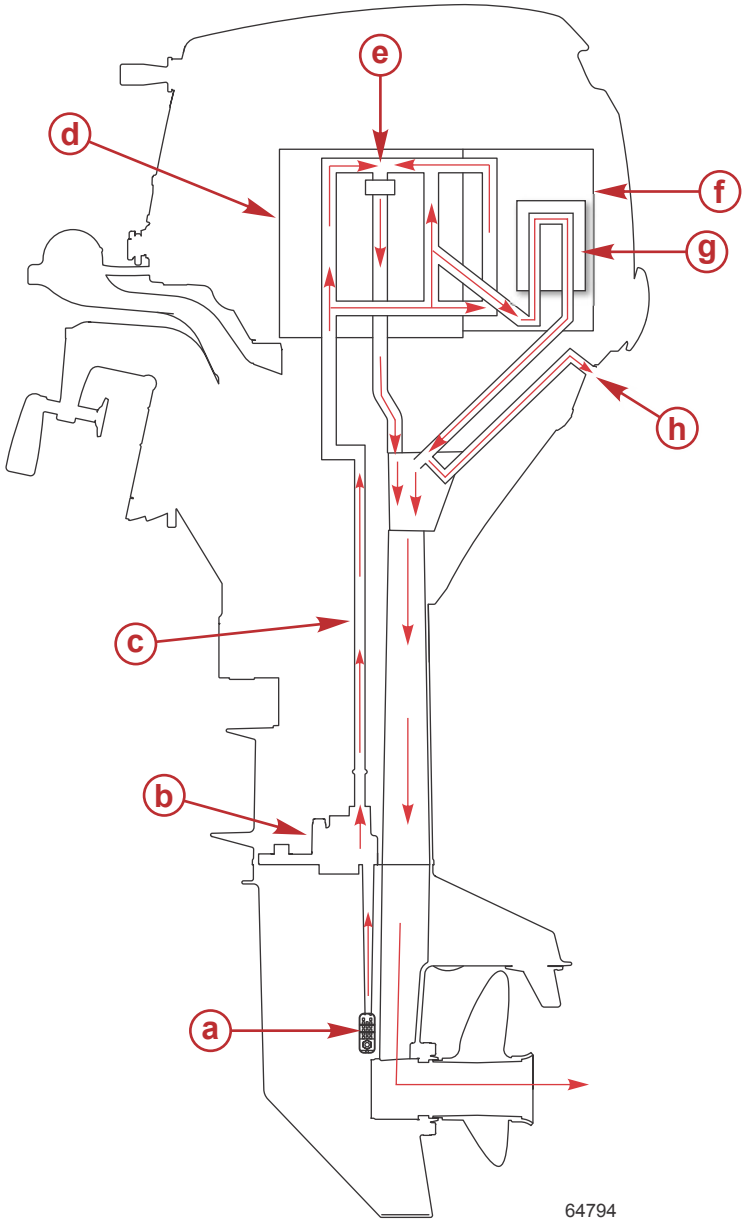
Description	Nm	lb-in.	lb-ft
Thermostat housing screws	9.0	79.7	–

5. Use the new cable tie to secure loose wires to the lower end of the electrical bracket.
6. Secure the wires to the upper end of the electrical bracket with the reusable cable tie.



a - Lower cable tie (new)
b - Screw (2)
c - Thermostat housing with new gasket
d - Reusable cable tie
e - Fuse housing
f - Electrical bracket

Water Flow Diagram



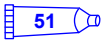
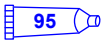
- **a -** Water inlet
- **b -** Water pump
- **c -** Water tube
- **d -** Cylinder block
- **e -** Thermostat
- **f -** Cylinder head
- **g -** Fuel cooler (part of the vapor separator tank)
- **h -** Water pump indicator outlet

Midsection

Section 5A - Clamp/Swivel Bracket and Driveshaft Housing

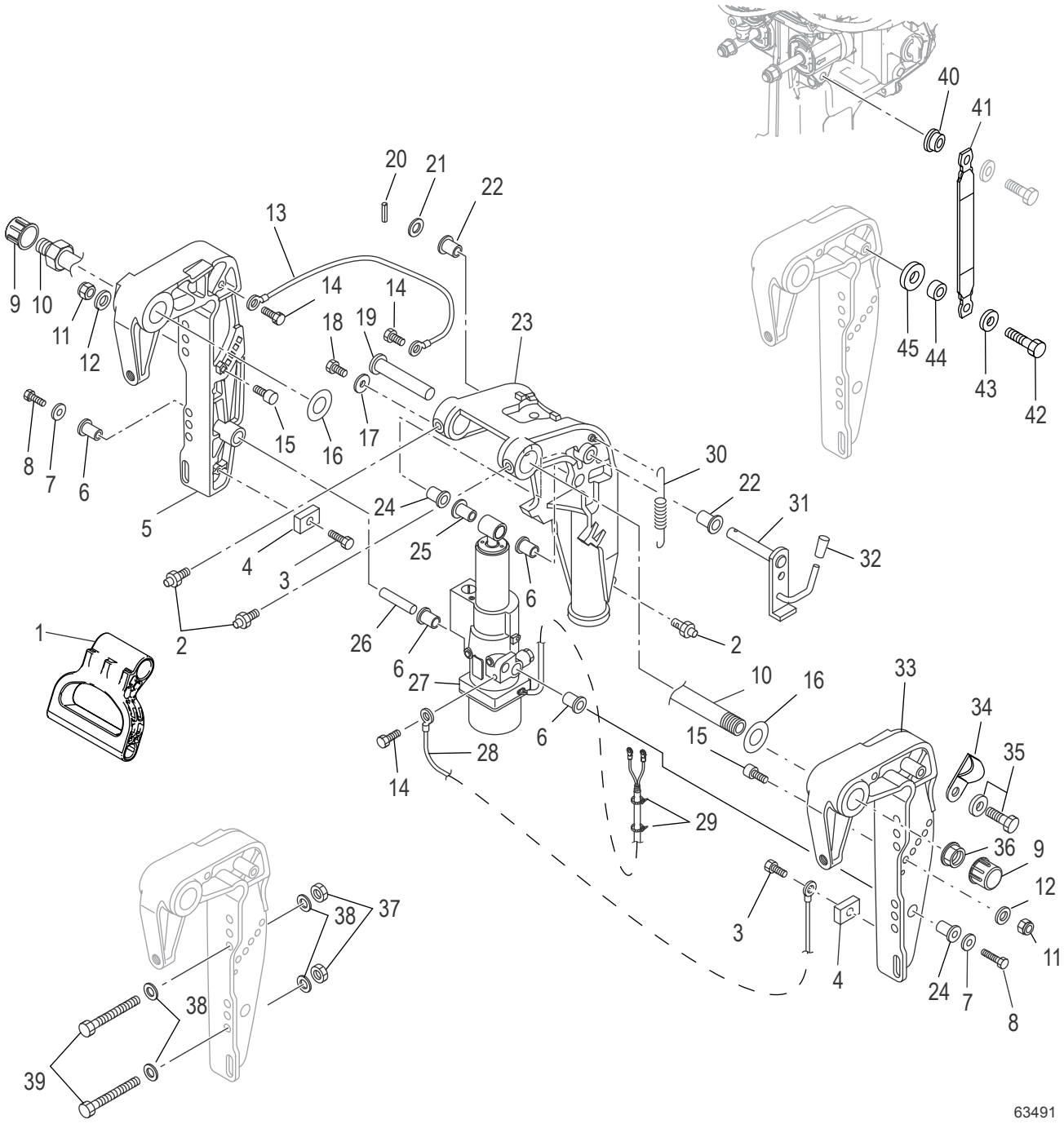
Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Loctite® 271 Threadlocker	Tiller handle screw threads	92-809819
	Loctite® 222 Threadlocker	Shoulder screw	92-809818
	Loctite® 242 Threadlocker	Idle exhaust port cover screws	92-809821
	2-4-C with PTFE	Tilt tube washer	92-802859A 1
		Swivel bracket bushings	
		Tilt pin and bushings	
		Tilt tube	
		Steering arm O-ring	

Notes:

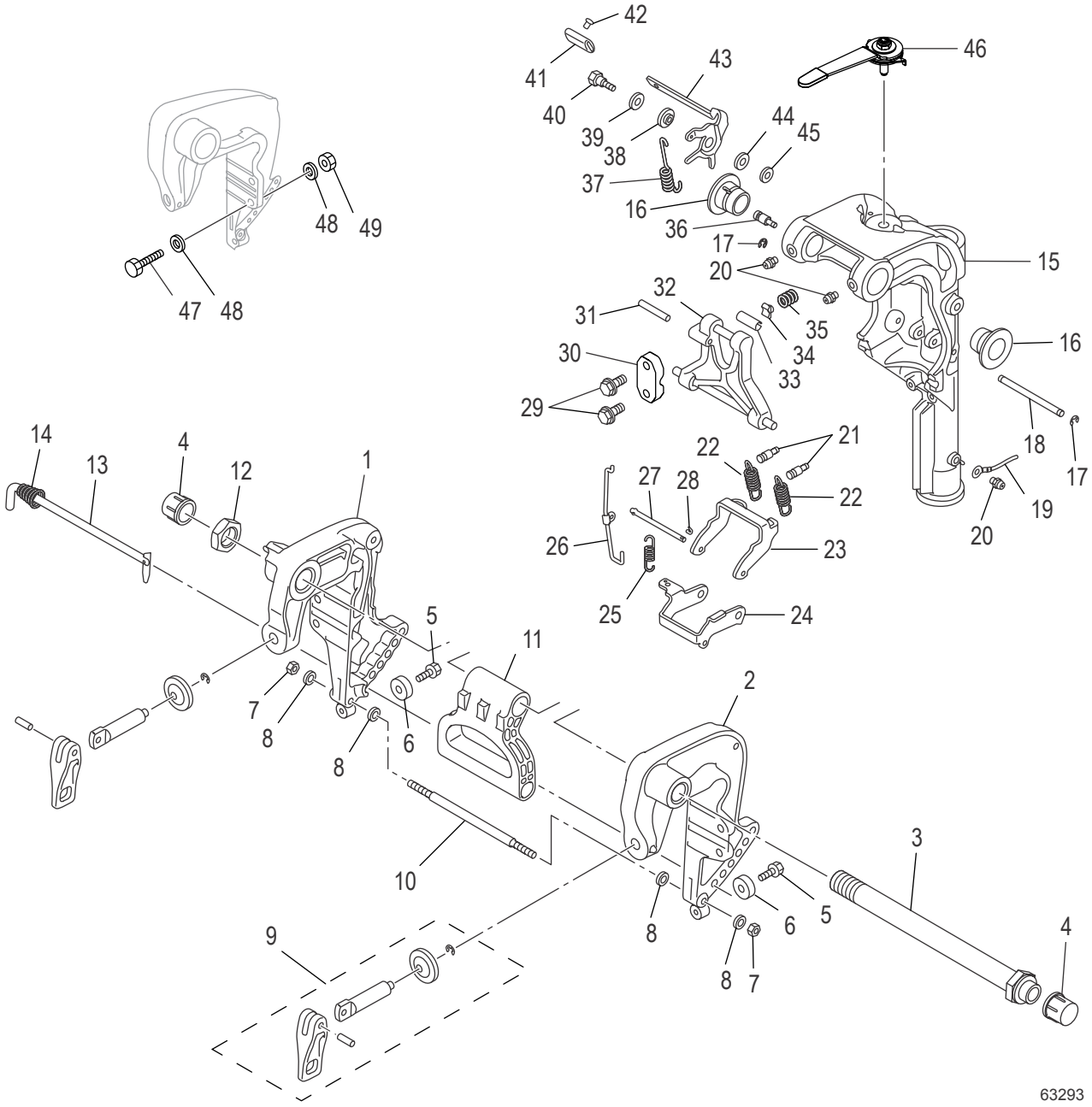
Clamp Bracket Components (Power Tilt)



Clamp Bracket Components (Power Tilt)

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Carrying handle			
2	3	Grease fitting			
3	2	Screw (M6 x 16)	6.0	53.1	–
4	2	Anode			
5	1	Starboard clamp bracket			
6	4	Bushing			
7	2	Washer			
8	2	Screw (M8 x 20)	13	115	–
9	2	Cap			
10	1	Tilt tube assembly			
11	2	Locknut (M8)	13	115	–
12	2	Washer			
13	1	Ground wire (starboard clamp bracket to swivel bracket)			
14	3	Screw (M6 x 12)	6.0	53.1	–
15	2	Tilt lock pin	13	115	–
16	2	Nylon washer			
17	1	Washer			
18	1	Screw (M6 x 12)	6.0	53.1	–
19	1	Upper pin			
20	1	Spring pin			
21	1	Washer			
22	2	Collar			
23	1	Swivel bracket			
24	2	Bushing			
25	1	Bushing			
26	1	Lower pin			
27	1	Power tilt assembly			
28	1	Ground wire (port clamp bracket to power tilt assembly)			
29	2	Cable tie			
30	1	Spring			
31	1	Tilt lock lever			
32	1	Grip			
33	1	Port clamp bracket			
34	1	P-clip			
35	1	Screw with washer (except ProKicker models)			
36	1	Nut	24.0	–	17.7
37	4	Nut	13.5	120	–
38	8	Washer			
39	4	Transom screw			
40	2	Stepped collar (ProKicker models)			
41	2	Strap (ProKicker models)			
42	2	Screw (M6 x 25) (ProKicker models)	6.0	53.1	–
43	2	Washer (ProKicker models)			
44	2	Collar (ProKicker models)			
45	2	Large washer (ProKicker models)			

Clamp Bracket Components (Manual Tilt)

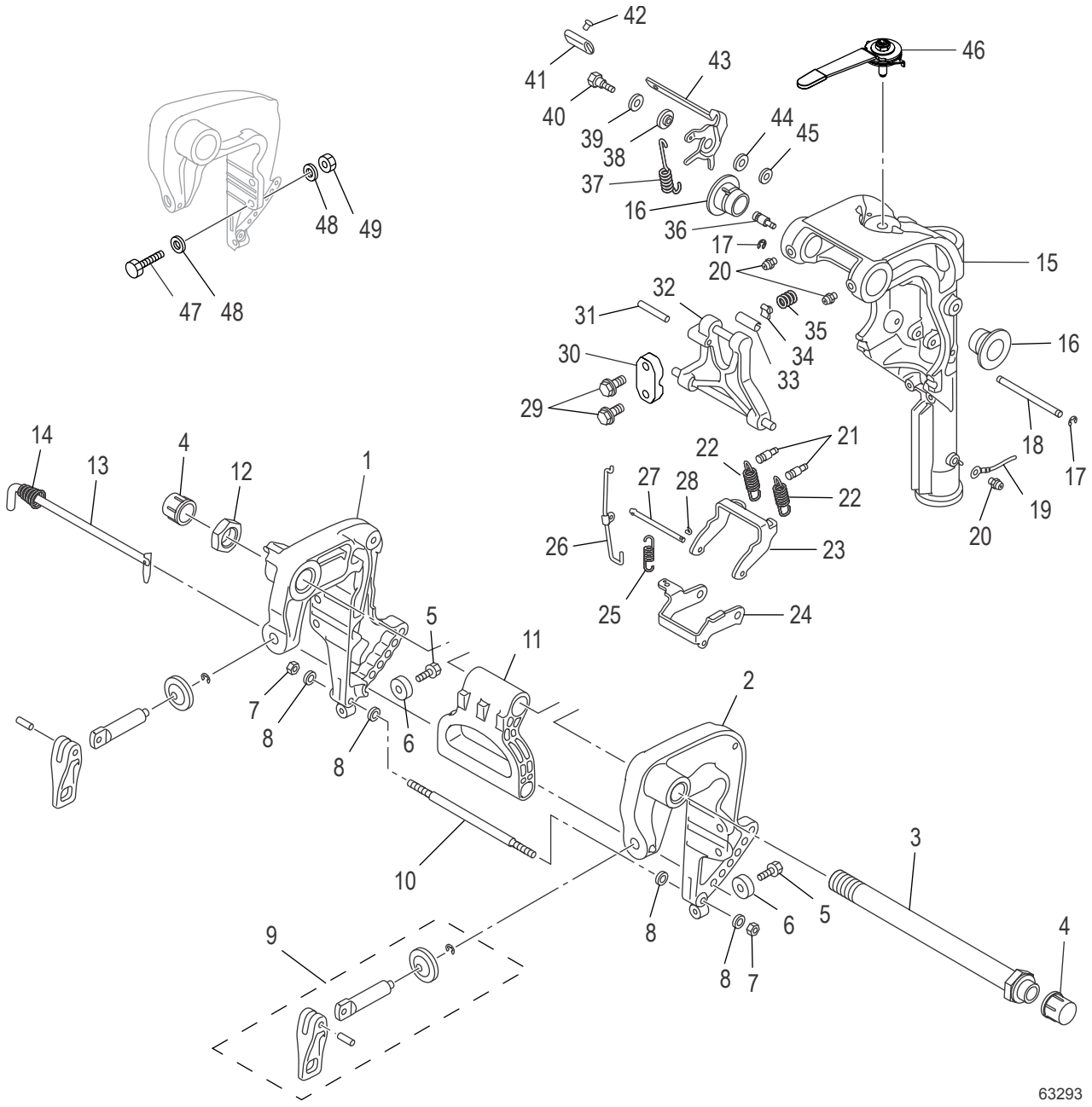


Clamp Bracket Components (Manual Tilt)

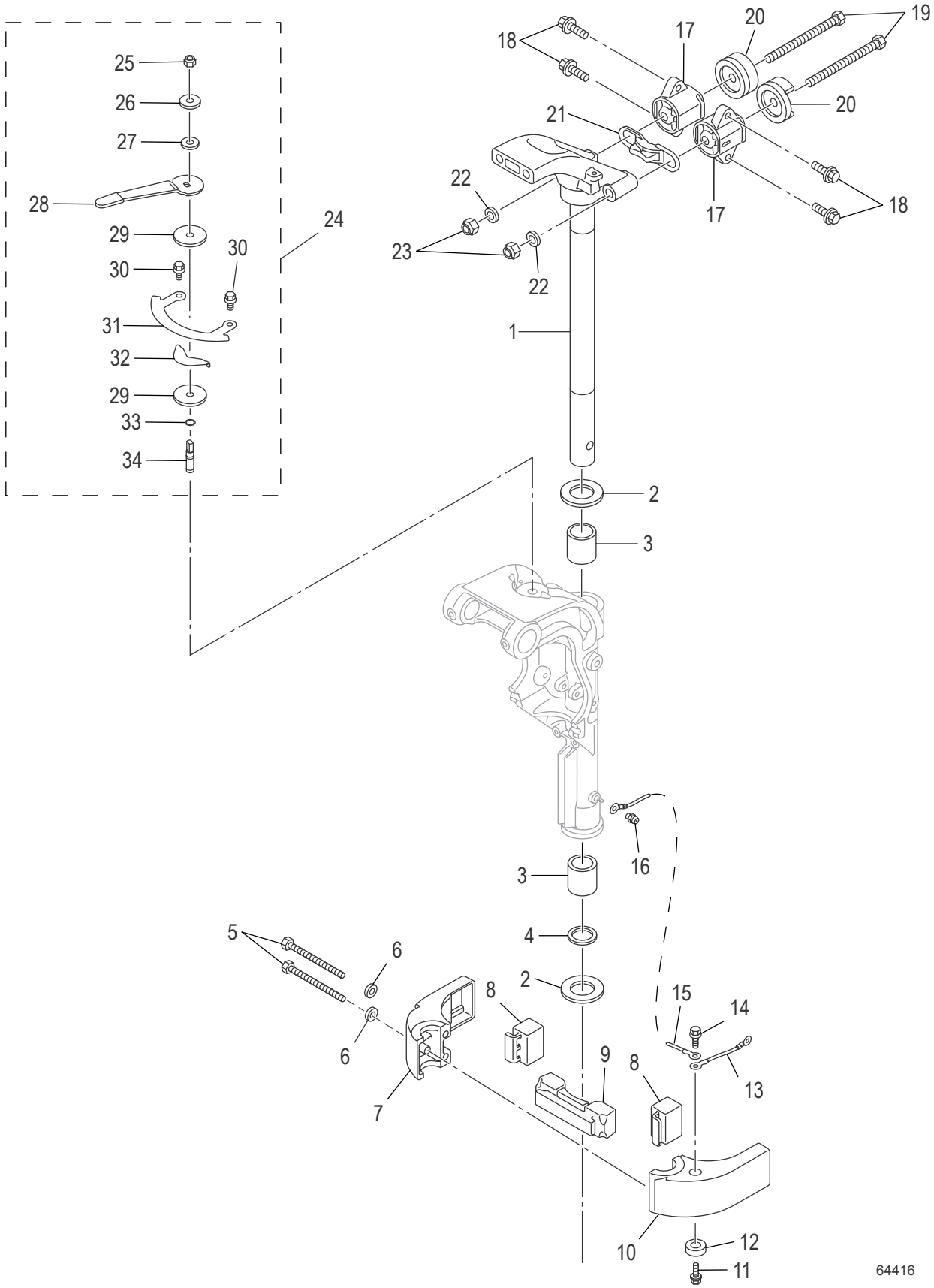
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Starboard clamp bracket			
2	1	Port clamp bracket			
3	1	Tilt tube			
4	2	Cap			
5	2	Screw	6.0	53.1	–
6	2	Anode			
7	2	Nut (M6)	6.0	53.1	–
8	4	Washer			
9	2	Thumb screw assembly			
10	1	Spacer			
11	1	Carrying handle			
12	1	Locknut	24.0	–	17.7
13	1	Tilt pin assembly			
14	1	Spring			
15	1	Swivel bracket			
16	2	Bushing			
17	2	E-clip			
18	1	Reverse lock shaft			
19	1	Ground wire (swivel bracket to lower mount bracket)			
20	3	Grease fitting			
21	2	Pin			
22	2	Reverse lock spring			
23	1	Reverse lock			
24	1	Reverse lock arm			
25	1	Reverse lock spring			
26	1	Reverse lock link			
27	1	Reverse lock rod			
28	1	Split pin			
29	2	Screw (M8 x 18)	13	115	–
30	1	Set plate			
31	1	Spring pin			
32	1	Tilt stopper			
33	1	Bushing			
34	1	Guide			
35	1	Friction spring			
36	1	Pin			
37	1	Reverse lock lever spring			
38	1	Bushing			
39	1	Washer			
40	1	Shoulder screw	13	115	–
41	1	Reverse lock lever grip			
42	1	Stopper			
43	1	Reverse lock lever			
44	1	Washer			
45	1	Washer			
46	1	Copilot assembly			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
47	2	Transom screw (M8 x 85)			
48	4	Washer			
49	2	Nut	13.5	120	–

Clamp Bracket Components (Manual Tilt)



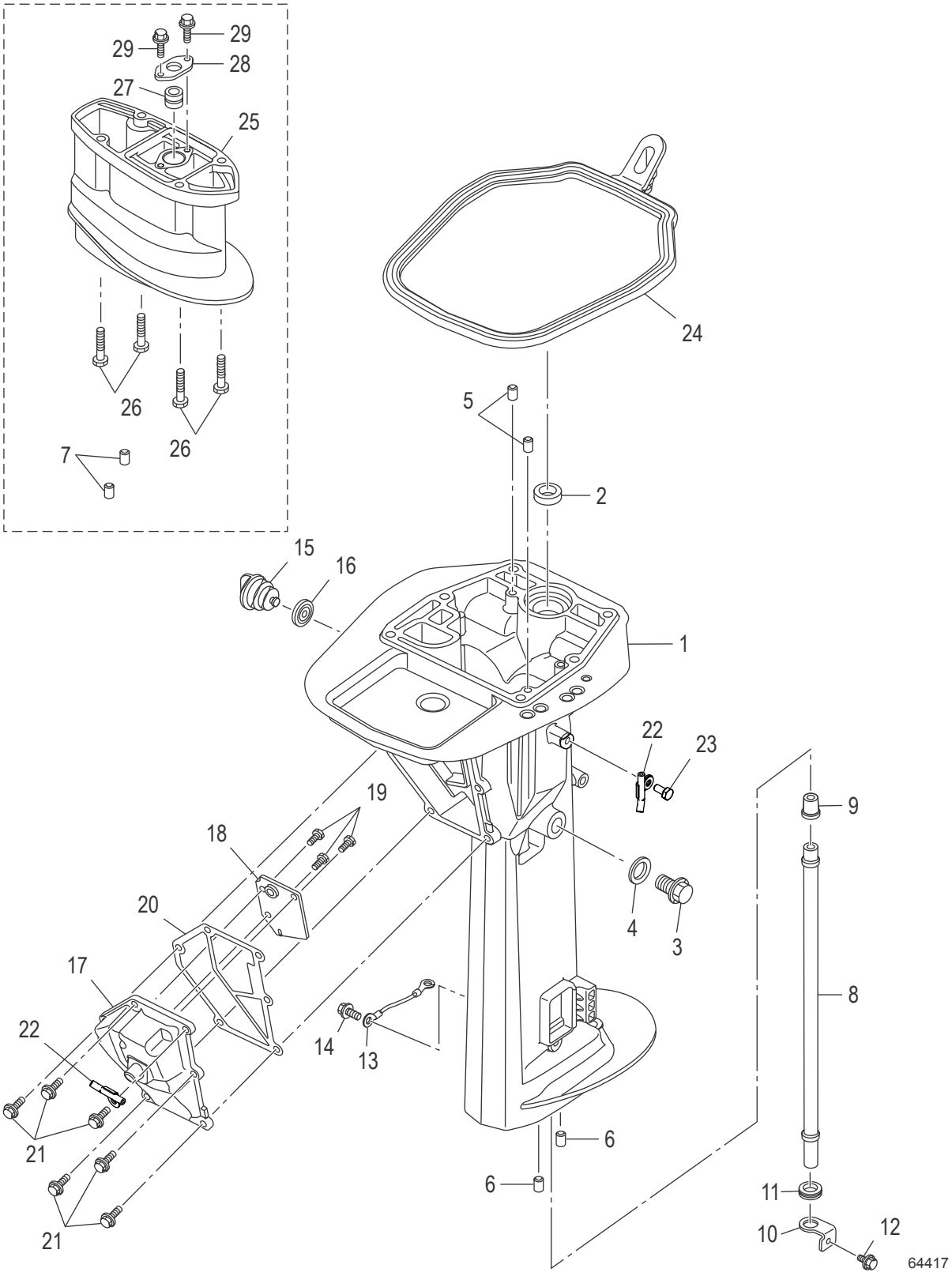
Steering Arm and Copilot Components



Steering Arm and Copilot Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Steering arm			
2	2	Thrust plate			
3	2	Bushing			
4	1	O-ring			
5	2	Screw (M8 x 85)	13	115	–
6	2	Washer			
7	1	Starboard mount bracket			
8	2	Lower rubber mount			
9	1	Lower damper			
10	1	Port mount bracket			
11	1	Screw (M6 x 20)	6.0	53.1	–
12	1	Anode			
13	1	Ground wire (driveshaft housing to lower mount bracket)			
14	1	Screw (M6 x 10)	6.0	53.1	–
15	1	Ground wire (swivel bracket to lower mount bracket)			
16	1	Grease fitting			
17	2	Upper rubber mount			
18	4	Screw	13	115	–
19	2	Screw			
20	2	Upper rubber damper			
21	1	Upper damper			
22	2	Washer			
23	2	Locknut	27.0	–	19.9
24	1	Copilot assembly			
25	1	Locknut	11.0	97.3	–
26	1	Washer			
27	1	Washer			
28	1	Copilot handle			
29	2	Disc			
30	2	Screw (M6 x 16)	6.0	53.1	–
31	1	Copilot plate			
32	1	Washer			
33	1	O-ring			
34	1	Copilot threaded rod			

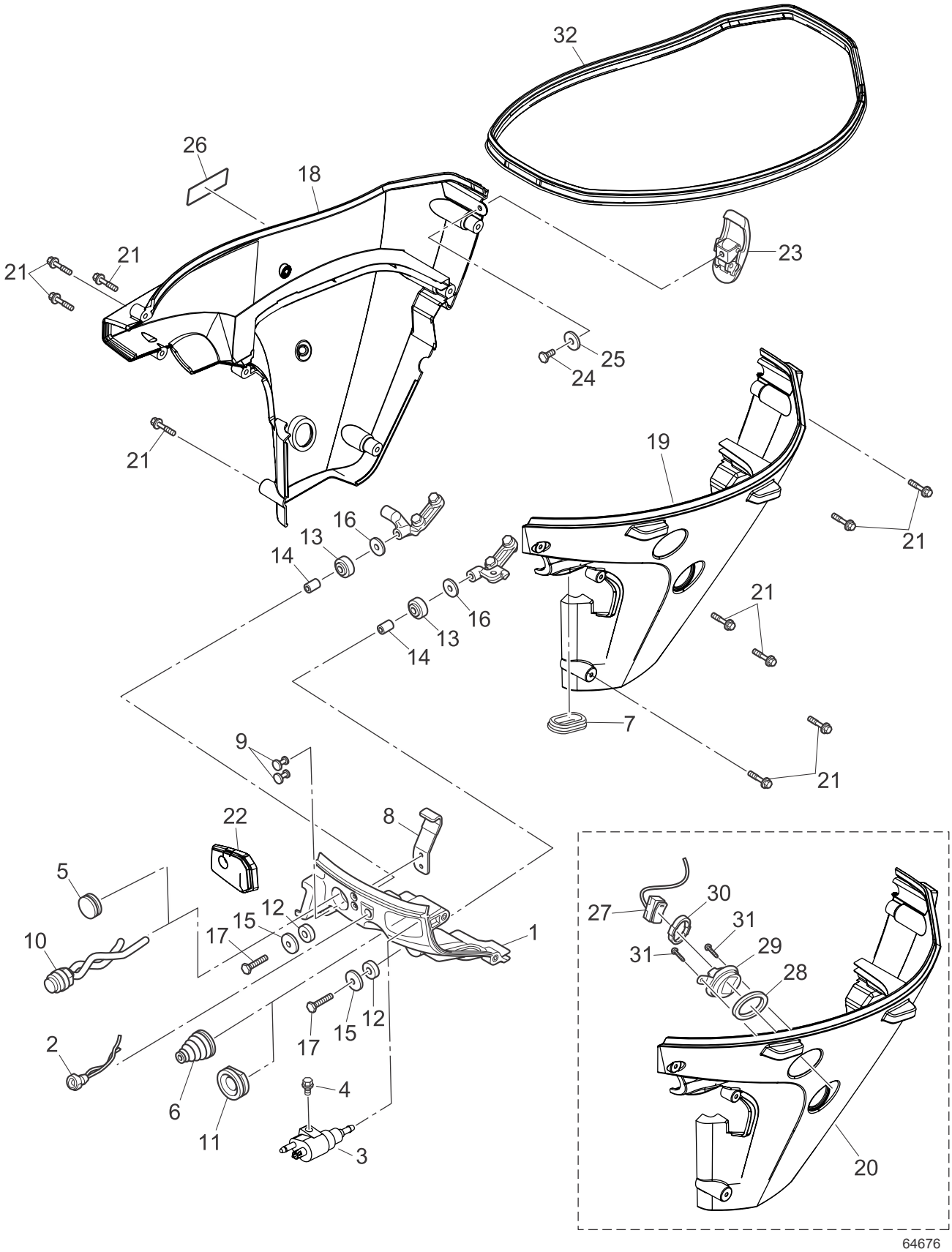
Driveshaft Housing Components



Driveshaft Housing Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Driveshaft housing assembly			
2	1	Oil seal			
3	1	Drain screw	24.0	–	17.7
4	1	Washer			
5	2	Dowel pin			
6	2	Dowel pin			
7	2	Dowel pin (driveshaft extension)			
8	1	Water tube			
9	1	Upper water tube seal			
10	1	Lock plate			
11	1	Guide			
12	1	Screw	6.0	53.1	–
13	1	Ground wire (driveshaft housing to lower mount bracket)			
14	1	Screw	6.0	53.1	–
15	1	Flushing connector cap			
16	1	Seal ring			
17	1	Idle exhaust port cover			
18	1	Idle exhaust cover plate			
19	3	Screw	4.0	35.4	–
20	1	Idle exhaust port gasket			
21	6	Screw (M6 x 16)	6.0	53.1	–
22	2	Water hose fitting			
23	1	Screw	6.0	53.1	–
24	1	Rubber seal			
25	1	Extension housing (driveshaft extension)			
26	4	Screws (driveshaft extension)	24.0	–	17.7
27	1	Driveshaft bushing (driveshaft extension)			
28	1	Stopper (driveshaft extension)			
29	2	Screw (M6 x 12) (driveshaft extension)	6.0	53.1	–

Driveshaft Housing Cover Components



Driveshaft Housing Cover Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Front panel			
2	1	Warning light			
3	1	Fuel connector			
4	1	Screw	6.0	53.1	–
5	1	Grommet			
6	1	Grommet			
7	1	Grommet			
8	1	Front cover stay			
9	2	Rivet			
10	1	Start switch (tiller handle, electric start models)			
11	1	Grommet			
12	2	Mount			
13	2	Rubber mount			
14	2	Collar			
15	2	Washer			
16	2	Washer			
17	2	Screw	6.0	53.1	–
18	1	Starboard driveshaft housing cover			
19	1	Port driveshaft housing cover (manual tilt models)			
20	1	Port driveshaft housing cover (power tilt models)			
21	10	Screw	6.0	53.1	–
22	1	Rigging ingress grommet			
23	1	Cowl latch assembly			
24	1	Screw	6.0	53.1	–
25	1	Washer			
26	1	Decal			
27	1	Power tilt switch (power tilt models)			
28	1	Gasket (power tilt models)			
29	1	Switch box (power tilt models)			
30	1	Switch box grommet (power tilt models)			
31	2	Screw (power tilt models)	2.5	22.1	–
32	1	Top cowl seal			

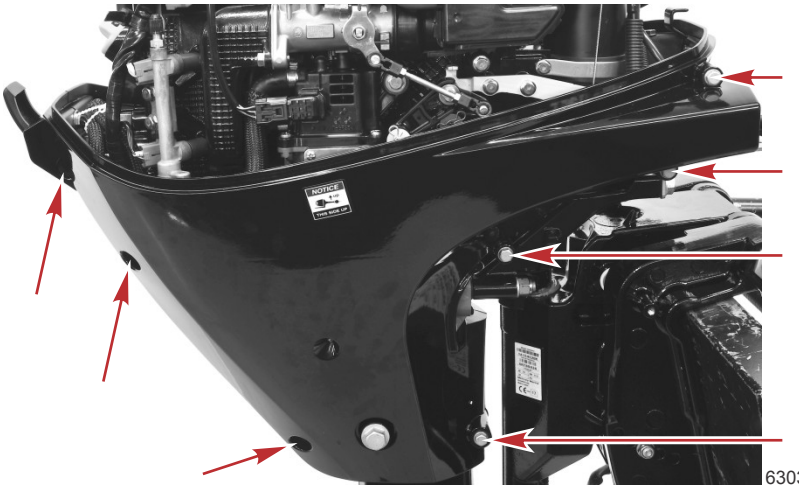
Driveshaft Housing Covers

Removal

1. Remove the top cowl.
2. Remove the cowl seal.
3. Loosen, but do not remove the screw that secures the cowl latch to the driveshaft housing covers.

63041

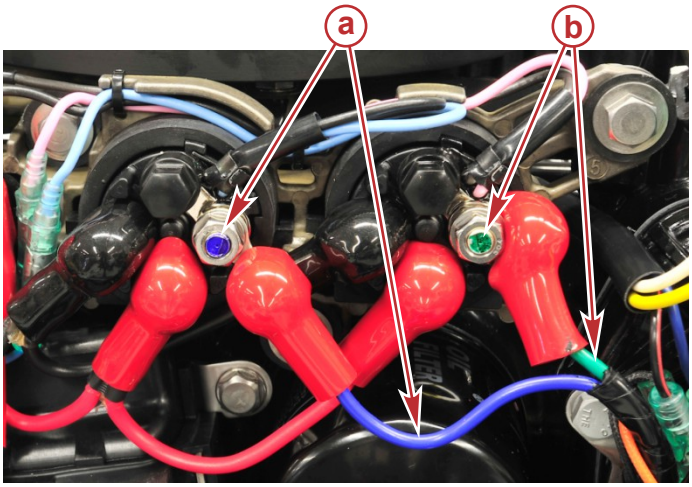
4. Loosen the seven captive screws that secure the starboard driveshaft cover, and remove the cover.



63039

NOTE: *To remove the port cover without removing the starboard cover, loosen only the three captive screws at the rear of the cover.*

5. To completely remove the port cover for models with power tilt:
   a. Disconnect the green and blue power tilt wires from the power tilt relays.

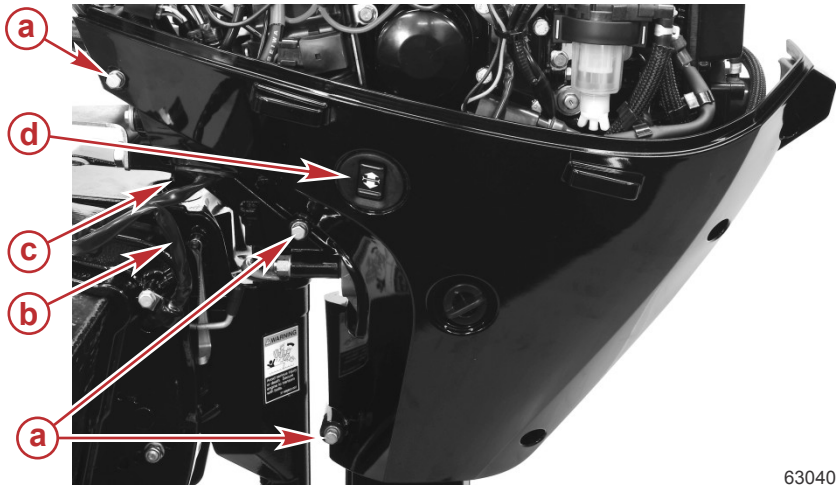


63064

a - Blue (up) tilt relay terminal and wire
b - Green (down) tilt relay terminal and wire

b. Cut the cable tie that secures the power tilt wires to the electrical bracket.
c. Pull the power tilt pump wires through the grommet in the port cover.
d. If the engine has a cowl-mounted tilt switch, disconnect the switch from the engine harness.

6. Loosen the three captive screws that secure the port cover, and remove the cover.



63040

a - Screws (3)
b - Power tilt pump wires
c - Grommet for power tilt pump wires
d - Cowl-mounted tilt switch (optional for power tilt models only)

Installation

NOTE: *Refer to* ***Removal****, preceding, for illustrations as required.*

1. For models with power tilt:
   a. Route the power tilt pump wires through the port cover. Ensure that the grommet remains properly seated in the cover.
   b. Connect the green tilt wire to the down relay terminal, and connect the blue tilt wire to the up relay terminal. Cover the connections with the attached rubber boots, and secure the wires to the electrical bracket with a cable tie.
   c. If the engine has a cowl-mounted tilt switch, ensure that the tilt switch is correctly installed in the port cover, and connect the switch to the engine harness.
2. Position the port cover on the driveshaft housing and secure it with the three captive screws.
3. Position the starboard cover on the driveshaft housing and secure it with the seven captive screws.
4. Tighten the three port-side screws, the seven starboard-side screws, and the cowl latch screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Driveshaft housing cover and cowl latch screws (11)	6.0	53.1	–

5. Attach the cowl seal.
6. Position the top cowl and secure it with the cowl latch.

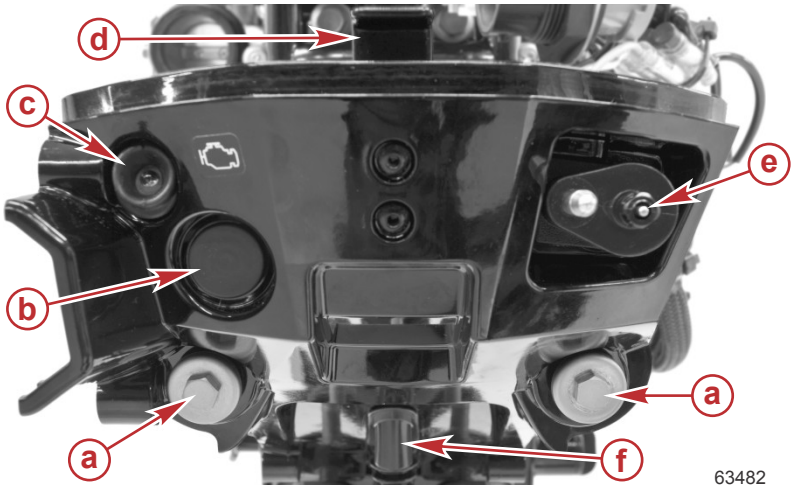
Front Cowl

The front cowl houses the fuel connection, the diagnostic light, and the optional start push-button. It also has a catch for the top cowl.

Removal

1. Remove the driveshaft housing covers. Refer to **Driveshaft Housing Covers**.

2. Remove the two screws that secure the front cowl to the shift lever brackets.



a - Screws (2)
b - Rubber plug (optional start push-button)
c - Diagnostic light
d - Top cowl catch
e - Fuel connection
f - Upper shift shaft boot

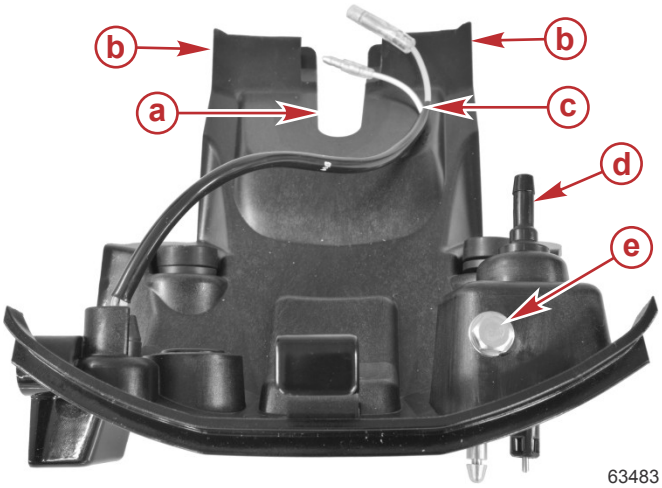
3. Disconnect the two bullet connectors for the diagnostic light.
4. Disconnect the two bullet connectors for the start switch, if equipped.
5. Remove the fuel inlet hose from the fuel inlet fitting.
6. To remove the fuel inlet fitting, remove one screw.

Installation

1. If the fuel inlet fitting was removed, install it, and secure it with one screw.
2. Slide the cowl into position, ensuring that the tabs engage with the midplate and the upper shift shaft boot seats in the notch in the front cowl.
3. Ensure that all of the grommets and washers are still in place, and secure the front cowl to the shift lever brackets with two screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Front cowl screws	6.0	53.1	–

4. Connect the diagnostic light bullet connectors to the engine harness.
5. Attach the fuel inlet hose to the fuel inlet fitting, and secure it with a spring-type hose clamp.



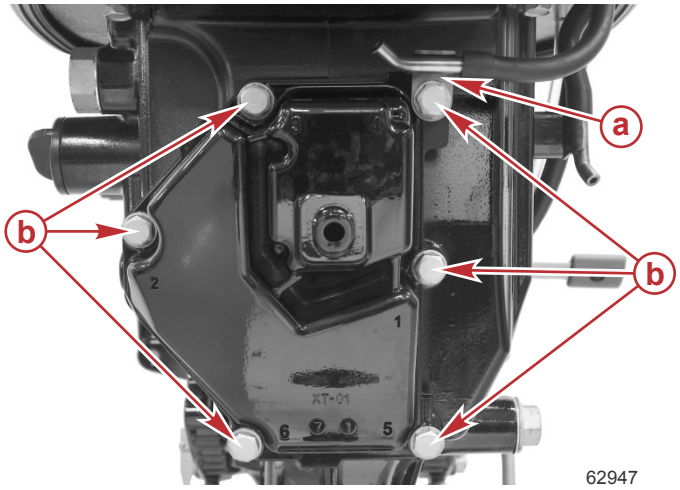
a - Notch for upper shift shaft boot
b - Tabs for midplate
c - Bullet connectors for diagnostic light
d - Fuel inlet fitting
e - Screw securing fuel inlet fitting

6. Install the driveshaft housing covers. Refer to **Driveshaft Housing Covers**.

Idle Exhaust Port Cover

Removal and Inspection

1. Remove the six screws securing the idle exhaust port cover, and remove the cover.



62947

a - Vent tank vent hose fitting
b - Screws (6)

2. Remove the gasket.
3. Remove the three screws securing the idle exhaust port plate.

62948

4. Inspect and clean the idle exhaust port cover.

Installation

NOTE: *Refer to the illustrations in the* ***Removal and Inspection*** *procedure, as required.*

1. Install the idle exhaust port plate, and tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Idle exhaust port plate screw	4.0	35.4	–

2. Clean the mounting surfaces on the driveshaft housing and on the idle exhaust port cover.
3. Place a new gasket onto the idle exhaust port cover.
4. Apply Loctite® 242 Threadlocker to the six idle exhaust port cover screws.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite® 242 Threadlocker	Idle exhaust port cover screws	92-809821

5. Attach the idle exhaust port cover and new gasket to the driveshaft housing, using the six screws. Ensure that the fitting for the vent tank vent hose is threaded onto screw 4 (upper left corner), and that the hose is connected to the fitting.
6. Follow the sequence marked on the cover, and tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Idle exhaust port cover screws	6.0	53.1	–

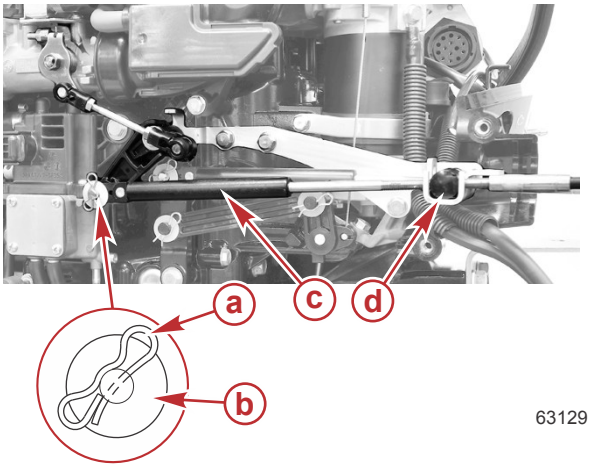
Powerhead/Midsection Assembly Separation

Several procedures require the separation of the powerhead/midsection assembly from the clamp/swivel bracket assembly. Refer to the following procedures as required.

Remote Control Throttle and Shift Cables

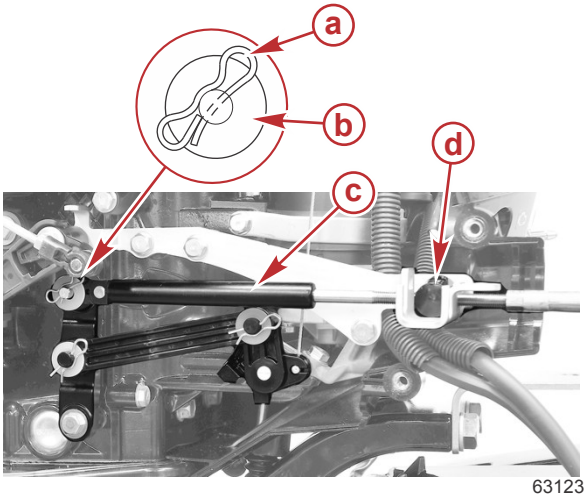
The throttle and shift cables must be removed before the powerhead/midsection assembly can be separated from the clamp/swivel bracket assembly.

1. Remove the bow-tie retainers and washers from the throttle and shift cables.



63129

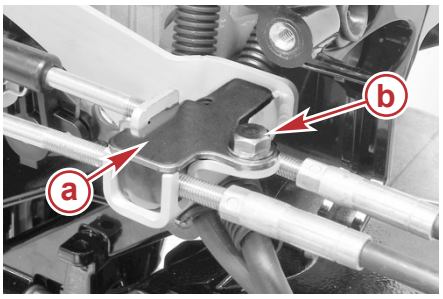
a - Bow-tie retainer
b - Flat washer
c - Throttle cable
d - Cable barrel



63123

a - Bow-tie retainer
b - Flat washer
c - Shift cable
d - Cable barrel

2. Remove the screw from the cable barrel retainer, and remove the throttle and shift cables.



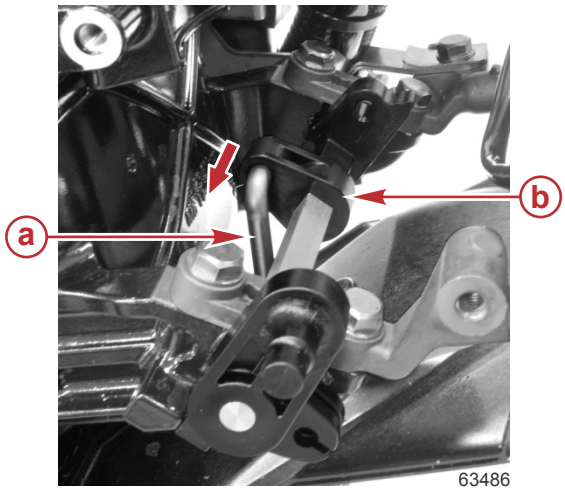
63131

a - Cable barrel retainer
b - Screw

Removal

1. For tiller handle models, remove the tiller handle. Refer to **Section 7B - Tiller Handle Removal**.
2. Completely remove both driveshaft housing covers. Refer to **Driveshaft Housing Covers**.
3. For electric start models, remove the starter motor. Refer to **Section 2B - Starter Motor Removal**.
4. Remove the upper shift shaft:

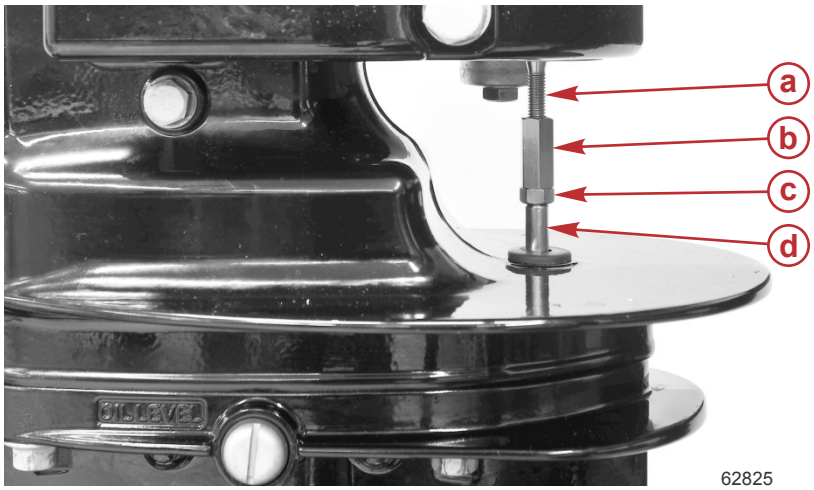
a. With the gearcase in neutral, disconnect the upper shift shaft from the shift lever by pulling the upper shift shaft toward starboard.



Pull the upper shift shaft toward starboard

a - Upper shift shaft
b - Shift lever

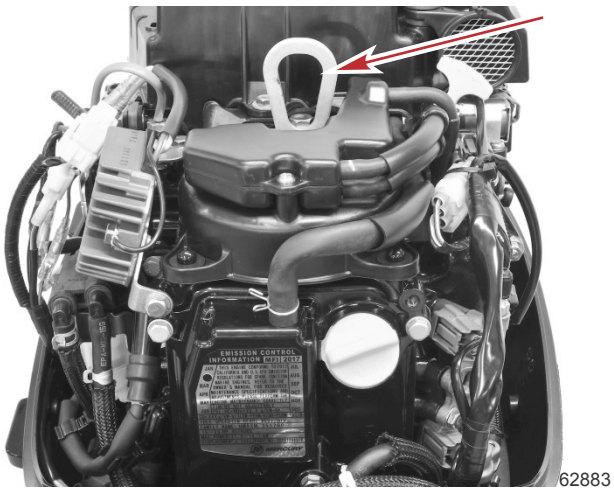
b. Disconnect the upper shift shaft from the lower shift shaft by turning the jam nut (down) and the coupler (up).



a - Upper shift shaft
b - Coupler
c - Jam nut
d - Lower shift shaft

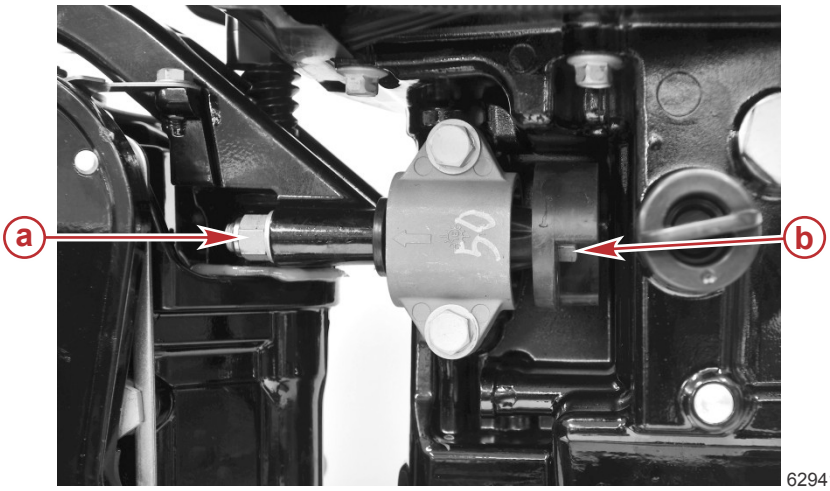
c. Remove the coupler from the upper shift shaft, and lift the upper shift shaft out of the steering arm/swivel bracket assembly.

5. Attach the engine lifting eye to an overhead hoist or other suitable lifting equipment. Remove the slack from the hoist.



6. Remove the lower mount. Refer to **Lower Mount**.

7. Remove the locknuts and washers from the ends of the long upper mount screws (one each side). Carefully remove the engine from the steering arm/swivel bracket.

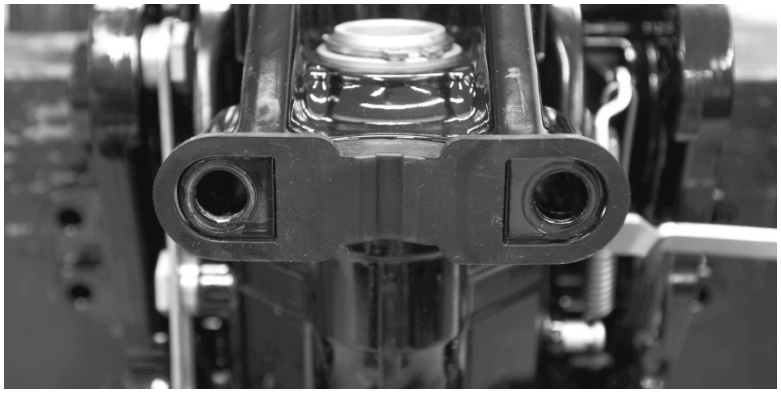


a - Locknut and washer on long upper mount screw
b - Screw head

Installation

For the following procedure, refer to the illustrations in the **Removal** procedure as required.

1. Ensure that the rubber damper is in place on the steering arm/swivel bracket.



2. Use a hoist or other suitable lifting mechanism to guide the engine into position so that the two long upper mount screws slide into the steering arm/swivel bracket.
3. Place two washers and two new locknuts onto the long upper mount screws (one each side). Tighten the locknuts to the specified torque.

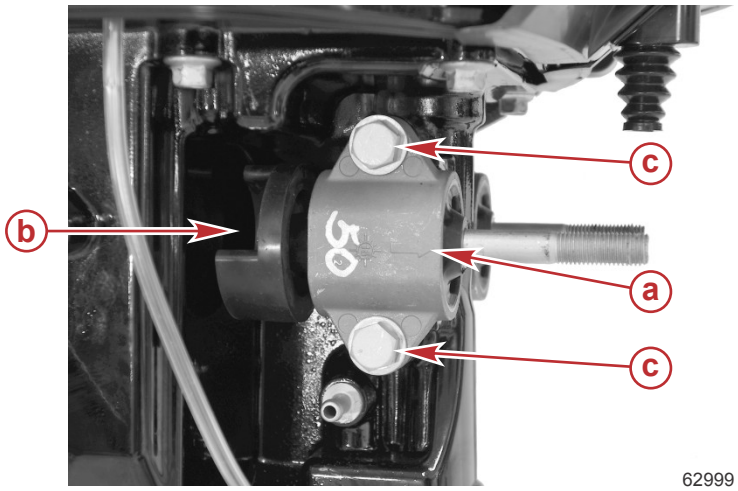
Description	Nm	lb-in.	lb-ft
Upper mount locknut	27	–	20

4. Install the lower mount. Refer to **Lower Mount**.
5. Install the upper shift shaft:
   a. Insert the upper shift shaft down through the midplate, shift shaft boot, and steering arm/swivel bracket assembly.
   b. Connect the upper shift shaft to the shift lever.
   c. Fully thread the coupler onto the upper shift shaft.
   d. Connect the upper shift shaft to the lower shift shaft by turning the coupler until it has engaged the lower shift shaft by a minimum of three rotations.
   e. Tighten the jam nut to secure the connection.
6. For electric start models, install the starter motor. Refer to **Section 2B - Starter Motor Installation**.
7. For tiller handle models, install the tiller handle, shift cable, and throttle cables. Complete the throttle cable adjustments, as required. Refer to **Section 7B - Tiller Handle**.
8. Install the driveshaft housing covers. Refer to **Driveshaft Housing Covers**.

Engine Mount Replacement

Upper Mount

IMPORTANT: The upper mounts cannot be replaced without removing the engine from the steering arm/swivel bracket, including removing the lower mounts.



Starboard mount shown, port mount similar

- **a -** Arrow pointing toward the transom
- **b -** Notch rotated for access to screw head
- **c -** Upper mount screws

Removal

1. Separate the engine and driveshaft housing from the steering arm/swivel bracket. Refer to **Powerhead/Midsection Assembly Separation**.
2. Remove the two screws that secure the mount to the driveshaft housing, and remove the mount assembly.

Installation

1. Slide the rubber spacer and the mount over the shaft of the long upper mount screw. Attach the mount assembly to the driveshaft housing with two screws.
   a. Ensure that the arrow on the mount is pointing toward the transom.
   b. Ensure that the notch in the rubber spacer is rotated to allow access to the head of the long upper mount screw.
   c. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Upper mount screws	13	115	–

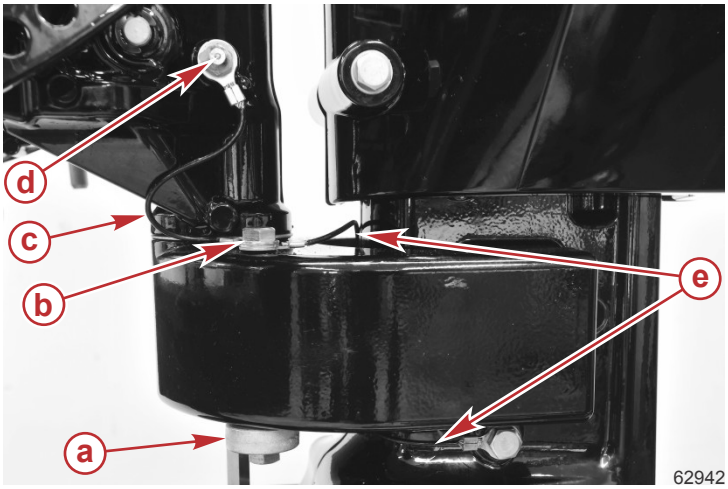
2. Attach the engine and driveshaft housing to the steering arm/swivel bracket. Refer to **Powerhead/Midsection Assembly Separation**.

Lower Mount

Removal

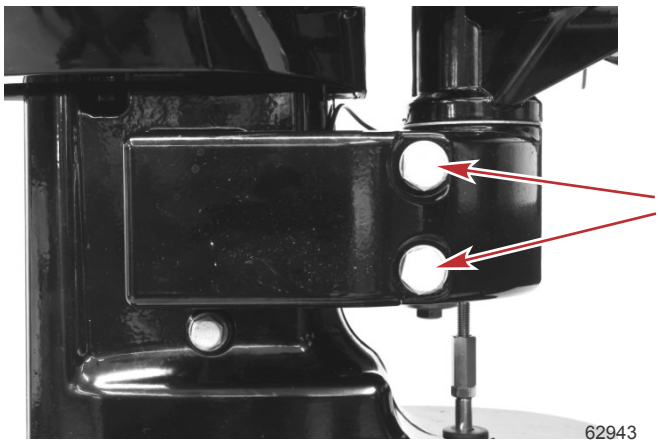
1. Remove the screw that secures the two continuity wires to the port side of the lower mount.

NOTE: *Inspect the anode. Replace if necessary; otherwise, it need not be removed.*



- **a -** Anode
- **b -** Screw
- **c -** Continuity wire (from swivel bracket to lower mount)
- **d -** Lubrication fitting
- **e -** Continuity wire (from lower mount to driveshaft housing)

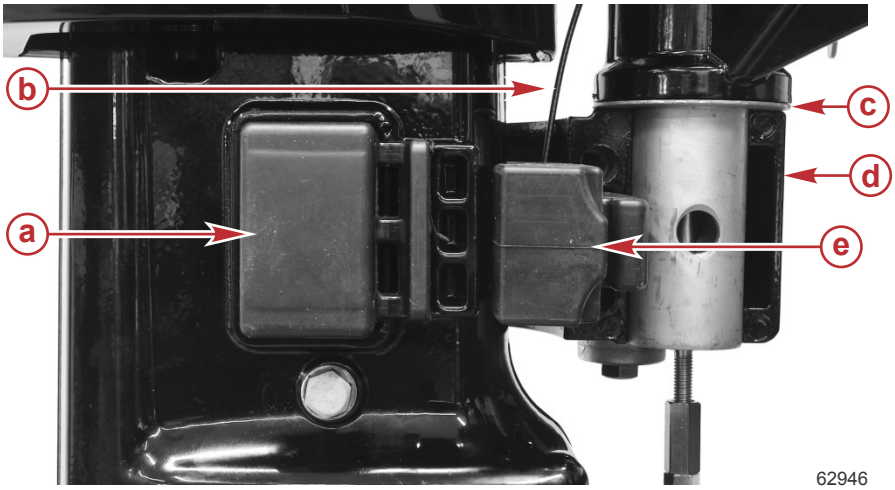
2. Remove the two screws that attach the two halves of the lower mount bracket.



3. Remove the lower mount bracket halves and three rubber mounts.
4. Inspect the rubber mounts for wear. Replace, if necessary.

Installation

1. Position the two smaller rubber mounts in the pockets on the driveshaft housing. The third, large rubber mount spans the two halves of the lower mount bracket. Ensure that the lower continuity wire passes between the large rubber mount and the driveshaft housing.
2. Ensure that the thrust plate is in place at the end of the tilt tube, and slide the port half of the lower mount bracket into position.



- **a -** Smaller rubber mount (one on each side)
- **b -** Lower continuity wire (from driveshaft housing to lower mount)
- **c -** Thrust plate
- **d -** Port half of the lower mount bracket
- **e -** Large rubber mount

3. Slide the starboard half of the lower mount bracket into position. Secure the bracket halves with two screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Lower mount screws	13	115	–

4. Attach the two continuity wires to the port side of the lower mount with a screw and washer. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Screw	6.0	53.1	–

Clamp Brackets, Swivel Bracket - Power Tilt Models

Clamp Brackets - Power Tilt

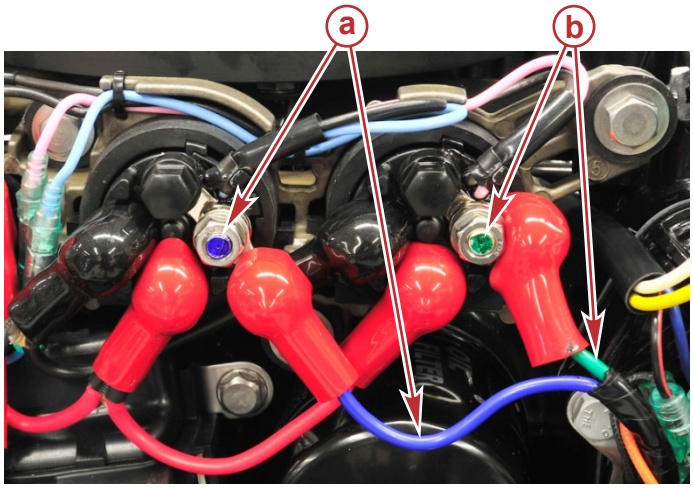
IMPORTANT: The following procedures assume that the steering cable has been removed.

Port Bracket Removal

NOTE: *To remove the clamp brackets:*

- *Use an overhead hoist to support the outboard by the lifting eye, or*
- *Lay the outboard on its back side.*

1. Disconnect the green and blue power tilt wires from the power tilt relays.

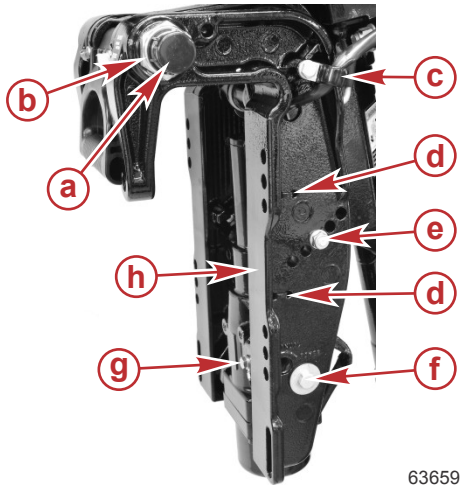


63064

a - Blue (up) tilt relay terminal and wire
b - Green (down) tilt relay terminal and wire

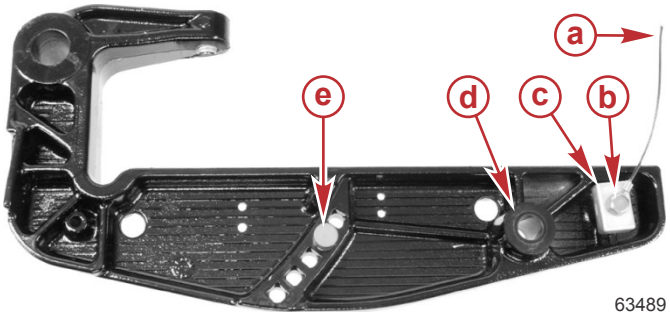
2. Cut the cable tie that secures the power tilt wires to the electrical bracket.
3. Pull the power tilt pump wires through the grommet in the port driveshaft housing cover.
4. Remove the P-clip that secures the power tilt pump wires to the outside of the clamp bracket.
5. Cut the cable ties securing the power tilt pump wires to the inside of the clamp bracket.
6. Remove the tilt tube cap and locknut.
7. Remove the power tilt lower pivot screw and washer.
8. Remove the screw securing the ground cable to the power tilt unit.

9. Remove the port clamp bracket from the tilt tube, feeding the power tilt pump wires out through the hole in the bracket.



a - Cap
b - Locknut
c - P-clip
d - Cable ties (2)
e - Tilt lock pin, locknut, and washer
f - Lower pivot pin screw (M8 x 20) and washer
g - Ground cable screw on power tilt unit
h - Port clamp bracket

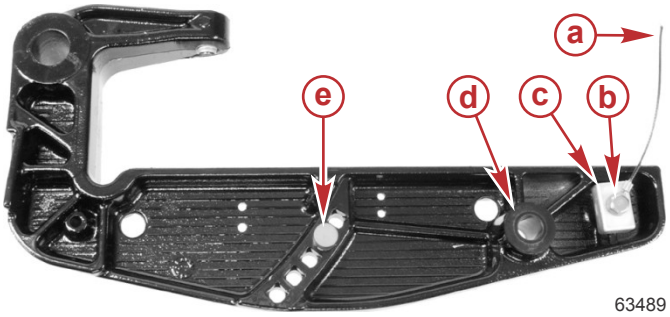
10. Inspect the tilt lock pin, lower pivot pin bushing, and anode.



a - Ground cable
b - Screw (M6 x 16)
c - Anode
d - Lower pivot pin bushing
e - Tilt lock pin

Port Bracket Installation

1. Install the lower pivot pin bushing.
2. Install the tilt lock pin. Tighten the locknut to the specified torque.
3. Install the anode and ground cable. Tighten the anode screw to the specified torque.

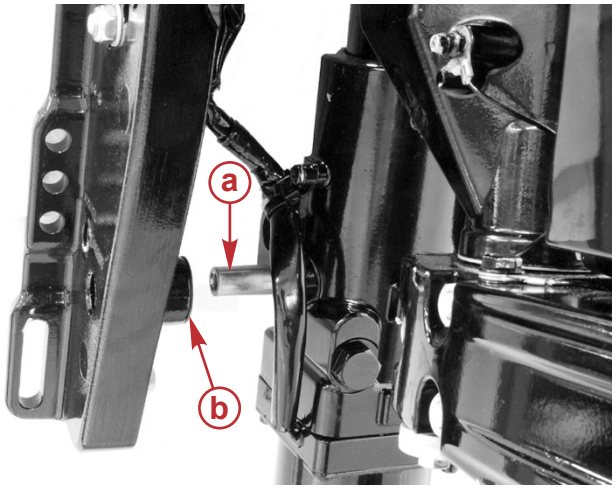


a - Ground cable
b - Screw (M6 x 16)
c - Anode
d - Lower pivot pin bushing
e - Tilt lock pin

Description	Nm	lb-in.	lb-ft
Anode screw (M6 x 16)	6.0	53.1	–
Tilt lock pin locknut	13	115	–

4. Install the clamp bracket partially onto the tilt tube.
5. Route and secure the power tilt pump wires:
   a. Feed the harness through the hole in the bracket.
   b. Secure the power tilt pump wires to the inside of the port clamp bracket with two cable ties.
   c. Secure the power tilt pump wires to the outside of the port clamp bracket with a P-clip.

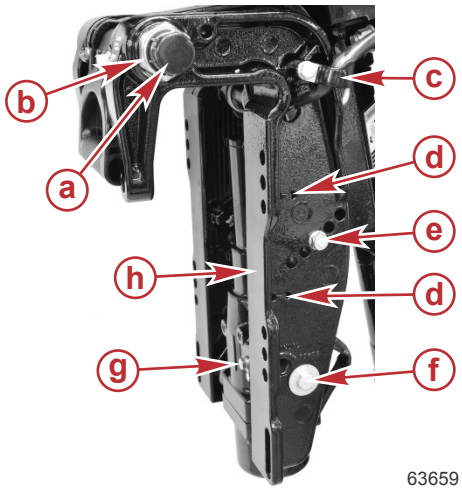
6. Align the lower pivot pin with the port clamp bracket bushing and push the clamp bracket onto the lower pivot pin.



35067

- **a -** Lower pivot pin
- **b -** Clamp bracket bushing

7. Install the lower pivot pin screw and washer. Tighten the screw to the specified torque.
8. Lubricate the plastic washer on the tilt tube with 2-4-C with PTFE.
9. Install the tilt tube locknut. Tighten the locknut to the specified torque.
10. Install the cap.



63659

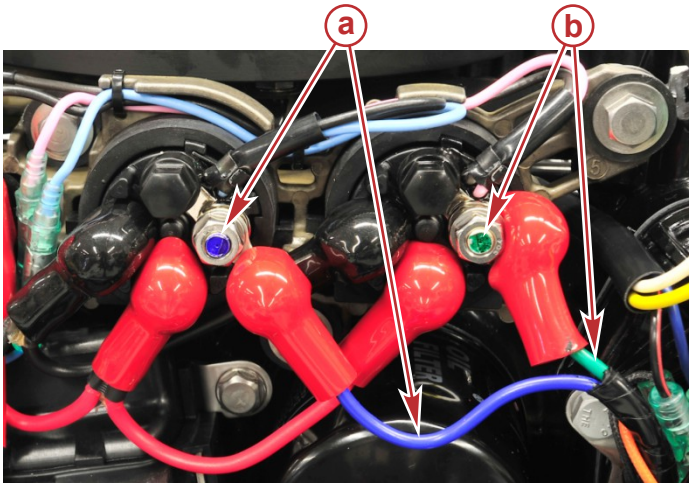
- **a -** Cap
- **b -** Locknut
- **c -** P-clip
- **d -** Cable ties (2)
- **e -** Tilt lock pin, locknut, and washer
- **f -** Lower pivot pin screw (M8 x 20) and washer
- **g -** Ground cable screw on power tilt unit
- **h -** Port clamp bracket

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tilt tube washer	92-802859A 1

Description	Nm	lb-in.	lb-ft
Lower pivot pin screw (M8 x 20)	13	115	–
Tilt tube locknut	24.0	–	17.7

11. Route the power tilt pump wires through the grommet in the port driveshaft housing cover. Ensure that the grommet is properly seated in the cover.

12. Connect the green and blue power tilt wires to the tilt relays. Cover the connections with the red boots.



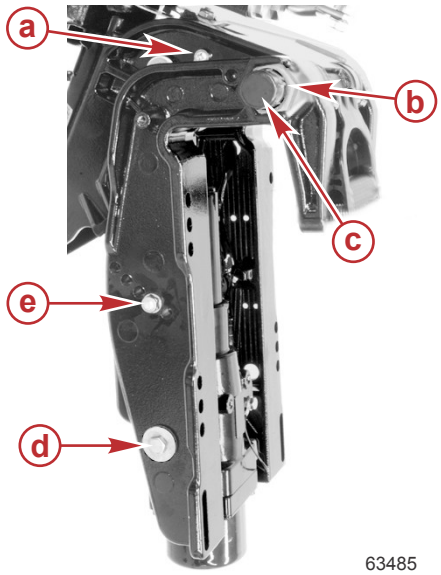
63064

a - Blue (up) tilt relay terminal and wire
b - Green (down) tilt relay terminal and wire

13. Secure the wires to the electrical bracket with a cable tie.

Starboard Bracket Removal

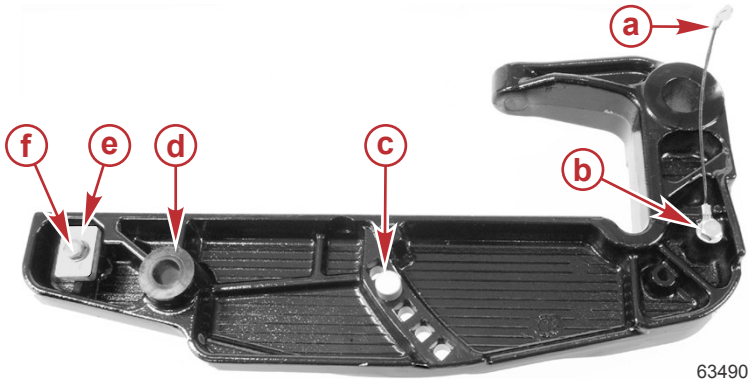
1. Remove the power tilt lower pivot screw and washer.
2. Remove the screw securing the ground cable.
3. Remove the port tilt tube cap.
4. Loosen the locknut.
5. Push the tilt tube towards the starboard side to allow the starboard nut to be removed.
6. Remove the tilt tube cap and nut.
7. Remove the starboard clamp bracket.



63485

a - Ground cable screw
b - Nut
c - Cap
d - Lower pivot pin screw (M8 x 20) and washer
e - Tilt lock pin, locknut, and washer

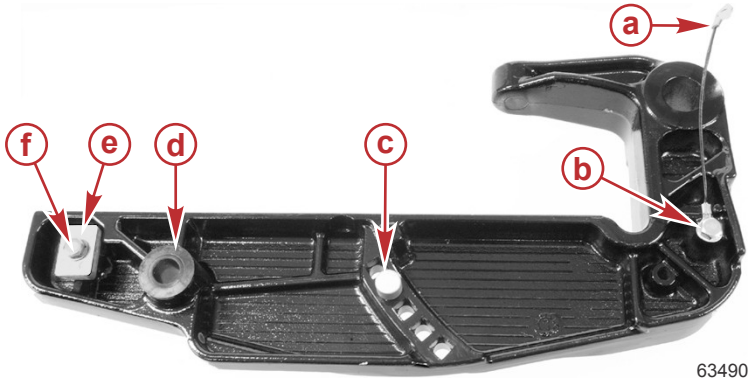
8. Inspect the tilt lock pin, lower pivot pin bushing, and anode.



a - Ground cable
b - Screw (M6 x 12)
c - Tilt lock pin
d - Lower pivot pin bushing
e - Anode
f - Screw (M6 x 16)

Starboard Bracket Installation

1. Install the lower pivot pin bushing.
2. Install the tilt lock pin. Tighten the locknut to the specified torque.
3. Install the anode and ground cable. Tighten the anode screw to the specified torque.

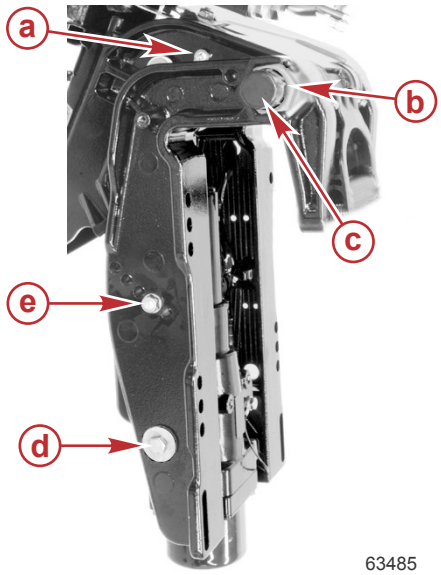


a - Ground cable
b - Screw (M6 x 12)
c - Tilt lock pin
d - Lower pivot pin bushing
e - Anode
f - Screw (M6 x 16)

Description	Nm	lb-in.	lb-ft
Anode screw (M6 x 16)	6.0	53.1	–
Tilt lock pin locknut	13	115	–
Ground cable screw (M6 x 12)	6.0	53.1	–

4. Install the clamp bracket partially onto the tilt tube.
5. Align the lower pivot pin with the port clamp bracket bushing and push the clamp bracket onto the lower pivot pin.
6. Install the lower pivot pin screw and washer. Tighten the screw to the specified torque.
7. Secure the ground cable with the screw.
8. Lubricate the plastic washer on the tilt tube with 2-4-C with PTFE.
9. Thread the nut onto the tilt tube to the end of the threads.
10. Push the tilt tube in until the nut is seated in the hex cavity.
11. Tighten the port tilt tube locknut to the specified torque.

12. Install the cap.



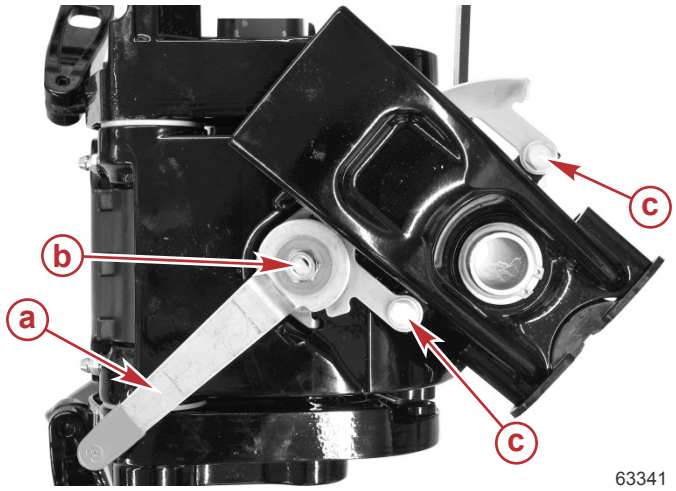
a - Ground cable screw
b - Nut
c - Cap
d - Lower pivot pin screw (M8 x 20) and washer
e - Tilt lock pin, locknut, and washer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tilt tube washer	92-802859A 1

Description	Nm	lb-in.	lb-ft
Lower pivot pin screw (M8 x 20)	13	115	–
Tilt tube locknut	24.0	–	17.7

Steering Arm Removal

1. Separate the powerhead/driveshaft housing/gearcase assembly from the clamp bracket/swivel bracket/steering arm assembly. Refer to **Powerhead/Midsection Assembly Separation**.
2. For tiller handle models, remove the copilot hardware:
   a. Remove one locknut to remove the copilot handle.
   b. Remove two screws with washers to remove the remaining copilot components from the swivel bracket.



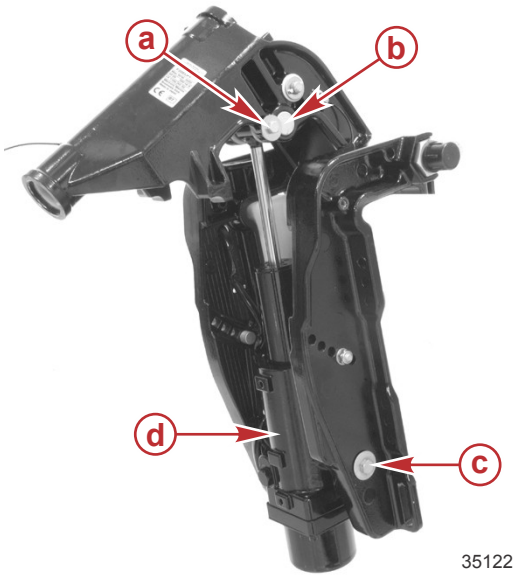
a - Copilot handle
b - Locknut
c - Screw with washer

3. Remove the steering arm.

Power Tilt Removal

1. Remove the steering arm. Refer to **Steering Arm Removal**.
2. Remove the P-clip that secures the power tilt pump wires to the outside of the port clamp bracket.
3. Cut the cable ties securing the power tilt pump wires to the inside of the port clamp bracket.
4. Pull the power tilt pump wires through the opening in the clamp bracket.
5. Remove the screw securing the power tilt ground cable to the power tilt unit.
6. Tilt the swivel bracket away from the rest of the assembly:
   a. Open the power tilt manual release valve.
   b. Raise the swivel bracket to the full tilt position.
   c. Close the manual release valve.

   For details, refer to **Section 5B - Power Tilt Features and Operation**.
7. Remove the screw and washer securing the upper pivot pin.
8. Remove one of the screws and washers securing the lower pivot pin.
9. Remove the upper pivot pin.
10. Remove the lower pivot pin and remove the power tilt unit.



a - Screw and washer
b - Upper pivot pin
c - Lower pivot pin screw and washer
d - Power tilt unit

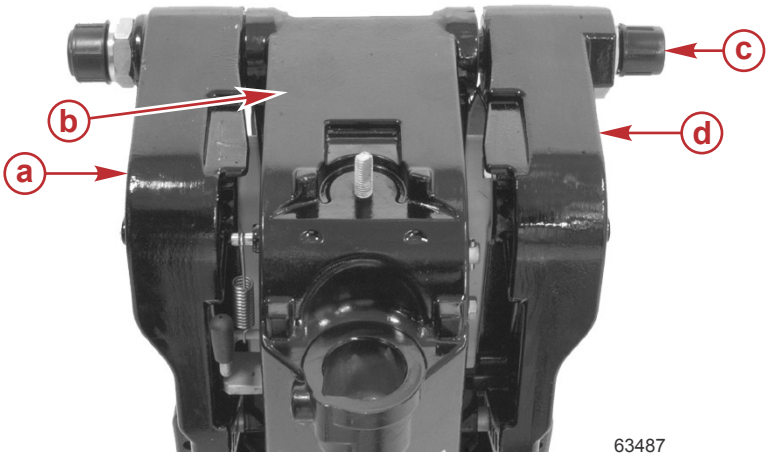
Swivel Bracket Removal

IMPORTANT: This procedure assumes the following prerequisite procedures have been completed:

1. **Powerhead/driveshaft housing/gearcase assembly removed from the clamp bracket/swivel bracket/steering arm assembly. Refer to Powerhead/Midsection Assembly Separation.**
2. **Steering arm removed from the swivel bracket. Refer to Steering Arm Removal.**
3. **Power tilt unit removed from the swivel bracket. Refer to Power Tilt Removal.**

To remove the swivel bracket:

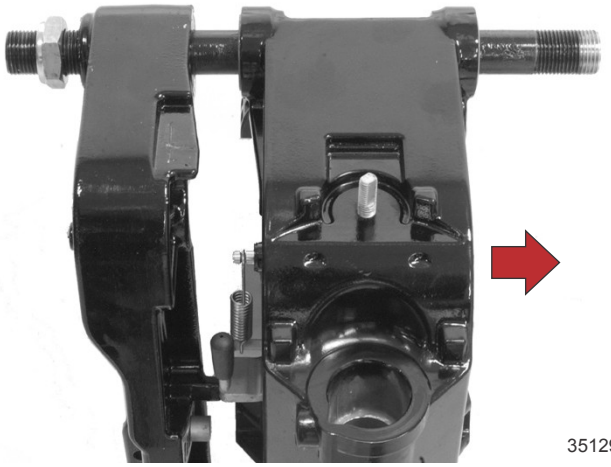
1. Remove the starboard side nut securing the tilt tube.



63487

a - Port clamp bracket
b - Swivel bracket
c - Tilt tube with cap and nut
d - Starboard clamp bracket

2. Partially remove the tilt tube from the port clamp bracket.
3. Remove the starboard ground wire.
4. Remove the starboard clamp bracket.
5. Remove the swivel bracket.

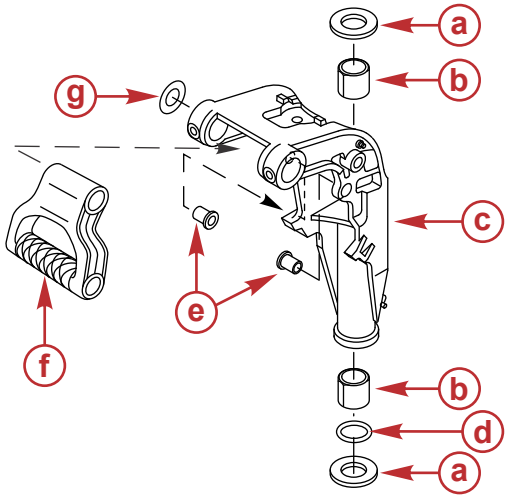


35129

Swivel Bracket Inspection

1. Remove the bushings from the swivel bracket.
2. Inspect for wear. Replace if necessary.
3. Clean the swivel bracket.
4. Apply 2-4-C with PTFE to the bushings.

5. Install the bushings into the swivel bracket.



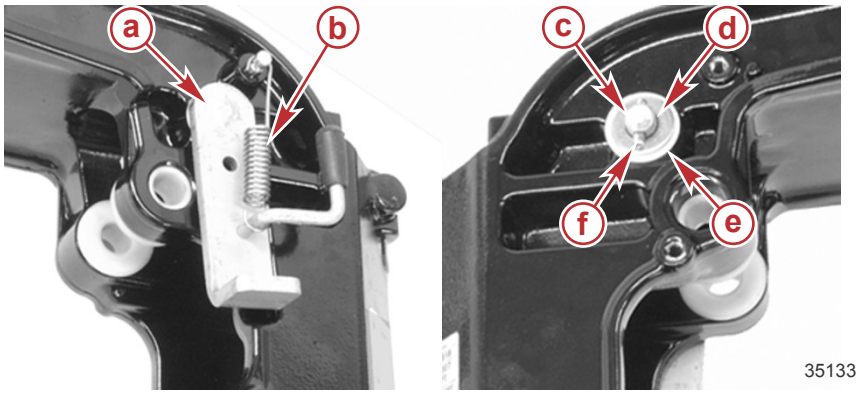
Power tilt model

- **a -** Thrust plate
- **b -** Swivel bracket bushing (2)
- **c -** Swivel bracket
- **d -** O-ring
- **e -** Lower pivot bushings (2)
- **f -** Carrying handle
- **g -** Washer (2)

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Swivel bracket bushings	92-802859A 1

Tilt Lock Lever

1. Remove the tilt spring from the swivel bracket.
2. Remove the spring pin from the tilt lock pin.
3. Remove the tilt lock pin.
4. Inspect the bushings. Replace if necessary.
5. Apply 2-4-C with PTFE to the pin and bushings.
6. Install the bushings and pin.
7. Install a washer onto the tilt lock pin.
8. Install the spring pin through the tilt lock pin.
9. Install the tilt spring onto the swivel bracket.



Port side shown at left, starboard shown at right

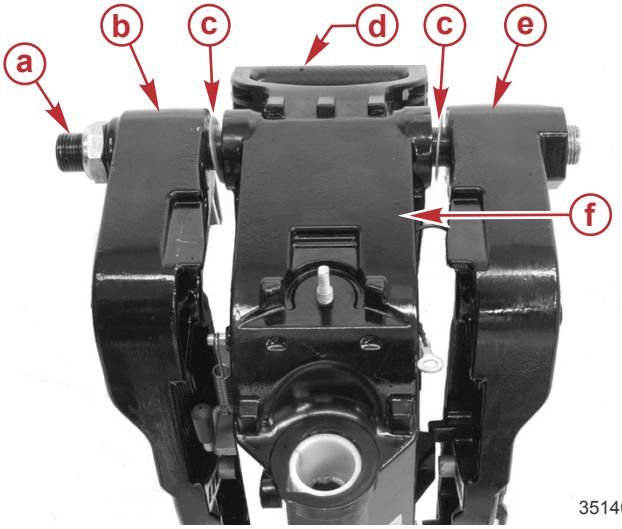
- **a -** Tilt lock lever
- **b -** Tilt spring
- **c -** Tilt lock pin
- **d -** Washer
- **e -** Bushing (2)
- **f -** Spring pin

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tilt pin and bushings	92-802859A 1

Swivel Bracket Installation

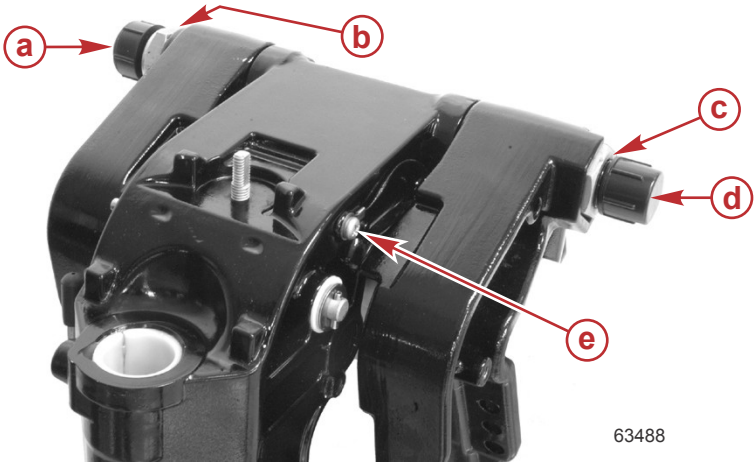
1. Clean the tilt tube and clamp brackets.
2. Insert the tilt tube through the port clamp bracket.
3. Install a washer onto the tilt tube.
4. Install the carrying handle.

5. Install a washer and the starboard clamp bracket onto the tilt tube.



- **a -** Tilt tube
- **b -** Port clamp bracket
- **c -** Washer
- **d -** Carrying handle
- **e -** Starboard clamp bracket
- **f -** Swivel bracket

6. Install the nut onto the tilt tube. Tighten the port side locknut to the specified torque.
7. Attach the starboard ground cable to the swivel bracket. Tighten the screw to the specified torque.
8. Install the tilt tube caps.



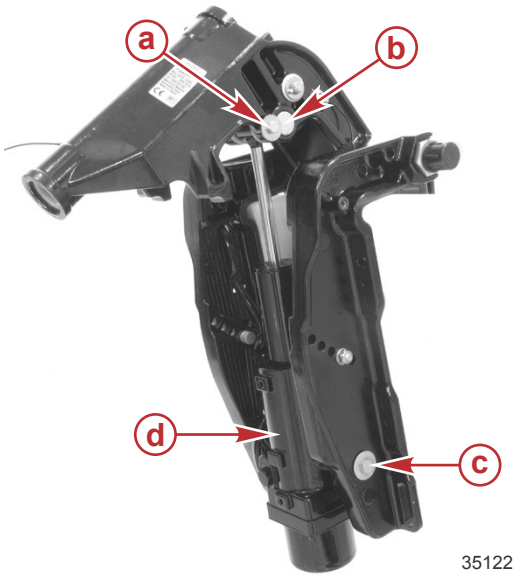
- **a -** Port cap
- **b -** Locknut
- **c -** Nut
- **d -** Starboard cap
- **e -** Ground cable screw (M6 x 12)

Description	Nm	lb-in.	lb-ft
Tilt tube locknut	24.0	–	17.7
Ground cable screw (M6 x 12)	6.0	53.1	–

Power Tilt Installation

1. Raise the swivel bracket and engage the tilt lock lever.
2. Ensure the tilt rod eye bushing and the lower pivot pin bushings are installed in the clamp brackets and power tilt unit.
3. Position the power tilt unit between the clamp brackets.
4. Install the lower pivot pin through the clamp brackets and the power tilt unit.
5. Install the upper pivot pin through the swivel bracket and the power tilt rod eye.
6. Install the lower pivot pin screw. Tighten the screw to the specified torque.

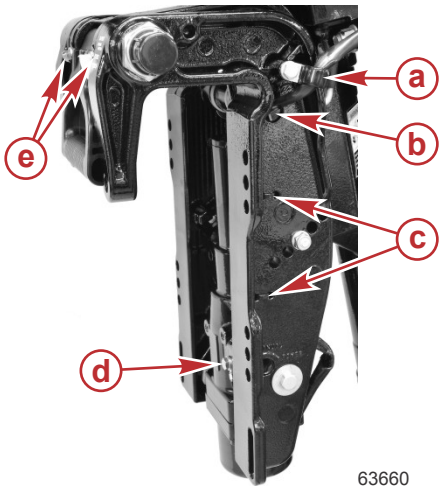
7. Install the screw and washer that secure the upper pivot pin. Tighten the screw to the specified torque.



a - Screw and washer
b - Upper pivot pin
c - Lower pivot pin screw and washer
d - Power tilt unit

Description	Nm	lb-in.	lb-ft
Lower pivot pin screw (M8 x 20)	13	115	–
Upper pivot pin screw (M6 x 12)	6.0	53.1	–

8. Route the power tilt pump wires through the port clamp bracket.
9. Secure the power tilt pump wires to the inside of the clamp bracket with two cable ties.
10. Secure the power tilt pump wires to the outside of the clamp bracket with a P-clip and screw.
11. Attach the ground cable to the power tilt unit. Tighten the screw to the specified torque.
12. Lubricate the tilt tube with 2-4-C with PTFE through the grease fittings on the swivel bracket.



a - P-clip
b - Hole through the port clamp bracket
c - Cable ties (two)
d - Ground cable screw
e - Grease fittings (two)

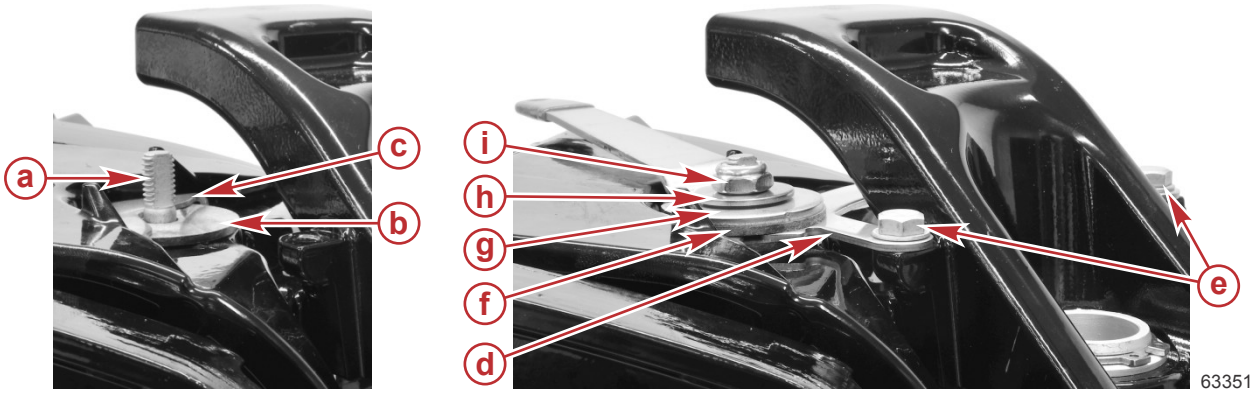
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tilt tube	92-802859A 1

Description	Nm	lb-in.	lb-ft
Ground cable screw (M6 x 12)	6.0	53.1	–

Steering Arm Installation

1. Install a washer onto the steering arm shaft.
2. Insert the steering arm into the swivel bracket. Ensure that the lower bushing remains in the swivel bracket.
3. For tiller handle models:

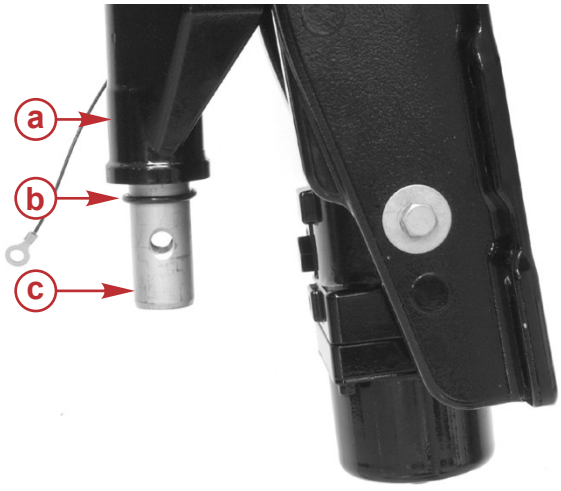
a. Install the copilot threaded rod into the swivel bracket.
b. Install one disc and washer (item c, shown following) onto the threaded rod.
c. Attach the plate to the steering arm with two screws and washers.
d. Install a disc, handle, washer, and locknut onto the threaded rod. Tighten the locknut to the specified torque.



a - Threaded rod
b - Disc
c - Washer
d - Plate
e - Screws and washers
f - Disc
g - Copilot handle
h - Washer
i - Locknut

Description	Nm	lb-in.	lb-ft
Copilot locknut	11.0	97.3	–

4. Lubricate the steering arm O-ring with 2-4-C with PTFE.
5. Install the O-ring onto the steering arm shaft.



a - Swivel bracket
b - O-ring
c - Steering arm shaft

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Steering arm O-ring	92-802859A 1

6. Attach the outboard to the swivel bracket. Refer to **Powerhead/Midsection Assembly Separation**.

IMPORTANT: Ensure that the upper mount locknuts are tightened to the specified torque.

Description	Nm	lb-in.	lb-ft
Upper mount locknut	27.0	–	19.9

Clamp Brackets, Swivel Bracket - Manual Tilt Models

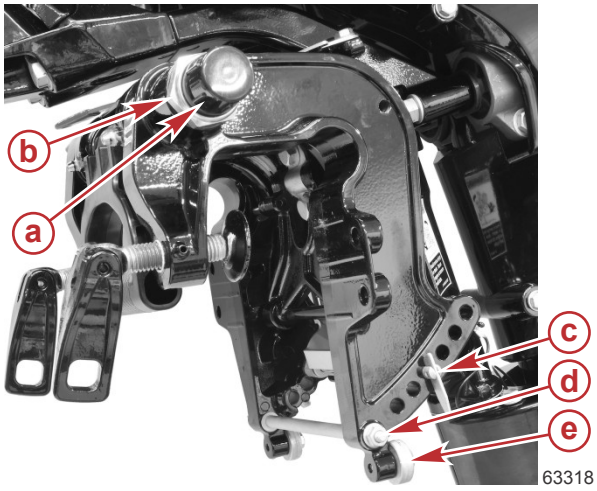
Clamp Brackets - Manual Tilt

NOTE: *To remove the clamp brackets:*

- *Use an overhead hoist to support the outboard by the lifting eye, or*
- *Lay the outboard on its back side.*

Port Bracket Removal

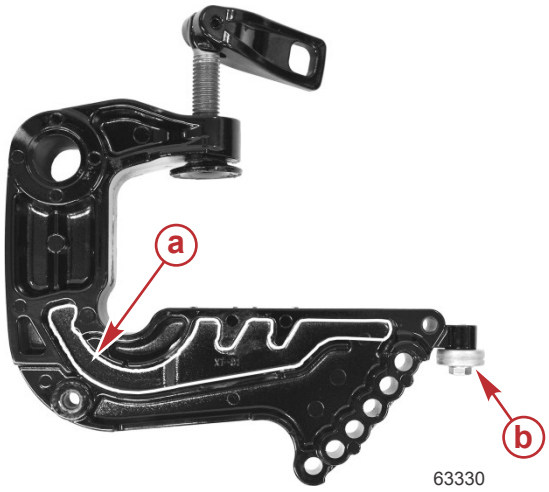
1. Remove the tilt tube cap and locknut.
2. Remove the tilt pin.
3. Remove the nut and washer from the port end of the clamp bracket spacer.
4. Remove the port clamp bracket from the tilt tube.
5. Inspect the anode.



a - Tilt tube cap
b - Locknut
c - Tilt pin
d - Nut and washer on the clamp bracket spacer
e - Anode

Port Bracket Installation

1. Install the anode. Tighten the screw to the specified torque.



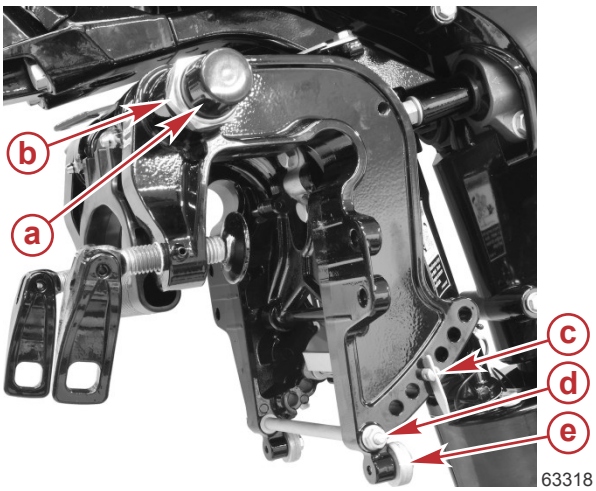
a - Channel for tilt lock guide bar
b - Anode

Description	Nm	lb-in.	lb-ft
Anode screw (M6 x 16)	6.0	53.1	–

2. Install the clamp bracket partially onto the tilt tube and clamp bracket spacer.
3. Lubricate the plastic washer on the tilt tube with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tilt tube washer	92-802859A 1

4. Ensure that the guide bar of the tilt lock is aligned in the channels of the clamp brackets.
5. Install the washer and nut onto the clamp bracket spacer. Tighten the nut to the specified torque.
6. Install the tilt tube locknut. Tighten the locknut to the specified torque.
7. Install the tilt tube cap.
8. Install the tilt pin.

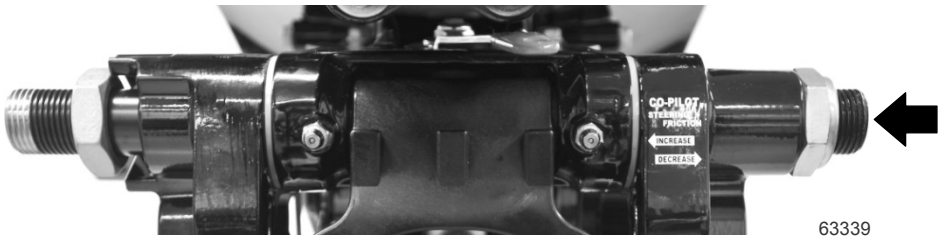


- **a -** Tilt tube cap
- **b -** Locknut
- **c -** Tilt pin
- **d -** Nut and washer on the clamp bracket spacer
- **e -** Anode

Description	Nm	lb-in.	lb-ft
Tilt tube locknut	24.0	–	17.7
Clamp bracket spacer nut	6.0	53.1	–

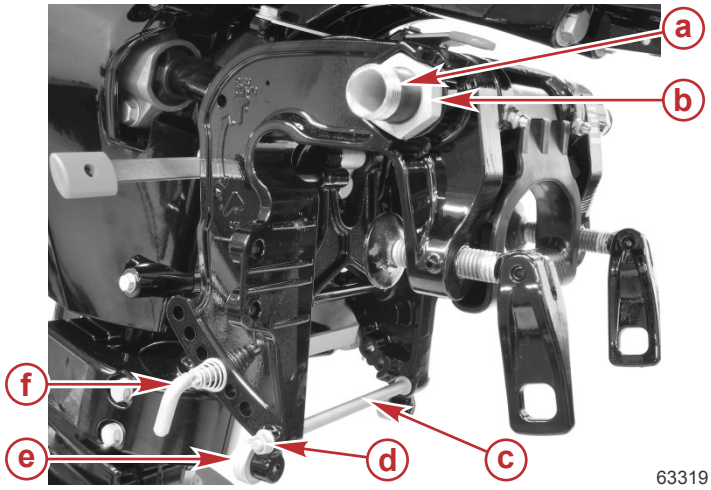
Starboard Bracket Removal

1. Remove the tilt tube caps.
2. Loosen the locknut on the port end of the tilt tube.
3. Push the tilt tube towards the starboard side to allow the starboard nut to be removed.



4. Remove the nut.
5. Remove the nut and washer from the clamp bracket spacer.
6. Remove the tilt pin.
7. Remove the starboard clamp bracket.

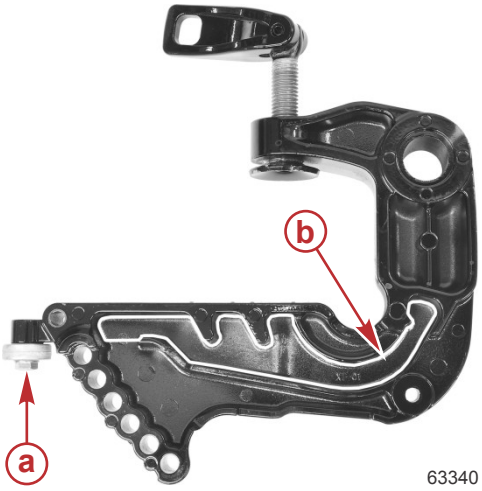
8. Inspect the anode.



a - Tilt tube
b - Nut
c - Spacer
d - Nut and washer
e - Tilt pin
f - Anode

Starboard Bracket Installation

1. Ensure that a good anode is installed on the starboard clamp bracket.



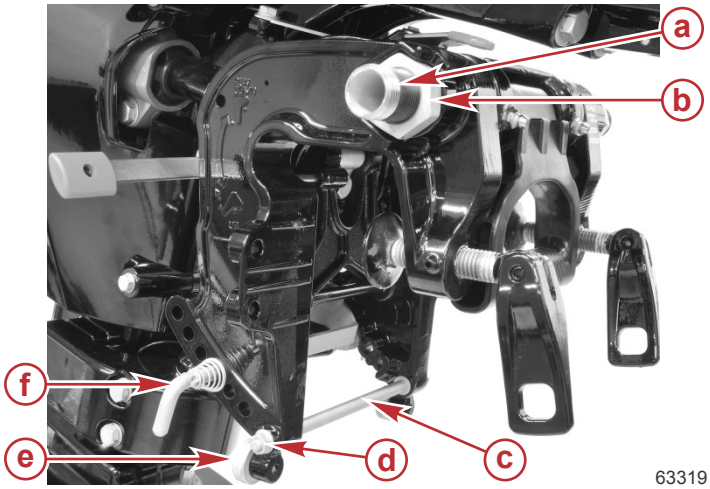
a - Anode
b - Channel for tilt lock

2. Install the clamp bracket partially onto the tilt tube.
3. Lubricate the plastic washer on the tilt tube with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tilt tube washer	92-802859A 1

4. Install the clamp bracket onto the spacer. Ensure that the tilt lock is in the channel. Then, install the washer and nut. Tighten the nut to the specified torque.
5. Thread the nut onto the starboard end of the tilt tube to the end of the threads.
6. Push the tilt tube in until the nut is seated in the hex cavity.
7. Tighten the port tilt tube locknut to the specified torque.
8. Install both caps onto the tilt tube.

9. Install the tilt pin.



a - Tilt tube
b - Nut
c - Spacer
d - Nut and washer
e - Tilt pin
f - Anode

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tilt tube washer	92-802859A 1

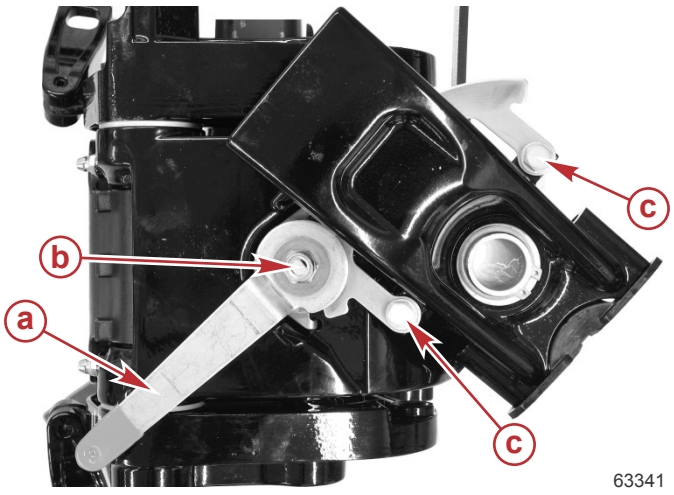
Description	Nm	lb-in.	lb-ft
Tilt tube locknut	24.0	–	17.7
Spacer nut	6.0	53.1	–

Steering Arm Removal

1. Separate the powerhead/driveshaft housing/gearcase assembly from the clamp bracket/swivel bracket/steering arm assembly. Refer to **Powerhead/Midsection Assembly Separation**.

   NOTE: *The air box need not be fully removed for this procedure. Removing the three screws and moving the air box far enough out of the way to allow the recoil starter to be removed is sufficient. This will ease reassembly.*

   NOTE: *Remove the tiller handle, and temporarily secure it to the powerhead with a cable tie to prevent damage.*
2. Remove one locknut to remove the copilot handle.
3. Remove two screws with washers to remove the remaining copilot components from the swivel bracket.

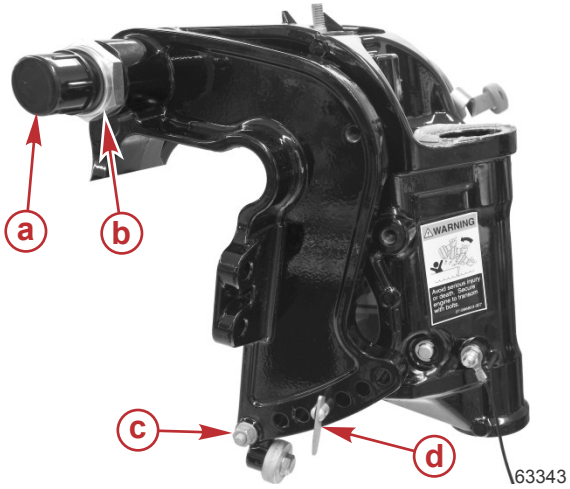


a - Copilot handle
b - Locknut
c - Screw with washer

4. Remove the steering arm.

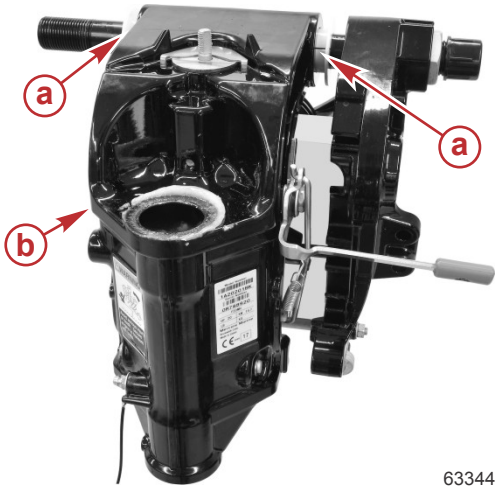
Swivel Bracket Removal

1. Remove the steering arm. Refer to **Steering Arm Removal**.
2. Remove the tilt tube port side cap and locknut, spacer bar nut and washer, and tilt pin.



a - Tilt tube cap
b - Tilt tube port side locknut
c - Spacer bar nut and washer
d - Tilt pin

3. Remove the swivel bracket and bushings from the tilt tube.

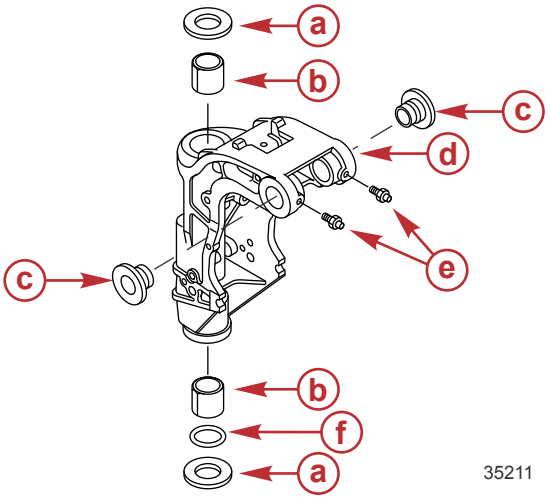


a - Bushing
b - Swivel bracket

Swivel Bracket Inspection

1. Remove the bushings from the swivel bracket.
2. Inspect for wear. Replace if necessary.

3. Clean the swivel bracket.
4. Apply 2-4-C with PTFE to the bushings.
5. Install the bushings into the swivel bracket.

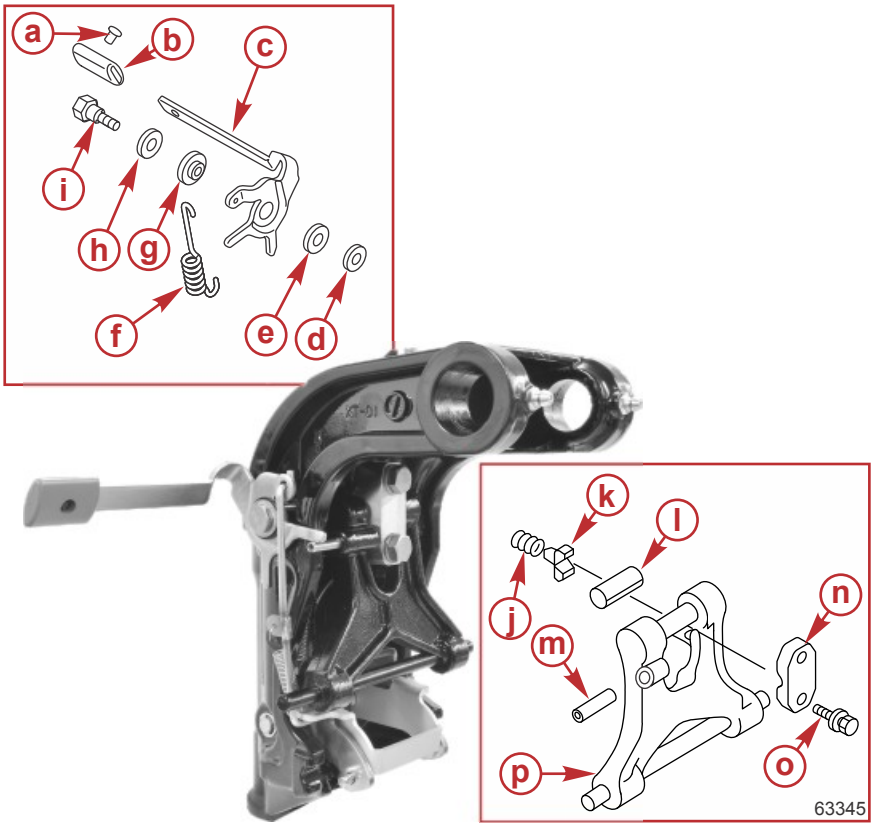


- **a -** Thrust plate (2)
- **b -** Swivel bushing (2)
- **c -** Tilt bushing (2)
- **d -** Swivel bracket
- **e -** Grease fitting
- **f -** O-ring

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Swivel bracket bushings	92-802859A 1

Tilt Stop and Reverse Lock Lever

IMPORTANT: When assembling the reverse lock lever, be certain to apply Loctite® 222 Threadlocker to the shoulder screw and tighten the screw to the specified torque.

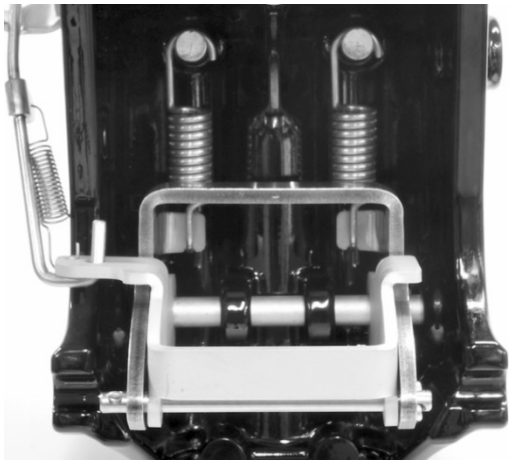


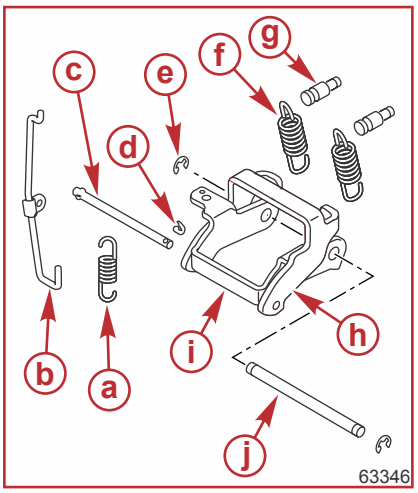
- **a -** Button
- **b -** Grip
- **c -** Lever
- **d -** Washer
- **e -** Washer
- **f -** Spring
- **g -** Bushing
- **h -** Washer
- **i -** Shoulder screw
- **j -** Spring
- **k -** Pivot guide
- **l -** Bushing
- **m -** Spring pin
- **n -** Plate
- **o -** Screw
- **p -** Tilt stopper

Tube Ref No.	Description	Where Used	Part No.
51	Loctite® 222 Threadlocker	Shoulder screw	92-809818

Description	Nm	lb-in.	lb-ft
Shoulder screw	13	115	–

Reverse Lock

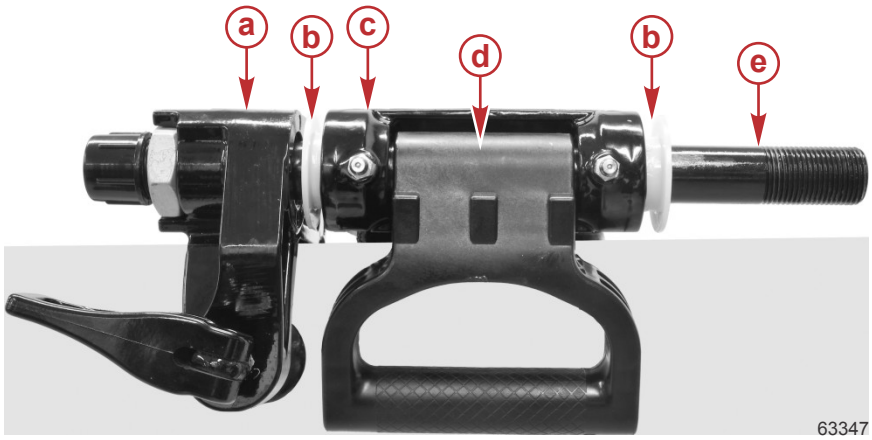




- **a -** Reverse lock spring
- **b -** Reverse lock link
- **c -** Reverse lock rod
- **d -** Split pin
- **e -** E-clip (2)
- **f -** Reverse lock spring (2)
- **g -** Pin (2)
- **h -** Reverse lock
- **i -** Reverse lock arm
- **j -** Reverse lock shaft

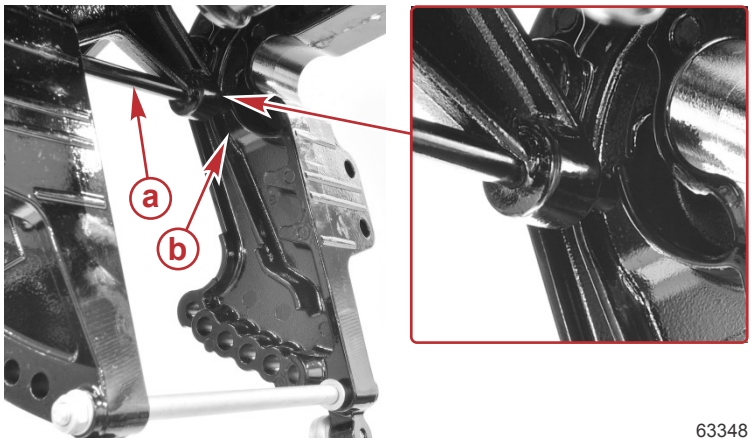
Swivel Bracket Installation

1. Clean the tilt tube and clamp brackets.
2. Insert the tilt tube through the starboard clamp bracket.
3. Install the two bushings, the swivel bracket, and the carry handle onto the tilt tube.



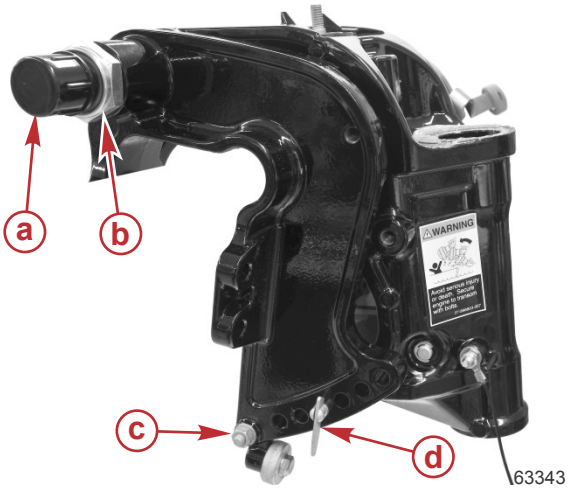
- **a -** Starboard clamp bracket
- **b -** Bushing (2)
- **c -** Swivel bracket
- **d -** Carry handle
- **e -** Tilt tube

4. Install a washer onto the clamp bracket spacer.
5. Install the port clamp bracket onto the tilt tube and clamp bracket spacer.
6. Ensure that the tilt lock guide bar is in the channels of the clamp brackets.



- **a -** Tilt lock guide bar
- **b -** Channel in the starboard clamp bracket (port similar)

7. Install the locknut onto the tilt tube. Tighten the locknut to the specified torque.
8. Install the washer and nut onto the clamp bracket spacer. Tighten the nut to the specified torque.
9. Install the tilt pin.
10. Install the tilt tube caps.

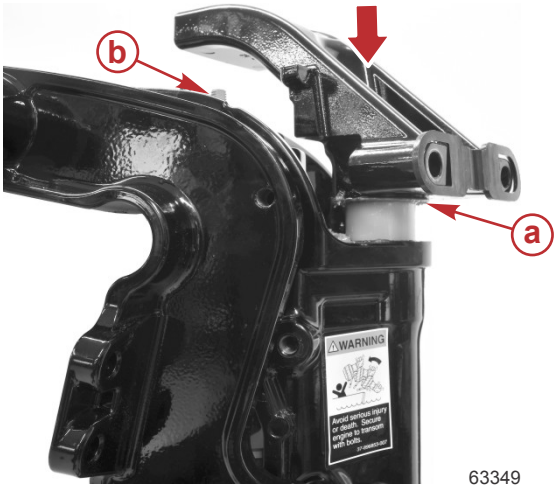


a - Tilt tube cap (one each end)
b - Locknut
c - Clamp bracket spacer nut and washer
d - Tilt pin

Description	Nm	lb-in.	lb-ft
Tilt tube locknut	24.0	–	17.7
Clamp bracket nut	6.0	53.1	–

Steering Arm Installation

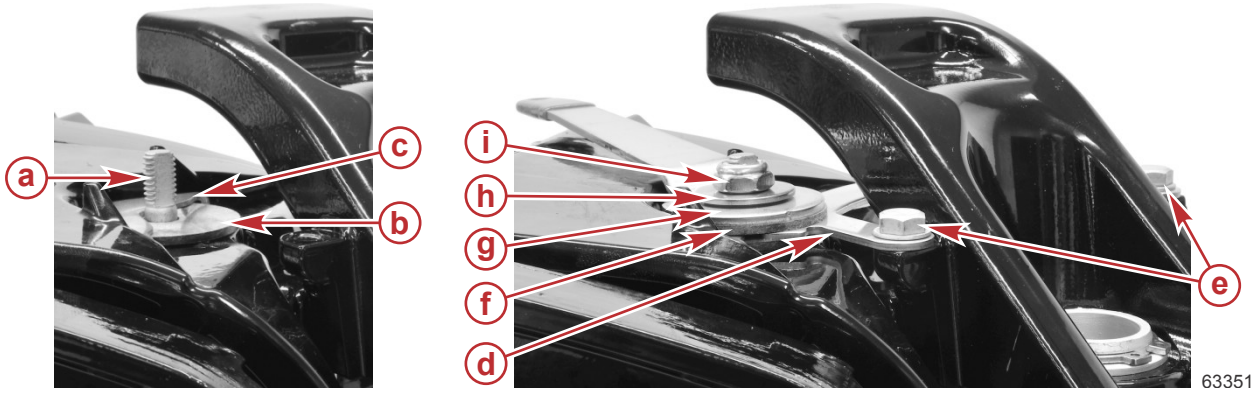
1. Install a washer onto the steering arm shaft.
2. Insert the steering arm into the swivel bracket. Ensure that the lower bushing remains in the swivel bracket.
3. Install the copilot hardware:
   a. Install the copilot threaded rod into the swivel bracket.



a - Washer
b - Copilot threaded rod

   b. Install one disc and washer (item c, shown following) onto the threaded rod.
   c. Attach the plate to the steering arm with two screws and washers.

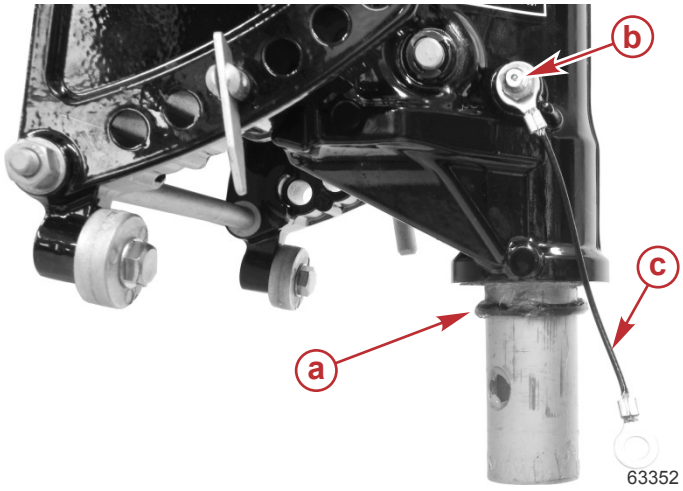
d. Install a disc, handle, washer, and locknut onto the threaded rod. Tighten the locknut to the specified torque.



a - Threaded rod
b - Disc
c - Washer
d - Plate
e - Screws and washers
f - Disc
g - Copilot handle
h - Washer
i - Locknut

Description	Nm	lb-in.	lb-ft
Copilot locknut	11.0	97.3	–

4. Lubricate the steering arm O-ring with 2-4-C with PTFE.
5. Install the O-ring onto the steering arm shaft.



a - O-ring
b - Grease fitting
c - Ground continuity wire

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Steering arm O-ring	92-802859A 1

6. Attach the outboard to the swivel bracket. Refer to **Powerhead/Midsection Assembly Separation**.

IMPORTANT: Ensure that the upper mount locknuts are tightened to the specified torque.

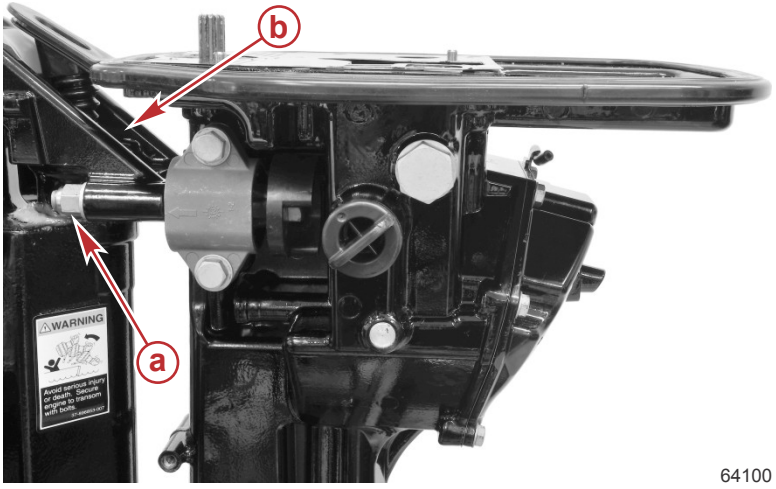
Be certain to coat the threads of the tiller handle screws with Loctite® 271 Threadlocker, and ensure that the tiller handle screws are tightened to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite® 271 Threadlocker	Tiller handle screw threads	92-809819

Description	Nm	lb-in.	lb-ft
Upper mount locknut	27.0	–	19.9
Tiller handle screws	40.0	–	29.5

Driveshaft Housing Removal

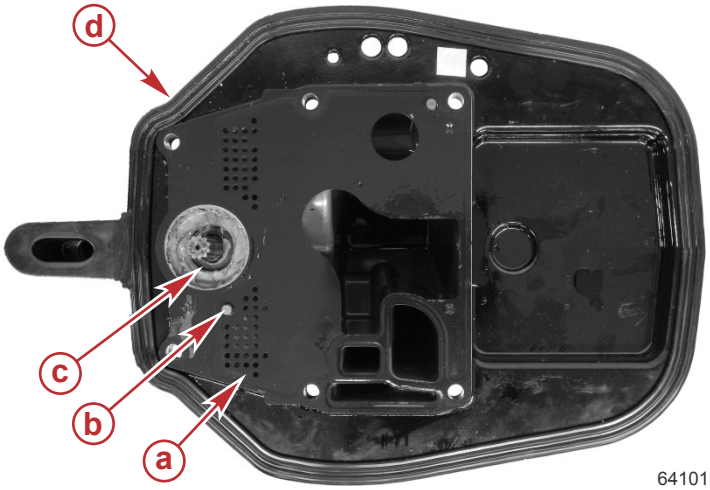
1. Completely remove the driveshaft housing covers, including disconnecting the cowl-mounted tilt switch (if equipped) and the power tilt pump wires (if equipped). Refer to **Driveshaft Housing Covers**.
2. Remove the front cowl. Refer to **Front Cowl**.
3. Remove the gear housing. Refer to **Section 6A - Gear Housing Removal**.
4. Remove the powerhead. Refer to **Section 4A - Powerhead Removal**.
5. Remove the lower mount. Refer to **Lower Mount**.
6. Remove the two upper mount nuts.
7. Remove the driveshaft housing from the steering arm.



64100

a - Nut (one each side)
b - Steering arm

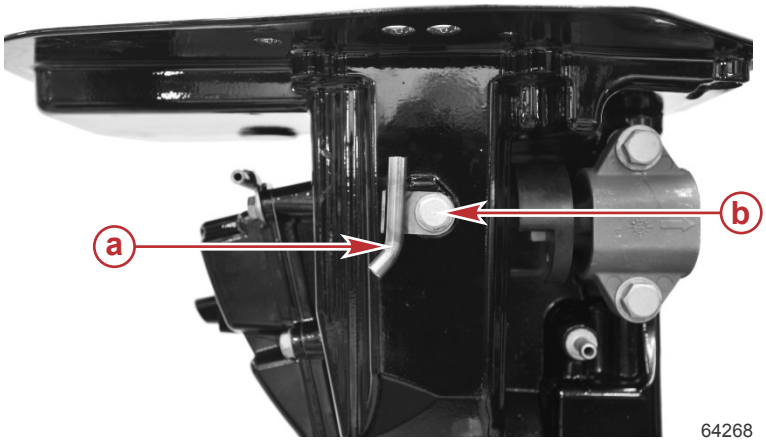
8. Remove the powerhead gasket.
9. Remove the driveshaft seal.
10. Remove the rubber seal from the driveshaft housing.



64101

a - Powerhead gasket
b - Dowel pin
c - Driveshaft seal
d - Rubber seal

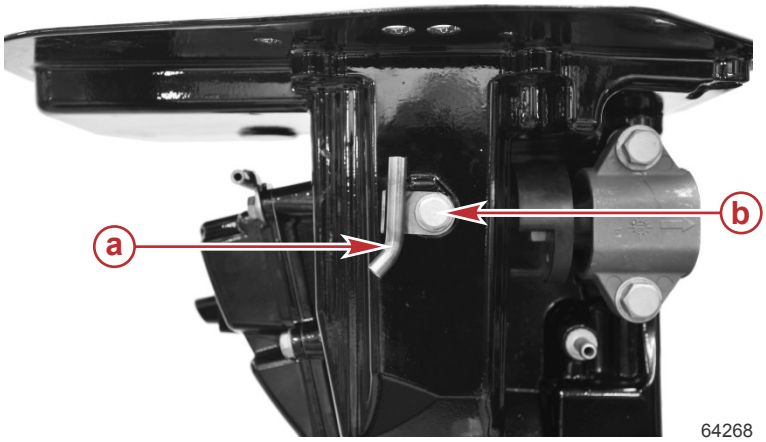
11. Remove one screw to remove the water pump indicator tube.



a - Water pump indicator tube
b - Screw

Driveshaft Housing Installation

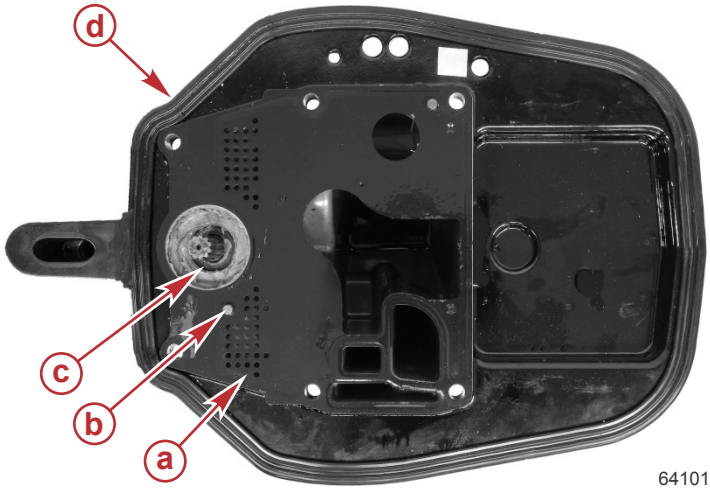
1. Using one screw, attach the water pump indicator tube to the driveshaft housing. Tighten the screw to the specified torque.



a - Water pump indicator tube
b - Screw

Description	Nm	lb-in.	lb-ft
Screw	6.0	53.1	–

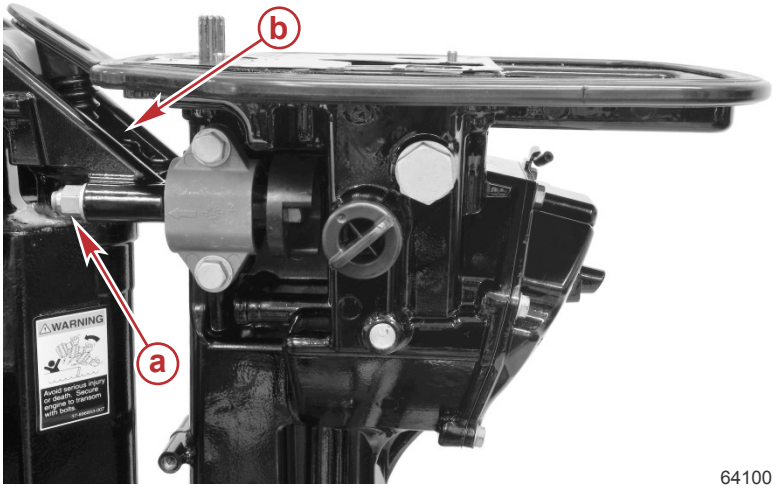
2. Install the rubber seal onto the driveshaft housing.
3. Install the driveshaft seal.
4. Install the powerhead gasket.



a - Powerhead gasket
b - Dowel pin
c - Driveshaft seal
d - Rubber seal

5. Install the driveshaft housing onto the steering arm.

6. Install the two upper mount locknuts. Tighten the locknuts to the specified torque.



64100

a - Locknut (one each side)
b - Steering arm

Description	Nm	lb-in.	lb-ft
Locknuts	27.0	–	19.9

7. Install the lower mount. Refer to **Lower Mount**.
8. Install the powerhead. Refer to **Section 4A - Powerhead Installation**.
9. Install the gear housing. Refer to **Section 6A - Gear Housing Installation**.
10. Install the front cowl. Refer to **Front Cowl**.
11. Install the driveshaft housing covers. Refer to **Driveshaft Housing Covers**.

Shift Operation

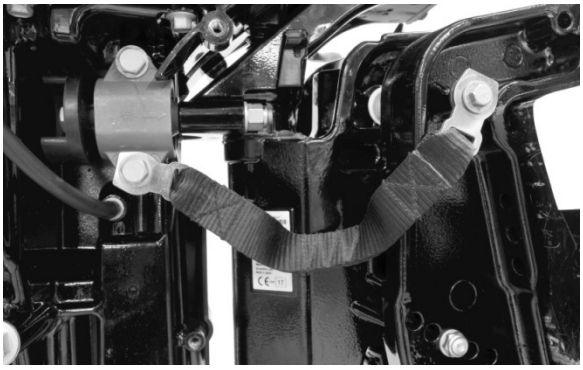
1. Check shift operation as follows:
   a. Place the shift handle or remote control in forward. The gear housing should ratchet when the propeller shaft is rotated clockwise. Resistance should be felt when the propeller shaft is rotated counterclockwise.
   b. Place the shift handle or remote control in neutral. Resistance should not be felt when the propeller shaft is rotated in either direction.
   c. Place the shift handle or remote control in reverse. Resistance should be felt when the propeller shaft is rotated in either direction.
2. If shift operation is not as described, refer to **Section 6A or 6B - Gear Housing Installation, or Section 7B - Throttle Cable/Linkage Adjustments.**

Kicker Strap (Tiller Handle Model)

⚠ WARNING

Avoid injury or death from loss of steering control. ProKicker centering straps prevent the outboard from turning when tilted up. If using a steering tie bar to a second outboard, disconnect the steering tie bar to allow steering of the second outboard before operating the boat.

The ProKicker tiller handle model is equipped with kicker straps located on each side of the outboard. The straps prevent the outboard from pivoting when the outboard is tilted up. When the outboard is in the full up position, the kicker straps should be tight and center the outboard.


63832

Shown with starboard driveshaft housing cover removed

Removal

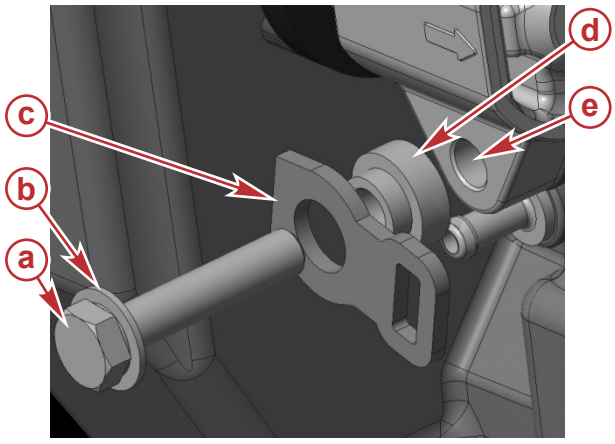
1. Remove the driveshaft housing cover for easier access to the kicker strap retaining hardware. Refer to **Driveshaft Housing Cover**.

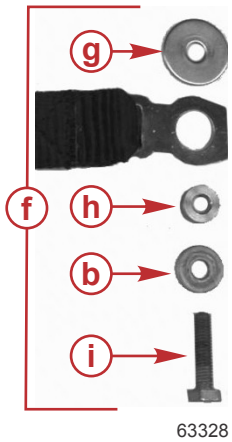
   NOTE: *For power tilt models, it is not necessary to disconnect the power tilt pump wires. Feed enough of the power tilt pump wires through the grommet in the port cover to allow the cover to hang out of the way.*
2. Remove the mounting hardware securing the starboard kicker strap to the clamp bracket.
3. Remove the mounting hardware securing the starboard kicker strap to the upper engine mount.
4. Repeat for the port kicker strap.
5. If the engine is being returned to service without the kicker strap, be certain to install the upper engine mount screws, and tighten them to the specified torque.

Description	Nm	lb-in.	lb-ft
Upper engine mount screw	13	115	–

Installation

1. Lower the outboard to the operating position.
2. Install the starboard kicker strap onto the clamp bracket and upper engine mount with hardware, as shown. The large diameter flat washer and long screw are used on the clamp bracket end of the kicker strap.





63328

a - Upper engine mount screw
b - Small diameter flat washer
c - End of kicker strap
d - Stepped bushing
e - Lower mounting hole on upper engine mount
f - To clamp bracket
g - Large diameter flat washer
h - Bushing
i - Screw

3. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Kicker strap attaching screw	6.0	53.1	–
Upper engine mount screw	13	115	–

4. Repeat the steps to install the port kicker strap.
5. Install the driveshaft housing cover onto the driveshaft housing. Refer to **Driveshaft Housing Cover**.

Notes:

Midsection

Section 5B - Power Tilt

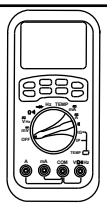
Table of Contents

5B

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Power tilt system	92-858074K01
		Lubrication of O-rings	
		Lubrication of power tilt O-rings	

Special Tools

DMT 2004 Digital Multimeter	91-892647A01
 4516	Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments.

Power Tilt Specifications

Parameter	Specification
System fluid	Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) (Type Dexron III)
Electric motor - Maximum current draw	35 A

General Troubleshooting

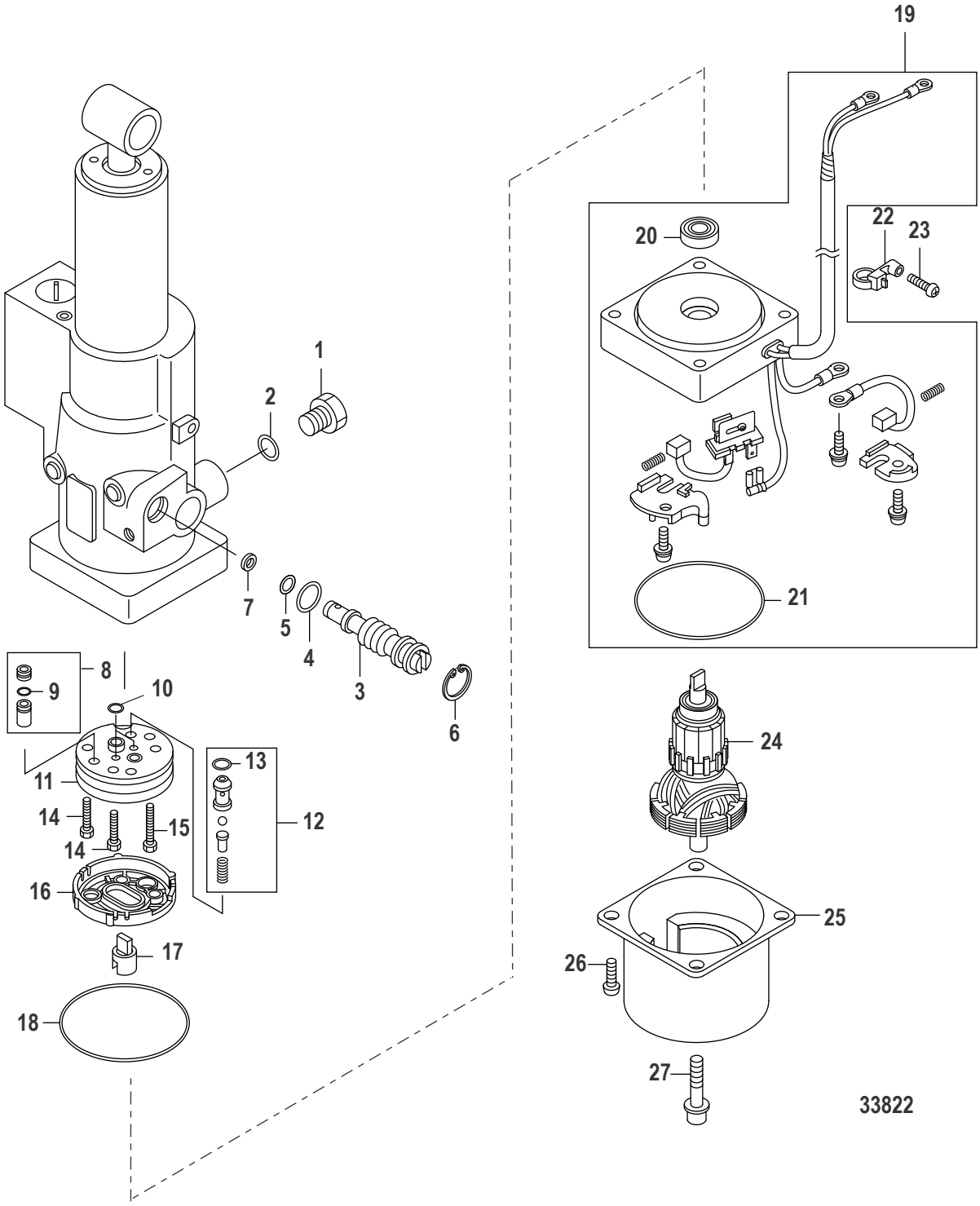
For general troubleshooting information, including connecting and using the CDS G3 diagnostic tool, refer to **Section 1E - General Troubleshooting**.

Power Tilt - General Information

- The power tilt system consists of an integral unit which contains an electric motor, hydraulic pump, fluid reservoir, and a tilt cylinder.
- The remote control (or tiller handle) has a switch that tilts the outboard up for trailering or down for operation.
- At low idle speed, the outboard can also be tilted to permit shallow water operation.
- The outboard cannot be trimmed at speeds above low idle.

Notes:

Power Tilt Components

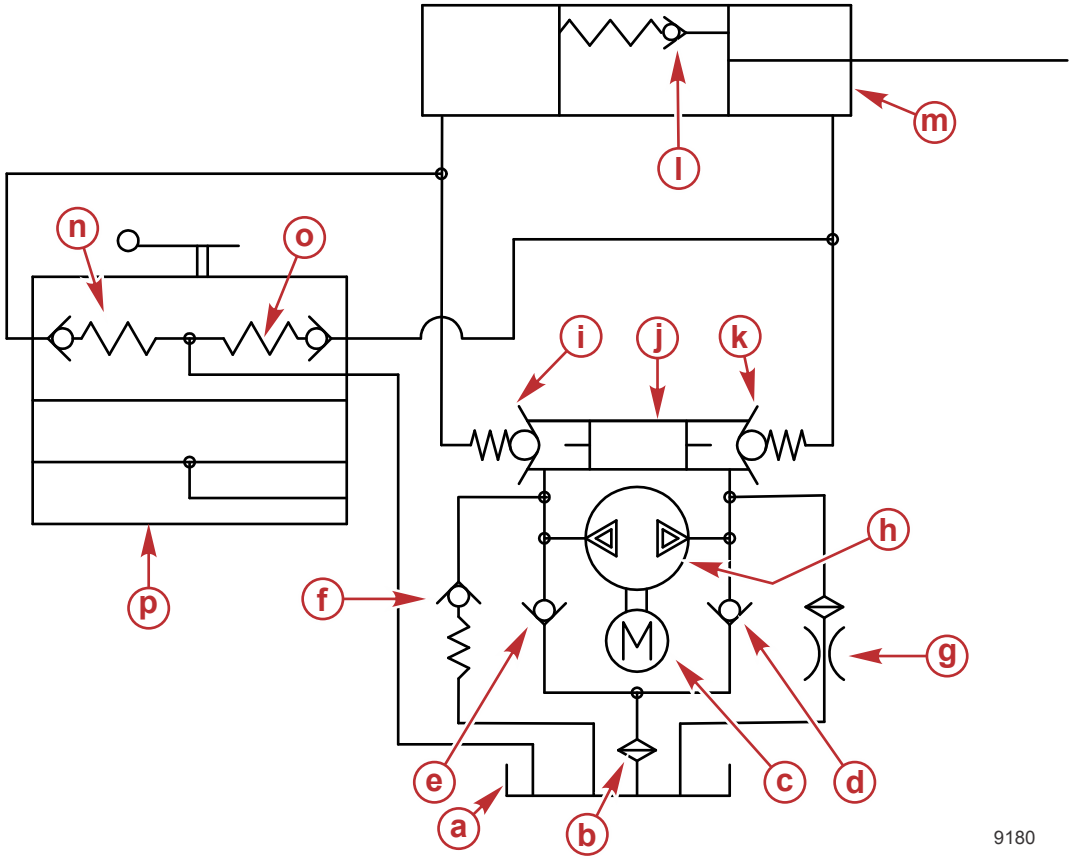


Power Tilt Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Cap assembly			
2	1	O-ring			
3	1	Manual release valve assembly			
4	1	O-ring			
5	1	O-ring			
6	1	C-ring			
7	1	Seal			
8	1	Down orifice assembly			
9	1	O-ring			
10	2	O-ring			
11	1	Pump			
12	1	Up relief valve assembly			
13	1	O-ring			
14	2	Bolt (M5 x 20)	5.2	46.0	–
15	1	Bolt (M5 x 25)	5.2	46.0	–
16	1	Filter			
17	1	Coupling			
18	1	O-ring			
19	1	Motor bracket assembly			
20	1	Oil seal			
21	1	O-ring			
22	1	Cable tie			
23	1	Screw	0.6	5.3	–
24	1	Armature assembly			
25	1	Housing			
26	2	Screw	5.2	46.0	–
27	2	Screw (M5)	5.2	46.0	–

Theory of Operation

Power Tilt Hydraulic Diagram



- **a -** Reservoir
- **b -** Filter
- **c -** Electric motor
- **d -** Tilt up inlet check valve
- **e -** Tilt down inlet check valve
- **f -** Up circuit relief valve
- **g -** Down circuit relief orifice
- **h -** Hydraulic pump
- **i -** Tilt up pressure operated check valve
- **j -** Shuttle valve
- **k -** Tilt down pressure operated check valve
- **l -** Impact relief valve
- **m -** Tilt cylinder
- **n -** Up circuit thermal relief valve
- **o -** Down circuit thermal relief valve
- **p -** Manual release valve

Operation

Tilt Circuit - Up

When the tilt up circuit is activated, the electric motor rotates the hydraulic pump. As the pump's gears rotate, fluid is drawn through a check valve and into the pump's inlet. The pump's flow passes through a check valve, then passes through a pressure operated (PO) check valve and to the bottom of the tilt cylinder. The fluid pushes the cylinder piston out, tilting the engine up. Oil, from the top side of the cylinder, returns through a passage in the cylinder wall to the inlet side of the pump. In this mode, as the tilt ram extends to its limit, up pressure increases and opens the up pressure relief valve. When the engine is not running, the outboard may be tilted to the full up position by opening the manual release valve.

Tilt Circuit - Down

When the down circuit is activated, the electric motor rotates in the opposite direction. As the pump's gears rotate, fluid is drawn through a check valve and into the pump's inlet. The pump flow passes through a check valve and to the top of the tilt cylinder. The fluid pushes the cylinder piston down and lowers the engine. Oil, from the bottom side of the cylinder, returns to the inlet side of the pump. As the tilt cylinder retracts to its limit, down pressure is limited by an orifice in the down pressure circuit.

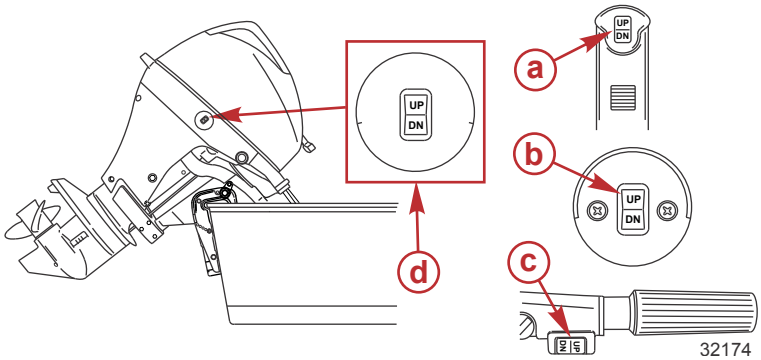
Trail Over System

Should the outboard motor strike a submerged object while in forward motion, hydraulic pressure on the top side of the cylinder will increase to cause the impact relief valve in the tilt cylinder to open. This allows the lower unit to trail over the obstruction. The fluid in the top side of the cylinder opens the impact relief valve and flows into the cavity between the memory piston and the cylinder piston. When the lower unit clears the submerged object, the thrust of the engine forces the engine back down. As the cylinder piston is lowered, fluid trapped between the memory piston and the cylinder piston escapes through a return check valve. Fluid below the memory piston is trapped in place, therefore, stopping the cylinder piston and returning the outboard to its previous tilt position.

Power Tilt Features and Operation

Power Tilt

Models equipped with power tilt allow the operator to use the tilt switch to adjust the tilt position of the outboard from full down to full up. This tilt system is designed to be adjusted when the engine speed is at idle speed or with the engine turned off. At low idle speed, the outboard can be tilted up to permit shallow water operation.



a - Remote control tilt switch
b - Panel mount tilt switch
c - Tiller handle tilt switch
d - Cowl-mounted tilt switch

Manual Tilt Release

If the outboard cannot be tilted using the power tilt switch, the outboard can be manually tilted.

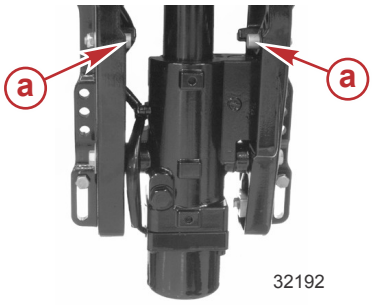
NOTE: *The manual tilt release valve must be tightened before operating the outboard to prevent the outboard from tilting up during reverse operation.*

Turn out the manual tilt release valve three turns counterclockwise. This allows manual tilting of the outboard. Tilt the outboard to the desired position and tighten the manual tilt release valve.

Tilt-in Stop Adjustment

NOTE: *The outboard should be positioned against the tilt-in stop pins during operation.*

The adjustment of the tilt-in stop pins will set the vertical operating angle of your outboard. Proper adjustment allows the boat to run stable, achieve optimum performance, and minimize steering effort.

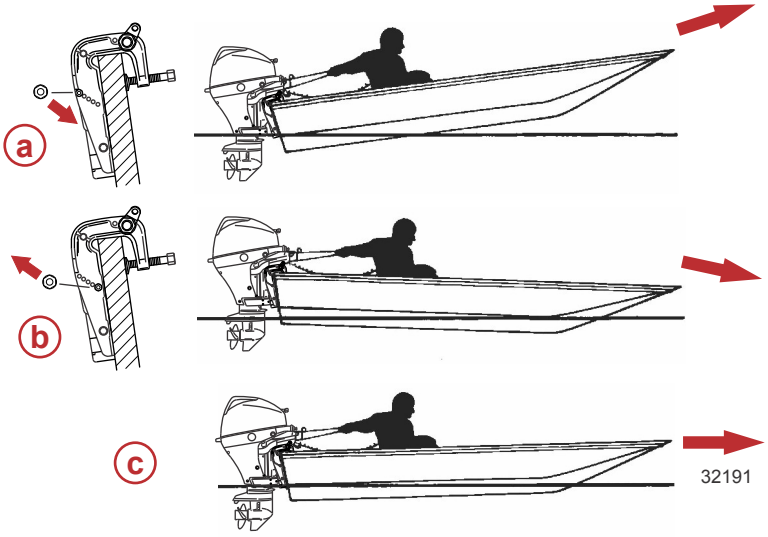


a - Tilt-in stop pins

NOTE: *Refer to the following when adjusting the operating angle of your outboard.*

The tilt-in stop pins should be adjusted so the outboard is positioned to run perpendicular to the water when the boat is running at full speed. This allows the boat to be driven parallel to the water.

Arrange passengers and load in the boat so the weight is distributed evenly.

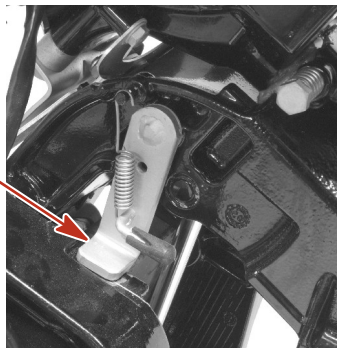


a - Too much angle (stern down - bow up)
b - Not enough angle (stern up - bow down)
c - Angle adjusted properly (bow slightly up)

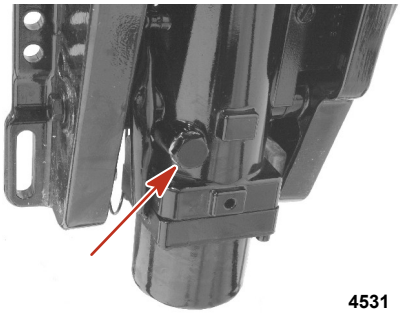
Check Fluid and Purge the Power Tilt System

Check Fluid

1. Tilt the outboard to the full up position and engage the tilt support lever.



2. Remove the fill plug and check the fluid level. The fluid level should be even with the bottom of the fill hole. Add Quicksilver or Mercury Precision Lubricants Power Trim and Steering Fluid. If not available, use automotive automatic transmission fluid (ATF).



Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Power tilt system	92-858074K01

3. Reinstall the fill plug.

Purging the Power Tilt System

IMPORTANT: The fill plug must be tightened securely before operating the power tilt system.

Operate the power tilt system in short spurts until the hydraulic pump is primed and the tilt cylinder moves.

- Cycle the outboard through the entire tilt range four times.
- To check for presence of air in the system, extend the cylinder slightly and push down on outboard. If the tilt cylinder retracts more than 3 mm (0.125 in.), air is present in the system. Cycle tilt cylinder again and repeat this step.
- Recheck the fluid level.

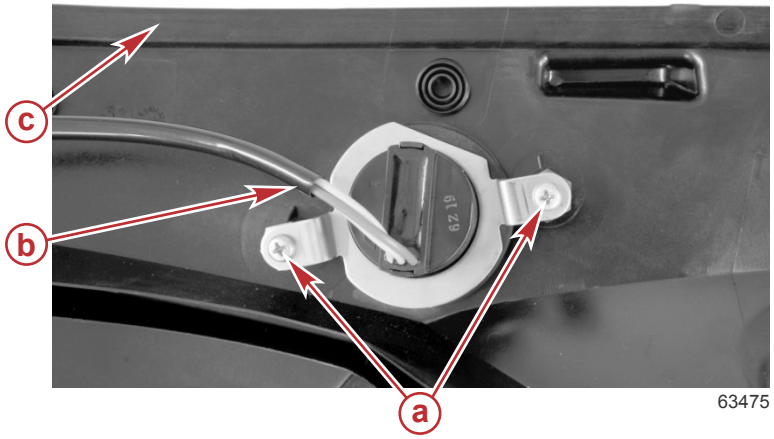
Cowl-Mounted Tilt Switch

On remote control models, the cowl-mounted tilt switch provides an easy way to raise or lower the outboard while performing maintenance or service procedures.

Removal

1. Remove the port-side driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.

   NOTE: *It is not necessary to disconnect the power tilt unit.*
2. Disconnect the tilt switch from the engine harness.
3. Remove the two screws that hold the tilt switch to the inside of the driveshaft housing cover.

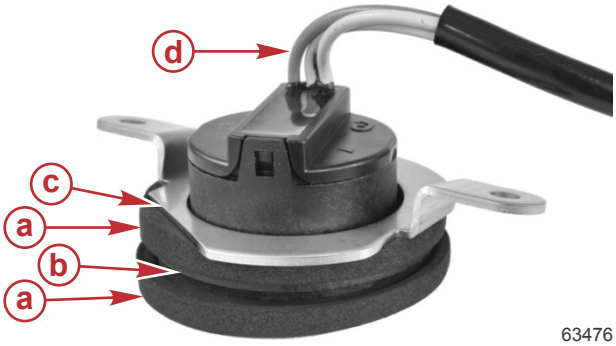


a - Screws (2)
b - Tilt switch harness
c - Top edge of port-side driveshaft housing cover

Installation

1. Place two foam gaskets and the mounting bracket on the tilt switch.
2. Install the tilt switch into the port-side driveshaft housing cover, using two screws.
   - The flat edge of the mounting bracket should face upward.

- The switch should be positioned with the harness at the bottom.
- Ensure that the switch is vertical before tightening the screws.



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a - Foam gasket
b - Flange on tilt switch housing
c - Flat edge of mounting bracket
d - Switch harness exits at the bottom of the switch

3. Install the port-side driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.
4. Confirm proper up/down operation of the tilt switch.

Troubleshooting the Power Tilt System

Preliminary Troubleshooting Steps

Determine if the problem is hydraulic or electrical related. Most often, if the electric motor operates, the problem is in the hydraulic system. If the electric motor does not operate, the problem is in the electrical system.

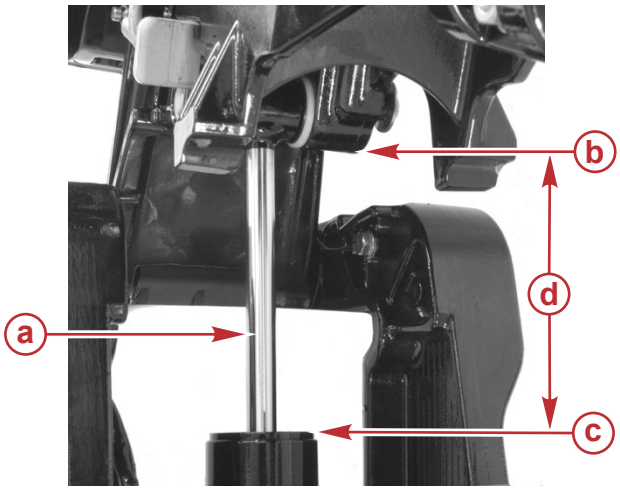
IMPORTANT: Operate the power tilt system after each check to see if the problem is corrected. If the problem has not been corrected, proceed with the next check.

1. Check that the manual release valve is tightened fully (clockwise).
2. Check the power tilt pump fluid level in the full up position. Fill if necessary. Refer to **Check Fluid and Purge the Power Tilt System**.
3. Check for external leakage in the power tilt system. Replace/repair the defective component if a leak is found. Maximum acceptable power tilt cylinder leak-down is 55 mm (2.2 in.) within a 24 hour period. Refer to **Power Tilt Leakage Test Procedure**.

Power Tilt Leakage Test Procedure

Method 1

1. Extend the power tilt cylinder to the full up position.
2. Measure the distance between the cylinder cap and the bottom of the power tilt cylinder rod eye.
3. Wait 24 hours and measure the distance again.



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a - Cylinder rod
b - Rod eye
c - Cylinder cap
d - Measured distance

Power Tilt System Leakage Specification	
Cylinder rod leak-down in 24 hour period	Less than 55 mm (2.2 in.)

Method 2

1. Extend the power tilt cylinder to the full up position.
2. Mark the tilt cylinder rod 55 mm (2.2 in.) above the cylinder cap with an indelible marker.
3. Wait 24 hours.
4. If the marked line is visible, the power tilt unit is within specifications for leakage.

Power Tilt System Leakage Specification	
Cylinder rod leak-down in 24 hour period	Less than 55 mm (2.2 in.)

Hydraulic System Troubleshooting

Condition/Problem

Condition of Tilt System	Problem
Tilt motor runs; tilt system does not move up or down	1, 2, 5, 7
Does not tilt full down. Up tilt OK.	1, 3, 4, 6, 7, 11
Does not tilt full up. Down tilt OK.	1, 4, 6, 7, 10
Partial or jerky down/up	1, 3, 6
Leaks down and does not hold tilt	4, 5
Tilt motor working hard and tilts slow up and down	7, 8, 9
Tilts up very slow	1, 2, 6, 7, 8, 9, 10
Starts to tilt up from full down position when the down tilt button is depressed	3, 4

Problem/Solution

No.	Problem	Solution
1.	Low fluid level	Add Power Trim and Steering Fluid or ATF (Type Dexron III).
2.	Defective hydraulic pump	Replace pump assembly.
3.	Tilt cylinder piston O-ring leaking or cut	Replace power tilt assembly.
4.	Manual release valve leaking (check condition of O-rings) (valve not fully closed)	Ensure that valve is fully closed. Inspect O-rings.
5.	Debris in system	Inspect for debris. Refill system with clean fluid.
6.	Battery low	Check battery.
7.	Electric motor defective	Refer to **Tilt Electrical System - General Troubleshooting**.
8.	Broken motor/pump driveshaft	Inspect for damage.
9.	Air pocket under pump	Purge system. Refer to **Purging the Power Tilt System**, preceding.
10.	Defective up relief valve	Inspect components. Refer to **Power Tilt Pump Disassembly**.
11.	Defective down relief valve	Inspect components. Refer to **Power Tilt Pump Disassembly**.

Tilt Electrical System - General Troubleshooting

General Checks

Before troubleshooting the power tilt electrical system, ensure the following:

- No wires are disconnected
- Connections are tight and corrosion-free
- Plug-in connections are fully engaged
- Battery is fully charged

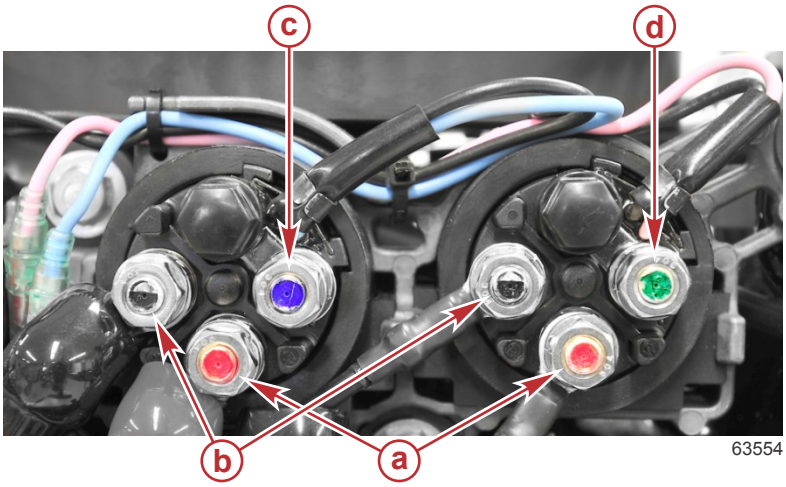
Condition/Problem

Condition of Tilt System	Problem No.
Tilt motor does not run when the tilt button is pressed	1, 3, 4, 5, 6, 7
Tilt system tilts opposite of buttons	2
Tiller handle mounted tilt buttons do not activate the tilt system	3, 4, 5, 6

Problem/Solution

No.	Problem	Solution
1.	Battery low or discharged	Check battery.
2.	Wiring reversed in remote control, handle switch, or tilt leads	Verify connections.
3.	Open circuit in tilt wiring	Check for an open connection.
4.	Wire harness corroded through	Replace wire harness.
5.	Internal motor problem (brushes, shorted armature)	Check for open connection. Replace motor.
6.	Tilt switch failure	Replace switch.
7.	Relay not operating	Verify relays are functioning correctly. Check voltage at tilt bullet connectors.
8.	Fuse open (blown)	Replace fuse.

Power Tilt Relay Test



a - Positive terminals (red)
b - Ground terminals (black)
c - Up relay terminal (blue)
d - Down relay terminal (green)

The tilt motor relay system, used on permanent magnet tilt systems, connects each of the two wires from the tilt motor to either ground or positive in order to allow the motor to run in both directions.

If the motor will not run in the up direction, it may be either the up relay is not making contact to 12 volts or the down relay is not making contact to ground. The opposite is true if the system will not run down. When the system is not energized, both relays should connect the heavy motor leads to ground.

To test which relay is faulty if the tilt system does not operate in one direction:

1. Disconnect the heavy gauge pump wires from the tilt control relay.
2. Check for continuity between the heavy leads from the tilt relays to ground.

Meter Test Leads		Meter Scale	Reading
Red	Black		
Blue relay terminal	Ground	Ω	< 20 Ω (full continuity)
Green relay terminal	Ground	Ω	< 20 Ω (full continuity)

3. Replace the power tilt relay if either test shows an open circuit.
4. Connect a voltmeter to the heavy blue lead and to ground. There should be 12 volts on the blue lead when the up switch is pushed. There should also be 12 volts on the green lead when the down switch is pushed.

Meter Test Leads		Meter Scale	Reading
Red	Black		
Blue relay terminal	Ground	DC voltage	Battery voltage (~12 V)
Green relay terminal	Ground	DC voltage	Battery voltage (~12 V)

5. Replace the power tilt relay if it does not switch either lead to positive.
6. Reconnect the heavy gauge pump wires to the tilt control relay.

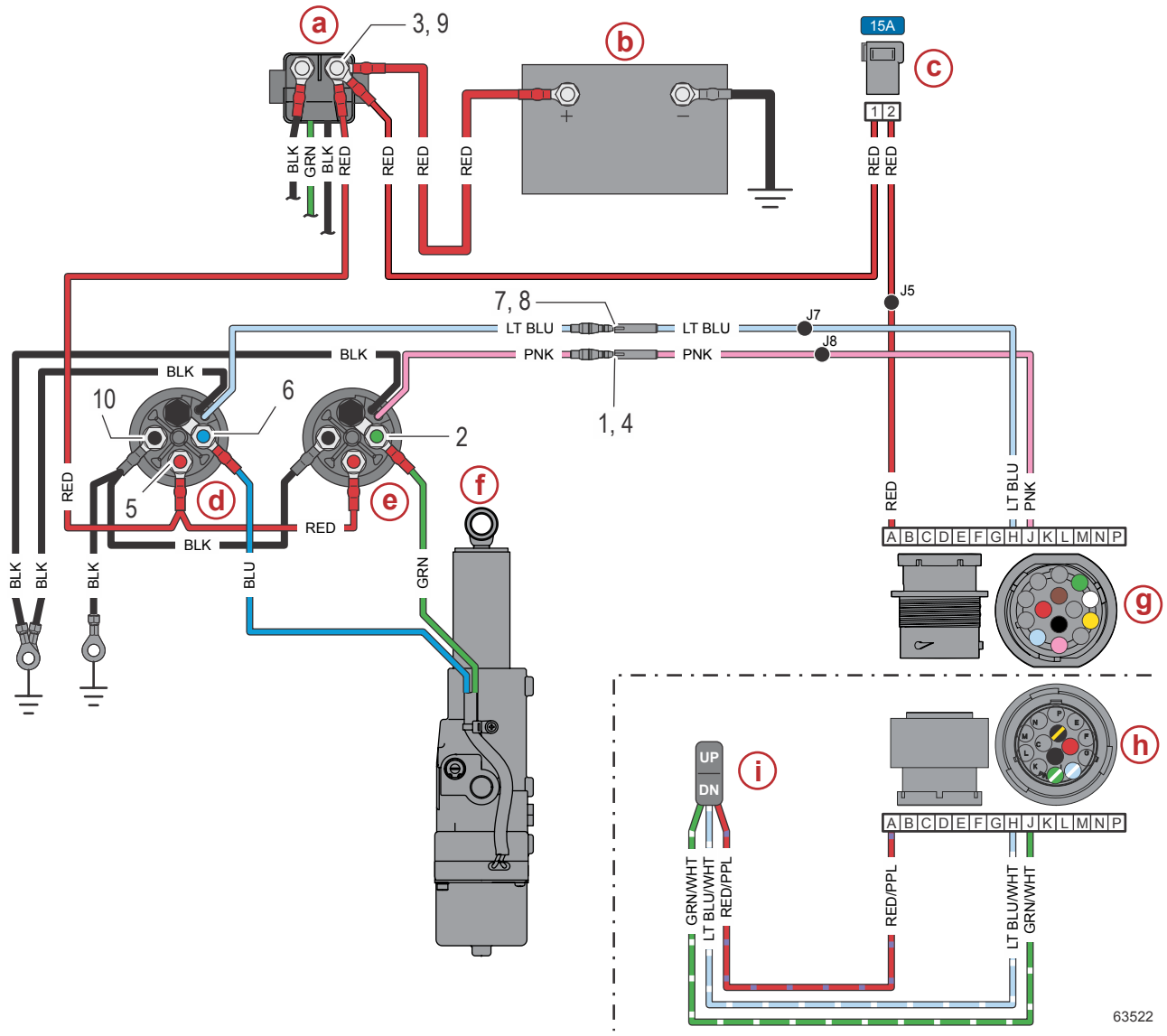
Wire Color Code Abbreviations

Wire Color Abbreviations				
BLK	Black		BLU	Blue
BRN	Brown		GRA	Gray
GRN	Green		ORN	Orange
PNK	Pink		PPL	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT	Light		DK	Dark

Tilt System Wiring Diagrams

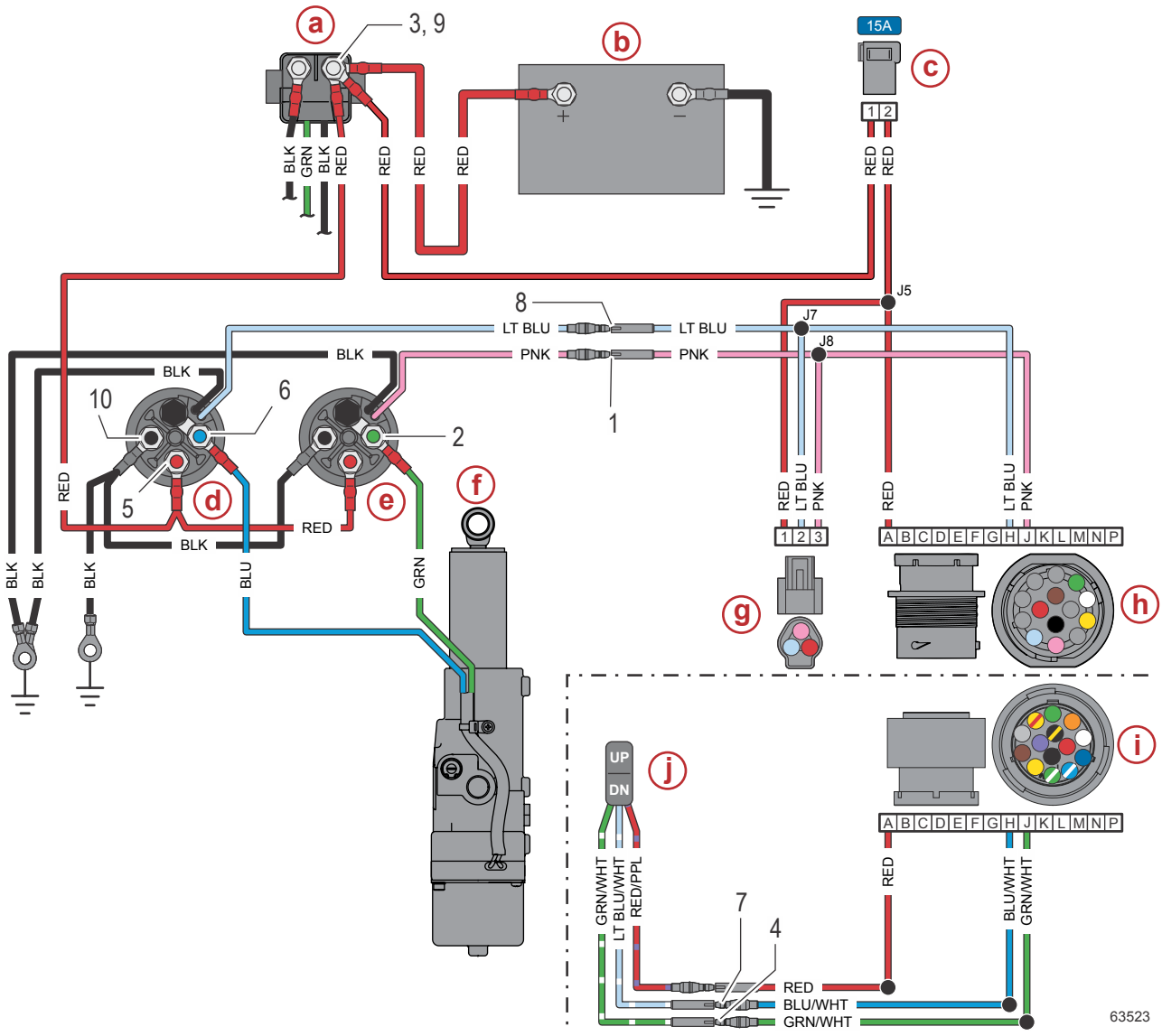
NOTE: *The numbered callouts in these wiring diagrams correspond to test points identified in the following* ***Tilt System Troubleshooting Charts****.*

Power Tilt Electrical Circuit - Tiller Handle



- **a -** Starter solenoid
- **b -** Battery
- **c -** 15-amp fuse
- **d -** Tilt up relay
- **e -** Tilt down relay
- **f -** Power tilt assembly
- **g -** Engine harness 14-pin connector
- **h -** Tiller handle harness 14-pin connector
- **i -** Tiller handle tilt switch

Power Tilt Electrical Circuit - Remote Control



Typical (side mount remote control shown, others similar)

- **a -** Starter solenoid
- **b -** Battery
- **c -** 15-amp fuse
- **d -** Tilt up relay
- **e -** Tilt down relay
- **f -** Power tilt assembly
- **g -** Cowl-mounted tilt switch
- **h -** Engine harness 14-pin connector
- **i -** Side mount remote control harness 14-pin connector
- **j -** Tilt switch on side mount remote control

Tilt System Troubleshooting Charts

Troubleshooting the Down Circuit

NOTE: *Refer to the preceding wiring diagrams for test points when troubleshooting the electrical systems. Test points are specified by number.*

Step	Test Procedure	Test Result
Step 1: Check for battery voltage at point 1.	1. Connect voltmeter red lead to point 1 and black lead to ground. 2. Press the down tilt button.	Battery voltage measured: • Go to step 2. No battery voltage measured: • Go to step 3.
Step 2: Check for battery voltage at point 3.	Connect voltmeter red lead to point 3 and black lead to ground.	Battery voltage measured: • Go to step 5. No battery voltage measured: • There is an open circuit between point 3 and positive (+) battery terminal. • Check for loose or corroded connections. • Check wires for open.
Step 3: Check for battery voltage at point 4.	1. Connect voltmeter red lead to point 4 and black lead to ground. 2. Press the down tilt button.	Battery voltage measured: • Wire is open between points 4 and 1. No battery voltage measured: • Go to step 4.
Step 4: Check for battery voltage at point 5.	Connect voltmeter red lead to point 5 and black lead to ground.	Battery voltage measured: • Tilt switch is faulty. No battery voltage measured: • Check for loose or corroded wire at point 5. • Open circuit in wire supplying current to point 5.
Step 5: Check for battery voltage at point 2.	1. Connect voltmeter red lead to point 2 and black lead to ground. 2. Press the down tilt button.	Battery voltage measured: • Go to step 6. No battery voltage measured: • Relay is defective.
Step 6: Check up relay.	Test up relay. Refer to **Power Tilt Relay Test**, preceding.	Relay is good: • Pump motor wiring is defective. • Pump motor is defective. Relay is faulty: • Replace relay.

Troubleshooting the Up Circuit

NOTE: *Refer to the preceding wiring diagrams for test points when troubleshooting the electrical systems. Test points are specified by number.*

Step	Test Procedure	Test Result
Step 1: Check for battery voltage at point 8.	1. Connect voltmeter red lead to point 8 and black lead to ground. 2. Press the up tilt button.	Battery voltage measured: • Go to step 2. No battery voltage measured: • Go to step 3.
Step 2: Check for battery voltage at point 9.	Connect voltmeter red lead to point 9 and black lead to ground.	Battery voltage measured: • Go to step 5. No battery voltage measured: • There is an open circuit between point 9 and positive (+) battery terminal. • Check for loose or corroded connections. • Check wires for open.
Step 3: Check for battery voltage at point 7.	1. Connect voltmeter red lead to point 7 and black lead to ground. 2. Press the up tilt button.	Battery voltage measured: • Wire is open between points 7 and 8. No battery voltage measured: • Go to step 4.

Step	Test Procedure	Test Result
Step 4: Check for battery voltage at point 5.	Connect voltmeter red lead to point 5 and black lead to ground.	Battery voltage measured: • Tilt switch is faulty. No battery voltage measured: • Check for loose or corroded wire at point 5. • Open circuit in wire supplying current to point 5.
Step 5: Check for battery voltage at point 6.	1. Connect voltmeter red lead to point 6 and black lead to ground. 2. Press the up tilt button.	Battery voltage measured: • Go to step 6. No battery voltage measured: • Relay is defective.
Step 6: Check down relay.	Test down relay. Refer to **Power Tilt Relay Test**, preceding.	Relay is good: • Pump motor wiring is defective. • Pump motor is defective. Relay is faulty: • Replace relay.

Troubleshooting the Down and Up Circuits (All Circuits Inoperative)

NOTE: *Refer to the preceding wiring diagrams for test points when troubleshooting the electrical systems. Test points are specified by number.*

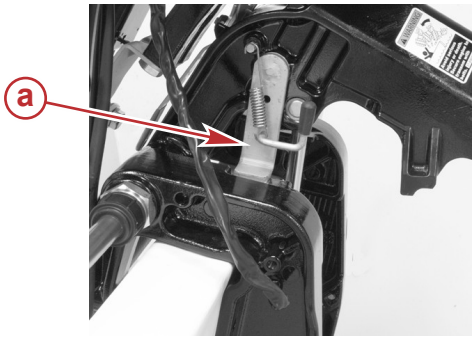
Step	Test Procedure	Test Result
Step 1: Check fuse.	Visually inspect power tilt motor fuse.	Fuse blown: • Correct problem that caused to blow, and • Replace fuse. Fuse not blown: • Go to step 2.
Step 2: Check battery voltage.	Connect voltmeter red lead to point 3 and black lead to ground.	No battery voltage: • Check battery leads for poor connections or open circuit. • Check battery charge. Battery voltage measured: • Go to step 3.
Step 3: Tilt switch.	1. Connect voltmeter red lead to point 8 and black lead to point 1. 2. Press the tilt down button.	No battery voltage: • Go to step 4. Battery voltage measured: • Check black ground wires for connection or poor ground at point 10. • Pump motor is faulty.

Step 4: Open circuits.	Connect voltmeter red lead to point 5 and black lead to ground.	No voltage measured:
		• Go to step 5.
		Battery voltage measured:
		• Tilt switch is faulty or
		• Open circuit in wires (green/white or blue/white) between tilt buttons and tilt pump motor.
		• Check
		  • Tilt switch.
		  • All tilt harness connections for loose or corroded connections.
		  • Pinched or severed wires.

Step	Test Procedure	Test Result
Step 5: Check voltage.	Check that voltage is being supplied to control by performing the following checks: 1. Do not start engine. 2. Turn ignition switch to "RUN" position. 3. Check for voltage at any instrument using a voltmeter.	No voltage measured: • Red wire is open between point 3 and red terminal on back of ignition switch. • Check for loose or corroded connections. • Check for open in wire. Battery voltage measured: • There is an open circuit between point 5 and red terminal on back of ignition switch.

Power Tilt Removal

1. Tilt the outboard to the full up position and engage the tilt support lever.



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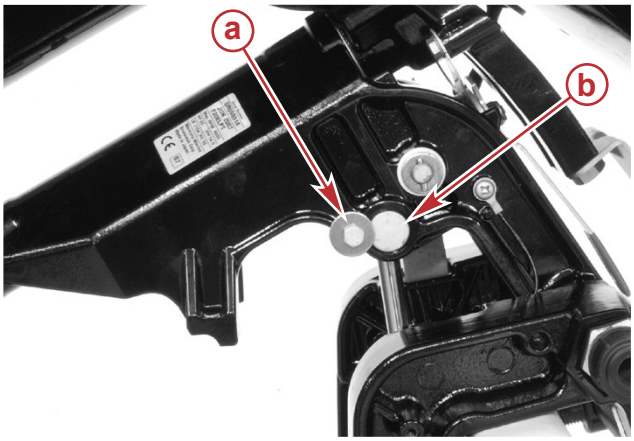
a - Tilt support lever

2. Remove the tilt cylinder rod pin retaining screw and washer.
3. Push the tilt cylinder rod pin through the bore from the port side.



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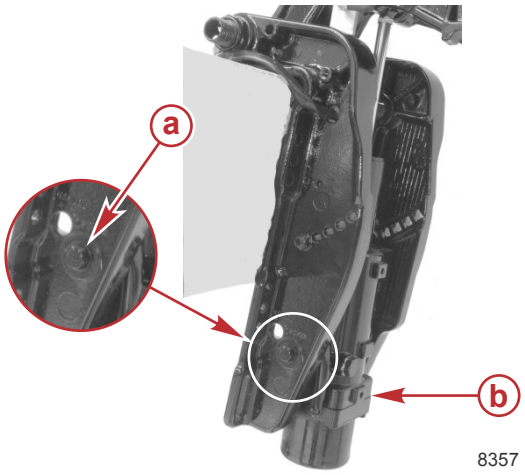
a - Tilt cylinder rod pin retaining screw and washer
b - Tilt cylinder rod pin

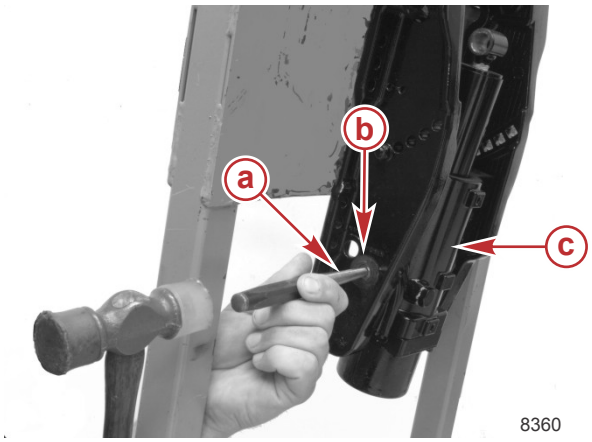
4. Retract the power tilt cylinder rod.
5. Disconnect the battery cables from the battery.
6. Disconnect the power tilt electrical wires.
7. Remove the ground wire.

8. Remove the port side screw from the power tilt pivot pin.



a - Pivot pin retaining screw
b - Power tilt assembly

9. Using a drift punch, remove the pivot pin from the power tilt assembly.



a - Drift punch
b - Pivot pin bore
c - Power tilt assembly

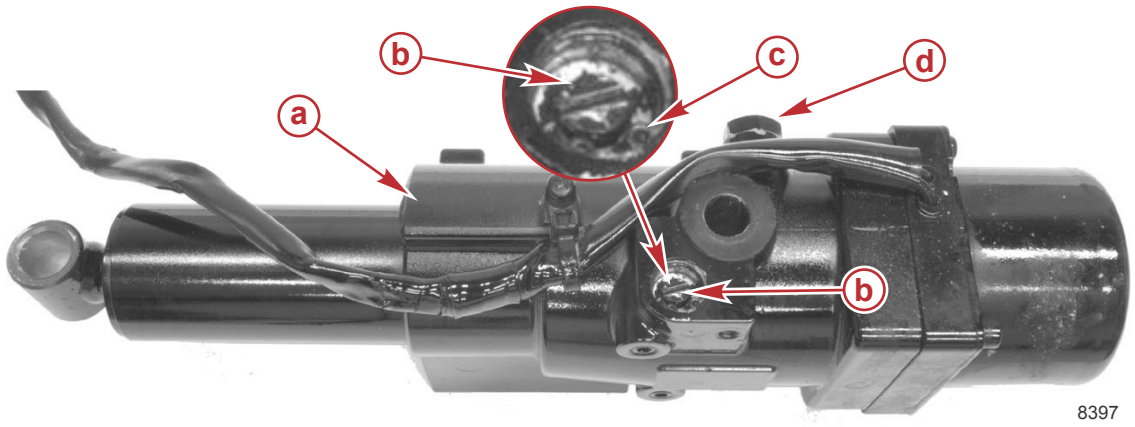
10. Remove the power tilt assembly from the clamp brackets.

Manual Release Valve Removal and Repair

IMPORTANT: The power tilt system is pressurized. The tilt cylinder rod must be fully extended in the up position prior to removing the reservoir plug or manual release valve.

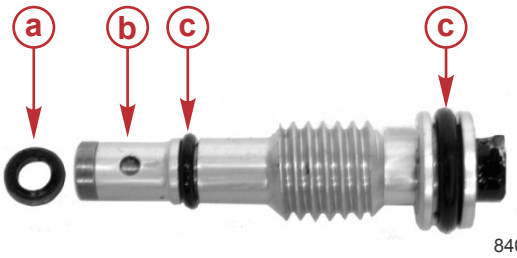
1. Extend the tilt cylinder rod to the full up position.
2. Slowly remove the power tilt reservoir fill plug.
3. Drain the power tilt fluid.
4. Remove the snap ring.

5. Remove the manual release valve by turning the valve counterclockwise.



a - Power tilt assembly
b - Manual release valve
c - Snap ring
d - Reservoir fill plug

6. Remove and discard the two O-rings from the valve.
7. Remove and discard the sealing washer from inside the manual release valve cavity.



a - Sealing washer
b - Manual release valve
c - O-ring

8. Install a new sealing washer in the manual release valve cavity.

NOTE: *Replace all O-rings with new O-rings when reassembling the power tilt assembly. Lubricate O-rings with clean Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) (Type Dexron III) prior to installation.*

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Lubrication of O-rings	92-858074K01

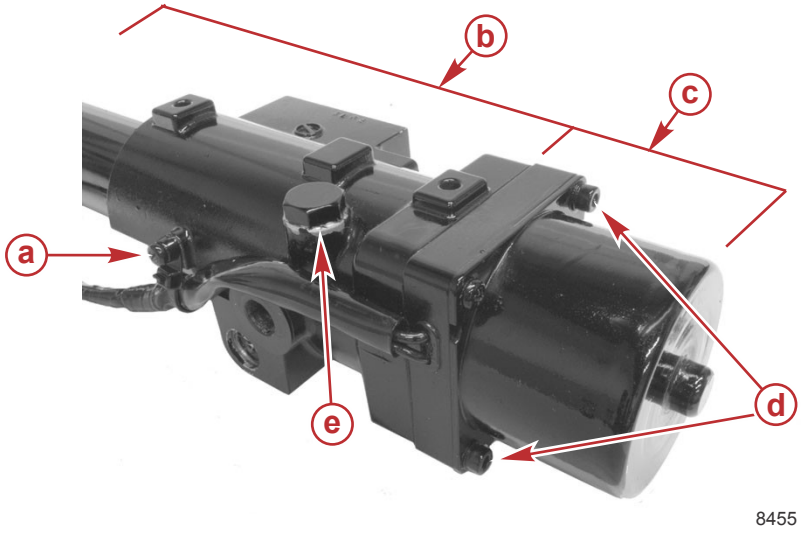
9. Install two new O-rings on the valve.
10. Install the manual release valve in the valve body.
11. Install the snap ring.

Power Tilt Motor

Power Tilt Motor Removal

1. Remove the power tilt unit from the outboard. Refer to **Power Tilt Removal**, preceding.
2. Slowly remove the power tilt reservoir fill plug.
3. Drain the power tilt fluid.
4. Remove the wire harness retaining screw.
5. Remove the two 4 mm internal hex screws securing the motor assembly to the power tilt pump and cylinder assembly.

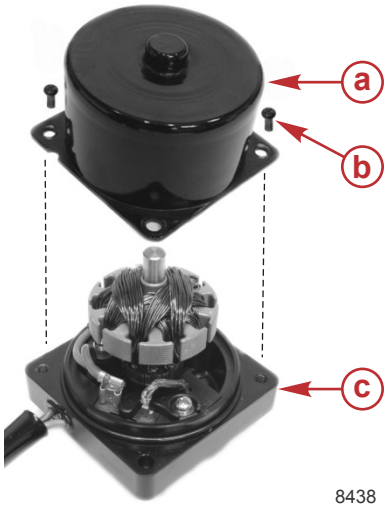
6. Separate the motor assembly from the power tilt pump and cylinder assembly.



a - Wire harness retaining screw
b - Power tilt pump and cylinder assembly
c - Motor assembly
d - 4 mm internal hex screw
e - Reservoir fill plug

Power Tilt Motor Disassembly, Inspection, and Repair

1. Remove the two cross slotted screws securing the motor housing to the bracket assembly.



a - Motor cover
b - Screws (2)
c - Motor bracket

2. Remove the armature from the motor housing.

Test for Short

1. Test armature on a growler. Follow the growler manufacturer's test instructions.
2. Indication of a short requires replacement of armature.

Test for Ground

Use a DMT multimeter (R x 1 scale). Place one lead of the meter on the armature shaft and the other lead on the commutator. If continuity is indicated, armature is grounded and must be replaced.

a - DMT multimeter
b - Armature
c - Commutator
d - Armature shaft

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Commutator	Armature shaft	R x 1	No continuity (OUCH)

Checking and Cleaning Commutator

NOTE: *If the commutator is worn, it can be turned down on an armature conditioner tool or on a lathe.*

Clean the commutator with number 00 sandpaper.

Field Tests

IMPORTANT: The commutator end of the armature must be installed in brushes when performing the following tests.

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Green motor wire	Blue motor wire	R x 1	0

1. If specific readings are not obtained, check for:
   - Defective armature
   - Dirty or worn brushes
   - Dirty or worn commutator
2. If defective components are found, repair or replace the component and retest.

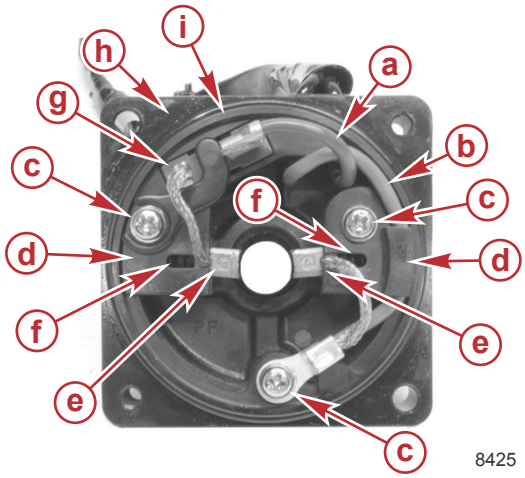
Motor Inspection

Brush replacement is required if brushes are pitted, chipped, or if the distance between the brush pigtail and end of brush holder slot is less than 1.6 mm (0.063 in.).

Brush Replacement

1. Remove the three screws securing the brush and breaker components to the motor bracket.
2. Remove the breaker.

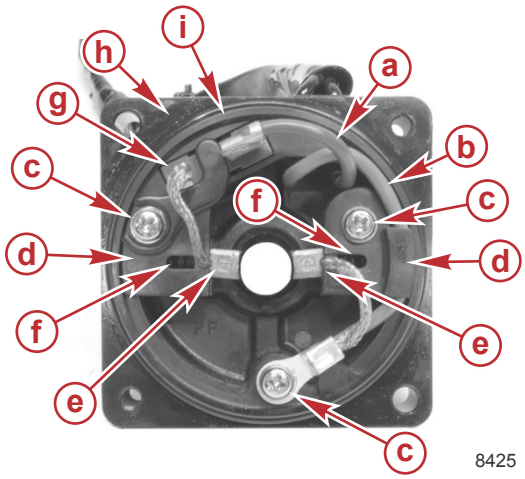
3. Remove the brush holder and brush.



a - Blue wire
b - Green wire
c - Screw
d - Brush holder
e - Brush
f - Spring
g - Breaker
h - Motor bracket
i - O-ring

Power Tilt Motor Reassembly

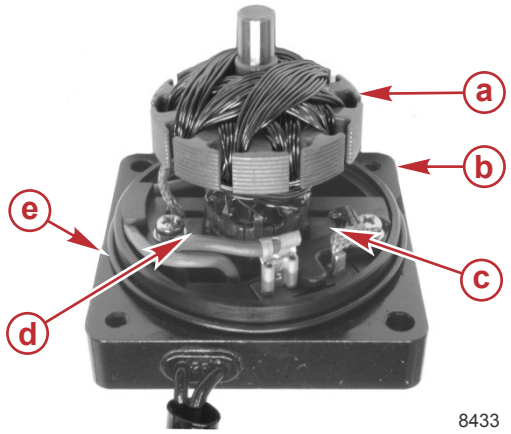
1. Install the breaker into the motor bracket.
2. Install the breaker holder and secure with a screw.
3. Attach the blue wire to the terminal post of the breaker.
4. Route the green wire along the inside diameter of the bracket.
5. Install the brush holder and secure with a screw.
6. Attach the green wire and brush wire terminal to the motor bracket. Secure with a screw.
7. Install two springs into the brush and breaker slots under the holders.
8. Install the breaker and the brush into the slots.



a - Blue wire
b - Green wire
c - Screw
d - Brush holder
e - Brush
f - Spring
g - Breaker
h - Motor bracket
i - O-ring

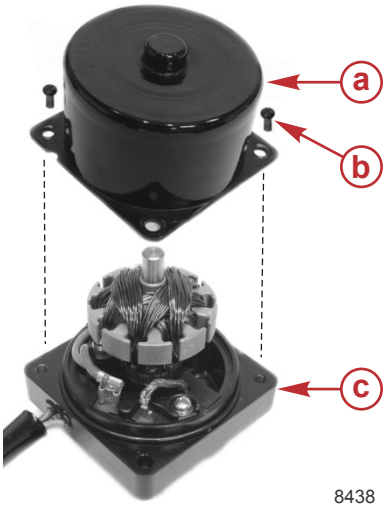
9. Hold the brushes in the slots while installing the armature into the motor bracket.

10. Install the O-ring.



a - Armature
b - Motor bracket
c - Brush
d - Brush
e - O-ring

11. Install the motor cover. Secure with two cross slotted screws.



a - Motor cover
b - Screws (2)
c - Motor bracket

Power Tilt Pump

Power Tilt Pump Disassembly

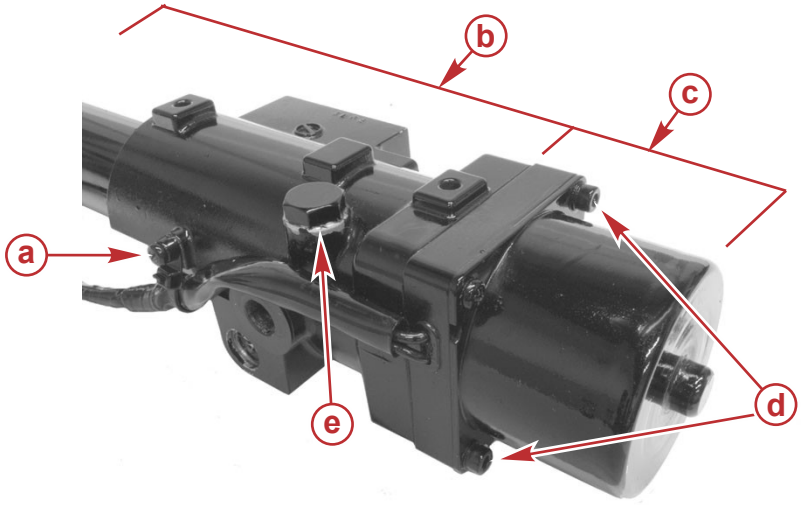
⚠ CAUTION

Contamination can damage the hydraulic system or cause the system to malfunction. Failure of power trim or steering components can result in injury or product damage. Ensure that the work area, shop tools and all components are clean and lint free during reassembly.

IMPORTANT: The power tilt system is pressurized. The tilt cylinder rod must be fully extended in the up position prior to removing the reservoir plug or manual release valve.

1. Remove the power tilt assembly from the outboard. Refer to **Power Tilt Removal**, preceding.
2. Extend the tilt cylinder rod to the full up position.
3. Slowly remove the power tilt reservoir fill plug.
4. Drain the power tilt fluid.
5. Remove the wire harness retaining screw.
6. Remove the power tilt motor by removing the two 4 mm internal hex screws.

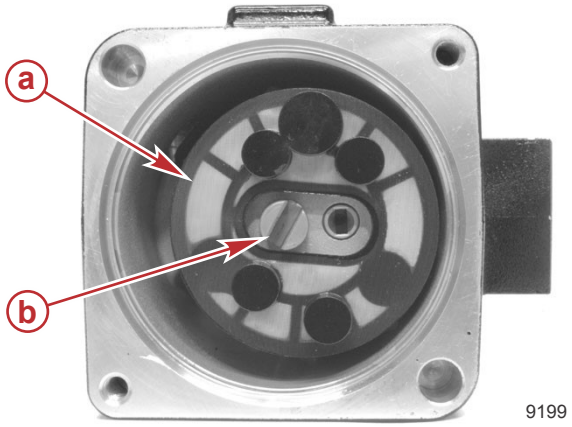
7. Separate the motor assembly from the power tilt pump and cylinder assembly.



8455

a - Wire harness retaining screw
b - Power tilt pump and cylinder assembly
c - Motor assembly
d - 4 mm internal hex screw
e - Reservoir fill plug

8. Remove the pump/motor coupling.
9. Remove the pump filter from the power tilt assembly.

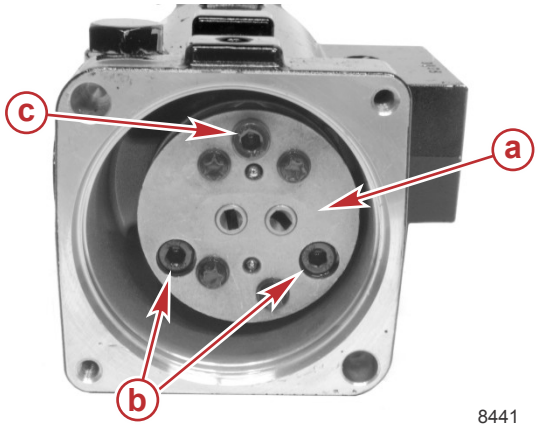


9199

a - Filter
b - Pump/motor coupling

NOTE: *Relief valve components are held in place by the power tilt pump. When removing the pump, ensure that these components are not lost.*

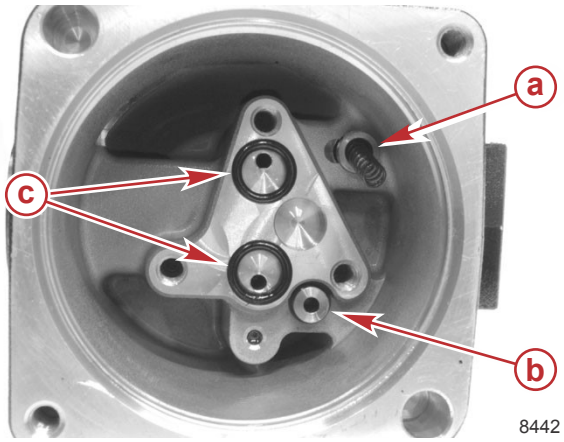
10. Remove the three internal hex screws securing the power tilt pump to the power tilt assembly.



8441

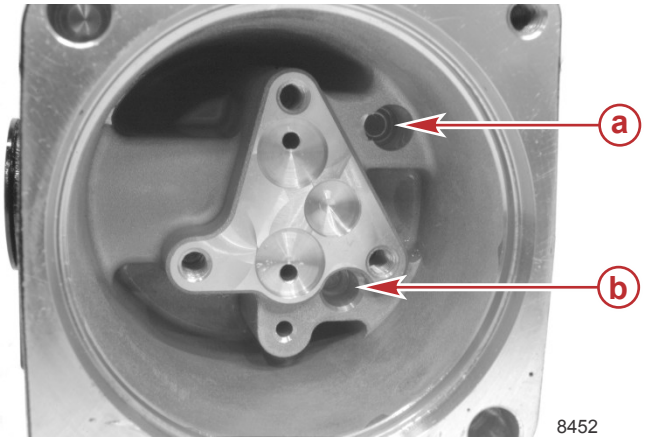
a - Power tilt pump
b - Internal hex screw (5 mm x 20)
c - Internal hex screw (5 mm x 25)

11. Remove the up relief valve components, down relief orifice, and O-rings from the power tilt housing.



a - Up relief valve components
b - Down relief orifice
c - O-ring

12. Inspect the down orifice screen and up relief valve seat.

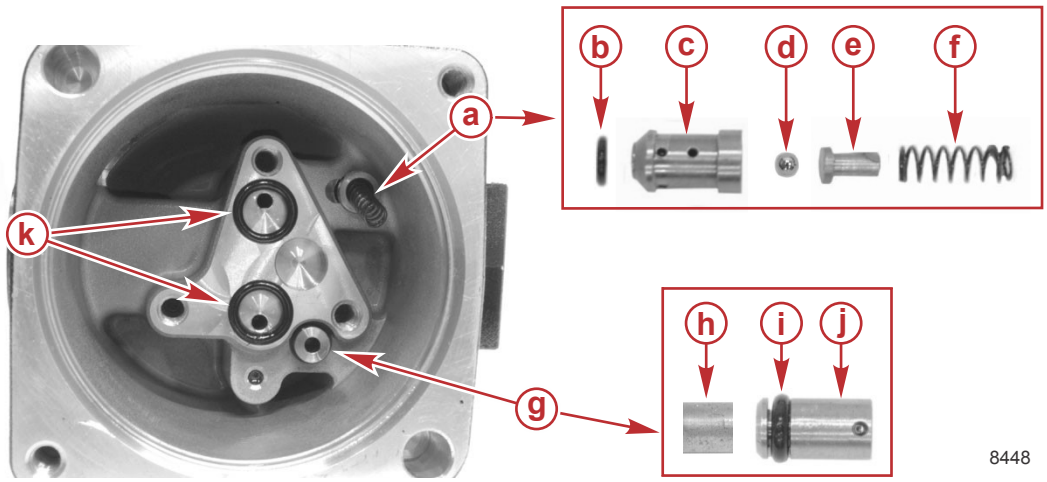


a - Up relief valve seat
b - Down orifice screen

Power Tilt Pump Reassembly

1. Install two new lubricated O-rings in the power tilt housing.
2. Install a new lubricated O-ring on orifice.
3. Install the filter and orifice.

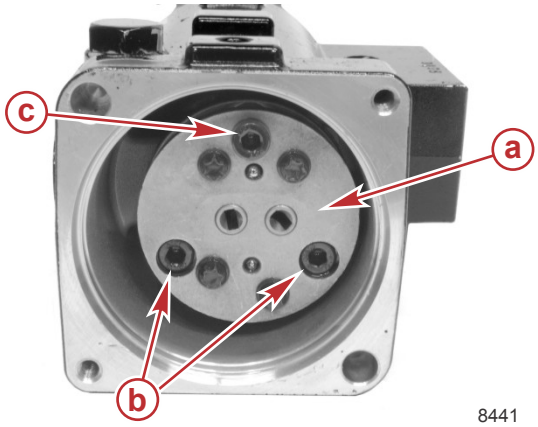
4. Install the up relief valve components in the power tilt housing.



a - Up relief valve assembly
b - O-ring
c - Valve seat
d - Ball
e - Spring guide
f - Spring
g - Down orifice assembly
h - Filter
i - O-ring
j - Orifice
k - O-ring

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Lubrication of power tilt O-rings	92-858074K01

5. Assemble the pump with three internal hex screws. Tighten the screws to the specified torque.

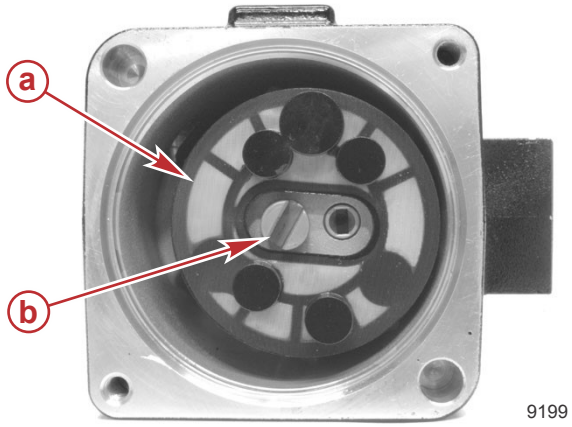


a - Power tilt pump
b - Internal hex screw (5 mm x 20)
c - Internal hex screw (5 mm x 25)

Description	Nm	lb. in.	lb. ft.
Pump mounting screws	5.2	46	

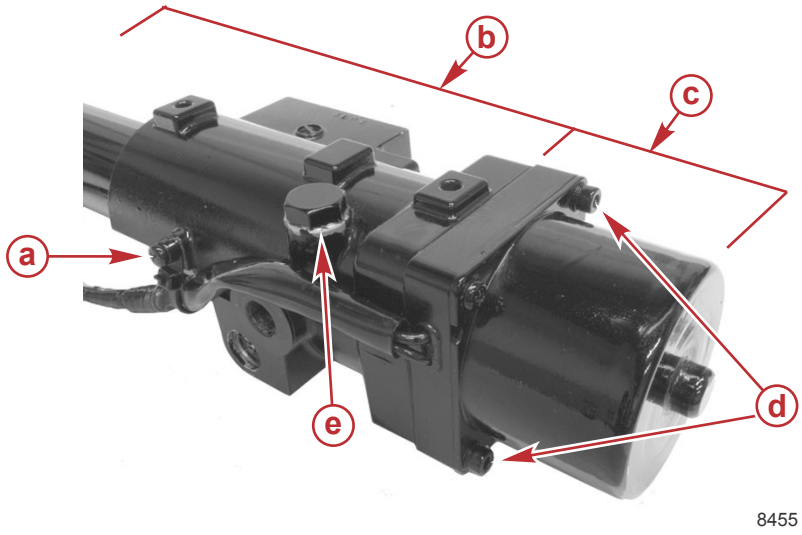
6. Install a clean pump filter.

7. Install the pump/motor coupling into the pump.



a - Pump filter
b - Pump/motor coupling

8. Assemble the motor assembly to the power tilt pump and cylinder assembly.
9. Install the wire harness retaining screw.
10. Install the two 4 mm internal hex screws securing the motor assembly to the power tilt pump and cylinder assembly. Tighten the screws to the specified torque.
11. Fill the power tilt system with Power Trim and Steering Fluid. Refer to **Check Fluid and Purge the Power Tilt System**, preceding.
12. Install the reservoir fill plug.



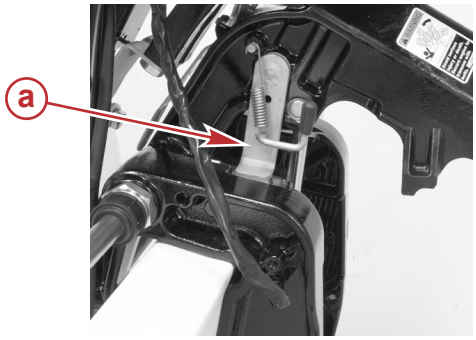
a - Wire harness retaining screw
b - Power tilt pump and cylinder assembly
c - Motor assembly
d - 4 mm internal hex screw
e - Reservoir fill plug

Description	Nm	lb. in.	lb. ft.
4 mm internal hex screws	5.2	46	
Wire harness attaching screw	0.6	5	

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Power tilt system	92-858074K01

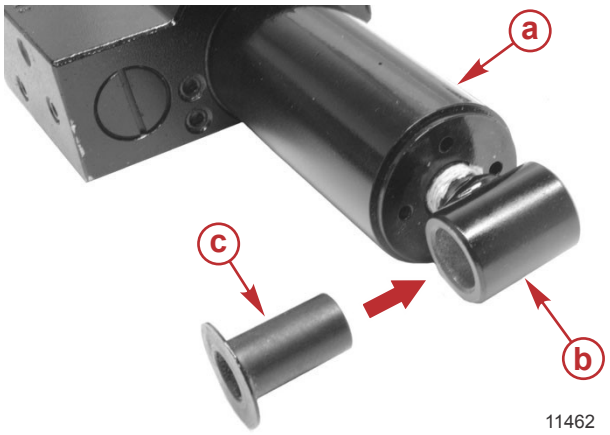
Power Tilt Installation

1. Tilt the outboard to the full up position and engage the tilt support lever.



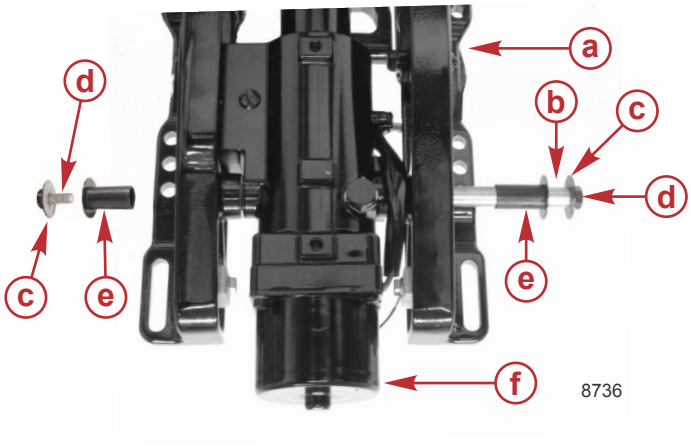
a - Tilt support lever

2. Install the bushing into the tilt cylinder rod eye.



a - Power tilt cylinder
b - Tilt cylinder rod eye
c - Bushing

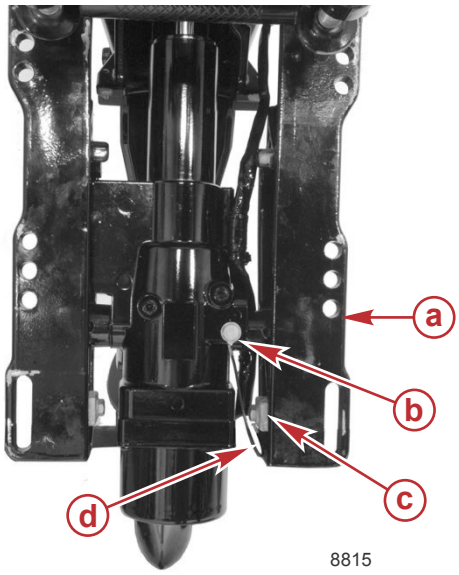
3. Install the pivot pin bushings in the clamp bracket.
4. Place the power tilt assembly between the clamp brackets.
5. Install the tilt cylinder pivot pin through the clamp brackets and the power tilt unit.
6. Install the washer and retaining screw into the pivot pin. Tighten the screws to the specified torque.



a - Clamp bracket
b - Pivot pin
c - Washer (2)
d - Retaining screw (2)
e - Pivot pin bushing (2)
f - Power tilt assembly

Description	Nm	lb-in.	lb-ft
Pivot pin retaining screw	13	115	–

7. Install the ground strap and retaining screws. Tighten the screws to the specified torque.

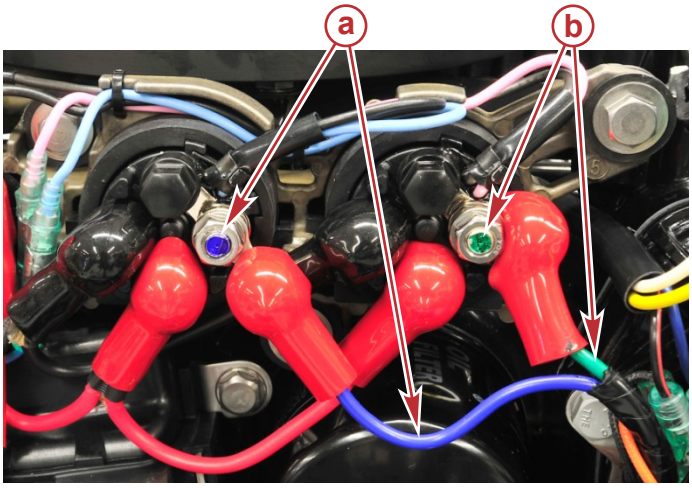


8815

a - Clamp bracket
b - Ground strap screw on power tilt unit
c - Ground strap screw on clamp bracket
d - Ground strap

Description	Nm	lb-in.	lb-ft
Ground strap screw	6.0	53.1	–

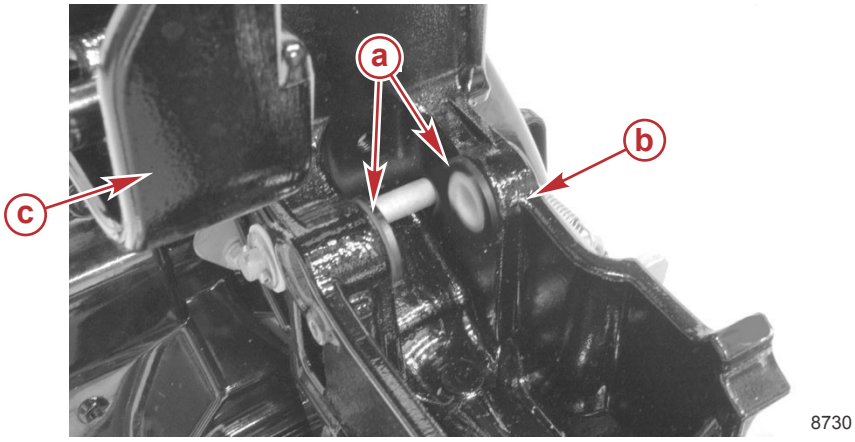
8. Connect the power tilt electrical wires to the power tilt relays.



63064

a - Blue (up) tilt relay terminal and wire
b - Green (down) tilt relay terminal and wire

9. Connect the battery cables to the battery.
10. Install the bushings into the swivel bracket.

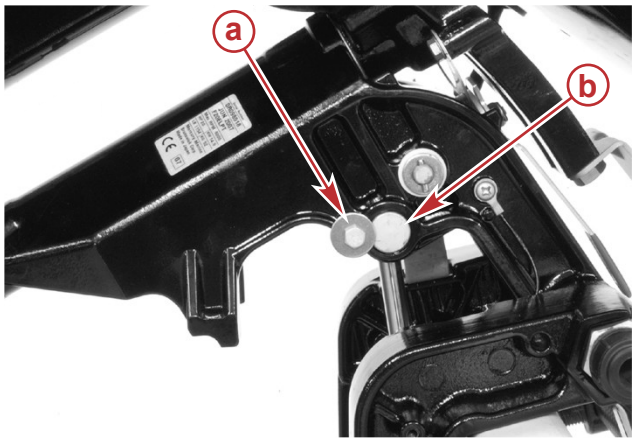


8730

a - Bushing (2)
b - Swivel bracket
c - Clamp bracket

11. Extend the power tilt cylinder rod.

12. Align the tilt cylinder rod eye between the swivel brackets.
13. Install the tilt cylinder rod pin.
14. Install the tilt cylinder rod pin retaining screw and washer. Tighten the screw to the specified torque.



63702

a - Tilt cylinder rod pin retaining screw and washer
b - Tilt cylinder rod pin

Description	Nm	lb-in.	lb-ft
Tilt cylinder rod pin retaining screw	6.0	53.1	–

15. Disengage the tilt support lever and lower the outboard.
16. Cycle the outboard up and down several times to purge air from the system.
17. Check the power tilt fluid level. Refer to **Check Fluid and Purge the Power Tilt System,** preceding.

Notes:

Lower Unit

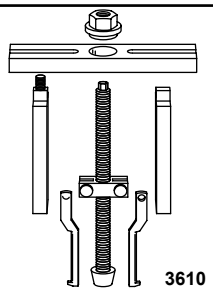
Section 6A - Gear Housing (2.15:1)

Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Propeller shaft splines	8M0071842
7	Loctite® 271 Threadlocker	Pinion nut threads	92-809819
82	Premium Gear Lubricant	Inside diameter and outside diameter of pinion bearing	92-858058K01
95	2-4-C with PTFE	Shift shaft O-ring	92-802859A 1
		Bearing carrier seal lips	
		Bearing carrier O-ring	
		Apply to seal lips and O-rings	
		Water pump drive key	
		Inside diameter of the water pump liner	
		Driveshaft splines	
		Propeller shaft splines	

Special Tools

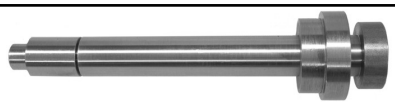
Bearing Puller Assembly	91- 83165T
 3610	Removes bearings, races, and bearing carriers

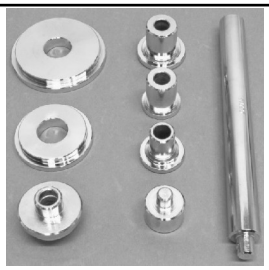
Torch Lamp	91- 63209
 8776	Heats surfaces to aid in the removal and installation of interference fit engine components.

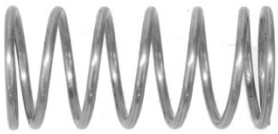
Spring Pin Removal Tool	91-853996-6
 3423	Aids in the removal of the spring pins

Driveshaft Holding Tool	91-804762
 12519	Holds the driveshaft while removing or installing the pinion gear nut

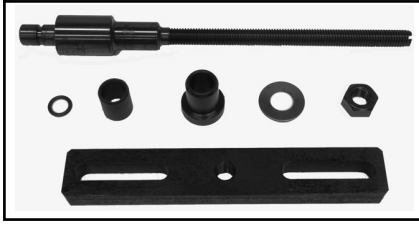
Universal Puller Plate	91-37241
 8505	Removes bearings from gears and the driveshaft.

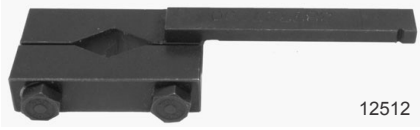
Pinion Bearing Installation Tool Assembly	8M0038865
 37832	Guides the removal and installation of the pinion bearing

Bearing Mandrel Kit	91- 83166M
 3421	Aids in the removal and installation of bearings and bearing races.

Spring	8M0011503
 37830	Applies upward force to the driveshaft for checking forward gear backlash.

Clamp	8M0033741
 37831	Used as part of an assembly to provide upward force on the driveshaft to check forward gear backlash. Part of Pinion Bearing Installation Tool Assembly 91-899015A02

Backlash Preload Tool	91-895195T04
 12520	Prevents forward gear movement when checking the forward gear backlash.

Backlash Indicator Arm	91-803133 12
 12512	Aids in determining the forward gear backlash; use with a dial indicator.

Dial Indicator	91- 58222A 1
 9479	Used to obtain a variety of measurements including gear backlash, pinion gear location, and TDC.

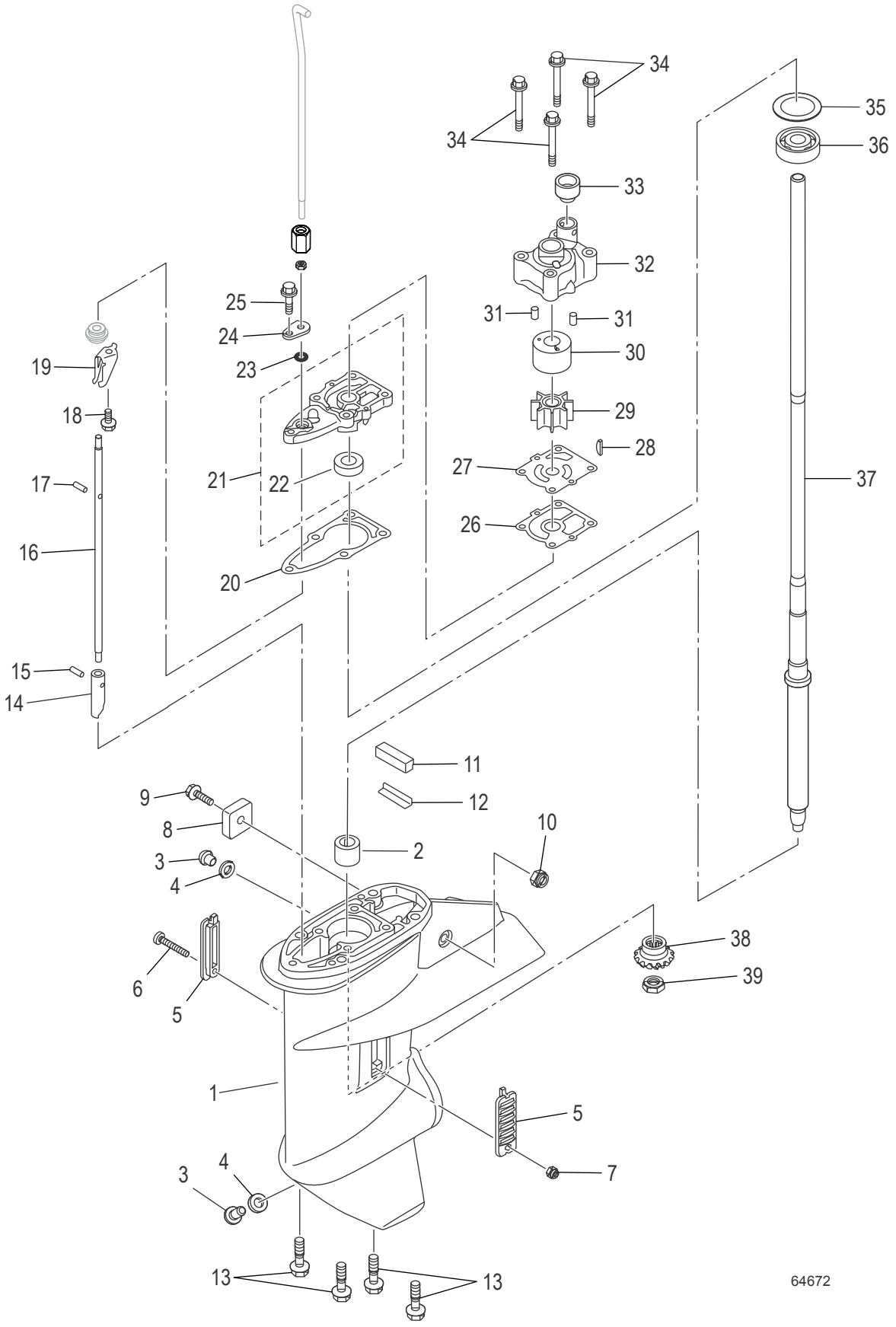
Dial Indicator Adapter	91-83155
 2999	Dial indicator holding fixture.

Gearcase Specifications

Parameter	Specification
Gear ratio	2.15:1
Gearcase capacity	460 ml (15.6 fl oz)
Gear lubricant type	Premium Gear Lubricant or GL5 SAE 80W-90
Pinion teeth	13
Pinion height	Floating
Clutch	Dog type (forward–neutral–reverse)
Forward, reverse teeth	28
Forward gear backlash	0.8–1.5 mm (0.030–0.059 in.)

Notes:

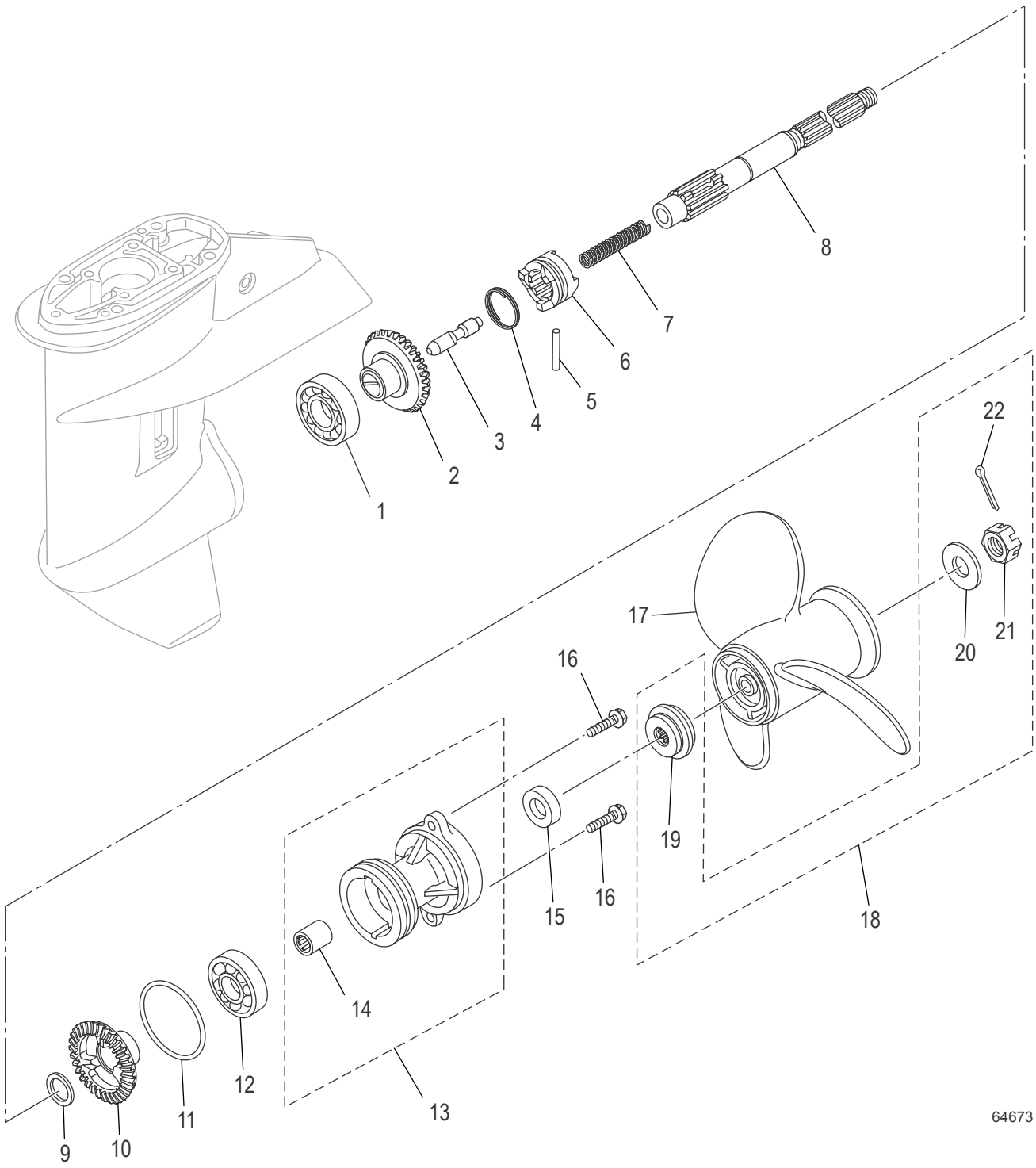
Gear Housing and Driveshaft



Gear Housing and Driveshaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing			
2	1	Roller bearing			
3	2	Plug	13.0	115	–
4	2	Gasket			
5	2	Water strainer			
6	1	Screw	1.5	13.3	–
7	1	Nut			
8	1	Anode			
9	1	Screw	6.0	53.1	–
10	1	Nut			
11	1	Rubber water seal			
12	1	Water seal plate			
13	4	Screw	24.0	–	17.7
14	1	Clutch cam			
15	1	Spring pin			
16	1	Cam rod			
17	1	Spring pin			
18	1	Screw	5.0	44.3	–
19	1	Stopper			
20	1	Lower pump case gasket			
21	1	Lower pump case assembly			
22	1	Oil seal			
23	1	O-ring			
24	1	Stopper			
25	1	Screw	6.0	53.1	–
26	1	Guide plate gasket			
27	1	Water pump guide plate			
28	1	Key			
29	1	Impeller			
30	1	Pump case liner			
31	2	Dowel pin			
32	1	Upper pump case			
33	1	Lower water pipe seal			
34	4	Screw	6.0	53.1	–
35	AR	Shim			
36	1	Ball bearing			
37	1	Driveshaft			
38	1	Pinion gear			
39	1	Nut	35.0	–	25.8

Propeller Shaft



Propeller Shaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Ball bearing			
2	1	Forward gear			
3	1	Push rod			
4	1	Retainer spring			
5	1	Clutch pin			
6	1	Clutch			
7	1	Spring			
8	1	Propeller shaft			
9	1	Thrust washer			
10	1	Reverse gear			
11	1	O-ring			
12	1	Ball bearing			
13	1	Bearing carrier			
14	1	Needle bearing			
15	1	Oil seal			
16	2	Screw	9.0	79.6	–
17	1	Propeller			
18	1	Propeller hardware kit			
19	1	Front thrust hub			
20	1	Washer			
21	1	Propeller nut	12.0	106.2	–
22	1	Cotter pin			

General Service Recommendations

There may be more than one way to disassemble or reassemble a particular part. It is recommended that the entire procedure be read prior to repair.

IMPORTANT: Read the following before attempting any repairs.

In many cases, disassembly of a sub-assembly may not be necessary, until cleaning and inspection reveals that disassembly is required for replacement of one or more components.

Service procedure order in this section is a normal disassembly/reassembly sequence. It is suggested that the sequence be followed without deviation to assure proper repairs. When performing partial repairs, follow the instructions to the point where the desired component can be replaced, then proceed to reassembly and installation of that component in the reassembly part of this section. Use the **Table of Contents** to find the correct page number.

Threaded parts are right hand (RH), unless otherwise indicated.

When holding, pressing, or driving is required, use soft metal vise jaw protectors or wood for protection of parts. Use a suitable mandrel (one that will contact only the bearing race) when pressing or driving bearings.

Whenever compressed air is used to dry a part, verify that no water is present in air line.

Bearings

Upon disassembly of the gear housing, all bearings must be cleaned and inspected. Clean the bearings with solvent and dry with compressed air. Air should be directed at the bearing so that it passes through the bearing. Do not spin the bearing with compressed air, as this may cause the bearing to score from lack of lubrication. After cleaning, lubricate the bearings with Premium Gear Lubricant. Do not lubricate tapered bearing cups until after inspection.

Inspect all bearings for roughness, catches, and bearing race side wear. Work the inner bearing race in and out, while holding the outer race, to check for side wear.

When inspecting tapered bearings, determine the condition of the rollers and the inner bearing race by inspecting the bearing cup for pitting, scoring, grooves, uneven wear, imbedded particles, and/or discoloration from overheating. Always replace the tapered bearing and race as a set.

Inspect the gear housing for bearing races that have spun in their respective bores. If the race has spun, the gear housing must be replaced.

Roller bearing condition is determined by inspecting the bearing surface of the shaft that the roller bearing supports. Check the shaft surface for pitting, scoring, grooves, imbedded particles, uneven wear, and/or discoloration from overheating. The shaft and bearing must be replaced, if the conditions described are found.

Shims

Keep a record of all shim amounts and their location during disassembly to aid in reassembly. Be sure to follow the shimming instructions during reassembly, as the gears must be installed to the correct depth and have the correct amount of backlash to avoid noisy operation and premature gear failure.

Seals

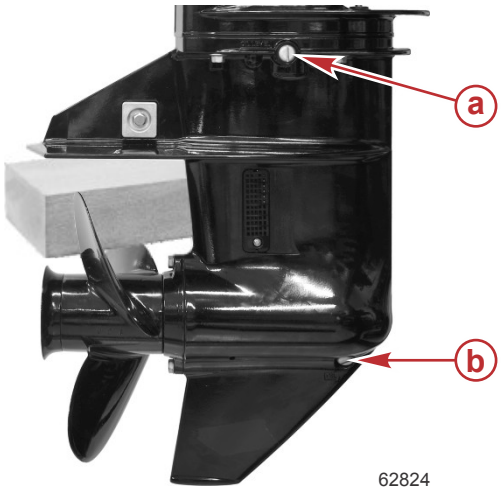
As a normal procedure, all O-rings and oil seals should be replaced without regard to appearance. To prevent leakage around the oil seals, apply Loctite 271 to the outer diameter of all the metal case oil seals. When using Loctite on seals or threads, surfaces must be clean and dry. To ease installation, apply 2-4-C with PTFE on all O-rings. To prevent wear, apply 2-4-C with PTFE on I.D. of oil seals.

Draining and Inspecting Gear Housing Lubricant

⚠ WARNING

Rotating propellers can cause serious injury or death. Never operate the boat out of the water with a propeller installed. Before installing or removing a propeller, place the drive unit in neutral and engage the lanyard stop switch to prevent the engine from starting. Place a block of wood between the propeller blade and the anti-ventilation plate.

1. Position a clean drain pan under the gear housing and remove the fill and vent screws from the gear housing.



62824

a - Vent screw
b - Fill screw

2. Inspect the gear lubricant for metal particles. Presence of a small amount of fine metal particles resembling powder indicates normal wear. Presence of larger particles or a large quantity of fine particles indicates a need for gear housing disassembly and component inspection.
3. Note the color of the gear lubricant. White or cream color indicates the presence of water in the lubricant. Check the drain pan for water separation from lubricant. Presence of water in the gear lubricant indicates the need for disassembly and inspection of oil seals, seal surfaces, O-rings, and gear housing components. Pressure check the gearcase prior to disassembly.

   NOTE: *When draining the gearcase for the first time, lubricant may appear cream colored due to the mixing of assembly lubricant and gear lubricant. This is not an indication of water intrusion. If, during subsequent draining of the gearcase, lubricant appears cream colored or milky, water may be present. The gearcase should be disassembled and all gaskets, seals, and O-rings replaced. Inspect all components for water damage.*

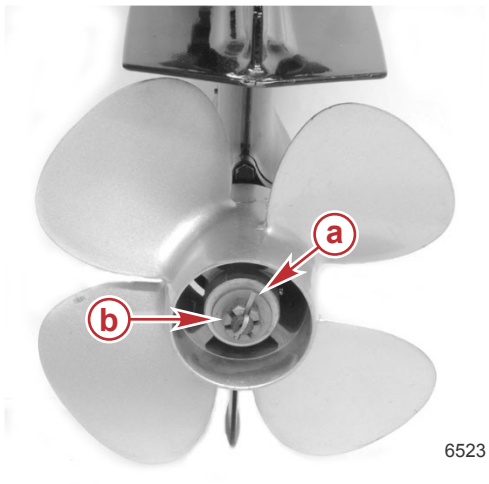
   NOTE: *Gear lubricant drained from a recently run gearcase will be a light chocolate brown in color due to agitation/ aeration. Oil that is stabilized will be a clear yellow brown in color.*

Gear Housing Removal

⚠ WARNING

Accidental starting can cause serious injury. Before removing or installing the gear housing, disconnect and isolate the spark plug leads. Disable the ignition system by removing the keys from the ignition (if equipped) and engaging the lanyard stop switch to prevent the engine from starting.

1. Remove the cotter pin from the propeller nut.

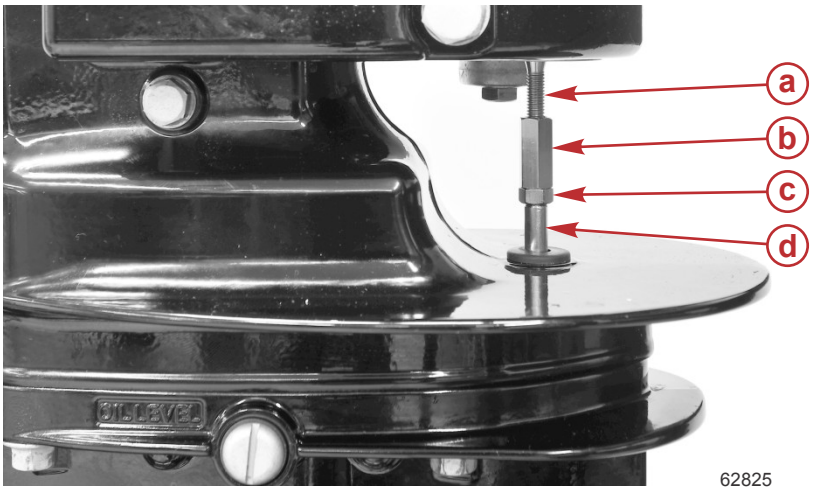


6523

a - Cotter pin
b - Propeller nut

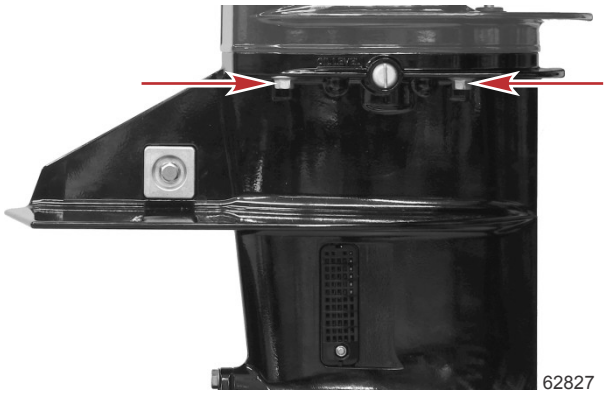
2. Remove the propeller nut, flat washer, propeller, and front thrust washer from the propeller shaft.
3. Turn the coupler to separate the upper and lower shift shafts.

4. Remove the jam nut from the lower shift shaft.



a - Upper shift shaft
b - Coupler
c - Jam nut
d - Lower shift shaft

5. Remove the four screws securing the gear housing to the driveshaft housing, and remove the gearcase.



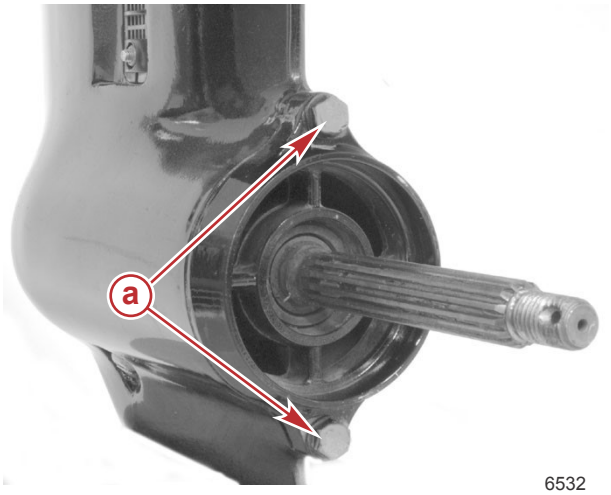
Gearcase screws (two per side)

Gear Housing Disassembly

IMPORTANT: It is recommended that during complete disassembly of the gear housing, all O-rings and oil seals be replaced regardless of their appearance.

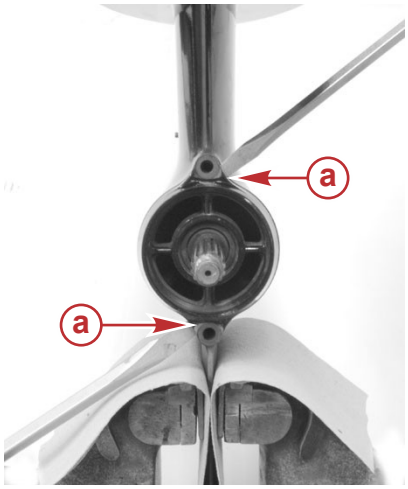
Bearing Carrier Disassembly

1. Remove the two screws securing the bearing carrier.



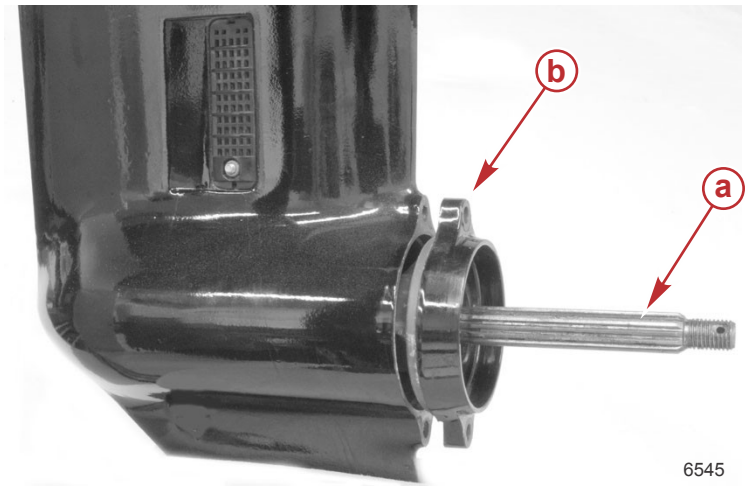
a - Screws (2)

2. Use prybars at the indicated pry points to aid in the removal of the bearing carrier assembly from the gearcase.



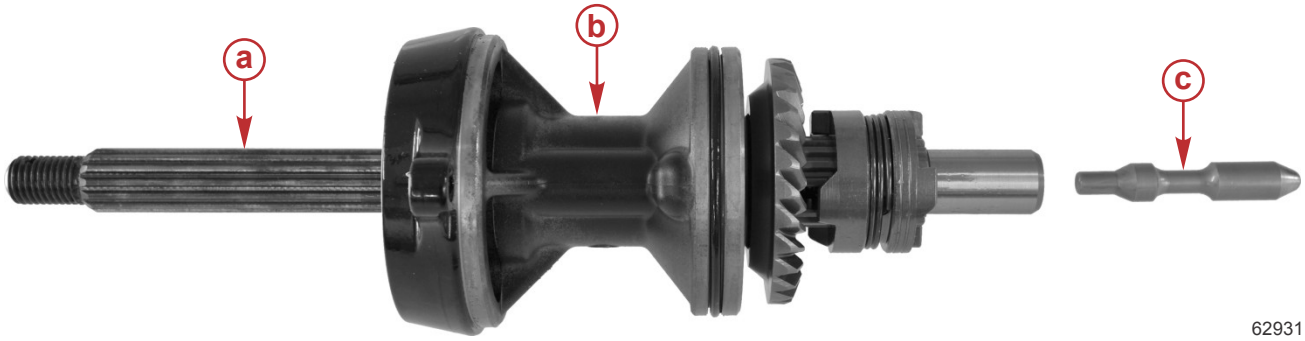
a - Pry points

3. Remove the bearing carrier and propeller shaft assembly from the gearcase.



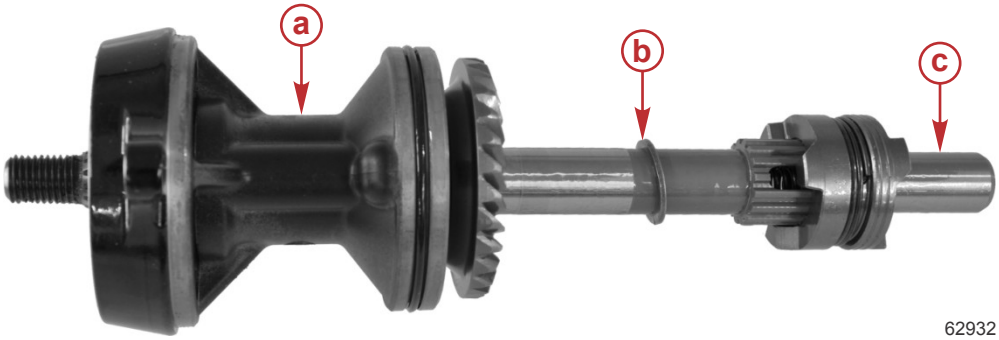
a - Propeller shaft
b - Bearing carrier assembly

NOTE: *The cam follower is free to slide out of the propeller shaft.*



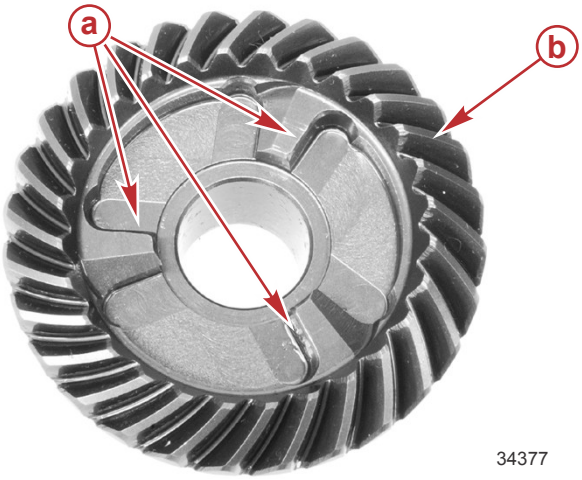
a - Propeller shaft
b - Bearing carrier assembly
c - Cam follower

4. Remove the propeller shaft from the reverse gear/bearing carrier assembly.



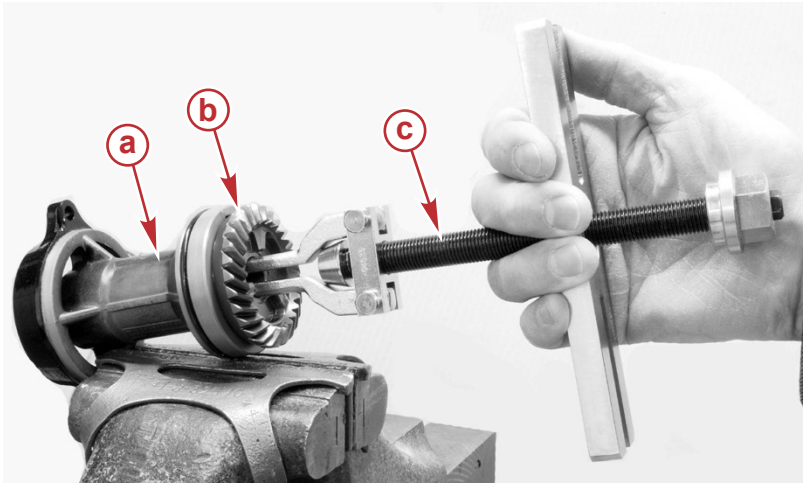
a - Reverse gear/bearing carrier assembly
b - Thrust washer
c - Propeller shaft

5. Replace the reverse gear if the gear teeth or clutch teeth are chipped or worn.



a - Clutch teeth
b - Gear teeth

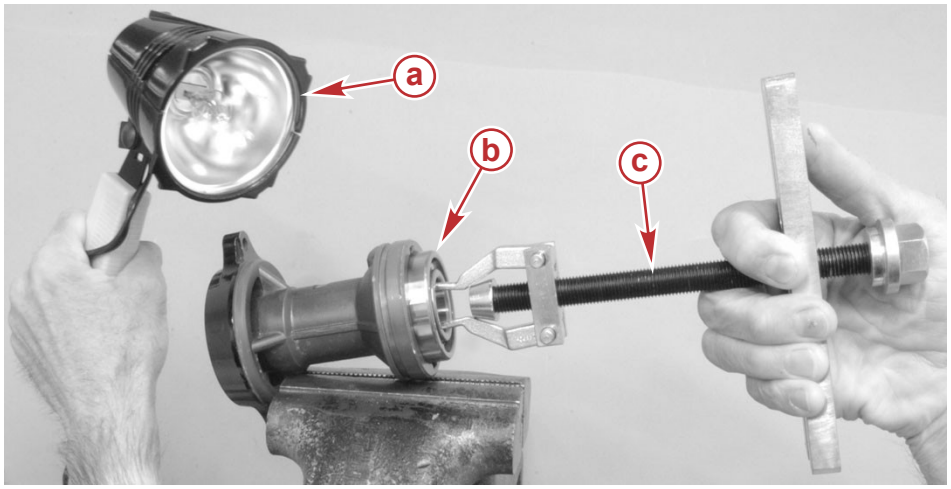
6. If the reverse gear must be replaced, use a bearing puller assembly to remove the reverse gear from the reverse gear bearing.



a - Bearing carrier assembly
b - Reverse gear
c - Bearing puller assembly

Bearing Puller Assembly	91- 83165T

7. Inspect the reverse gear bearing for roughness, catches, pits, or discoloration from lack of lubricant. If the bearing must be replaced, use a torch lamp to warm the bearing carrier assembly to aid in removal. Remove the O-ring from the carrier to prevent heat damage. Use a bearing puller assembly to remove the bearing from the bearing carrier.

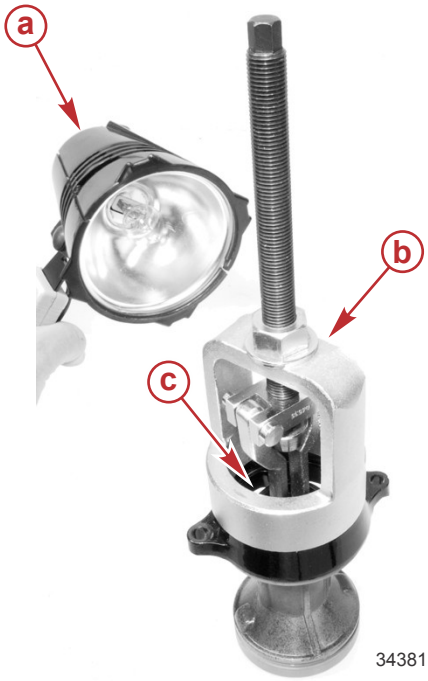


a - Torch lamp
b - Reverse gear bearing
c - Bearing puller assembly

Bearing Puller Assembly	91- 83165T
Torch Lamp	91- 63209

8. Use a torch lamp to warm the outer surface of the bearing carrier where the carrier seal is located. Use a bearing puller assembly to remove the carrier seal.

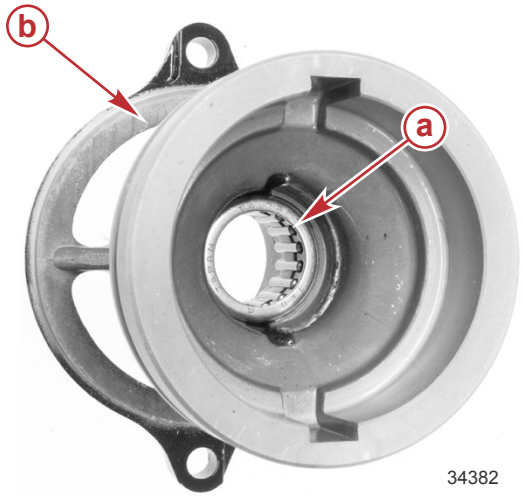
NOTE: *When removing the carrier seal, do not scar the carrier seal surface. If the carrier seal surface is damaged, replace the carrier.*



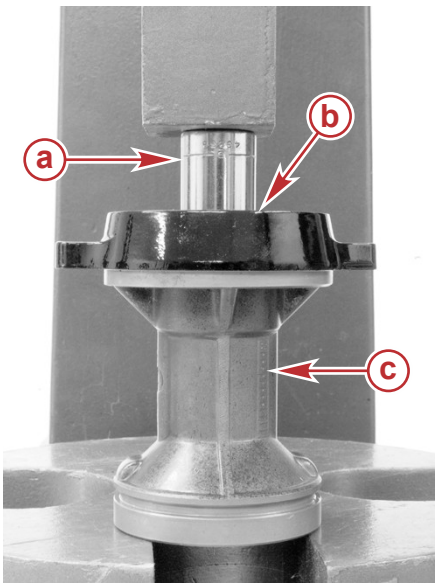
a - Torch lamp
b - Bearing puller assembly
c - Oil seal

Bearing Puller Assembly	91- 83165T
Torch Lamp	91- 63209

9. Use a suitable mandrel to press the needle bearing out of the bearing carrier.



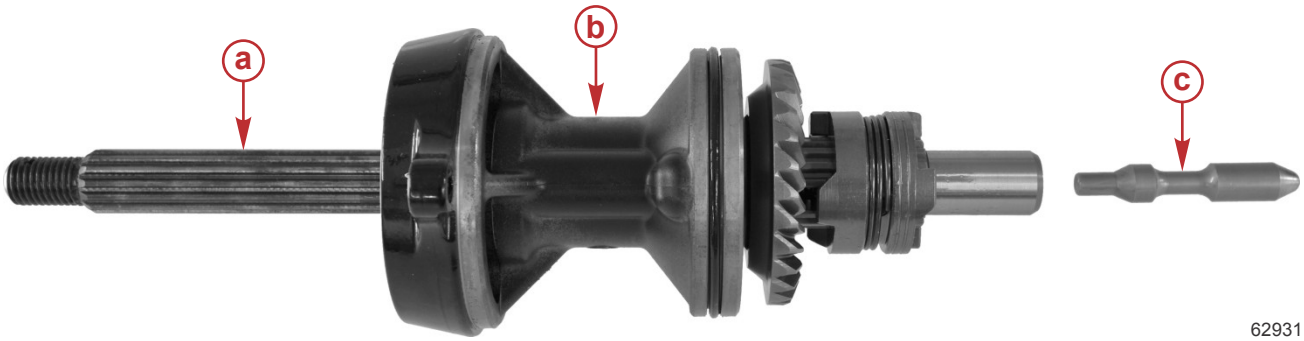
a - Needle bearing
b - Bearing carrier



a - Mandrel
b - Needle bearing (hidden)
c - Bearing carrier

Propeller Shaft Disassembly

1. Inspect the cam follower for wear. Replace the follower if it is worn.



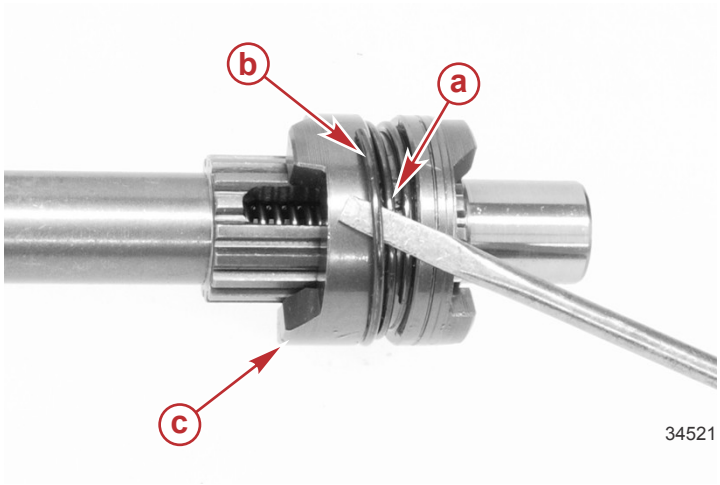
a - Propeller shaft
b - Bearing carrier assembly
c - Cam follower

2. Remove the clutch pin retainer spring from the clutch.

⚠ CAUTION

The spring-loaded clutch pin can disengage from the clutch and propel through the air, causing possible eye injury. Always wear protective eye equipment when disassembling the clutch assembly.

3. Remove the clutch pin from the sliding clutch/propeller shaft. Removal of the clutch pin allows the clutch spring to discharge. Wear appropriate eye protection. Discard the clutch pin after removal.

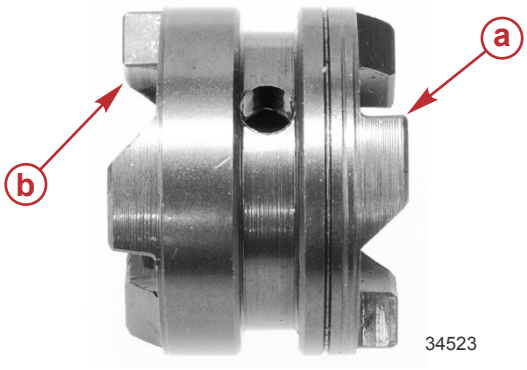


a - Clutch pin (under spring)
b - Retainer spring
c - Sliding clutch

4. Remove the spring and the sliding clutch.

a - Sliding clutch
b - Clutch pin
c - Ring (faces forward gear)
d - Clutch spring

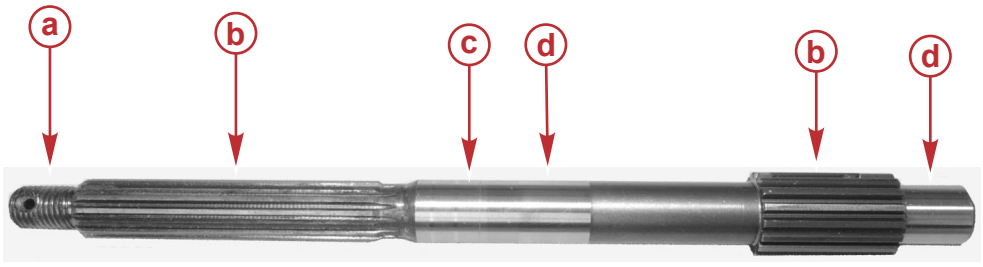
5. Replace the clutch if the jaws are rounded or chipped. Rounded jaws may be caused by the following:
   - Improper shift cable or linkage adjustment
   - Engine idle speed too high while shifting
   - Shifting too slowly from neutral into forward or reverse



a - Forward gear clutch jaws
b - Reverse gear clutch jaws

6. Inspect the needle bearing surface of the propeller shaft for pitting and wear. Replace the propeller shaft and needle bearing (in the bearing carrier) if wear or pitting is present.
7. Replace the propeller shaft if any of the following exist:
   - Splines are twisted or worn

- Oil seal surface is grooved
- Shaft has a noticeable wobble or is bent more than 0.15 mm (0.006 in.)

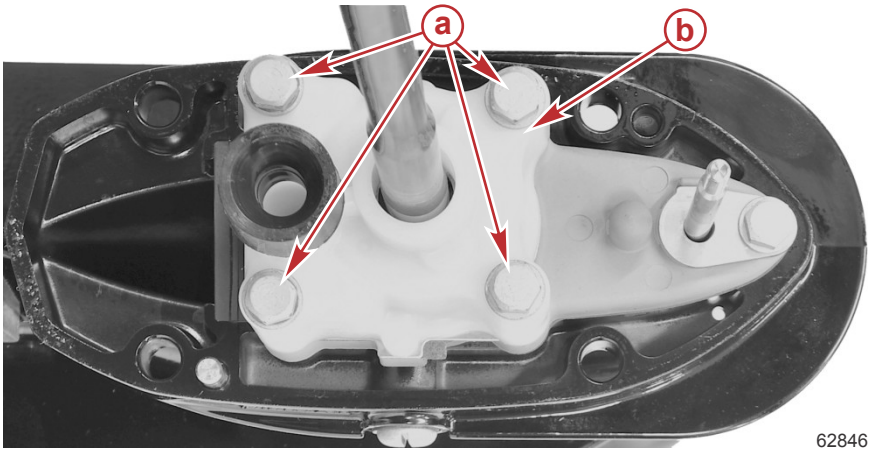


6567

a - Check shaft for wobble
b - Check for twisted splines
c - Check for seal surface grooves
d - Check for needle bearing surface pits or wear

Water Pump, Driveshaft, and Shift Shaft Disassembly

1. Remove the four screws and four washers from the water pump cover.

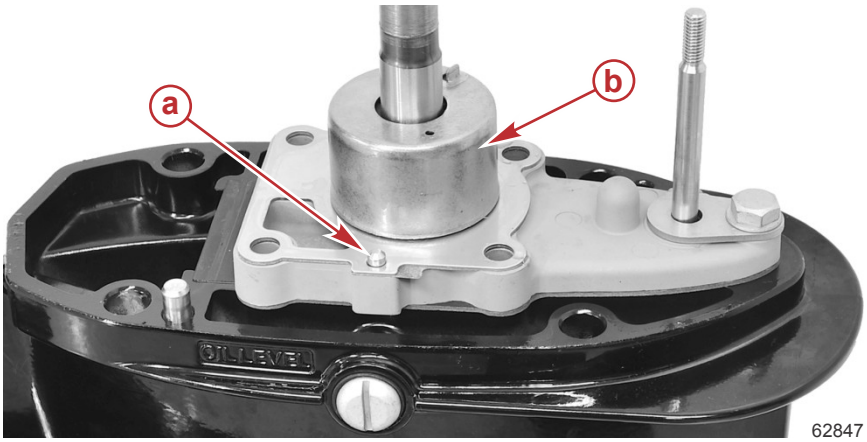


62846

a - Screws (4) and washers (4)
b - Water pump cover

2. Remove the cover from the driveshaft. Be careful to not lose the two dowel pins.

   NOTE: *The water pump cover liner may remain with the impeller when the cover is removed. This is not a problem.*



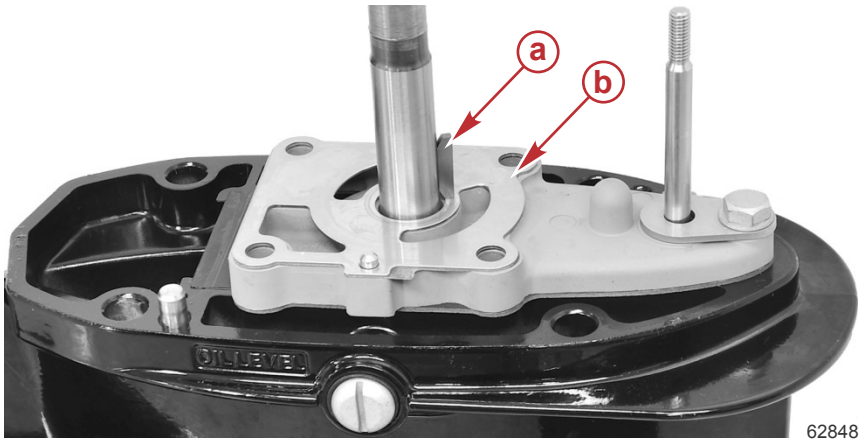
62847

a - Dowel pins (2)
b - Water pump cover liner; impeller is inside the liner

3. Remove the impeller and the drive key from the driveshaft.

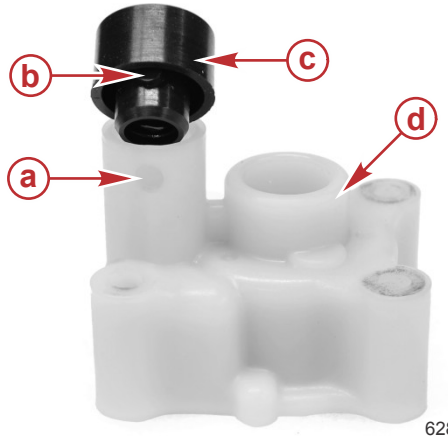
   IMPORTANT: The impeller should be replaced, regardless of appearance, whenever the gearcase is serviced. If the old impeller must be used, it must be installed in the direction of the original rotation. Installing the impeller with the vanes reversed from their original direction will result in vane breakage.

4. Remove the faceplate.



a - Drive key
b - Faceplate

5. Remove the water tube grommet from the pump cover. Inspect the grommet for wear or damage. Replace the grommet as required. When installing the grommet into the pump cover, align the grommet tabs with the holes in the pump cover.

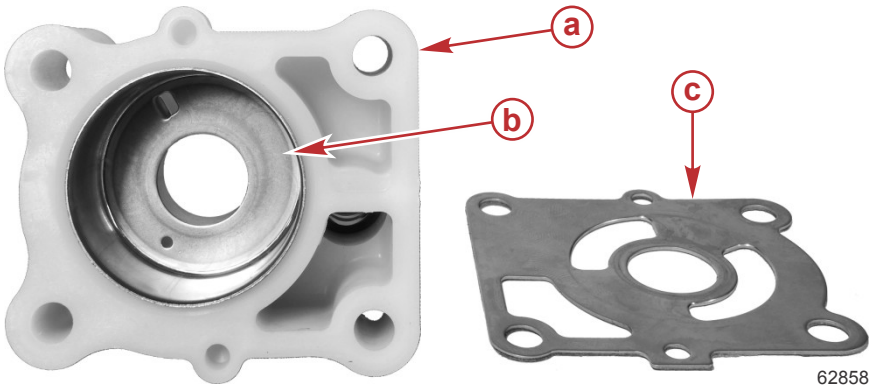


a - Hole (2)
b - Tab (2)
c - Grommet
d - Water pump cover

6. Inspect the pump cover for damage from excessive heat; charring, blistering, or discoloration. Replace the cover as required.

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

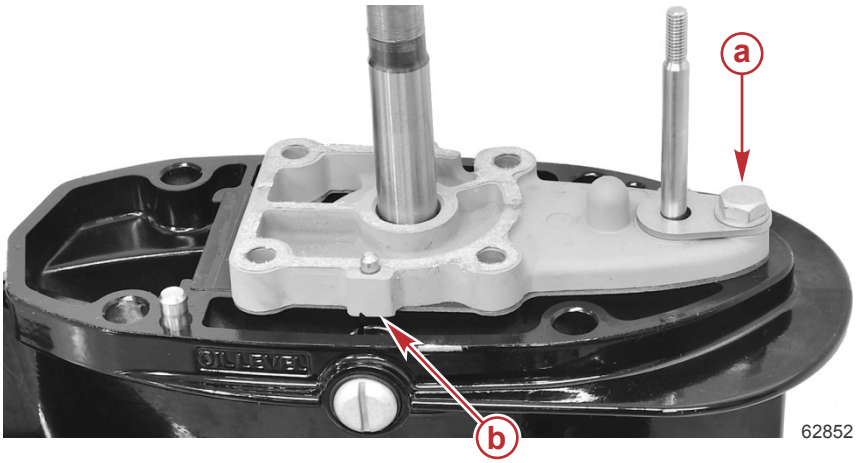
7. Inspect the water pump liner and the faceplate for grooves or rough surfaces.



a - Water pump cover
b - Water pump liner
c - Faceplate

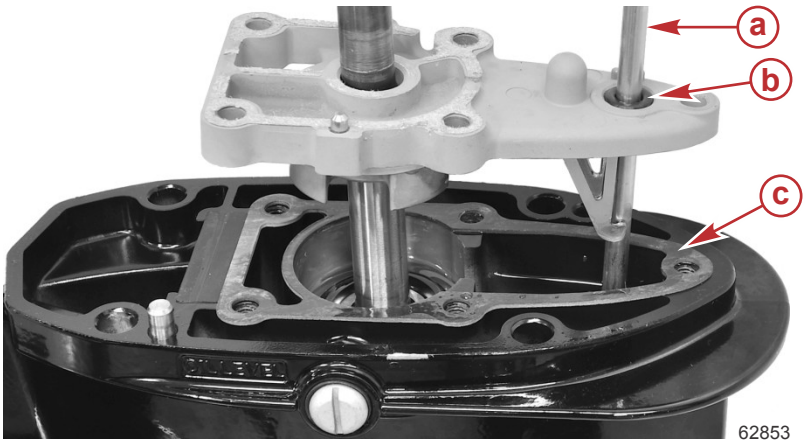
8. Replace the liner or faceplate if the grooves (other than sealing grooves) are more than 0.762 mm (0.030 in.).
9. Remove the screw and clamp securing the water pump base.
10. Use the pry points to remove the water pump base from the gear housing. The shift shaft will lift out with the base.

NOTE: *Be careful to not lose the two dowel pins.*



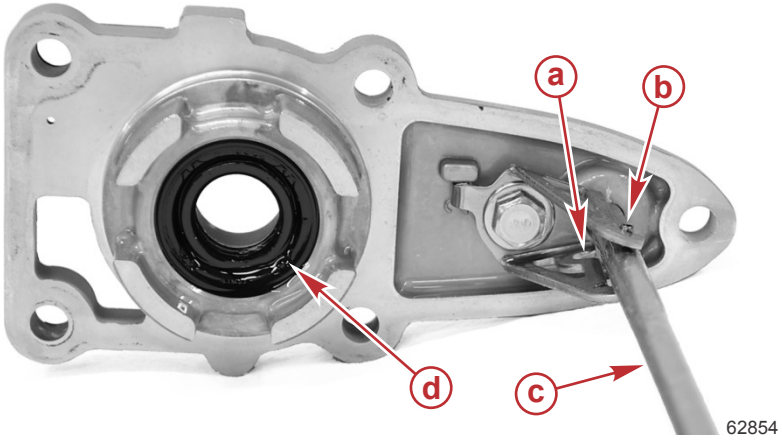
a - Screw and clamp
b - Pry point (one each side of base)

11. Remove the gasket from the gear housing.



a - Shift shaft
b - O-ring
c - Gasket

12. Lift the shift shaft until the spring pin aligns with the notch in the shift shaft bracket. Rotate the shift shaft 90 degrees, and slide the shift shaft out of the water pump base.
13. Remove the water pump base seal with a seal puller. Do not scar the water pump base seal surface with the seal puller. If the surface is damaged, replace the water pump base.



a - Notch in shift shaft bracket
b - Spring pin
c - Shift shaft
d - Water pump base seal

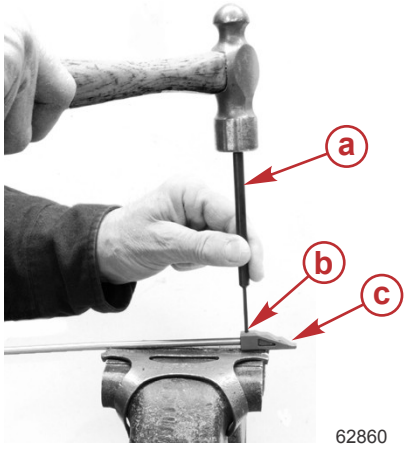
14. Remove and replace the shift shaft O-ring from the top of the water pump base. Apply 2-4-C with PTFE to the O-ring before installation.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift shaft O-ring	92-802859A 1

15. Inspect the shift cam for wear. If the cam follower is worn, replace the shift cam.

a - Shift cam

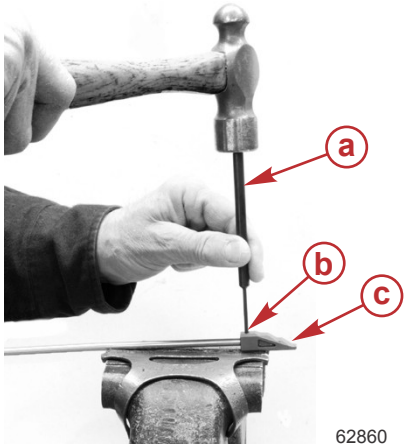
a. Use a spring pin removal tool to remove the retainer pin securing the shift cam to the shift shaft. Discard the retainer pin.



a - Spring pin removal tool
b - Retainer pin
c - Shift cam

Spring Pin Removal Tool	91-853996-6

b. Use a spring pin removal tool to secure the shift cam to the shift shaft with a new retainer pin. The retainer pin must be flush with the shift cam surface.



a - Spring pin removal tool
b - Retainer pin
c - Shift cam

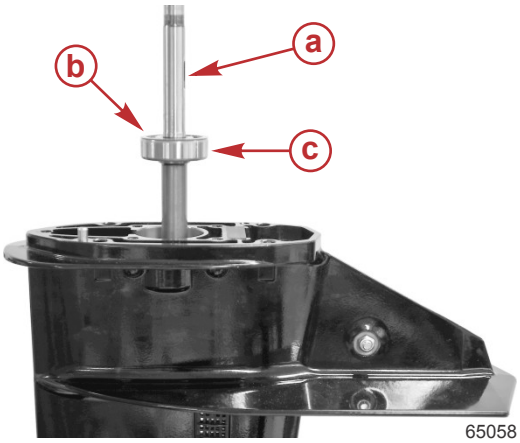
Spring Pin Removal Tool	91-853996-6

Driveshaft Removal

1. Use the driveshaft holding tool to hold the driveshaft while removing the pinion nut.

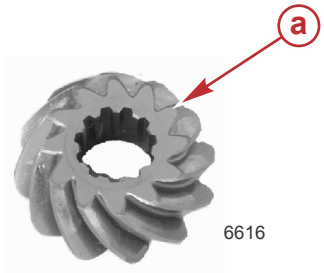
Driveshaft Holding Tool	91-804762

2. Remove the driveshaft from the gearcase. Retain the shims located above the upper driveshaft bearing.



a - Driveshaft
b - Shims (retained)
c - Upper driveshaft bearing

3. Inspect the pinion gear teeth for breakage, rust, chipping, or excessive wear.

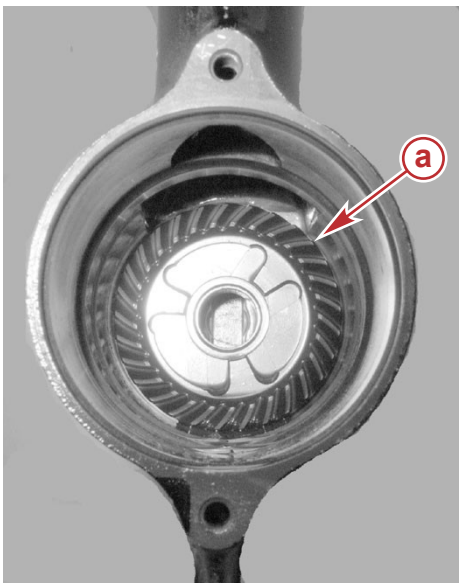


a - Pinion gear teeth

4. If the pinion gear teeth are damaged, inspect the forward and reverse gears for damage.

Forward Gear and Reverse Gear Inspection

1. Inspect the forward gear and the reverse gear teeth for breakage, rust, chipping, and excessive wear.

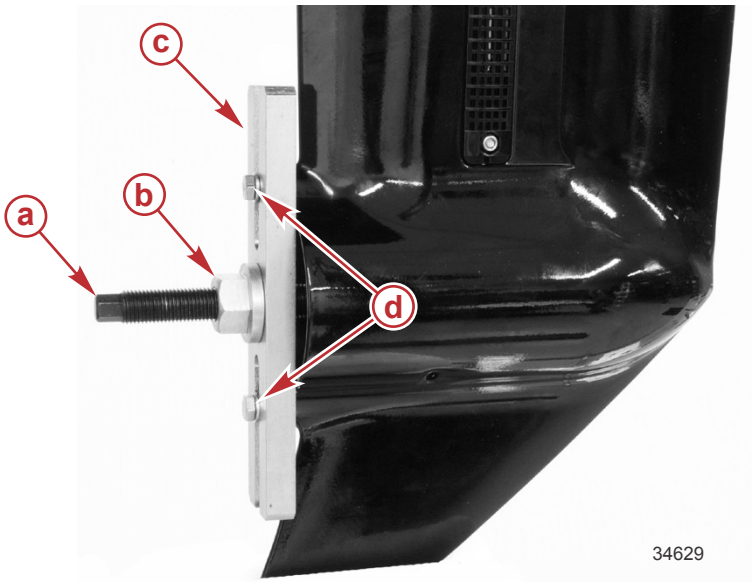


a - Forward gear

NOTE: *Do not remove the forward gear and bearing assembly from the gearcase unless replacement is necessary. The removal process will damage the bearing and forward gear bushing.*

2. Inspect the forward gear ball bearing for roughness or excessive wear.
3. If the bearing is in serviceable condition, do not remove the bearing from the gearcase. The removal process may damage the bearing and forward gear bushing.

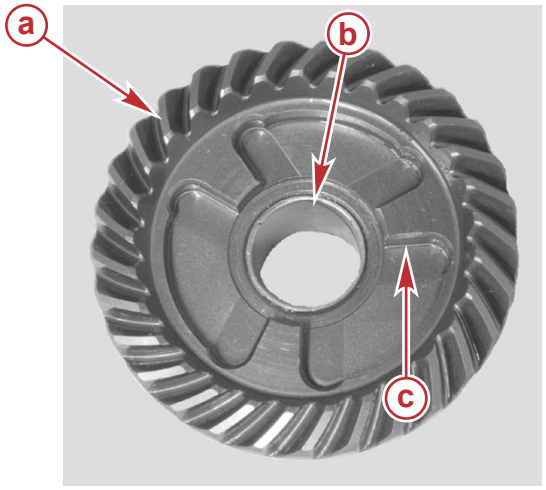
4. Use a bearing puller to remove the forward gear bearing assembly.



a - Puller shaft
b - Puller nut
c - Plate
d - Screw and washer

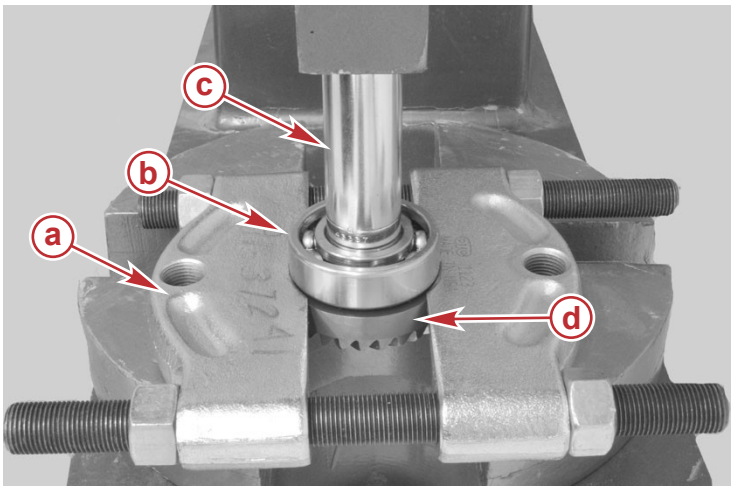
Bearing Puller Assembly	91- 83165T

5. Inspect the forward and reverse gear clutch jaws for wear. Rounded jaws indicate the following:
   a. Improper shift cable or linkage adjustment
   b. Engine idle speed too high
   c. Shifting too slowly



a - Forward gear teeth
b - Propeller shaft bushing
c - Clutch jaws

6. If the forward gear ball bearing must be replaced, use a suitable mandrel, press, and universal puller plate to remove the bearing from the forward gear.

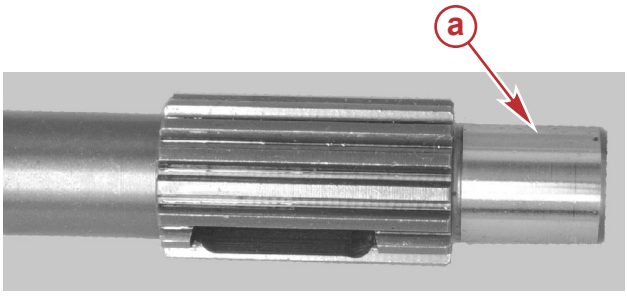


7046

a - Universal puller plate
b - Ball bearing
c - Mandrel
d - Forward gear

Universal Puller Plate	91-37241

7. Inspect the propeller shaft forward gear bushing surface to determine the condition of the forward gear bushing. If the surface is discolored from lack of lubricant, pitted, or worn, the propeller shaft and forward gear should be replaced.



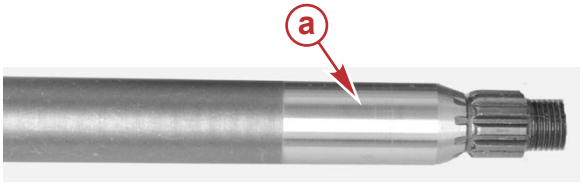
6700

a - Forward gear bushing surface

Driveshaft Pinion Bearing Removal

IMPORTANT: Do not remove the lower driveshaft pinion bearing from the gear housing unless replacement is necessary. The removal process will damage the bearing.

1. Inspect the pinion bearing surface on the driveshaft. Replace the driveshaft if it is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles.



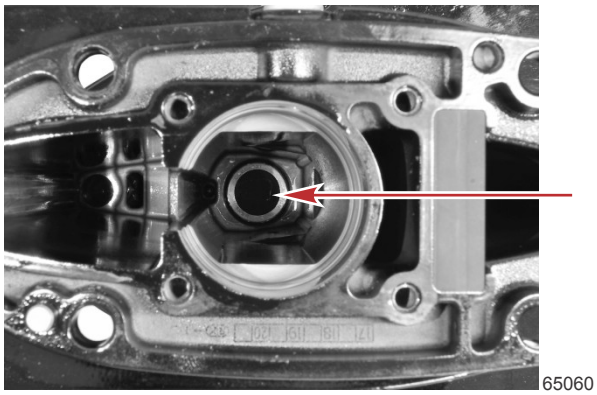
7070

a - Pinion bearing surface

IMPORTANT: Remove the forward gear assembly from the gearcase before removing the pinion bearing. Failure to remove the forward gear assembly will result in the pinion bearing hitting against the forward gear during removal. The pinion gear tool will bind in the pinion bearing bore, making the removal of the tool difficult and possibly causing damage to the gearcase.

2. Inspect the pinion bearing for signs of damage.

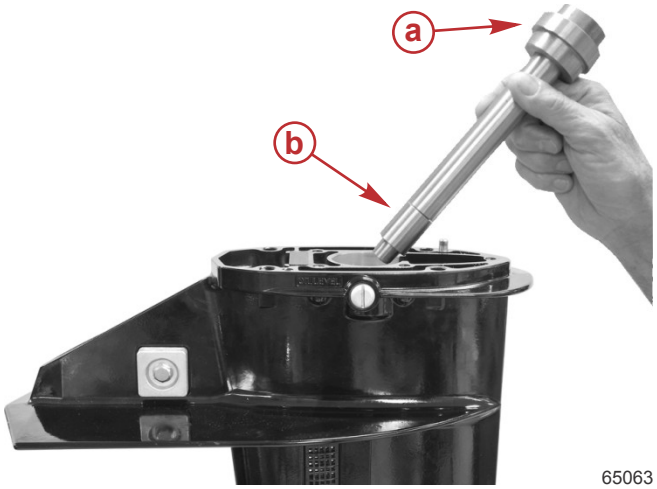
3. If the pinion bearing must be replaced, use the pinion bearing tool to remove the pinion bearing.


65060

Pinion bearing

Pinion Bearing Installation Tool Assembly	8M0038865

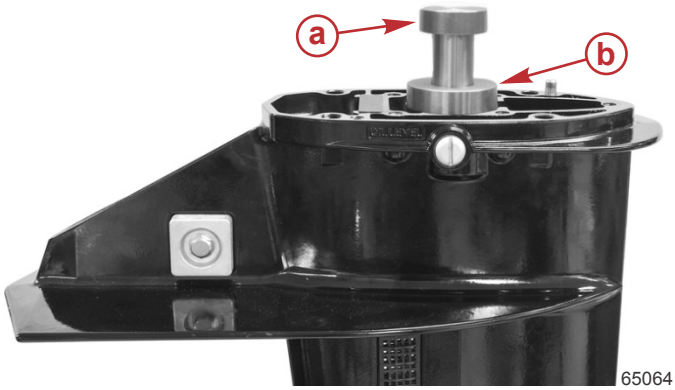
a. With the sleeve installed on the end of the tool, push the tool into the driveshaft bore until the flange of the tool guide rests against the surface of the gear housing.



65063

a - Pinion bearing tool guide
b - Sleeve

b. Tap on the head of the tool until the head seats against the tool flange. The pinion bearing will drop into the gear housing cavity. Discard the pinion bearing. The bearing cannot be reused after removal. Remove the tool from the driveshaft bore.



65064

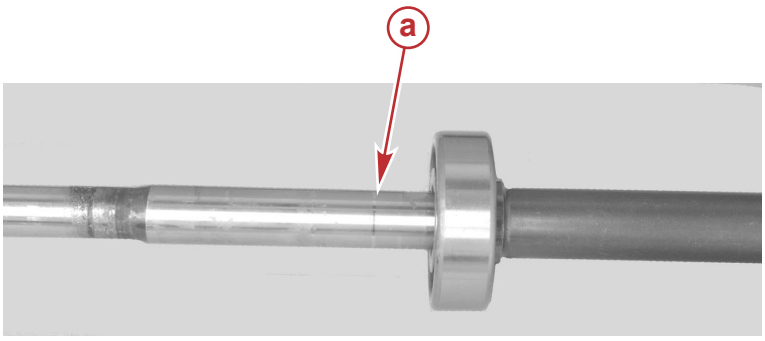
a - Head of tool
b - Tool flange

IMPORTANT: If the forward gear ball bearing, upper driveshaft bearing, or pinion bearing appear to be spinning in their respective bores, the gear housing must be replaced.

Driveshaft Inspection

1. Inspect the splines at both ends of the driveshaft for a worn or twisted condition. Replace the driveshaft if either condition exists.

2. Inspect the driveshaft for grooves where the water pump base oil seals contact the shaft. Replace the driveshaft if grooves are found.



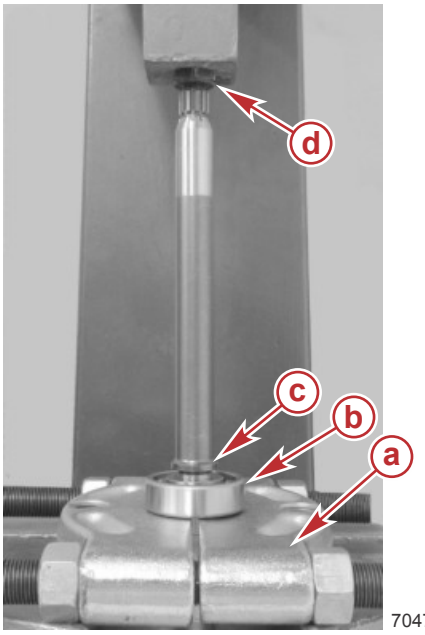
6708

a - Water pump oil seal surface

Upper Driveshaft Bearing Inspection

IMPORTANT: Do not remove the upper driveshaft ball bearing from the driveshaft unless replacement is necessary. The removal process will damage the bearing.

1. Inspect the upper driveshaft ball bearing for rust, roughness, or excessive wear.
2. If the bearing is not in serviceable condition, use a suitable mandrel, press, and universal puller plate to remove the bearing from the driveshaft.
3. To install the new bearing, place the bearing onto the driveshaft. Partially thread the old pinion nut onto the driveshaft. Place the driveshaft assembly into the press and apply pressure to the old pinion nut to push the driveshaft through the new bearing until the bearing seats against the ledge of the driveshaft.



7047

a - Universal puller plate
b - Upper driveshaft bearing
c - Ledge
d - Old pinion nut

Universal Puller Plate	91-37241

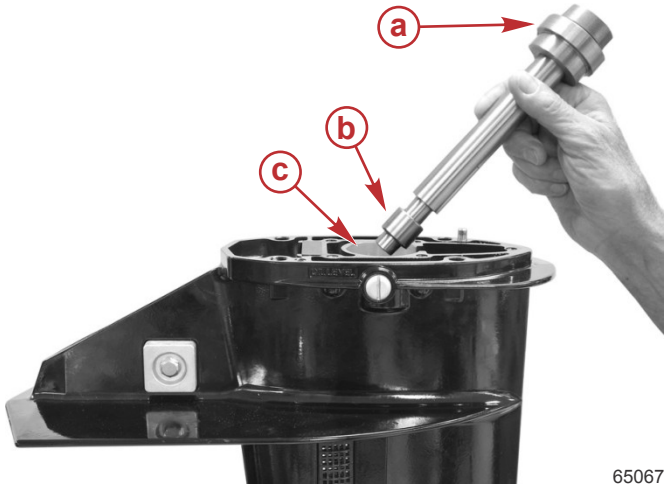
Gear Housing Assembly

Pinion Bearing Installation

1. Remove the sleeve from the pinion bearing tool.
2. Apply Premium Gear Lubricant to the inside diameter and outside diameter of the new pinion bearing. Install the pinion bearing with numbers/letters facing up toward the pinion bearing tool.

Tube Ref No.	Description	Where Used	Part No.
82	Premium Gear Lubricant	Inside diameter and outside diameter of pinion bearing	92-858058K01

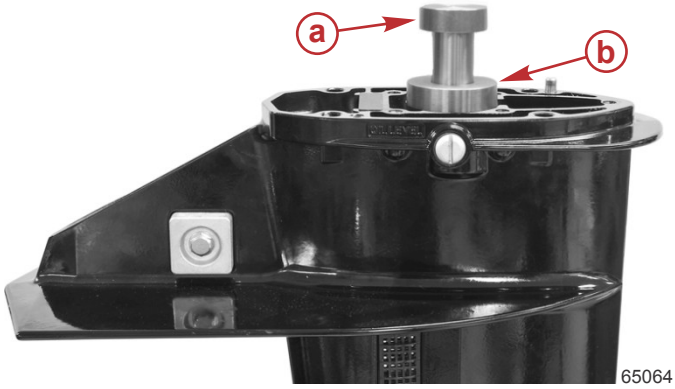
3. Insert the pinion bearing tool with the new pinion bearing into the driveshaft housing bore.



a - Pinion bearing tool
b - Pinion bearing
c - Driveshaft housing bore

Pinion Bearing Installation Tool Assembly	8M0038865

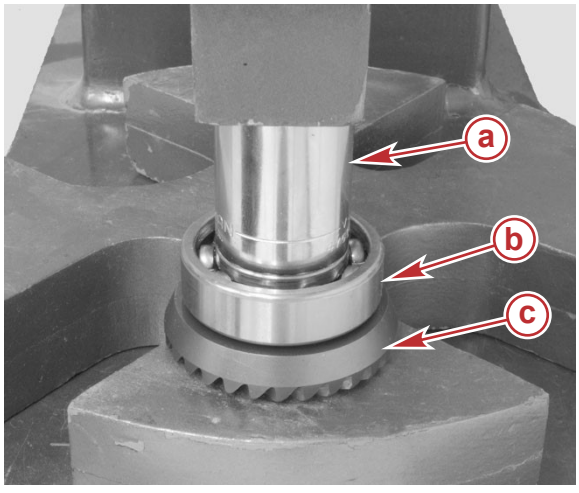
4. Tap on the head of the tool until the tool head seats against the tool flange. The pinion bearing will then be installed at the correct height in the driveshaft housing bore.



a - Head of pinion bearing tool
b - Tool flange

Forward Gear Bearing Installation

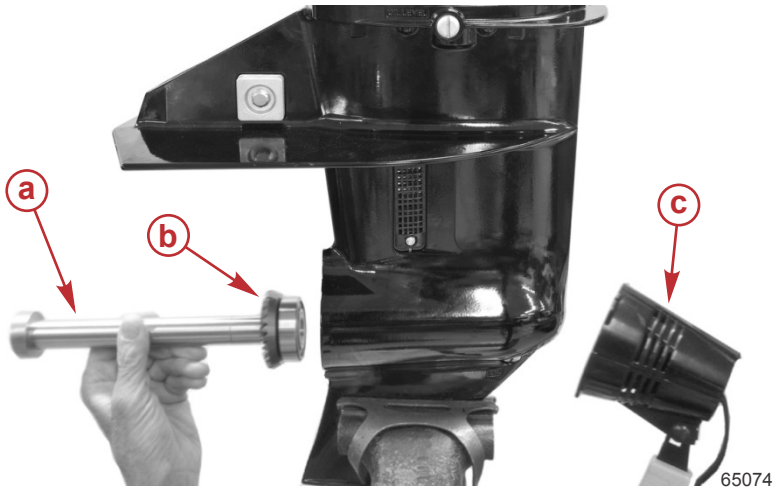
1. Using a mandrel that contacts only the inner diameter of the bearing race, press the bearing onto the forward gear.



a - Mandrel
b - Forward gear bearing
c - Forward gear

2. Use a torch lamp to warm the gearcase in the forward gear bearing area.

3. Use the pinion bearing tool to install the bearing and forward gear assembly into the gearcase.



a - Pinion bearing tool
b - Bearing and forward gear assembly
c - Torch lamp

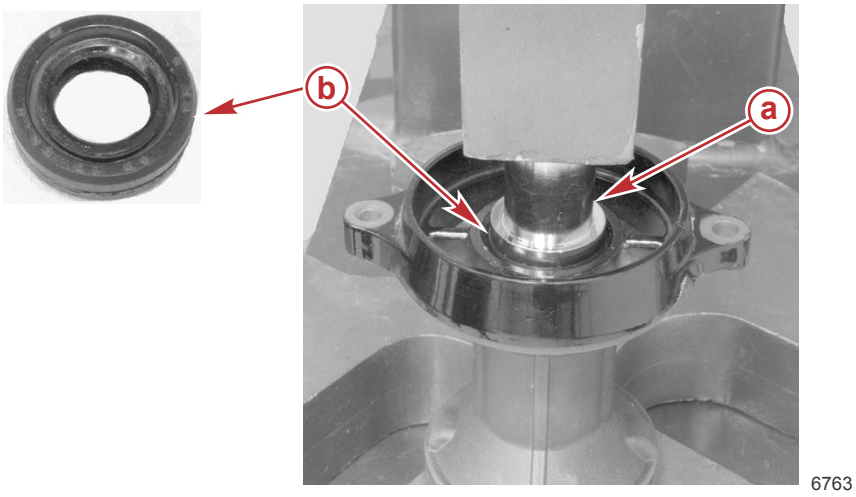
Torch Lamp	91- 63209
Pinion Bearing Installation Tool Assembly	8M0038865

Bearing Carrier Assembly

1. Apply 2-4-C with PTFE to the bearing carrier seal lips.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier seal lips	92-802859A 1

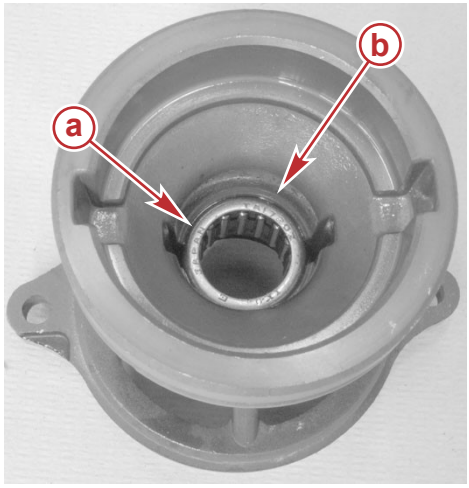
2. Install the seal with the seal face up.
3. Using a suitable mandrel from the bearing mandrel kit, press the seal into the bearing carrier until seated.



a - Mandrel
b - Seal (install face up)

Bearing Mandrel Kit	91- 83166M

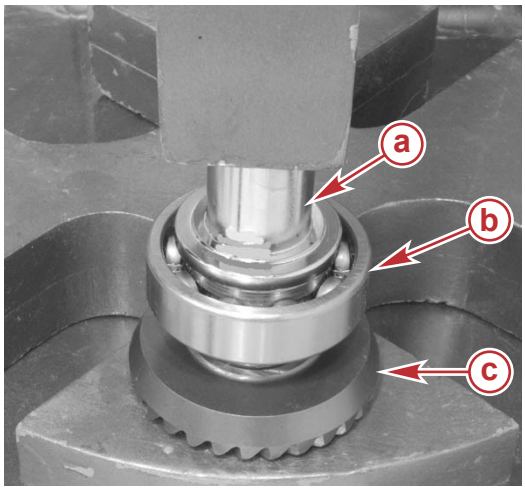
4. When installing the new needle bearing, press on the letter side of the bearing until the bearing is just below the ledge.



11461

a - Letter side of bearing
b - Ledge

5. Using a mandrel that contacts the inner diameter of the bearing race, press the new bearing onto the reverse gear.

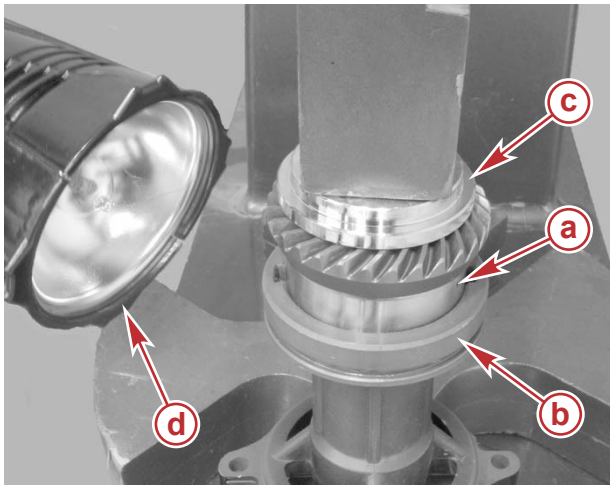


6766

a - Mandrel
b - Reverse gear bearing
c - Reverse gear

IMPORTANT: Do not install the bearing carrier O-ring if the torch lamp will be used on the bearing carrier. The O-ring will be damaged by the heat.

6. Use a torch lamp to warm the bearing carrier. Use a suitable mandrel to press the reverse gear assembly into the bearing carrier until the bearing is seated.

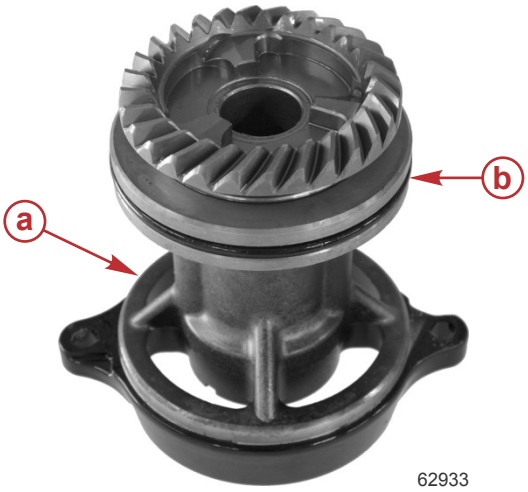


6772

a - Reverse gear assembly
b - Bearing carrier
c - Mandrel
d - Torch lamp

Bearing Mandrel Kit	91- 83166M
Torch Lamp	91- 63209

7. Apply 2-4-C with PTFE to the new bearing carrier O-ring. Install the O-ring onto the bearing carrier.

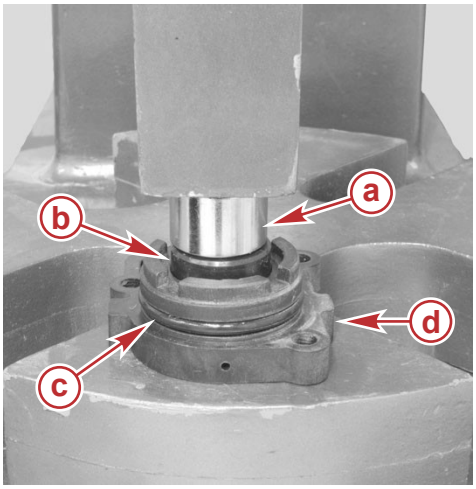


a - Bearing carrier
b - O-ring

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier O-ring	92-802859A 1

Water Pump Base Assembly

1. Using a suitable mandrel, press on the face of the water pump seal until the seal is seated in the water pump base.
2. Apply 2-4-C with PTFE to the seal lips.
3. Apply 2-4-C with PTFE onto a new O-ring and install the O-ring onto the water pump base.

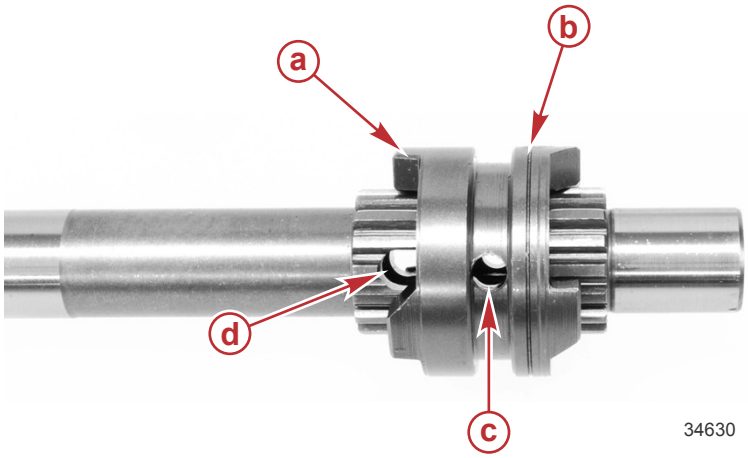


a - Mandrel
b - Seal
c - O-ring
d - Water pump base

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Apply to seal lips and O-rings	92-802859A 1

Propeller Shaft Assembly

1. Slide the clutch onto the propeller shaft with the ring on the clutch facing toward the forward gear. Ensure the hole in the clutch aligns with the slot in the propeller shaft.

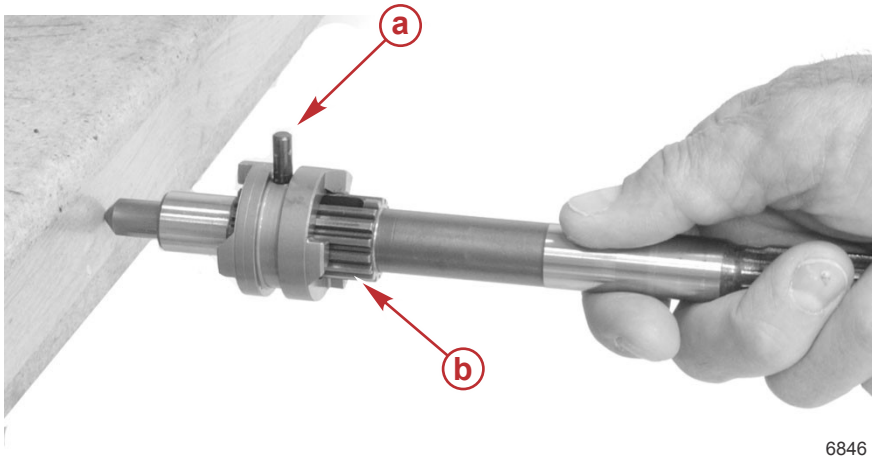


a - Clutch
b - Ring faces toward forward gear
c - Cross pin hole
d - Slot

2. Install the clutch spring and cam follower into the propeller shaft.

a - Propeller shaft
b - Clutch
c - Clutch spring
d - Cam follower

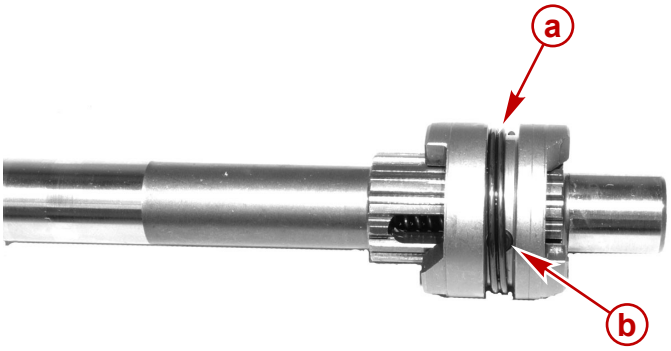
3. Compress the cam follower against a hard surface while aligning the clutch pin hole with the slots in the propeller shaft.
4. Insert the clutch cross pin through the clutch and propeller shaft until the clutch pin is flush with the clutch surface.



a - Clutch pin
b - Propeller shaft

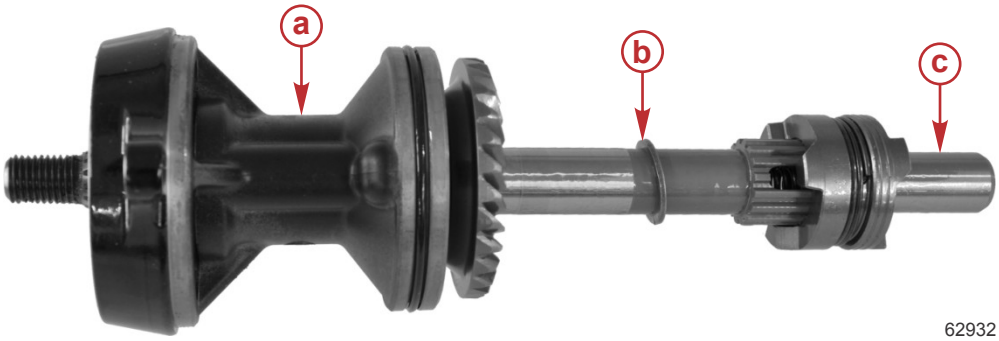
5. Install the thrust washer into the propeller shaft.

6. Install the retainer spring onto the clutch. Do not overlap the retainer spring coils.



a - Clutch retainer spring
b - Clutch pin

7. Install the propeller shaft assembly into the bearing carrier assembly.

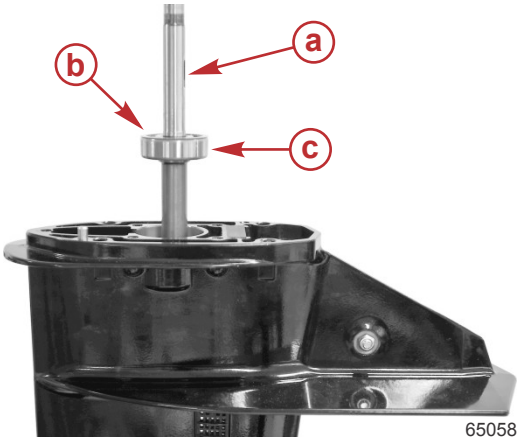


a - Reverse gear/bearing carrier assembly
b - Thrust washer
c - Propeller shaft

Pinion Gear and Driveshaft Installation

IMPORTANT: Remove any lubricant from the driveshaft pinion nut threads.

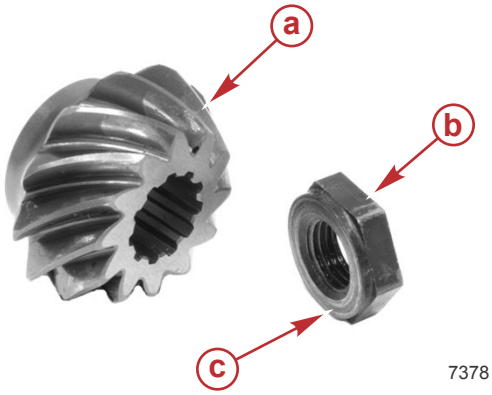
1. Install the driveshaft assembly, with the shims retained on top of the driveshaft bearing, through the pinion bearing.



a - Driveshaft
b - Shims (retained)
c - Upper driveshaft bearing

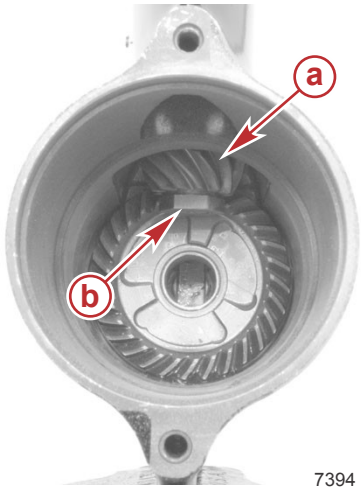
2. Lift the driveshaft slightly and install the pinion gear. It may be necessary to rotate the driveshaft slightly to engage the pinion gear with the splines of the driveshaft and forward gear teeth.
3. Apply Loctite® 271 Threadlocker to the pinion nut threads.

IMPORTANT: Install the pinion nut with the step side of the nut against the pinion gear.



a - Pinion gear
b - Pinion nut
c - Step side (install toward pinion gear)

4. Use the driveshaft holding tool and a suitable wrench to tighten the pinion nut to the specified torque.



a - Pinion gear
b - Pinion nut

Driveshaft Holding Tool	91-804762

Tube Ref No.	Description	Where Used	Part No.
7	Loctite® 271 Threadlocker	Pinion nut threads	92-809819

Description	Nm	lb-in.	lb-ft
Pinion nut	35	–	25.8

Forward Gear Backlash

NOTE: *There are no shims behind the forward gear bearing assembly. Forward gear backlash is changed by adding or subtracting shims located between the lower water pump base and the upper driveshaft bearing. Adding shims reduces backlash, removing shims increases backlash.*

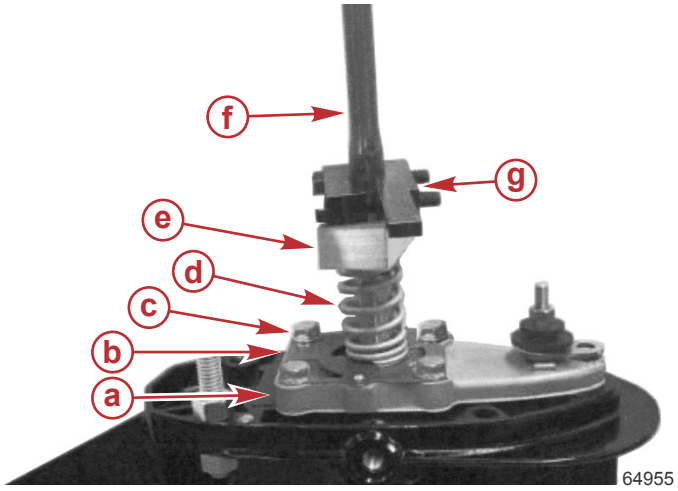
1. Secure the gearcase in a vise or gearcase holding fixture. The driveshaft must be kept vertical to provide the most accurate measurements.

   NOTE: *Verify the shims are installed above the upper driveshaft bearing before installing the water pump base.*

2. Place the water pump base gasket on the gear housing, slide the water pump base down the driveshaft, and seat the base into the gear housing.
3. Install the water pump guide plate gasket and water pump guide plate.
4. Secure the water pump base assembly to the gearcase with four M6 x 1 screws (obtain locally). Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Screw (M6 x 1)	6.0	53.1	–

5. Slide the spring and clamp over the driveshaft. Compress the spring approximately 6 mm (0.25 in.), and tighten the fastener on the clamp.

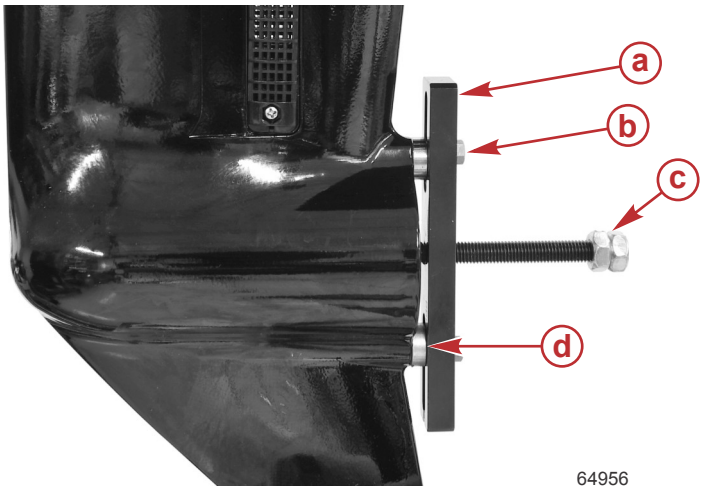


- **a -** Water pump base
- **b -** Water pump guide plate (with gasket)
- **c -** M6 x 1 screw (4)
- **d -** Spring, compress 6 mm (0.25 in.)
- **e -** Clamp
- **f -** Driveshaft
- **g -** Backlash indicator arm (install later)

Spring	8M0011503
Clamp	8M0033741

NOTE: *It may be easier to rotate the gearcase nose down, while preloading the forward gear. Rotate the nose back up so the driveshaft is vertical before taking measurements.*

6. Preload the forward gear:
   a. Insert the backlash preload tool into the gearcase so that it presses against the forward gear.
   b. Attach the preload tool to the gearcase, using two spacers and two screws.
   c. Tighten the screws to the specified torque.
   d. Thread two nuts onto the end of the backlash preload tool, and tighten (jam) the two nuts against each other.
   e. Using the jam nuts, tighten the preload tool to the specified torque.



- **a -** Backlash preload tool
- **b -** Screws (2)
- **c -** Jam nuts (2)
- **d -** Spacers (2)

Description	Nm	lb-in.	lb-ft
Preload tool screws	9.0	79.6	–
Preload tool jam nuts	5.1	45.1	–

Backlash Preload Tool	91-895195T04

7. Slide a backlash indicator arm over the driveshaft until it rests on the clamp. Secure the arm with the two integral fasteners, to ensure that it does not move.

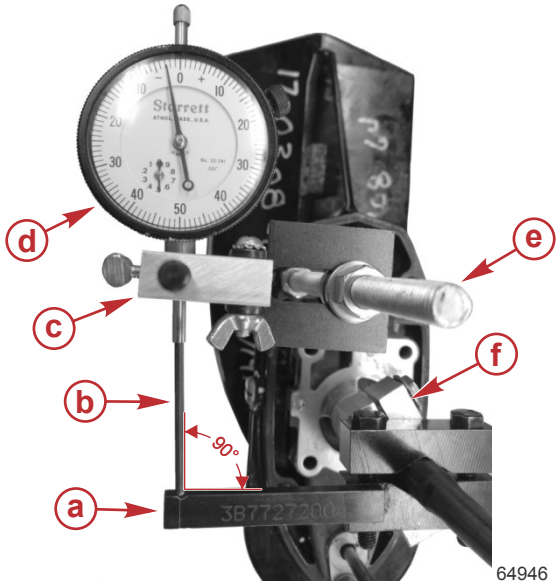
Backlash Indicator Arm	91-803133 12

8. Attach a dial indicator and dial indicator adapter to the gearcase, using a piece of threaded rod and two nuts (obtain locally).

Dial Indicator	91- 58222A 1
Dial Indicator Adapter	91-83155

9. Position the dial indicator tip so that it is perpendicular to and touching the notch in the indicator arm, as shown. Adjust the angle of the backlash indicator arm, as required. Tighten the fasteners on the dial indicator adapter so that the dial indicator does not move.

   NOTE: *Ensure that the dial makes at least one full revolution as the tip is compressed into the dial indicator.*



a - Backlash indicator arm
b - Dial indicator tip
c - Dial indicator adapter
d - Dial indicator
e - Threaded rod (obtain locally)
f - Clamp on driveshaft (compresses spring)

10. Zero the dial indicator.
11. Take the backlash reading by lightly turning the driveshaft back and forth.

Forward Gear	
Backlash	0.8–1.5 mm (0.031–0.059 in.)

12. If the backlash is not within specification, add or remove shims located between the upper driveshaft bearing and the water pump base.

    NOTE: *Removing a 0.1 mm (0.004 in.) shim will increase the axial play value by 0.1 mm (0.004 in.).*
    Adding a 0.1 mm (0.004 in.) shim will decrease the axial play value by 0.1 mm (0.004 in.).
13. After making shim adjustments, repeat the measurement procedure to ensure the correct backlash specification is obtained. Then remove all items installed for this procedure.

Shift Shaft and Water Pump Base Installation

1. Inspect the shift shaft bracket, located on the underside of the water pump base. Replace it, if it is damaged.

Description	Nm	lb-in.	lb-ft
Shift shaft bracket screw	5.0	44.3	–

2. Insert the shift shaft into the water pump base. Ensure that the new shift shaft O-ring remains properly seated.

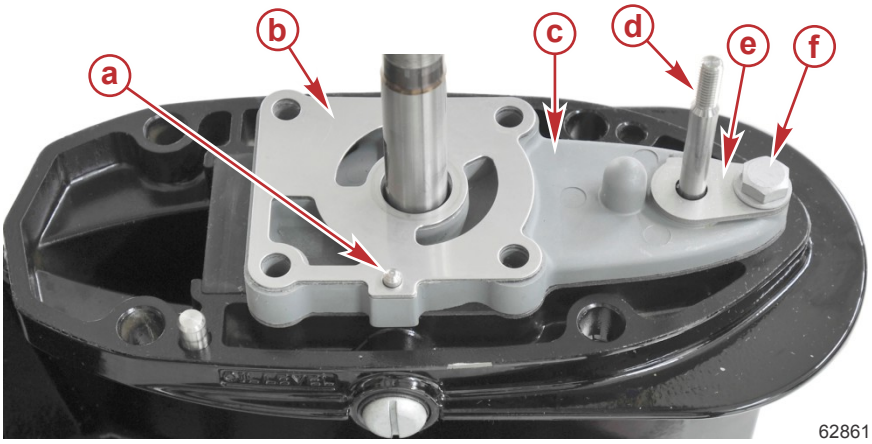
3. Position the shift shaft such that the spring pin is level with the notch in the shift shaft bracket. Rotate the shift shaft so that the spring pin rides along the edges of the bracket and the cam is facing in the correct direction (ramped face towards the cam follower, when installed into the gearcase).

a - Shift cam ramped face

4. Place a new water pump gasket onto the gearcase housing.
5. Install the water pump base assembly onto the gearcase housing. Some adjusting may be required to allow the shift cam to fit into place. The base should rest easily on the gasket, without force to close the gap, when all parts are positioned correctly.
6. Slide the clamp over the shift shaft, and secure it and the water pump base to the gearcase with a screw and washer.
7. Ensure that the clamp does not interfere with the shift shaft, and tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Shift shaft clamp screw	6.0	53.1	–

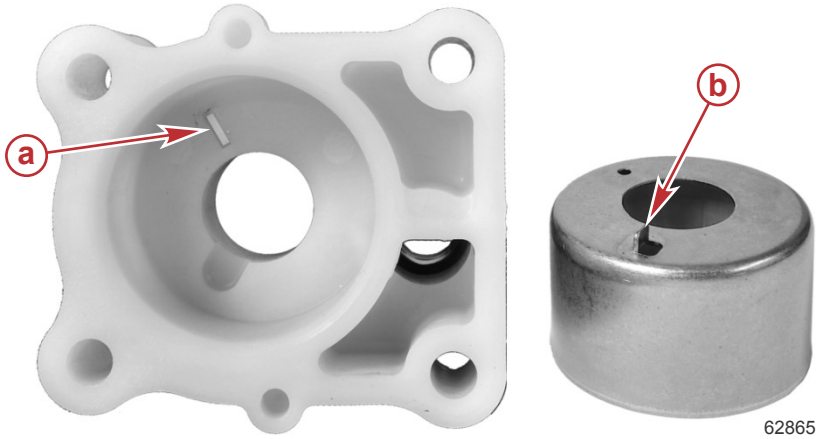
8. Insert the dowel pins into the water pump base.
9. Ensure that the sealing surfaces of the water pump base and the faceplate are clean. Using a new gasket, install the faceplate.



a - Dowel pin (2)
b - Faceplate (with new gasket beneath)
c - Water pump base (gasket beneath)
d - Shift shaft
e - Clamp
f - Screw and washer

Water Pump Cover Assembly

1. Align the locating tab on top of the water pump liner with the slot in the pump cover. Insert the liner into the pump cover.



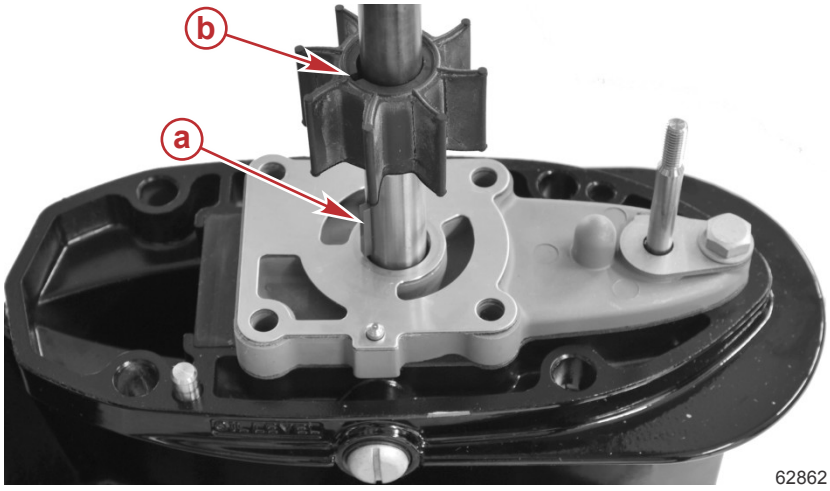
a - Slot in the water pump cover
b - Tab on top of the water pump liner

2. Install the water pump drive key. Use 2-4-C with PTFE to hold the key to the driveshaft.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Water pump drive key	92-802859A 1

IMPORTANT: The impeller should be replaced, regardless of appearance, whenever the gearcase is serviced. If the old impeller must be used, it must be installed in the direction of the original rotation. Installing the impeller with the vanes reversed from their original direction will result in vane breakage.

3. Align the slot in the impeller with the drive key, and install the impeller.

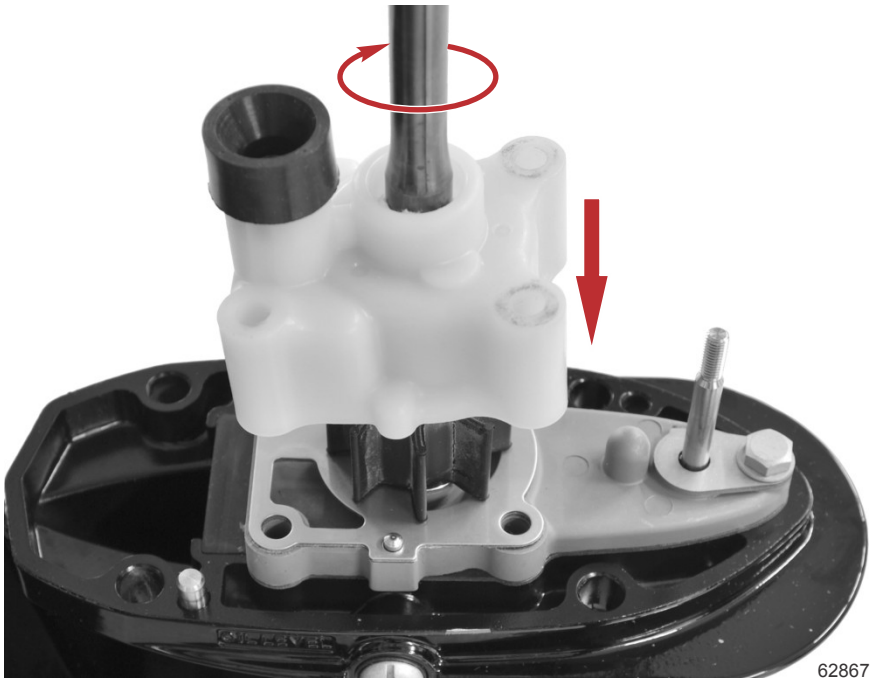


a - Water pump drive key
b - Slot in impeller

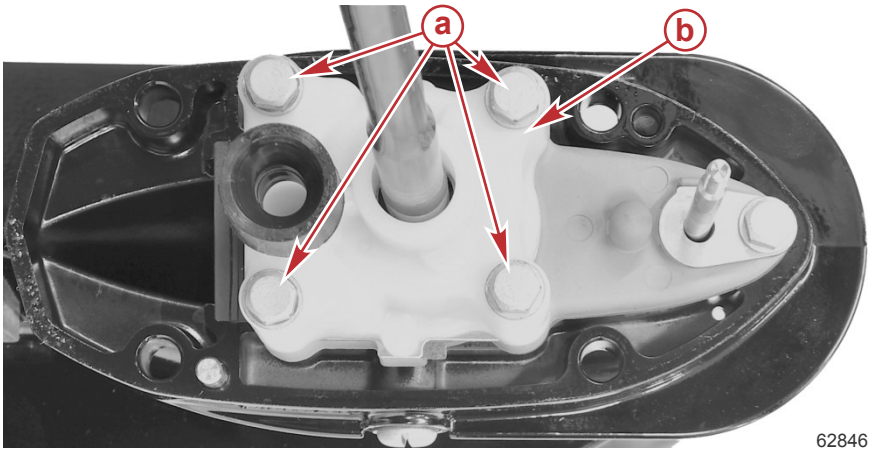
4. Lubricate the inside diameter of the water pump liner with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Inside diameter of the water pump liner	92-802859A 1

5. Slide the pump cover onto the driveshaft. While pushing down on the water pump cover, rotate the driveshaft clockwise to install the pump cover over the impeller.



6. Secure the water pump cover with four screws. Tighten the screws to the specified torque.



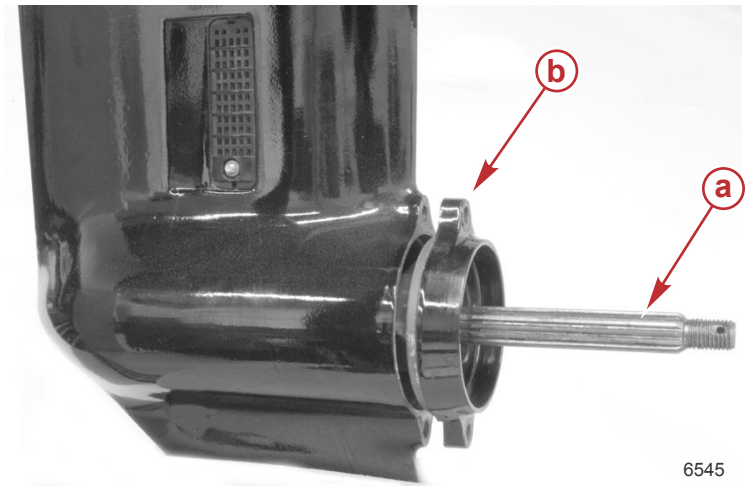
a - Screws (4)
b - Water pump cover

Description	Nm	lb-in.	lb-ft
Water pump cover screws	6.0	53.1	–

Propeller Shaft and Bearing Carrier Installation

1. Apply 2-4-C with PTFE to the bearing carrier O-ring.

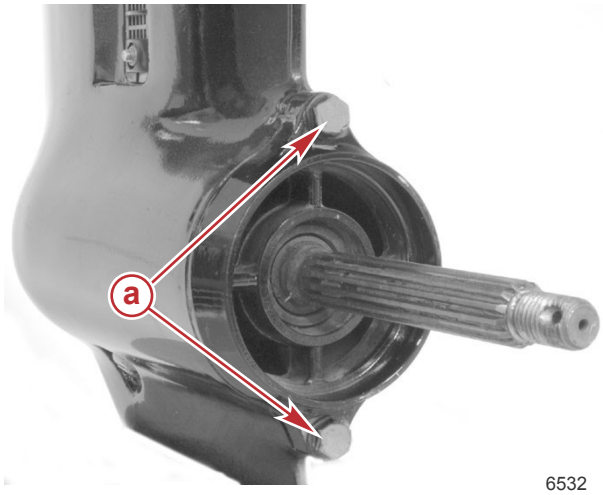
2. Rotate the driveshaft while seating the bearing carrier assembly into the gear housing, to ensure that the pinion and reverse gears are in mesh.



a - Propeller shaft
b - Bearing carrier assembly

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier O-ring	92-802859A 1

3. Secure the bearing carrier with two screws. Tighten the screws to the specified torque.



a - Screws (2)

Description	Nm	lb-in.	lb-ft
Bearing carrier assembly screws	9.0	79.6	–

Gear Housing Installation

⚠ WARNING

Accidental starting can cause serious injury. Before removing or installing the gear housing, disconnect and isolate the spark plug leads. Disable the ignition system by removing the keys from the ignition (if equipped) and engaging the lanyard stop switch to prevent the engine from starting.

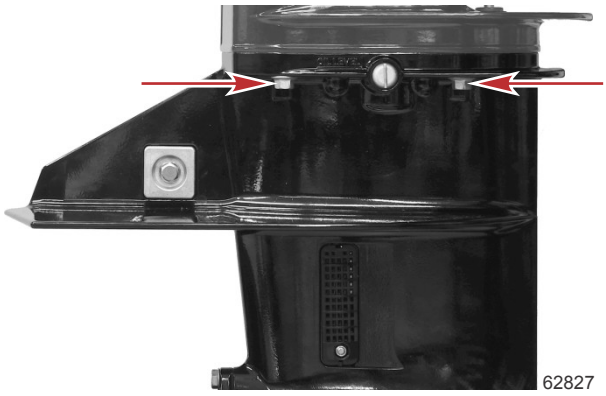
1. Remove and isolate the spark plug leads from the spark plugs.
2. Place the shift handle (tiller models) or shift lever (remote control models) into reverse.
3. Place the gear housing into reverse by pushing down on the lower shift shaft until it stops. A hard stop should be felt as the shift shaft spring pin comes to rest on the tabs at the bottom of the shift shaft bracket.
4. Apply 2-4-C with PTFE to the driveshaft splines.

NOTICE

Installing the gear housing to the powerhead without adequately cleaning the top of the driveshaft can result in severe product damage. Any lubricant trapped in the space between the driveshaft and the crankshaft prevent the two from properly engaging. Always clean the top of the driveshaft before installing the gear housing.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Driveshaft splines	92-802859A 1

5. Guide the gear housing into the driveshaft housing. Rotate the gearcase slightly, as necessary, to engage the driveshaft with the crankshaft.
6. Secure the gearcase with four screws and washers. Tighten the screws to the specified torque.

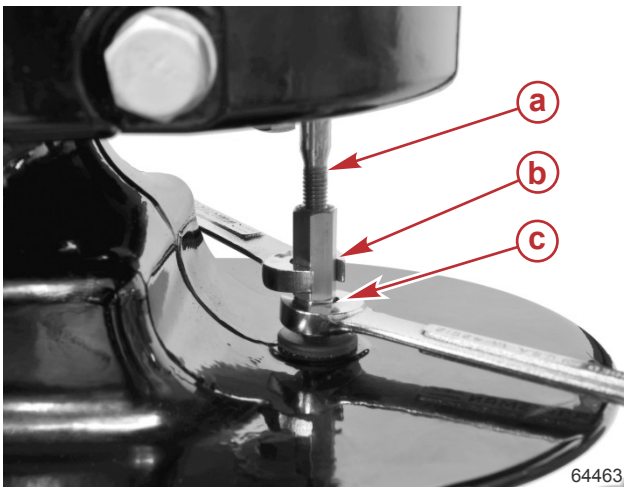


Gearcase screws (two per side)

Description	Nm	lb-in.	lb-ft
Gearcase screws	24.0	–	17.7

7. Thread the jam nut onto the lower shift shaft until it stops turning.
8. Maintain alignment of the upper and lower shift shafts while threading the coupler at least five turns onto the lower shift shaft.

   IMPORTANT: Take care to not rotate the lower shift shaft. Doing so will damage components within the gearcase.
9. Use two wrenches to lock the jam nut against the coupler.



a - Upper vertical shift shaft
b - Wrench on coupler
c - Wrench on jam nut

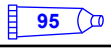
10. Check the shift operation as follows:
    - Place the shift lever in forward. The gear housing should ratchet when the propeller shaft is turned clockwise and resistance should be felt when the propeller is turned counterclockwise.
    - Place the shift lever in neutral. Resistance should not be felt when the propeller shaft is rotated in either direction.
    - Place the shift lever in reverse. Resistance should be felt when the propeller shaft is rotated in either direction.
    - If the shift operation is not as described, check the coupler installation procedure. If the coupler installation procedure is correct, the gearcase is not properly assembled or internal parts are excessively worn and must be replaced.

Propeller Installation

⚠ WARNING

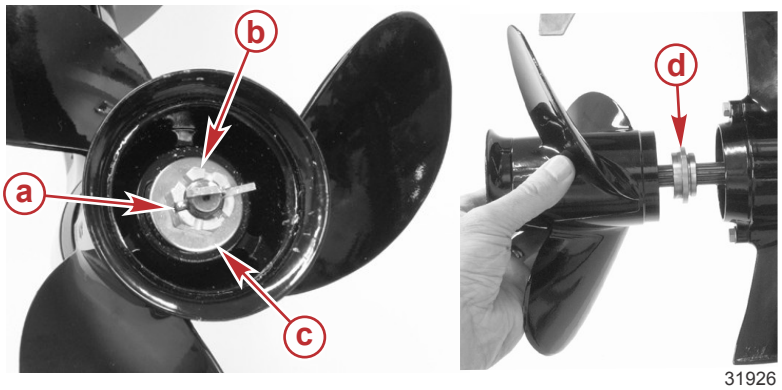
Rotating propellers can cause serious injury or death. Never operate the boat out of the water with a propeller installed. Before installing or removing a propeller, place the drive unit in neutral and engage the lanyard stop switch to prevent the engine from starting. Place a block of wood between the propeller blade and the anti-ventilation plate.

1. Coat the propeller shaft splines with one of the following Mercury products:

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Propeller shaft splines	8M0071842
	2-4-C with PTFE	Propeller shaft splines	92-802859A 1

2. Install the front thrust hub onto the propeller shaft so that the larger diameter end is facing the propeller.
3. Install the propeller, rear thrust washer, and propeller nut onto the propeller shaft.
4. Place a block of wood between the gearcase and the propeller to prevent rotation. Tighten the propeller nut to the specified torque. Secure the nut to the propeller shaft with a cotter pin.

   NOTE: *If the propeller nut does not align with the propeller shaft hole after tightening, tighten the nut further to align with the hole.*
5. Align the propeller nut with the propeller shaft hole. Insert a new cotter pin into the hole and bend the ends.



a - Cotter pin
b - Propeller nut
c - Rear thrust washer
d - Front thrust hub (large diameter end towards the propeller)

Description	Nm	lb-in.	lb-ft
Propeller nut	12.0	106.2	–

Notes:

Attachments

Section 7A - Throttle and Shift Linkage

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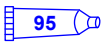
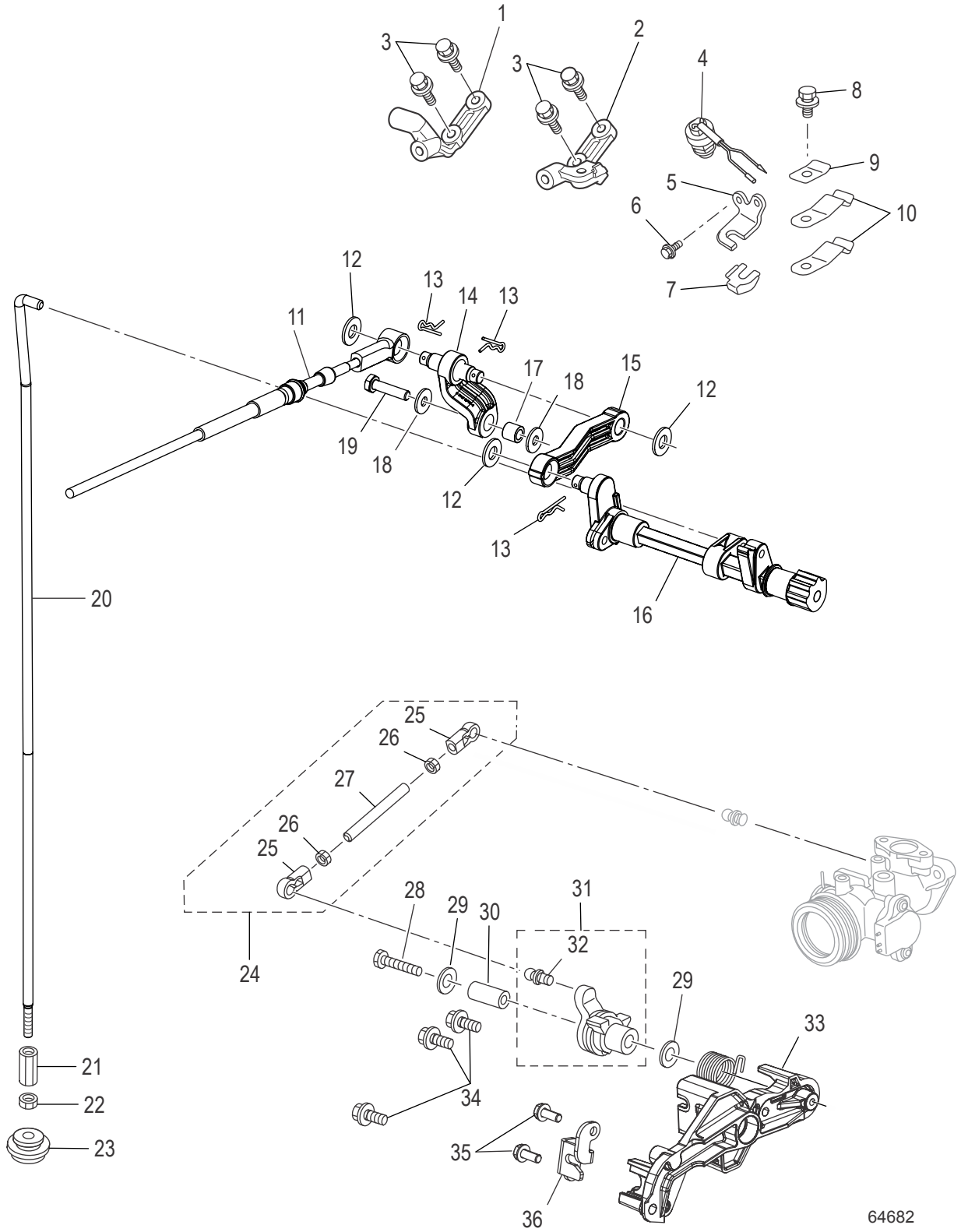
7
A

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	2-4-C with PTFE	Shift shaft assembly detents and contact surfaces	92-802859A 1

Notes:

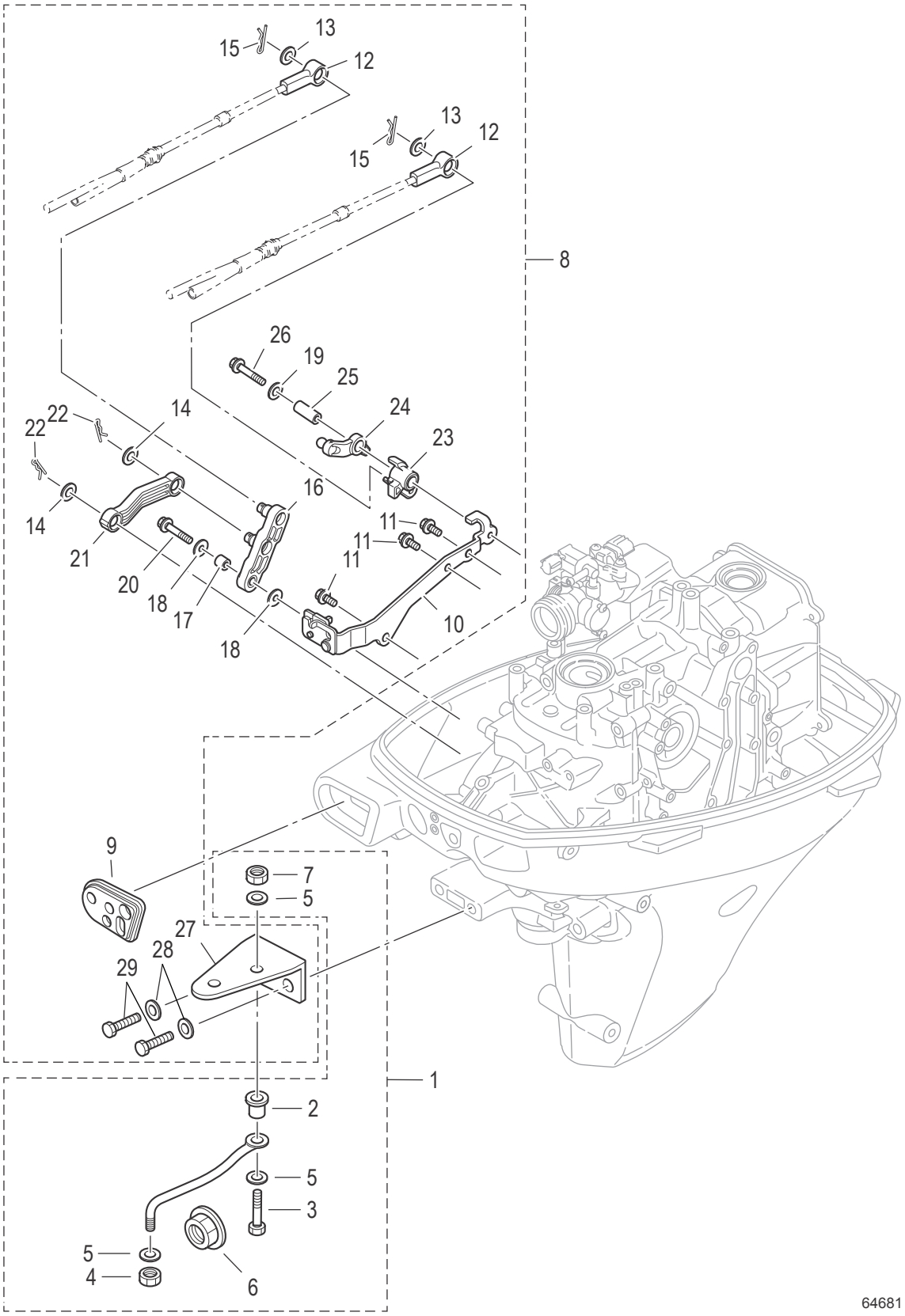
Throttle and Shift Components (Tiller Models)



Throttle and Shift Components (Tiller Models)

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Starboard horizontal shift shaft bracket			
2	1	Port horizontal shift shaft bracket			
3	4	Screw	6.0	53.1	–
4	1	Neutral start switch			
5	1	Bracket			
6	1	Screw	6.0	53.1	–
7	1	Switch actuator			
8	1	Screw	6.0	53.1	–
9	1	Short detent spring			
10	2	Detent spring			
11	1	Shift cable assembly			
12	3	Plastic washer			
13	3	Retaining clip			
14	1	Lower shift arm			
15	1	Upper shift arm			
16	1	Horizontal shift shaft			
17	1	Bushing			
18	2	Washer			
19	1	Screw	6.0	53.1	–
20	1	Vertical shift shaft			
21	1	Shift shaft coupler	4.0	35.4	–
22	1	Jam nut	4.0	35.4	–
23	1	Grommet			
24	1	Throttle link rod assembly			
25	2	Ball joint connector			
26	2	Jam nut	3.0	26.6	–
27	1	Throttle rod			
28	1	Screw	6.0	53.1	–
29	2	Washer			
30	1	Bushing			
31	1	Throttle drum assembly			
32	1	Ball joint			
33	1	Throttle and shift cable bracket			
34	3	Screw	6.0	53.1	–
35	2	Screw			
36	1	Cable latch			

Remote Control Components



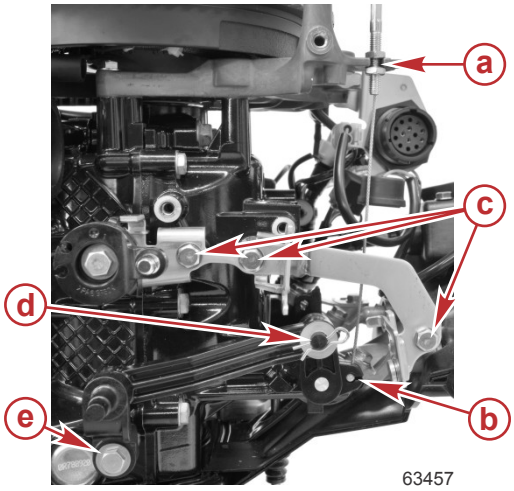
Remote Control Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Drag link assembly			
2	1	Spacer			
3	1	Screw			
4	1	Nylon insert locknut	Tighten until it seats, then back off 1/4 turn		
5	3	Washer			
6	1	Seal ring			
7	1	Nylon insert locknut	27.0	–	19.9
8	1	Steering hook plate			
9	2	Washer			
10	2	Screw	26.0	–	19.2
11	1	Throttle and shift bracket			
12	3	Screw	6.0	53.1	–
13	2	Cable joint			
14	2	Washer			
15	2	Washer			
16	2	Retaining clip			
17	1	Shift arm			
18	1	Collar			
19	2	Washer			
20	1	Washer			
21	1	Screw	6.0	53.1	–
22	1	Shift lever rod			
23	2	Retaining clip			
24	1	Throttle arm			
25	1	Throttle opener			
26	1	Collar			
27	1	Screw	6.0	53.1	–
28	2	Ball joint connector			
29	2	Jam nut	3.0	26.6	–
30	1	Throttle link rod			
31	1	Screw	6.0	53.1	–
32	1	Short detent spring			
33	2	Detent spring			
34	4	Screw	6.0	53.1	–
35	1	Starboard horizontal shift shaft bracket			
36	1	Port horizontal shift shaft bracket			
37	1	Horizontal shift shaft			
38	1	Vertical shift shaft			
39	1	Shift shaft coupler	4.0	35.4	–
40	1	Jam nut	4.0	35.4	–
41	1	Grommet			

Tiller Handle Models

Throttle and Shift Linkage Removal

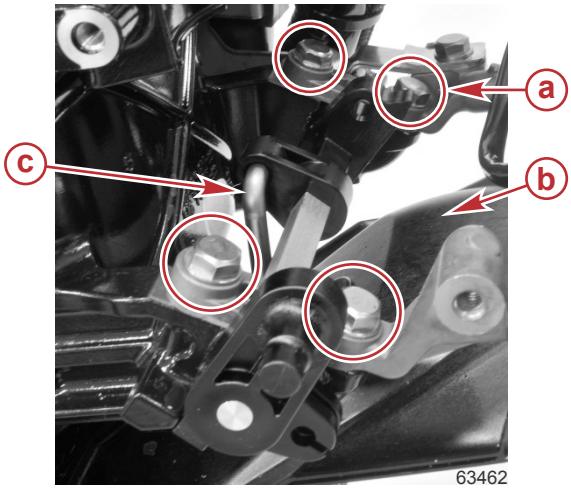
1. Remove the starboard driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.
2. Remove the tiller handle control cable. Refer to **Section 7B - Tiller Handle Removal**.
   NOTE: *It is not necessary to remove the tiller handle from the engine.*
3. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.
4. Loosen one of the interlock cable jam nuts, and remove the interlock cable from the shift lever.
5. Remove three screws to remove the throttle and shift bracket.
6. Remove the retaining clip and washer from the shift link.
7. Remove one screw, two washers, and a bushing to remove the shift link from the engine.



Bracket style may vary

a - Jam nuts
b - Interlock cable connection to the shift linkage
c - Throttle and shift bracket screws (3)
d - Retaining clip and washer
e - Screw, two washers, and bushing

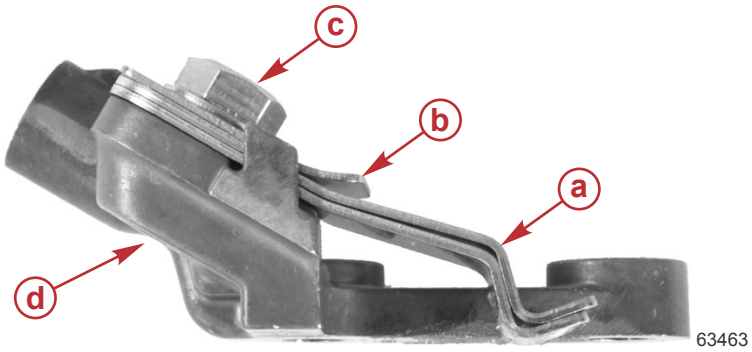
8. Electric start models:
   a. Remove the starter. Refer to **Section 2B - Starter Motor Removal**.
   b. Remove the neutral safety switch.
9. Remove the four screws securing the two shift lever shaft brackets. The front cowl will come loose with the brackets.
10. Disconnect the vertical shift shaft from the shift lever, and remove the shift lever.



a - Shift lever shaft bracket screws (4)
b - Front cowl
c - Vertical shift shaft

Shift Detent

Inspect the shift detent hardware. Replace any worn or damaged components.



a - Shift detent springs
b - Short detent spring
c - Screw
d - Port shift lever bracket

Throttle and Shift Linkage Installation

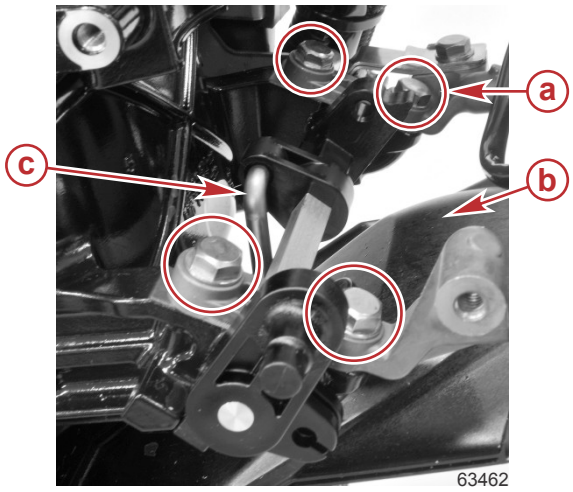
1. Ensure the gearcase is in neutral.
2. Install the vertical shift shaft, if it was removed.
3. Apply 2-4-C with PTFE to the shift shaft assembly detents and contact surfaces.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift shaft assembly detents and contact surfaces	92-802859A 1

4. Install the shift shaft lever, being certain to engage the vertical shift shaft.
5. Ensure that the shift detent hardware is assembled on the port shift shaft lever bracket. Refer to **Shift Detent**.
6. Secure the shift shaft lever with two brackets and four screws.
7. Ensure that the front cowl properly engages the midplate and the vertical shift shaft boot.

   NOTE: *If the front cowl was removed from the shift lever brackets, install it now.*
8. Tighten the four shift shaft lever bracket screws (two per bracket) and the shift detent screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Shift shaft lever bracket screws	6.0	53.1	–
Shift detent screw	6.0	53.1	–



a - Shift shaft lever bracket screws (4)
b - Front cowl
c - Vertical shift shaft

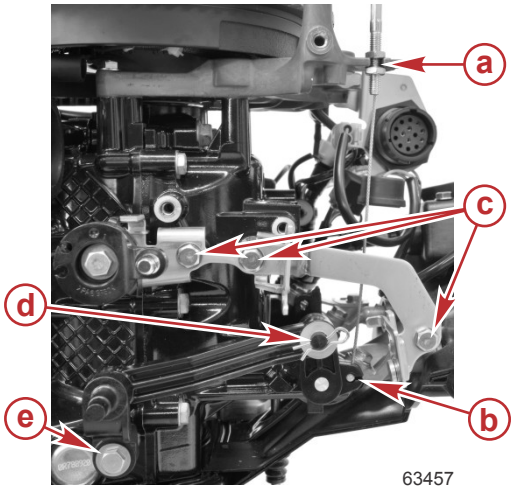
9. Electric start models:
   a. Install the neutral safety switch.
   b. Install the starter motor. Refer to **Section 2B - Starter Motor Installation**.
10. Install the shift link, using one screw, two washers (one each side), and one bushing. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Shift link screw	6.0	53.1	–

11. Attach the shift link to the shift lever using a retaining clip and washer.
12. Install the throttle and shift bracket. Tighten the three screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Throttle and shift bracket screws	6.0	53.1	–

13. Attach the end of the neutral interlock cable to the shift lever. Temporarily secure the cable to the starter mounting bracket with the two jam nuts.



Bracket style may vary

- **a -** Jam nuts
- **b -** Interlock cable connection to the shift lever
- **c -** Throttle and shift bracket screws (3)
- **d -** Retaining clip and washer
- **e -** Screw, two washers, and bushing

14. Install the recoil starter assembly. Refer to **Section 8A - Recoil Starter**. Adjust the interlock cable as required, and tighten the jam nuts.
15. Install the air box. Refer to **Section 3C - Air Box Installation**.
16. Install the tiller handle shift and throttle control cables. Refer to **Section 7B - Shift Cable Installation** and **Section 7B - Throttle Cable Installation**.
17. Install the starboard driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.

Remote Models

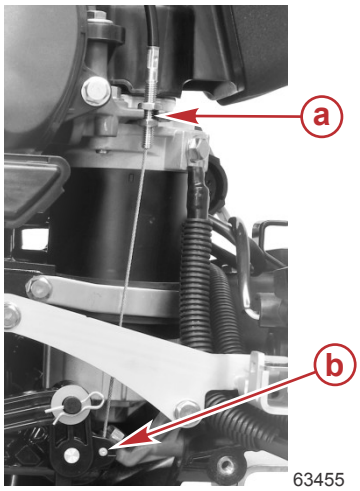
Throttle and Shift Linkage Removal

⚠ WARNING

Performing service or maintenance without first disconnecting the battery can cause product damage, personal injury, or death due to fire, explosion, electrical shock, or unexpected engine starting. Always disconnect the battery cables from the battery before maintaining, servicing, installing, or removing engine or drive components.

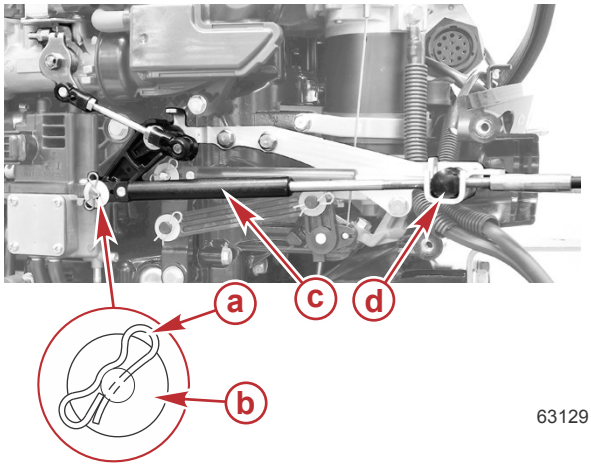
1. Disconnect the battery cables from the battery.
2. Remove the starboard driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.
3. Remove the air box and recoil starter.
   - It is easiest to remove and install these two items together.
   - Refer to **Section 3C - Air Box Removal** and **Section 8A - Recoil Starter**.

4. Loosen one of the interlock cable jam nuts, and remove the interlock cable from the shift lever.

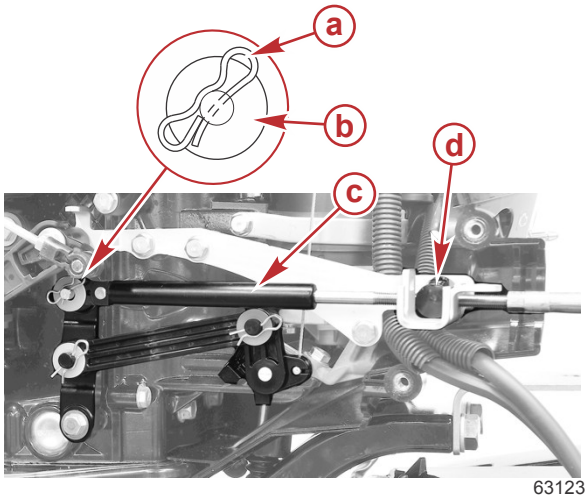


a - Jam nuts
b - Interlock cable anchored in the shift lever

5. Remove the bow-tie retainers and washers from the throttle and shift cables.

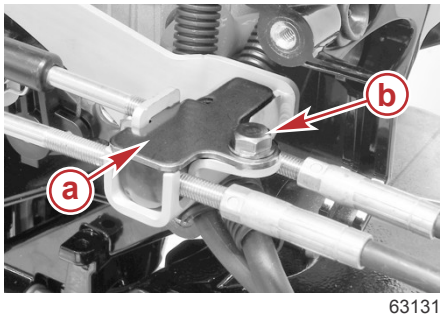


a - Bow-tie retainer
b - Flat washer
c - Throttle cable
d - Cable barrel



a - Bow-tie retainer
b - Flat washer
c - Shift cable
d - Cable barrel

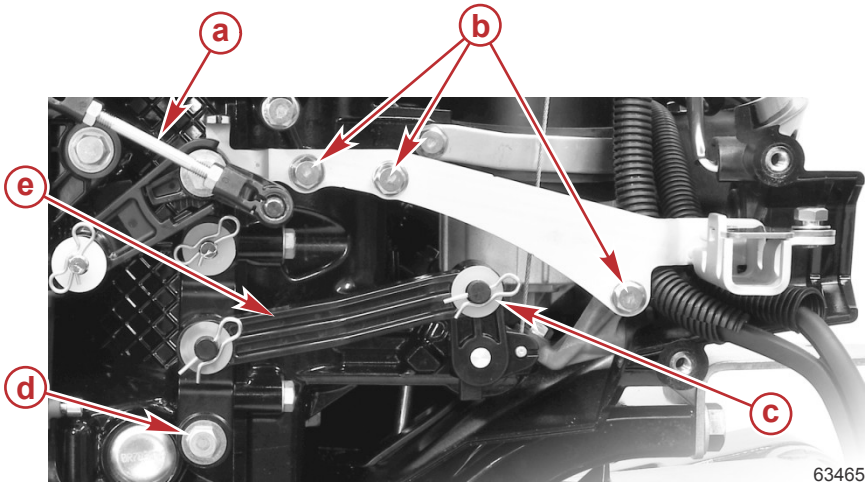
6. Remove the screw from the cable barrel retainer, and remove the throttle and shift cables.



a - Cable barrel retainer
b - Screw

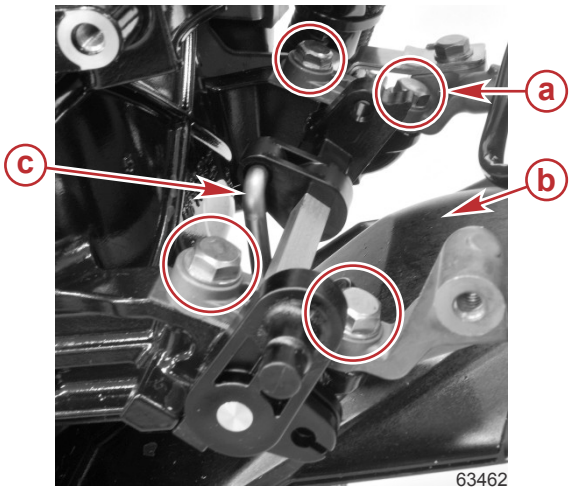
7. Remove the throttle link.
8. Remove three screws to remove the throttle and shift bracket.
9. Remove the retaining clip and washer and remove the shift lever rod from the shift arm.

10. Remove one screw, two washers, and a bushing to remove the shift link from the engine.



- **a -** Throttle link
- **b -** Throttle and shift bracket screws (3)
- **c -** Retaining clip and washer
- **d -** Screw, two washers, and bushing
- **e -** Shift link

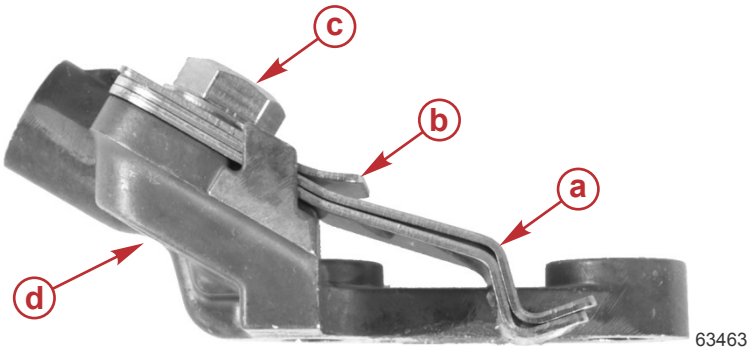
11. Remove the starter motor. Refer to **Section 2B - Starter Motor Removal**.
12. Remove the four screws securing the two shift lever shaft brackets. The front cowl will come loose with the brackets.
13. Disconnect the upper shift shaft from the shift lever, and remove the shift lever shaft assembly.



- **a -** Shift lever bracket screws (4)
- **b -** Front cowl
- **c -** Upper shift shaft

Shift Detent

Inspect the shift detent hardware. Replace any worn or damaged components.



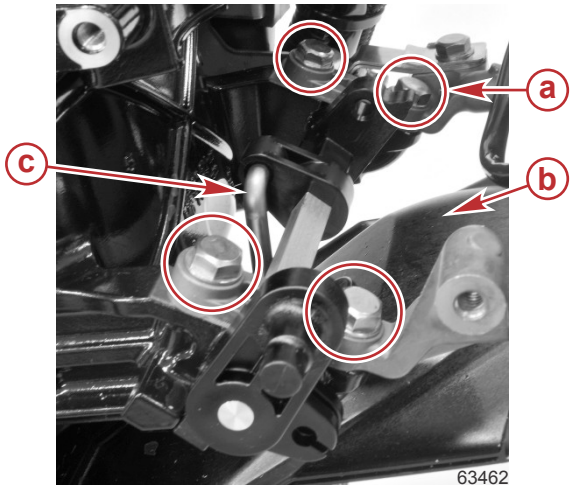
- **a -** Shift detent springs
- **b -** Short detent spring
- **c -** Screw
- **d -** Port shift lever bracket

Throttle and Shift Linkage Installation

1. Install the upper shift shaft, if it was removed.
2. Apply 2-4-C with PTFE to the shift shaft assembly detents and contact surfaces.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift shaft assembly detents and contact surfaces	92-802859A 1

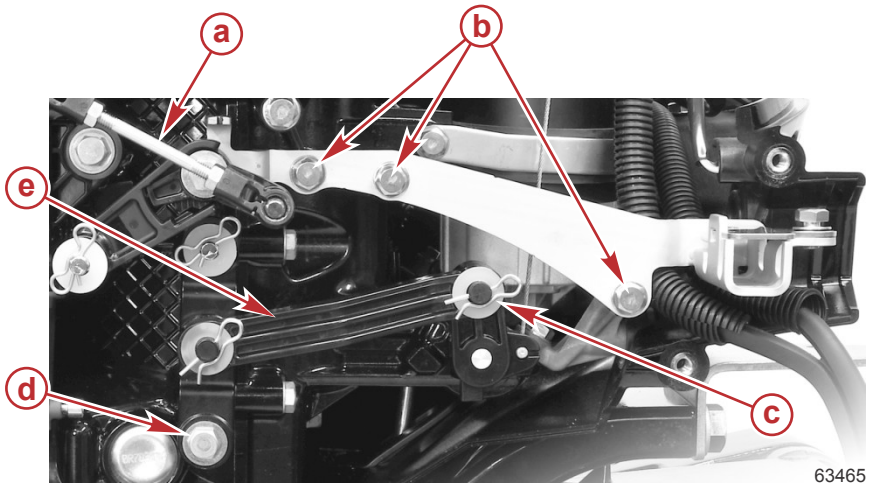
3. Install the shift shaft lever, being certain to engage the vertical shift shaft.
4. Secure the shift shaft lever with two brackets and four screws.
5. Ensure that the front cowl properly engages the midplate and the vertical shift shaft boot.
   NOTE: *If the front cowl was removed from the shift lever brackets, install it now.*
6. Tighten the four shift shaft lever bracket screws (two per bracket) and the shift detent screw to the specified torque.



a - Shift shaft lever bracket screws (4)
b - Front cowl
c - Vertical shift shaft

Description	Nm	lb-in.	lb-ft
Shift shaft lever bracket screws (4)	6.0	53.1	–
Shift detent screw	6.0	53.1	–

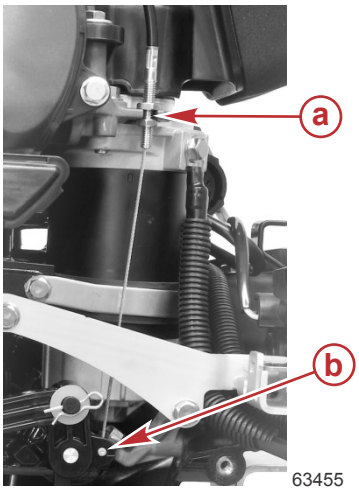
7. Install the starter motor. Refer to **Section 2B - Starter Motor Installation**.
8. Install the shift link, using one screw, two washers (one each side), and one bushing. Tighten the screw to the specified torque.
9. Attach the shift link to the shift lever using a retaining clip and washer.
10. Install the throttle and shift bracket. Tighten the three screws to the specified torque.
11. Install the throttle link.



a - Throttle link
b - Throttle and shift bracket screws (3)
c - Retaining clip and washer
d - Screw, two washers, and bushing
e - Shift link

Description	Nm	lb-in.	lb-ft
Throttle and shift bracket screws (3)	6.0	53.1	–
Shift link screw	6.0	53.1	–

12. Attach the interlock cable to the shift arm, and temporarily secure the cable to the starter bracket with the two jam nuts.



a - Jam nuts
b - Interlock cable anchored in the shift arm

13. Install the shift and throttle cables. Refer to **Section 1D - Remote Wiring Harness and Control Cable Installation**.
14. Install the recoil starter and air box.
    - It is easiest to install the recoil starter and air box together.
    - Refer to **Section 8A - Recoil Starter Installation** and **Section 3C - Air Box Installation**.
15. Adjust the interlock cable jam nuts to remove any slack in the cable.
16. Install the starboard driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.

Attachments

Section 7B - Tiller Handle

Table of Contents

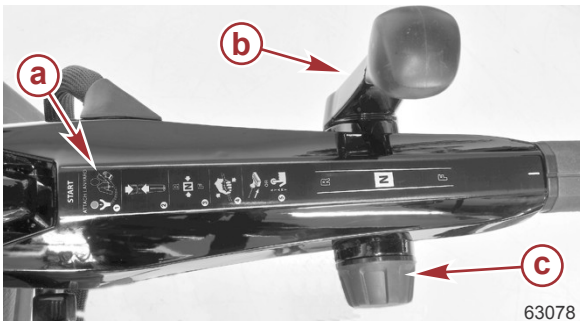
7
B

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
7	Loctite® 271 Threadlocker	Exposed threads of the pivot screw	92-809819
		Tiller handle mounting screws	
95	2-4-C with PTFE	Throttle cable end barrels, pulley face, and pulley O.D.	92-802859A 1
		Shift handle bushings	
		Shift cable input rod and eyelet	
		Throttle shaft bracket I.D.	
		Friction knob shaft threads	
		Tiller handle plastic bushing I.D.	
		Unthreaded portion of the shift cable output rod	
		Throttle cable anchors	

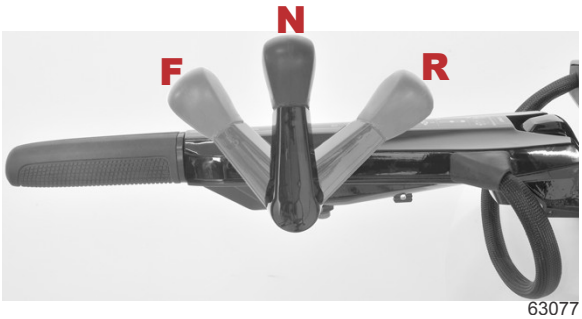
Tiller Handle Features

- A decal on the tiller handle provides quick reference for starting the engine.
- The friction knob allows the user to increase friction on the tiller throttle shaft, to hold the throttle at a desired speed, or decrease friction to allow the throttle to automatically return to idle when the grip is released.

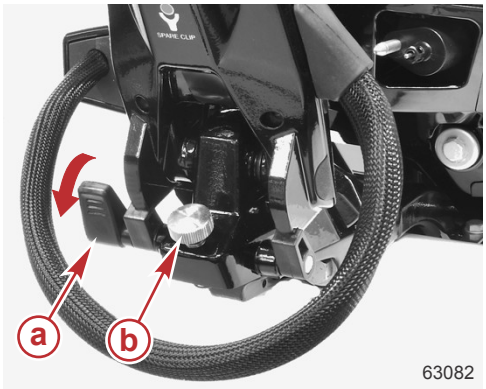


a - Quick reference decal
b - Shift lever
c - Throttle grip friction knob

- The shift lever has three positions to control engine operation: forward (F), neutral (N), and reverse (R). A shift detent helps the operator locate the neutral position.

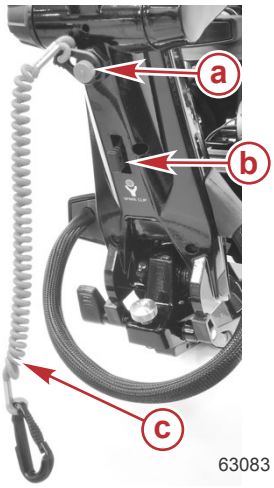


- The tiller handle can be tilted up for convenient handling during transportation or storage.
- Push the lock release lever down to allow the tiller handle to be lowered.
- Turn the adjustment knob to raise or lower the tiller handle in its operating position.



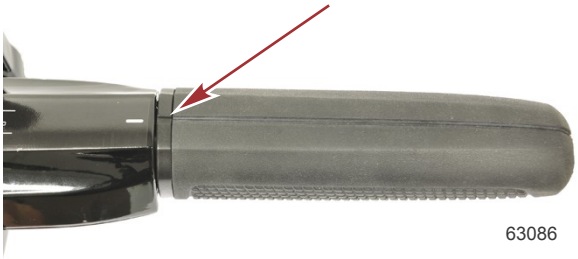
a - Tiller lock release lever
b - Tiller handle adjustment knob

- Tiller handle yaw can be adjusted to change the angle of the handle to the engine. Refer to **Tiller Handle Yaw**.
- The tiller handle is equipped with a lanyard stop switch and a spare lanyard stop switch clip.



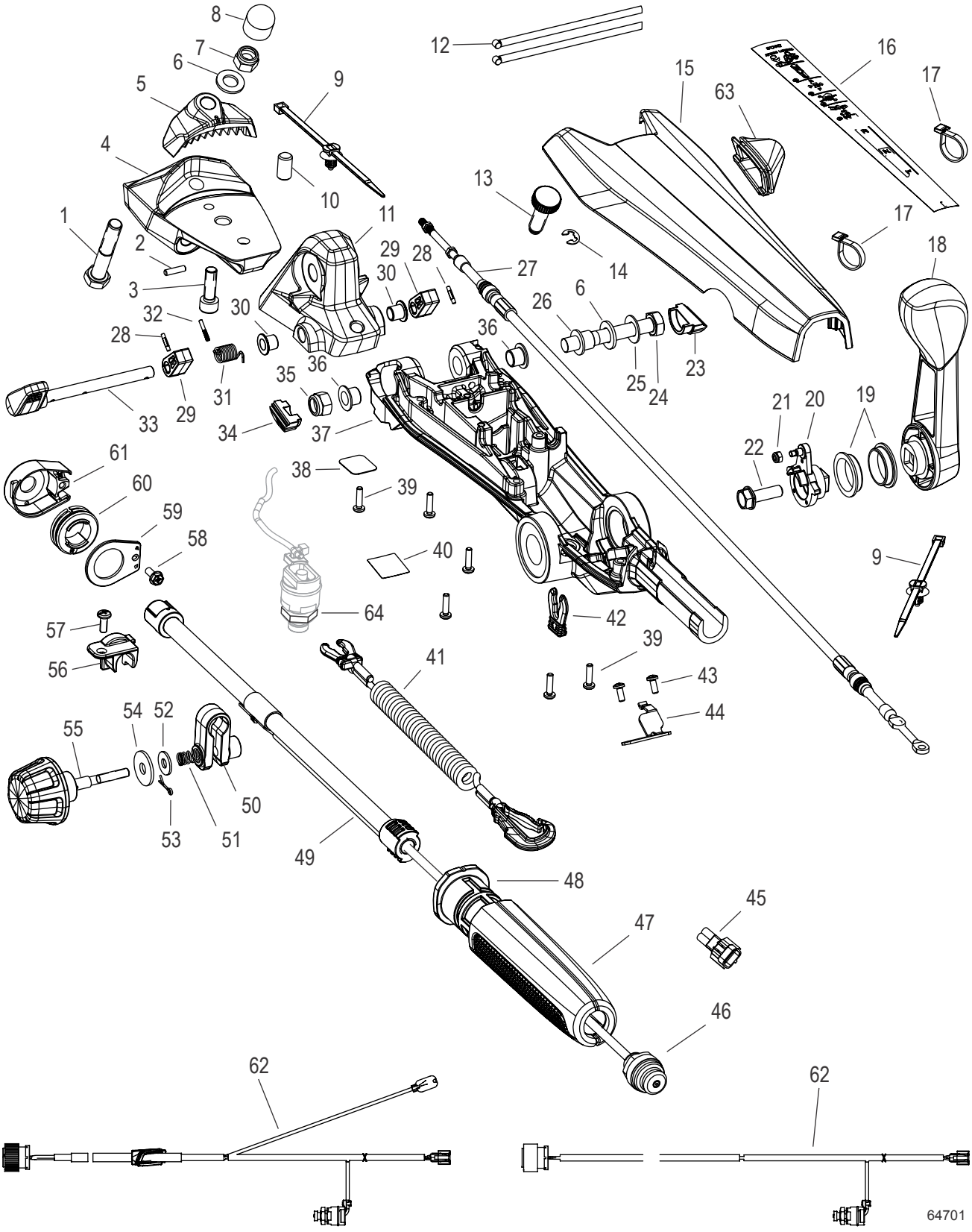
a - Lanyard stop switch
b - Spare lanyard stop switch clip
c - Lanyard

- A stop switch at the end of the tiller handle allows the operator to easily stop the engine.
- Align the throttle grip with the idle mark on the tiller handle when starting or shifting into or out of gear. Twist the throttle grip to increase the engine speed. The tiller handle can be configured for right-hand or left-hand throttle operation; refer to **Throttle Cable Installation**.



- Models with power tilt have a tilt switch located on the underside of the tiller handle.

Tiller Handle Components

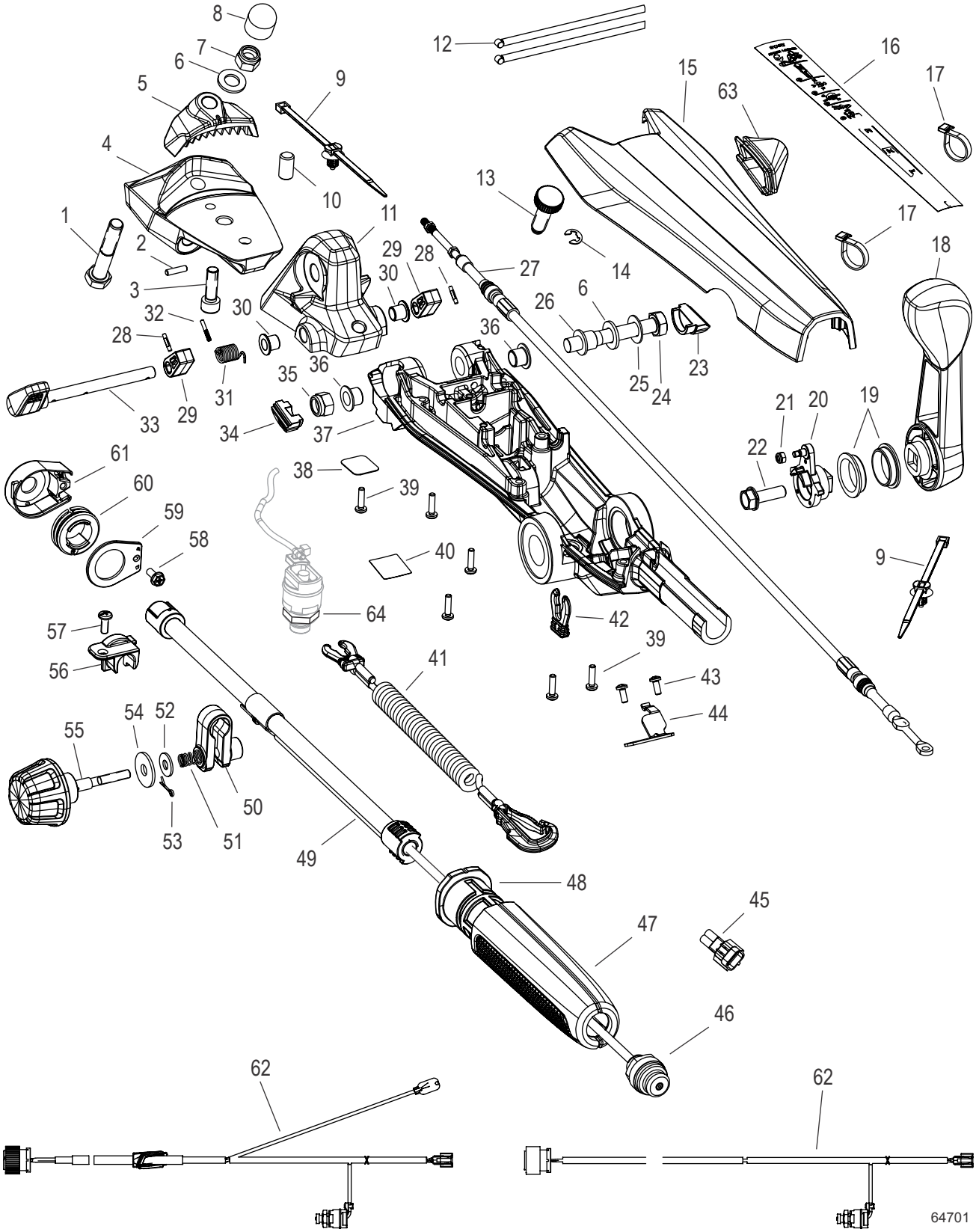


Tiller Handle Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Hex head screw			
2	1	Pin			
3	1	Socket head screw	24	–	17.7
4	1	Lower bracket			
5	1	Toe clamp			
6	2	Plain washer			
7	1	Locknut	50.0	–	36.9
8	1	Rubber cap			
9	2	Cable tie with anchor			
10	1	Dowel pin			
11	1	Tiller handle bracket			
12	2	Throttle cable			
13	1	Down stop adjustment screw			
14	1	E-ring			
15	1	Tiller handle cover			
16	1	Tiller operation decal			
17	2	Cable tie			
18	1	Shift handle assembly			
19	2	Flange bushing			
20	1	Shift lever assembly			
21	1	Locknut	1.1	9.7	–
22	1	Hex head screw	20.3	180	–
23	1	Plug			
24	1	Hex head cap screw			
25	1	Belleville washer			
26	1	Flange spacer			
27	1	Shift cable			
28	2	Pin			
29	2	Tilt locking tab			
30	2	Flange bearing			
31	1	Spring			
32	1	Pin			
33	1	Tilt lever and shaft			
34	1	Plug			
35	1	Locknut	20.3	180	–
36	2	Flange bushing			
37	1	Tiller handle chassis			
38	1	Pad			
39	6	Pan head screw	2.3	20.3	–
40	1	Spare clip decal			
41	1	Lanyard cord assembly			
42	1	Spare lanyard clip			
43	2	Pan head screw	2.3	20.3	–
44	1	Flat spring shift detent			
45	1	2-pin male connector (for stop switch assembly)			
46	1	Stop switch assembly (without connector)			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
47	1	Throttle handle outer grip			
48	1	Inner throttle handle			
49	1	Throttle shaft			
50	1	Tension clamp			
51	1	Compression spring			
52	1	Plain washer			
53	1	Cotter pin			
54	1	Washer			
55	1	Tiller handle adjusting nut			
56	1	Tiller handle bracket			
57	1	Pan head screw	2.3	20.3	–
58	1	Self-tapping hex head screw	2.0	17.7	–
59	1	Pulley cover			
60	1	Throttle cable pulley			
61	1	Throttle cable case			
62	1	Tiller handle with tilt harness assembly			
		Tiller handle harness assembly			
63	1	Grommet			
64	1	Plastic nut	2.0	17.7	–

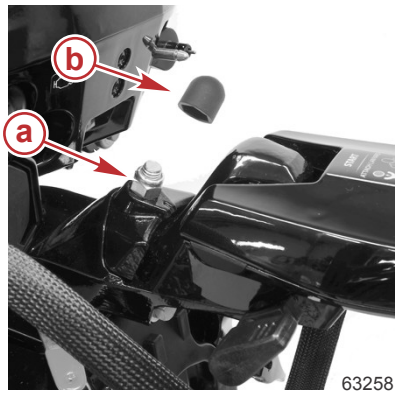
Tiller Handle Components



Tiller Handle Yaw

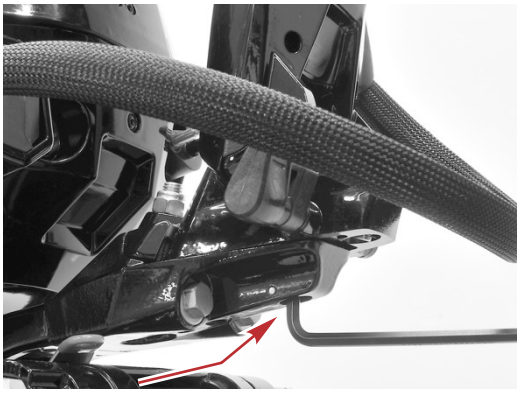
The tiller handle yaw allows the operator to change the angle of the handle up to 18° left or right of center. Each increment demarcation is 6°.

1. Remove the rubber boot covering the clamp screw nut.
2. Remove the 15 mm locknut.



a - Locknut
b - Rubber boot

3. Loosen the 6 mm Allen socket head pivot screw.

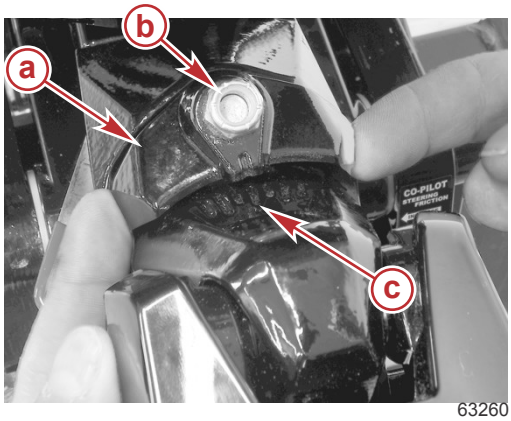


4. Apply Loctite® 271 Threadlocker to the exposed threads of the pivot screw.

NOTE: *It may be necessary to loosen the pivot screw a couple of turns to gain sufficient access to the screw threads.*

Tube Ref No.	Description	Where Used	Part No.
7	Loctite® 271 Threadlocker	Exposed threads of the pivot screw	92-809819

5. Lift the clamp with your fingers and rotate the tiller handle to the desired angle.



a - Clamp
b - Locknut
c - Center demarcation

6. Install the locknut, tighten it to the specified torque, and install the rubber boot.

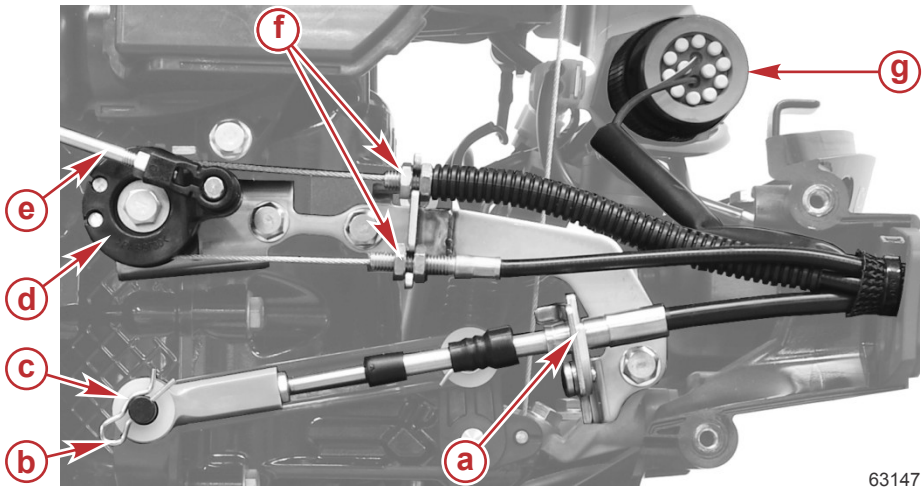
Description	Nm	lb-in.	lb-ft
Locknut	50.0	–	36.9

7. Tighten the 6 mm Allen socket head pivot screw to the specified torque.

Description	Nm	lb-in.	lb-ft
6 mm Allen socket head pivot screw	24.0	–	17.7

Tiller Handle Removal

1. Remove the starboard driveshaft housing cover. Refer to **Section 5A - Driveshaft Housing Covers**.
2. Undo the shift cable bracket clip by rotating the top away from the engine.
3. Remove the shift linkage clip. The plastic washer will come free with the shift cable.
4. Disconnect the throttle link from the throttle barrel, to allow free movement of the barrel.
5. Loosen the throttle cable jam nuts.
6. Remove the throttle cables from the throttle barrel.
7. Disconnect the 14-pin connector.

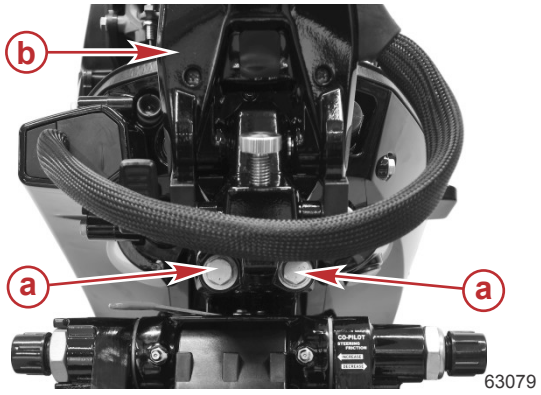


63147

Manual tilt model shown, power tilt models similar

- **a -** Shift cable bracket clip
- **b -** Shift linkage clip
- **c -** Plastic washer
- **d -** Throttle drum
- **e -** Throttle link
- **f -** Throttle cable jam nuts
- **g -** 14-pin connector

8. Remove the control cable and electrical harness assembly from the engine.
9. Remove the two tiller handle mounting screws, and remove the tiller handle.



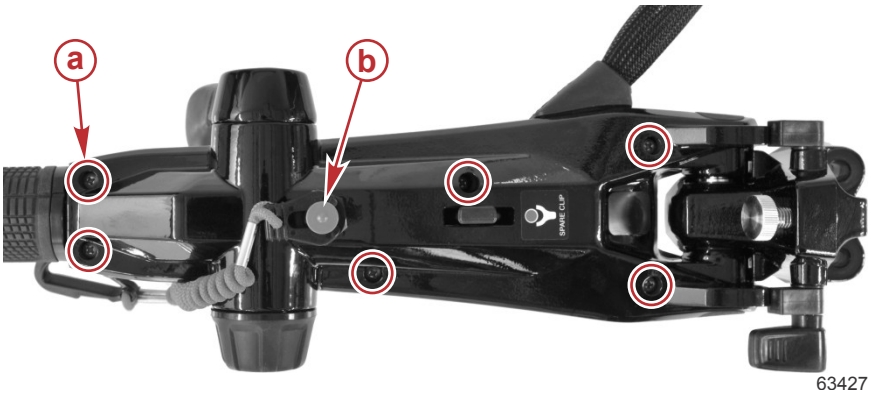
63079

- **a -** Tiller handle mounting screws (2)
- **b -** Tiller handle

Tiller Handle Disassembly

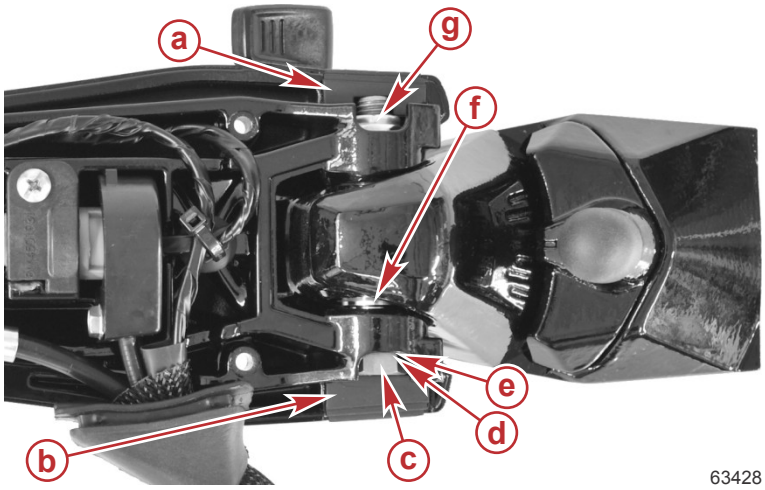
1. Remove the lanyard cord and the hex nut securing the lanyard stop switch to the underside of the tiller handle.

2. Remove six screws from the underside of the tiller handle, and remove the top cover.



a - Screws (6)
b - Lanyard stop switch

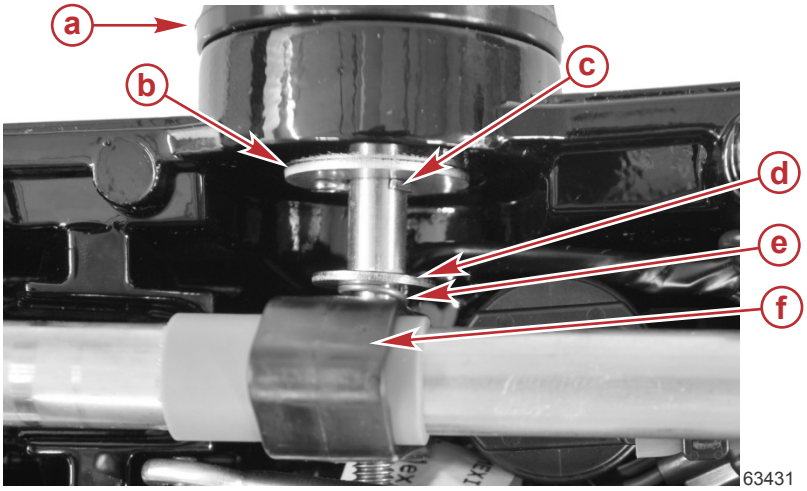
3. Remove the two grommets from the tiller handle, and remove the screw, Belleville washer, flat washer, flange spacer, and locknut that secure the tiller handle mount.



a - Small grommet
b - Large grommet
c - Screw head
d - Belleville washer
e - Flat washer
f - Flange spacer
g - Locknut

NOTE: *Two plastic bushings fit into the tiller handle bracket. If they are loose, remove and retain them for reuse.*

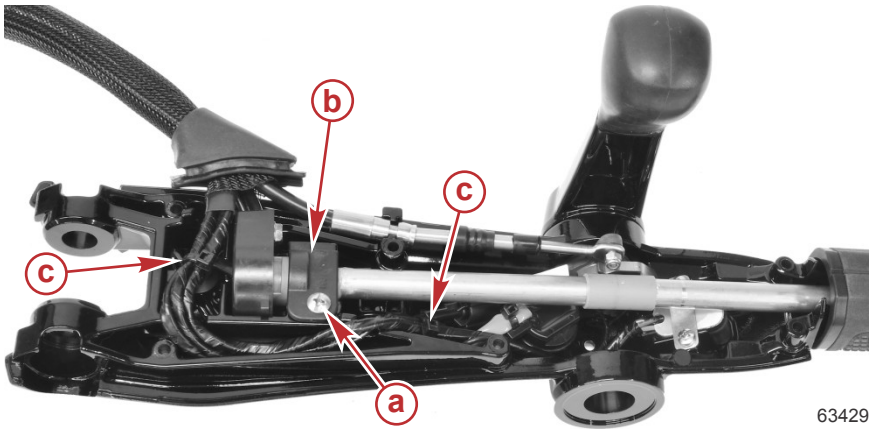
4. Remove the cotter pin from the friction control knob.
5. Turn the friction control knob to remove the knob assembly from the throttle shaft clamp. Two washers and a spring will come loose with the assembly.



a - Friction knob
b - Large washer
c - Cotter pin
d - Small washer
e - Spring
f - Throttle shaft clamp

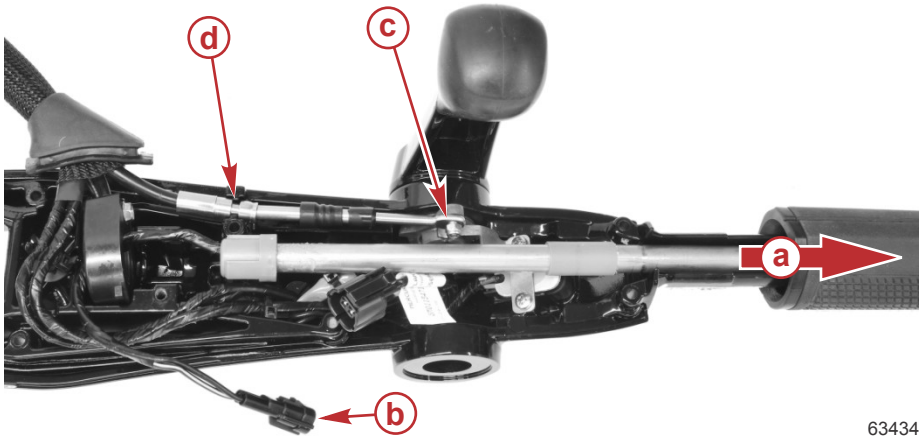
6. Remove the screw that secures the throttle shaft bracket. Lift up to remove the bracket.

7. Cut the cable ties that secure the tiller handle harness.



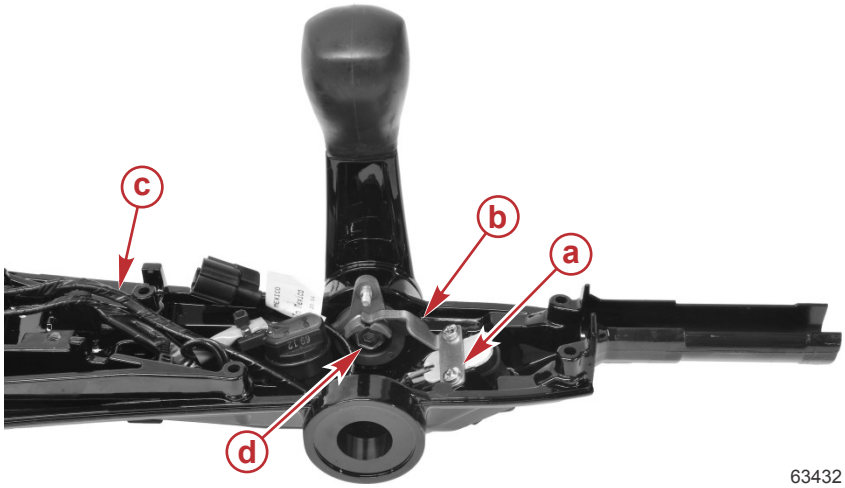
- **a -** Screw
- **b -** Throttle shaft bracket
- **c -** Cable tie (2)

8. Pull the throttle handle out far enough to gain access to the stop switch electrical connector. Disconnect and depin the 2-pin male connector.
9. Pull the throttle handle and lift to remove it from the tiller handle housing.
10. Remove the locknut that secures the shift cable to the shift lever. Lift the shift cable from the retaining slot.



- **a -** Pull throttle handle partially out
- **b -** Stop switch electrical connector (disconnect and depin)
- **c -** Locknut
- **d -** Retaining slot

11. Remove two screws that secure the shift detent spring, and remove the spring.
12. Remove the tiller handle harness.
13. Remove one screw to remove the shift handle and shift cam from the tiller handle housing.



Power tilt model shown, manual tilt model similar

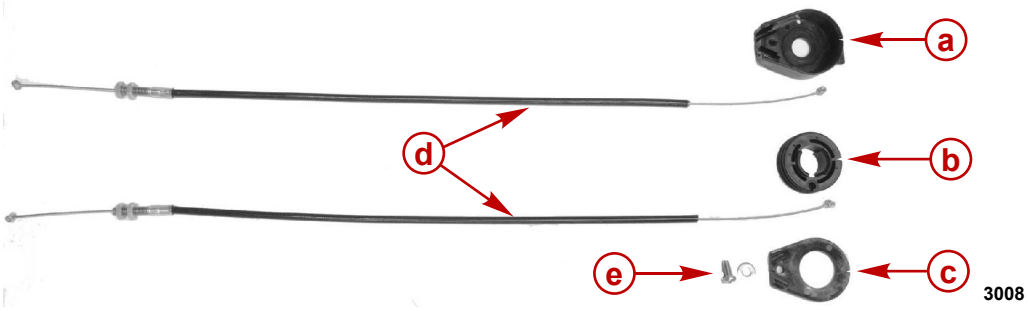
- **a -** Screws (2)
- **b -** Shift detent spring
- **c -** Tiller handle harness
- **d -** Shift handle screw

Throttle Cable Case

Disassembly/Inspection

1. Remove the screw and remove the cover from the cable holder.

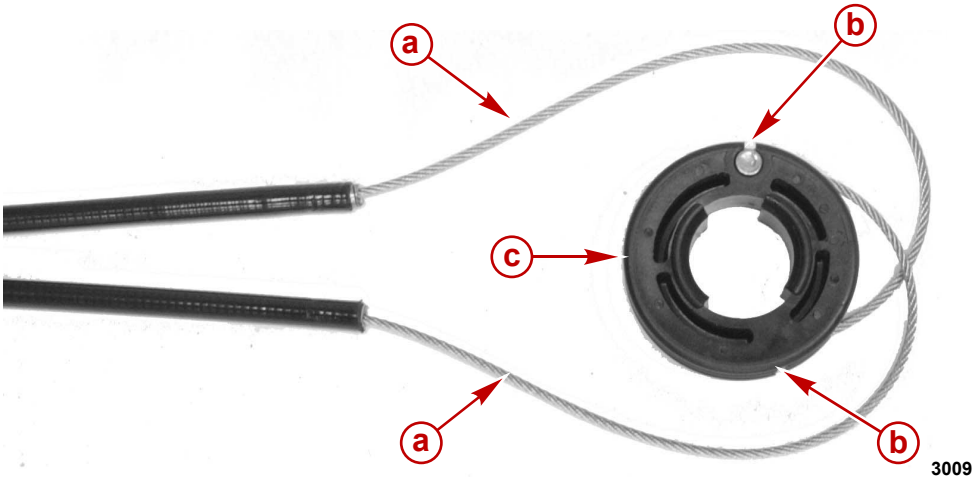
2. Remove the cables and pulley from the cable case.
3. Inspect the pulley for cracks. Inspect the cables for kinks, frayed or broken cables. Ensure that the cables slide freely in the outer jacket.
4. If any defects are found, replace the component.



a - Cable case
b - Pulley
c - Cover
d - Cables
e - Screw and washer

Assembly

1. Install the cable end barrel into the slot on the pulley.



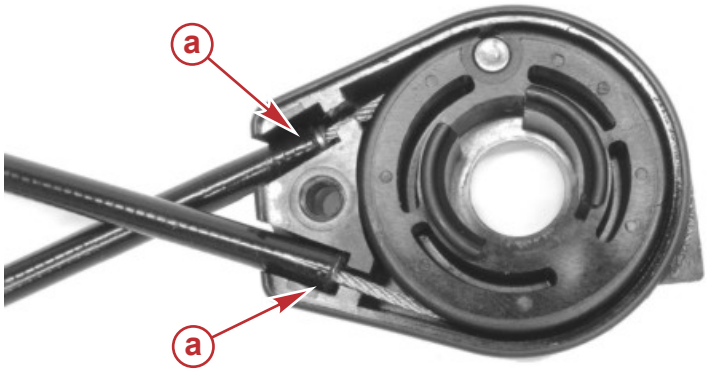
a - Throttle cable
b - Cable end barrel in slot
c - Pulley

2. Apply 2-4-C with PTFE to the throttle cable end barrels, the face of the pulley, and the outer diameter of the pulley.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Throttle cable end barrels, pulley face, and pulley O.D.	92-802859A 1

3. Install the pulley with the cables into the case.

4. Ensure that the cable ends are fully installed in the case.



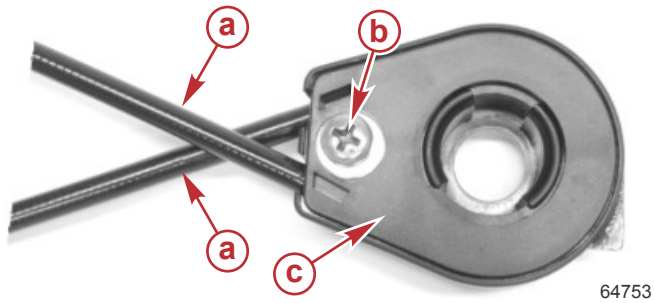
3010

a - Cable ends installed in case

5. Hold the cables in place and install the cover with a screw. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Pulley cover screw	2.0	17.7	–

6. Rotate the pulley, and ensure that the cables move freely.



64753

a - Throttle cable (2)
b - Pulley cover screw
c - Pulley cover

Tiller Handle Assembly

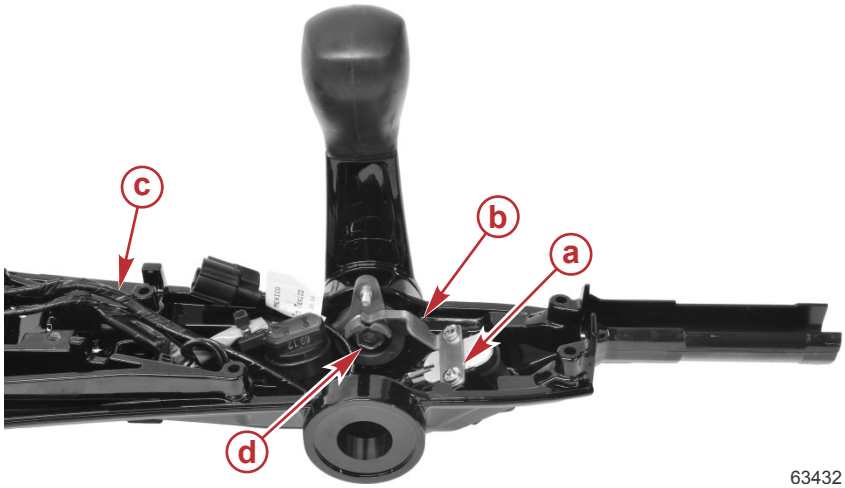
1. Apply 2-4-C with PTFE to the shift handle bushings.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift handle bushings	92-802859A 1

2. Attach the shift handle and cam to the tiller handle housing with a screw. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Shift handle screw	20.3	180	–

3. Power tilt models: Place the tilt switch into position in the tiller handle housing.
4. Install the detent spring and secure it with two screws.

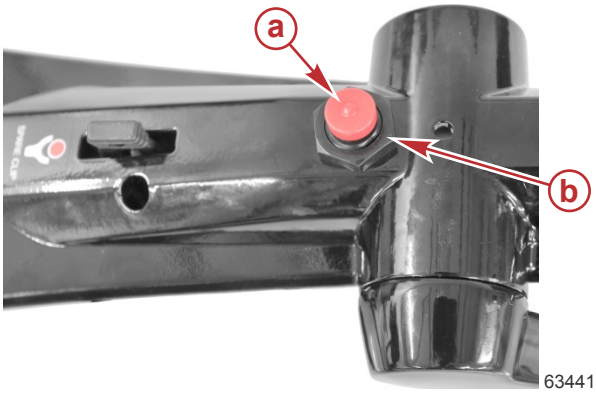


63432

Power tilt model shown, manual tilt model similar

a - Screws (2)
b - Shift detent spring
c - Tiller handle harness
d - Shift handle screw

5. Insert the lanyard stop switch through the tiller handle housing and secure it from below with a plastic nut. Tighten the nut to the specified torque.



a - Lanyard stop switch
b - Nut

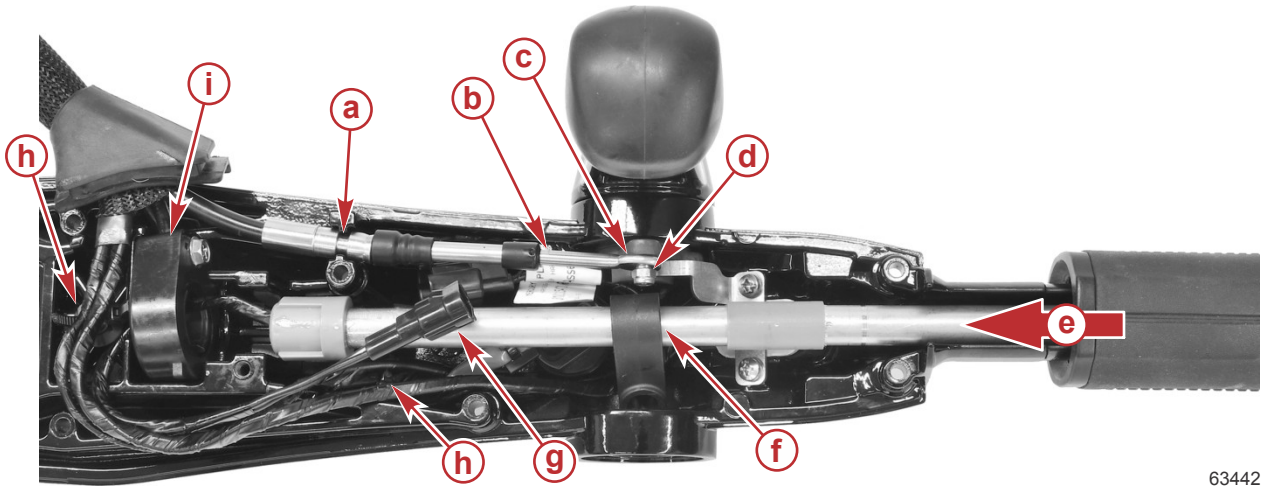
Description	Nm	lb-in.	lb-ft
Plastic nut	2.0	17.7	–

6. Apply 2-4-C with PTFE to the shift cable input rod and eyelet.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift cable input rod and eyelet	92-802859A 1

7. Place the shift cable in the retaining slot, and attach the shift cable to the shift handle with a locknut.
8. Thread new cable ties in the cable tie mounts.
9. Install the throttle handle:
   a. Position the throttle cable pulley housing.
   b. Install the friction clamp on the throttle handle shaft.
   c. Slide the throttle handle partially over the end of the tiller handle chassis.

d. Feed the stop switch wires through the throttle cable pulley housing, attach the 2-pin male connector to the wires, and connect the connector to the tiller handle harness.



63442

Model with power tilt shown, manual tilt model similar

- **a -** Shift cable retaining slot
- **b -** Shift cable input rod
- **c -** Shift cable eyelet
- **d -** Locknut
- **e -** Throttle handle (slide partially on)
- **f -** Friction clamp
- **g -** 2-pin male electrical connector (stop switch)
- **h -** Cable tie anchor (2)
- **i -** Throttle cable pulley housing

e. Ensure that the electrical connector is tucked next to the lanyard stop switch.

f. Adjust the throttle cable ends so they are equal in length.

g. Ensure that the throttle handle is in the idle position, with the nontextured surface facing up.

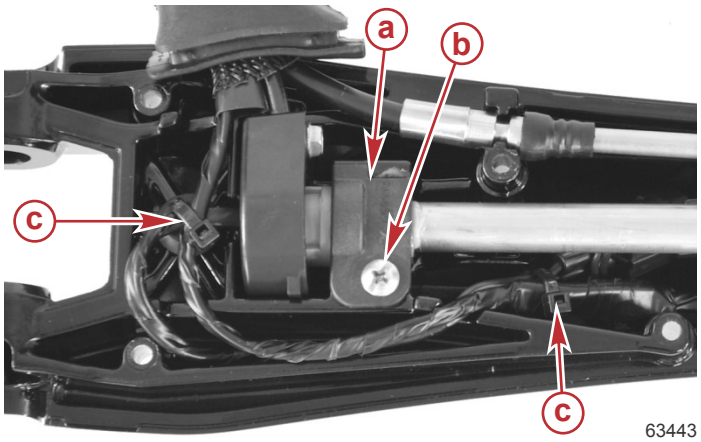
__NOTE:__ The end of the throttle shaft will only engage with the cable pulley housing when they are both in the correct positions.

h. Slide the throttle handle assembly fully onto the tiller handle chassis, inserting the end into the cable pulley housing.

i. Lubricate the inner diameter of the throttle shaft bracket with 2-4-C with PTFE, install the bracket over the throttle shaft, and secure it with a screw.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Throttle shaft bracket I.D.	92-802859A 1

10. Route the wires through the notches in the tiller handle housing. Secure the wires with the cable ties, ensuring that they will not interfere with the throttle shaft or the cover fit.



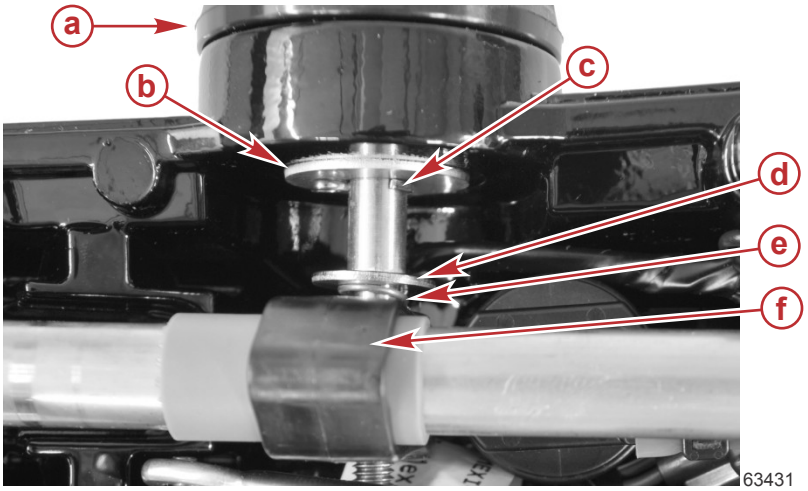
63443

- **a -** Throttle shaft bracket
- **b -** Screw
- **c -** Cable ties (2)

11. Install the friction knob:
    a. Apply 2-4-C with PTFE to the threads of the friction knob shaft.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Friction knob shaft threads	92-802859A 1

    b. Insert the friction knob through the tiller handle housing.
    c. Place the large washer, small washer, and spring on the friction knob shaft.
    d. Thread the shaft into the throttle shaft clamp until it stops.
    e. Insert the cotter pin through the hole in the friction knob shaft, and bend back the tangs.



- **a -** Friction knob
- **b -** Large washer
- **c -** Cotter pin
- **d -** Small washer
- **e -** Spring
- **f -** Throttle shaft clamp

12. Ensure that the two plastic bushings are inserted into the tiller handle bracket. Apply 2-4-C with PTFE to the inside diameter of the bushings.

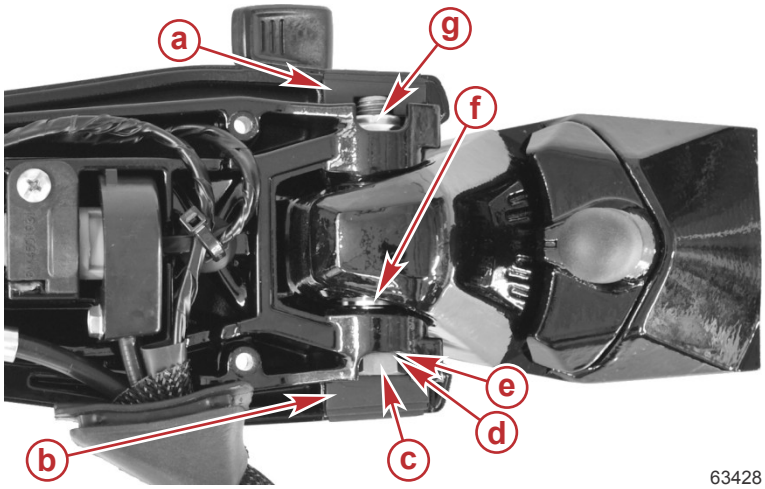
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Tiller handle plastic bushing I.D.	92-802859A 1

13. Turn and hold the tilt lock lever downward, to clear the tiller handle. Then attach the tiller handle mount to the tiller handle with a screw, a belleville washer, a flat washer, a flange spacer, and a locknut. Tighten the locknut to the specified torque or to operator preference.

Description	Nm	lb-in.	lb-ft
Tiller handle mount locknut	20.3	180	–

NOTE: *Increasing the torque applied to the tiller handle mount locknut will increase the effort to raise and lower the tiller handle; decreasing the torque will decrease the effort. The specified torque is a baseline value that may be varied according to operator preference.*

14. Insert one large and one small grommet.

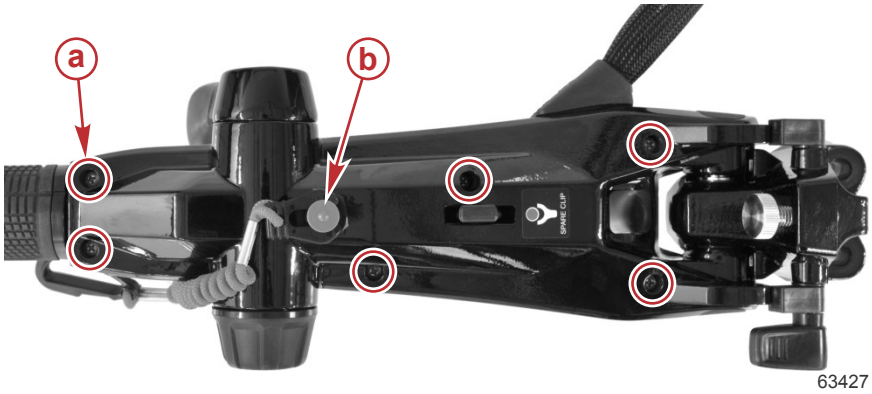


- **a -** Small grommet
- **b -** Large grommet
- **c -** Screw head
- **d -** Belleville washer
- **e -** Flat washer
- **f -** Flange spacer
- **g -** Locknut

15. Attach the cover to the tiller handle, using six screws. Ensure that the tiller harness grommet is correctly seated between the cover and the tiller handle housing. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Tiller handle cover screws	2.3	20.3	–

16. Attach the lanyard cord to the lanyard stop switch.



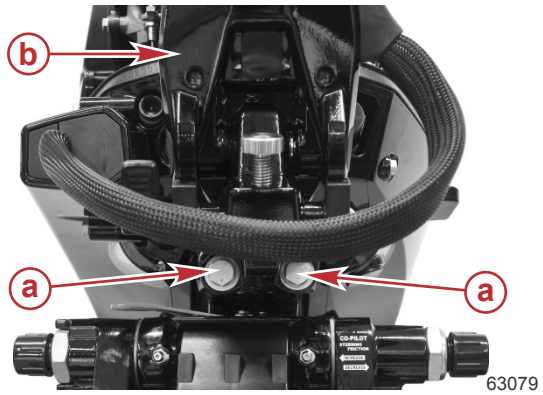
a - Screws (6)
b - Lanyard stop switch

Tiller Handle Installation

1. Apply Loctite® 271 Threadlocker to the two tiller handle mounting screws.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite® 271 Threadlocker	Tiller handle mounting screws	92-809819

2. Attach the tiller handle to the outboard with the two screws. Tighten the screws to the specified torque.



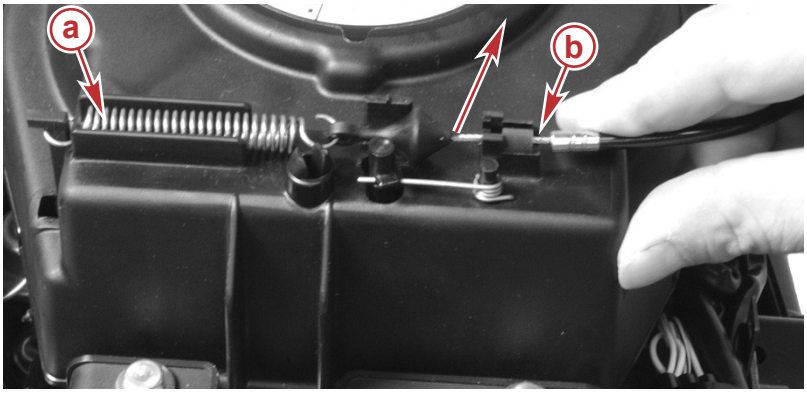
a - Tiller handle mounting screws (2)
b - Tiller handle

Description	Nm	lb-in.	lb-ft
Tiller handle mounting screws	40	–	29.5

3. Route the tiller handle harness through the grommet.
4. Connect the 14-pin connector to the engine harness.
5. Connect the throttle and shift cables. Refer to **Throttle and Shift Cable Installation**.

Shift Cable Installation

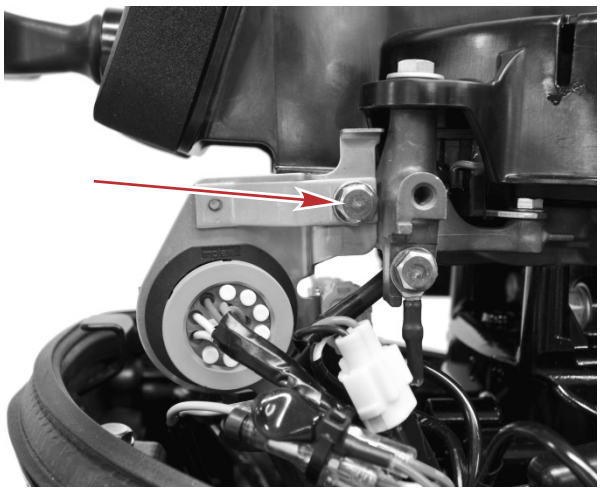
1. Release the tension on the neutral interlock cable by pulling it out and away from the recoil housing.



9696

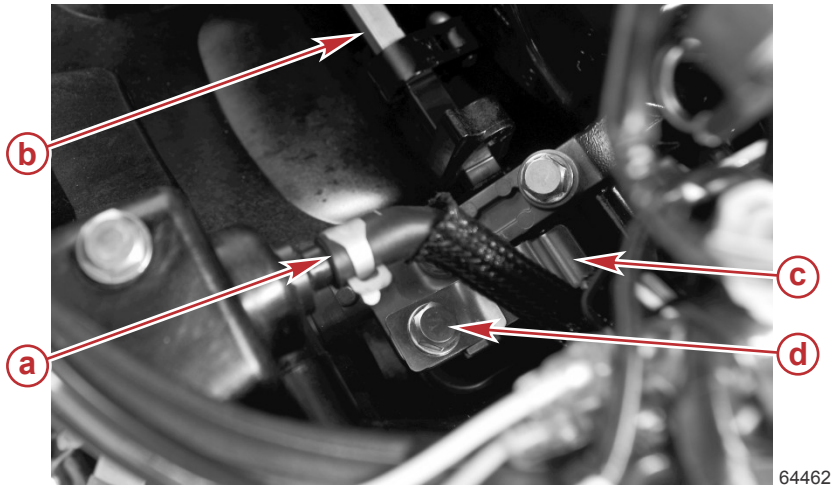
a - Neutral interlock cable tension spring
b - Neutral interlock cable

2. Remove the single screw that secures the 14-pin connector bracket, and remove the bracket.



64461

3. Loosen the shift detent screw.

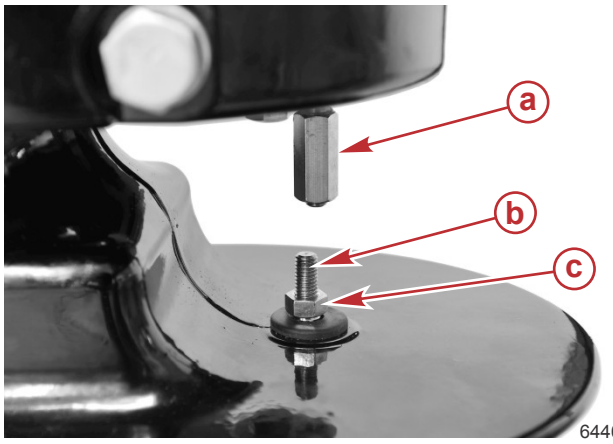


64462

a - Fuel inlet hose
b - Horizontal shift shaft
c - Shift shaft detent springs
d - Shift detent screw

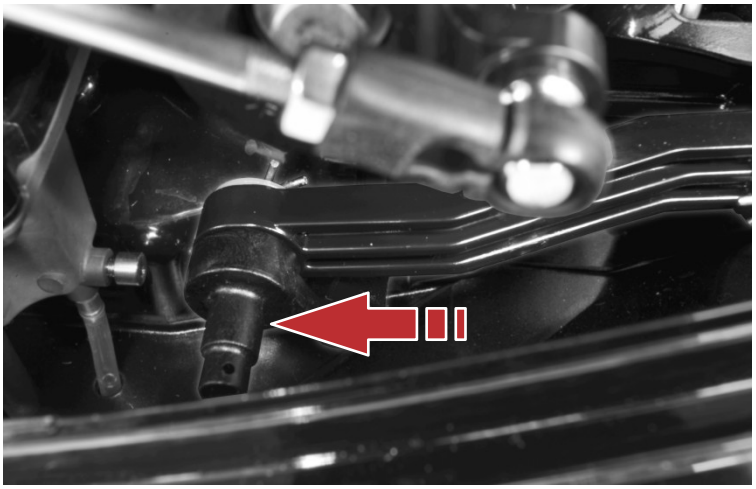
4. Couple the upper and lower vertical shift shafts:
   a. Ensure that the upper and lower shift shafts are separated.
   b. Turn the jam nut on the lower vertical shift shaft until it is all of the way down.

c. Push the lower shift shaft down to the reverse stop.



a - Coupler on upper shift shaft
b - Lower shift shaft in reverse (full down)
c - Jam nut all of the way down

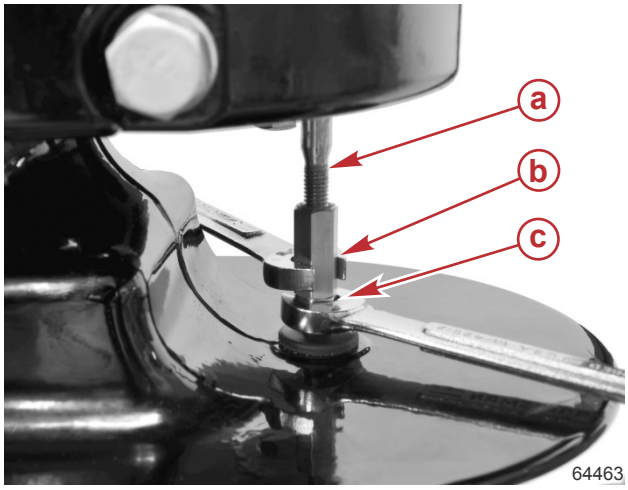
d. Press the shift linkage aft to rotate the outboard's horizontal shift shaft to the full reverse stop.



e. Maintain alignment of the upper and lower shift shafts while threading the coupler at least five turns onto the lower shift shaft.

IMPORTANT: Take care to not rotate the lower shift shaft. Doing so will damage the gearcase.

f. Use two wrenches to lock the jam nut against the coupler.

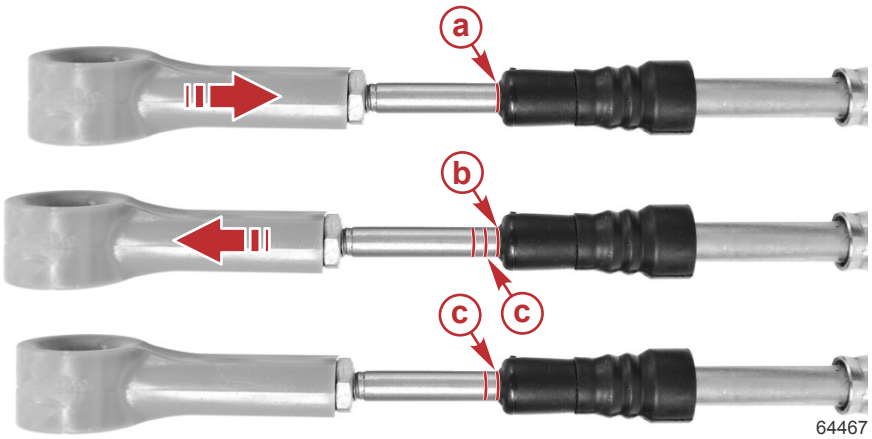


a - Upper vertical shift shaft
b - Wrench on coupler
c - Wrench on jam nut

5. Use a flat-blade screwdriver or other suitable tool to ensure that the detent springs are fully seated in the reverse detent. Tighten the shift detent screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Shift detent screw	6.0	53.1	–

6. Verify the detent spring position:
   a. Verify no engagement or clutch drag when the horizontal shift shaft is rotated to neutral (detent spring fully seated in the neutral detent).
   b. Verify forward gear engagement when the horizontal shift shaft is rotated to forward (detent spring fully seated in the forward detent).
   c. Adjust the detent spring position as required.
7. Determine the center of the lost motion of the shift cable:
   a. Shift the tiller handle to neutral.
   b. Push the end of the shift cable to full compression. Mark the cable (a) at the end of the jacket.
   c. Pull the end of the shift cable to full extension. Mark the cable (b) at the end of the jacket.
   d. Determine and mark the center of the lost motion (c).



64467

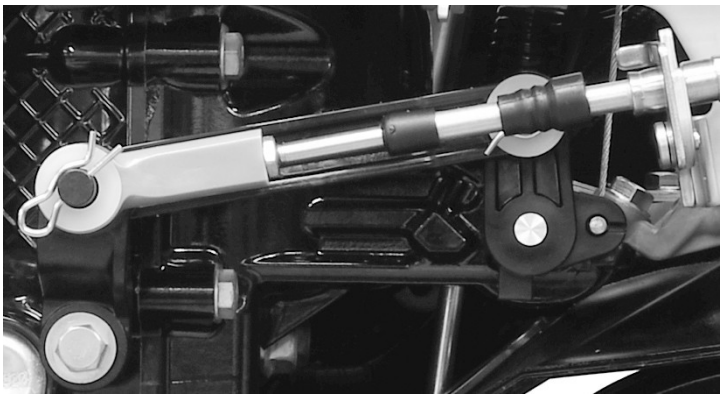
Motion exaggerated for clarity; typical motion ~ 2.5 mm (0.1 in.)

a - Push cable to full compression and mark

b - Pull cable to full extension and mark

c - Determine midpoint and mark; use this mark to center the cable during installation

8. Connect the tiller shift cable:
   a. Rotate the horizontal shift shaft to shift the gearcase to neutral.
   b. Install the shift cable's ferrule into the shift bracket.
   c. Ensure that the shift cable is extended to the center of the lost motion (position c, shown preceding).
   d. Adjust the cable rod end to line up with the shift lever in the neutral position.
   e. Tighten the jam nut on the shift cable.
   f. Slide the rod end onto the shift lever, and install the washer and retaining clip.


64482

9. Return the neutral interlock cable to its installed position. Verify proper alignment when shifting into neutral from both forward and reverse. Adjust accordingly.
10. With the engine off, verify the installation:
    a. Shift the tiller into forward, moving the shift handle fully forward to hard stop, and release the handle.
       - Verify clutch/gear engagement.
       - Verify the detent spring is fully seated in the horizontal shift shaft cam notch.
    b. Shift the tiller into neutral.
       - Verify no engagement or clutch drag in neutral.
       - Verify the detent is fully seated in the horizontal shift shaft cam notch.

- Verify the recoil starter interlock is disengaged.
- Verify the electric neutral start switch allows the engine to fire.

c. Shift the tiller into reverse.
- Verify clutch/gear engagement.
- Verify the detent spring is fully seated in the horizontal shift shaft cam notch.
- Lightly coat the unthreaded portion of the shift cable output rod with 2-4-C with PTFE.

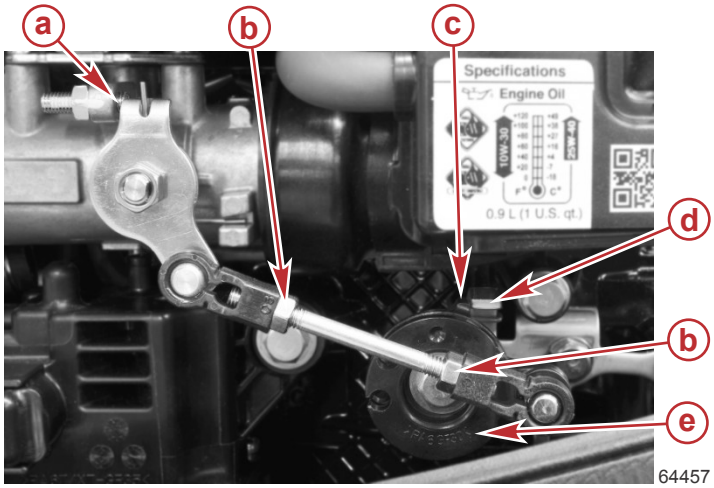
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Unthreaded portion of the shift cable output rod	92-802859A 1

d. Shift the tiller into neutral.
- Verify no engagement or clutch drag in neutral.
- Verify the detent is fully seated in the horizontal shift shaft cam notch.
- Verify the recoil starter interlock is disengaged.
- Verify the electric neutral start switch allows the engine to fire.

e. Make adjustments as necessary to the following:
- Shift cable rod end
- Detent spring
- Starter interlock cable
- Vertical shift shaft coupler

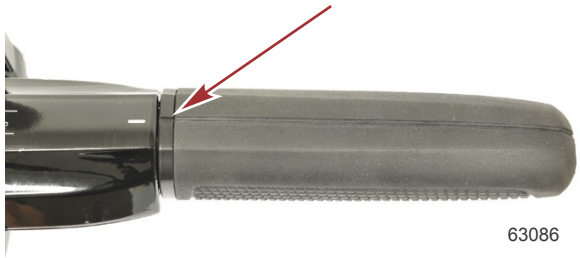
Throttle Cable Installation

1. Ensure that the throttle link is set correctly. When the throttle is against the idle set screw, the throttle drum idle stop should rest against the throttle bracket idle stop. Make any necessary adjustments to the throttle link, and tighten the jam nuts.



a - Throttle idle set screw
b - Throttle link jam nuts (2)
c - Throttle drum idle stop
d - Throttle bracket idle stop
e - Throttle drum

2. Rotate the tiller handle grip to idle. The idle position is where the groove in the grip aligns with the idle mark on the tiller handle.



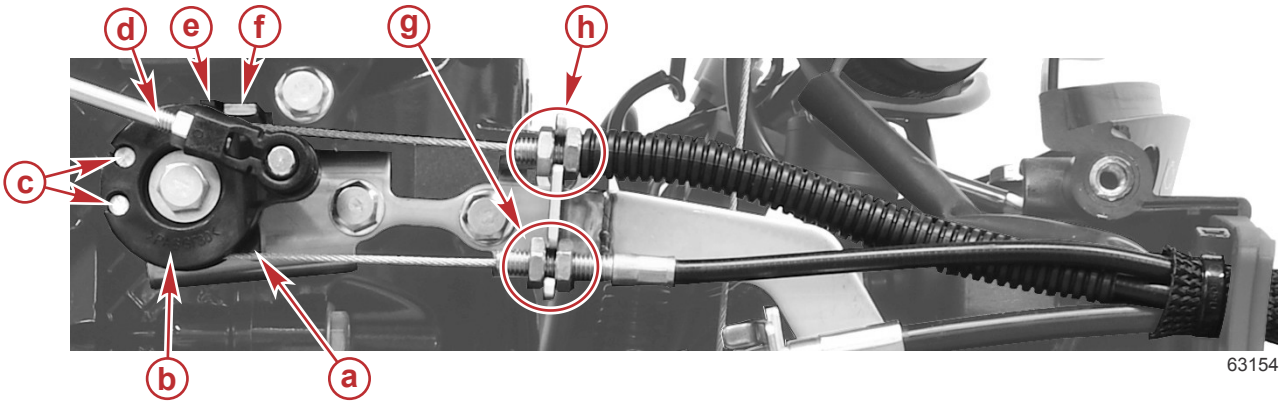
3. Rotate the grip in the desired direction toward WOT, and observe the cable motion. The cable that retracts will be the bottom cable; the cable that extends will be the upper cable.

NOTE: *The standard installation is with counterclockwise rotation of the throttle grip from idle to WOT. To change throttle grip rotation to clockwise, swap the cable positions on the throttle drum and bracket.*

4. Insert the anchor of the bottom cable into the lower slot in the throttle drum. Insert the anchor of the top cable into the upper slot in the throttle drum. Coat both anchors with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Throttle cable anchors	92-802859A 1

5. Rotate the throttle grip to the idle position.
6. Slide the throttle cables into the slots on the throttle bracket. Temporarily secure the cables so as to allow throttle grip rotation.
7. Rotate the throttle grip to WOT. The throttle drum should contact the throttle drum WOT stop.
   - If the throttle operates properly, tighten the lower throttle cable jam nuts to secure the lower cable.
   - If the drum does not contact the WOT stop, adjust the lower cable jam nuts until proper contact is made.
8. Return the throttle grip to idle.
   a. Ensure that the throttle drum rests on the idle stop.
   b. Tighten the upper throttle cable jam nuts to minimize slack in the upper cable.

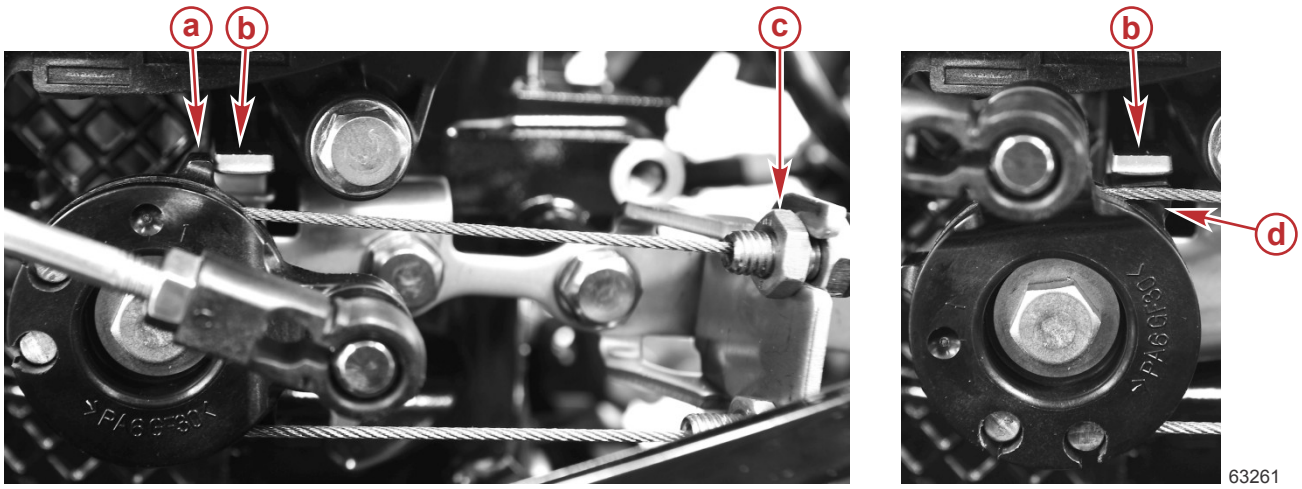


a - Throttle drum WOT stop
b - Throttle drum
c - Throttle cable ends
d - Throttle link
e - Throttle drum idle stop
f - Bracket throttle stop
g - Lower throttle cable jam nuts
h - Upper throttle cable jam nuts

Throttle Cable Adjustments

1. Rotate the tiller twist grip to the idle position.
2. Adjust the cable lengths by using the jam nuts to bring the idle stop on the throttle drum against the throttle stop.
   a. Make adjustments to the lower cable first.
   b. Remove slack in the upper cable by adjusting the upper jam nuts. Do not overtighten.

3. Rotate the tiller twist grip to the wide-open throttle (WOT) position. Ensure that the wide-open throttle stop on the throttle drum rests against the throttle stop.



a - Throttle drum idle stop
b - Throttle stop
c - Throttle cable jam nut (one of four)
d - Throttle drum WOT stop

Notes:

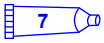
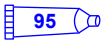
Manual Starter

Section 8A - Recoil Starter

Table of Contents

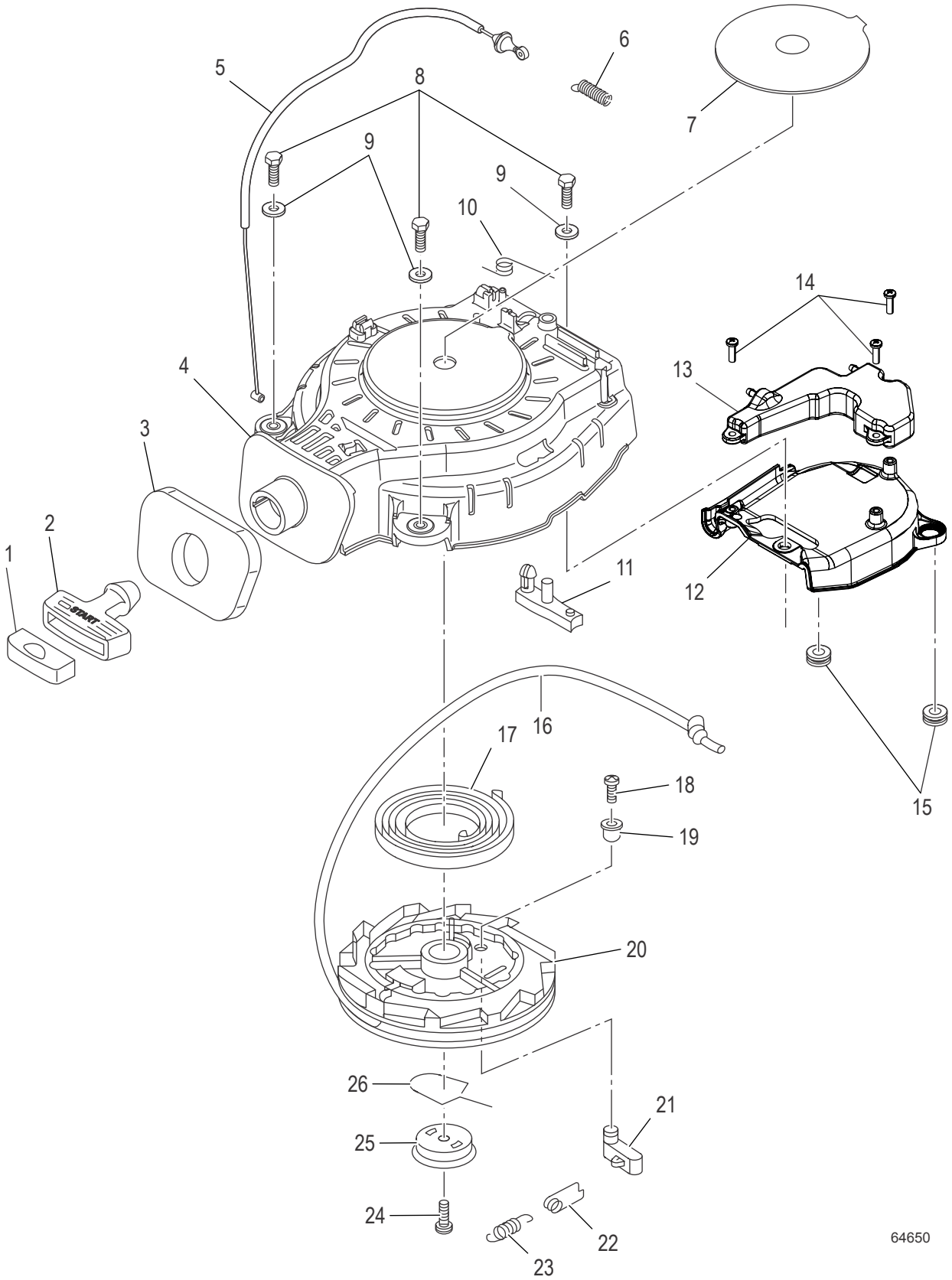
8
A

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Loctite® 271 Threadlocker	Threads of the friction plate retaining screw	92-809819
		Threads of the recoil starter assembly screws	
	2-4-C with PTFE	Recoil housing	92-802859A 1
		Starter pawl bore on the sheave	
		Friction plate	

Notes:

Recoil Starter Components



Recoil Starter Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Handle cap			
2	1	Handle			
3	1	Seal			
4	1	Recoil starter housing			
5	1	Lock cable			
6	1	Lock cam spring			
7	1	Caution decal			
8	3	Screw with nylon lock patch (M6 x 20)	6.0	53.1	–
9	3	Washer			
10	1	Lock spring			
11	1	Lock			
12	1	Cam gear cover			
13	1	Vent tank			
14	3	Screw			
15	2	Grommet			
16	1	Starter rope			
17	1	Spring			
18	1	Tapping screw			
19	1	Bushing			
20	1	Sheave			
21	1	Starter pawl			
22	1	Starter pawl guide			
23	1	Return spring			
24	1	Starter shaft screw	6.0	53.1	–
25	1	Friction plate			
26	1	Friction plate spring			

Recoil Starter Removal

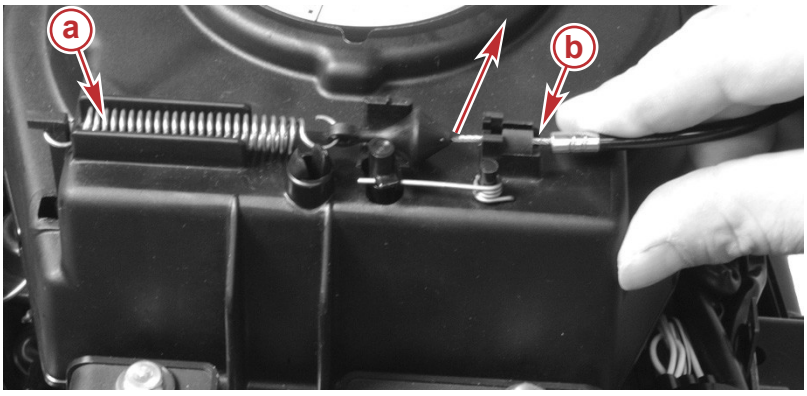
1. Remove the three screws that secure the air box to the engine, and remove the air box or position it out of the way. Refer to **Section 3C - Air Box Removal**.

   NOTE: *Due to the routing of the crankcase breather hose behind the throttle body, it is easiest to not fully remove the air box, if no other components are being removed.*
2. Remove the three screws securing the recoil starter assembly to the engine.

62950

Shown with air box removed

3. Pull the neutral interlock cable to disengage the neutral interlock cable from the recoil housing.
4. Lift the neutral interlock cable up and remove the neutral interlock cable tension spring from the recoil housing.



9696

a - Neutral interlock cable tension spring
b - Neutral interlock cable

5. Remove the recoil starter assembly.

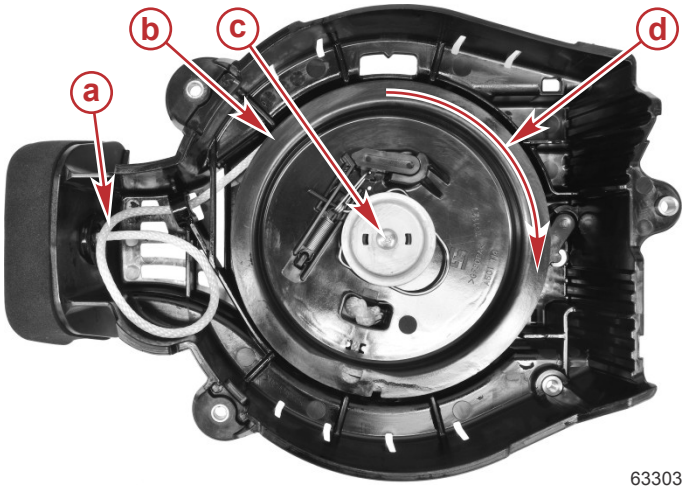
Recoil Starter Disassembly

⚠ WARNING

Uncontrolled release of the rewind spring can cause serious injury. Wear eye protection when servicing the rewind starter in case the spring uncoils.

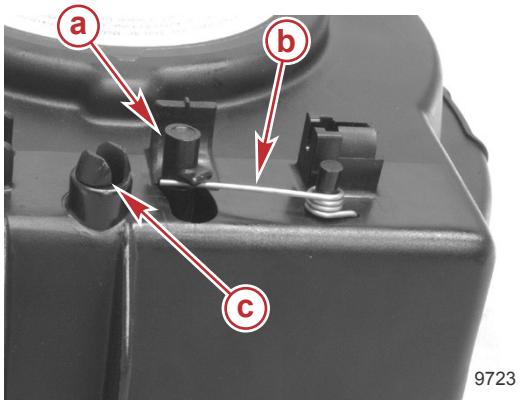
1. Remove the handle cap from the recoil handle.
2. Cut or untie the recoil rope from the recoil handle.
3. Slowly allow the sheave to unwind completely.
4. Rotate the sheave clockwise to disengage the recoil spring from the sheave.

5. Remove the screw securing the recoil friction plate to the recoil housing. Remove the recoil friction plate.



a - Recoil rope
b - Sheave
c - Screw securing recoil friction plate
d - Rotate sheave clockwise

6. Carefully remove the sheave.
7. Remove the recoil spring if replacement is needed.
8. Disengage the interlock lever spring from the recoil lock.
9. Pinch the recoil lock retainer and push the recoil lock out of the recoil housing.



a - Recoil lock
b - Interlock lever spring
c - Recoil lock retainer (pinch to remove)

10. Remove the E-ring securing the starter pawl to the sheave.

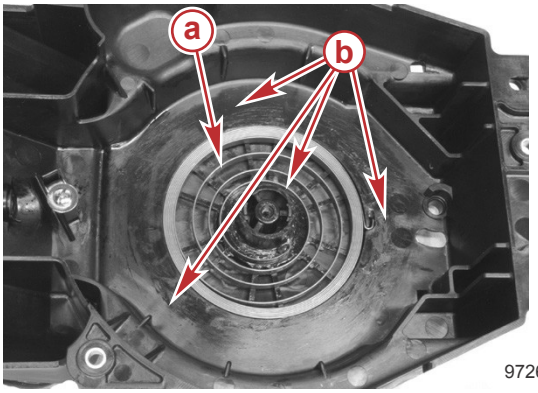
11. Push the starter pawl out of the sheave.
12. Inspect the starter rope for damage. Replace as required.

Recoil Starter Assembly

⚠ WARNING

Uncontrolled release of the rewind spring can cause serious injury. Wear eye protection when servicing the rewind starter in case the spring uncoils.

1. Using 2-4-C with PTFE, lubricate the area of the recoil housing where the recoil spring is located.
2. Install the recoil spring into the recoil housing.

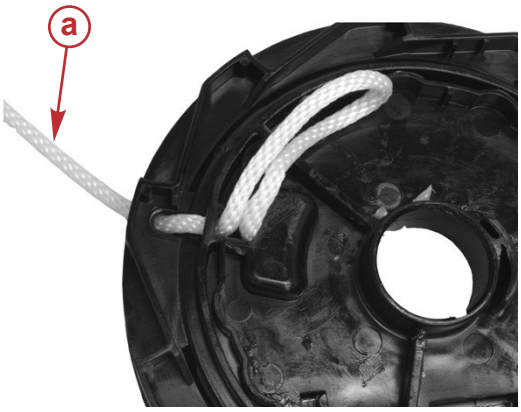


9726

a - Recoil spring
b - Lubricate with 2-4-C with PTFE

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Recoil housing	92-802859A 1

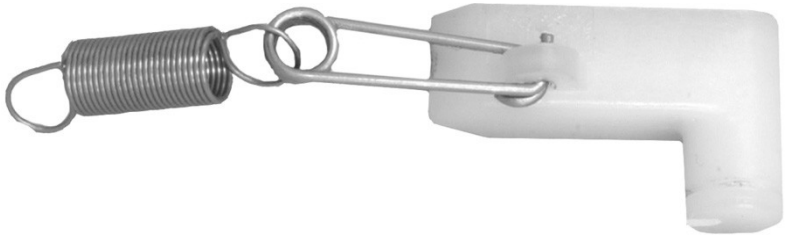
3. Attach the recoil rope to the sheave:
   a. Tie a knot on one side of the recoil rope and insert the recoil rope through the sheave.
   b. Thread the recoil rope through the sheave as shown.
   c. Pull the recoil rope tight in the sheave.



9727

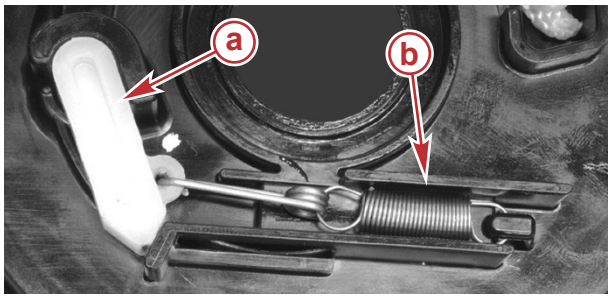
a - To recoil handle

4. Assemble and install the starter pawl:
   a. Assemble the starter pawl as shown.


9728

   b. Lubricate the starter pawl bore on the sheave with 2-4-C with PTFE.
   c. Install the starter pawl return spring onto the sheave.

d. Install the starter pawl onto the sheave.

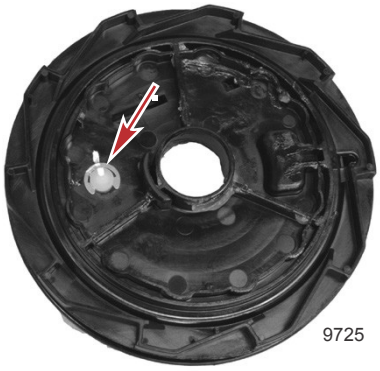


9730

a - Starter pawl
b - Starter pawl return spring

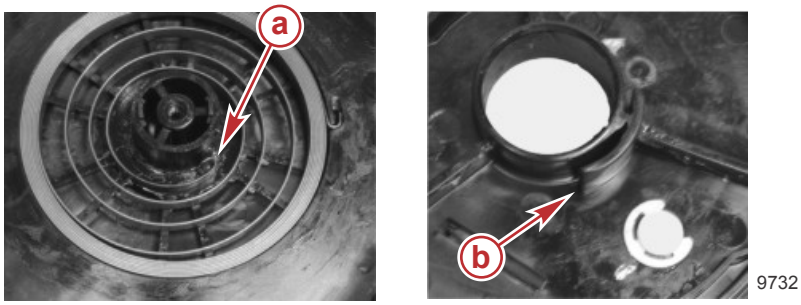
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Starter pawl bore on the sheave	92-802859A 1

e. Secure the starter pawl with the E-ring retained during disassembly.



9725

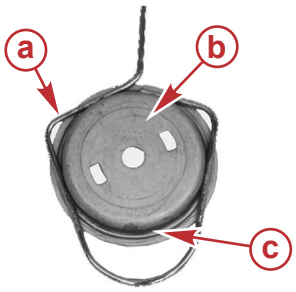
5. Install the sheave onto the recoil housing. The sheave catch must interlock with the recoil spring for the recoil to function properly.



9732

a - Recoil spring
b - Sheave catch

6. With a slight downward pressure, rotate the sheave counterclockwise to engage the spring into the catch on the sheave. If the spring is properly positioned on the sheave, resistance will be felt while winding the sheave counterclockwise.
7. Assemble and install the friction plate:
   a. Install the friction plate spring onto the friction plate. Lubricate the friction plate with 2-4-C with PTFE.

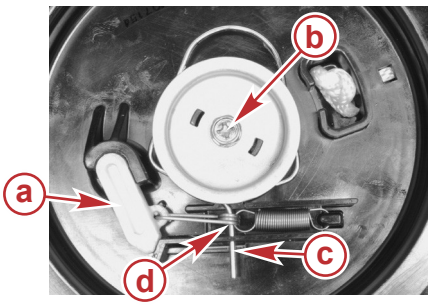


9740

a - Friction plate spring
b - Friction plate
c - Lubricate with 2-4-C with PTFE

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Friction plate	92-802859A 1

b. Insert the friction plate spring through the wire loop.
c. Align the tabs on the recoil housing with the holes on the friction plate.
d. Apply Loctite® 271 Threadlocker to the threads of the friction plate retaining screw. Tighten the friction plate retaining screw to the specified torque.



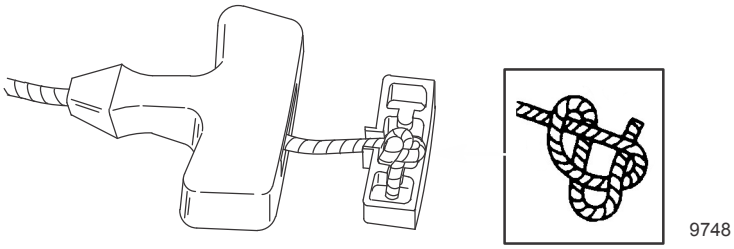
9741

a - Starter pawl
b - Friction plate retaining screw
c - Friction plate spring
d - Wire loop

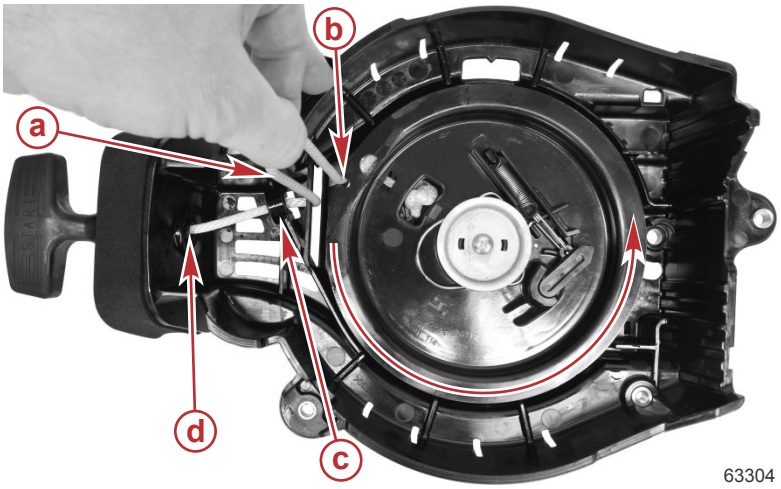
Description	Nm	lb-in.	lb-ft
Friction plate retaining screw	6.0	53.1	–

Tube Ref No.	Description	Where Used	Part No.
7	Loctite® 271 Threadlocker	Threads of the friction plate retaining screw	92-809819

8. Complete the rope installation:
   a. Insert the recoil rope into the guide and through the recoil housing.
   b. Insert the rope end through the recoil handle.
   c. Tie a knot as shown. Place the rope knot into the handle cap, and insert the cap into the recoil handle.


9748

   d. Insert the recoil rope into the notch on the sheave.
   e. Wind the sheave three turns counterclockwise to preload the recoil spring.

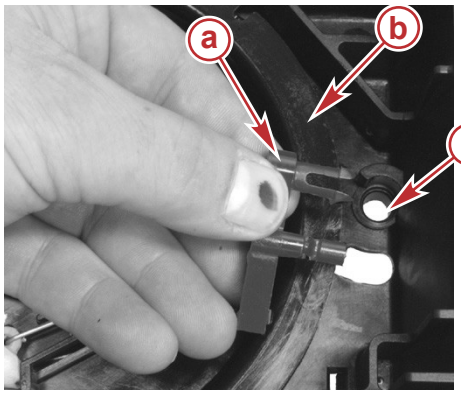


63304

a - Recoil rope
b - Sheave notch
c - Recoil rope guide
d - Recoil housing opening

   f. Allow the recoil rope to retract into the sheave.
   g. Ensure the recoil rope retracts and extends fully.

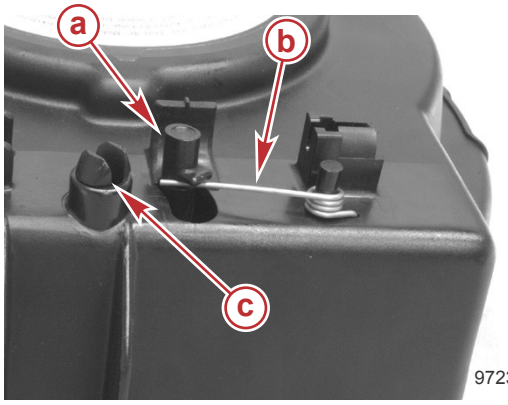
9. Install the recoil lock:
   a. Insert the recoil lock into the recoil housing.
   b. Push the recoil lock until it snaps into place.



9749

a - Recoil lock
b - Sheave
c - Recoil lock bore

   c. Place the interlock lever spring onto the recoil lock.

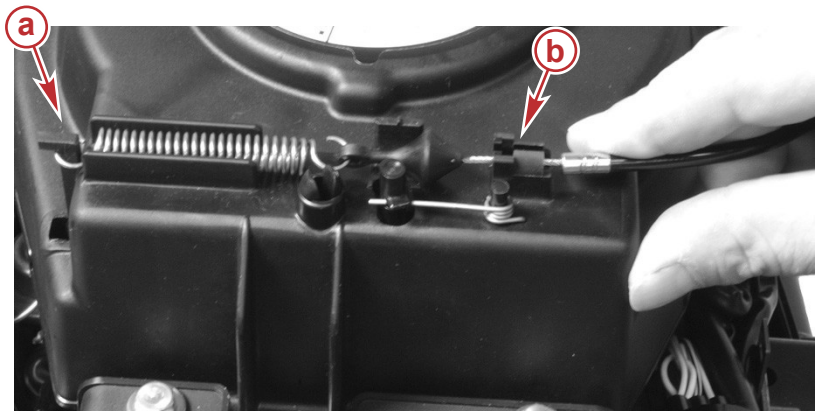


9723

a - Recoil lock
b - Interlock lever spring
c - Recoil lock retainer

Recoil Starter Installation

1. Place the recoil starter into position on the engine.
2. Install the neutral interlock cable tension spring onto the recoil housing catch and the neutral interlock cable end.
3. Pull on the neutral interlock cable and insert the cable end into the neutral interlock cable retainer on the recoil housing.



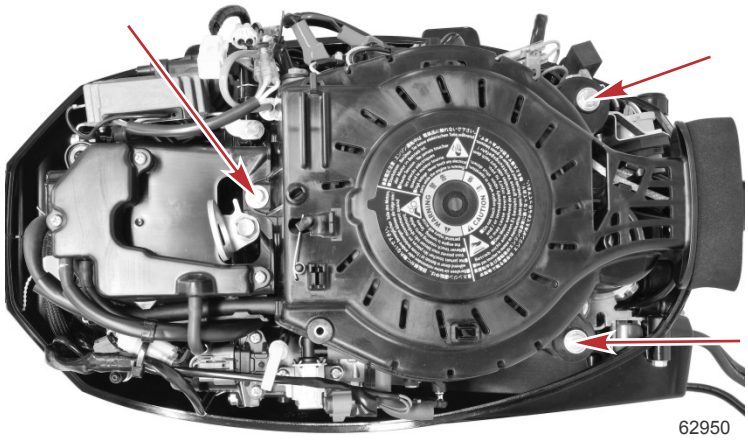
9717

a - Recoil housing catch
b - Neutral interlock cable retainer

4. If the air box was removed, lift the recoil housing, position the air box next to the engine, and attach the crankcase breather hose to the air box.
5. Apply Loctite® 271 Threadlocker to the threads of the three recoil starter assembly screws.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Threads of the recoil starter assembly screws	92-809819

6. Secure the recoil starter assembly to the engine with the three screws. Tighten the screws to the specified torque.


62950

Description	Nm	lb-in.	lb-ft
Recoil starter assembly screws (3)	6.0	53.1	–

7. Complete the air box installation. Refer to **Section 3C - Air Box Installation**.

Neutral Interlock Cable Adjustment

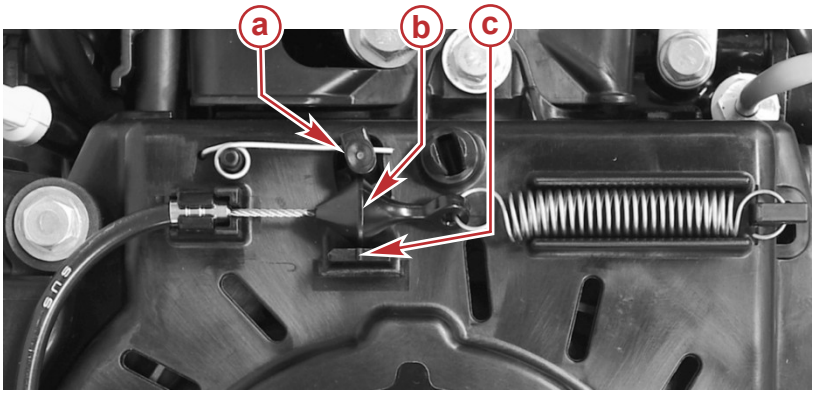
1. On tiller models: Ensure the tiller handle shift cable is properly adjusted. Refer to **Section 7B - Shift Cable Installation**.
2. Ensure the outboard is in neutral.
3. Loosen the interlock cable jam nuts.

63089

Electric start model shown, manual start model similar

a - Neutral interlock cable
b - Upper jam nut
c - Lower jam nut

4. Adjust the upper jam nut until the neutral interlock cable ball is centered on the centering mark.



63087

a - Recoil lock
b - Neutral interlock cable ball
c - Centering mark

5. Tighten the lower jam nut.
6. Verify that the ball centers when shifting from forward and when shifting from reverse. Adjust the jam nuts as necessary.

Color Diagrams

Section 9A - Color Diagrams

Table of Contents

9A

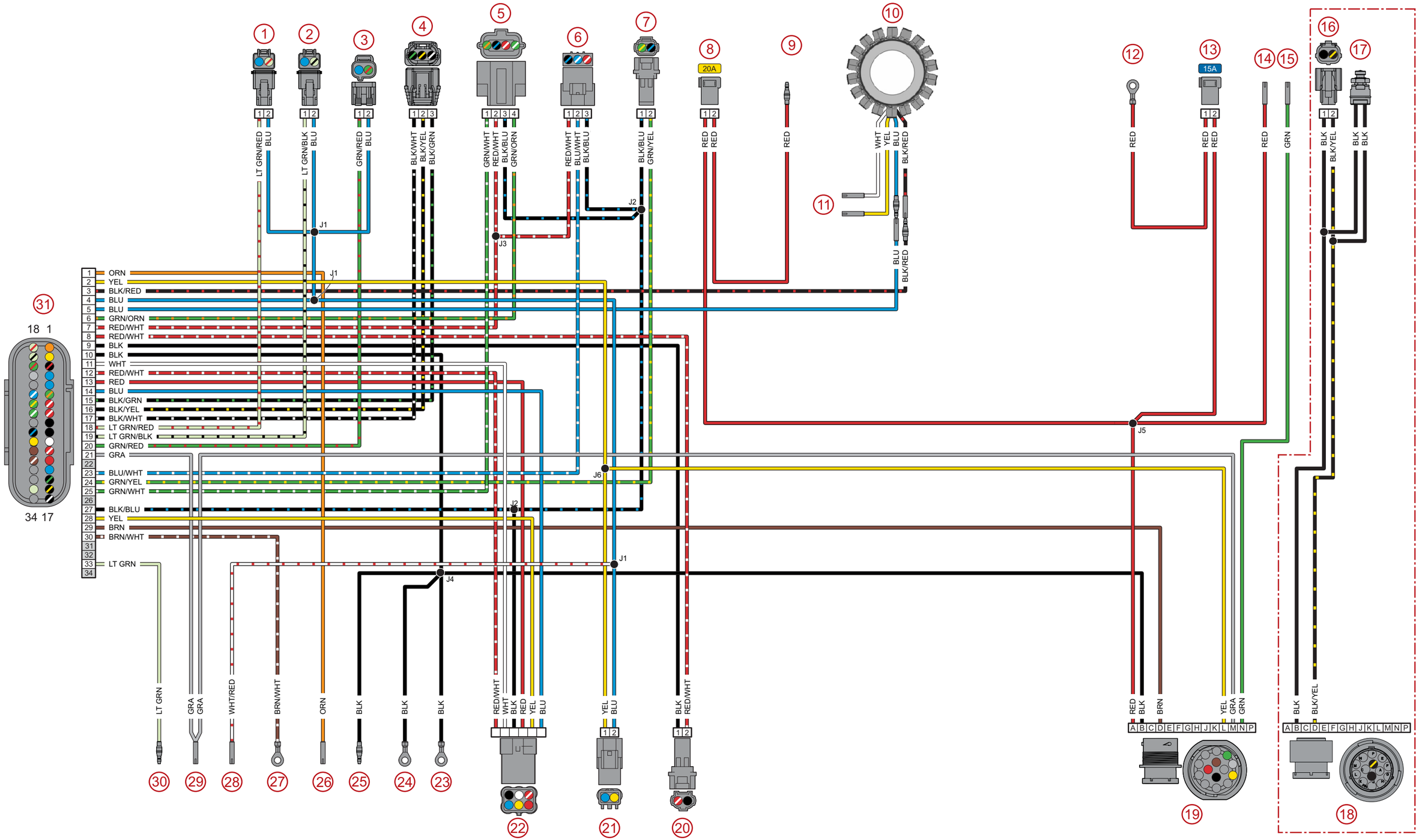
Notes:

Notes:

15/20 EFI FourStroke, Manual Start, Manual Tilt

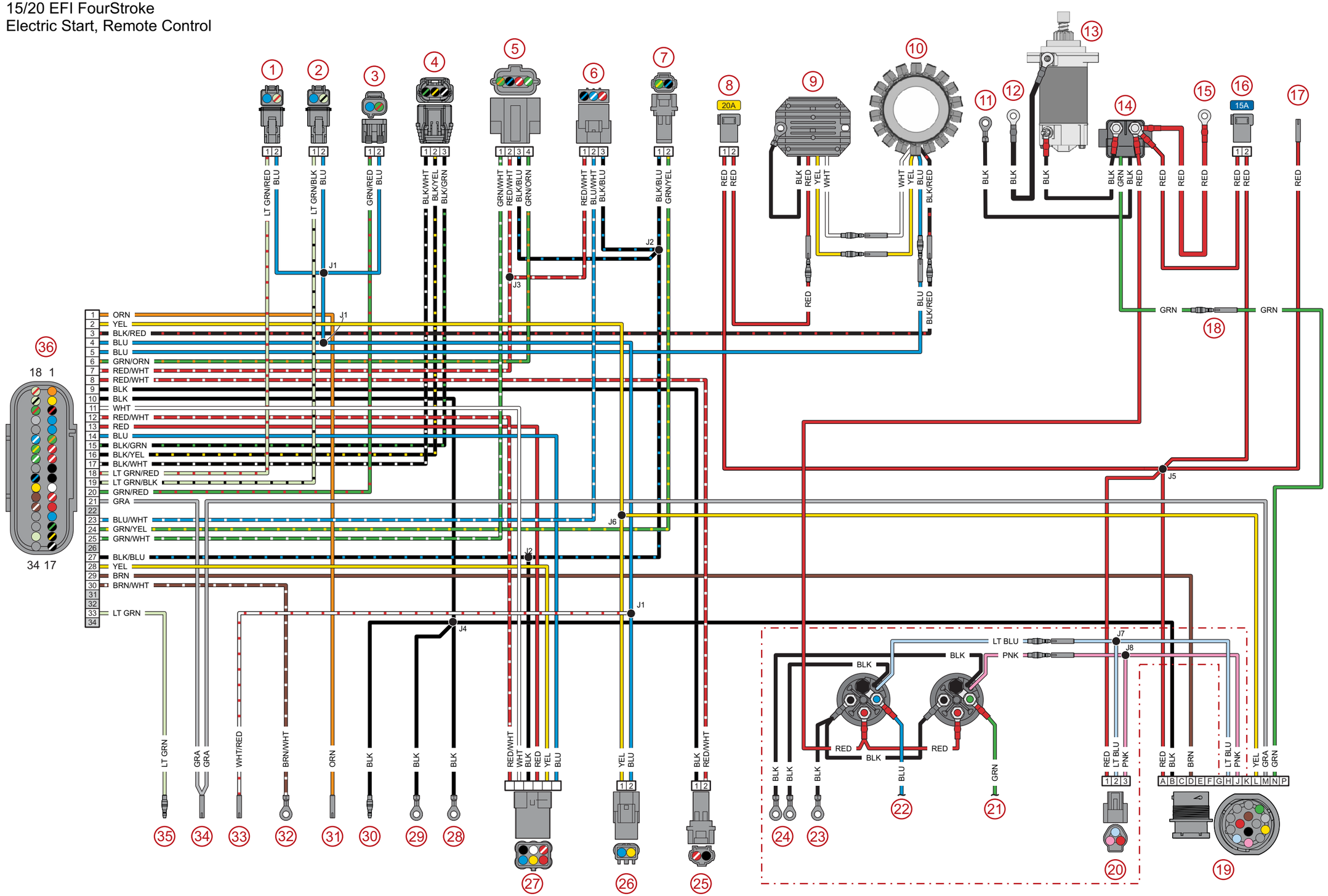
1 - Injector #1
2 - Injector #2
3 - Idle speed control valve (idle air control)
4 - Vapor separator tank/high-pressure fuel pump
5 - Temperature and manifold absolute pressure (TMAP) sensor
6 - Throttle position sensor (TPS)
7 - Engine coolant temperature (ECT) sensor
8 - 20-amp fuse (not used)
9 - Not used (weather capped)
10 - Stator
11 - Stator yellow and white wires (not used)
12 - Not used
13 - 15-amp fuse (not used)
14 - Cowl-mounted start switch (not used)
15 - Not used
16 - Tiller models: Tiller handle stop push button
17 - Tiller models: Tiller handle E-stop switch (lanyard operated)
18 - Tiller models: Tiller handle 14-pin harness connector
19 - 14-pin connector for remote control/tiller harness
20 - Crankshaft position sensor (CPS)
21 - Warning horn
22 - Diagnostic connector
23 - Ground (coil bracket)
24 - Ground (cylinder block)
25 - Ignition coil ground
26 - Ignition coil power
27 - Oil pressure sender
28 - Warning light (power)
29 - Tach signal
30 - Warning light (signal)
31 - Engine control module (ECM)

15/20 EFI FourStroke
Manual Start, Manual Tilt



62820

15/20 EFI FourStroke
Electric Start, Remote Control



62819

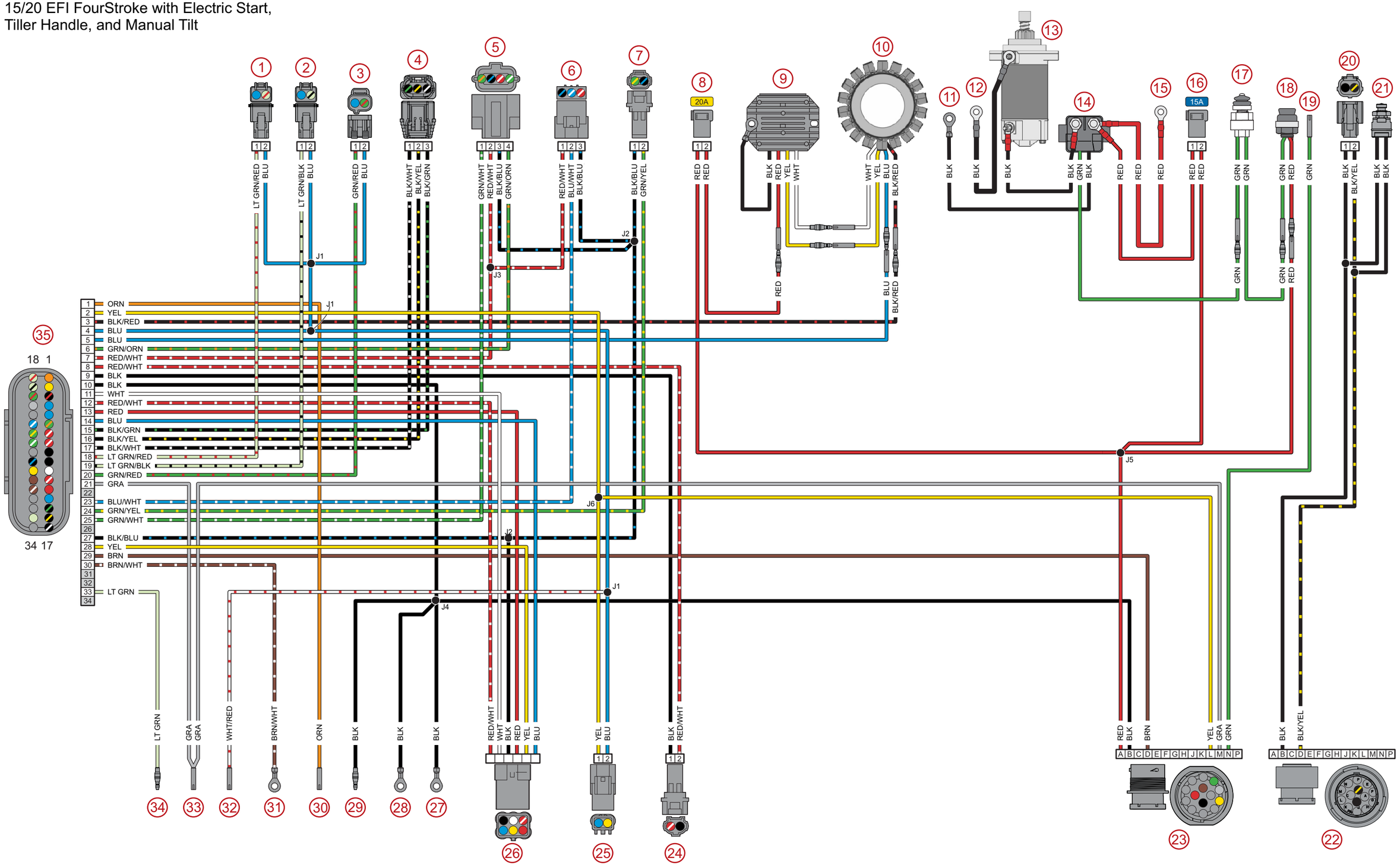
15/20 EFI FourStroke, Electric Start, Remote Control

1 - Injector #1
2 - Injector #2
3 - Idle speed control valve (idle air control)
4 - Vapor separator tank/high-pressure fuel pump
5 - Temperature and manifold absolute pressure (TMAP) sensor
6 - Throttle position sensor (TPS)
7 - Engine coolant temperature (ECT) sensor
8 - 20-amp fuse (stator output)
9 - Voltage rectifier/regulator
10 - Stator
11 - Starter solenoid ground
12 - Battery negative (–)
13 - Starter
14 - Starter solenoid
15 - Battery positive (+)
16 - 15-amp fuse (starting control circuit power, tilt switch power when engine is not running)
17 - Cowl-mounted start switch (not used)
18 - Starter solenoid power (start signal)
19 - 14-pin connector for remote control harness
20 - Power tilt models: Cowl-mounted power tilt switch
21 - Power tilt models: Tilt down power (power tilt pump wires)
22 - Power tilt models: Tilt up power (power tilt pump wires)
23 - Power tilt models: Tilt relay ground
24 - Power tilt models: Tilt relay coil ground wires
25 - Crankshaft position sensor (CPS)
26 - Warning horn
27 - Diagnostic connector
28 - Ground (coil bracket)
29 - Ground (cylinder block)
30 - Ignition coil ground
31 - Ignition coil power
32 - Oil pressure sender
33 - Warning light (power)
34 - Tach signal
35 - Warning light (signal)
36 - Engine control module (ECM)

15/20 EFI FourStroke with Electric Start, Tiller Handle, and Manual Tilt

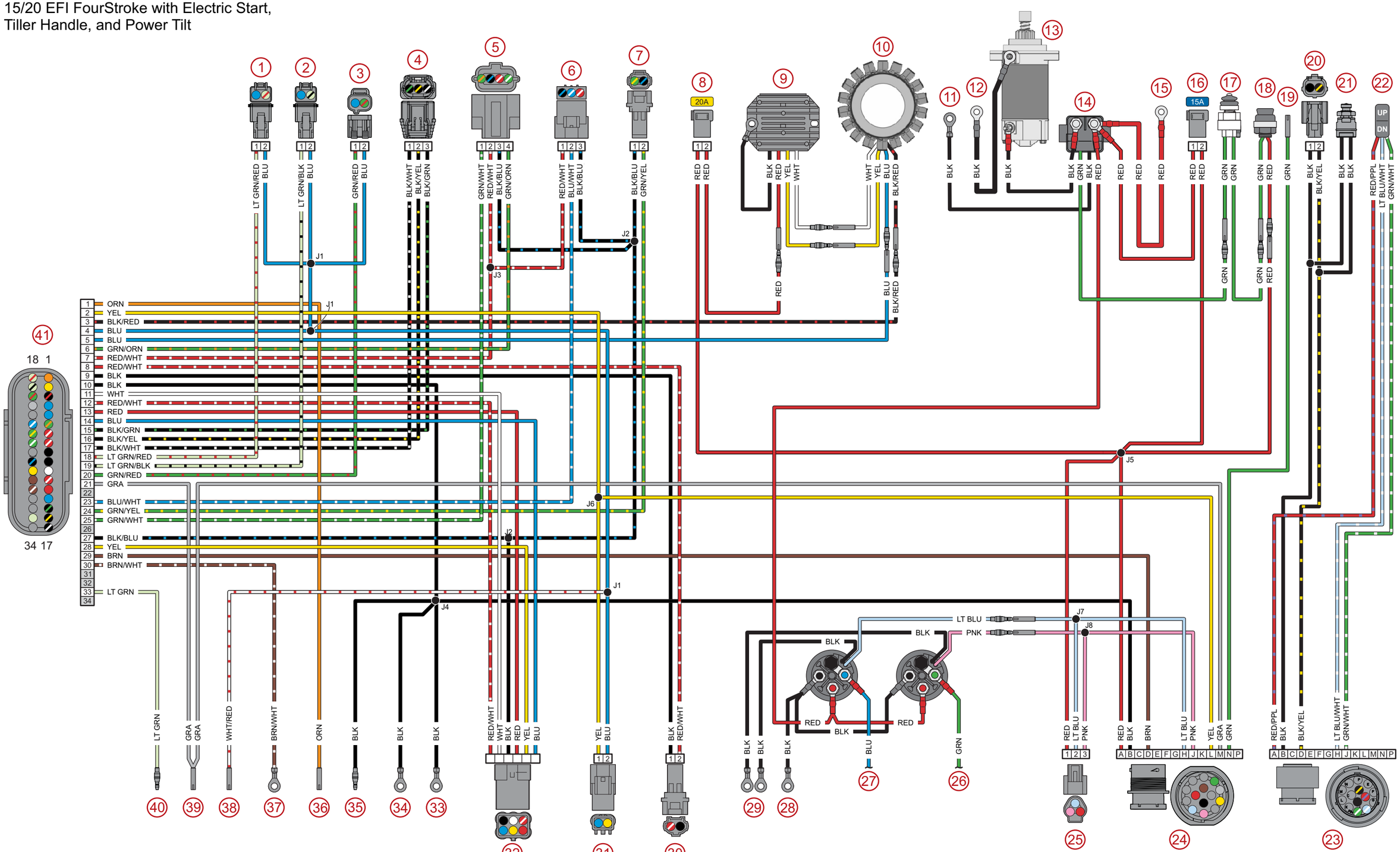
1 - Injector #1
2 - Injector #2
3 - Idle speed control valve (idle air control)
4 - Vapor separator tank/high-pressure fuel pump
5 - Temperature and manifold absolute pressure (TMAP) sensor
6 - Throttle position sensor (TPS)
7 - Engine coolant temperature (ECT) sensor
8 - 20-amp fuse (stator output)
9 - Voltage rectifier/regulator
10 - Stator
11 - Starter solenoid ground
12 - Battery negative (–)
13 - Starter
14 - Starter solenoid
15 - Battery positive (+)
16 - 15-amp fuse (starting control circuit)
17 - Neutral start switch
18 - Cowl-mounted start switch
19 - Not used
20 - Tiller handle stop push button
21 - Tiller handle E-stop switch (lanyard operated)
22 - Tiller handle 14-pin harness connector
23 - 14-pin connector for tiller harness
24 - Crankshaft position sensor (CPS)
25 - Warning horn
26 - Diagnostic connector
27 - Ground (coil bracket)
28 - Ground (cylinder block)
29 - Ignition coil ground
30 - Ignition coil power
31 - Oil pressure sender
32 - Warning light (power)
33 - Tach signal
34 - Warning light (signal)
35 - Engine control module (ECM)

15/20 EFI FourStroke with Electric Start,
Tiller Handle, and Manual Tilt



63518

15/20 EFI FourStroke with Electric Start,
Tiller Handle, and Power Tilt



63519

15/20 EFI FourStroke with Electric Start, Tiller Handle, and Power Tilt

1 - Injector #1
2 - Injector #2
3 - Idle speed control valve (idle air control)
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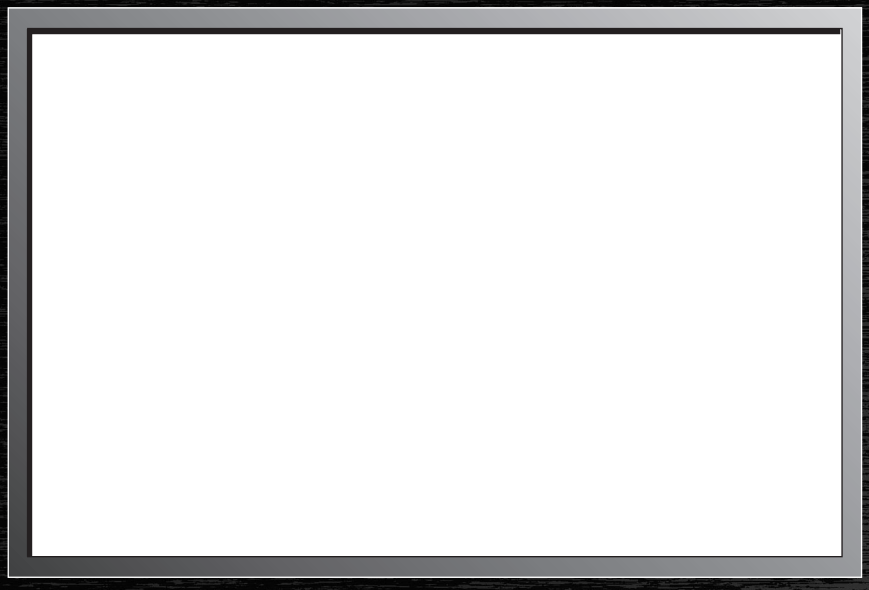
7 - Engine coolant temperature (ECT) sensor
8 - 20-amp fuse (stator output)
9 - Voltage rectifier/regulator
10 - Stator
11 - Starter solenoid ground
12 - Battery negative (–)
13 - Starter
14 - Starter solenoid
15 - Battery positive (+)
16 - 15-amp fuse (starting control circuit power, tilt switch power when engine is not running)
17 - Neutral start switch
18 - Cowl-mounted start switch
19 - Not used
20 - Tiller handle stop push button
21 - Tiller handle E-stop switch (lanyard operated)
22 - Tiller handle power tilt switch
23 - Tiller handle 14-pin harness connector
24 - 14-pin connector for tiller harness
25 - Cowl-mounted power tilt switch
26 - Tilt down power (power tilt pump wires)
27 - Tilt up power (power tilt pump wires)
28 - Tilt relay ground
29 - Tilt relay coil ground wires
30 - Crankshaft position sensor (CPS)
31 - Warning horn
32 - Diagnostic connector
33 - Ground (coil bracket)
34 - Ground (cylinder block)
35 - Ignition coil ground
36 - Ignition coil power
37 - Oil pressure sender
38 - Warning light (ground)
39 - Tach signal
40 - Warning light (signal)
41 - Engine control module (ECM)

Notes:



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