Manual Outline

Notice to Users of This Manual

Throughout this publication, dangers, warnings, cautions, and notices (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 them 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.

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

⚠ 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.

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

IMPORTANT: Identifies 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 Service Department of Mercury Marine to aid our dealers' mechanics and company service personnel when servicing the products described herein. We reserve the right to make changes to this manual without prior notification.

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 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/or results of each method. Therefore, anyone who uses a service procedure and/or tool, which is not recommended by the manufacturer, first must completely satisfy himself that neither his nor the products 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 and/or service these products.

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

It should be kept in mind, while working on the product, 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.

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 tolerances measured in the ten thousands of an inch/mm. When any product component is serviced, care and cleanliness are important. It should be understood that proper cleaning and protection of machined surfaces and friction areas is a 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.

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

Important Information

Section 1A - Master Specifications

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135/150/175/200 Verado FourStroke Master Specifications

General Specifications

Model Specifications	
Kilowatts (horsepower)	100.6 kW (135 hp) 111.8 kW (150 hp) 130.5 kW (175 hp) 149.1 kW (200 hp)
Weight	
Dry weight* 135/150/175/200 ELPT	240 kg (528 lb)
Dry weight* 135/150/175/200 EXLPT	247kg (544 lb)
Running weight** 135/150/175/200 ELPT	254 kg (560 lb)
Running weight** 135/150/175/200 EXLPT	261 kg (576 lb)
	N/A
Displacement (all hp)	1731 cc (105.7 in.³)
RPM	
Idle	500–600 RPM
WOT	5800–6400 RPM
Induction system	SmartCraft DTS® electronic throttle, intercooled supercharged aspiration with electronic boost pressure control
Fuel system	Computer controlled sequential multi-port electronic fuel injection
Ignition system	SmartCraft propulsion control module (PCM) 03 digital inductive
Charging system	Regulated belt driven 70 A alternator
Exhaust system	Through the propeller
Cooling system	Water-cooled - thermostat with pressure control
Lubrication system	
Integrated dry sump	6.0 liters (6.3 US qt)
Engine control system	SmartCraft PCM 03 digital throttle and shift (DTS)
Trim system	SmartCraft programmable
Maximum tilt range	73° (–5° to 68°)
Maximum trim range	20° (–5° to 15°)
Steering system	Electric - Hydraulic power steering with integral hydraulic cylinder

* Dry weight includes gear lube and steering cylinder.

** Running weight includes gear lube, engine oil, steering cylinder, propeller, and battery cables.

Ignition Specifications

Ignition Specifications	
Full throttle RPM	
135/150/175/200 hp	5800–6400
Idle RPM (all models)	650
Ignition type	Digital inductive
Spark plug type	NGK ILFR6G or NGK ILFR6GE
Spark plug gap	0.8 mm (0.031 in.)
Spark plug hex size	16 mm
Spark plug torque	27 Nm (20 lb-ft)
Spark plug hole size	14 mm
Firing order	1-3-4-2
Ignition timing at idle	Approximately 2° ATDC; PCM controlled
Ignition timing at WOT	PCM controlled
PCM overspeed limiter	Activates at 6500 RPM

Charging and Starting Specifications

Charging and Starting Specifications	
Alternator output (regulated)	
Output at battery (at 1000 RPM)	37–44 A
Output at battery (at 3000 RPM)	53–69 A
Output at alternator (at 1000 RPM)	48–54 A
Output at alternator (at 3000 RPM)	65–72 A
Voltage set point	14.5 ± 0.25 volts
Regulator current draw[1.]	
Ignition switch "OFF" (maximum)	1.0 mA
Ignition switch "ON"	350 mA
Starter draw (under load)	160 A
Starter draw (no load)	60 A
Minimum brush length	6.54 mm (0.25 in.)
Starting battery rating	
Required starting battery type	12 volt absorbed glass mat (AGM) battery
Required USA and Canada (SAE) starting battery type*	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 RC25 rating
Required international (EN) starting battery type*	975 minimum cold cranking amps (CCA) with a minimum of 65 ampere hour (Ah)

*Different test methods are used to determine cranking ratings in different parts of the world.

IMPORTANT: The battery selected must meet or exceed both required specifications:

- **USA and Canada (SAE rating)–Both MCA and RC25**
- **International (EN rating)–Both CCA and Ah**

Boatbuilders who use batteries rated to SAE specifications must meet both the 800 marine cranking amps (MCA) and 135 RC25 specifications following SAE test procedures. If a boat is shipped anywhere in the world, a battery rating per SAE specifications is acceptable.

1. All model alternator specifications require an amperage draw of less than 1.0 mA with the ignition key in the "OFF" position and an amperage draw of not more than 350.0 mA with key in the "ON" position.

Boatbuilders who use batteries rated to EN specifications must meet both the 975 cold cranking amps (CCA) and 65 ampere hour (Ah) specifications following EN test procedures. If a boat is shipped anywhere in the world, a battery rating per EN specifications is acceptable.

Fuel System Specifications

Fuel System Specifications	
Type of fuel	Automotive unleaded with a minimum pump posted octane rating of 87 (90 RON)
Approximate fuel pressure at idle	281–345 kPa (41–50 psi)
Fuel filtration	
Fuel inlet water separator	2 microns
High pressure	20 microns

Cylinder Block/Crankcase Specifications

Cylinder Block/Crankcase Specifications	
Number of cylinders	4
Displacement	1.7 liters (105.6 CID)
Compression ratio	8.25:1
Standard bore	82.00 mm (3.228 in.)
Stroke	82.00 mm (3.228 in.)
Cylinder bore maximum taper (service)	0.0762 mm (0.003 in.)
Cylinder bore maximum out of round (service)	0.0762 mm (0.003 in.)
Cylinder block main bearing	65.997–66.013 mm (2.5982–2.5989 in.)
Crankshaft main bearing journal	59.985–60.001 mm (2.3616–2.3622 in.)
Crankshaft pin journal	49.982–50.00 mm (1.9678–1.968 in.)
Crankshaft end play	0.08–0.19 mm (0.003–0.007 in.)
Crankshaft runout	0.05 mm (0.002 in.)
Crankshaft main bearing oil clearance (without expansion)	0.014–0.042 mm (0.0005–0.0016 in.)
Crankshaft pin bearing oil clearance (without expansion)	0.020–0.050 mm (0.0008–0.0019 in.)
Connecting rod wrist pin bore diameter	22.005–22.014 mm (0.8663–0.8666 in.)
Connecting rod crankshaft pin diameter	53.000–53.018 mm (2.0866–2.0873 in.)
Piston skirt standard diameter	81.975 mm (3.2273 in.)
Piston wrist pin bore diameter	22.004–22.011 mm (0.8662–0.8665 in.)
Wrist pin diameter	21.997–22.000 mm (0.8660–0.8661 in.)
Top ring groove width	1.25 mm (0.049 in.)
Second ring groove width	1.23 mm (0.048 in.)
Third ring groove width	2.03 mm (0.080 in.)
Top ring thickness	1.19 mm (0.047 in.)
Second ring thickness	1.19 mm (0.047 in.)
Third ring thickness	1.98 mm (0.078 in.)
Top ring side clearance	0.04–0.08 mm (0.001–0.003 in.)
Second ring side clearance	0.04–0.08 mm (0.001–0.003 in.)
Third ring side clearance	0.05–0.17 mm (0.002–0.006 in.)
Top ring end gap	0.27–0.42 mm (0.010–0.016 in.)
Second ring end gap	0.42–0.62 mm (0.016–0.024 in.)
Oil ring end gap	0.2–0.7 mm (0.007–0.027 in.)

Cylinder Head Specifications

Cylinder Head Specifications	
Maximum deck warp	0.075 mm (0.003 in.)
Number of valves	16
Number of valves per cylinder	4
Number of cams	2
Cam bearing journal (intake and exhaust)	28.95 mm (1.140 in.)
Camshaft bearing cap ID	29.000–29.021 mm (1.1417–1.1425 in.)
Cam lobe	
Intake	42.50 mm (1.6732 in.)
Exhaust	43.55 mm (1.7145 in.)
Valve lash	
Intake	0.150–0.230 mm (0.0059–0.009 in.)
Exhaust	0.350–0.430 mm (0.0137–0.0169 in.)
Valve seat angles	30°, 45°, 60°
Valve spring free length	48.77 mm (1.920 in.)
Valve outside diameter	
Intake	32.0 ± 0.15 mm (1.259 ± 0.0059 in.)
Exhaust	27.2 ± 0.190 mm (1.0708 ± 0.0059 in.)
Valve face width (intake and exhaust)	2.25 mm (0.0886 in.)
Valve margin	
Intake	0.75 mm (0.0295 in.)
Exhaust	0.65 mm (0.0256 in.)
Valve guide bore ID (intake and exhaust)	6.00–6.016 mm (0.2362–0.2368 in.)
Valve stem diameter	
Intake	5.97 mm (0.235 in.)
Exhaust	5.96 mm (0.2346 in.)
Valve stem runout (maximum)	0.038 mm (0.0015 in.)
Valve stem to valve guide clearance	
Intake	0.03–0.046 mm (0.0011–0.0018 in.)
Exhaust	0.04–0.056 mm (0.0015–0.0022 in.)
Valve seat contact width (intake and exhaust)	2.25 mm (0.0886 in.)

Lubrication System Specifications

Lubrication System Specifications	
Engine capacity with filter replacement	6 liters (6.3 US qt)
Oil filter	P/N 35-896546T
Gen I oil pressure (warm) (S/N 1B517158 and below)	
at 650 RPM	Minimum 50 kPa (7 psi)
at 6000 RPM	Minimum 220 kPa (32 psi)
at 650 RPM (typical range)	60–120 kPa (9–18 psi)
at 6000 RPM (typical range)	300–450 kPa (44–65 psi)
Gen II oil pressure (warm) (S/N 1B517159 and above)	
at 650 RPM	Minimum 35 kPa (5 psi)
at 6000 RPM	Minimum 200 kPa (29 psi)
at 650 RPM (typical range)	90–190 kPa (13–28 psi)
at 6000 RPM (typical range)	300–450 kPa (44–65 psi)
IOM thermostat opening temperature	62 °C (144 °F)

Power Trim Specifications

Power Trim Specifications	
Trim up relief valve - tilt extended relief pressure	6100–7750 kPa (885–1125 psi)
Trim down relief valve pressure	4400–7300 kPa (640–1060 psi)
System fluid	Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) Type F, FA, Dexron II, or Dexron III

Gear Housing Specifications

Gear Housing Specifications	
Gear ratio	2.08:1 (12/25 teeth)
Gearcase capacity	970 ml (32.8 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Pinion height	0.635 mm (0.025 in.)
Forward gear backlash	0.432–0.635 mm (0.017–0.025 in.)
Reverse gear backlash	1.24–1.45 mm (0.049–0.057 in.)
Water pressure at RPM	
At 650 RPM (idle)	15.2 kPa (2.2 psi)
At 6000 RPM (WOT)	
Warm water slow boat	88 kPa (12.8 psi)
Cold water fast boat	220 kPa (32 psi)
Gear housing pressure (without gear lubricant, five minutes without leakage)	103.4 kPa (15 psi)

Power Steering Specifications

Power Steering Specifications	
Fluid type	Synthetic Power Steering Fluid SAE 0W-30
Capacity	Typical 1–2 liters (1–2 US quarts)
Current draw	Not to exceed 75 A
Steering ratio (32 cc helm and single steering cylinder, lock to lock) - preferred configuration	3.8 turns
Steering ratio (40 cc helm and single steering cylinder, lock to lock)	3.0 turns
Steering ratio (50 cc helm and single steering cylinder, lock to lock)	2.4 turns
Steering ratio (32 cc helm with dual steering cylinders, lock to lock)	7.6 turns
Steering ratio (40 cc helm with dual steering cylinders, lock to lock) - preferred configuration	6.0 turns
Steering ratio (50 cc helm with dual steering cylinders, lock to lock)	4.8 turns

Hydraulic Steering Specifications

Hydraulic Steering Specifications	
Fluid type	Hydraulic Helm Steering Fluid
Steering ratio (28 cc helm and single steering cylinder, lock to lock) - preferred configuration	4.3 turns
Steering ratio (33 cc helm and single steering cylinder, lock to lock)	3.7 turns
Steering ratio (39 cc helm and single steering cylinder, lock to lock)	3.1 turns
Steering ratio (28 cc helm with dual steering cylinders, lock to lock)	8.6 turns
Steering ratio (33 cc helm with dual steering cylinders, lock to lock)	7.3 turns
Steering ratio (39 cc helm with dual steering cylinders, lock to lock) - preferred configuration	6.2 turns

135 Verado FourStroke Propeller Information Chart

- Wide-open throttle RPM: 5200–6400
- Recommended transom height: 50.8 cm (20 in.), 63.5 cm (25 in.), 76.2 cm (30 in.)
- Gear reduction: 2.08:1
- Right-hand rotation (RH) standard, left-hand rotation (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
13.75	24	4	Trophy Plus	Up to 861.83 kg (1900 lb)	Up to 5.5 m (18 ft)	82.08–104.61 km/h (51–65 MPH)	48-825940A47
14.62	24	3	Tempest Plus	Up to 861.83 kg (1900 lb)	Up to 5.5 m (18 ft)	82.08–104.61 km/h (51–65 MPH)	48-825872A47
13.75	23	4	Trophy Plus	771.11–997.9 kg (1700–2200 lb)	5.2–5.8 m (17–19 ft)	78.86–99.78 km/h (49–62 MPH)	48-825938A47
14.62	23	3	Tempest Plus	771.11–997.9 kg (1700–2200 lb)	5.2–5.8 m (17–19 ft)	78.86–99.78 km/h (49–62 MPH)	48-825864A47 (RH) 48-825865A47 (LH)
13.25	23	5	HighFive	771.11–997.9 kg (1700–2200 lb)	5.2–5.8 m (17–19 ft)	78.86–99.78 km/h (49–62 MPH)	48-815762A46
14.00	23	4	VenSura	771.11–997.9 kg (1700–2200 lb)	5.2–5.8 m (17–19 ft)	78.86–99.78 km/h (49–62 MPH)	48-825906A48 (RH) 48-825907A48 (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
13.50	23	3	Vengeance	771.11–997.9 kg (1700–2200 lb)	5.2–5.8 m (17–19 ft)	78.86–99.78 km/h (49–62 MPH)	48-16320A46 (RH) 48-16321A46 (LH)
13.75	23	3	Laser II	771.11–997.9 kg (1700–2200 lb)	5.2–5.8 m (17–19 ft)	78.86–99.78 km/h (49–62 MPH)	48-16548A46 (RH) 48-16547A46 (LH)
14.00	23	3	Black Max Aluminum	771.11–997.9 kg (1700–2200 lb)	5.2–5.8 m (17–19 ft)	75.64–96.56 km/h (47–60 MPH)	48-832834A45
13.75	21	4	Trophy Plus	861.83–1179.34 kg (1900–2600 lb)	5.2–6.1 m (17–20 ft)	69.20–91.73 km/h (43–57 MPH)	48-825934A47
14.62	21	3	Tempest Plus	861.83–1179.34 kg (1900–2600 lb)	5.2–6.1 m (17–20 ft)	69.20–91.73 km/h (43–57 MPH)	48-825862A47 (RH) 48-825863A47 (LH)
14.75	21	3	Mirage Plus	861.83–1179.34 kg (1900–2600 lb)	5.2–6.1 m (17–20 ft)	69.20–91.73 km/h (43–57 MPH)	48-13702A46 (RH) 48-13703A46 (LH)
13.25	21	5	HighFive	861.83–1179.34 kg (1900–2600 lb)	5.2–6.1 m (17–20 ft)	69.20–91.73 km/h (43–57 MPH)	48-815760A46
14.00	21	4	VenSura	861.83–1179.34 kg (1900–2600 lb)	5.2–6.1 m (17–20 ft)	69.20–91.73 km/h (43–57 MPH)	48-825902A48 (RH) 48-825903A48 (LH)
13.75	21	3	Vengeance	997.90–1179.34 kg (1900–2600 lb)	5.2–6.1 m (17–20 ft)	69.20–91.73 km/h (43–57 MPH)	48-16318A46 (RH) 48-16319A46 (LH)
14.25	21	3	Black Max Aluminum	997.90–1179.34 kg (1900–2600 lb)	5.2–6.1 m (17–20 ft)	65.98–88.51 km/h (41–55 MPH)	48-832832A45
14.00	20	4	Alpha 4 Aluminum	907.18–1270.06 kg (2000–2800 lb)	5.5–6.4 m (18–21 ft)	64.37–85.30 km/h (40–53 MPH)	48-834854A45 (RH) 48-834855A45 (LH)
14.62	19	3	Tempest Plus	952.54–1360.78 kg (2100–3000 lb)	5.5–6.4 m (18–21 ft)	61.16–82.08 km/h (38–51 MPH)	48-825860A47 (RH) 48-825861A47 (LH)
15.25	19	3	Mirage Plus	952.54–1360.78 kg (2100–3000 lb)	5.5–6.4 m (18–21 ft)	61.16–82.08 km/h (38–51 MPH)	48-13700A46 (RH) 48-13701A46 (LH)
13.25	19	5	HighFive	952.54–1360.78 kg (2100–3000 lb)	5.5–6.4 m (18–21 ft)	61.16–82.08 km/h (38–51 MPH)	48-815758A46
14.00	19	4	VenSura	952.54–1360.78 kg (2100–3000 lb)	5.5–6.4 m (18–21 ft)	61.16–82.08 km/h (38–51 MPH)	48-825900A48 (RH) 48-825901A48 (LH)
14.00	19	3	Vengeance	952.54–1360.78 kg (2100–3000 lb)	5.5–6.4 m (18–21 ft)	61.16–82.08 km/h (38–51 MPH)	48-16316A46 (RH) 48-16317A46 (LH)
14.50	19	3	Black Max Aluminum	952.54–1360.78 kg (2100–3000 lb)	5.5–6.4 m (18–21 ft)	59.55–80.47 km/h (37–50 MPH)	48-832830A45
15.38	18	3	Mirage Plus	1043.26–1496.86 kg (2300–3300 lb)	5.8–6.7 m (19–22 ft)	56.33–77.25 km/h (35–48 MPH)	48-889620A46 (RH) 48-889619A46 (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
14.50	18	4	Alpha 4 Aluminum	1043.26–1496.86 kg (2300–3300 lb)	5.8–6.7 m (19–22 ft)	56.33–77.25 km/h (35–48 MPH)	48-834852A45 (RH) 48-834853A45 (LH)
15.50	17	3	Mirage Plus	1088.62–1632.93 kg (2400–3600 lb)	5.8–7.0 m (19–23 ft)	51.50–74.03 km/h (32–46 MPH)	48-18278A46 (RH) 48-90159A46 (LH)
13.50	17	5	HighFive	1088.62–1632.93 kg (2400–3600 lb)	5.8–7.0 m (19–23 ft)	51.50–74.03 km/h (32–46 MPH)	48-821154A46
14.25	17	4	VenSura	1088.62–1632.93 kg (2400–3600 lb)	5.8–7.0 m (19–23 ft)	51.50–74.03 km/h (32–46 MPH)	48-825898A48 (RH) 48-825899A48 (LH)
14.50	17	3	Vengeance	1088.62–1632.93 kg (2400–3600 lb)	5.8–7.0 m (19–23 ft)	51.50–74.03 km/h (32–46 MPH)	48-16314A46 (RH) 48-16315A46 (LH)
15.00	17	3	Black Max Aluminum	1088.62–1632.93 kg (2400–3600 lb)	5.8–7.0 m (19–23 ft)	49.89–72.42 km/h (31–45 MPH)	48-832828A45
15.00	16	4	Alpha 4 Aluminum	1179.34–1859.73 kg (2600–4100 lb)	6.1–7.3 m (20–24 ft)	46.67–69.20 km/h (29–43 MPH)	48-834850A45 (RH) 48-834851A45 (LH)
15.75	15	3	Mirage Plus	1270.06–2177.24 kg (2800–4800 lb)	6.4–7.6 m (21–25 ft)	40.23–64.37 km/h (25–40 MPH)	48-19838A46 (RH) 48-19841A46 (LH)
14.62	15	4	Revolution 4	1270.06–2177.24 kg (2800–4800 lb)	6.4–7.6 m (21–25 ft)	40.23–64.37 km/h (25–40 MPH)	48-857022A46
15.25	15	3	Black Max	1270.06–2177.24 kg (2800–4800 lb)	6.4–7.6 m (21–25 ft)	40.23–64.37 km/h (25–40 MPH)	48-78116A45
16.00	13	3	Mirage Plus	1587.57–2948.35 kg (3500–6500 lb)	6.7–7.9 m (22–26 ft)	30.58–53.11 km/h (19–33 MPH)	48-826072A46
16.00	13	3	Black Max Aluminum	1587.57–2948.35 kg (3500–6500 lb)	6.7–7.9 m (22–26 ft)	30.58–53.11 km/h (19–33 MPH)	48-78114A45
16.00	12	3	Black Max Aluminum	2267.96+ kg (5000+ lb)	Pontoon/ Work	25.75–43.45 km/h (16–27 MPH)	48-16436A45
16.00	11	3	Black Max Aluminum	2721.55+ kg (6000+ lb)	Workboat	1.61–46.67 km/h (1–29 MPH)	48-78112A45 (RH) 48-78117A40 (LH)

150 Verado FourStroke Propeller Information Chart

- Wide-open throttle RPM: 5800–6400
- Recommended transom height: 50.8 cm (20 in.), 63.5 cm (25 in.), 76.2 cm (30 in.)
- Gear reduction: 2.08:1
- Right-hand rotation (RH) standard, left-hand rotation (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
13.75	26	4	Trophy Plus	Up to 861.83 kg (1900 lb)	Up to 5.8 m (19 ft)	101.39–114.26 km/h (63–71 MPH)	48-825944A47
14.62	26	3	Tempest Plus	Up to 861.83 kg (1900 lb)	Up to 5.8 m (19 ft)	101.39–114.26 km/h (63–71 MPH)	48-825874A47
13.75	25	4	Trophy Plus	771.11–907.18 kg (1700–2000 lb)	5.2–5.8 m (17–19 ft)	98.17–109.44 km/h (61–68 MPH)	48-825942A47

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
14.62	25	3	Tempest Plus	771.11–907.18 kg (1700–2000 lb)	5.2–5.8 m (17–19 ft)	98.17–109.44 km/h (61–68 MPH)	48-825866A47
13.25	25	5	HighFive	771.11–907.18 kg (1700–2000 lb)	5.2–5.8 m (17–19 ft)	98.17–109.44 km/h (61–68 MPH)	48-816374A46
13.75	25	3	Laser II	771.11–907.18 kg (1700–2000 lb)	5.2–5.8 m (17–19 ft)	98.17–109.44 km/h (61–68 MPH)	48-16550A46 (RH) 48-16549A46 (LH)
13.75	24	4	Trophy Plus	816.47–952.54 kg (1800–2100 lb)	5.5–6.1 m (18–20 ft)	93.34–104.61 km/h (58–65 MPH)	48-825940A47
14.62	24	3	Tempest Plus	816.47–952.54 kg (1800–2100 lb)	5.5–6.1 m (18–20 ft)	93.34–104.61 km/h (58–65 MPH)	48-825872A47
13.75	23	4	Trophy Plus	861.83–952.54 kg (1900–2100 lb)	5.5–6.1 m (18–20 ft)	90.12–99.78 km/h (56–62 MPH)	48-825938A47
14.62	23	3	Tempest Plus	861.83–952.54 kg (1900–2100 lb)	5.5–6.1 m (18–20 ft)	90.12–99.78 km/h (56–62 MPH)	48-825864A47 (RH) 48-825865A47 (LH)
13.25	23	5	HighFive	861.83–952.54 kg (1900–2100 lb)	5.5–6.1 m (18–20 ft)	90.12–99.78 km/h (56–62 MPH)	48-815762A46
14.00	23	4	VenSura	861.83–952.54 kg (1900–2100 lb)	5.5–6.1 m (18–20 ft)	90.12–99.78 km/h (56–62 MPH)	48-825906A48 (RH) 48-825907A48 (LH)
13.50	23	3	Vengeance	861.83–952.54 kg (1900–2100 lb)	5.5–6.1 m (18–20 ft)	90.12–99.78 km/h (56–62 MPH)	48-16320A46 (RH) 48-16321A46 (LH)
13.75	23	3	Laser II	861.83–952.54 kg (1900–2100 lb)	5.5–6.1 m (18–20 ft)	90.12–99.78 km/h (56–62 MPH)	48-16548A46 (RH) 48-16547A46 (LH)
14.00	23	3	Black Max Aluminum	861.83–952.54 kg (1900–2100 lb)	5.5–6.1 m (18–20 ft)	86.90–96.56 km/h (54–60 MPH)	48-832834A45
13.75	21	4	Trophy Plus	952.54–1088.62 kg (2100–2400 lb)	5.5–6.4 m (18–21 ft)	80.47–91.73 km/h (50–57 MPH)	48-825934A47
14.62	21	3	Tempest Plus	952.54–1088.62 kg (2100–2400 lb)	5.5–6.4 m (18–21 ft)	80.47–91.73 km/h (50–57 MPH)	48-825862A47 (RH) 48-825863A47 (LH)
14.75	21	3	Mirage Plus	952.54–1088.62 kg (2100–2400 lb)	5.5–6.4 m (18–21 ft)	80.47–91.73 km/h (50–57 MPH)	48-13702A46 (RH) 48-13703A46 (LH)
13.25	21	5	HighFive	952.54–1088.62 kg (2100–2400 lb)	5.5–6.4 m (18–21 ft)	80.47–91.73 km/h (50–57 MPH)	48-815760A46
14.00	21	4	VenSura	952.54–1088.62 kg (2100–2400 lb)	5.5–6.4 m (18–21 ft)	80.47–91.73 km/h (50–57 MPH)	48-825902A48 (RH) 48-825903A48 (LH)
13.75	21	3	Vengeance	952.54–1088.62 kg (2100–2400 lb)	5.5–6.4 m (18–21 ft)	80.47–91.73 km/h (50–57 MPH)	48-16318A46 (RH) 48-16319A46 (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
14.25	21	3	Black Max Aluminum	952.54–1088.62 kg (2100–2400 lb)	5.5–6.4 m (18–21 ft)	77.25–88.51 km/h (48–55 MPH)	48-832832A45
14.00	20	4	Alpha 4 Aluminum	997.90–1179.34 kg (2200–2600 lb)	5.8–6.7 m (19–22 ft)	74.03–85.30 km/h (46–53 MPH)	48-834854A45 (RH) 48-834855A45 (LH)
14.62	19	3	Tempest Plus	1088.62–1270.06 kg (2400–2800 lb)	5.8–6.7 m (19–22 ft)	70.81–82.08 km/h (44–51 MPH)	48-825860A47 (RH) 48-825861A47 (LH)
15.25	19	3	Mirage Plus	1088.62–1270.06 kg (2400–2800 lb)	5.8–6.7 m (19–22 ft)	70.81–82.08 km/h (44–51 MPH)	48-13700A46 (RH) 48-13701A46 (LH)
13.25	19	5	HighFive	1088.62–1270.06 kg (2400–2800 lb)	5.8–6.7 m (19–22 ft)	70.81–82.08 km/h (44–51 MPH)	48-815758A46
14.00	19	4	VenSura	1088.62–1270.06 kg (2400–2800 lb)	5.8–6.7 m (19–22 ft)	70.81–82.08 km/h (44–51 MPH)	48-825900A48 (RH) 48-825901A48 (LH)
14.00	19	3	Vengeance	1088.62–1270.06 kg (2400–2800 lb)	5.8–6.7 m (19–22 ft)	70.81–82.08 km/h (44–51 MPH)	48-16316A46 (RH) 48-16317A46 (LH)
14.50	19	3	Black Max Aluminum	1088.62–1270.06 kg (2400–2800 lb)	5.8–6.7 m (19–22 ft)	70.81–82.08 km/h (44–51 MPH)	48-832830A45
15.38	18	3	Mirage Plus	1133.98–1406.14 kg (2500–3100 lb)	5.8–7.0 m (19–23 ft)	65.98–78.86 km/h (41–49 MPH)	48-889620A46 (RH) 48-889619A46 (LH)
14.50	18	4	Alpha 4 Aluminum	1133.98–1406.14 kg (2500–3100 lb)	5.8–7.0 m (19–23 ft)	65.98–78.86 km/h (41–49 MPH)	48-834852A45 (RH) 48-834853A45 (LH)
15.50	17	3	Mirage Plus	1224.70–1496.86 kg (2700–3300 lb)	5.8–7.0 m (19–23 ft)	61.16–74.03 km/h (38–46 MPH)	48-18278A46 (RH) 48-90159A46 (LH)
13.50	17	5	HighFive	1224.70–1496.86 kg (2700–3300 lb)	5.8–7.0 m (19–23 ft)	61.16–74.03 km/h (38–46 MPH)	48-821154A46
14.25	17	4	VenSura	1224.70–1496.86 kg (2700–3300 lb)	5.8–7.0 m (19–23 ft)	61.16–74.03 km/h (38–46 MPH)	48-825898A48 (RH) 48-825899A48 (LH)
14.50	17	3	Vengeance	1224.70–1496.86 kg (2700–3300 lb)	5.8–7.0 m (19–23 ft)	61.16–74.03 km/h (38–46 MPH)	48-16314A46 (RH) 48-16315A46 (LH)
15.00	17	3	Black Max Aluminum	1224.70–1496.86 kg (2700–3300 lb)	5.8–7.0 m (19–23 ft)	61.16–74.03 km/h (38–46 MPH)	48-832828A45
15.00	16	4	Alpha 4 Aluminum	1315.42–1723.65 kg (2900–3800 lb)	6.1–7.3 m (20–24 ft)	56.33–69.20 km/h (35–43 MPH)	48-834850A45 (RH) 48-834851A45 (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
15.75	15	3	Mirage Plus	1406.14–1905.09 kg (3100–4200 lb)	6.4–7.6 m (21–25 ft)	49.89–64.37 km/h (31–40 MPH)	48-19838A46 (RH) 48-19841A46 (LH)
14.62	15	4	Revolution 4	1406.14–1905.09 kg (3100–4200 lb)	6.4–7.6 m (21–25 ft)	49.89–64.37 km/h (31–40 MPH)	48-857022A46
15.25	15	3	Black Max	1406.14–1905.09 kg (3100–4200 lb)	6.4–7.6 m (21–25 ft)	49.89–64.37 km/h (31–40 MPH)	48-78116A45
16.00	13	3	Mirage Plus	1769.01–2540.12 kg (3900–5600 lb)	6.7–7.9 m (22–26 ft)	38.62–54.72 km/h (24–34 MPH)	48-826072A46
16.00	13	3	Black Max Aluminum	1769.01–2540.12 kg (3900–5600 lb)	6.7–7.9 m (22–26 ft)	38.62–54.72 km/h (24–34 MPH)	48-78114A45
16.00	12	3	Black Max Aluminum	2267.96+ kg (5000+ lb)	Pontoon/ Work	25.75–43.45 km/h (16–27 MPH)	48-16436A45
16.00	11	3	Black Max Aluminum	3175.15+ kg (7000+ lb)	Workboat	1.61–46.67 km/h (1–29 MPH)	48-78112A45 (RH) 48-78117A40 (LH)

175 Verado FourStroke Propeller Information Chart

- Wide-open throttle RPM: 5800–6400
- Recommended transom height: 50.8 cm (20 in.), 63.5 cm (25 in.), 76.2 cm (30 in.)
- Gear reduction: 2.08:1
- Right-hand rotation (RH) standard, left-hand rotation (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
13.75	27	4	Trophy Plus	Up to 952.54 kg (2100 lb)	Up to 5.5 m (18 ft)	106.22–119.09 km/h (66–74 MPH)	48-825946A47
14.62	27	3	Tempest Plus	Up to 952.54 kg (2100 lb)	Up to 5.5 m (18 ft)	106.22–119.09 km/h (66–74 MPH)	48-825868A47
13.75	26	4	Trophy Plus	861.83–997.90 kg (1900–2200 lb)	Up to 5.8 m (19 ft)	101.39–114.26 km/h (63–71 MPH)	48-825944A47
14.62	26	3	Tempest Plus	861.83–997.90 kg (1900–2200 lb)	Up to 5.8 m (19 ft)	101.39–114.26 km/h (63–71 MPH)	48-825874A47
13.75	25	4	Trophy Plus	907.18–1043.26 kg (2000–2300 lb)	5.2–6.1 m (17–20 ft)	98.17–109.44 km/h (61–68 MPH)	48-825942A47
14.62	25	3	Tempest Plus	907.18–1043.26 kg (2000–2300 lb)	5.2–6.1 m (17–20 ft)	98.17–109.44 km/h (61–68 MPH)	48-825866A47
13.75	24	4	Trophy Plus	952.54–1088.62 kg (2100–2400 lb)	5.5–6.1 m (18–20 ft)	93.34–104.61 km/h (58–65 MPH)	48-825940A47
14.62	24	3	Tempest Plus	952.54–1088.62 kg (2100–2400 lb)	5.5–6.1 m (18–20 ft)	93.34–104.61 km/h (58–65 MPH)	48-825872A47
13.75	23	4	Trophy Plus	997.90–1133.98 kg (2200–2500 lb)	5.8–6.4 m (19–21 ft)	90.12–99.78 km/h (56–62 MPH)	48-825938A47
14.62	23	3	Tempest Plus	997.90–1133.98 kg (2200–2500 lb)	5.8–6.4 m (19–21 ft)	90.12–99.78 km/h (56–62 MPH)	48-825864A47 (RH) 48-825865A47 (LH)
13.25	23	5	HighFive	997.90–1133.98 kg (2200–2500 lb)	5.8–6.4 m (19–21 ft)	90.12–99.78 km/h (56–62 MPH)	48-815762A46

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
14.00	23	4	VenSura	997.90–1133.98 kg (2200–2500 lb)	5.8–6.4 m (19–21 ft)	90.12–99.78 km/h (56–62 MPH)	48-825906A48 (RH) 48-825907A48 (LH)
13.50	23	3	Vengeance	997.90–1133.98 kg (2200–2500 lb)	5.8–6.4 m (19–21 ft)	90.12–99.78 km/h (56–62 MPH)	48-16320A46 (RH) 48-16321A46 (LH)
14.00	23	3	Black Max Aluminum	997.90–1133.98 kg (2200–2500 lb)	5.8–6.4 m (19–21 ft)	86.90–96.56 km/h (54–60 MPH)	48-832834A45
13.75	21	4	Trophy Plus	1133.98–1270.06 kg (2500–2800 lb)	5.8–6.7 m (19–22 ft)	80.47–91.73 km/h (50–57 MPH)	48-825934A47
14.62	21	3	Tempest Plus	1133.98–1270.06 kg (2500–2800 lb)	5.8–6.7 m (19–22 ft)	80.47–91.73 km/h (50–57 MPH)	48-825862A47 (RH) 48-825863A47 (LH)
14.75	21	3	Mirage Plus	1133.98–1270.06 kg (2500–2800 lb)	5.8–6.7 m (19–22 ft)	80.47–91.73 km/h (50–57 MPH)	48-13702A46 (RH) 48-13703A46 (LH)
13.25	21	5	HighFive	1133.98–1270.06 kg (2500–2800 lb)	5.8–6.7 m (19–22 ft)	80.47–91.73 km/h (50–57 MPH)	48-815760A46
14.00	21	4	VenSura	1133.98–1270.06 kg (2500–2800 lb)	5.8–6.7 m (19–22 ft)	80.47–91.73 km/h (50–57 MPH)	48-825902A48 (RH) 48-825903A48 (LH)
13.75	21	3	Vengeance	1133.98–1270.06 kg (2500–2800 lb)	5.8–6.7 m (19–22 ft)	80.47–91.73 km/h (50–57 MPH)	48-16318A46 (RH) 48-16319A46 (LH)
14.25	21	3	Black Max Aluminum	1133.98–1270.06 kg (2500–2800 lb)	5.8–6.7 m (19–22 ft)	77.25–88.51 km/h (48–55 MPH)	48-832832A45
14.00	20	4	Alpha 4 Aluminum	1179.34–1360.78 kg (2600–3000 lb)	5.8–7.0 m (19–23 ft)	74.03–85.30 km/h (46–53 MPH)	48-834854A45 (RH) 48-834855A45 (LH)
14.62	19	3	Tempest Plus	1270.06–1496.86 kg (2800–3300 lb)	6.1–7.0 m (20–23 ft)	70.81–82.08 km/h (44–51 MPH)	48-825860A47 (RH) 48-825861A47 (LH)
15.25	19	3	Mirage Plus	1270.06–1496.86 kg (2800–3300 lb)	6.1–7.0 m (20–23 ft)	70.81–82.08 km/h (44–51 MPH)	48-13700A46 (RH) 48-13701A46 (LH)
13.25	19	5	HighFive	1270.06–1496.86 kg (2800–3300 lb)	6.1–7.0 m (20–23 ft)	70.81–82.08 km/h (44–51 MPH)	48-815758A46
14.00	19	4	VenSura	1270.06–1496.86 kg (2800–3300 lb)	6.1–7.0 m (20–23 ft)	70.81–82.08 km/h (44–51 MPH)	48-825900A48 (RH) 48-825901A48 (LH)
14.00	19	3	Vengeance	1270.06–1496.86 kg (2800–3300 lb)	6.1–7.0 m (20–23 ft)	70.81–82.08 km/h (44–51 MPH)	48-16316A46 (RH) 48-16317A46 (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
14.50	19	3	Black Max Aluminum	1270.06–1496.86 kg (2800–3300 lb)	6.1–7.0 m (20–23 ft)	70.81–82.08 km/h (44–51 MPH)	48-832830A45
15.38	18	3	Mirage Plus	1315.42–1632.93 kg (2900–3600 lb)	6.1–7.0 m (20–23 ft)	65.98–78.86 km/h (41–49 MPH)	48-889620A46 (RH) 48-889619A46 (LH)
14.50	18	4	Alpha 4 Aluminum	1315.42–1632.93 kg (2900–3600 lb)	6.1–7.0 m (20–23 ft)	65.98–78.86 km/h (41–49 MPH)	48-834852A45 (RH) 48-834853A45 (LH)
15.50	17	3	Mirage Plus	1406.14–1769.01 kg (3100–3900 lb)	6.4–7.3 m (21–24 ft)	61.16–74.03 km/h (38–46 MPH)	48-18278A46 (RH) 48-90159A46 (LH)
13.50	17	5	HighFive	1406.14–1769.01 kg (3100–3900 lb)	6.4–7.3 m (21–24 ft)	61.16–74.03 km/h (38–46 MPH)	48-821154A46
14.25	17	4	VenSura	1406.14–1769.01 kg (3100–3900 lb)	6.4–7.3 m (21–24 ft)	61.16–74.03 km/h (38–46 MPH)	48-825898A48 (RH) 48-825899A48 (LH)
14.50	17	3	Vengeance	1406.14–1769.01 kg (3100–3900 lb)	6.4–7.3 m (21–24 ft)	61.16–74.03 km/h (38–46 MPH)	48-16314A46 (RH) 48-16315A46 (LH)
15.00	17	3	Black Max Aluminum	1406.14–1769.01 kg (3100–3900 lb)	6.4–7.3 m (21–24 ft)	61.16–74.03 km/h (38–46 MPH)	48-832828A45
15.00	16	4	Alpha 4 Aluminum	1542.21–2041.17 kg (3400–4500 lb)	6.4–7.6 m (21–25 ft)	56.33–69.20 km/h (35–43 MPH)	48-834850A45 (RH) 48-834851A45 (LH)
15.75	15	3	Mirage Plus	1406.14–2222.6 kg (3700–4900 lb)	6.7–7.9 m (22–26 ft)	49.89–64.37 km/h (31–40 MPH)	48-19838A46 (RH) 48-19841A46 (LH)
14.62	15	4	Revolution 4	1406.14–2222.6 kg (3700–4900 lb)	6.7–7.9 m (22–26 ft)	49.89–64.37 km/h (31–40 MPH)	48-857022A46
15.25	15	3	Black Max	1406.14–2222.6 kg (3700–4900 lb)	6.7–7.9 m (22–26 ft)	49.89–64.37 km/h (31–40 MPH)	48-78116A45
16.00	13	3	Mirage Plus	1859.7–2630.8 kg (4100–5800 lb)	6.7–7.9 m (22–26 ft)	38.62–54.72 km/h (24–34 MPH)	48-826072A46
16.00	13	3	Black Max Aluminum	2041.1+ kg (4500+ lb)	Pontoon	38.62–54.72 km/h (24–34 MPH)	48-78114A45
16.00	12	3	Black Max Aluminum	2721.5+ kg (6000+ lb)	Pontoon/ Work	25.75–43.45 km/h (16–27 MPH)	48-16436A45
16.00	11	3	Black Max Aluminum	3628.7+ kg (8000+ lb)	Workboat	1.61–46.67 km/h (1–29 MPH)	48-78112A45 (RH) 48-78117A40 (LH)

200 Verado FourStroke Propeller Information Chart

- Wide-open throttle RPM: 5800–6400
- Recommended transom height: 50.8 cm (20 in.), 63.5 cm (25 in.), 76.2 cm (30 in.)
- Gear reduction: 2.08:1

- Right-hand rotation (RH) standard, left-hand rotation (LH)

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
13.75	27	4	Trophy Plus	Up to 1135 kg (2500 lb)	Up to 5.8 m (19 ft)	101–119 km/h (63–74 MPH)	48-825946A47
14.63	27	3	Tempest Plus	Up to 1135 kg (2500 lb)	Up to 5.8 m (19 ft)	101–119 km/h (63–74 MPH)	48-825868A47
13.75	26	4	Trophy Plus	1000–1180 kg (2200–2600 lb)	5.2–5.8 m (17–19 ft)	100–113 km/h (62–70 MPH)	48-825944A47
14.63	26	3	Tempest Plus	1000–1180 kg (2200–2600 lb)	5.2–5.8 m (17–19 ft)	100–113 km/h (62–70 MPH)	48-825874A47
14.50	25	3	Mirage Plus	1145–1225 kg (2300–2700 lb)	5.2–5.8 m (17–19 ft)	95–108 km/h (59–67 MPH)	48-13706A46 (RH) 48-13707A46 (LH)
13.75	25	4	Trophy Plus	1145–1225 kg (2300–2700 lb)	5.2–5.8 m (17–19 ft)	95–108 km/h (59–67 MPH)	48-825942A47
14.63	25	3	Tempest Plus	1145–1225 kg (2300–2700 lb)	5.2–5.8 m (17–19 ft)	95–108 km/h (59–67 MPH)	48-825866A47
13.75	24	4	Trophy Plus	1135–1275 kg (2500–2800 lb)	5.5–6.1 m (18–20 ft)	92–103 km/h (57–64 MPH)	48-825940A47
14.63	24	3	Tempest Plus	1135–1275 kg (2500–2800 lb)	5.5–6.1 m (18–20 ft)	92–103 km/h (57–64 MPH)	48-825872A47
13.75	23	4	Trophy Plus	1180–1365 kg (2600–3000 lb)	5.5–6.1 m (18–20 ft)	87–98 km/h (54–61 MPH)	48-825938A47
14.63	23	3	Tempest Plus	1180–1365 kg (2600–3000 lb)	5.5–6.1 m (18–20 ft)	87–98 km/h (54–61 MPH)	48-825864A47
14.63	23	3	Mirage Plus	1180–1365 kg (2600–3000 lb)	5.5–6.1 m (18–20 ft)	87–98 km/h (54–61 MPH)	48-13704A46 (RH) 48-13705A46 (LH)
13.25	23	5	HighFive	1180–1365 kg (2600–3000 lb)	5.5–6.1 m (18–20 ft)	87–98 km/h (54–61 MPH)	48-815762A46
14.00	23	4	VenSura	1180–1365 kg (2600–3000 lb)	5.5–6.1 m (18–20 ft)	87–98 km/h (54–61 MPH)	48-825906A48 (RH) 48-825907A46 (LH)
14.00	23	3	Aluminum	1180–1365 kg (2600–3000 lb)	5.5–6.1 m (18–20 ft)	87–98 km/h (54–61 MPH)	48-832834A45
13.50	22	3	Enertia	1275–1455 kg (2800–3200 lb)	5.5–6.4 m (18–21 ft)	82–93 km/h (51–58 MPH)	48-899202A46
13.75	21	4	Trophy Plus	1320–1500 kg (2900–3300 lb)	5.8–6.4 m (19–21 ft)	79–89 km/h (49–55 MPH)	48-825934A47
14.63	21	3	Tempest Plus	1320–1500 kg (2900–3300 lb)	5.8–6.4 m (19–21 ft)	79–89 km/h (49–55 MPH)	48-825862A47
13.63	21	3	Enertia	1320–1500 kg (2900–3300 lb)	5.8–6.4 m (19–21 ft)	79–89 km/h (49–55 MPH)	48-899002A46 (RH) 48-899003A46 (LH)
13.25	21	5	HighFive	1320–1500 kg (2900–3300 lb)	5.8–6.4 m (19–21 ft)	79–89 km/h (49–55 MPH)	48-815760A46
14.00	21	4	VenSura	1320–1500 kg (2900–3300 lb)	5.8–6.4 m (19–21 ft)	79–89 km/h (49–55 MPH)	48-825902A48 (RH) 48-825903A48 (LH)
14.25	21	3	Aluminum	1320–1500 kg (2900–3300 lb)	5.8–6.4 m (19–21 ft)	79–89 km/h (49–55 MPH)	48-832832A45
13.75	20	3	Enertia	1365–1635 kg (3000–3600 lb)	5.8–6.7 m (19–22 ft)	74–85 km/h (46–53 MPH)	48-899000A46
14.63	19	3	Tempest Plus	1500–1775 kg (3300–3900 lb)	6.1–7.0 m (20–23 ft)	69–80 km/h (43–50 MPH)	48-825860A47

Diameter	Pitch	No. of Blades	Model	Approx. Gross Boat Wgt.	Approx. Boat Length	Speed Range	Propeller Part Number
14.00	19	3	Enertia	1500–1775 kg (3300–3900 lb)	6.1–7.0 m (20–23 ft)	69–80 km/h (43–50 MPH)	48-898998A46 (RH) 48-898999A46 (LH)
15.25	19	3	Mirage Plus	1500–1775 kg (3300–3900 lb)	6.1–7.0 m (20–23 ft)	69–80 km/h (43–50 MPH)	48-13700A46 (RH) 48-13701A46 (LH)
13.25	19	5	HighFive	1500–1775 kg (3300–3900 lb)	6.1–7.0 m (20–23 ft)	69–80 km/h (43–50 MPH)	48-815758A46
14.00	19	4	VenSura	1500–1775 kg (3300–3900 lb)	6.1–7.0 m (20–23 ft)	69–80 km/h (43–50 MPH)	48-825900A48 (RH) 48-825901A48 (LH)
14.50	19	3	Aluminum	1500–1775 kg (3300–3900 lb)	6.1–7.0 m (20–23 ft)	69–80 km/h (43–50 MPH)	48-832830A45
14.25	18	3	Enertia	1590–1955 kg (3500–4300 lb)	6.4–7.0 m (21–23 ft)	63–76 km/h (39–47 MPH)	48-898996A46
15.38	18	3	Mirage Plus	1590–1955 kg (3500–4300 lb)	6.4–7.0 m (21–23 ft)	63–76 km/h (39–47 MPH)	48-889620A46 (RH) 48-889619A46 (LH)
14.50	17	3	Enertia	1725–2135 kg (3800–4700 lb)	6.4–7.3 m (21–24 ft)	58–71 km/h (36–44 MPH)	48-898994A46 (RH) 48-898995A46 (LH)
15.50	17	3	Mirage Plus	1725–2135 kg (3800–4700 lb)	6.4–7.3 m (21–24 ft)	58–71 km/h (36–44 MPH)	48-18278A46 (RH) 48-90159A46 (LH)
13.50	17	5	HighFive	1725–2135 kg (3800–4700 lb)	6.4–7.3 m (21–24 ft)	58–71 km/h (36–44 MPH)	48-821154A46
14.25	17	4	VenSura	1725–2135 kg (3800–4700 lb)	6.4–7.3 m (21–24 ft)	58–71 km/h (36–44 MPH)	48-825898A48 (RH) 48-825899A48 (LH)
15.00	17	3	Aluminum	1725–2135 kg (3800–4700 lb)	6.4–7.3 m (21–24 ft)	58–71 km/h (36–44 MPH)	48-832828A45
14.75	16	3	Enertia	1865–2365 kg (4100–5200 lb)	6.7–7.6 m (22–25 ft)	53–66 km/h (33–41 MPH)	48-898992A46
16.00	16	3	Aluminum	1865–2365 kg (4100–5200 lb)	6.7–7.6 m (22–25 ft)	53–66 km/h (33–41 MPH)	48-16440A45
15.00	15	3	Enertia	2000–2725 kg (4400–6000 lb)	6.7–7.9 m (22–26 ft)	47–61 km/h (29–38 MPH)	48-898990A46 (RH) 48-898991A46 (LH)
15.75	15	3	Mirage Plus	1635–2000 kg (3600–4400 lb)	6.7–7.9 m (22–26 ft)	47–61 km/h (29–38 MPH)	48-19838A46 (RH) 48-19841A46 (LH)
15.50	15	3	Aluminum	1635–2000 kg (3600–4400 lb)	6.7–7.9 m (22–26 ft)	47–61 km/h (29–38 MPH)	48-78116A45
15.13	14	3	Enertia	2225–3090 kg (4900–6800 lb)	7.0–8.2 m (23–27 ft)	42–56 km/h (26–35 MPH)	48-898988A46
16.00	14	3	Aluminum	2225–3090 kg (4900–6800 lb)	7.0–8.2 m (23–27 ft)	42–56 km/h (26–35 MPH)	48-16438A45
16.00	13	3	Mirage Plus	2455–3725 kg (5400–8200 lb)	7.3–8.8 m (24–29 ft)	35–51 km/h (22–32 MPH)	48-826072A46
16.00	13	3	Aluminum	2455–3725 kg (5400–8200 lb)	7.3–8.8 m (24–29 ft)	35–51 km/h (22–32 MPH)	48-78114A45
16.00	12	3	Aluminum	2865–4410 kg (6300–9700 lb)	7.6–9.8 m (25–32 ft)	31–45 km/h (19–28 MPH)	48-16436A45
16.00	11	3	Aluminum	Greater than 3175 kg (7000 lb)	Workboat	1–40 km/h (1–25 MPH)	48-78112A45 (RH) 48-78117A40 (LH)

Important Information

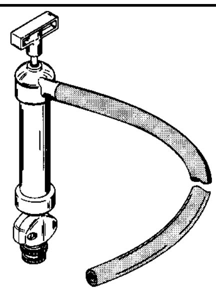
Section 1B - Maintenance

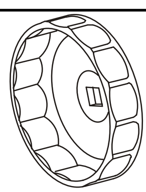
Table of Contents

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
81	Anti-Seize Compound	Spark plug threads	92-881091K 1
94	Anti-Corrosion Grease	Propeller shaft splines	92-802867Q 1
95	2-4-C with Teflon	Propeller shaft splines	92-802859A 1
114	Power Trim and Steering Fluid	Power trim system	92-858074K01
119	Storage Seal Rust Inhibitor	Spark plug holes	92-858081K01
120	Corrosion Guard	External metal surfaces	92-802878 55
124	Fuel System Treatment and Stabilizer	Fuel tank	858071K01
138	Synthetic Power Steering Fluid SAE 0W-30	Power steering system	92-858076K01

Special Tools

Crankcase Oil Pump	91-90265A 5
 11591	Aids in the removal of engine oil without draining the crankcase.

Oil Filter Wrench	91-802653Q02
 5221	Assists in removal of oil filter.

Selecting Accessories for Your Outboard

Genuine Mercury Precision or Quicksilver Accessories have been specifically designed and tested for your outboard. These accessories are available from Mercury Marine dealers.

IMPORTANT: Check with your dealer before installing accessories. The misuse of approved accessories or the use of nonapproved accessories can damage the product.

Some accessories not manufactured or sold by Mercury Marine are not designed to be safely used with your outboard or outboard operating system. Acquire and read the installation, operation, and maintenance manuals for all your selected accessories.

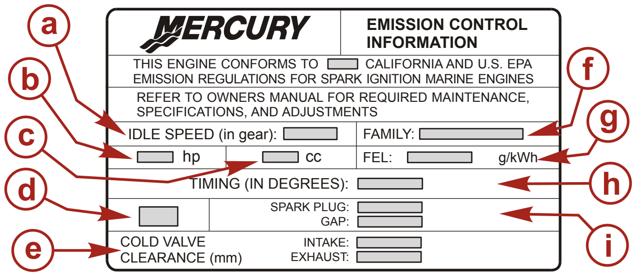
EPA Regulations

All new outboards manufactured by Mercury Marine 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, wherever practicable, returned to the original intent of the design. **Maintenance, replacement, or repair of the emission control devices and systems may be performed by any marine spark ignition (SI) engine repair establishment or individual.**

EPA Emissions

Emission Certification Label

An emission certification label, showing emission levels and engine specifications directly related to emissions, is placed on the engine at time of manufacture.



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- a - Idle speed
- b - Engine horsepower
- c - Piston displacement
- d - Date of manufacture
- e - Valve clearance (if applicable)
- f - Family number
- g - Maximum emission output for the engine family
- h - Timing specification
- i - Recommended spark plug and gap

Owner Responsibility

The owner/operator is required to have routine 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 emissions levels to exceed their predetermined factory specifications.

Inspection and Maintenance Schedule

Before Each Use

- Check engine oil level. Refer to Fuel and Oil - Checking and Adding Engine Oil.
- Check that lanyard stop switch stops the engine.
- Inspect the outboard for tightness to the boat transom. If any looseness of the outboard or mounting fasteners exist, retorque the outboard mounting fasteners to 75 Nm (55 lb-ft).
- Visually inspect the fuel system for deterioration or leaks.
- Check outboard for tightness on transom.
- Check steering system for binding or loose components.
- Visually check hydraulic steering fittings and hoses for leaks or signs of damage. Check tie bar fasteners (multiple outboard rigs) for proper tightness.
- Check propeller blades for damage.

After Each Use

- Flush out the outboard cooling system if operating in salt or polluted water. Refer to Flushing the Cooling System.
- Wash off all salt deposits and flush out the exhaust outlet of the propeller and gearcase with fresh water if operating in saltwater.

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

- Retorque the outboard mounting fasteners that fasten the outboard to the boat transom. Torque to 75 Nm (55 lb-ft).[1.]
- 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 Changing Engine Oil.
- Inspect the thermostat visually for corrosion or for a broken spring. Make sure the thermostat closes completely at room temperature.[1.]
- Check the engine water separating fuel filter for contaminants. Clean and/or replace filter. Refer to Fuel System.
- Check the corrosion control anodes. Check more frequently when used in saltwater. Refer to Corrosion Control Anode.
- Drain and replace the gearcase lubricant. Refer to Gearcase Lubrication.
- Check power trim fluid. Refer to **Checking Power Trim Fluid**.
- Check power steering fluid (if so equipped). Refer to **Checking Power Steering Fluid.**
- Inspect the battery. Refer to Battery Inspection.

1. These items should be serviced by an authorized dealer.

- Saltwater usage. Remove and inspect spark plugs for corrosion and replace spark plugs as necessary. Apply a thin coating of Anti-Seize Compound only on the threads of the spark plugs prior to installation. Refer to **Spark Plug Inspection and Replacement**.

Tube Ref No.	Description	Where Used	Part No.
81	Anti-Seize Compound	Spark plug threads	92-881091K 1

- Check wiring and connectors.
- Check tightness of bolts, nuts, and other fasteners.

Every 300 Hours of Use or Three Years

IMPORTANT: The engine oil must be drained before removing the gearcase to avoid oil spillage. Perform the scheduled water pump replacement in combination with an engine oil change.

- Replace water pump impeller (more often if overheating occurs or reduced water pressure is noted).[1.]
- Replace high-pressure in-line fuel filter.[1.]
- Replace spark plugs at first 300 hours or three years. After that, inspect spark plugs every 300 hours or three years. Replace spark plugs as needed. Refer to **Spark Plug Inspection and Replacement**.
- Replace accessory drive belt. Refer to **Accessory Drive Belt Inspection**.[1.]

Before Periods of Storage

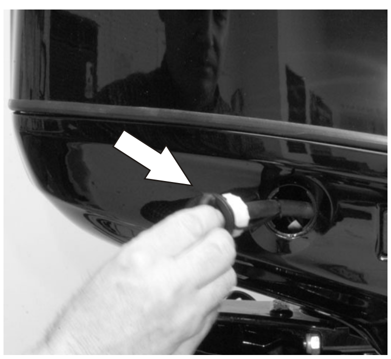
- Refer to storage procedure. Refer to **Storage** section.

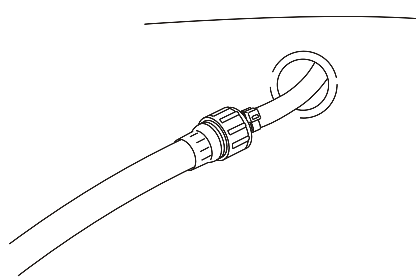
Flushing the Cooling System

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.

NOTE: The outboard can be tilted or in the vertical operating position during flushing.

1. With the engine turned off, place the outboard in either the operating position (vertical) or in a tilted position.
2. Remove the flush connector from the bottom cowl.
3. Remove the cover from the flush connector and thread a water hose into the flush connector.





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4. Turn on the water tap (1/2 maximum) and let the water flush through the cooling system for about 15 minutes.
5. When flushing is complete, turn off water and disconnect the water hose.
6. Reinstall the cover on the flush connector. Place the flush connector back into the bottom cowl.

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).

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. Make sure 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. Make sure the battery is equipped with a nonconductive shield to prevent accidental shorting of battery terminals.

DTS Battery Specifications

IMPORTANT: Do not use deep-cycle batteries for the main engine starting battery.

IMPORTANT: Boating industry standards (BIA, ABYC, etc.), federal standards, and Coast Guard regulations must be adhered to when installing the battery. Ensure the battery cable installation meets the pull test requirements and that the positive battery terminal is properly insulated in accordance with regulations.

IMPORTANT: It is recommended (required in some states) the battery be installed in an enclosed case. Refer to regulations for your area.

Required starting battery type	12 volt absorbed glass mat (AGM) battery
Required USA and Canada (SAE) starting battery type*	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 RC25 rating
Required international (EN) starting battery type*	975 minimum cold cranking amps (CCA) with a minimum of 65 ampere hour (Ah)

*Different test methods are used to determine cranking ratings in different parts of the world.

IMPORTANT: The battery selected must meet, or exceed, both required specifications:

- **USA and Canada (SAE rating) - both MCA and RC25**
- **International (EN rating) - both CCA and Ah**

Boatbuilders who use batteries rated to SAE specifications must meet both the 800 marine cranking amps (MCA) and 135 RC25 specifications following SAE test procedures. If a boat is shipped anywhere in the world, a battery rating per SAE specifications is acceptable.

Boatbuilders who use batteries rated to EN specifications must meet both the 975 cold cranking amps (CCA) and 65 ampere hour (Ah) specifications following EN test procedures. If a boat is shipped anywhere in the world, a battery rating per EN specifications is acceptable.

IMPORTANT: For DTS products, each engine must be equipped with its own starting battery. If your boat application requires additional battery loads for boat accessories or marine electronics, it is recommended that an auxiliary battery, or batteries, be installed.

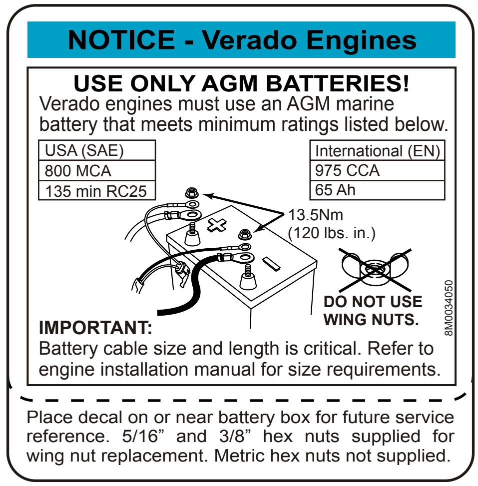
⚠ WARNING
Failure to properly secure the battery leads can result in a loss of power to the Digital Throttle and Shift (DTS) system, leading to serious injury or death due to loss of boat control. Secure the battery leads to the battery posts with hex nuts to avoid loose connections.

When connecting the engine battery, hex nuts must be used to secure the battery leads to the battery posts. Tighten the nuts to the specified torque.

Description	Nm	lb-in.	lb-ft
Battery hex nuts	13.5	120	

IMPORTANT: Battery cable size and length is critical. Refer to Section 1D - Battery Cable Size tables or engine installation manual for size requirements.

Decal needs to be placed on or near the battery box for future service reference. One 5/16 in. and one 3/8 in. hex nut are supplied per battery for wing nut replacement. Metric hex nuts are not supplied.



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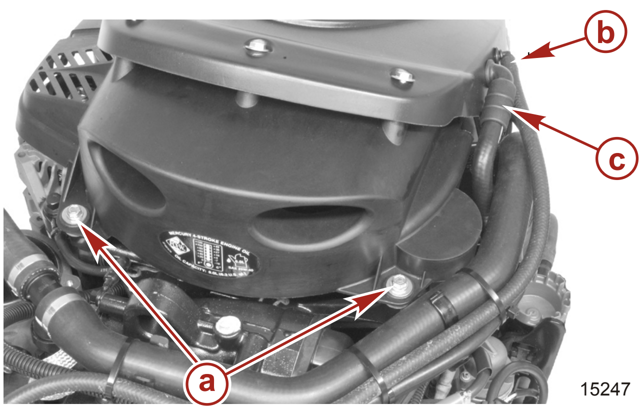
Air Filter

The air filter is located within the flywheel cover assembly. The air filter removes airborne particles which may damage engine components. The air filter design allows for maximum unrestricted air flow during engine operation.

Air Filter Removal

1. Remove the FSM vent hose and the engine ventilation hose from the flywheel cover.
2. Remove the bolts securing the flywheel cover to the rear mounting posts.



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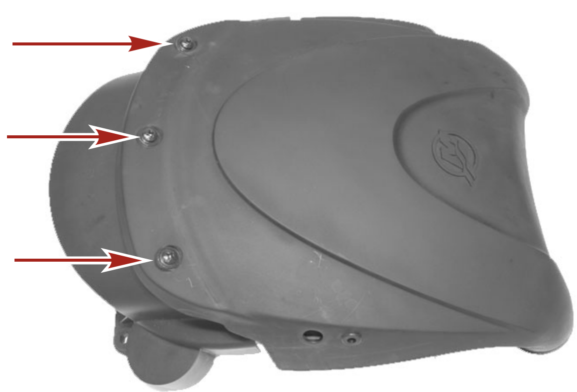
a - Flywheel cover bolt and washer (2)
b - FSM vent hose
c - Crankcase ventilation hose

3. Lift the flywheel cover off the front mounting post and the intake resonator.
4. Remove three screws holding the upper flywheel cover to the lower flywheel cover.



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5. Separate the two flywheel cover subassemblies to access the air filter.

6. Remove the air filter from the lower flywheel cover assembly.

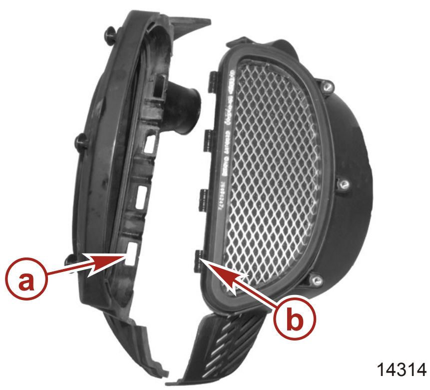
a - Flywheel cover subassembly
b - Air filter

Air Filter Installation

1. Install the air filter onto the flywheel cover subassembly.

a - Flywheel cover subassembly
b - Air filter

2. Install the upper half of the flywheel cover subassembly to the lower flywheel cover subassembly. Ensure the upper flywheel cover latch opening is properly secured to the lower flywheel cover.

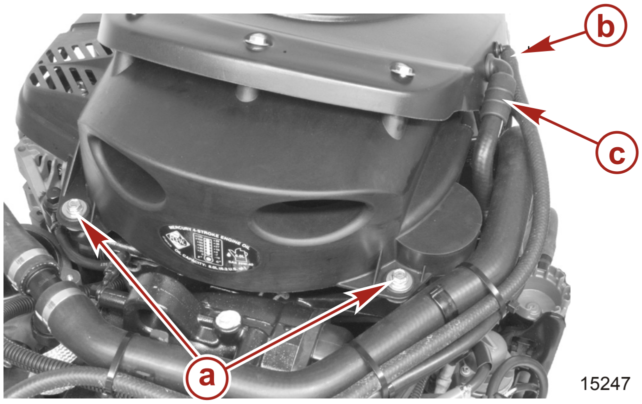


a - Upper flywheel cover latch opening
b - Lower flywheel cover latch

3. Push the two subassemblies together and install three screws. Tighten the three screws to the specified torque.

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

4. Install the flywheel cover onto the resonator and the front mounting post.
5. Align the flywheel cover rear bolt holes with the rear mounting posts.
6. Secure the flywheel cover to the rear mounting posts with two bolts with washers. Tighten bolts to the specified torque.



a - Flywheel cover bolt and washer (2)
b - FSM vent hose
c - Crankcase ventilation hose

Description	Nm	lb-in.	lb-ft
Flywheel cover bolt	10	88.5	

Fuel System

⚠ WARNING

Fuel is flammable and explosive. Ensure 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: Use an approved container to collect and store fuel. Wipe up spilled fuel immediately. Material used to contain spilled fuel must be disposed of in an approved receptacle.

Before servicing any part of the fuel system:

1. Stop engine and disconnect the battery.
2. Perform fuel system service in a well-ventilated area.
3. Inspect any completed service work for sign of fuel leakage.

Fuel Line Inspection

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

Water Separating Fuel Filter

NOTE: The warning system will turn on when water in the fuel filter reaches the full level.

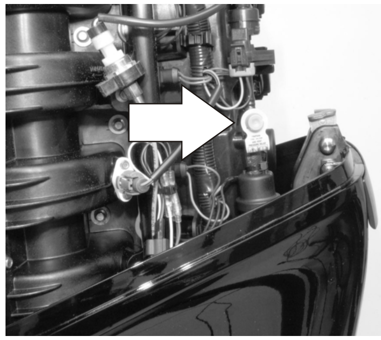
This filter removes moisture and debris from the fuel. If the filter holder becomes filled with water, the water can be removed. If the filter becomes plugged with debris, replace the filter.

Refer to the **Inspection and Maintenance Schedule** for the proper maintenance interval.

Filter Removal

1. Turn ignition key switch to "OFF" position.

2. Remove fuel vapor purge relief valve cap located at the rear of the engine.



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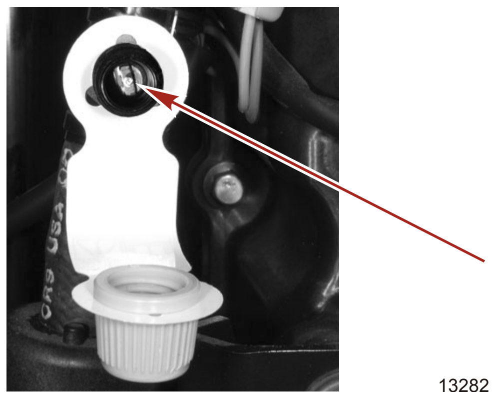
⚠ CAUTION

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.

3. Place a rag or towel around the valve, release pressure by pushing core of valve end in.



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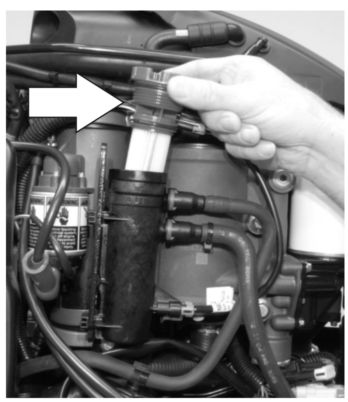
4. Unscrew the filter in a counterclockwise direction to remove.



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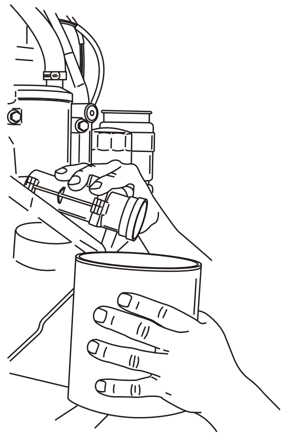
Filter Draining

1. Slide filter holder up to release from bracket. Hoses and wire harness can remain attached to filter holder.

2. Tip the filter holder to drain any fluid into an approved container.



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Filter Installation

1. Position filter holder onto bracket and secure filter holder in place.
2. Lubricate the sealing ring on the filter with oil.
3. Install the filter and tighten securely by hand.

   IMPORTANT: Visually inspect for fuel leakage from the filter while turning the ignition key to the "RUN" position, forcing fuel into the filter.

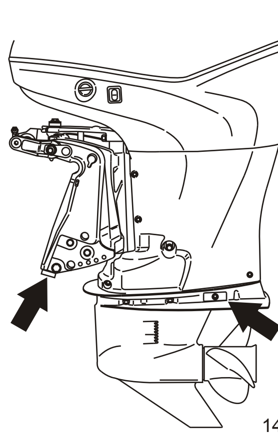
14764

Corrosion Control Anode

The outboard has corrosion control anodes at different locations. An anode helps protect the outboard against galvanic corrosion by sacrificing its metal to be slowly eroded instead of the outboard metals.

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

Two anodes are located on each side of the gearcase. Another anode is installed on the bottom of the transom bracket assembly.



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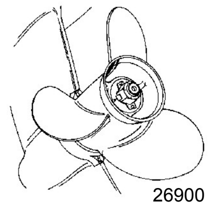
Propeller Replacement

1. Shift outboard to neutral position.
2. Straighten the bent tabs on the propeller nut retainer.



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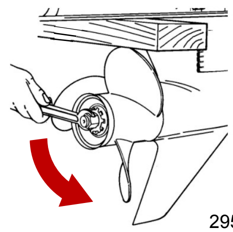
3. Place a block of wood between gearcase and propeller to hold propeller and remove propeller nut.



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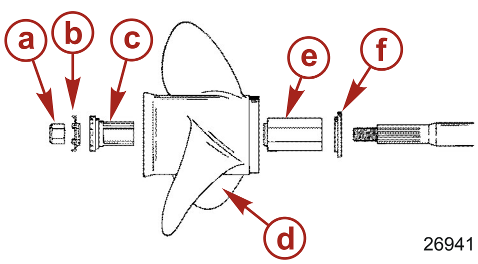
4. Pull propeller straight off shaft. If propeller is seized to the shaft and cannot be removed, have the propeller removed by an authorized dealer.
5. To aid in future removal of the propeller, liberally coat the propeller shaft splines with one of the following Mercury/Quicksilver products:

Tube Ref No.	Description	Where Used	Part No.
94	Anti-Corrosion Grease	Propeller shaft splines	92-802867Q 1
95	2-4-C with Teflon	Propeller shaft splines	92-802859A 1

6. **Flo-Torq II drive hub propellers** - Install forward thrust hub, replaceable drive sleeve, propeller, thrust hub, propeller nut retainer, and propeller nut onto the shaft.



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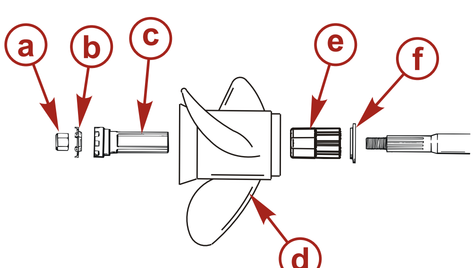
a - Propeller nut
b - Propeller nut retainer
c - Thrust hub
d - Propeller
e - Replaceable drive sleeve
f - Forward thrust hub

7. **Flo-Torq IV drive hub propellers** - Install forward thrust hub, replaceable drive sleeve, propeller, thrust hub, propeller nut retainer, and propeller nut onto the shaft.



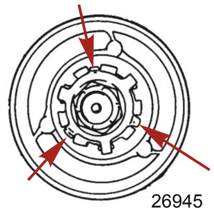
14797

a - Propeller nut
b - Propeller nut retainer
c - Thrust hub
d - Propeller
e - Replaceable drive sleeve
f - Forward thrust hub

8. Place a block of wood between gearcase and propeller and torque to specifications.

Description	Nm	lb-in.	lb-ft
Propeller nut	75		55

9. Secure propeller nut by bending three of the tabs into the thrust hub grooves.



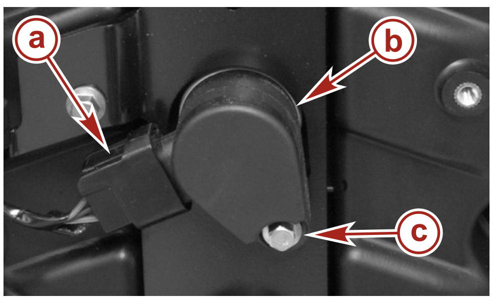
26945

Spark Plug Inspection and Replacement

NOTE: To gain access to the bottom spark plug, remove the rear cover and rear cowl lock. Refer to ***Section 4A - Cowling Removal and Installation*** *for instructions.*

Spark Plug Removal and Inspection

1. Disconnect the wiring harness connectors from the pencil coils.
2. Remove the mounting bolts that are securing the pencil coils. Pull the pencil coils from the spark plugs using a twisting motion.



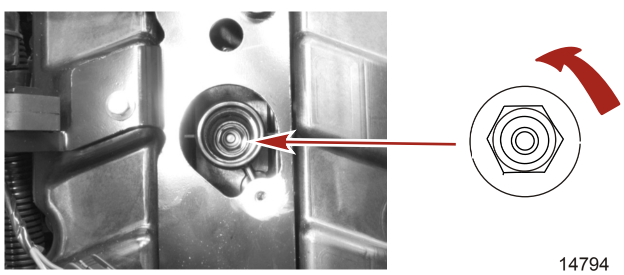
41316

Design I

Design II

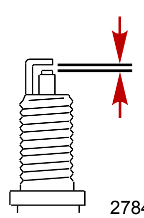
a - Wiring harness connector
b - Pencil coil
c - Bolt (8 mm hex flange head)

3. Remove the spark plugs to inspect. Replace spark plug if electrode is worn, threads of seal area are corroded, or the insulator is rough, cracked, broken, blistered, or fouled.



14794

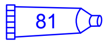
4. Set the spark plug gap to specifications.



27848

Spark Plug	
Spark plug gap	0.8 mm (0.0315 in.)

5. Saltwater use - Apply a thin coating of Anti-Seize Compound only on threads of the spark plugs.

Tube Ref No.	Description	Where Used	Part No.
	Anti-Seize Compound	Spark plug threads	92-881091K 1

Spark Plug Installation

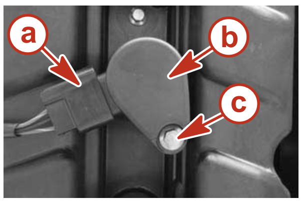
1. Before installing the spark plugs, clean off any dirt on the spark plug seats. Install plugs finger-tight, and then tighten 1/4 turn or torque to specifications.

Description	Nm	lb-in.	lb-ft
Spark plug	27		20

2. Push the pencil coils into place over the spark plugs using a twisting motion.
3. Secure the coils with retained bolts. Torque to specifications.

Description	Nm	lb-in.	lb-ft
Bolts	8	71	

4. Connect the wiring harness connectors to the pencil coil connections.



3658

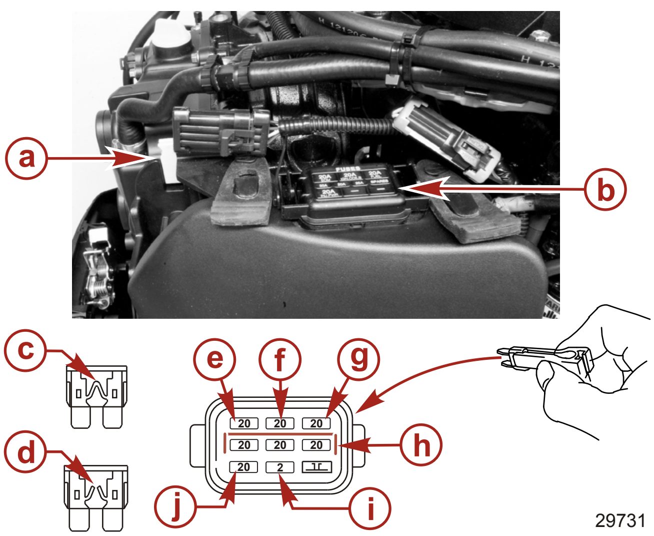
a - Wiring harness connector
b - Pencil coil
c - Bolt

5. Install the cowl lock, rear cowl, and rear cowl latch. Refer to **Section 4A - Cowling Removal and Installation**.

Fuses

The electrical wiring circuits on the outboard are protected from overload by fuses in the wiring. If a fuse is blown, try to locate and correct the cause of the overload. If the cause is not found, the fuse may blow again.

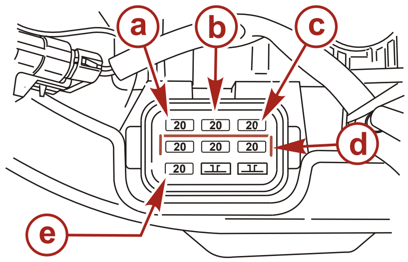
1. Remove the top cowl. Locate the fuse holder on the starboard side of the engine.
2. Remove the plastic cover from the fuse holder.
3. Remove the fuse puller from the fuse holder.
4. Remove the suspected blown fuse to determine if the silver colored band is broken.
5. Replace the fuse with a new fuse of the same amperage rating.



29731

Gen 1 and newer fuse holder

a - Fuse puller
b - Fuse holder
c - Good fuse
d - Blown fuse
e - Engine control module, start relay, and purge valve, "ECM" - 20 amp fuse
f - Ignition coils, "IGN. COILS" - 20 amp fuse
g - Fuel delivery, "FUEL" - 20 amp fuse
h - Spare fuses (3)
i - Diagnostic terminal - 2 amp fuse
j - Injector power and boost valve, "INJ. PWR." - 20 amp fuse



28776

Early model fuse holder

a - Engine control module and purge valve, "ECM" - 20 amp fuse
b - Ignition coils, "IGN. COILS" - 20 amp fuse
c - Fuel delivery, "FUEL" - 20 amp fuse
d - Spare fuses - 20 amp fuse
e - Injector power and boost valve, "INJ. PWR." - 20 amp fuse

DTS Wiring System

⚠ WARNING

Splicing or probing will damage the wire insulation allowing water to enter the wiring. Water intrusion may lead to wiring failure and loss of throttle and shift control. To avoid the possibility of serious injury or death from loss of boat control, do not splice or probe into any wire insulation of the DTS system.

- Verify the harnesses are not routed near sharp edges, hot surfaces, or moving parts.
- Verify all unused connectors and receptacles are covered with a weather cap.
- Verify the harnesses are fastened along the routing path.

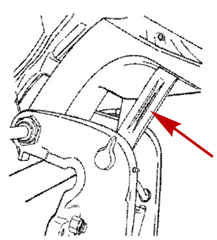
Accessory Drive Belt Inspection

Inspect the accessory drive belt and have it replaced by an authorized dealer if any of the following conditions are found.

- Cracks in the back of the belt or in the base of V grooves.
- Excessive wear at the roots of the grooves.
- Rubber portion swollen by oil.
- Belt surfaces roughened.
- Signs of wear on edges or outer surfaces of belt.

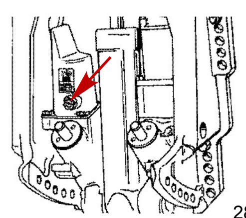
Checking Power Trim Fluid

1. Tilt outboard to the full up position and engage the tilt support lever.



27877

2. Remove fill cap and check fluid level. The fluid level should be even with the bottom of the fill hole. Add Quicksilver or Mercury Precision Lubricant Power Trim and Steering Fluid. If not available, use automotive automatic transmission fluid (ATF).

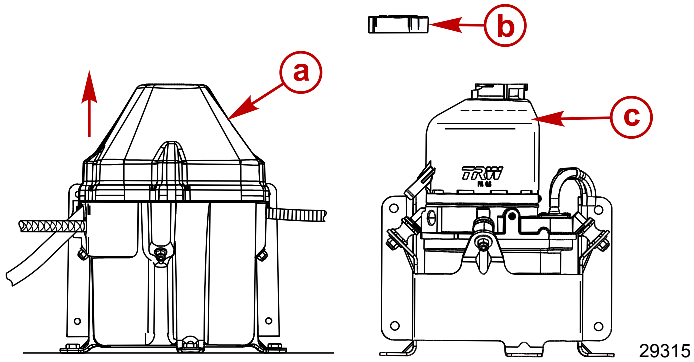


28460

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Power trim system	92-858074K01

Checking Power Steering Fluid

Remove power steering cover and fill cap to check fluid level. The fluid level should be slightly below the bottom of the fill hole. Use SAE 0W-30 synthetic power steering fluid, if needed.



a - Power steering cover
b - Fill cap
c - Fill/full level

Tube Ref No.	Description	Where Used	Part No.
138	Synthetic Power Steering Fluid SAE 0W-30	Power steering system	92-858076K01

Changing Engine Oil

Engine Oil Capacity

Engine oil capacity is approximately 6.0 liter (6.3 US qt).

Pump Method

IMPORTANT: Tilt outboard out/up past vertical for approximately one minute to allow trapped oil to drain back to the oil sump.

IMPORTANT: To reduce or prevent oil spillage when removing the oil filter, ensure the outboard is upright (not tilted) and the engine is cold or has not run for at least one hour.

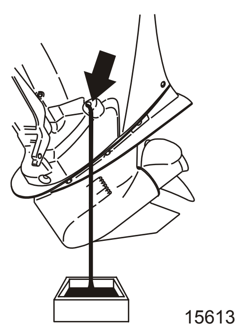
1. Tilt outboard out/up past vertical for approximately one minute to allow trapped oil to drain back to the oil sump.
2. Place the outboard in a vertical position.
3. Remove dipstick and slide adapter tube of crankcase oil pump through oil dipstick hole, to bottom of engine oil sump.

Crankcase Oil Pump	91-90265A 5

4. Pump out the engine oil into an appropriate container.

Drain Method

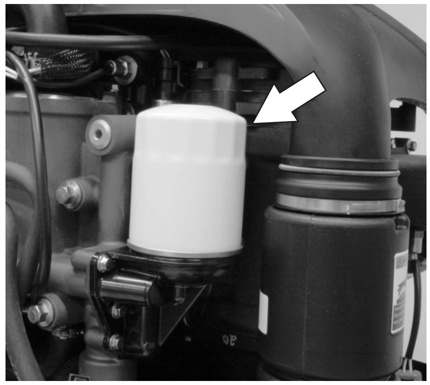
1. Tilt outboard up to the trailer position.
2. Turn the outboard so the drain hole is facing downward.
3. Remove the drain plug/seal and drain the engine oil into an appropriate container.
4. Lubricate seal washer on the drain plug with oil and reinstall.



Changing Oil Filter

IMPORTANT: To reduce or prevent oil spillage when removing the oil filter, ensure the outboard is upright (not tilted) and the engine is cold or has not run for at least one hour.

1. Remove the top cowl.
2. Place a rag or towel below the oil filter to absorb any spilled oil.
3. Unscrew old filter using oil filter wrench and turning the filter counterclockwise.



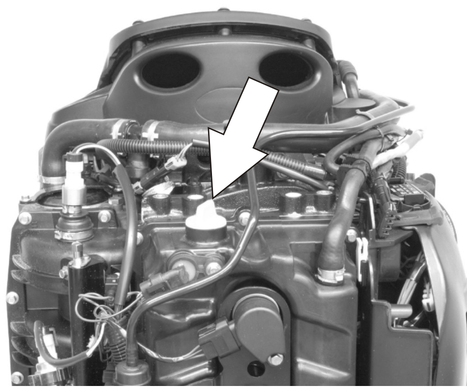
14772

Oil Filter Wrench	91-802653Q02

4. Clean the oil filter mounting base.
5. Apply a film of clean oil to filter gasket. Do not use grease.
6. Screw new filter on until gasket contacts base, then tighten 3/4 to 1 turn.

Oil Filling

1. Remove the oil fill cap and add recommended oil to the midpoint of the operating range (midpoint of cross hatched region). Adding approximately 6 liter (6.3 US qt) will bring oil level to midpoint of cross hatched region.



14770

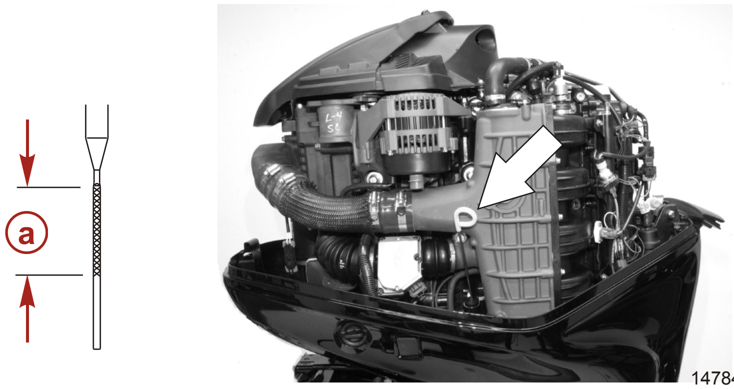
2. Install oil fill cap.
3. With outboard in water or cooling water flush hose connected, idle engine for five minutes to check for leaks at the oil filter.
4. Stop engine and check oil level. Refer to **Fuel and Oil - Checking and Adding Engine Oil**.

Checking and Adding Engine Oil

IMPORTANT: Do not overfill. Tilt outboard out/up past vertical for approximately one minute to allow trapped oil to drain back to the oil sump. Tilt outboard to vertical (not tilted) position when checking engine oil. For accurate readings, check oil only when engine is cold or after engine has not run for at least an hour.

1. Before starting (cold engine) tilt outboard out/up past vertical to allow trapped oil to drain back to the oil sump. Allow outboard to remain tilted for approximately one minute.
2. Tilt outboard to vertical operating position.
3. Remove the top cowl.
4. Pull out the dipstick. Wipe the dipstick end with a clean rag or towel and push it back in all the way.
5. Pull the dipstick back out again and observe the oil level. Oil should be in the operating range (cross hatched region).

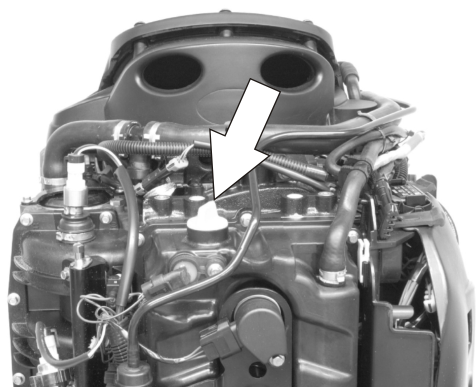
IMPORTANT: Do not try to fill the oil level to the top of the operating range (cross hatched region). Oil level is correct as long as it appears in the operating range (cross hatched region).



14784

a - Oil level operating range

6. If the oil level is below the operating range (cross hatched region), remove the oil filler cap and add approximately 500 ml (16 oz) of specified outboard motor oil. Allow a few minutes for the added oil to drain to the oil sump and recheck the dipstick. Repeat the process until oil level is on the operating range (cross hatched region). Do not try to fill to the upper end of the operation range (cross hatched region).



14770

IMPORTANT: Inspect oil for signs of contamination. Oil contaminated with water will have a milky color to it; oil contaminated with fuel will have a strong fuel smell. If contaminated oil is noticed, have the engine checked by your dealer.

7. Push the dipstick back in all the way.
8. Install the oil fill cap hand tight.
9. Install the top cowl.

Gearcase Lubrication

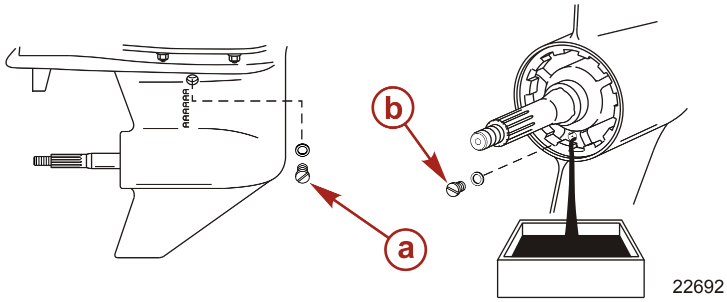
When adding or changing gearcase lubricant, visually check for the presence of water in the lubricant. If water is present, it may have settled to the bottom and will drain out prior to the lubricant, or it may be mixed with the lubricant, giving it a milky colored appearance. If water is noticed, have the gearcase checked by your dealer. Water in the lubricant may result in premature bearing failure or, in freezing temperatures, will turn to ice and damage the gearcase.

Examine the drained gearcase lubricant for metal particles. A small amount of metal particles indicates normal gear wear. An excessive amount of metal filings or larger particles (chips) may indicate abnormal gear wear and should be checked by an authorized dealer.

Draining Gearcase

1. Place outboard in a vertical operating position.
2. Remove propeller. Refer to **Propeller Replacement**.
3. Place drain pan below outboard.

4. Remove vent plug and fill/drain plug and drain lubricant.



a - Vent plug
b - Fill/drain plug

Gearcase Lubricant Capacity

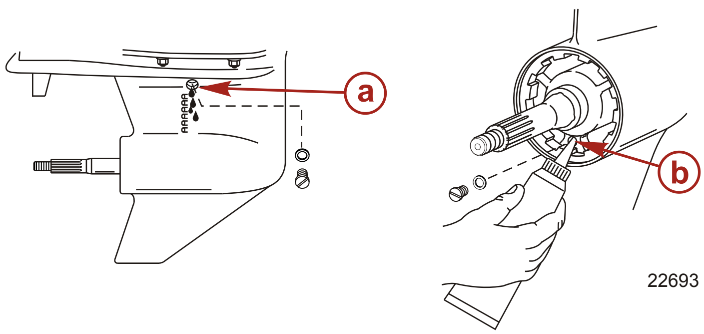
Gearcase lubricant capacity is approximately 970 ml (32.8 fl oz).

Gearcase Lubricant Recommendation

Mercury or Quicksilver High Performance Gear Lubricant.

Checking Lubricant Level and Refilling Gearcase

1. Place outboard in a vertical operating position.
2. Remove vent plug/sealing washer.
3. Remove fill/drain plug. Place lubricant tube into the fill hole and add lubricant until it appears at the vent hole.



a - Vent hole
b - Fill hole

IMPORTANT: Replace sealing washers if damaged.

4. Stop adding lubricant. Install the vent plug and sealing washer before removing the lubricant tube.
5. Remove lubricant tube and reinstall cleaned fill/drain plug and sealing washer.

Storage

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.

The following storage procedures should be followed to prepare your outboard for out of season storage or prolonged storage (two months or longer).

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.

Fuel System

IMPORTANT: Gasoline containing alcohol (ethanol or methanol) can cause a 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.

IMPORTANT: This outboard is equipped with a closed fuel system when the engine is not running. With this closed system, fuel within the engine's fuel system, other than the fuel tank, will remain stable during normal storage periods without the addition of fuel treatment stabilizers.

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 Fuel System Treatment and Stabilizer (follow instructions on container) into fuel tank. Tip fuel tank back and forth to mix stabilizer with the fuel.
- Permanently installed fuel tank - Pour the required amount of Fuel System Treatment and Stabilizer (follow instructions on container) into a separate container and mix with approximately one liter (one quart) of gasoline. Pour this mixture into fuel tank.

Tube Ref No.	Description	Where Used	Part No.
124	Fuel System Treatment and Stabilizer	Fuel tank	858071K01

Protecting External Outboard Components

- Touch up any paint nicks. See your dealer for touch-up paint.
- 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	92-802878 55

Protecting Internal Engine Components

IMPORTANT: Refer to Maintenance - Spark Plug Inspection and Replacement for correct procedure for removing spark plugs.

- Remove pencil coils and spark plugs.
- Spray approximately 30 ml (1 fl oz) of Storage Seal Rust Inhibitor into each spark plug hole.

Tube Ref No.	Description	Where Used	Part No.
119	Storage Seal Rust Inhibitor	Spark plug holes	92-858081K01

- Actuate key/push button start switch to crank the engine through one start cycle, which will distribute the storage seal throughout the cylinders.
- Install spark plugs and pencil coils.

Gearcase

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

Positioning Outboard for Storage

Store outboard in an upright (vertical) position to allow water to drain out of the outboard.

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.

Battery Storage

- Follow the battery manufacturer's instructions for storage and recharging.
- Remove the battery from the boat and check water level. Recharge if necessary.
- Store the battery in a cool, dry place.
- Periodically check the water level and recharge the battery during storage.

Submerged Outboard

A submerged outboard will require service within a few hours by an authorized dealer once the outboard is recovered from the water. This immediate attention by a servicing dealer is necessary once the engine is exposed to the atmosphere to minimize internal corrosion damage to the engine.

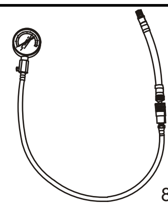
Notes:

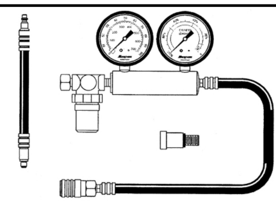
Important Information

Section 1C - General Information

Table of Contents

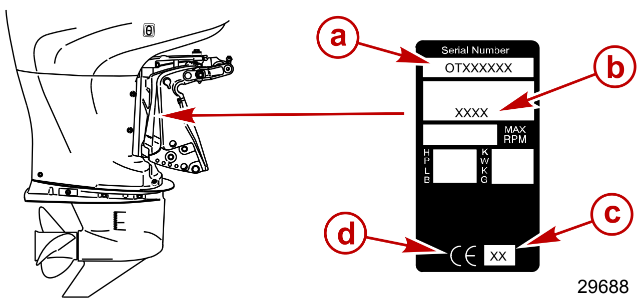
Special Tools

Compression Tester with Adapter	Snap-On EEPV303B
 8511	Checks cylinder compression. Use with M14 x 1.25 adapter.

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

Recording Serial Number

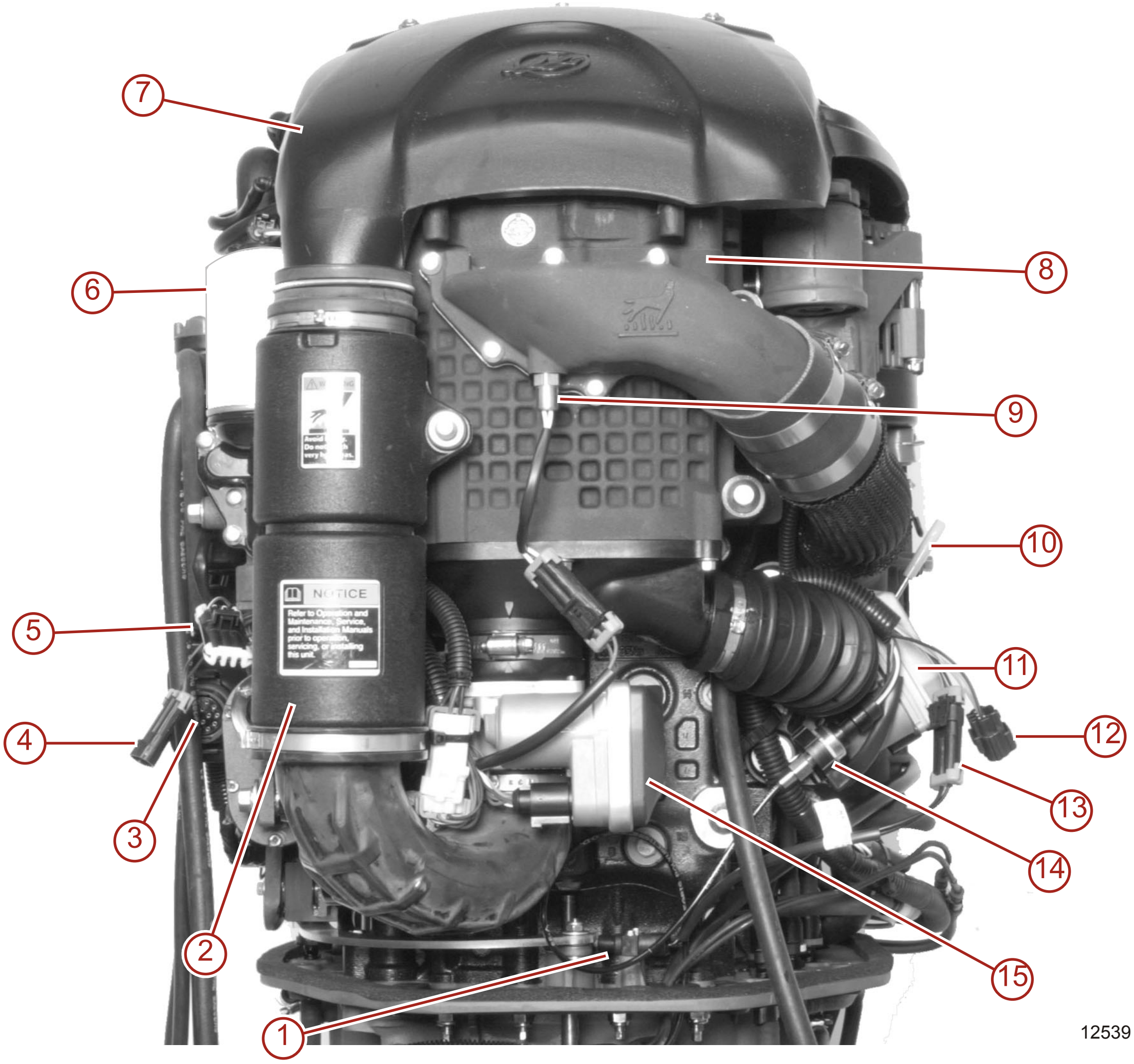
It is important to record this number for future reference. The serial number is located on the outboard as shown.



29688

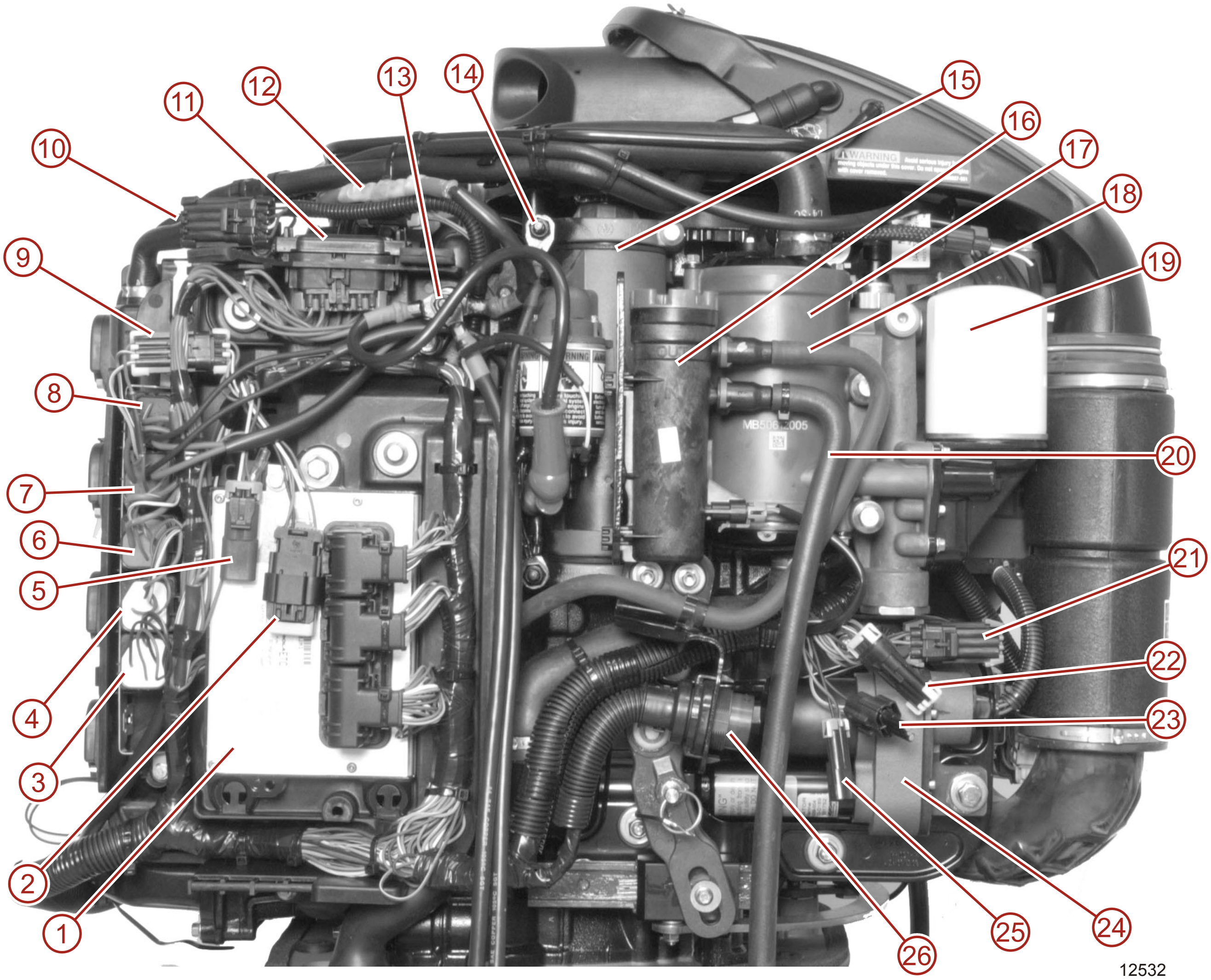
a - Serial number
b - Model designation
c - Year manufactured
d - Certified Europe Insignia (as applicable)

Verado 4 Cylinder Powerhead Front View (S/N 1B227000 and Above)



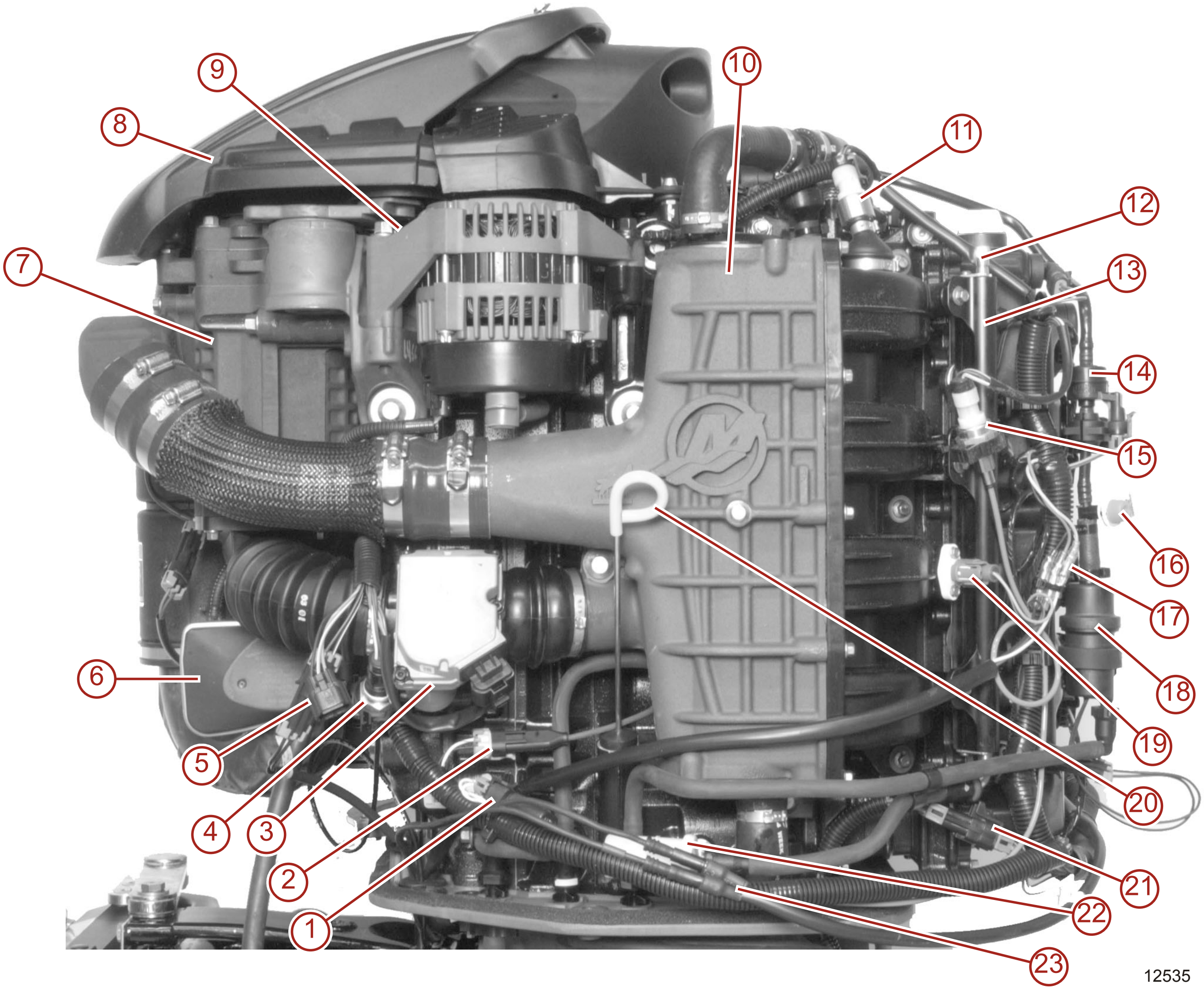
1 - Shift switch
2 - Resonator
3 - 14 pin engine harness connector
4 - DTS power harness connector
5 - Power steering signal harness connector
6 - Oil filter
7 - Flywheel cover/air filter
8 - Supercharger
9 - Supercharger boost air temperature sensor
10 - Oil level dipstick
11 - Electronic boost control (EBC) valve
12 - Trim switch harness connector
13 - Shift switch harness connector
14 - Speedometer sensor
15 - Electronic throttle control (ETC)

Verado 4 Cylinder Powerhead Starboard View (S/N 1B227000 and Above)



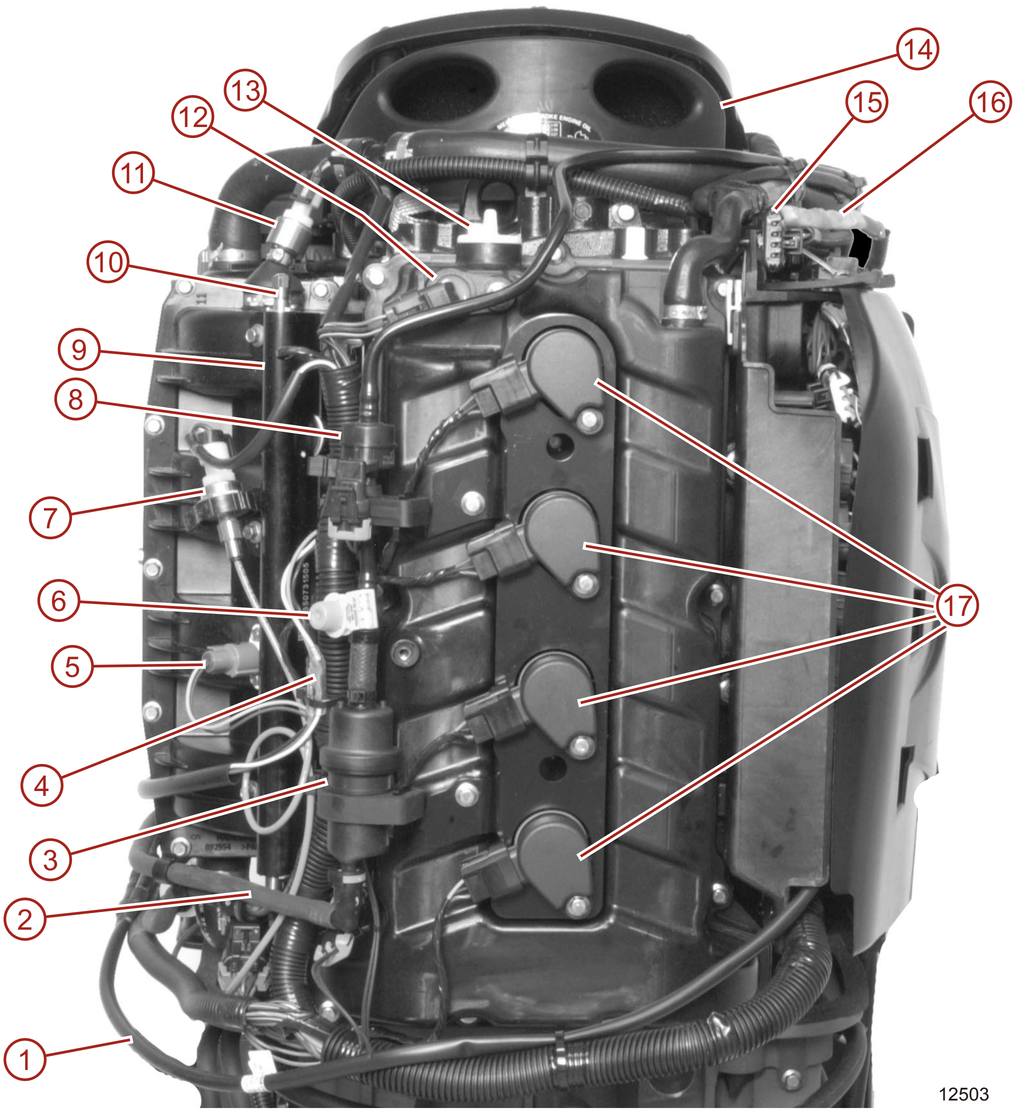
1 - PCM
2 - CAN 1 terminator resistor
3 - Fuel pump relay
4 - Starter relay
5 - CAN 2 terminator resistor
6 - Main power relay
7 - Trim up relay
8 - Trim down relay
9 - Trim relay engine harness connector
10 - Diagnostic port
11 - Fuses
12 - 150 amp fusible link
13 - Hot stud (battery positive)
14 - Battery ground cable connection
15 - Starter
16 - Water separating fuel filter (2 microns)
17 - Integrated oil module (IOM)
18 - Fuel supply line to FSM
19 - Oil filter
20 - Fuel delivery from boat
21 - Boat sensor harness connector
22 - Power steering signal harness connector
23 - Tilt switch harness connector (optional switch, starboard)
24 - Shift actuator
25 - DTS power harness connector
26 - 14 pin engine harness connector

Verado 4 Cylinder Powerhead Port View (S/N 1B227000 and Above)



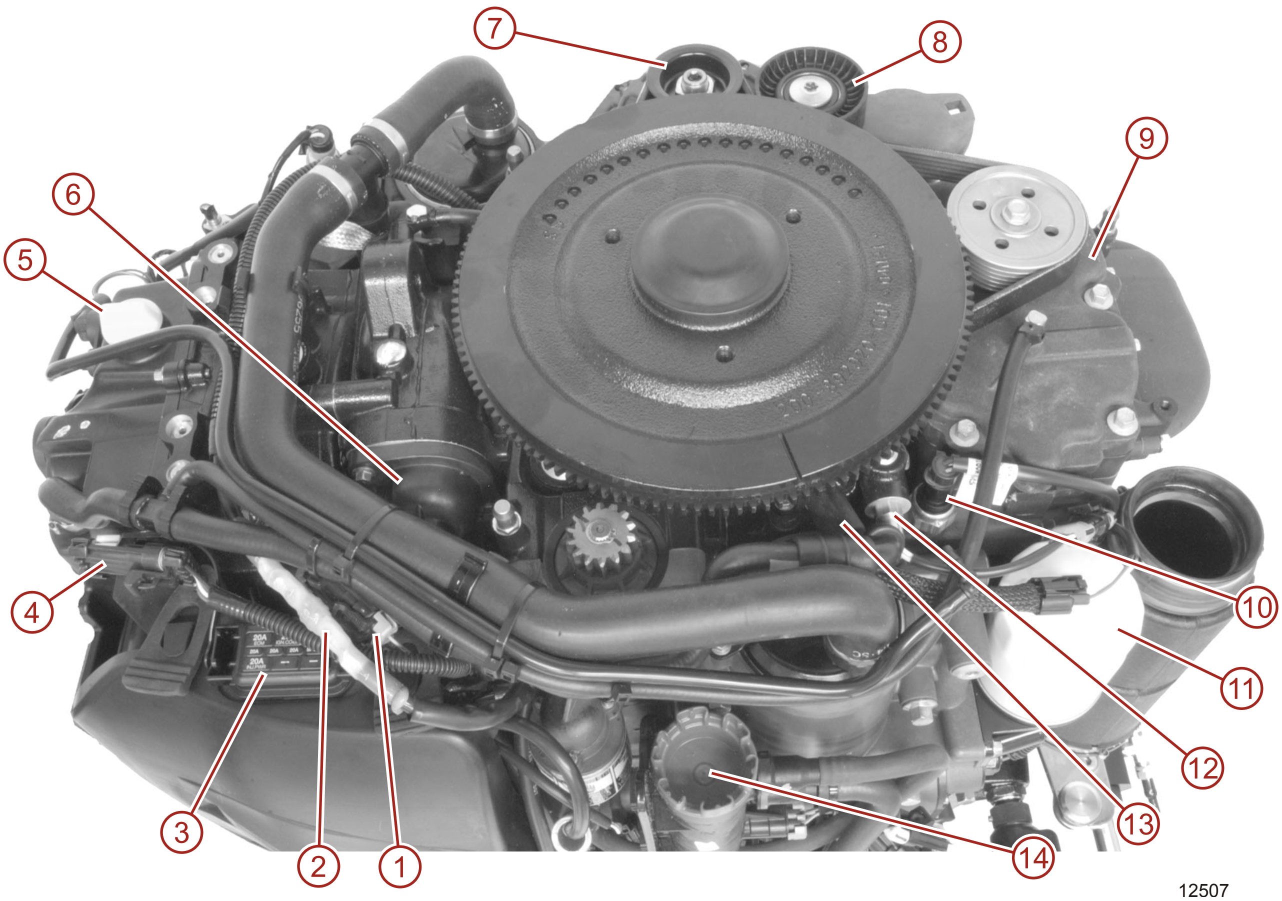
1 - Resistor (20 k ohms)
2 - Knock sensor harness connector
3 - Electronic boost control (EBC)
4 - Speedometer sensor
5 - Tilt switch harness connector (optional switch, port)
6 - Electronic throttle control (ETC)
7 - Supercharger
8 - Flywheel cover/air filter
9 - Alternator
10 - Charge air cooler (CAC)
11 - Manifold absolute pressure (MAP) sensor
12 - Fuel pressure port
13 - Fuel rail
14 - Vent canister purge valve (VCPV)
15 - Block water pressure sensor
16 - FSM purge valve
17 - Trim position sensor bullet connectors
18 - Vent canister float switch (VCFS)
19 - Manifold air temperature (MAT) sensor
20 - Oil dipstick
21 - FSM harness connector
22 - High-pressure fuel filter (in-line)
23 - Power trim bullet connectors

Verado 4 Cylinder Powerhead Aft View (S/N 1B227000 and Above)



1 - Power trim relay bullet connector wire harness
2 - FSM vent hose
3 - Vent canister float switch (VCFS)
4 - Trim position sensor bullet connectors
5 - Manifold air temperature (MAT)
6 - FSM purge valve
7 - Block water pressure sensor
8 - FSM purge valve
9 - Fuel rail
10 - Fuel pressure port
11 - Manifold absolute pressure (MAP) sensor
12 - Cam position sensor
13 - Oil fill plug
14 - Flywheel cover/air filter
15 - Diagnostic port
16 - 150 amp fusible link
17 - Pencil coils

Verado 4 Cylinder Powerhead Top View (S/N 1B227000 and Above)



1 - Cylinder block temperature sensor connector
2 - 150 amp fusible link
3 - Fuse holder
4 - Diagnostic port (4 pin)
5 - Oil fill plug
6 - Thermostat cover
7 - Alternator
8 - Accessory belt tensioner
9 - Supercharger
10 - Oil pressure sensor
11 - Oil filter
12 - Oil temperature sensor
13 - Crankshaft position sensor
14 - Fuel filter/water separator cover

Conditions Affecting Performance

Weather

It is a known fact that weather conditions exert a profound effect on the power output of internal combustion engines. Established horsepower ratings refer to the power the engine will produce at its rated RPM under a specific combination of weather conditions.

Corporations internationally have settled on adoption of International Standards Organization (ISO) engine test standards, as set forth in ISO 3046 standardizing the computation of horsepower from data obtained on the dynamometer. All values are corrected to the power the engine will produce at sea level, at 30% relative humidity, at 25 °C (77 °F) temperature, and a barometric pressure of 29.61 inches of mercury.

Summer conditions of high temperature, low barometric pressure, and high humidity all combine to reduce the engine power. This, in turn, is reflected in decreased boat speeds as much as 3 to 5 km/h (2 to 3 MPH) in some cases. Nothing will regain this speed for the boater but cooler, dry weather.

Pointing out the consequences of weather effects, an engine running on a hot, humid day may encounter a loss of as much as 14% of the horsepower it would produce on a dry, brisk day. The horsepower that any internal combustion engine produces, depends upon the density of the air that it consumes. The density of air is dependent upon the ambient air temperature, the barometric pressure, and the humidity (water vapor) content.

Accompanying the effects of weather inspired loss of power is a second, but more subtle loss. Consider a boat rigged during cooler, less humid weather with a propeller that allowed the engine to turn within its recommended RPM range at full throttle. Higher temperatures with high humidity weather will consequently decrease the available horsepower. The propeller, in effect, is too large for the atmospheric conditions and the engine operates at less than its recommended RPM.

The engine rated horsepower is a direct relation to the engines' RPM. An engine with too large a propeller will have a further loss of horsepower and subsequent decrease in boat speed. This secondary loss of RPM and boat speed can be regained by switching to a smaller pitch propeller that allows the engine to run at recommended RPM.

For boaters to realize optimum engine performance under changing weather conditions, it is essential the engine has the proper propeller to allow it to operate at, or near, the top end of the recommended maximum RPM range at wide-open throttle with a normal boat load. Not only does this allow the engine to develop full power, but equally important, the engine will be operating in an RPM range that discourages damaging detonation. This enhances overall reliability and durability of the engine.

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)

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.

Water Absorption

It is imperative that all thru-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.

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

Ventilation

Ventilation is caused by surface air or exhaust gases that are introduced around the propeller resulting in propeller speed-up and a reduction in boat speed. Air bubbles strike the propeller blade and cause erosion of the blade surface. If allowed to continue, eventual blade failure (breakage) will occur. Excessive ventilation is usually caused by:

- Drive unit trimmed out too far
- A missing propeller diffuser ring
- A damaged propeller or gear housing, which allows exhaust gases to escape between propeller and gear housing

- Drive unit installed too high on transom

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

Following Complete Engine 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 and/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 engine at full trim in.
3. Remove cowling.
4. Flush exterior of outboard with freshwater to remove mud, weeds, etc. Do not attempt to start engine if sand has entered powerhead. Disassemble powerhead, if necessary, to clean components.
5. Remove spark plugs and get as much water as possible out of powerhead. Most of the water inside the combustion chambers, can be eliminated by rotating the flywheel while the engine is tilted in.
6. Remove the rubber boot from the ETC assembly. Drain water from the rubber boot.
7. Remove spark plugs and pour approximately one teaspoon of engine oil into each spark plug opening. Rotate flywheel to distribute oil in cylinders.
8. Change the engine oil. 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.
9. Dry all wiring and electrical components using compressed air.
10. Disassemble the engine starter motor and dry all the internal parts with compressed air. Be careful not to lose the brush springs.
11. Install spark plugs.
12. Attempt to start engine, using a fresh fuel source. If engine starts, it should be run for at least one hour to eliminate any water in engine. 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 as previously mentioned.

    NOTE: The fuel system is closed to the ambient air at all times when the engine is not running.
13. If engine fails to start, determine if the cause is fuel, electrical, or mechanical. The engine should be run within two hours after recovery from the water, or serious internal damage will occur. If unable to start engine within two hours of recovery, disassemble the engine and clean all parts. Apply oil as soon as possible.

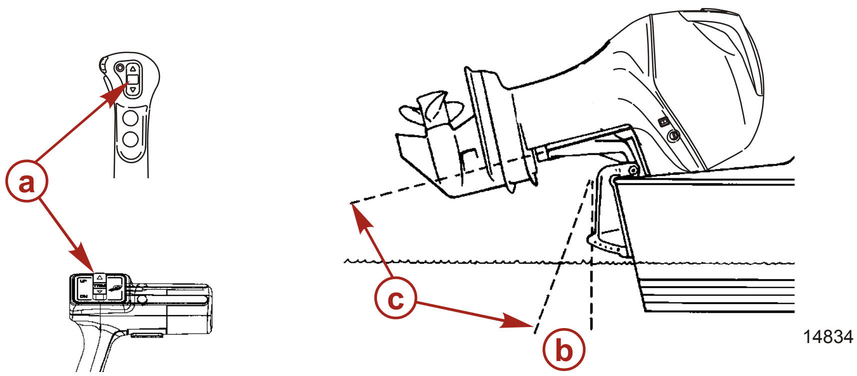
Saltwater Submersion (Special Instructions)

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.

Power Trim and Tilt

Power Trim And Tilt

The outboard has a trim/tilt control called power trim. This enables the operator to easily adjust the position of the outboard by pressing the trim switch. Moving the outboard in closer to the boat transom is called trimming in or down. Moving the outboard further away from the boat transom is called trimming out or up. The term trim generally refers to the adjustment of the outboard within the first 20° range of travel. This is the range used while operating the boat on plane. The term tilt is generally used when referring to adjusting the outboard further up out of the water. With the engine turned off and ignition switch turned on, the outboard can be tilted out of the water. At low idle speed, the outboard can also be tilted up past the trim range to permit, for example, shallow water operation.



a - Trim switch
b - Trim range
c - Tilt range

Power Trim Operation

With most boats, operating around the middle of the trim range will give satisfactory results. However, to take full advantage of the trimming capability there may be times when you choose to trim your outboard all the way in or out. Along with an improvement in some performance aspects comes a greater responsibility for the operator, and this is being aware of some potential control hazards.

The most significant control hazard is a pull or torque that can be felt on the steering wheel or tiller handle. This steering torque results from the outboard being trimmed so the propeller shaft is not parallel to the water surface.

⚠ WARNING

Trimming the outboard beyond a neutral steering condition may result in a pull on the steering wheel or tiller handle and loss of boat control. Maintain control of the boat if trimming beyond a neutral steering condition.

Consider the following lists carefully.

1. Trimming in or down can:
    - Lower the bow
    - Result in quicker planing off, especially with a heavy load or a stern heavy boat
    - Generally improve the ride in choppy water
    - Increase steering torque or pull to the right (with the normal right-hand rotation propeller)
    - In excess, can lower the bow of some boats to a point where they begin to plow with their bow in the water while on plane. This can result in an unexpected turn in either direction (called bow steering or oversteering) if any turn is attempted, or if a significant wave is encountered.

⚠ WARNING

Operating the boat at high speeds with the outboard trimmed too far under can create excessive bow steer, resulting in the operator losing control of the boat. Install the trim limit pin in a position that prevents excessive trim under and operate the boat in a safe manner.

    - In rare circumstances, the owner may decide to limit the trim in. This can be accomplished by purchasing a stainless steel tilt pin from your dealer and inserting it in whatever adjustment hole in the transom brackets is desired. The nonstainless steel shipping bolt should not be used in this application other than on a temporary basis.

2. Trimming out or up can:
    - Lift the bow higher out of the water
    - Generally increase top speed
    - Increase clearance over submerged objects or a shallow bottom

- Increase steering torque or pull to the left at a normal installation height (with the normal right hand rotation propeller)
- In excess, can cause boat porpoising (bouncing) or propeller ventilation
- Cause engine overheating if any cooling water intake holes are above the waterline

Tilting to Full Up Position

Tilt at Helm

NOTE: The trim/tilt switch will remain active for 15 minutes after the ignition key switch has been turned off.

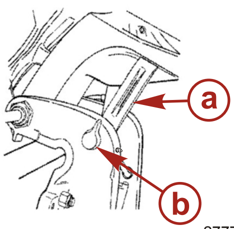
1. If the ignition key switch has been turned off for over 15 minutes, turn it to the "ON" position.
2. Press the trim/tilt switch to the up position. The outboard will tilt up until the switch is released or it reaches its maximum tilt position.

Tilt at Engine

The cowl mounted auxiliary tilt switch can be used to tilt the outboard with the key switch in the "OFF" position.

Tilt Support Lever

1. Engage the tilt support lever, by rotating knob to bring the support lever upward.
2. Lower outboard to rest on the tilt support lever.
3. Disengage the tilt support lever, by raising the outboard off the support lever and rotating the tilt support lever down. Lower the outboard.



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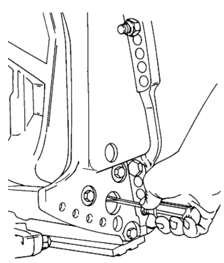
a - Tilt support lever
b - Knob

Manual Tilting

If the outboard cannot be tilted using the power trim/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.



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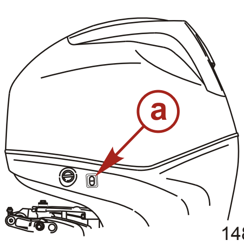
Auxiliary Tilt Switch

NOTE: This model allows the auxiliary tilt switch to be mounted on either the port side (shown) or on the starboard side.

This switch can be used to tilt the outboard up or down using the power trim system.



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a - Auxiliary tilt switch (port side)

Shallow Water Operation

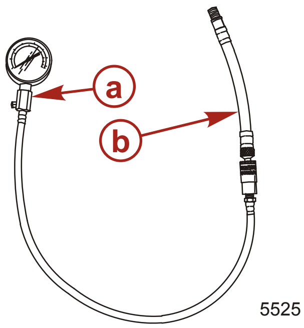
When operating your boat in shallow water, you can tilt the outboard beyond the maximum trim range to prevent hitting bottom.

1. Reduce engine speed below 2000 RPM.
2. Tilt outboard up. Make sure all the water intake holes stay submerged at all times.
3. Operate the engine at slow speed only. If engine speed exceeds 2000 RPM, the outboard will automatically return down to the maximum trim range.

Compression Check

Engine compression should be checked with the engine block at operating temperatures, all spark plugs removed, and using a fully charged battery.

1. Remove spark plugs.
2. Install compression gauge in spark plug hole.



a - Compression gauge
b - 14 mm adapter

Compression Tester with Adapter	Snap-On EEPV303B

3. Crank the engine over until the compression reading peaks on the gauge. Record the reading.
4. 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) may indicate a total engine wear problem. **The following example chart below, 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)

5. 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).
6. 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.
7. A variance of more than 103.4 kPa (15 psi) indicates the need for a powerhead inspection/disassembly.

Cylinder Leakage Testing

Engine Firing Order	
Cylinder sequence	1 - 3 - 4 - 2

NOTE: Cylinder leakage testing, 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. Refer to the manufacturer's tester instructions for proper testing procedures.

Cylinder Leakage Tester	Snap-On EEPV309A

1. Remove the spark plugs from cylinders 2, 3, and 4.
2. Rotate the engine clockwise until resistance is felt.
3. Continue to rotate flywheel so the timing marks on the flywheel and cylinder block are in alignment. This will be the compression stroke for cylinder #1.
4. Remove the spark plug from cylinder #1.
5. Complete the cylinder leak down test on the #1 spark plug hole. Refer to the manufacturer's tester instructions for proper testing procedures.
6. After testing cylinder #1, install a dial indicator on the next firing order sequence cylinder.
7. Rotate the flywheel so the piston is at TDC.

8. Complete the cylinder leak down test.
9. Proceed with the succeeding firing order cylinder TDC and complete the cylinder leak down test.
10. Complete the procedure in sequence on the remaining cylinders.

Analysis

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

If excessive leakage is present, first check that 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 leaks, you must locate where the air is escaping from. Listen for air escaping through the intake, adjacent spark plug holes, exhaust pipe, and crankcase oil fill plug. Use the following table to aid in locating the source of cylinder leakage.

Air Escaping From	Possible Location
Air induction	Intake valve
Exhaust system	Exhaust valve
Oil fill plug	Piston/rings
Adjacent cylinder	Head gasket

Painting Procedures

⚠ 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 eyeware, clothing, and respirators.

Propellers

1. Sand the entire area to be painted with 3M 120 Regalite Polycut or coarse Scotch-Brite disc or belts.
2. Feather edges of all broken paint edges. Try not to sand through the primer.
3. Clean the surface to be painted using PPG Industries DX330 Wax and Grease Remover or equivalent (Xylene or M.E.K.).
4. If bare metal has been exposed, use Mercury/Quicksilver 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/Quicksilver EDP Propeller Black.

Gear Housing

The following procedures should be used in refinishing gear housings. This procedure will provide the most durable paint system available in the field. The materials recommended are of high quality and approximate marine requirements. The following procedure will provide a repaint job that compares with a properly applied factory paint finish. It is recommended the listed materials be purchased from a local Ditzler Automotive Finish Supply Outlet. The minimum package quantity of each material shown following is sufficient to refinish several gear housings.

1. Wash the gear housing with a muriatic acid base cleaner to remove any type of marine growth, and rinse with water.
2. Wash the gear housing with soap and water. Rinse with clean water.
3. Sand blistered area with 3M 180 grit sandpaper or P180 Gold Film Disc to remove paint blisters only. Feather edge all broken paint edges.
4. Clean gear housing thoroughly with DX-330 Wax and Grease Remover.
5. Spot repair surfaces where bare metal is exposed with DX-503 Alodine Treatment.

   IMPORTANT: Do not use aerosol spray paints as the paint will not properly adhere to the surface, nor will the coating be sufficiently thick to resist future paint blistering.
6. Mix Epoxy Chromate Primer DP-90LF with equal part catalyst DP-402LF per the manufacturer's instructions. Allow proper induction period for permeation of the epoxy primer and catalyst.
7. Allow a minimum of one hour drying time and no more than one week before the top coat application.
8. Use Ditzler Urethane DU9300 for Mercury Black, DU34334 for Mariner Grey, DU35466 for Force Charcoal, DU33414M for Sea Ray White, and DFHS 37372H for Verado Silver. Catalyze all five colors with Ditzler DU5 catalyst mixed 1:1 ratio. Reduce with solvents per Ditzler label.

⚠ 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 eyeware, clothing, and respirators.

NOTE: Apply one half to one mil even film thickness with a spray gun. Allow the paint to flash off for five minutes before applying the second even coat of one half to one mil film thickness. Urethane paint will dry to the touch in a matter of hours, but will remain sensitive to scratches and abrasions for a few days.

9. The type of spray gun used will determine the proper reduction ratio of the paint.

   IMPORTANT: Do not paint sacrificial anode.

10. Cut out a cardboard plug for trim tab pocket to keep paint off of mating surface to maintain good continuity circuitry between trim tab and gear housing.

Decal Removal

1. Mark decal location before removal to assure proper alignment of new decal.
2. Carefully soften decal and decal adhesive with a heat gun or heat blower while removing old decal.
3. Clean decal contact area with a 1:1 mixture of isopropyl alcohol and water.
4. Thoroughly dry decal contact area and check for a completely cleaned surface.

Decal Application

1. Mix 16 ml (1/2 oz) of dishwashing liquid in 4 liter (1 US gal) of cool water to use as a wetting solution.

   NOTE: Leave protective masking on the face of the decal until final steps of decal installation. This will ensure the vinyl decal keeps its shape during installation.

2. Place the decal face down on a clean work surface and remove the paper backing from adhesive side of decal.
3. Using a spray bottle, flood the entire adhesive side of the decal with the premixed wetting solution.
4. Flood area where the decal will be positioned with wetting solution.
5. Position prewetted decal on wetted surface and slide into position.
6. Starting at the center of the decal, lightly squeegee out the air bubbles and wetting solution with overlapping strokes to the outer edge of the decal. Continue going over the decal surface until all wrinkles are gone and adhesive bonds to the cowl surface.
7. Wipe decal surface with a soft paper towel or cloth.
8. Wait 10–15 minutes.
9. Starting at one corner, carefully and slowly pull the masking off the decal surface at a 180° angle.

NOTE: To remove any remaining bubbles, pierce the decal at one end of the bubble with a stick pin and press out the entrapped air or wetting solution with your thumb, moving toward the puncture.

1
D

Important Information

Section 1D - Outboard Motor Installation

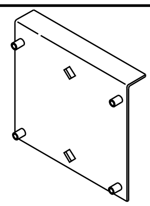
Table of Contents

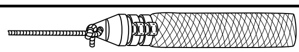
Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
94	Anti-Corrosion Grease	Propeller shaft splines	92-802867Q 1
95	2-4-C with Teflon	Propeller shaft splines	92-802859A 1

Special Tools

Flywheel Puller/Lifting Ring	91-895343T02
 14869	Removes flywheel from engine. Used for lifting powerhead/engine.

Transom Drilling Fixture	91-98234A2
 5489	Aids in engine installation by acting as a template for engine mounting holes.

Data Cable Puller	888462A 1
 4618	Attaches to end of DTS data harness to aid in pulling harness through boat. Prevents damage to DTS data harness.

Notice to Installer

This Product Requires Electronic Calibration Before Use.

Installation of this product will require electronic calibration. This calibration must not be attempted by anyone other than the Original Equipment Manufacturer (OEM) or a Mercury technician trained in Digital Throttle and Shift systems (DTS) at an authorized Mercury dealership. Improper installation and calibration of the DTS product will result in a system which is inoperable or unsafe for use.

Avoiding Loss of Throttle and Shift Control

⚠ WARNING

Splicing or probing will damage the wire insulation allowing water to enter the wiring. Water intrusion may lead to wiring failure and loss of throttle and shift control. To avoid the possibility of serious injury or death from loss of boat control, do not splice or probe into any wire insulation of the DTS system.

Accessory Electric Fuel Pump/Fuel Line Primer Bulb

IMPORTANT: Do not install an accessory electric fuel pump or a fuel line primer bulb into the fuel system of this engine.

Avoiding Fuel Flow Restriction

IMPORTANT: Adding components to the fuel supply system (filters, valves, fittings, etc.) may restrict the fuel flow. This may cause engine stalling at low speed, and/or a lean fuel condition at high RPM that could cause engine damage.

Boat Horsepower Capacity

⚠ WARNING

Exceeding the boat's maximum horsepower rating can cause serious injury or death. Overpowering the boat can affect boat control and flotation characteristics or break the transom. Do not install an engine that exceeds the boat's maximum power rating.

Do not overpower or overload your boat. Most boats will carry a required capacity plate indicating the maximum acceptable power and load as determined by the manufacturer following certain federal guidelines. If in doubt, contact your dealer or the boat manufacturer.

U.S. COAST GUARD CAPACITY	
MAXIMUM HORSEPOWER	XXX
MAXIMUM PERSON CAPACITY (POUNDS)	XXX
MAXIMUM WEIGHT CAPACITY	XXX

26777

Selecting Accessories for Your Outboard

Genuine Mercury Precision or Quicksilver Accessories have been specifically designed and tested for this outboard.

Some accessories not manufactured or sold by Mercury Marine are not designed to be safely used with this outboard or outboard operating system. Acquire and read the installation, operation, and maintenance manuals for all selected accessories.

Fuel Tanks

Portable Fuel Tank

Select a suitable location in the boat within the engine fuel line length limitations and secure the tank in place.

Permanent Fuel Tank

Permanent fuel tanks should be installed in accordance with industry and federal safety standards, which include recommendations applicable to grounding, anti-siphon protection, ventilation, etc.

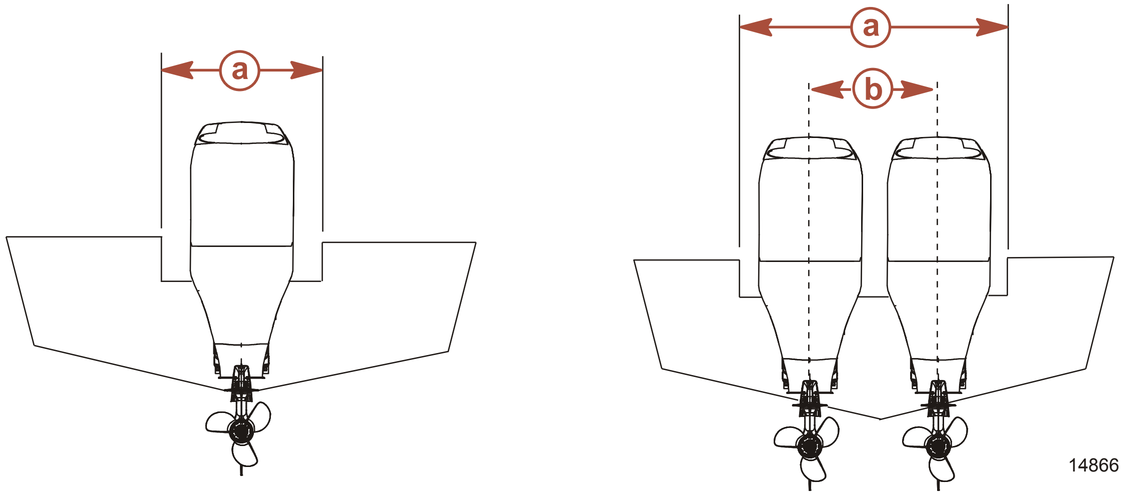
Low Permeation Fuel Hose Requirement

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/gm²/24 h with CE 10 fuel at 23 °C as specified in SAE J 1527 - marine fuel hose.

Installing Outboard

Installation Specifications



a - Minimum transom opening
b - Engine centerline for dual engine - 66.0 cm (26 in.)

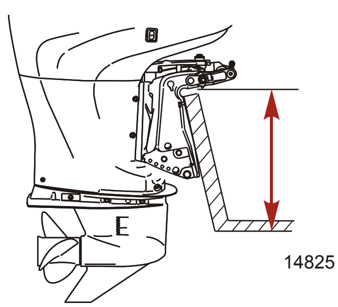
Minimum Transom Opening	
Single engine	99.0 cm (39 in.)
Dual engine	165.0 cm (65 in.)

⚠ WARNING

Operating this engine in any length configuration other than as configured by Mercury Marine can cause serious injury or death. Do not convert this outboard's driveshaft length without first contacting Mercury Marine Technical Service to obtain the necessary approval and instructions.

Maximum Outboard Mounting Height

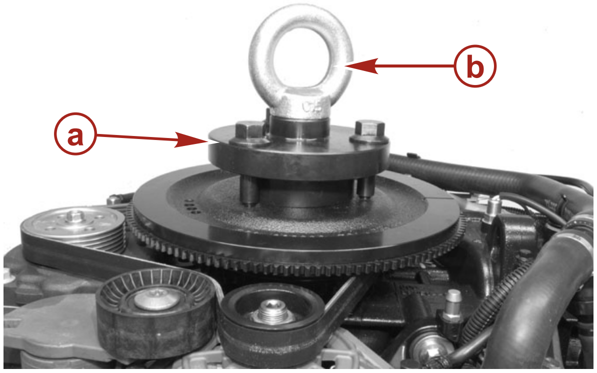
The mounting height of the outboard must not exceed 50.8 cm (20 in.) for L models, or 63.5 cm (25 in.) for XL models. Mounting the outboard higher may cause damage to the gearcase components.



Lifting Outboard

1. Remove top cowl and engine flywheel cover.
2. Install lifting base to flywheel. Tighten bolts securely.
3. Thread the lifting eye into the lifting base.
4. Connect a hoist that has a minimum lift capacity of 450 kg (1000 lb.) to the lifting eye.

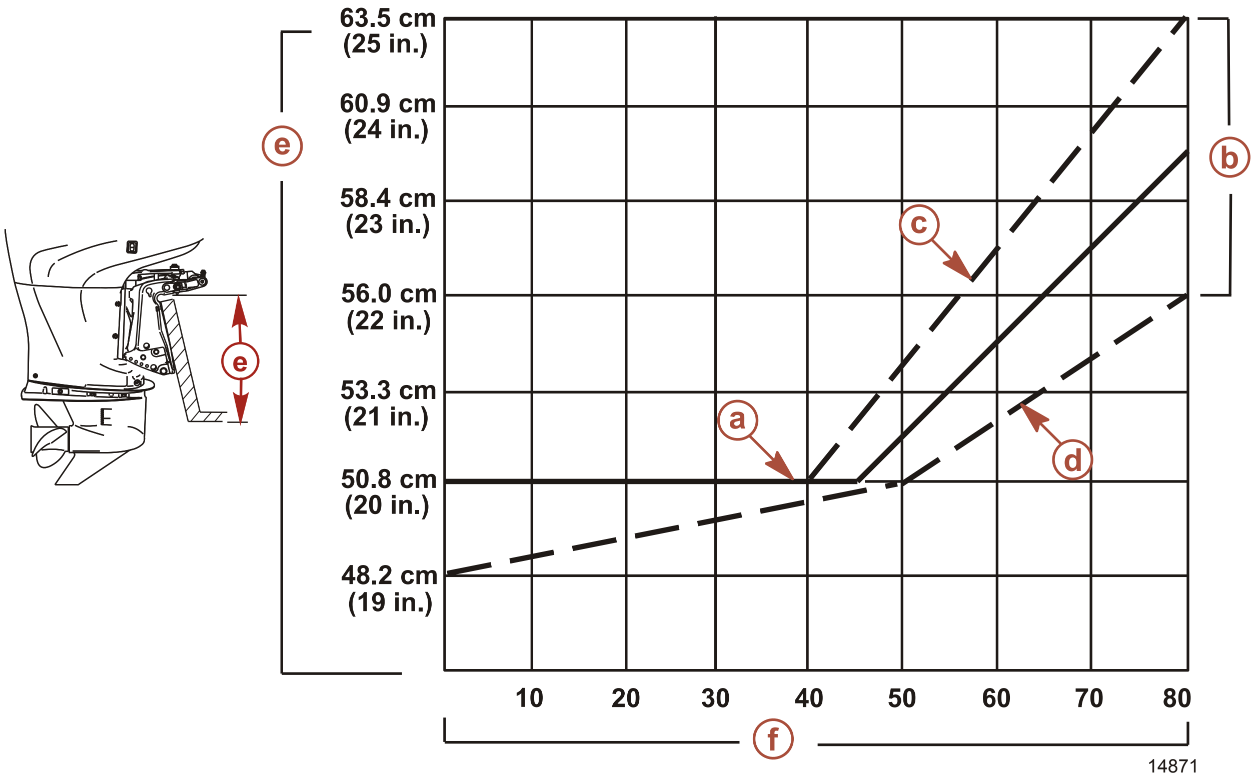
5. Lift the outboard and place it on the transom.



a - Lifting base
b - Mounting eye

Flywheel Puller/Lifting Ring	91-895343T02

Determining Recommended Outboard Mounting Height



a - The solid line is recommended to determine the outboard mounting height
b - The broken lines represent the extremes of known successful outboard mounting height dimensions
c - The line may be preferred to determine outboard mounting height dimension, if maximum speed is the only objective
d - The line may be preferred to determine outboard mounting height dimension for dual outboard installation
e - Outboard mounting height (height of outboard mounting brackets from bottom of boat transom). For height over 56.0 cm (22 in.) a propeller designed for surfacing operation is usually preferred.
f - Maximum boat speed (MPH) anticipated

NOTICE
• The outboard should be mounted high enough on the transom so the exhaust relief hole will stay at least 25.4 mm (1 in.) above the waterline when the engine is running at idle speed. Having the exhaust relief hole above the waterline will prevent exhaust restrictions. Exhaust restrictions will result in poor performance at idle. • Add 12.7 cm (5 in.) for XL models and 25.4 cm (10 in.) for XXL models to listed outboard mounting height. • The mounting height of the outboard must not exceed 63.5 cm (25 in.) for XL models and 76.2 cm (30 in.) for XXL models. Mounting the outboard higher may cause damage to the gearcase components.

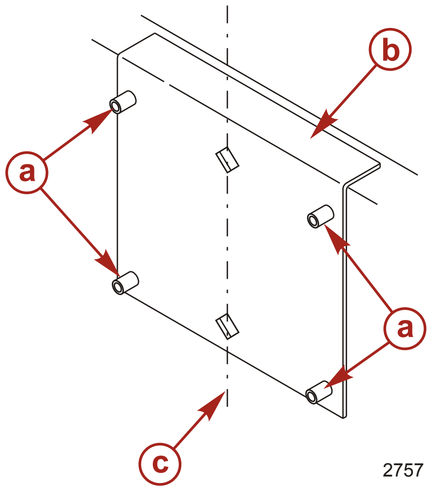
Increasing the mounting height will usually:

- Increase top speed
- Increase boat stability
- Cause propeller to break loose during planing or turning

Drilling Outboard Mounting Holes

IMPORTANT: Before drilling any mounting holes, carefully read Determining Recommended Outboard Mounting Height and install outboard to the nearest recommended mounting height.

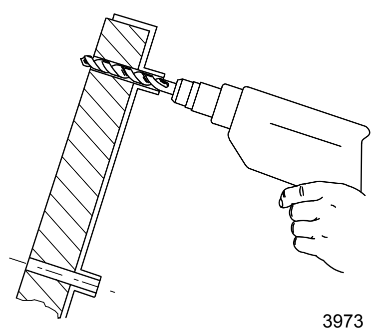
1. Mark four mounting holes on the transom using the transom drilling fixture.



a - Drill guide holes
b - Transom drilling fixture
c - Transom centerline

Transom Drilling Fixture	91-98234A2

2. Drill four 13.5 mm (17/32 in.) mounting holes.



Fastening the Outboard to the Transom

Mounting Bolts

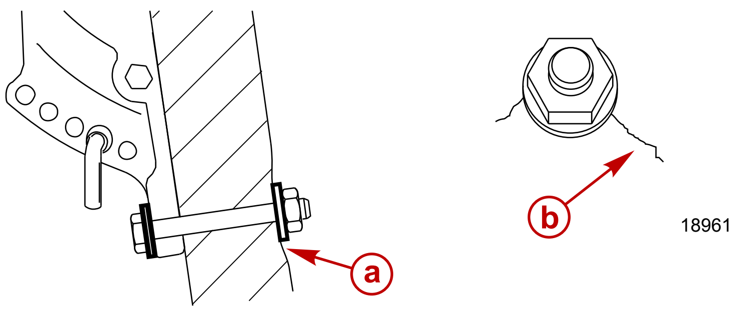
Outboard Transom Mounting Hardware - Supplied with Outboard		
Part Number	Part Name	Description
10-67755-1	Outboard mounting bolt	½-20 x 4.50 in. long (2.25 in. thread)
11-826711-17	Nylon insert locknut	½-20
12-28421	Flat washer	1-1/2 in. diameter

Outboard Transom Mounting Hardware - Supplied with Outboard		
Part Number	Part Name	Description
12-54012	Flat washer	7/8 in. diameter

Available Outboard Mounting Bolts	
Part Number	Description
10-67755005	½-20 x 2.50 in. long (1.25 in. thread)
10-67755006	½-20 x 3.50 in. long (1.25 in. thread)
10-814259	½-20 x 4.00 in. long (2.25 in. thread)
10-67755-1	½-20 x 4.50 in. long (2.25 in. thread)
10-8M0033366	½-20 x 5.00 in. long (3.25 in. thread)
10-67755-003	½-20 x 5.50 in. long (3.25 in. thread)
10-67755-2	½-20 x 6.50 in. long (2.75 in. thread)
10-8M0028080	½-20 x 7.50 in. long (2.75 in. thread)
10-8M0032860	½-20 x 8.00 in. long (2.75 in. thread)

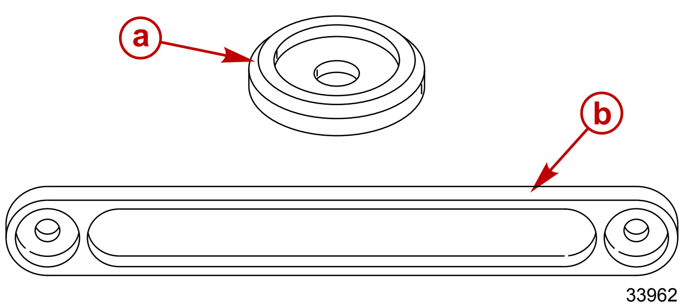
Checking Boat Transom Construction

IMPORTANT: Determine the strength of the boat transom. The outboard mounting locknuts and bolts should be able to hold 75 Nm (55 lb-ft) of torque without the boat transom yielding or cracking. If the boat transom yields or cracks under this torque, the construction of the transom may not be adequate. The boat transom must be strengthened or the load carrying area increased.



a - Transom yielding under bolt torque
b - Transom cracking under bolt torque

Use a dial torque wrench to determine transom strength. If the bolt or nut continues to turn without the torque reading on the dial increasing, it is an indication that the transom is yielding. The load area can be increased by using a larger washer or a transom reinforcement plate.

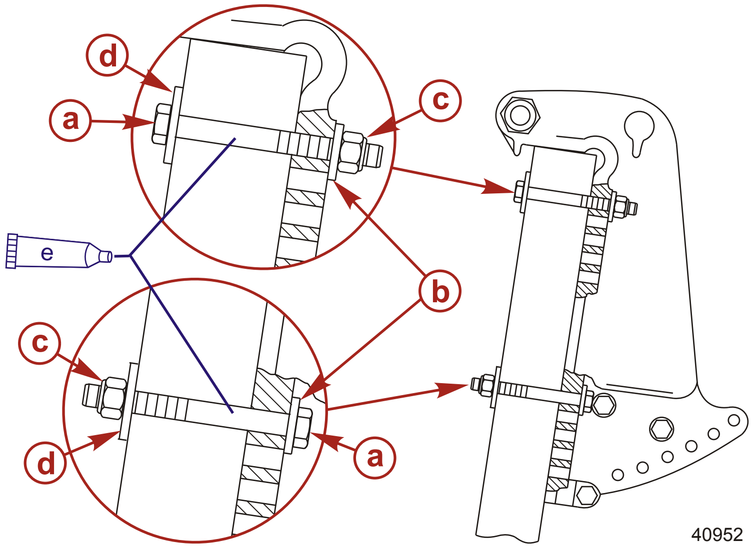


a - Large transom washer
b - Transom reinforcement plate

1. Apply marine sealer to the shanks of the bolts, not to the threads.
2. Fasten the outboard with the correct mounting hardware. Tighten the locknuts to the specified torque.

   IMPORTANT: Ensure a minimum of two full threads of the mounting bolts extend beyond the locknut after tightening. The locknut must be drawn tight while still engaging the bolt threads and not contacting the shank of the bolt.

NOTE: For more accurate torque, tighten the mounting locknuts rather than the outboard mounting bolts.



- a - 1/2 in. diameter outboard mounting bolt (4)
- b - 7/8 in. flat washer (4)
- c - Nylon insert locknut (4)
- d - 1-1/2 in. flat washer (4)
- e - Marine sealer - apply to the shank of the bolts, not the threads

Description	Nm	lb-in.	lb-ft
Outboard mounting locknuts and bolts - standard boat transom	75		55
Outboard mounting locknuts and bolts - metal lift plates and setback brackets	122		90

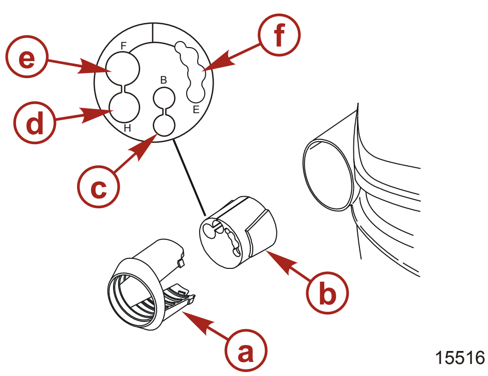
Wiring and Installation

Routing Connections Through the Cowl

IMPORTANT: Ensure that sufficient excess exists in the wiring harness and battery cables routed between the cowl fitting and the engine attachment point to relieve stress and prevent hoses from being kinked or pinched. Ensure that excess exists in all hoses and cables in full left and right turns and full tilt position.

NOTE: Mercury Marine suggests routing the wiring, cables, and fuel hose through a rigging hose or flexible sleeve from the engine to the boat's gunnel or motor well. Follow the installation instructions included with the rigging hose or flexible sleeve kit.

1. Pull out the grommet fitting and rubber grommet from the front cowl opening. Route the wiring harnesses, battery cables, and fuel hose through the correct openings in the rubber grommet as shown.



- a - Grommet fitting
- b - Rubber grommet
- c - Battery cables
- d - Data harness
- e - Fuel hose
- f - DTS power harness, vessel sensor harness, power steering pump harness

2. Insert rubber grommet into grommet fitting and secure grommet fitting in front cowl opening.

Wire Color Code Abbreviations

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

Installation Guidelines for DTS System Components

⚠ WARNING

Splicing or probing will damage the wire insulation allowing water to enter the wiring. Water intrusion may lead to wiring failure and loss of throttle and shift control. To avoid the possibility of serious injury or death from loss of boat control, do not splice or probe into any wire insulation of the DTS system.

Data Harness

⚠ WARNING

Prevent serious injury or death from a loss of boat control. Pulling on or flexing connectors can loosen terminals and cause open or intermittent electrical connections, which will interrupt control of throttle and shifting. Do not pull on cable connectors when pulling cables through the boat. Do not allow cables to flex at connection points. Fasten all electrical harnesses within 25 cm (10 in.) of any connection.

Connectors

IMPORTANT: Connectors should never have to be forced into the receptacle. Ensure that connectors are free of any lubricant or dielectric grease before installation. When the connector is properly aligned, it will only take a small amount of pressure to insert it into the receptacle. Rotate the locking collar to secure the electrical connection.

NOTE: Connect only one data harness of the required length between the engine and helm. If a data harness is too short, do not connect multiple harnesses together to make up the required length. For installations requiring a data harness length longer than 12.2 m (40 ft.), contact Mercury Marine for more information.

DTS Wiring Guidelines

⚠ WARNING

Splicing or probing will damage the wire insulation allowing water to enter the wiring. Water intrusion may lead to wiring failure and loss of throttle and shift control. To avoid the possibility of serious injury or death from loss of boat control, do not splice or probe into any wire insulation of the DTS system.

- Never attempt to connect, network, tie into, switch, and/or sink source voltage or current from the DTS wiring harnesses.
- Never attempt to connect any type of communication or navigation equipment into the DTS wiring harnessing other than at the designated connection point.
- Boat accessory equipment being installed must be connected to an appropriate power source such as a fuse panel or junction box.
- Never attempt to tap directly into any of the DTS electrical wiring harnesses for a source of power.

Wiring Guidelines for Electrical Boat Accessories

⚠ WARNING

Excessive voltage drop may compromise the DTS system, leading to serious injury or death from loss of throttle and shift control. Do not wire any electrical accessory into the 12-volt ignition key switch circuits of the DTS system.

IMPORTANT: Do not connect boat accessories to 12 volt or ignition key switch DTS circuits. Use a separate switched 12 volt source for wiring boat accessories.

The DTS system requires a consistent 12 volt power source. Splicing or connecting accessories to the 12 volt or ignition key switch DTS circuits (purple, purple/white, or red wires) could blow a fuse or overload circuits, causing intermittent or complete loss of operation.

Harness Installation Guidelines

- Locate a routing path for the harness connections so they reach their installation points.
- Inspect the routing path to ensure surfaces are free of any sharp edges or burrs that could cut the harness.
- Fasten and support the harness with clamps or cable ties along the routing path. A clamp or cable tie must be used within 25.4 cm (10 in.) of any connection in a DTS system.
- Ensure all connections are tight and seal all unused connectors with weather caps.

Data Harness Pulling Procedure

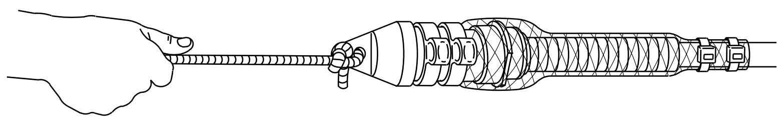
IMPORTANT: Do not route data harness near engine ignition components (coils, spark plug leads, and spark plugs), high power VHF coax, or radios. An electrical field generated from these components could cause interference with data transmission.

IMPORTANT: Do not route data harness near sharp edges, hot surfaces, or moving parts. Fasten cables away from any sharp edges, fasteners, or objects that could wear into the harness.

IMPORTANT: Avoid sharp bends in the data harness. Minimum bend radius should be 7.6 cm (3 in.) for the final wiring installation.

1. Inspect the routing path to ensure surfaces are free of any sharp edges or burrs that could cut the harness.
2. Install cable pulling tool to data harness.
3. Secure pulling tool with two cable ties.

   IMPORTANT: The cable ties must be tight to prevent any slipping during installation.



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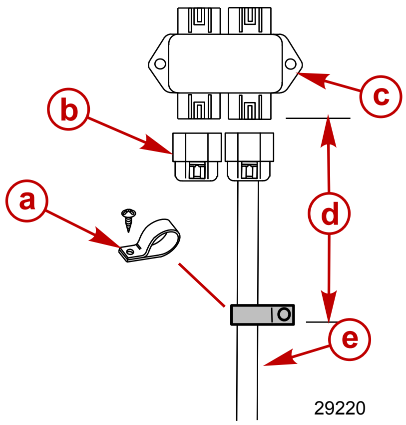
Data Cable Puller	888462A 1

IMPORTANT: Carefully inspect data harness pins to ensure all pins are securely fastened to data harness connector end following installation.

NOTE: Data harness should be secured with mounting clips or cable ties along the routing path.

Junction Box (if Equipped)

- Although the junction box connections are watertight, it is recommended the junction box be mounted in an area that stays relatively dry.
- Mount in an area where the wiring connection will not get stepped on or disturbed.
- Mount in an area that is accessible for troubleshooting and servicing the system.
- Ensure the DTS command module harness will reach all the connection points.
- Fasten all junction box connections within 25.4 cm (10 in.) of the junction box.
- Seal all unused connections with weather caps.



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a - Clamp
b - Weather cap (859318T 2)
c - Junction box
d - 25.4 cm (10 in.)
e - DTS command module harness

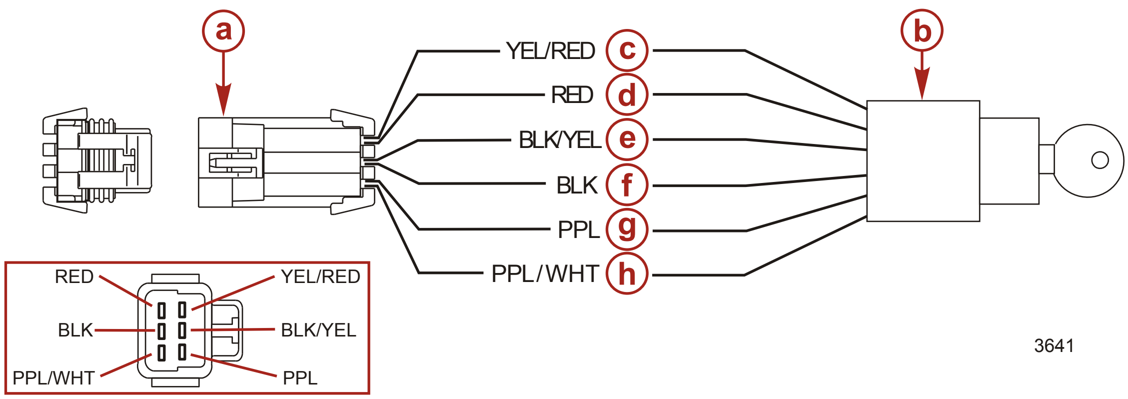
Wiring Instructions for Non-Mercury Marine Ignition Key Switch

⚠ CAUTION

Ignition switches not sold by Mercury Marine can exceed acceptable current flow and voltage drop specifications, causing the engine to start unexpectedly. Only install switches sold through Mercury Marine.

IMPORTANT: We recommend only the use of Mercury Marine brand SmartCraft and DTS accessories. Mercury Marine designs and manufactures these accessories specifically for use on our SmartCraft or DTS systems, with each of these accessories passing through an extensive product qualification process. It is impossible to test our systems with all accessories manufactured and sold by other entities. If a boatbuilder or dealer chooses to disregard this recommendation, any non-Mercury Marine components connected to a SmartCraft or DTS system must adhere to all specifications provided. Documentation exhibiting compliance with these specifications must be submitted and approved by Mercury Marine before releasing the finished product for sale. Damage caused by the use of accessories or parts not manufactured or sold by Mercury Marine is not covered under warranty.

- The ignition key switch must comply with Mercury specifications for key switches and controller input switches (897741-S or 897791-S). Switches that do not meet these specifications could leak current.
- Switches must contain an emergency stop circuit.



a - Connector - Packard Metripack 150 Series sealed (6 pin)
b - Ignition key switch
c - Crank
d - +12 volts
e - Lanyard stop
f - Ground
g - Run
h - Accessory

Wiring Accessories

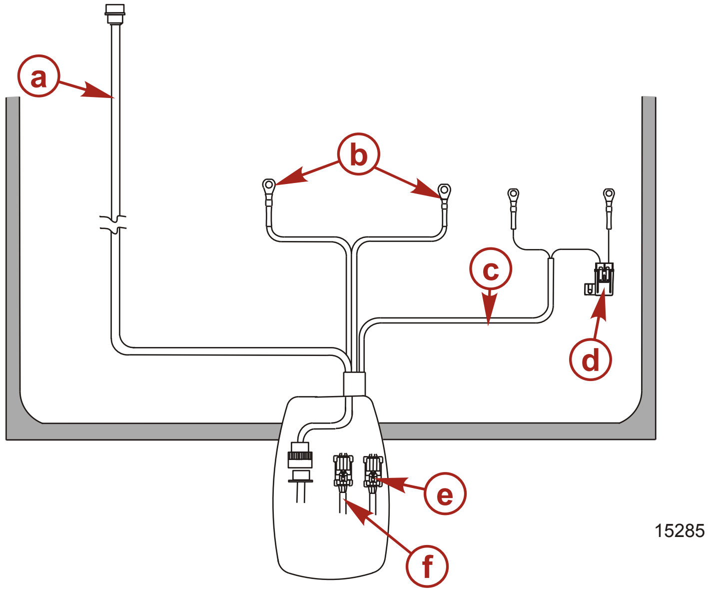
*NOTE: Refer to **Mercury Precision Parts Accessories Guide**.*

System Wiring Reference Points

Features

- **DTS power harness** - Requires connection to the engine starting battery. Provides 12 V power to the DTS system. If starting battery is located at the helm, a DTS accessory power harness kit is required to minimize voltage drop. Use cable ties to secure power harness leads to battery cables, beginning within 15 cm (6 in.) of battery posts and continuing along the entire length of the harness.
- **Battery cables** - Connect to the engine starting battery.
- **Vessel sensor harness plug** - The vessel sensor harness connects between the plug on the engine and the main fuel tank sensor, auxiliary fuel tank, remote oil tank sensor (2 stroke models), and the paddle wheel speed/temperature sensor, if equipped.
- **Power steering pump harness plug** - The power steering pump harness connects between the plug on the engine and the power steering pump, if equipped.

- **14 pin data harness** - Connects between the command module harness at the helm and the engine.



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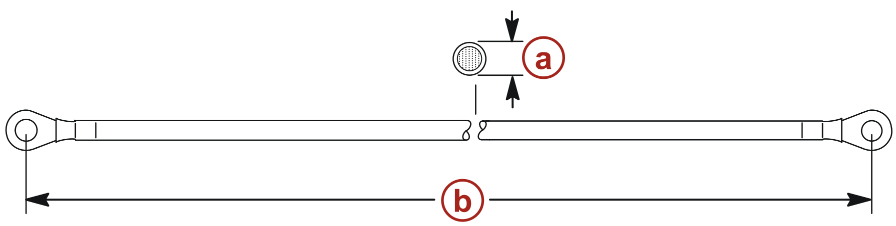
- a - 14 pin data harness
- b - Battery cables
- c - DTS power harness
- d - 5 amp fuse
- e - Power steering pump harness plug
- f - Vessel sensor harness plug

Battery Cable Size for Outboard Models

IMPORTANT: Only use copper battery cables. Do not use aluminum cables for any outboard marine installations.

- If longer battery cables are required, the wire gauge size must increase. See chart following for correct wire gauge size.



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- a - Wire gauge size
- b - Battery cable length

Copper Battery Cable Wire Gauge Size					
Wire Gauge Size Number SAE					
Models		6–25 hp	30–115 hp (except OptiMax)	125–250 hp (except OptiMax)	OptiMax/Verado
Cable Length	2.4 m (8 ft)	8[1.]	6[1.]	-	-
	2.7 m (9 ft)	6	4	-	-
	3.0 m (10 ft)	6	4	6[1.]	-
	3.4 m (11 ft)	6	4	4	-
	3.7 m (12 ft)	6	4	4	4[1.]
	4.0 m (13 ft)	6	2	4	2
	4.3 m (14 ft)	4	2	4	2
	4.6 m (15 ft)	4	2	4	2
	4.9 m (16 ft)	4	2	2	2
	5.2 m (17 ft)	4	2	2	2
	5.5 m (18 ft)	4	2	2	2
	5.8 m (19 ft)	4	2	2	2
	6.1 m (20 ft)	4	2	2	2
	6.4 m (21 ft)	2	1	2	1
	6.7 m (22 ft)	2	1	2	1
	7.0 m (23 ft)	2	1	2	1
	7.3 m (24 ft)	2	1	2	1
	7.6 m (25 ft)	2	1	2	1
	7.9 m (26 ft)	2	1/0	1	1/0
	8.2 m (27 ft)	2	1/0	1	1/0
	8.5 m (28 ft)	2	1/0	1	1/0
	8.8 m (29 ft)	2	1/0	1	1/0
	9.1 m (30 ft)	2	1/0	1	1/0
	9.4 m (31 ft)	2	1/0	1	1/0
	9.8 m (32 ft)	2	1/0	1	1/0
	10.1 m (33 ft)	2	2/0	1/0	2/0
	10.4 m (34 ft)	2	2/0	1/0	2/0
	10.7 m (35 ft)	1	2/0	1/0	2/0
	11.0 m (36 ft)	1	2/0	1/0	2/0
	11.3 m (37 ft)	1	2/0	1/0	2/0
	11.6 m (38 ft)	1	2/0	1/0	2/0
	11.9 m (39 ft)	1	2/0	1/0	2/0
	12.2 m (40 ft)	1	2/0	1/0	2/0

Verado Engine Battery Specifications

IMPORTANT: Verado engines require a 12 volt absorbed glass mat (AGM) marine starting battery that meets the minimum ratings.

For best performance, Mercury Marine does not recommend using the more common flooded (wet cell) or gel cell type lead acid batteries for starting Verado engines.

Each Verado engine must be equipped with its own starting battery.

If the boat application requires additional battery loads for boat accessories or marine electronics, it is recommended that an auxiliary battery, or batteries, be installed.

Choose a 12 volt AGM battery which meets the following ratings.

1. Standard (original) cable length and wire gauge size.

USA (SAE) Verado Starting Battery Rating	
Required Verado starting battery	12 volt AGM battery
Required marine cranking amps (MCA) and reserve capacity	800 minimum marine cranking amps with a minimum reserve capacity of 135 minutes RC25 rating

International (EN) Verado Starting Battery Rating	
Required Verado starting battery	12 volt AGM battery
Required cold cranking amps (CCA) and amp hour (Ah)	975 minimum cold cranking amps (CCA) with a minimum of 65 amp hours (Ah)

NOTE: Do not use an engine starting battery that does not meet the specified ratings. If a battery that does not meet the ratings is used, the electrical system may perform poorly.

IMPORTANT: Boating industry standards (BIA, ABYC, etc.), federal standards, and Coast Guard regulations must be adhered to when installing the battery. Ensure that battery cable installation meets the pull test requirements and that the positive battery terminal is properly insulated in accordance with regulations.

It is recommended (required in some states) that the battery be installed in an enclosed case. Refer to regulations for your area.

When connecting the engine battery, hex nuts must be used to secure the battery leads to the battery posts. Tighten the hex nuts to the specified torque.

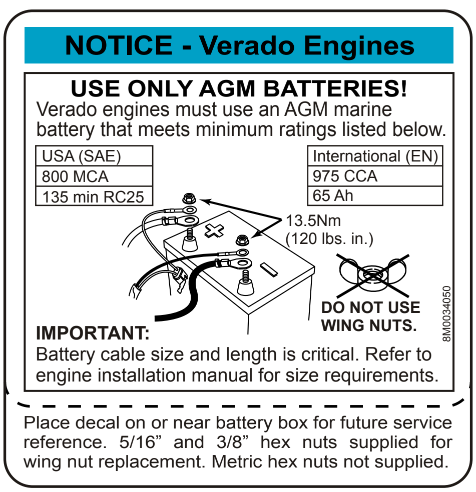
⚠ WARNING

Failure to properly secure the battery leads can result in a loss of power to the Digital Throttle and Shift (DTS) system, leading to serious injury or death due to loss of boat control. Secure the battery leads to the battery posts with hex nuts to avoid loose connections.

Description	Nm	lb-in.	lb-ft
Hex nuts	13.5	120	

IMPORTANT: Battery cable size and length is critical. Refer to Battery Cable Size tables or engine installation manual for size requirements.

The decal needs to be placed on or near the battery box for future service reference. One 5/16 in. and one 3/8 in. hex nut is supplied per battery for wing nut replacement. Metric hex nuts are not supplied.



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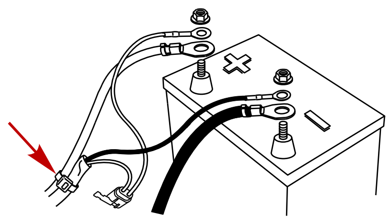
Connecting Battery Cables and DTS Power Harness

⚠ CAUTION

The DTS power harness connection may be pulled off the battery, resulting in a possible loss of electrical power and loss of throttle and shift control. To avoid the possibility of serious injury or death from a loss of boat control, fasten the DTS power harness to one of the battery cables near the battery with cable tie.

- Install DTS power harness directly to the starting battery only.
- Do not extend lead length of harness.

- See accessory manual for optional lead connection kit.



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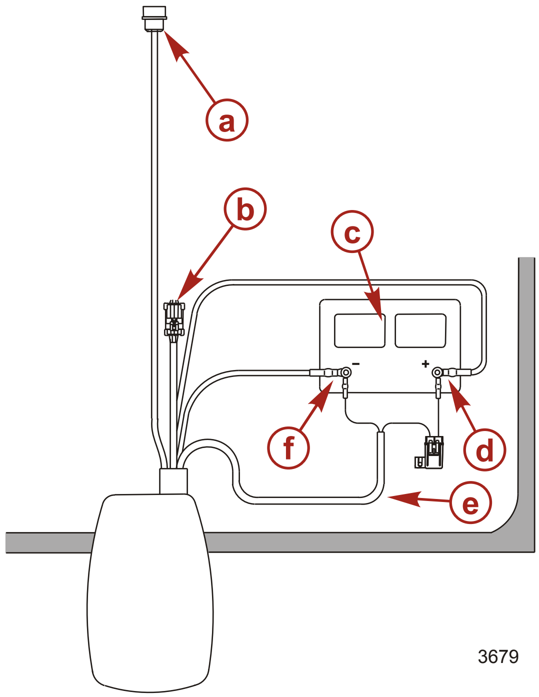
Single Engine - Battery at Stern



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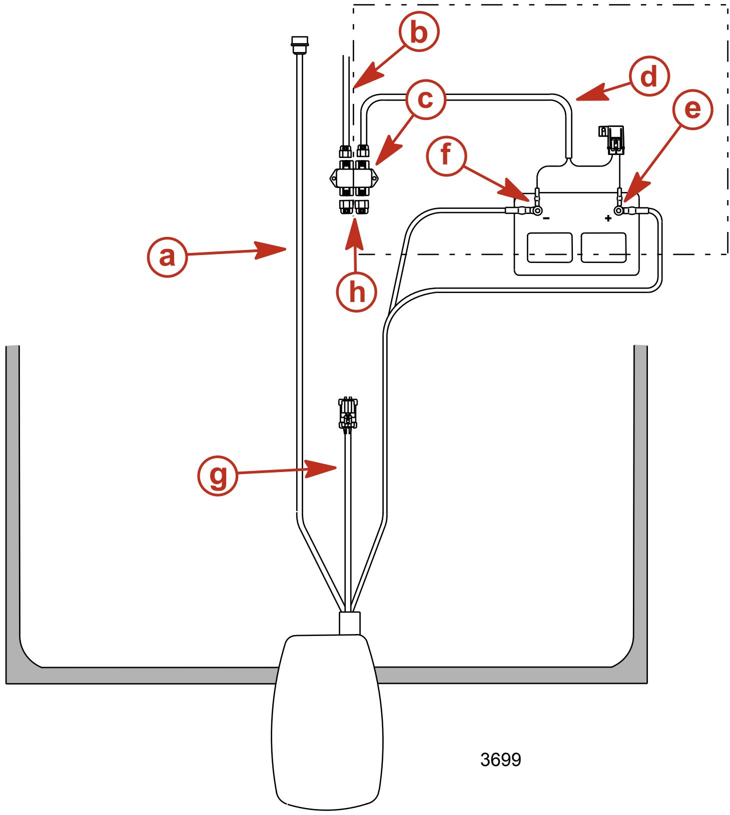
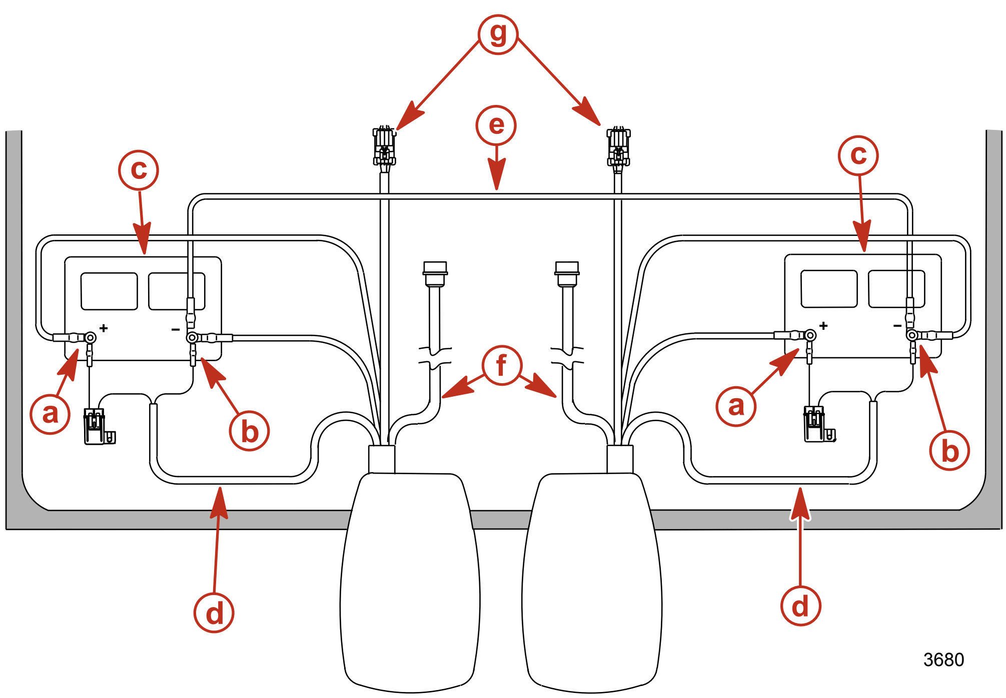
a - 14 pin DTS data harness
b - Vessel sensor harness
c - Battery
d - Red sleeve (positive)
e - DTS power harness (provided)
f - Black sleeve (negative)

Single Engine - Battery at Helm



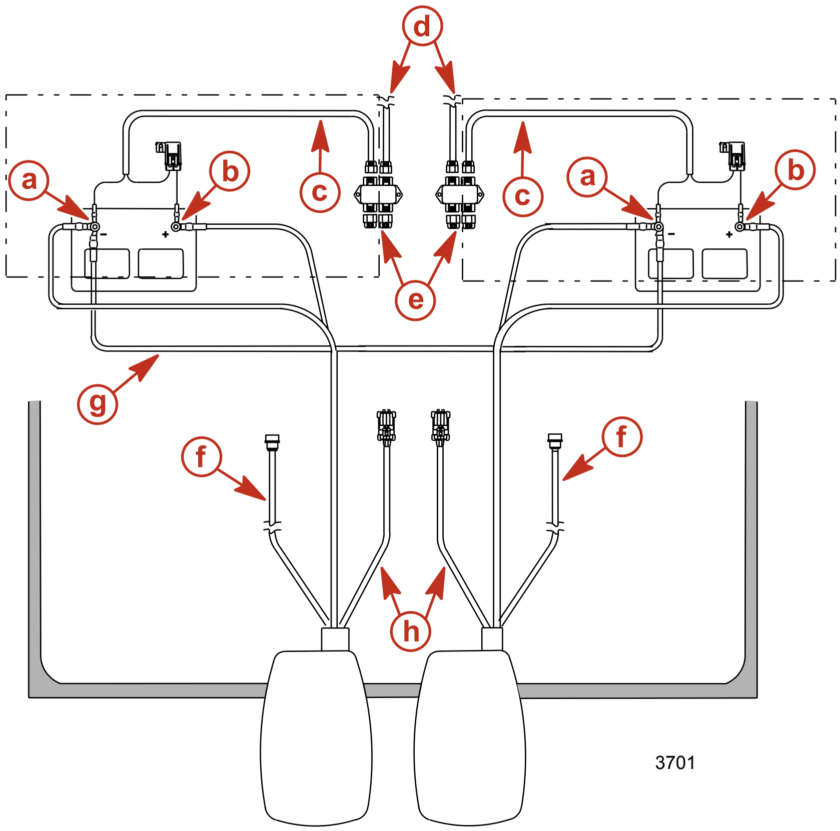
- a - 14 pin data harness
- b - DTS command module harness
- c - Junction box
- d - Helm DTS power harness (optional)
- e - Red sleeve (positive)
- f - Black sleeve (negative)
- g - Vessel sensor harness
- h - Weather caps

Dual Engine - Battery at Stern



- a - Red sleeve (positive)
- b - Black sleeve (negative)
- c - Battery
- d - DTS power harness (provided)
- e - Ground cable
- f - Data cable
- g - Vessel sensor harness

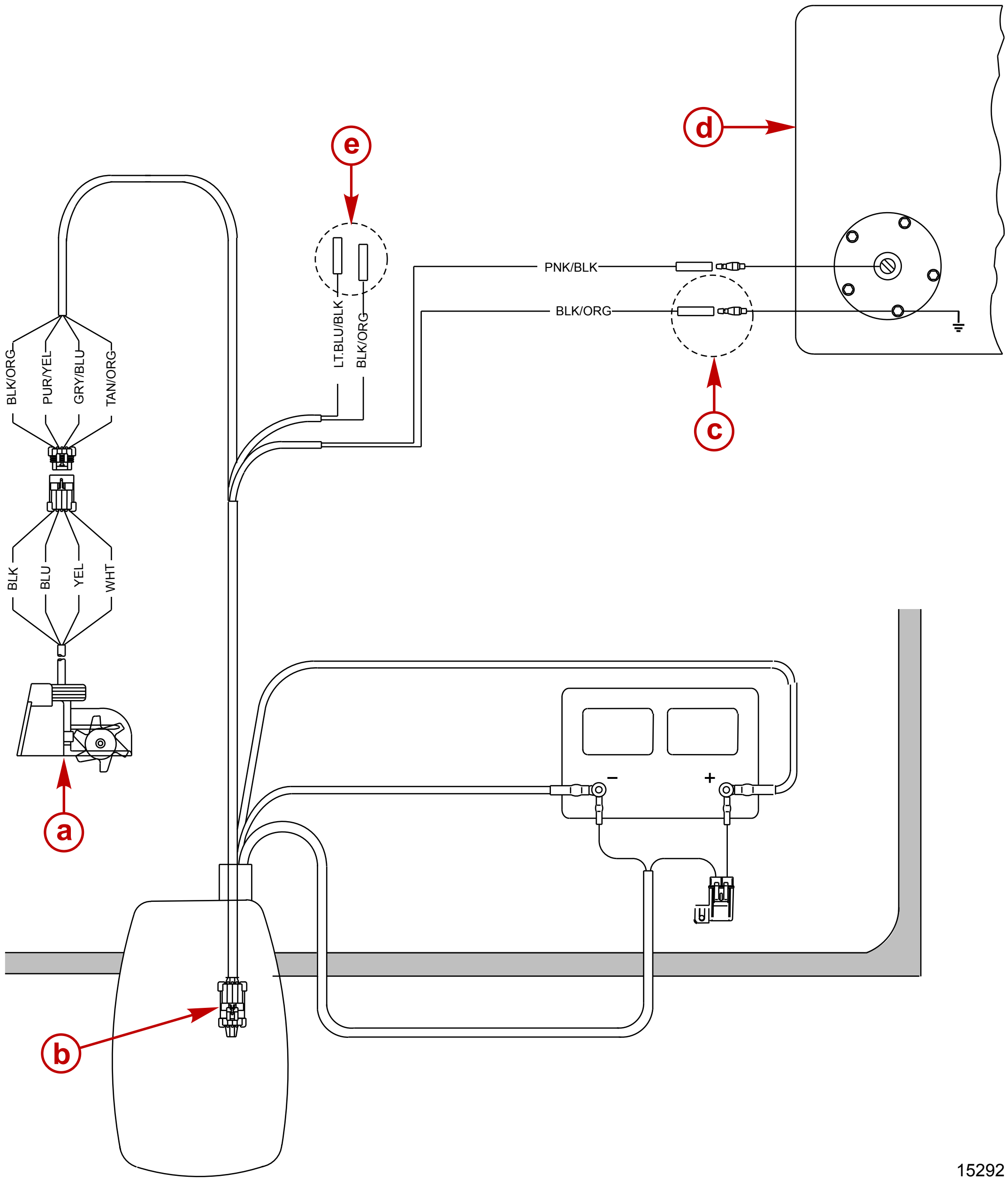
Dual Engine - Battery at Helm



- a - Black sleeve (negative)
- b - Red sleeve (positive)
- c - Helm DTS power harness (optional)
- d - DTS command module harness
- e - Junction box weather caps
- f - 14 pin data harness
- g - Ground cable
- h - Vessel sensor harness

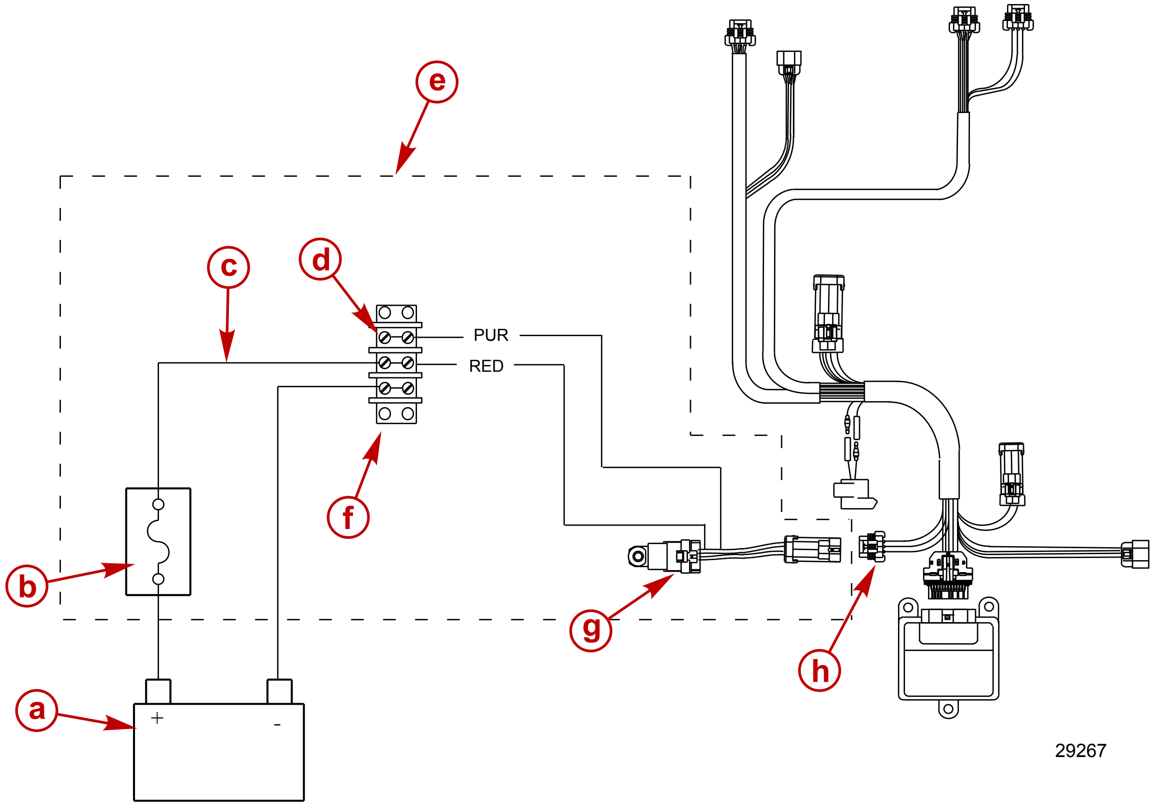
Connecting Fuel Tank and Speed Sensor

IMPORTANT: Do not connect the BLK/ORG wire (if equipped) to the fuel tank sensor when there is an engine battery ground strap connected to the fuel tank or sender assembly. If not used, plug the unused open bullet connector with a rubber plug. Metal fuel tanks must be grounded to hull or battery ground in accordance to Coast Guard regulations.
If fuel tank is plastic and fuel sensor mounting plate is not connected to battery ground, connect BLK/ORG wire (if equipped) to fuel sender mounting plate.



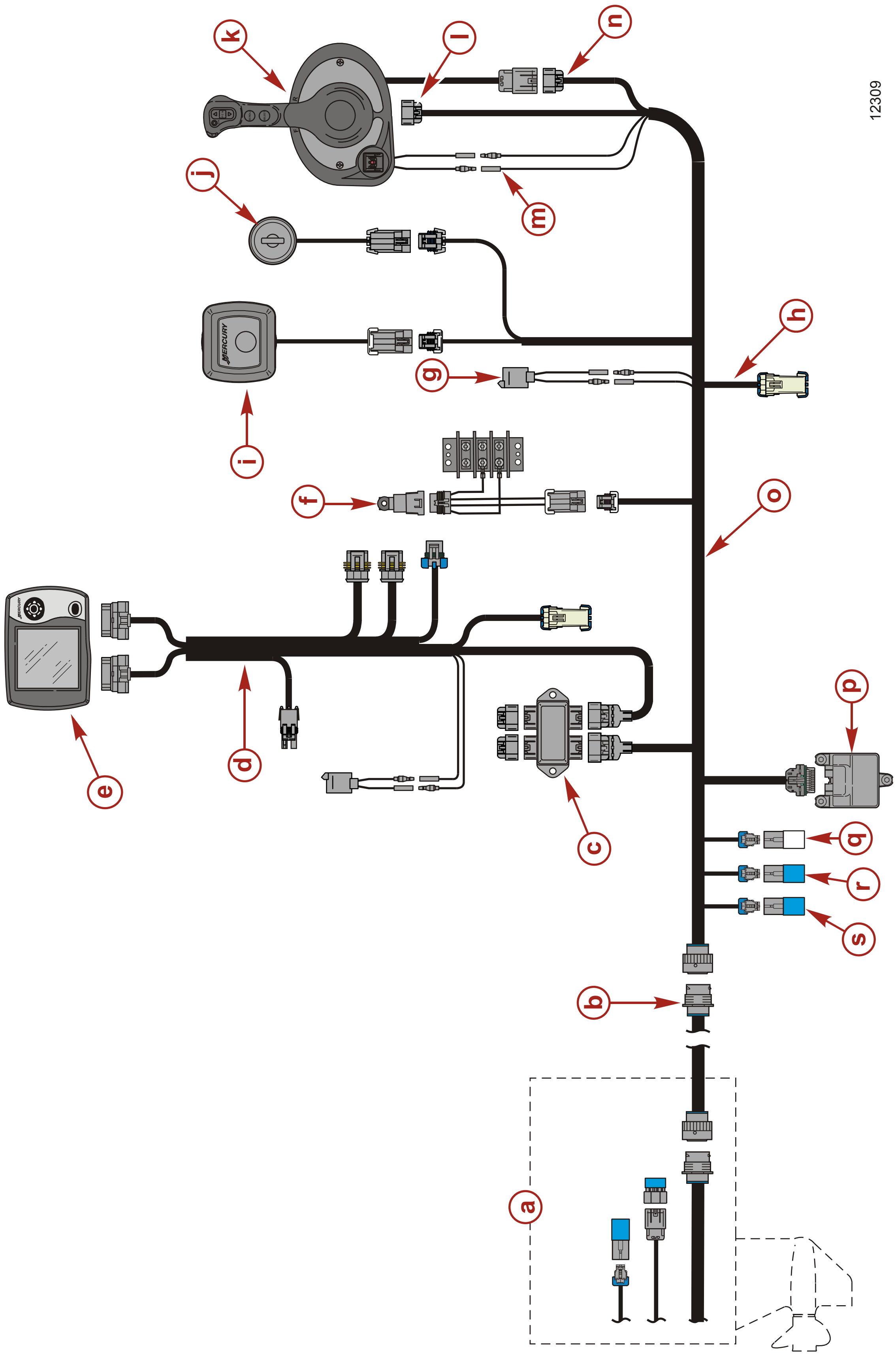
- a - Paddle wheel kit
- b - Vessel harness
- c - Black/orange wire connection, if equipped
- d - Fuel tank
- e - To second fuel tank

Switched 12 V Accessory Connection



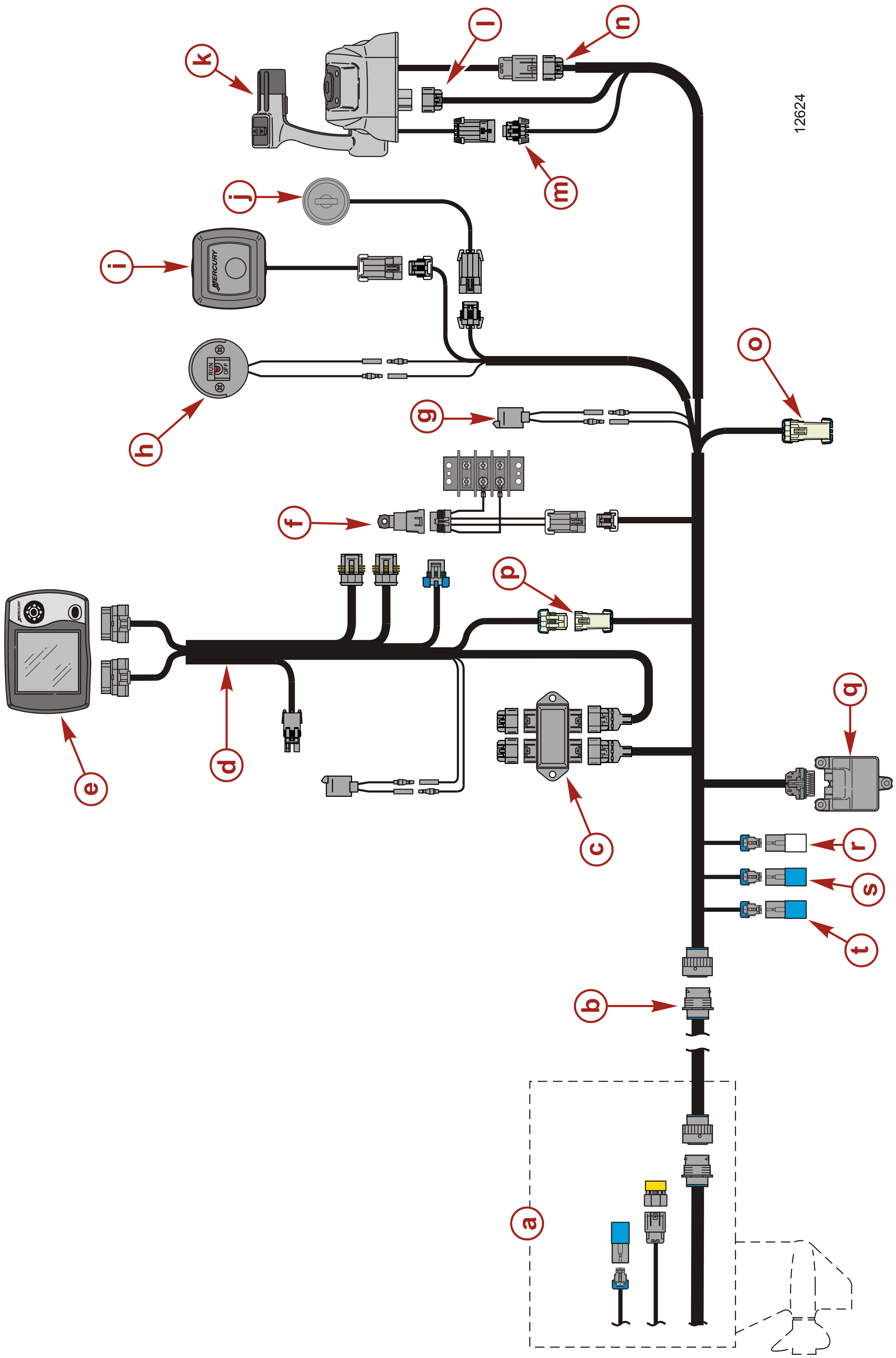
a - Battery
b - Fuse - 40 amp
c - Power harness with 40 amp fuse
d - Switched 12 V
e - Complete kit
f - Terminal block
g - Accessory power relay
h - DTS command module harness

DTS Panel Mount Control Wiring



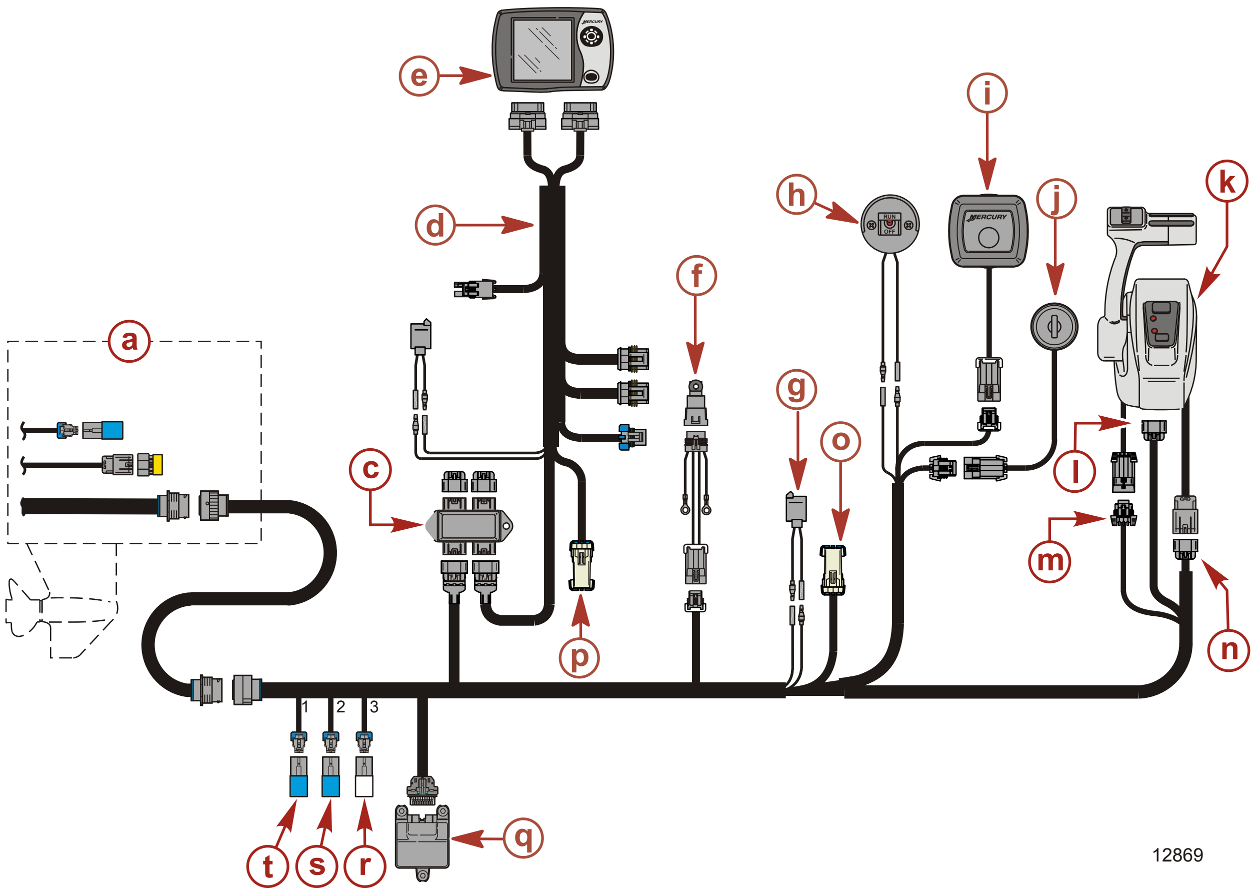
a - Engine
b - 14 pin data harness
c - Junction box
d - System View harness
e - System View
f - Switched power relay
g - Warning horn
h - Foot throttle connector
i - Start/stop switch (optional)
j - Ignition key switch
k - Panel mount control
l - Lever 1 connector
m - Lanyard stop switch connectors
n - Handle connector
o - Command module harness
p - Command module
q - CAN 3 connector (orange and green)
r - CAN 2 connector (brown and yellow)
s - CAN 1 connector (blue and white)

DTS Single Console Mount Control Wiring - Single Helm



a - Engine
b - 14 pin data harness
c - Junction box
d - System View harness
e - System View
f - Switched power relay
g - Warning horn
h - Lanyard stop switch
i - Start/stop switch (optional)
j - Ignition key switch
k - Single console control
l - Lever 1 connector
m - Handle connector
n - Trackpad connector
o - Foot throttle connector
p - System View/trackpad connector
q - Command module
r - CAN 3 (orange and green) (weather cap)
s - CAN 2 (brown and yellow) (terminator)
t - CAN 1 (blue and white) (terminator)

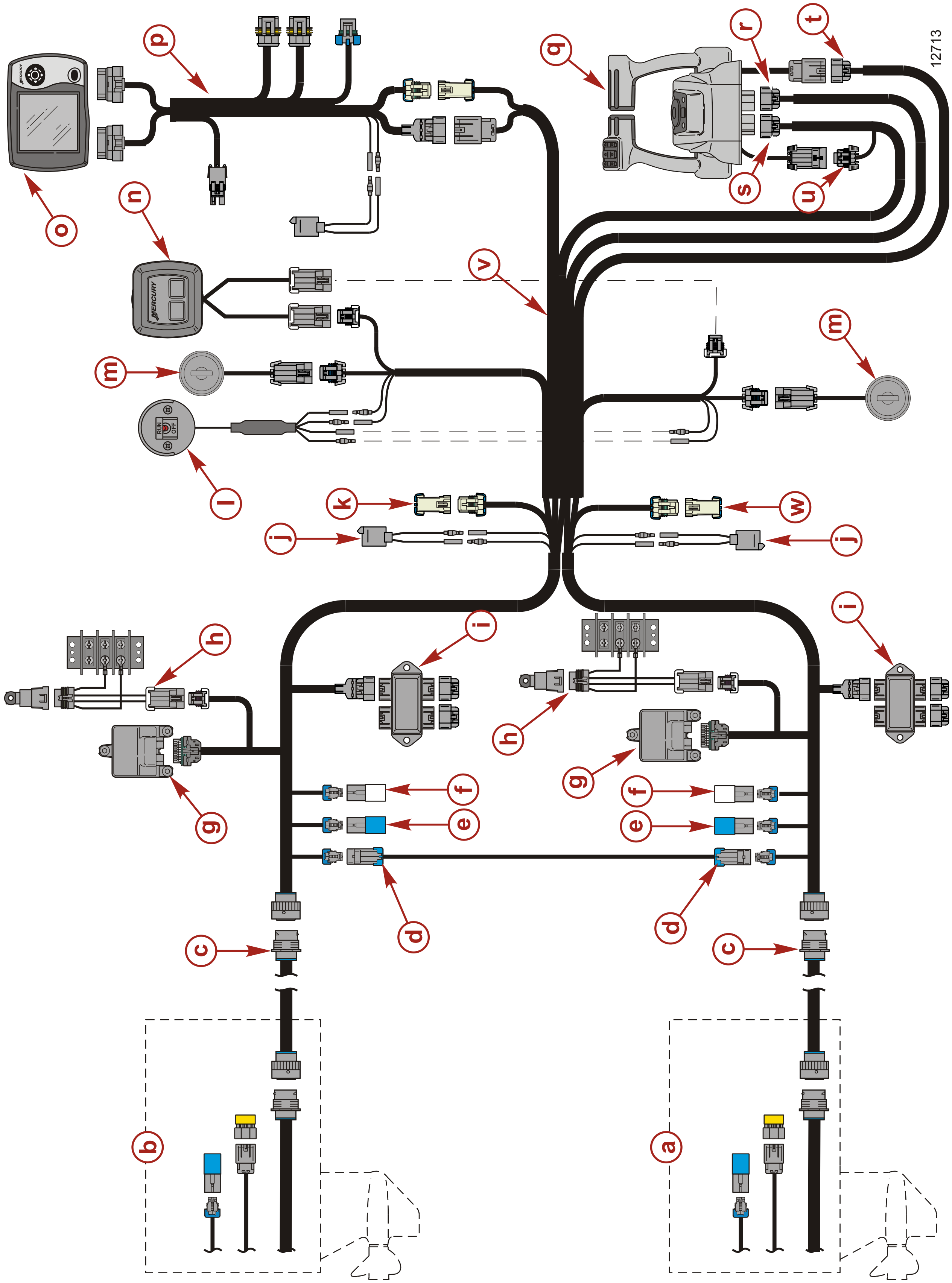
DTS Slim Binnacle Single Console Mount Control Wiring - Single Helm



- a - Engine
- b - 14 pin data harness
- c - Junction box
- d - System View harness
- e - System View
- f - Switched power relay
- g - Warning horn
- h - Lanyard stop switch
- i - Start/stop switch (optional)
- j - Ignition key switch
- k - Slim binnacle single console control
- l - Lever 1 connector
- m - Handle connector
- n - Start/stop panel connector
- o - Foot throttle connector
- p - System View/trackpad connector
- q - Command module
- r - CAN 3 (orange and green) (weather cap)
- s - CAN 2 (brown and yellow) (terminator)
- t - CAN 1 (blue and white) (terminator)

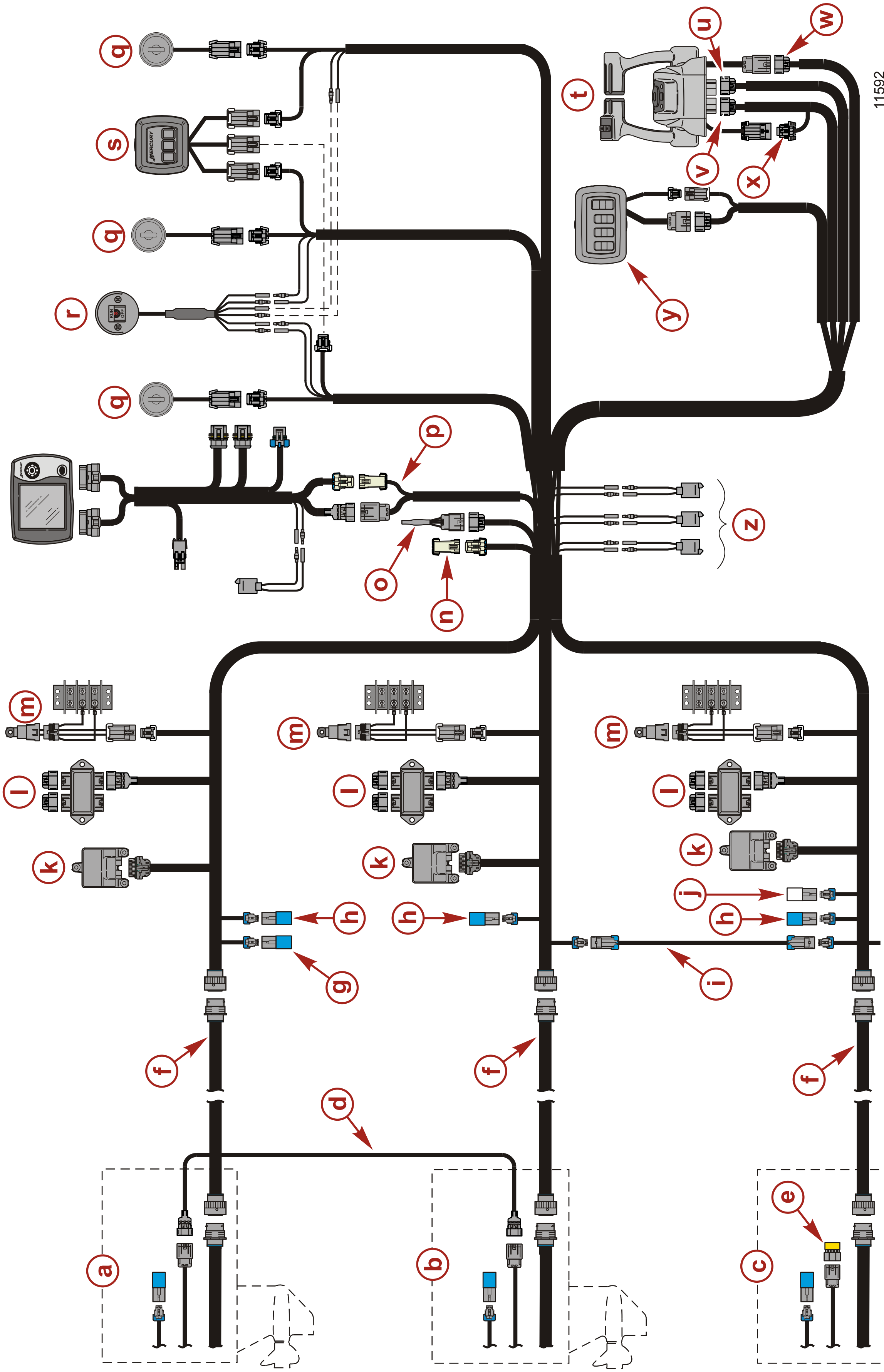
Notes:

DTS Dual Console Mount Control Wiring - Single Helm



a - Starboard engine
b - Port engine
c - 14 pin data harness
d - CAN 1 link harness
e - CAN 2 (brown and yellow) (terminator)
f - CAN 3 (orange and green) (weather cap)
g - Command module
h - Accessory power relay
i - Junction box
j - Warning horn
k - Lever 3 connector
l - Lanyard stop switch
m - Ignition key switch
n - Start/stop switch (optional)
o - System View
p - System View harness
q - Dual console control
r - Lever 1 connector
s - Lever 2 connector
t - Trackpad connector
u - Trim connector
v - Command module harness
w - Lever 4 connector

DTS Triple Engine Shadow Mode Control Wiring - Single Helm



a - Port engine
b - Starboard inner engine
c - Starboard outer engine
d - 10 pin CAN link harness
e - CAN 1 connector - terminator
f - 14 pin data harness
g - CAN 1 (blue and white) - terminator resistor
h - CAN 2 (brown and yellow) - terminator resistor
i - 2 pin CAN link harness
j - CAN 3 (orange and green) - weather cap
k - Command module
l - Junction box
m - Accessory power relay
n - For future use
o - Resistor pack (#93)
p - Gauge connectors
q - Ignition key switch
r - Lanyard stop switch
s - Start/stop switch
t - Shadow mode control
u - Lever 1 connector
v - Lever 2 connector
w - Trackpad connector
x - Handle trim connector
y - Dash mounted trim switch
z - Warning horns

System Wiring Installation Checklist

Data Cable

- ☐ Verify the data harness is not routed near sharp edges, hot surfaces, or moving parts.
- ☐ Verify data harness is not routed near ignition components (coils, spark plug leads, and spark plugs), high power VHF coax, or radios.

Junction Box (if equipped)

- ☐ Verify the data harness is not routed near sharp edges, hot surfaces, or moving parts.
- ☐ Ensure the harness connections are fastened within 25.4 cm (10 in.) of the junction box.
- ☐ Verify that all unused receptacles are covered with a weather cap.

Non-Mercury Marine Supplied Ignition Key Switch

- ☐ If a non-Mercury Marine ignition key is used, verify that it passes the ingress protection testing per IEC IP66 specification minimum. Ignition switches must pass this specification.

Electronic Remote Control

- ☐ Ensure electronic remote control (ERC) connections are completed following ERC installation instructions prior to engine operation.

DTS Command Module Harness

- ☐ Verify that all connectors are properly inserted and locked in their receptacle (remote control, key switch, command module, lanyard stop switch, and junction box, if equipped).
- ☐ Verify that while moving the remote control handle (full forward and full reverse) the harness has unobstructed movement (moves freely).
- ☐ Verify that the lanyard stop switch is wired into the system correctly.
- ☐ Verify that the harness is fastened along the routing path.
- ☐ Verify that all unused connectors have weather caps to prevent corrosion.

Battery

- [ ] Verify that wing nuts have been replaced with hex nuts, provided.
- [ ] Verify that all engine battery cables are connected to the correct terminals.
- [ ] Verify that the DTS power harness leads are connected to the starting battery and secured with locknuts.
- [ ] Ensure the 5 amp fuse for the DTS power harness is accessible.

Lanyard Stop Switch

- [ ] Verify that the switch is installed.
- [ ] Verify that the switch is connected to the DTS command module harness.

Propeller Installation

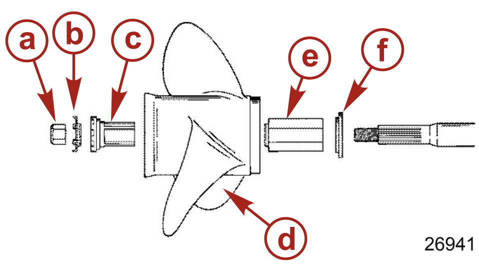
⚠ WARNING

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. To aid in future removal of the propeller, liberally coat the propeller shaft splines with one of the following Mercury/Quicksilver products:

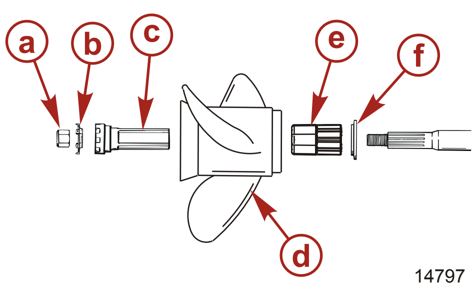
Tube Ref No.	Description	Where Used	Part No.
94	Anti-Corrosion Grease	Propeller shaft splines	92-802867Q 1
95	2-4-C with Teflon	Propeller shaft splines	92-802859A 1

2. **Flo-Torq II drive propellers -** Install forward thrust hub, replaceable drive sleeve, propeller, thrust hub, propeller nut retainer, and propeller nut onto the shaft.



a - Propeller nut
b - Propeller nut retainer
c - Thrust hub
d - Propeller
e - Replaceable drive sleeve
f - Forward thrust hub

3. **Flo-Torq IV drive propellers -** Install forward thrust hub, replaceable drive sleeve, propeller, thrust hub, propeller nut retainer, and propeller nut onto the shaft.

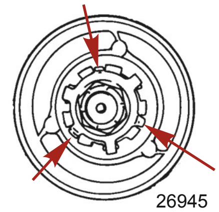


a - Propeller nut
b - Propeller nut retainer
c - Thrust hub
d - Propeller
e - Replaceable drive sleeve
f - Forward thrust hub

4. Place a block of wood between gearcase and propeller and torque nut to specification.

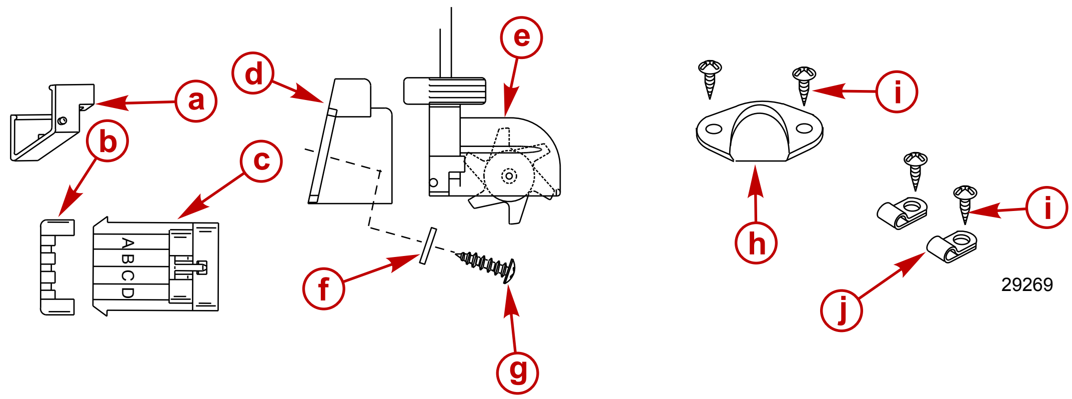
Description	Nm	lb-in.	lb-ft
Nut	75		55

5. Secure propeller nut by bending three of the tabs into the thrust hub grooves.



Paddle Wheel Speed Sensor Installation (if Equipped)

Parts Provided



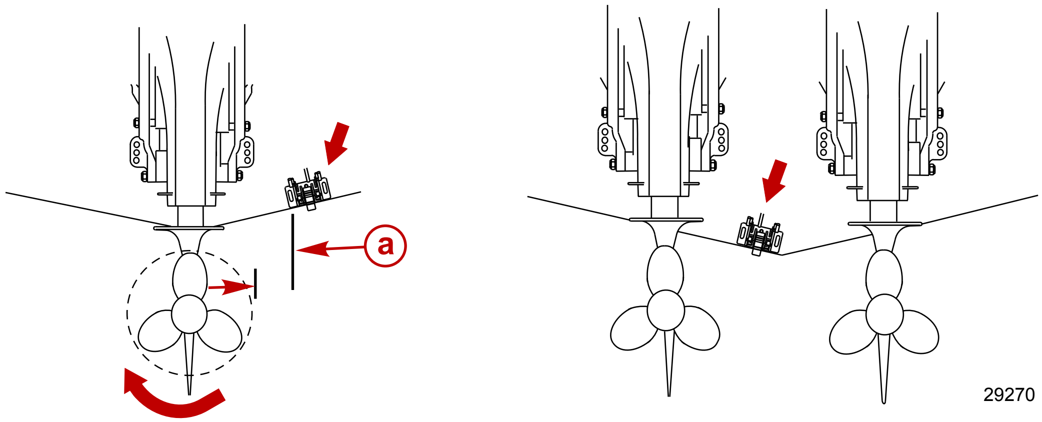
a - Spare pin yoke
b - Wire retainer
c - Connector
d - Bracket
e - Paddle wheel
f - Flat washer (2)
g - #10 screw - 19 mm (3/4 in.) (4)
h - Cable cap
i - #6 screw - 12 mm (1/2 in.) (4)
j - Clamp (2)

Selecting Location

Single engine installation - Mount paddle wheel on the transom where the propeller blade is rotating downward. Usually the right (starboard) side to minimize cavitation. If feasible, mount at least 50 mm (2 in.) beyond the swing radius of the propeller.

Dual engine installation - Mount the paddle wheel between the engines as close to the centerline (keel) of the boat as possible. On slower, heavier displacement boats, however, positioning it farther from the keel is acceptable.

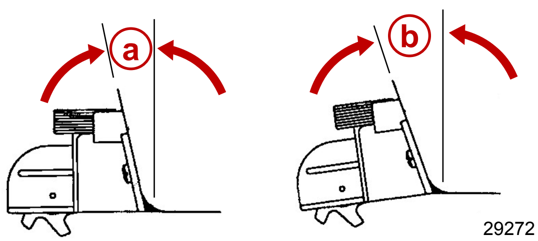
NOTE: Do not mount the paddle wheel directly behind any stakes, ribs, intakes, or outlets for livewells or any protrusion that may cause turbulence or cavitation.



a - 50 mm (2 in.)

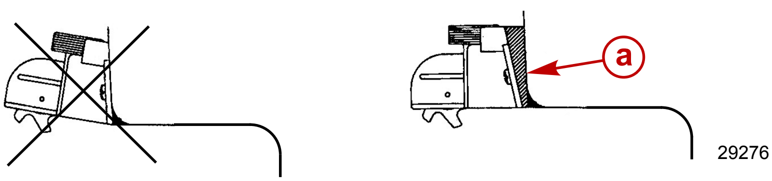
Transom Angle Requirements

Standard 13° to 20° transoms - No special adjustment required.



a - 13° transom angle
b - 20° transom angle

Stepped or undercut transom with 3 angles - A small shim of tapered plastic, metal, or wood must be fabricated and installed, as shown. Mount the paddle wheel on the step for best performance.



a - Shim

Installing Bracket

1. Cut out the template. At the location selected, tape the template to the transom. Make sure the black dotted line on the template is aligned with the transom bottom edge, as shown.

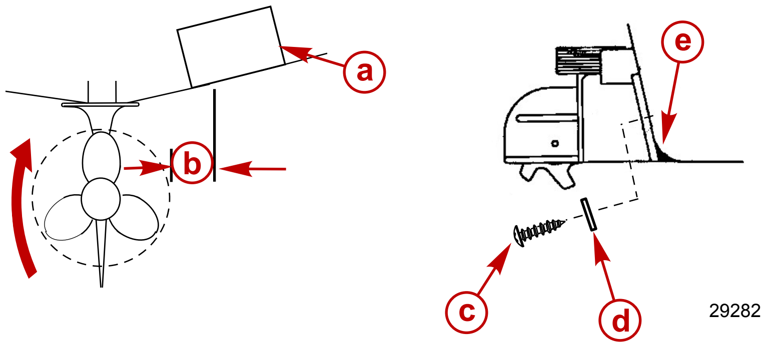
   NOTE: The mounting template provided is located on the last page of this manual.

2. Using a #28 or 9/64 in. bit, drill two 22 mm (7/8 in.) deep holes where indicated on the template. To prevent drilling too deeply, wrap masking tape around the drill bit 22 mm (7/8 in.) from the point end of drill bit.

   NOTE: In fiberglass hulls, first chamfer the gelcoat using a 6 mm (1/4 in.) drill; drilling about 1.5 mm (1/16 in.) deep to prevent surface cracks.

3. To prevent water seepage into the transom, apply a marine sealer (such as RTV) to the two #10 screws provided. Using the washer provided, attach and tighten the bracket to the hull making sure the bracket is flush with the underside of the hull.

4. Fill any gap between the housing and the transom with a caulking material, as shown. Using a putty knife, smooth the surface to ensure proper water flow.



a - Template
b - 50 mm (2 in.)
c - #10 screw
d - Flat washer (2)
e - Caulking

Routing the Cable

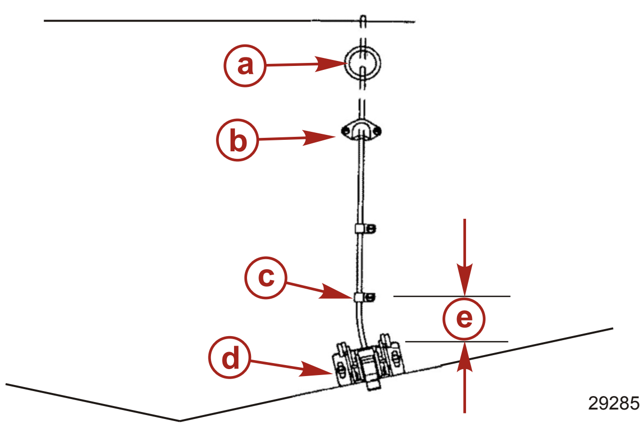
Drilling Hole Through Transom (optional)

1. Select a transom location for the hole above the waterline that does not interfere with other cables and controls.
2. Drill a 15 mm (5/8 in.) diameter hole.
3. Route the cable through the drilled hole. Seal the transom hole with silicone (RTV) or a comparable marine sealer after the cable has been routed through.

   NOTE: *The hole for the first clamp should be 25 mm (1 in.) above the paddle wheel. The hole for the second clamp should be positioned halfway between the first clamp and the cap covering the transom hole drilled for the cable.*
4. Using a 2.8 mm (7/64 in.) bit, drill holes for the clamps and cap approximately 13 mm (1/2 in.) deep.
5. Apply silicone sealer (RTV) or a comparable marine sealer to the screw threads, install the cable clamps, and feed the cable through the cable cap.

Without Drilling Hole Through Transom (optional)

Route the cable over the transom or through a drain hole that is above the waterline.

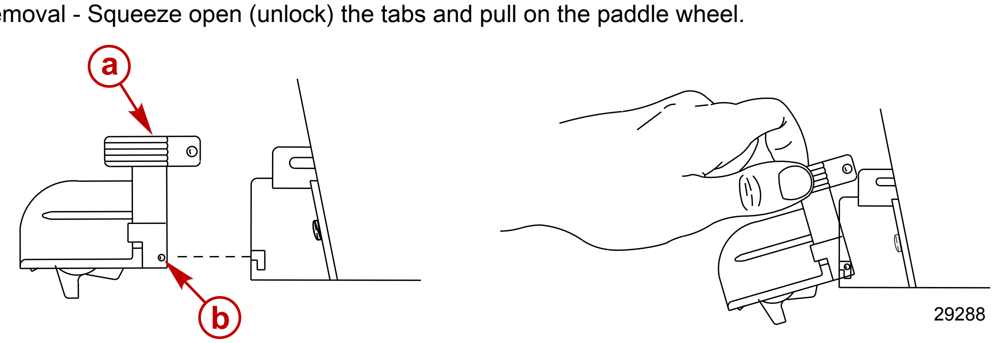


a - Splash well drain hole
b - Cable cap
c - Cable clamp
d - Paddle wheel assembly
e - Distance between first cable clamp and top of paddle wheel - 25.4 mm (1.0 in.)

Installing and Removing the Paddle Wheel

Installation - Slide the pins into the slots in the bracket and snap the tabs into place.

Removal - Squeeze open (unlock) the tabs and pull on the paddle wheel.

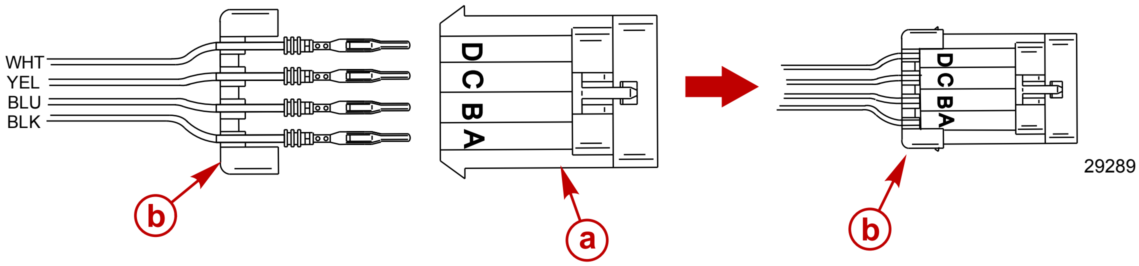


a - Tabs
b - Pins

Wiring Connections

IMPORTANT: Before making wire connections, make sure wires are routed through the transom.

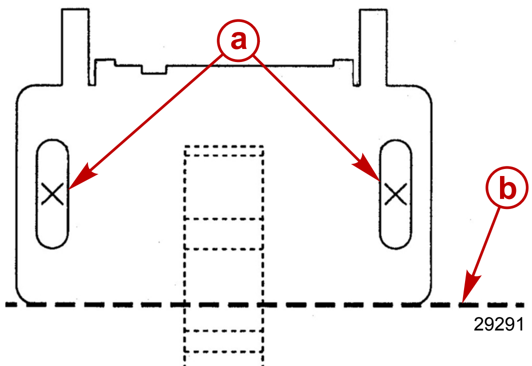
NOTE: Wires can only be pushed into the connector one way. Align the wire terminal with the tabs inside the connector. Have the wiring routed through the transom. Push each wire terminal into its respective location in the connector. Push wire in until they snap into place. Secure wires into connector with the wire retainer.



a - Connector

b - Wire retainer

Template - Paddle Wheel Speed Sensor



a - Drill holes here

b - Align dotted line with the transom bottom edge and fold under

Electrical

Section 2A - Ignition

2
A

Table of Contents

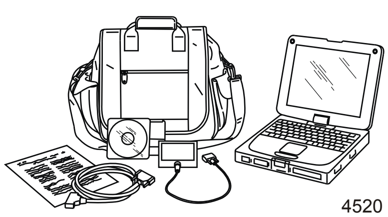
Ignition Specifications

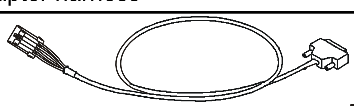
Ignition Specifications	
Full throttle RPM	
135/150/175/200 hp	5800–6400
Idle RPM (all models)	650
Ignition type	Digital inductive
Spark plug type	NGK ILFR6G or NGK ILFR6GE
Spark plug gap	0.8 mm (0.031 in.)
Spark plug hex size	16 mm
Spark plug torque	27 Nm (20 lb-ft)
Spark plug hole size	14 mm
Firing order	1-3-4-2
Ignition timing at idle	Approximately 2° ATDC; PCM controlled
Ignition timing at WOT	PCM controlled
PCM overspeed limiter	Activates at 6500 RPM

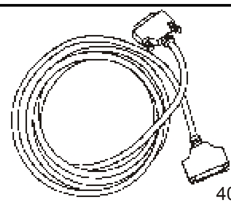
Lubricant, Sealant, Adhesives

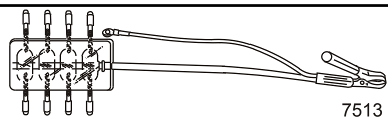
Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Oil pressure sensor threads	92-809822
25	Liquid Neoprene	All ring terminal connections	92- 25711 3
136	Lubriplate SPO 255	Camshaft position sensor O-ring	Obtain Locally

Special Tools

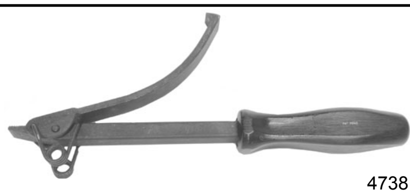
Computer diagnostic system (CDS)	Order through SPX
 4520	Monitors all electrical systems for proper function, diagnostics, and calibration purposes. For additional information, pricing, or to order the Computer Diagnostic System contact: SPX Corporation 28635 Mound Rd. Warren, MI 48092 or call: USA - 1-800-345-2233 Canada - 800-345-2233 Europe - 49 6182 959 149 Australia - (03) 9544-6222

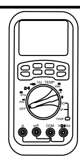
Adapter harness	84-822560A13
 5826	Data link harness between the engine and the Computer Diagnostic System (CDS).

Extension cable	84-825003A1
 4012	Data link extension harness (3.05 m[10 ft.]) between adapter harness and the Computer Diagnostic System (CDS).

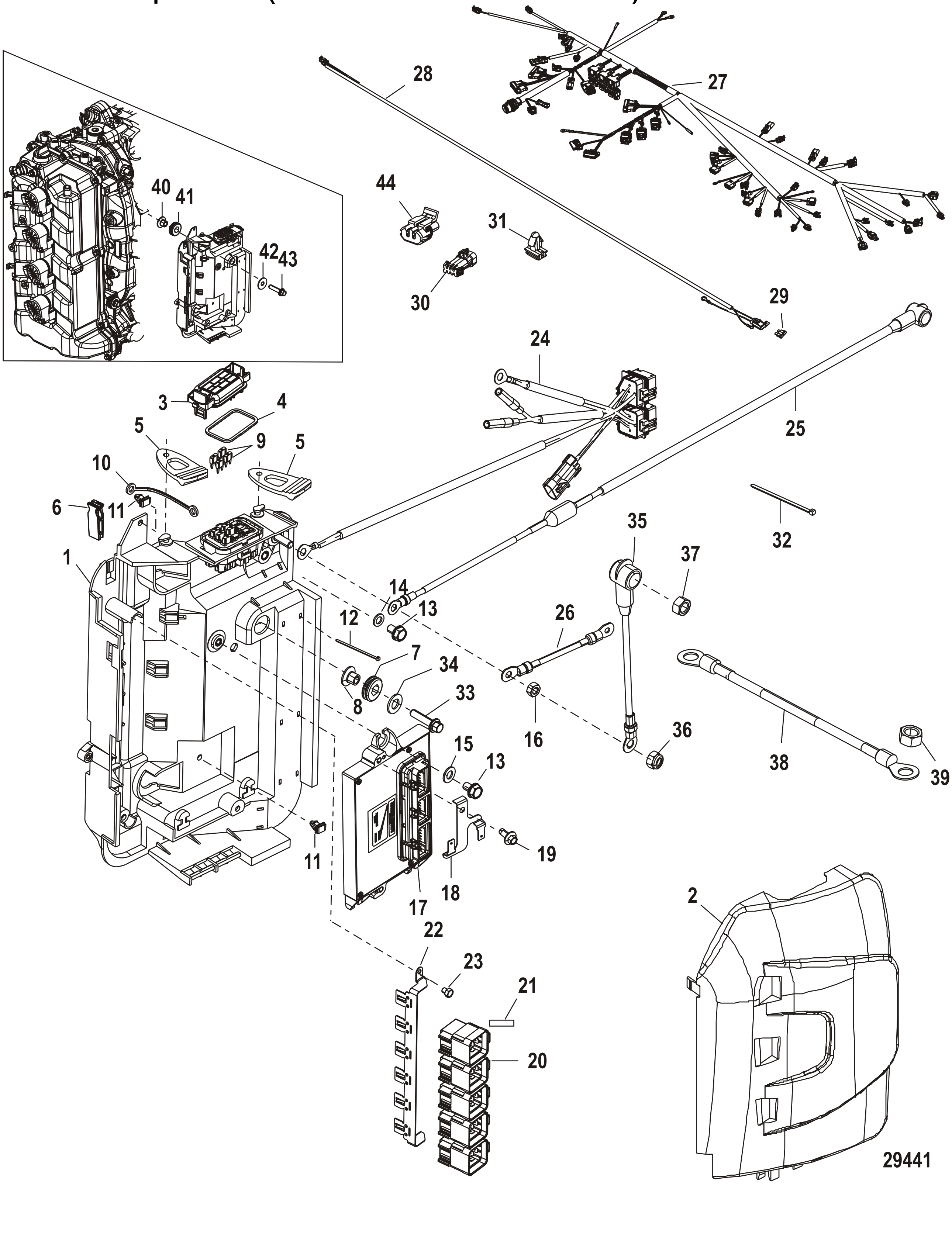
Spark gap tester	91-850439T 1
 7513	Provides a visual indication of spark/coil efficiency.

Flywheel Puller/Lifting Ring	91-895343T02
 14869	Removes flywheel from engine. Used for lifting powerhead/engine.

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.

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

Electrical Components (135–200 In-line FourStroke)

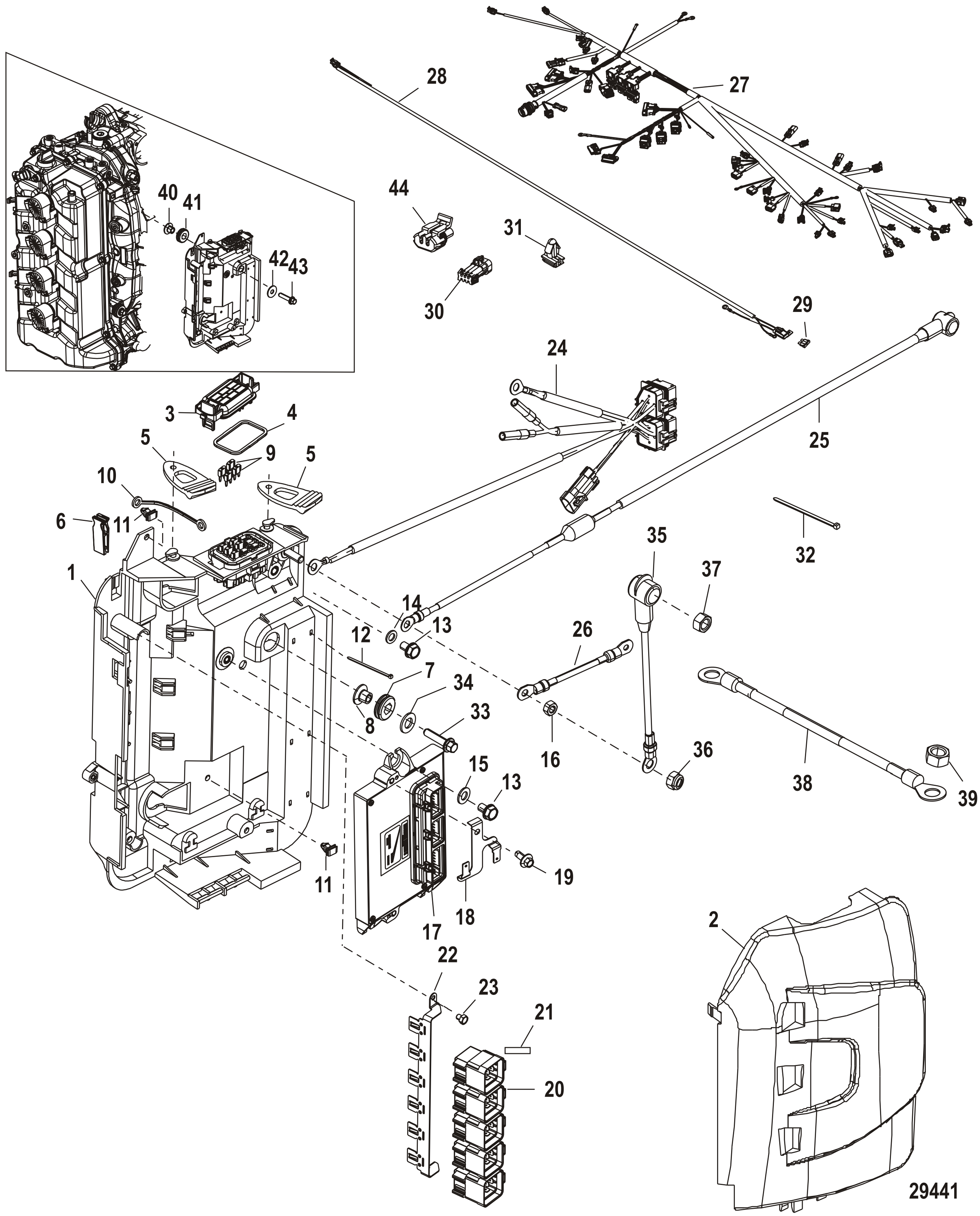


Electrical Components (135–200 In-line FourStroke)

Ref. No.	Qty.	Description	Torque Nm	Torque lb-in.	Torque lb-ft
1	1	Electrical box base			
2	1	Electrical box cover			
3	1	Fuse cover			
4	1	Seal			
5	2	Strap			
6	1	Fuse extractor			
7	1	Grommet			
8	1	Bushing			
9	7	Fuse			
10	1	Strap			
11	2	Clip			
12	8	Cable tie			
13	2	Bolt (M8 x 10)	9	80	
14	1	Washer			
15	1	Washer			
16	1	Nut (M8)	17	150	
17	1	PCM			
18	1	Clip			
19	1	Screw (M6 x 14)	6	53	
20	5	Relay assembly			
21	5	Decal			
22	1	Relay bracket assembly			
23	2	Bolt (M5 x 6)	4.5	40	
24	1	Trim harness assembly			
25	1	Fuse harness assembly (150 amp)			
26	1	Starter cable assembly			
27	1	Engine harness assembly			
28	1	Command harness interface power harness assembly			
29	1	Command harness interface power fuse (tan 5 amp)			
30	1	Weather cap			
31	1	Clip			
32	AR	Cable tie			
33	1	Bolt (M8 x 35)	24	212	
34	1	Washer			
35	1	Positive battery cable			
36	2	Nut (M8)	17	150	
37	1	Nut (0.312-18)	13.5	120	
38	1	Negative battery cable			
39	1	Nut (0.312-18)	17	150	
40	2	Bushing			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
41	2	Grommet			
42	2	Washer			
43	2	Bolt (M8 x 35)	24	212	
44	1	Weather cap - 2 pin female			

Electrical Components (135–200 In-line FourStroke)



Troubleshooting without a Computer Diagnostic System (CDS)

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

Typical failures usually do not involve the PCM. Connectors, set-up, or mechanical wear are most likely at fault.

- Verify the ignition coils are securely installed (pushed in) into 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 PCM Fault History. Use the CDS to view the PCM fault history when troubleshooting/repair is completed.

- If all cylinders exhibit similar symptoms, the problem is with a sensor or harness input to the PCM.
- If 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.

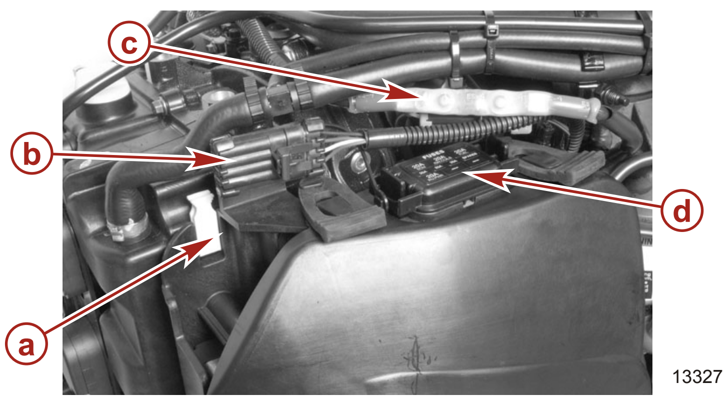
Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	All ring terminal connections	92- 25711 3

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

Troubleshooting with the Computer Diagnostic System (CDS)

The CDS is designed to help technicians diagnose and repair Mercury Marine 2 and 4 cycle engines.

Attach the adapter harness diagnostic cable to the PCM diagnostic connector. This will enable the technician to monitor sensors and PCM data values including status switches. Use the 3 m (10 ft) extension cable between the CDS diagnostic connector and the PCM adapter to monitor the engine system while at the helm.



a - Fuse removal tool
b - Diagnostic terminal connector
c - 150 amp fusible link
d - Fuse holder

The PCM program can help diagnose intermittent engine problems. It will record the state of the engine sensors and switches for a period of time and then can be played back to review the recorded information.

Refer to the CDS reference manual for complete diagnostic procedures.

Computer diagnostic system (CDS)	Order through SPX
Adapter harness	84-822560A13
Extension cable	84-825003A1

Troubleshooting Guide

Spark gap tester	91-850439T 1
Computer diagnostic system (CDS)	Order through SPX

1. Engine Cranks but Will Not Start	
Cause	Action
1.0 Weak battery or bad starter motor, battery voltage drops below 11 volts while cranking (PCM cuts out below 8 volts) (fuel pump requires 9 volts)	Replace/recharge battery. Inspect condition of starter motor. Check condition of battery terminals and cables.
1.1 No fuel	Turn the key switch to the "RUN" position to verify fuel pump runs for 5 seconds and then turns off. If no fuel is available, pump will run for as long as 45 seconds before shutting off. *NOTE: Running fuel pump for up to 45 seconds due to lack of fuel will damage the fuel pump.*
1.2 Low fuel pressure	Measure fuel pressure (valve on top of fuel rail). Fuel pressure should be 281–345 kPa (41–50 psi).
1.3 Flywheel key sheared or flywheel key not installed	Remove flywheel and inspect.
1.4 Blown fuse	Inspect 20 amp fuse in fuse holder and replace if blown.
1.5 Main power relay not functioning	Listen for relay to click when the key switch is turned on. If relay does not click, inspect harness and connector pins for damage.
1.6 Spark plugs[1.]	Remove fuel pump fuse ("FUEL") fuse holder. Remove spark plugs from each cylinder. Install the spark gap tester to each ignition coil. Crank the engine, or use CDS output load test for each ignition coil, and observe spark. If no spark is present, replace appropriate ignition coil. If spark is present, replace spark plugs.
1.7 PCM not functioning[1.]	Fuel injection system: • Listen for injector ticking when cranking or connect spare injector to each respective harness. Ignition system: • Install spark gap tester between the ignition coil and engine ground. Check for strong spark while cranking engine. • Check for battery voltage (red/yellow lead) at ignition coils. • Check for blown 20 amp fuse. • Check for battery voltage to fuse from main power relay (purple lead). • Check for shorted stop wire (black/yellow lead). Check all power connections. Defective PCM.
1.8 Crankshaft position sensor not functioning	Check that magnet is not missing from end of sensor. Perform ohm resistance check of sensor. Refer to specifications for ohm test. Defective crankshaft position sensor.

2. Engine Will Not Crank	
Cause	Action
2.0 Defective PCM	Use CDS to determine proper functioning of the electronic throttle control (ETC).
2.1 Defective main power relay	Use CDS to determine proper functioning of the main power relay.
2.2 Main power relay fuse blown	Check for blown 20 amp fuse.
2.3 Lanyard stop switch in wrong position	Reset lanyard stop switch.

3. Engine Cranks, Starts and Stalls	
Cause	Action
3.0 Low fuel pressure in fuel rail	See 1.3.

1. Spark jumping the gap from all cylinders at the same time in the spark gap tool may cause interference in the PCM. The interference may cause the absence of spark on some cylinders and a false diagnosis of a no spark condition. Crank the engine over with only one spark plug wire connected to spark gap tool at a time or use the CDS to fire one cylinder at a time.

3. Engine Cranks, Starts and Stalls	
Cause	Action
3.1 Abnormally high friction in engine	Check for scuffed piston or other sources of high friction.
3.2 Air in fuel system/lines	See 1.3. Crank and start engine several times to purge.
3.3 Defective electronic throttle control	Use CDS to determine proper functioning of ETC. Replace ETC.
3.4 Harness connections are poor from engine to helm	Clean and inspect all harness connections.
3.5 Flywheel misaligned during installation	Flywheel key sheared or missing.

4. Engine Idle is Rough	
Cause	Action
4.1 Fouled spark	Replace spark plug if carbon bridges electrode gap or if it is completely black; or if it is not firing and is wet with fuel. *NOTE: If spark plug is gray or completely black with aluminum specs, this indicates a scuffed piston.*
4.2 Failed fuel injector	Refer to specifications for ohm test.
4.3 Bad ignition coil/weak spark	Refer to specifications for ohm test.
4.4 Flywheel misaligned during installation	Flywheel key sheared or missing.
4.5 Engine not running on all cylinders	Inspect for mechanical damage.

5. Engine Idles Fast (RPM above 700) or Surges	
Cause	Action
5.1 Defective ETC	Use CDS to determine proper functioning of ETC. Replace ETC.

6. Engine Runs Rough below 3000 RPM	
Cause	Action
6.1 Fouled spark plug	Replace spark plug if carbon bridges electrode gap or if it is completely black; or if it is not firing and is wet with fuel. *NOTE: If spark plug is gray or completely black with aluminum specs, this indicates a scuffed piston.*
6.2 Low fuel pressure in fuel rail	Measure fuel pressure (valve on top of fuel rail). Fuel pressure should be 281–45 kPa (41–50 psi).
6.3 Defective ETC	Use CDS to determine proper functioning of ETC. Replace ETC.
6.4 Bad ignition coil/weak spark	Refer to specifications for ohm test.
6.5 Fuel supply module (FSM) float fails in conjunction with failure of vent canister switch	Excess fuel will enter air intake. Use CDS system to determine proper function of vent canister switch.
6.6 Engine not running on all cylinders	Inspect for mechanical damage.

7. Engine Runs Rough above 3000 RPM	
Cause	Action
7.1 Fouled spark plug	Replace spark plug if carbon bridges electrode gap or if it is completely black; or if it is not firing and is wet with fuel. *NOTE: If spark plug is gray or completely black with aluminum specs, this indicates a scuffed piston.*
7.2 Defective ETC	Use CDS to determine proper functioning of ETC. Replace ETC.

7. Engine Runs Rough above 3000 RPM	
Cause	**Action**
7.3 Low fuel pressure in fuel rail	Measure fuel pressure (valve on top of fuel rail). Fuel pressure should be 281–345 kPa (41–50 psi).
7.4 Speed reduction	Refer to SmartCraft gauges for low oil, engine overheat, or sensor/actuator out of range. CDS will help identify proper functioning of sensors/actuator.
7.5 Defective crankshaft position sensor	Refer CDS for fault identification.

8. Speed Reduction (RPM Reduced to Idle)	
Cause	**Action**
8.1 Engine communication/remote control failure	Refer to CDS for fault identification.
8.2 Sensor/actuator is out of range	Refer to CDS for fault identification.
8.3 Low oil pressure	Check oil dipstick for proper oil level.
8.4 Engine overheat	Check engine cooling system for proper functioning.

9. Speed Reduction (RPM Reduced to 75%)	
Cause	**Action**
9.1 Sensor/actuator is out of range	Refer CDS for fault identification.
9.2 Low oil pressure	Check oil dipstick for proper oil level.
9.3 Engine overheat	Check engine cooling system for proper functioning.

Flywheel Cover

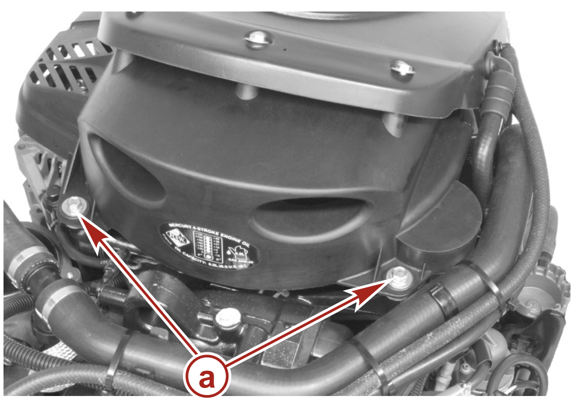
The purpose of the flywheel cover is to provide basic protection against accidental contact with the flywheel, starter motor pinion gear, and alternator/supercharger drive belt while the engine is running.

Removal of the flywheel cover provides access to the flywheel, alternator/supercharger drive belt, starter motor pinion gear, crankshaft position sensor, oil temperature sensor, oil pressure sensor, and the air filter.

The flywheel cover is secured to the engine with two bolts with washers at the rear of the flywheel cover and one rubber grommet pressed over a mounting post on the supercharger.

Removal

1. Remove the two bolts with washers securing the flywheel cover to the rear mounting posts.

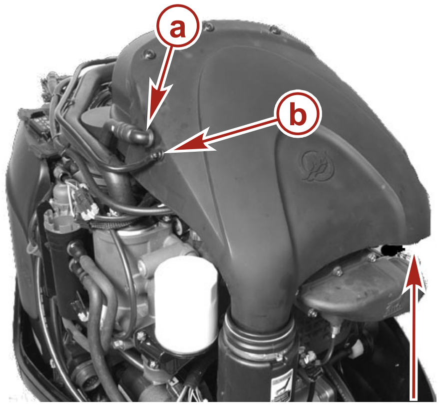


15251

a - Flywheel cover bolt and washer (2)

2. Remove the crankcase ventilation hose grommet from the flywheel cover.
3. Remove the FSM vent hose from the flywheel cover.

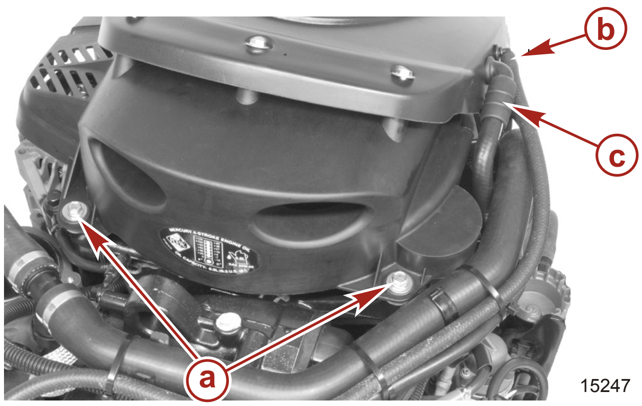
4. Push up on the flywheel cover to remove.



a - Crankcase ventilation hose
b - FSM vent hose

Installation

1. Push the flywheel cover into the intake resonator.
2. Install the flywheel cover to the mounting post on the supercharger.
3. Align the flywheel cover rear bolt holes with the rear mounting posts.
4. Install the crankcase ventilation hose grommet onto the flywheel cover.
5. Install the FSM vent hose into the flywheel cover.
6. Secure the flywheel cover with two bolts with washers. Tighten bolts to the specified torque.



a - Flywheel cover bolt and washer (2)
b - FSM vent hose
c - Crankcase ventilation hose

Description	Nm	lb-in.	lb-ft
Flywheel cover bolts	10	88.5	

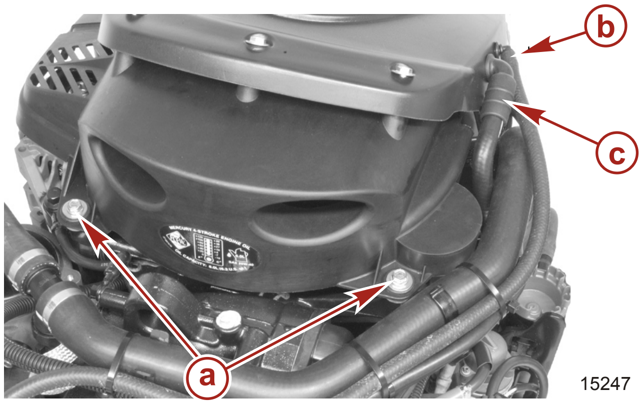
Air Filter

The air filter is located within the flywheel cover assembly. The air filter removes airborne particles which may damage engine components. The air filter design allows for maximum unrestricted air flow during engine operation.

Air Filter Removal

1. Remove the FSM vent hose and the engine ventilation hose from the flywheel cover.

2. Remove the bolts securing the flywheel cover to the rear mounting posts.



a - Flywheel cover bolt and washer (2)
b - FSM vent hose
c - Crankcase ventilation hose

3. Lift the flywheel cover off the front mounting post and the intake resonator.
4. Remove three screws holding the upper flywheel cover to the lower flywheel cover.

5. Separate the two flywheel cover subassemblies to access the air filter.
6. Remove the air filter from the lower flywheel cover assembly.

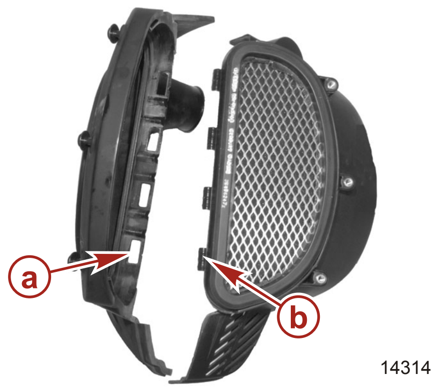
a - Flywheel cover subassembly
b - Air filter

Air Filter Installation

1. Install the air filter onto the flywheel cover subassembly.

a - Flywheel cover subassembly
b - Air filter

2. Install the upper half of the flywheel cover subassembly to the lower flywheel cover subassembly. Ensure the upper flywheel cover latch opening is properly secured to the lower flywheel cover.



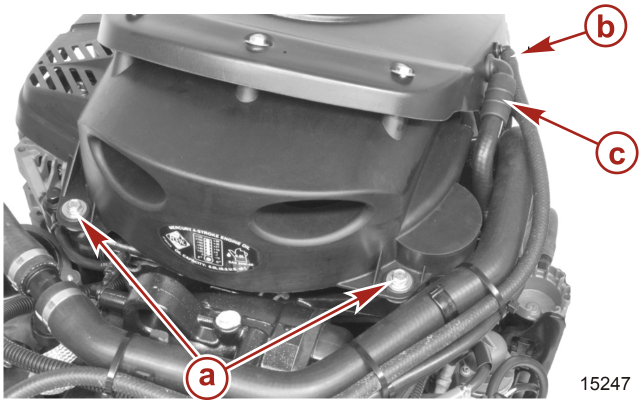
a - Upper flywheel cover latch opening
b - Lower flywheel cover latch

3. Push the two subassemblies together and install three screws. Tighten the three screws to the specified torque.

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

4. Install the flywheel cover onto the resonator and the front mounting post.
5. Align the flywheel cover rear bolt holes with the rear mounting posts.

6. Secure the flywheel cover to the rear mounting posts with two bolts with washers. Tighten bolts to the specified torque.



a - Flywheel cover bolt and washer (2)
b - FSM vent hose
c - Crankcase ventilation hose

Description	Nm	lb-in.	lb-ft
Flywheel cover bolt	10	88.5	

Flywheel

The flywheel is weighted and balanced to improve engine running characteristics. The flywheel is secured to the crankshaft by a M20 x 68 bolt and washer. The flywheel has two ring gears. The top ring gear is used with the starter motor to start the engine. The lower ring gear has 54 teeth with 6 teeth missing at specific locations. As the lower ring gear passes the crankshaft position sensor, an electrical pulse is generated and sent to the propulsion control module (PCM). The frequency of these pulses in conjunction with the missing tooth locations on the ring gear provides crankshaft location information to the PCM. The PCM will use this information to regulate ignition and fuel injector timing.

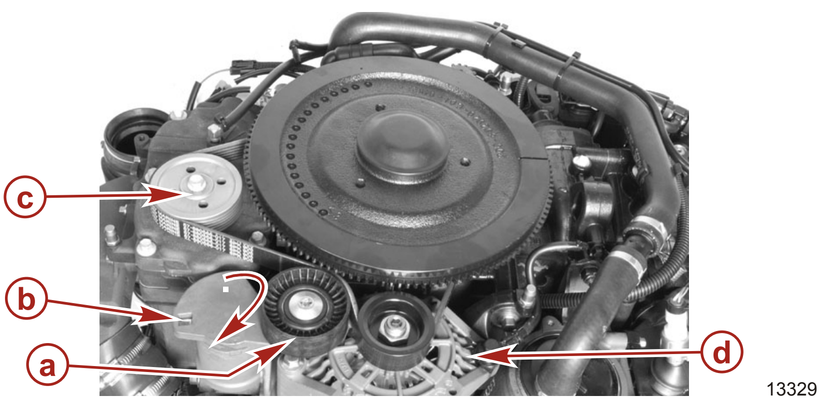
Flywheel Removal

The flywheel has three threaded holes which are used with the flywheel puller/lifting ring to remove the flywheel. These three holes can also be used with the flywheel puller/lifting ring to remove or install the complete outboard on a boat.

Flywheel Puller/Lifting Ring	91-895343T02

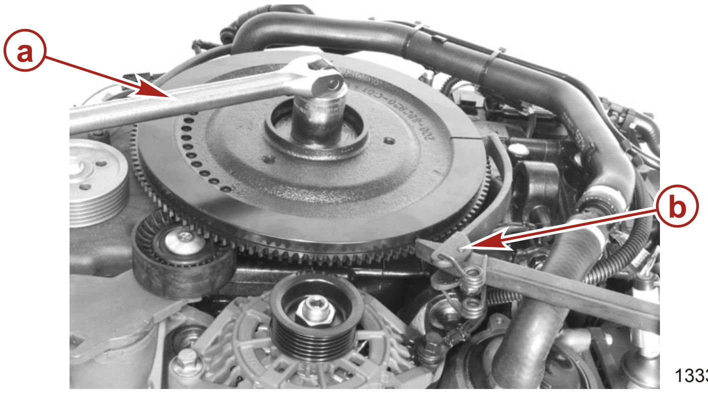
IMPORTANT: Striking or heating the flywheel to ease removal will damage the flywheel. Do not strike or heat the flywheel.

1. Remove the flywheel cover.
2. Remove the flywheel bolt cap from the flywheel.
3. Use a breaker bar to release the alternator/supercharger belt tension and remove the belt from the flywheel.



a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

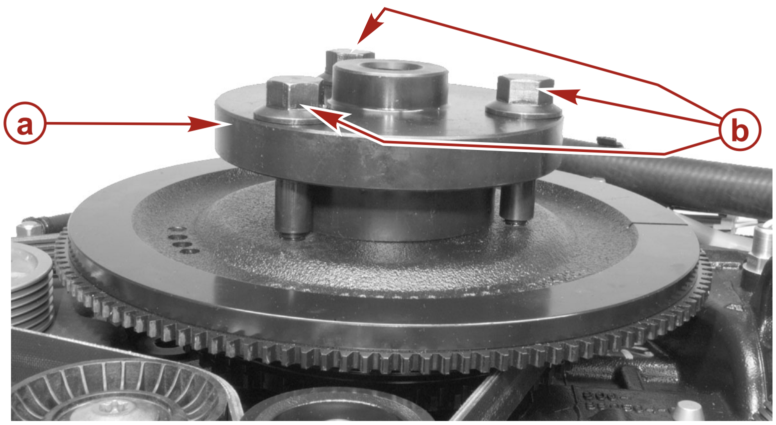
4. Hold the flywheel with the flywheel holding tool. Loosen the flywheel bolt four turns out from a light seat.



a - 30 mm socket
b - Flywheel holding tool

Flywheel Holding Tool	91-52344

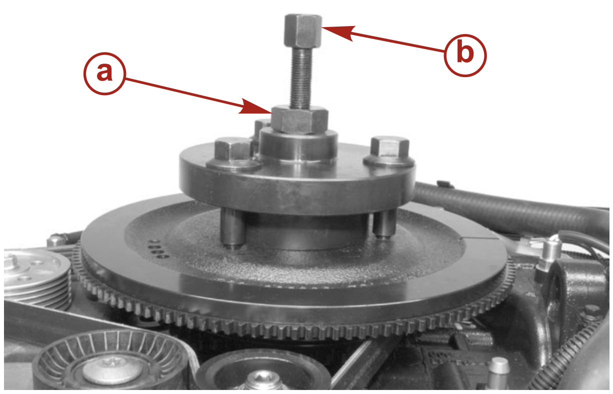
5. Install the flywheel puller base to the flywheel with three bolts. Tighten the three bolts securely.



a - Puller base
b - Bolts

Flywheel Puller/Lifting Ring	91-895343T02

6. Thread the flywheel puller adapter into the puller base until it bottoms out.
7. Thread the flywheel puller bolt into the flywheel puller adapter.



a - Adapter
b - Puller bolt

Flywheel Puller/Lifting Ring	91-895343T02

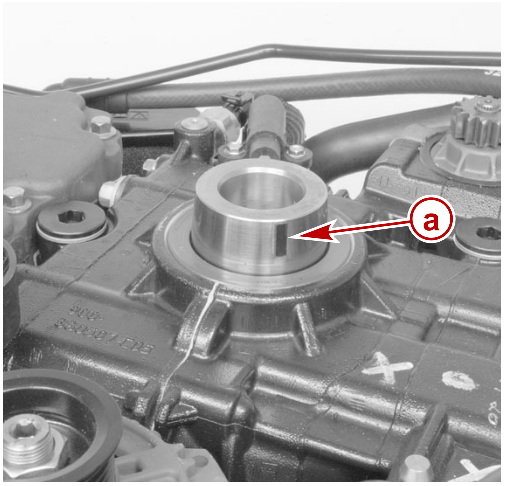
8. Tighten the flywheel puller bolt until the flywheel becomes loose. Remove the flywheel.

   NOTE: *Do not use power tools to remove the flywheel.*

Flywheel Installation

IMPORTANT: Clean flywheel/crankshaft taper with solvent and assemble dry.

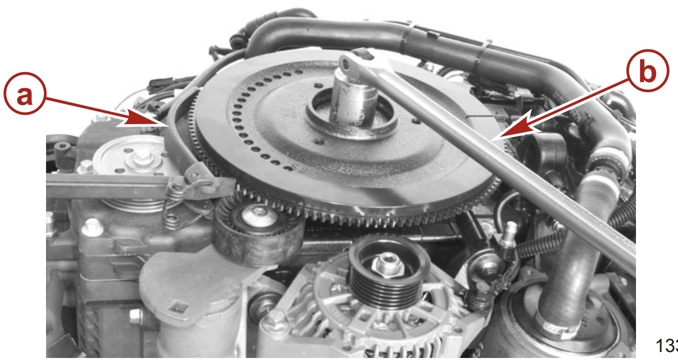
1. Install the flywheel key into the crankshaft.



5463

a - Flywheel key

2. Align the flywheel with the key and install the flywheel onto the crankshaft.
3. Secure the flywheel with a bolt and washer. Use the flywheel holding tool to hold the flywheel and torque the bolt in two steps to specification.



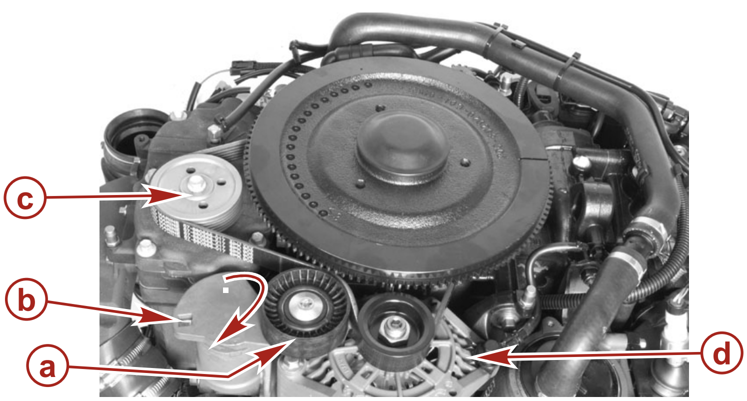
13341

a - Flywheel holding tool
b - Torque wrench with a 30 mm socket

Flywheel Holding Tool	91-52344

Description		Nm	lb-in.	lb-ft
Flywheel bolt	**First**	60		44
	Final	180		133

4. Using a breaker bar in the tensioner release slot, install the alternator/supercharger belt.



13329

a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

5. Install the flywheel cover.

Propulsion Control Module (PCM)

The PCM requires 8 VDC minimum to operate. If the PCM should fail, the engine will stop running. The inputs to the PCM can be monitored and tested by the CDS.

Computer Diagnostic System (CDS)	Order through SPX

The PCM controls the following functions:

- Calculates the precise fuel and ignition timing requirements based on engine speed, throttle position, manifold absolute pressure (MAP), manifold air temperature (MAT), and cylinder block coolant temperature.
- Directly controls the ground circuit to: fuel injectors, ignition coil driver, ETC motor drive, EBC motor drive, ESC motor drive, main power relay activation, power steering pump, vent canister purge valve (VCPV), trim up, trim down, fuel lift pump, diagnostics, Engine Guardian, and tachometer link (analog tachometer output or link gauge driver).
- Indirectly controls the positive circuit to: fuel injectors, ignition coils, ETC motor drive, EBC motor drive, ESC motor drive, main power relay activation, VCPV, and high-pressure fuel pump.

The PCM operates in four modes: power off, stall, crank, and run. The PCM also provides for a smooth throttle response between varying throttle positions and engine loads. A warm-up mode is integrated with the run mode and disengaged after the engine accumulates a given amount of power or engine temperature.

Power off mode - With the ignition key switch "OFF," the PCM allows the trim system to function for up to 15 minutes. 12 VDC is available from the battery at the fuses, positive cable terminal in the electrical box, and at the alternator.

Stall mode - With the ignition key switch in the "RUN" position, the PCM is energized and provides power to the main power relay and the fuel pump relay for five seconds. It also provides 5 VDC power to the sensors. The PCM records barometric pressure from the MAP sensor, intake air temperature from the MAT sensor, and coolant temperature from the coolant temperature sensor. The PCM will use this information to establish a warm-up strategy that will control fuel delivery and engine speed during warm-up and idle.

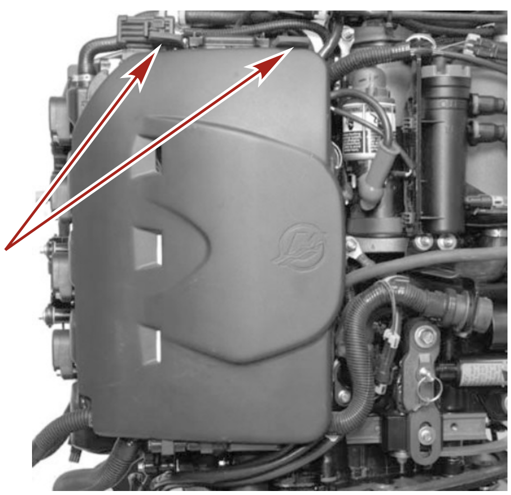
Crank mode - The PCM controls all aspects of the starter, including how long the starter is energized. When the ignition key switch is turned to the "START" position, the start relay is grounded through the PCM, energizing the starter solenoid. While the engine rotates, a pulse will be generated at the crankshaft position sensor which provides the PCM engine speed information. The PCM will then supply power to the fuel pump and ignition coils through the main power relay and the fuel pump relay.

Run mode - At approximately 500 RPM, the PCM will transition to the run mode.

- The warm-up strategy will continue to adjust engine speed with the fuel injector pulse width and engine spark advance until the engine accumulates a given amount of power.
- The camshaft position sensor provides cylinder compression phasing information to the PCM for sequential fuel injection.
- The MAT sensor, TPS, and MAP sensor are monitored to determine proper spark timing, boost control, and the fuel needs necessary to develop the amount of power asked for by the operator.

PCM Removal

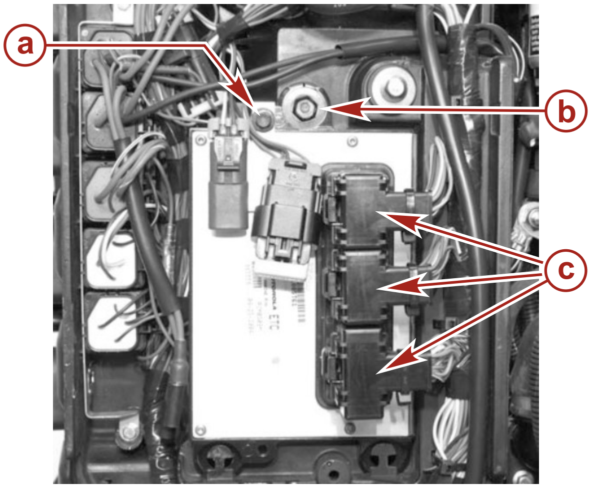
1. Release the two straps securing the electrical box cover.



13343

2. Lift the electrical box cover up to remove it from the electrical box.
3. Remove the bolt securing the bracket for the terminator resistors.
4. Disconnect the three harness connectors.

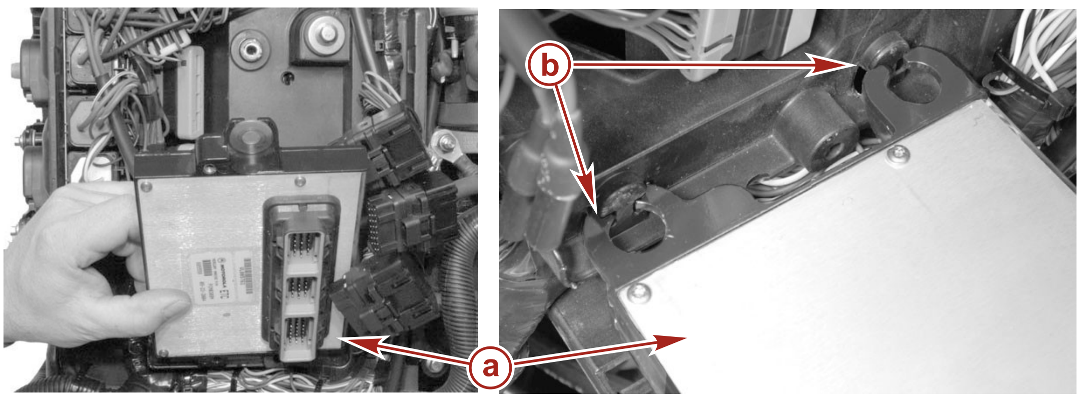
5. Remove the bolt securing the PCM to the electrical box.



13344

a - Bolt securing terminator resistor bracket
b - Bolt securing PCM
c - Engine harness connectors

6. Carefully tilt the top of the PCM out to disengage the PCM from the electrical box lower PCM mounts.

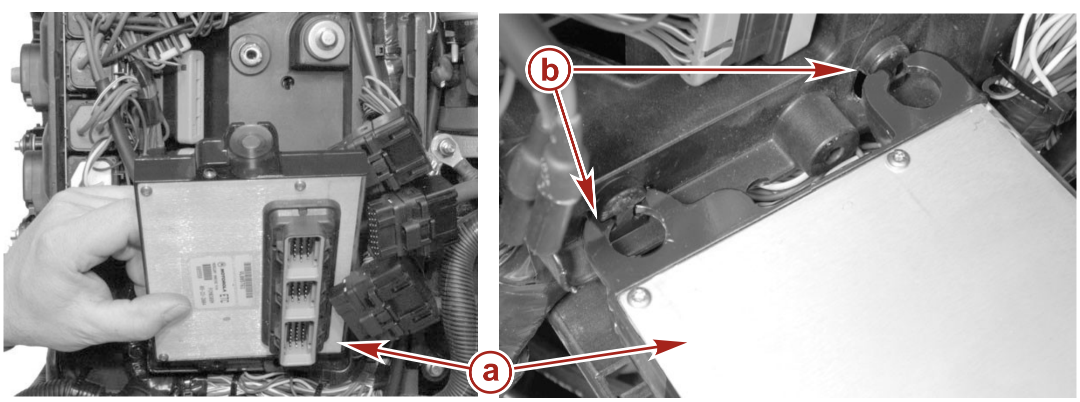


13345

a - PCM
b - Electrical box lower PCM mounts

PCM Installation

1. Align the PCM with the electrical box lower PCM mounts.
2. Install the PCM onto the electrical box.
3. Carefully tilt the PCM up to align the threaded mounting hole.

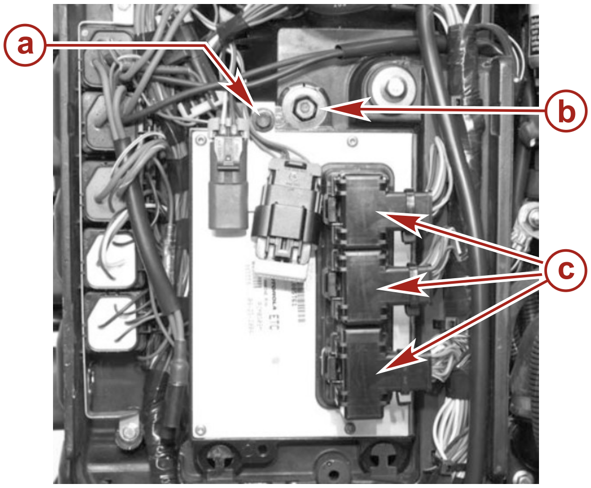


13345

a - PCM
b - Electrical box lower PCM mounts

4. Secure the PCM with a bolt. Tighten bolt to the specified torque.
5. Install the three engine harness connectors into the PCM.

6. Secure the bracket for the terminator resistors with a bolt and tighten to the specified torque.

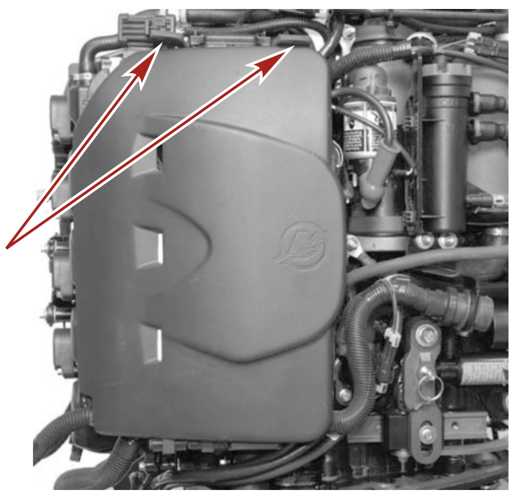


13344

a - Bolt securing terminator resistor bracket
b - Bolt securing PCM
c - Engine harness connectors

Description	Nm	lb-in.	lb-ft
Bolt securing PCM (M8 x 13)	9	80	
Bolt securing terminator resistor bracket (M6 x 14)	6	53	

7. Install the electrical box cover and secure with the two straps.



13343

Wire Color Code Abbreviations

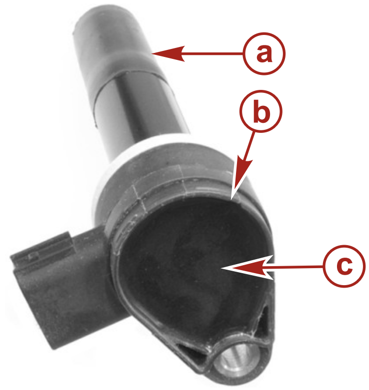
Wire Color Abbreviations					
BLK	Black		BLU	Blue
BRN	Brown		GRY	Gray
GRN	Green		ORN or ORG	Orange
PNK	Pink		PPL or PUR	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT or LIT	Light		DK or DRK	Dark

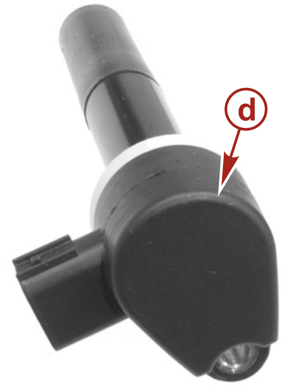
Ignition Pencil Coil Designs

A new pencil coil (design II) went into production during 2009.

- The spark plug boot is bonded in place
- The coil cover is removed

- The coil is sealed with a black epoxy material





41024

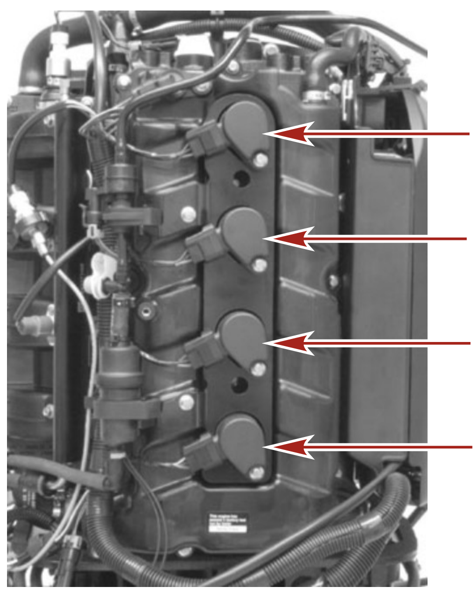
Design II pencil coil

Design I pencil coil

a - Bonded spark plug boot
b - No coil cover
c - Black epoxy
d - Coil cover in place

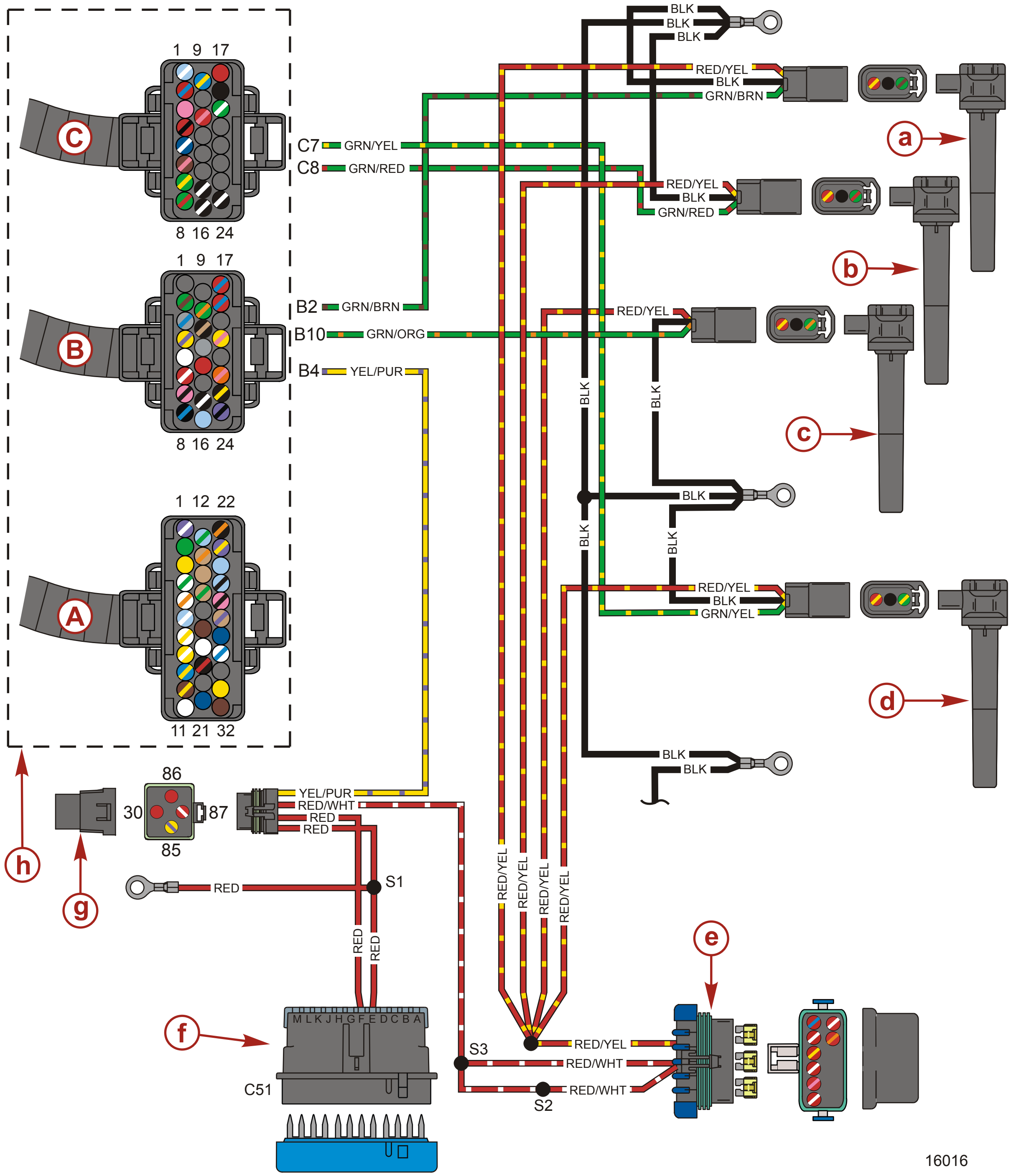
Ignition Pencil Coil

The engine ignition system utilizes four ignition coils, one for each cylinder. The ignition coils are inductive type coils, with each coil having its own integrated driver. Battery voltage is present at each coil red/yellow wire whenever the main power relay is activated. Each coil is triggered by a 5 VDC digital pulse from the PCM. Each ignition coil is capable of producing a 40,000 volt spark.



13356

Ignition Coil Test



- **a -** Cylinder #1 ignition coil
- **b -** Cylinder #2 ignition coil
- **c -** Cylinder #3 ignition coil
- **d -** Cylinder #4 ignition coil
- **e -** Fuse holder
- **f -** Splice saver
- **g -** Main power relay
- **h -** Propulsion control module (PCM)

⚠ WARNING

High voltage is present any time the key is turned on, especially when starting or operating the engine. Do not touch ignition components or metal test probes and stay clear of spark plug leads when performing live tests.

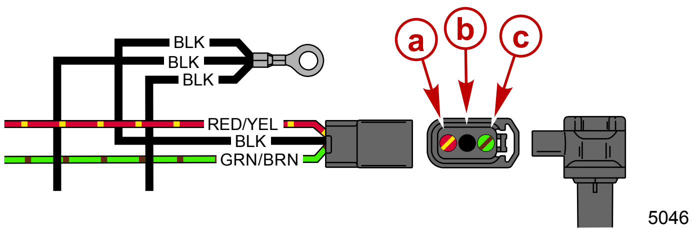
NOTE: With the key switch in the "RUN" position and the engine "OFF," battery voltage is only available to the red/yellow wire for three seconds when no crankshaft position sensor signal is received by the PCM.

1. Disconnect the connector from the coil being tested.
2. Perform a visual inspection of the pins at the coil and the wires coming to the connector. Look for broken, bent, and corroded pins at the coil; and loose, broken, or corroded wires at the connector.

   NOTE: Shake or move the harness and connector when performing the following tests. If the voltmeter readings change during the tests, inspect for a broken, loose, or corroded wire. Repair the problem wire and retest the circuit as follows.
3. Connect a voltmeter across the red/yellow and the black wires at the connector.

DMT 2004 Digital Multimeter	91-892647A01

NOTE: The main power relay must be on for battery voltage to be present at the red/yellow wire. If voltage is not present, the main power relay may be defective or the 20 amp fuse in the fuse holder is blown.



a - +12 volt (red/yellow)
b - Ground (black)
c - Output from PCM (5 volt digital pulse) (green/brown)

   a. If battery voltage is not present, connect the voltmeter across the red/yellow wire and the engine ground. If the voltmeter indicates battery voltage, there is an open in the ground circuit. Repair the problem wire and retest the circuit.

      NOTE: All coil ground wires are spliced together and connected to a common engine ground. The most likely failure would be at the connector or in between the connector and the engine ground.

   b. If battery voltage is not present on the red/yellow wire to the engine ground, there is an open circuit between the splice point and the red/yellow wire connector.

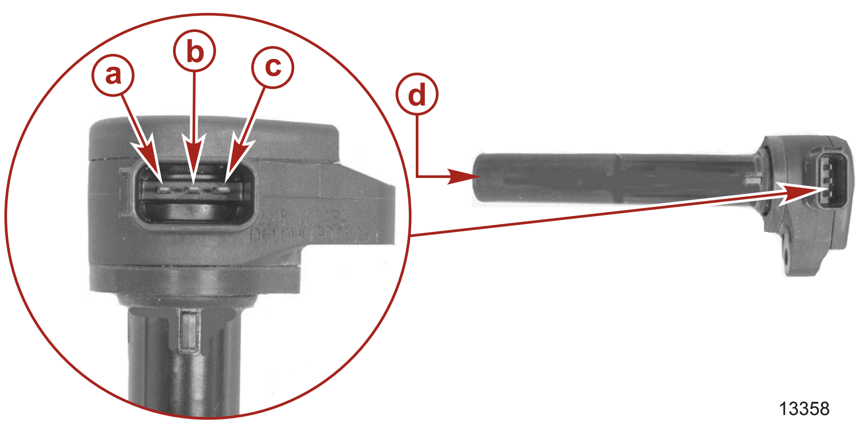
      NOTE: All 12 VDC power wires for the coils are spliced together. Unless all the coils have failed, the most likely failure would be at the splice point, the connector, or in between the connector and the splice point.
4. Check the input wire (5 VDC) for continuity between the connector and the PCM. Repair if needed.

Ignition Coil Ohm Test

Use a digital volt/ohmmeter to check the ignition coil. If resistance is not within specification, replace the ignition coil.

DMT 2004 Digital Multimeter	91-892647A01

NOTE: Some meter brands may require the test lead polarity to be reversed in order to obtain the correct ohm specifications.

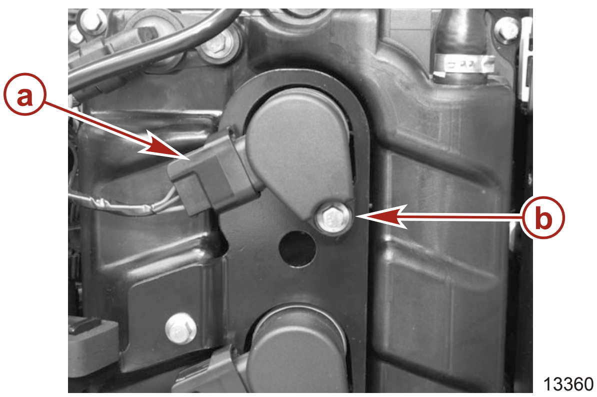


a - Green with stripe (electronic spark trigger)
b - Black (ground)
c - Red/yellow (battery +)
d - Spring

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Electronic spark trigger	Ground	Auto	4.3–5.3 kΩ
	Battery +	Auto	2–4 M ohms
	Secondary	Auto	Infinite (O.L.)
Ground	Electronic spark trigger	Auto	4.3–5.3 kΩ
	Battery +	Auto	2–4 M ohms
	Secondary	Auto	Infinite (O.L.)
Battery +	Electronic spark trigger	Auto	Infinite (O.L.)
	Ground	Auto	Infinite (O.L.)
	Secondary	Auto	Infinite (O.L.)
Secondary	Electronic spark trigger	Auto	Infinite (O.L.)
	Ground	Auto	Infinite (O.L.)
	Battery +	Auto	Infinite (O.L.)

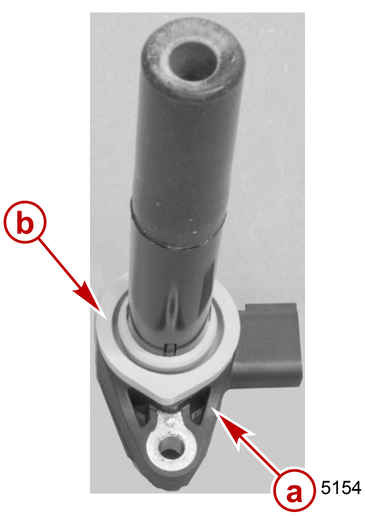
Ignition Coil Removal

1. Disconnect the electrical harness from the coil.
2. Remove the bolt securing the coil.



a - Electrical harness
b - Bolt

3. Inspect the coil sealing ring for cuts or abrasion. Replace the sealing ring if damaged.

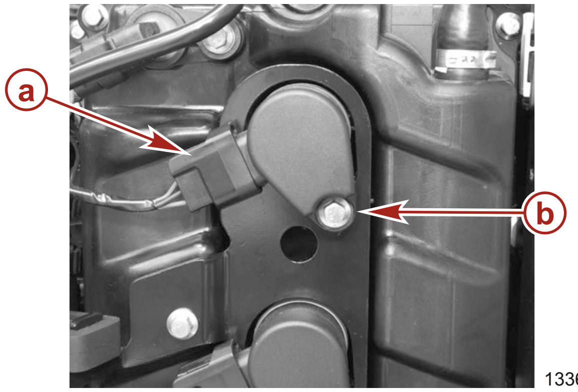


a - Ignition coil
b - Sealing ring

Ignition Coil Installation

1. Insert the ignition coil into the spark plug access hole in the cylinder head. Secure the ignition coil with a bolt. Tighten the bolt to the specified torque.

2. Connect the electrical harness to the ignition coil.



13360

a - Electrical harness
b - Bolt

Description	Nm	lb-in.	lb-ft
Bolt (M6 x 25)	8	70	

Knock Sensor

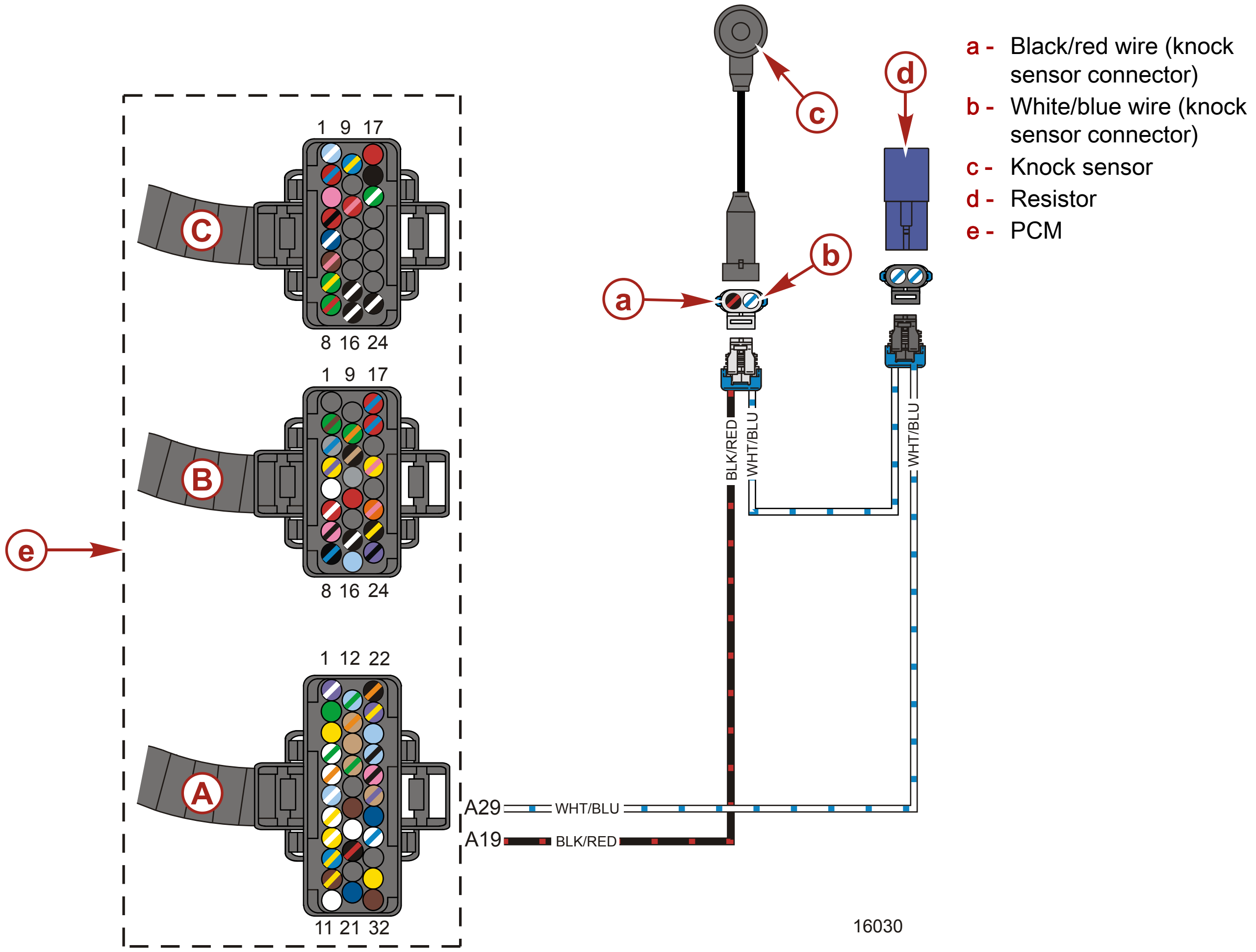
The knock sensor is located on the port side of the engine behind the CAC. The knock sensor is piezoelectric transducers with a 1–2 mv per G-force output signal. When detonation occurs in a cylinder, a vibration is generated in the cylinder block which activates the knock sensor to produce an output signal to the PCM. The PCM will reduce timing and/or increase fuel into the cylinders until the detonation stops.

Knock Sensor Test

There is no practical field test for this device. Check connector for bent, broken, or corroded pins. Perform continuity check between knock sensor connectors and PCM. Consult the PCM fault codes. If the PCM indicates a fault, test the connector and wire connections.

- PCM connector A, pin 29 to the knock sensor connector white/blue wire is 20 k ohms (± 10%).

- PCM connector A, pin 19 to the knock sensor connector black/red wire is less than 1 ohm.



16030

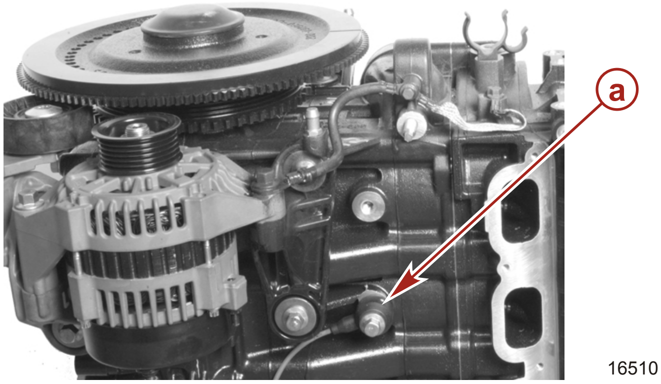
DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 29	Knock sensor connector (white/blue wire)	Auto	20 k ± 10%
Connector A, pin 19	Knock sensor connector (black/red wire)	Auto	Less than 1

Knock Sensor Removal

1. Disconnect the battery.
2. Remove all cowls. Refer to **Section 4A - Cowling Removal**.
3. Remove the CAC. Refer to **Section 3C - Charge Air Cooler (CAC) Intake Manifold Removal/Disassembly/Installation**.
4. Disconnect knock sensor harness connector.

5. Remove bolt and washer securing knock sensor.



16510

a - Bolt/washer securing knock sensor

Knock Sensor Installation

IMPORTANT: The knock sensor mounting bolt/washer must be torqued to specification. Failure to torque the knock sensor to specification will result in an inaccurate sensor output signal to the PCM.

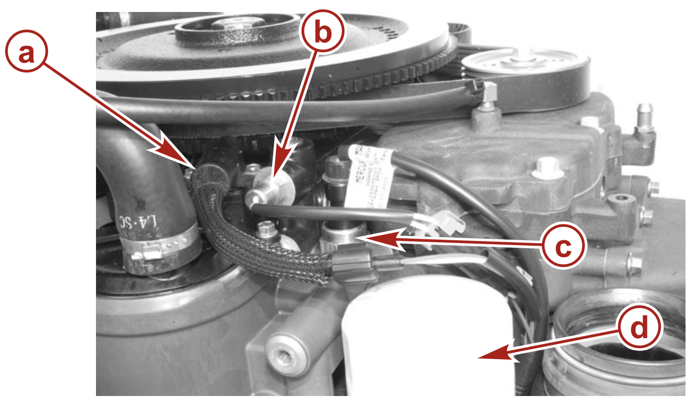
1. Secure knock sensor with bolt and washer. Torque bolt to specification.

Description	Nm	lb-in.	lb-ft
Bolt (M10 x 35)	20	177	

2. Connect sensor harness to sensor.
3. Install the CAC. Refer to **Section 3C - Charge Air Cooler (CAC) Intake Manifold Removal/Disassembly/Installation**.
4. Install the cowling. Refer to **Section 4A - Cowling Installation**.

Crankshaft Position Sensor (CPS)

The CPS is located at the top of the cylinder block next to the flywheel. The sensor contains a magnet which is positioned next to the flywheel's lower ring gear. This ring gear has 54 teeth with 6 missing teeth at specific locations. The close proximity of the CPS magnet to the 54 teeth allows a magnetic field to be created each time a tooth passes the sensor. This field collapses and creates an AC voltage pulse. This AC pulse is sent to the PCM. The timing and frequency of these pulses allows the PCM to regulate ignition and fuel injector timing. If the crankshaft position sensor fails, the engine will run rough or stop running.



13387

a - CPS
b - Oil temperature sensor
c - Oil pressure sensor
d - Oil filter

Crankshaft Position Sensor (CPS) Test

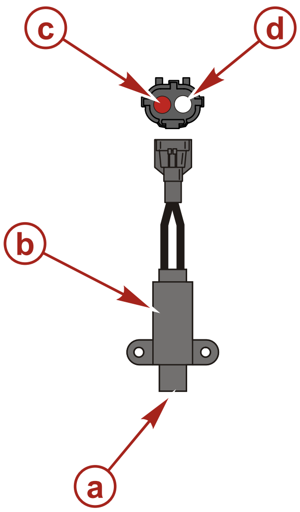
NOTE: It is recommended that the flywheel cover and flywheel be removed to gain access to the CPS.

1. Perform a visual inspection of the sensor. The tip of the sensor must be flush across the end; if not, replace the sensor.
2. The tip of the sensor must be clean. There should be no metal debris (ring gear filings) attached to the sensor tip.

   NOTE: There is a magnet mounted in the sensor's tip. If the magnet is missing, the sensor will not operate properly.
3. Inspect the flywheel timing wheel for:
   - Excessive corrosion
   - The teeth should have square edges
   - There should only be one missing tooth on either side of the two teeth, three teeth, or four teeth groups.
4. Replace the flywheel if it does not meet inspection requirements.

5. Perform a visual inspection of the sensor pins and the wires coming from the connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
6. Disconnect the connector from the sensor. Measure the resistance across the sensor pins. Replace the sensor if out of specification.

NOTE: If engine problem occurs above 3000 RPM (runs rough, no high RPM), the ohm test of the crankshaft position sensor may be good, but the sensor can still be defective.



a - Magnet
b - CPS
c - Pin 1 (red)
d - Pin 2 (white)

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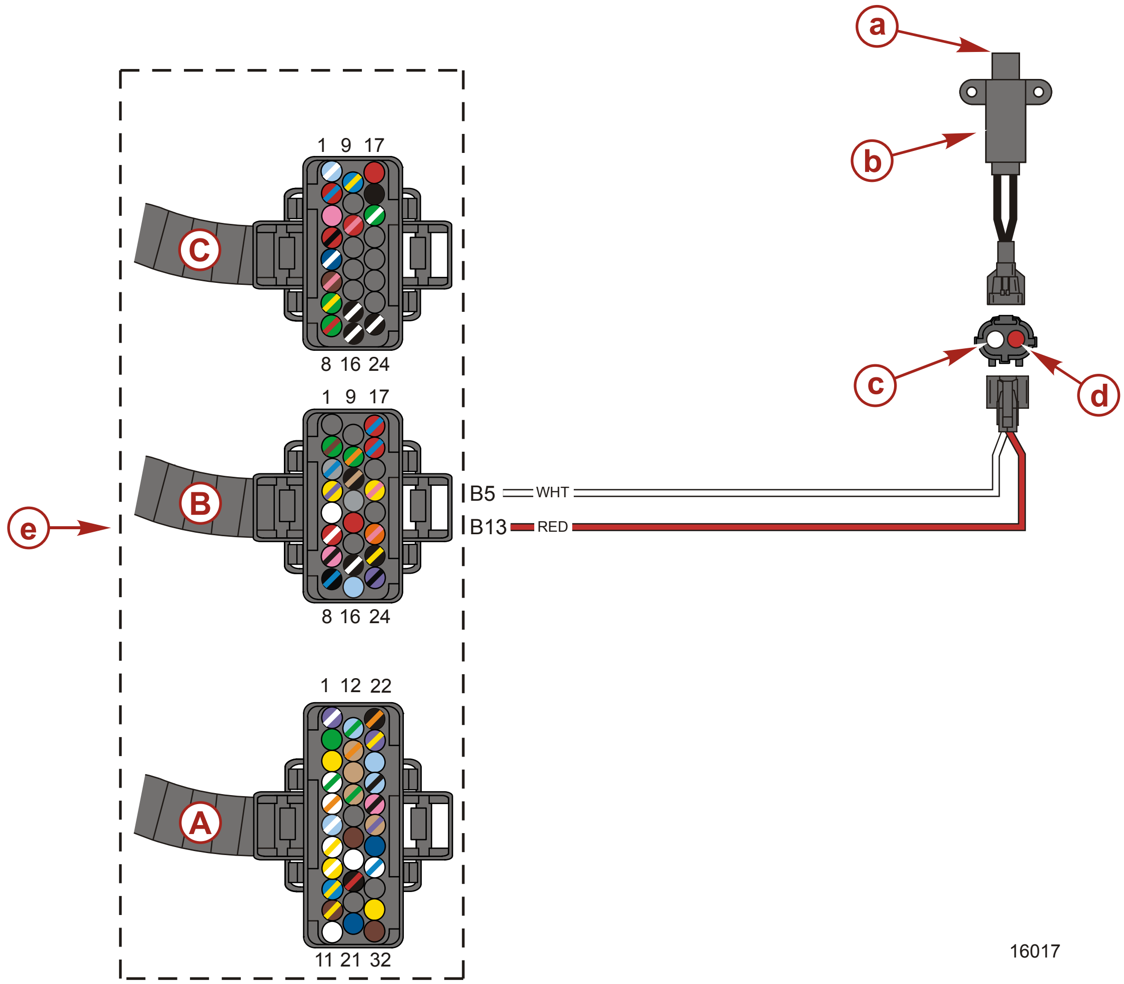
Crankshaft Position Sensor	
Resistance at 21 °C (70 °F)	300–350 ohms

7. Connect the harness to the sensor. Disconnect connector B from the PCM and measure the resistance across pins 5 and 13. Resistance must be within specification. If not, repair the wiring between the PCM and the sensor.



a - Magnet
b - CPS
c - Pin 2 (white)
d - Pin 1 (red)
e - PCM

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Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector B, pin 5	Connector B, pin 13	Auto	300–350 ohms at 21 °C (70 °F)

8. If the tests in the preceding steps are satisfactory, replace the PCM.

Crankshaft Position Sensor Removal

1. Remove flywheel cover/air filter and flywheel.
2. Disconnect sensor harness connector.
3. Remove two screws securing sensor and remove sensor.

Crankshaft Position Sensor Installation

1. Position the sensor on the engine and secure the sensor with two screws. Torque screws to specification.

Description	Nm	lb-in.	lb-ft
Screw (M5 x 16)	5	45	

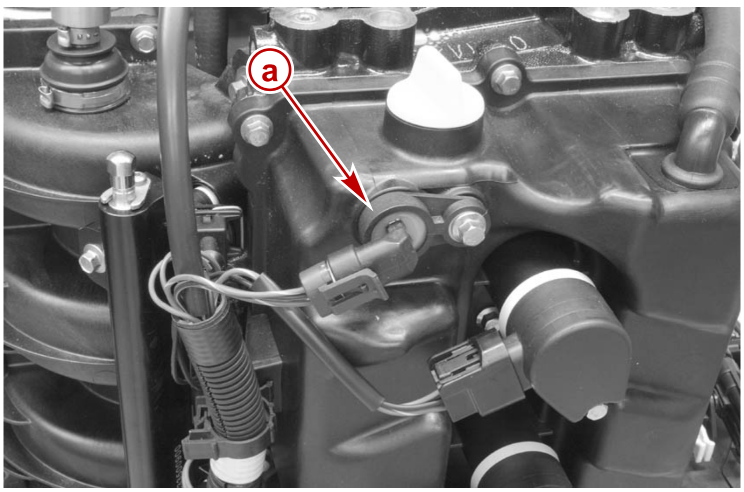
2. Connect sensor harness to sensor.
3. Install the flywheel.
4. Install the flywheel cover/air filter.

Camshaft Position Sensor

The camshaft position sensor is located at the top of the valve cover. It supplies the PCM with timing and RPM information. When the camshaft position sensor is functioning, the PCM controls the fuel injection in a sequential, multi-port timing strategy. When the camshaft position sensor has failed, the PCM controls the fuel injection in a batch fire strategy. The engine may not start as quickly and the Guardian System will limit power to 75%. The PCM will generate and store a failure code when the camshaft position sensor fails.

A sequential firing strategy means that the fuel injectors fire once per engine cycle (every two crankshaft revolutions). The fuel injection event is complete just before the intake valve closes and the coils fire only once per engine cycle. Sequential is ideal for emissions, driveability transients and slight horsepower advantages.

Batch fire strategy means that the fuel injectors fire every revolution (1/2 the fuel needed per revolution/per cycle) and the coils also fire every revolution (wasted spark). This strategy does not consider the phase of the engine; whether a particular cylinder is on a compression or exhaust stroke. Batch fire engines do not require a camshaft position sensor.



5540

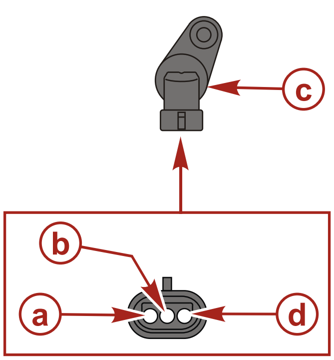
a - Camshaft position sensor

Camshaft Position Sensor Test

The camshaft position sensor output to the PCM will change from +5 volts to 0 volts each time the number 1 or number 4 cylinder reaches TDC. This voltage change can be monitored by the CDS. If the voltage change is not occurring, shake or move the harness by hand. If the voltage readings vary, look for a broken, loose, or corroded wire.

Computer Diagnostic System (CDS)	Order through SPX

1. Disconnect the connector from the sensor.
2. Perform a visual inspection of the sensor pins and the wires coming from the connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
3. If the wiring appears serviceable, perform an ohm check on the sensor. Ensure the resistance for the cam sensor at 21 °C (70 °F) is within specification.



16968

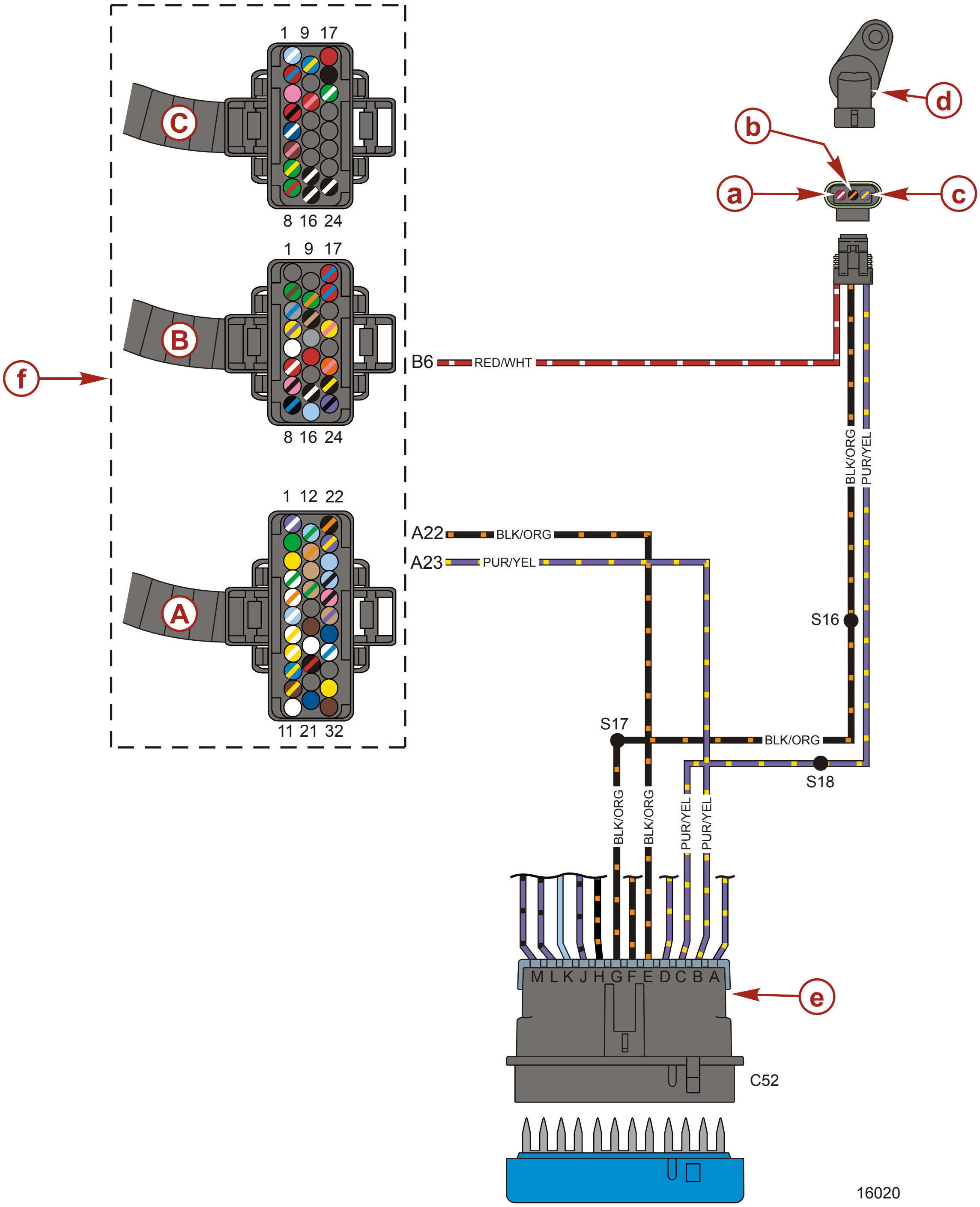
a - Pin a = output voltage
b - Pin b = ground
c - Camshaft position sensor
d - Pin c = reference voltage (5 V)

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (M Ω)
Red	**Black**		
Pin a	Pin b	Auto	3.8–7.0
Pin a	Pin c	Auto	0.7–1.3
Pin b	Pin a	Auto	2.0–3.8
Pin b	Pin c	Auto	2.0–3.8
Pin c	Pin a	Auto	0.7–1.3
Pin c	Pin b	Auto	3.8–7.0

4. If the ohm check of the camshaft position sensor indicates that the sensor is serviceable, perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

NOTE: All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or between the connector and the splice point.



- a - Pin a (red/white)
- b - Pin b (black/orange)
- c - Pin c (purple/yellow)
- d - Camshaft position sensor
- e - Splice saver
- f - PCM

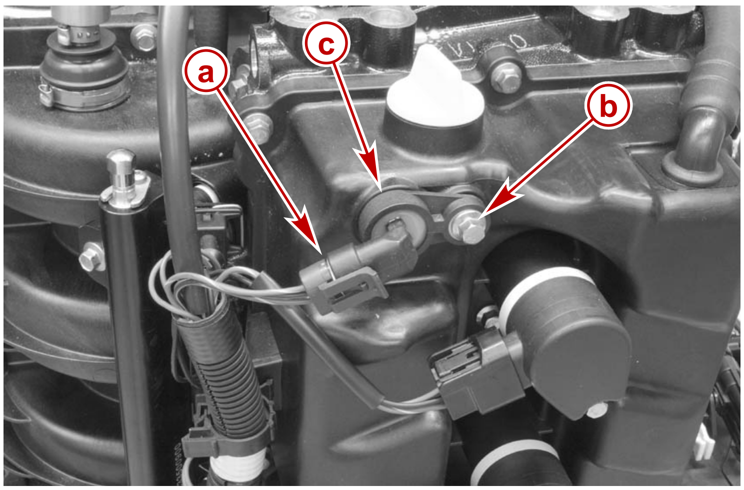
DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector B, pin 6	Engine harness sensor connector (red/white wire)	Auto	Less than 1
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 23	Engine harness sensor connector (purple/yellow wire)	Auto	Less than 1

5. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Camshaft Position Sensor Removal

1. Disconnect sensor harness from sensor.
2. Remove screw securing camshaft sensor and remove sensor.

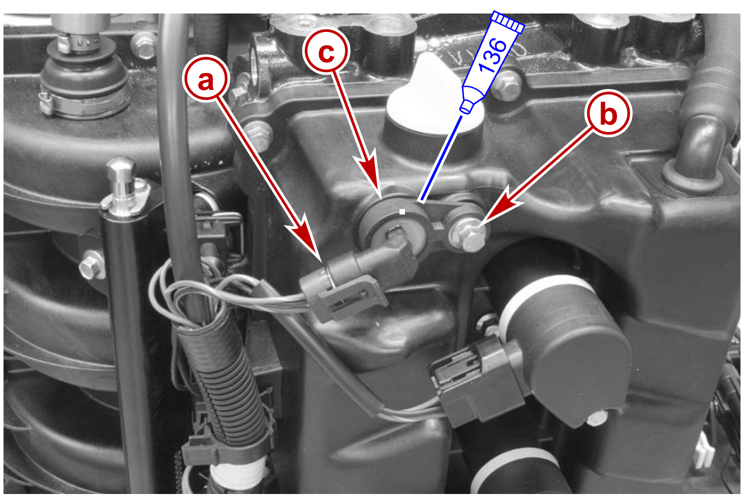


4569

a - Sensor harness
b - Screw securing camshaft sensor
c - Camshaft position sensor

Camshaft Position Sensor Installation

1. Apply Lubriplate SPO 255 to sensor O-ring.
2. Install sensor into valve cover.
3. Secure sensor with screw. Torque screw to specification.
4. Connect harness to sensor.



5879

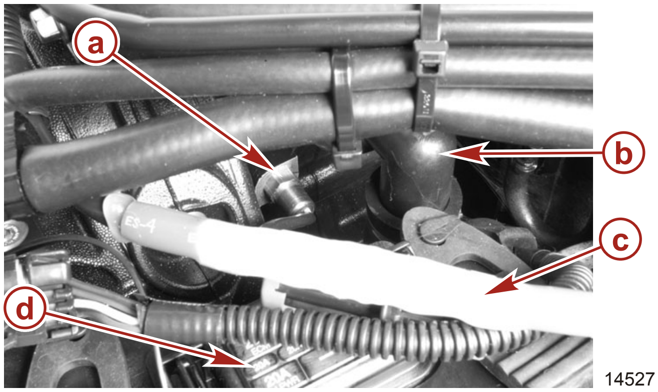
a - Sensor harness
b - Screw securing camshaft sensor
c - Camshaft position sensor

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Camshaft position sensor O-ring	Obtain Locally

Description	Nm	lb-in.	lb-ft
Screw (M6 x 16)	8	70	

Cylinder Block Temperature Sensor

The cylinder block temperature sensor is located below the thermostat cover, behind the electrical box. It is a thermistor immersed in the engine coolant path. It supplies the PCM with engine temperature information. The PCM adjusts the timing and the amount of fuel delivered according to the water temperature in the cylinder block. Low coolant temperature produces high resistance, while high temperature causes low resistance.



14527

a - Cylinder block temperature sensor
b - Thermostat housing
c - 150 amp fusible link
d - Fuse holder

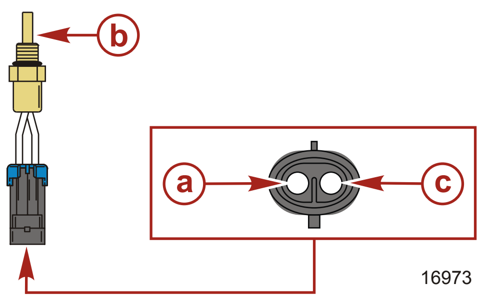
Cylinder Block Temperature Sensor Test

The CDS will determine the proper functioning of the cylinder block temperature sensor by providing a numerical readout of the block temperature before and after the engine is started. With the engine not running, block temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in block temperature to approximately 60–70 °C (140–158 °F). Outside air temperature and the temperature of the water that the engine is operating in will directly affect the engine block temperature.

1. With the engine running and the CDS connected to the engine, if the block temperature sensor does not appear to be indicating a temperature change, shake or move the sensor harness and connector. If the temperature begins to change, look for a broken, loose, or corroded wire.

Computer Diagnostic System (CDS)	Order through SPX

2. Disconnect the connector from the sensor.
3. Perform a visual inspection of the sensor pins and the wires coming from the connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
4. The sensor can be tested with an ohmmeter by removing the sensor from the cylinder block and heating or cooling the end of the sensor in a temperature controlled media. If the readings do not match those in the table, replace the sensor and retest.



16973

a - Pin a (black/orange)
b - Cylinder block temperature sensor
c - Pin b (tan/green)

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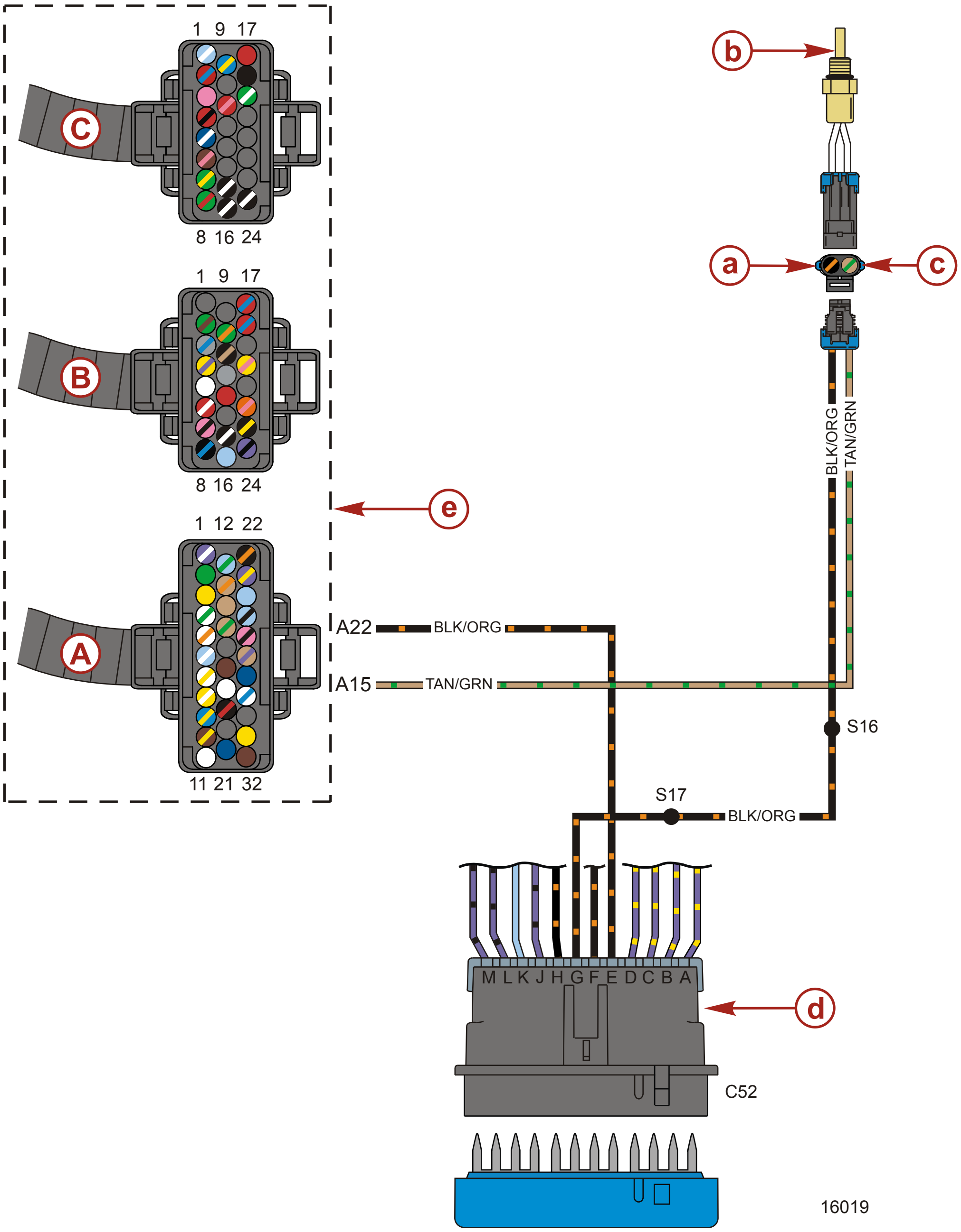
Block Temperature Sensor Ohm Test	
Temperature	Reading (kΩ)
-10 °C (14 °F)	16.50–23.50
21 °C (70 °F)	10.65–11.95
38 °C (100 °F)	5.32–6.02
65 °C (150 °F)	1.90–2.20
95 °C (203 °F)	0.735–0.865

5. If the ohm check of the block temperature sensor indicates that the sensor is serviceable, perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

NOTE: All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or between the connector and the splice point.



- a - Pin a (black/orange)
- b - Cylinder block temperature sensor
- c - Pin b (tan/green)
- d - Splice saver
- e - PCM

DMT 2004 Digital Multimeter	91-892647A01

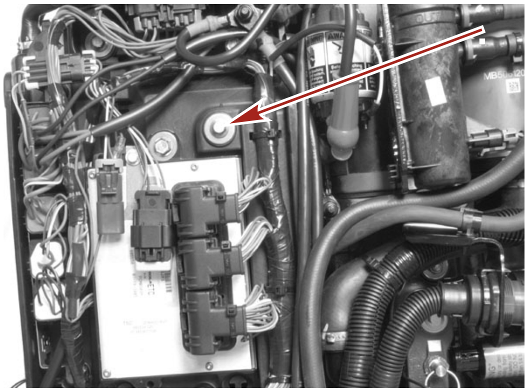
Meter Test Leads		Meter Scale	Reading (Ω)
Red	Black		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 15	Engine harness sensor connector (tan/green wire)	Auto	Less than 1

6. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Computer Diagnostic System (CDS)	Order through SPX

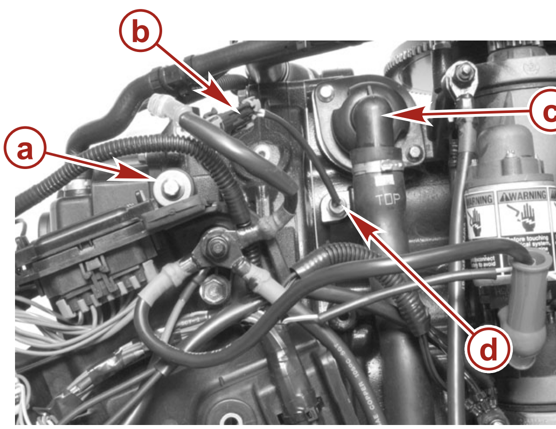
Cylinder Block Temperature Sensor Removal

1. Remove the bolt securing the electrical box to the cylinder block.



14529

2. Move the electrical box aft to remove the electrical box off the two mounting grommets.
3. Disconnect the sensor harness connector.
4. Remove the sensor from the cylinder block.



14531

a - Mounting grommet
b - Cylinder block harness connector
c - Thermostat housing
d - Cylinder block temperature sensor

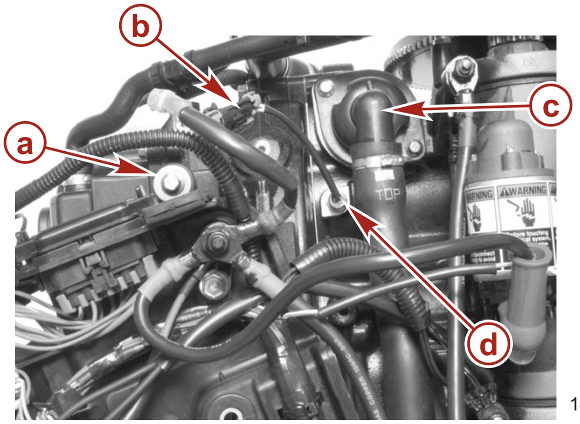
Cylinder Block Temperature Sensor Installation

1. Install a new O-ring onto the sensor.

13384

2. Install the sensor into the cylinder block. Tighten the sensor to the specified torque.

3. Connect the engine harness to the sensor.

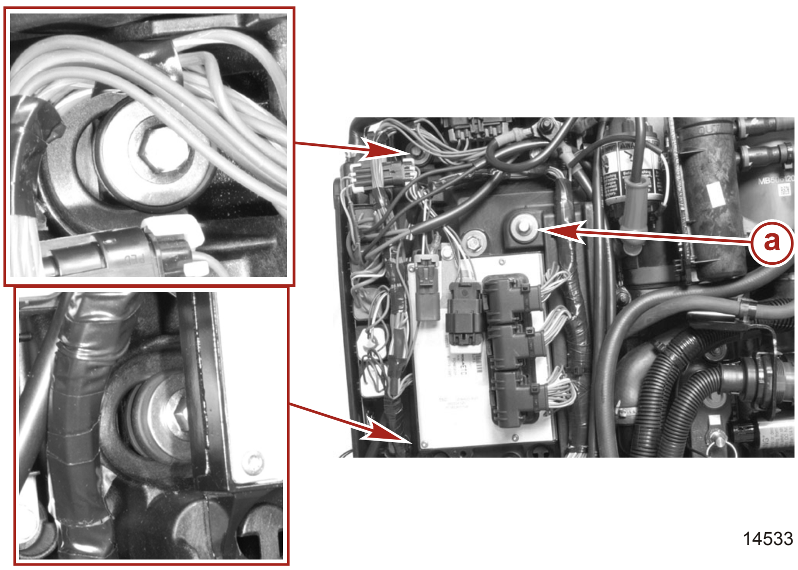


14531

a - Mounting grommet
b - Cylinder block harness connector
c - Thermostat housing
d - Cylinder block temperature sensor

Description	Nm	lb-in.	lb-ft
Cylinder block temperature sensor	15	133	

4. Align the upper and lower electrical box support grommets while pushing the electrical box towards the front of the motor.
5. Install the bolt and washer to secure the electrical box to the cylinder block. Tighten the bolt to the specified torque.



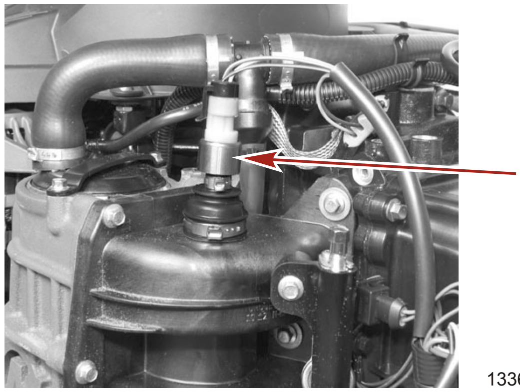
14533

a - Bolt securing electrical box to cylinder block

Description	Nm	lb-in.	lb-ft
Bolt (M8 x 35)	23	203	17

Manifold Absolute Pressure (MAP) Sensor

The MAP sensor measures the changes in the intake manifold pressure. It is located at the top of the intake manifold. When the ignition key switch is turned "ON," the MAP sensor reads the ambient atmospheric pressure. This information is used by the PCM as an indication of altitude and is referred to as BARRO. The MAP will change as a result of engine load and speed changes.



13369

Manifold Absolute Pressure Sensor Test

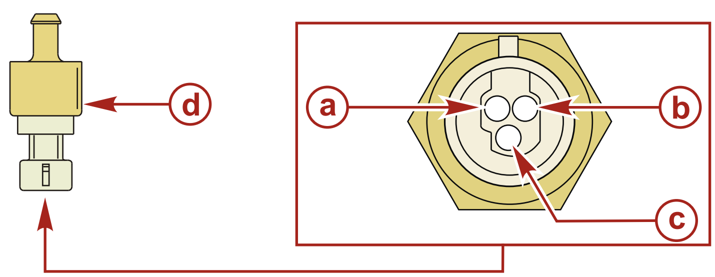
The CDS will display the functioning of the MAP sensor by providing a numerical readout of the sensor after the engine is started.

Manifold Absolute Pressure (MAP) Sensor Readings	
At idle	35–48 kPa (5–7 psi)
At wide-open throttle	195–200 kPa (28–29 psi)

1. Start the engine and connect the CDS to the engine. If the MAP sensor does not appear to be indicating a pressure change, shake or move the sensor harness and connector. If the pressure begins to change, look for broken, loose, or corroded wires.

Computer Diagnostic System (CDS)	Order through SPX

2. Turn the ignition key switch to the "OFF" position. Disconnect the engine harness connector from the sensor.
3. Visually inspect the sensor pins and the wires to the connector. Look for broken, bent, or corroded pins at the sensor; and loose, broken, or corroded wires at the connector.
4. Check the MAP sensor with a digital ohmmeter between pins a, b, and c.



17001

a - Pin a (black/orange)
b - Pin b (purple/yellow)
c - Pin c (yellow)
d - MAP sensor

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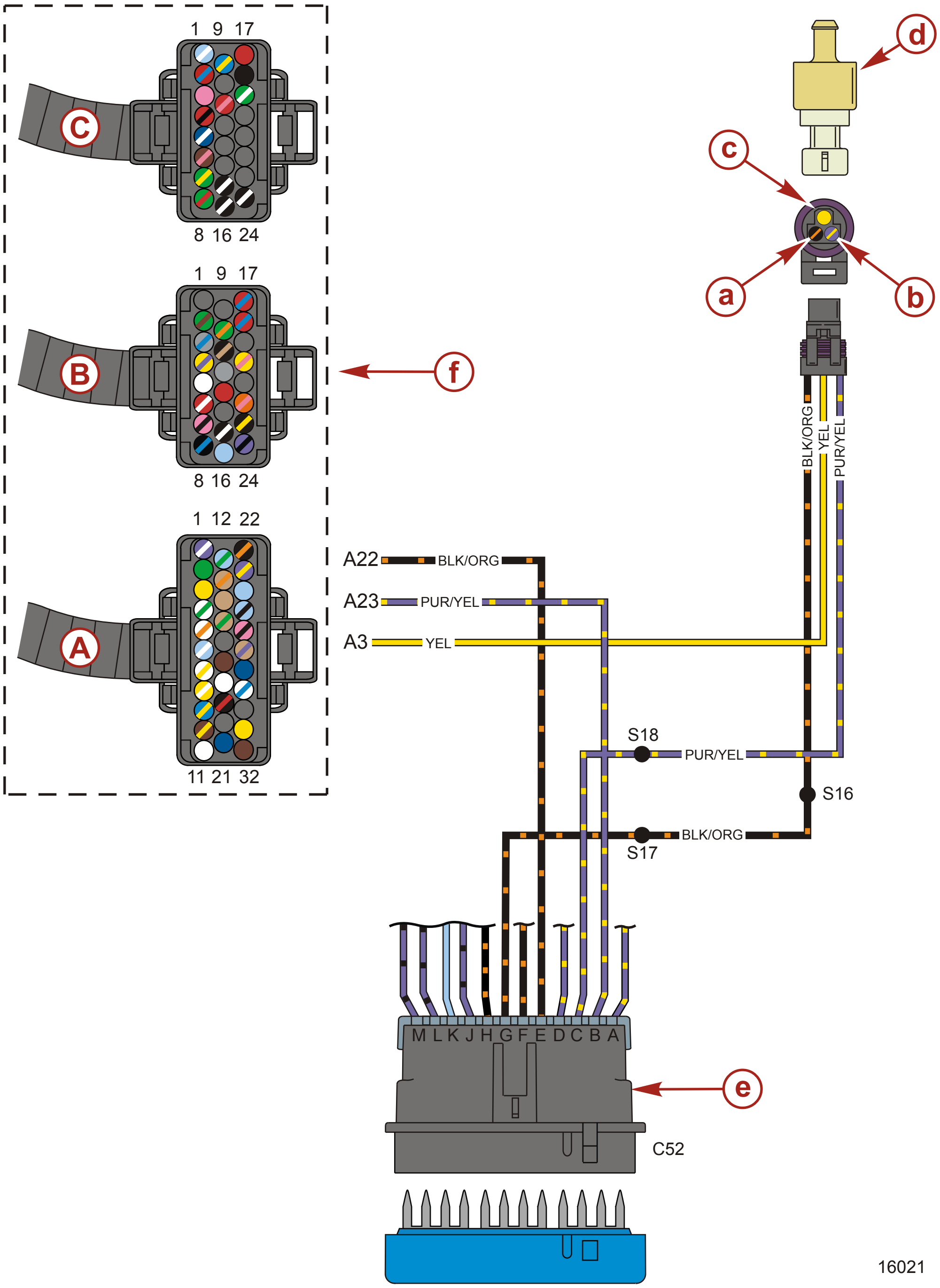
Meter Test Leads		Meter Scale	Reading (kΩ)
Red	**Black**		**At 21 °C (70 °F)**
a	b	Auto	78.4–145.6
a	c	Auto	182.0–338.0
b	a	Auto	78.4–145.6
b	c	Auto	100.8–187.2
c	a	Auto	182.0–338.0
c	b	Auto	100.8–187.2

5. If the ohm check of the MAP sensor indicates that the sensor is serviceable, perform an ohm check on the sensor wiring between the sensor connector and the PCM as follows:

***NOTE:** All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or between the connector and the splice point.*



- **a -** Pin a (black/orange)
- **b -** Pin b (purple/yellow)
- **c -** Pin c (yellow)
- **d -** MAP sensor
- **e -** Splice saver
- **f -** PCM

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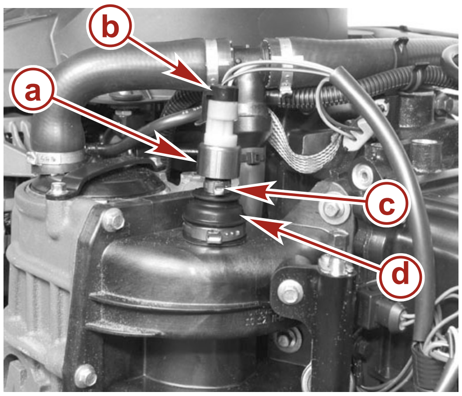
Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 3	Engine harness sensor connector (yellow wire)	Auto	Less than 1
Connector A, pin 23	Engine harness sensor connector (purple/yellow)	Auto	Less than 1

6. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Computer Diagnostic System (CDS)	Order through SPX

Manifold Absolute Pressure (MAP) Sensor Removal

1. Disconnect the engine harness connector.
2. Remove the 15.7 mm diameter clamp.
3. Remove the sensor from the adapter boot.
4. Inspect the adapter boot for cuts, cracks, or abrasion. Replace the boot as required.



13372

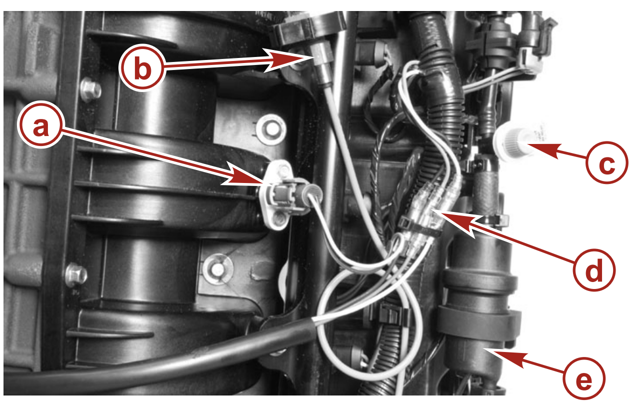
a - MAP sensor
b - Engine harness connector
c - 15.7 mm diameter clamp
d - Adapter boot

Manifold Absolute Pressure (MAP) Sensor Installation

1. Install a 15.7 mm diameter clamp onto the adapter boot.
2. Install the sensor into the adapter boot.
3. Secure the sensor with the 15.7 mm diameter clamp.
4. Connect the engine harness to the sensor.

Intake Manifold Air Temperature (MAT) Sensor

The MAT sensor is a thermistor that controls a signal voltage to the PCM. It is located in the middle of the intake manifold close to the fuel rail. It informs the PCM of the air temperature inside the intake manifold. The PCM adjusts the fuel injection duration needed to run the engine at optimum efficiency according to the MAT information. When intake air is cold, the sensor resistance is high. As the air temperature rises, resistance lowers.



13374

a - MAT sensor
b - Block water pressure sensor
c - FSM vent cap
d - Trim position sensor bullet connectors
e - Vent canister float switch

Intake Manifold Air Temperature (MAT) Sensor Test

The CDS determines the proper functioning of the MAT sensor by providing a numerical readout of the sensor temperature before and after the engine is started. With the engine not running, intake air temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in air intake temperature. Outside air temperature directly affects the engine intake manifold air temperature.

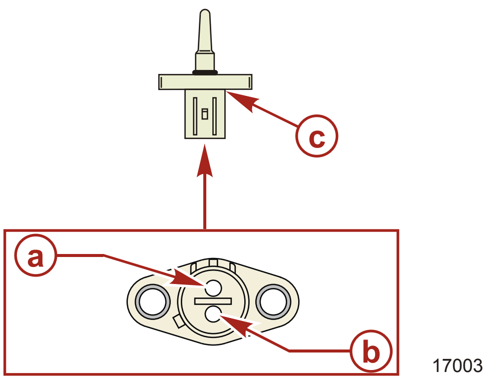
1. Start the engine and connect the CDS. If the MAT sensor does not appear to be indicating a temperature change, shake or move the sensor harness and connector. If the temperature begins to change, look for a broken, loose, or corroded wire.

Computer Diagnostic System (CDS)	Order through SPX

2. Disconnect the engine harness connector from the sensor.
3. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
4. The sensor can be tested with an ohmmeter. Remove the sensor from the intake manifold.

DMT 2004 Digital Multimeter	91-892647A01

5. Immerse the sensor into a temperature controlled media. If the readings do not match those in the table, replace the sensor and retest.

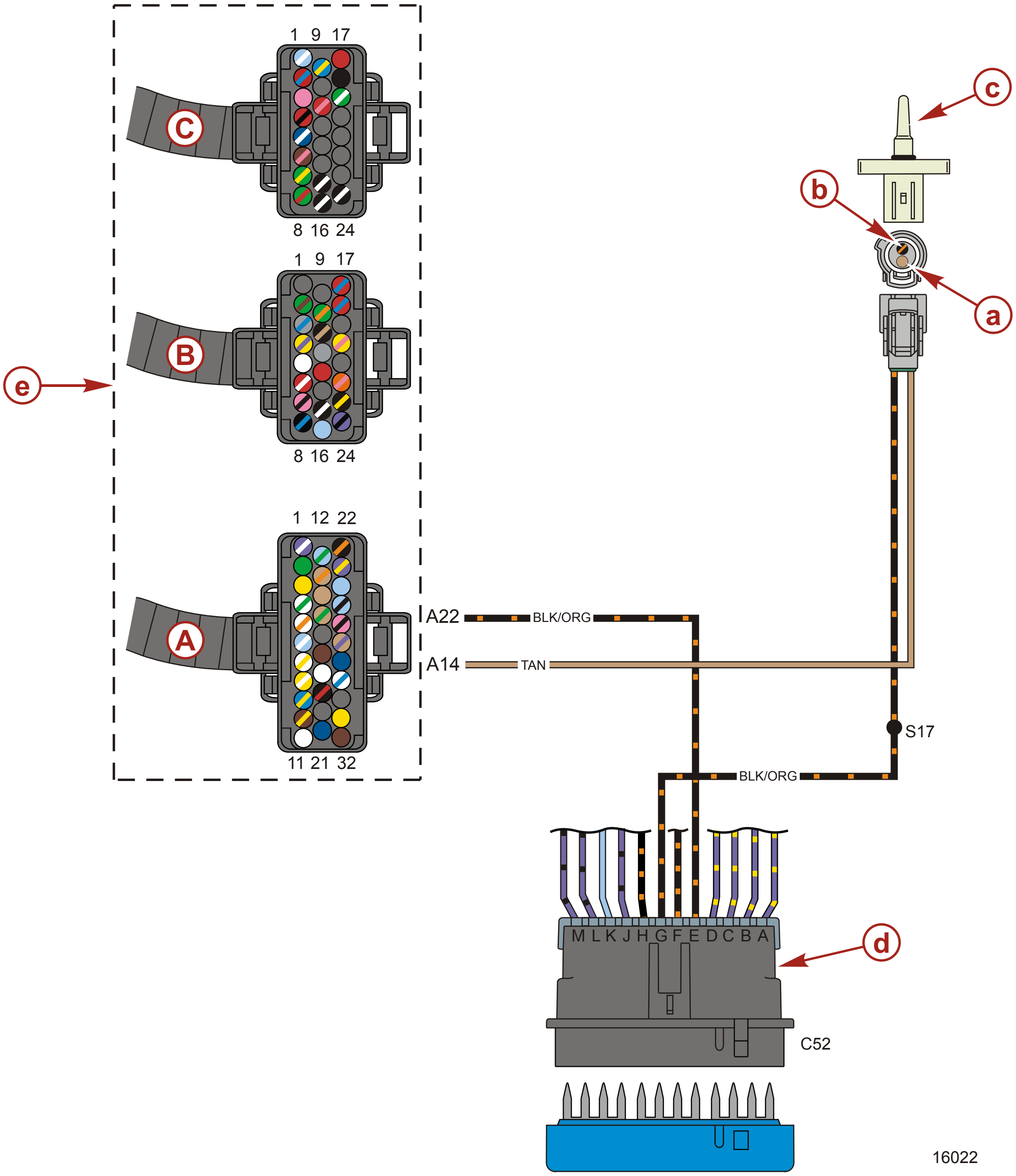


a - Pin a (tan)
b - Pin b (black/orange)
c - MAT sensor

Intake Manifold Air Temperature Sensor Ohm Test	
Temperature	**Reading (kΩ)**
0 °C (32 °F)	6.18–6.83
15 °C (59 °F)	3.04–3.36
25 °C (77 °F)	2.00–2.21
100 °C (212 °F)	0.14–0.16

6. If the ohm check of the MAT sensor indicates that the sensor is serviceable, perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

NOTE: All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, the connector, or between the connector and the splice point.



- **a -** Pin a (tan)
- **b -** Pin b (black/orange)
- **c -** MAT sensor
- **d -** Splice saver
- **e -** PCM

DMT 2004 Digital Multimeter	91-892647A01

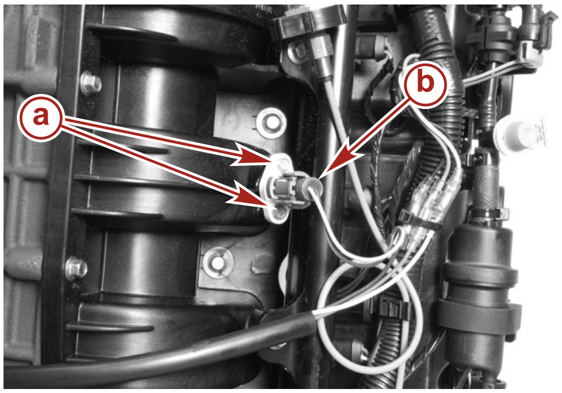
Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 14	Engine harness sensor connector (tan wire)	Auto	Less than 1

7. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Computer Diagnostic System (CDS)	Order through SPX

Intake Manifold Air Temperature (MAT) Sensor Removal

1. Disconnect the engine harness connector from the MAT sensor.
2. Remove two screws securing the sensor and remove the sensor.

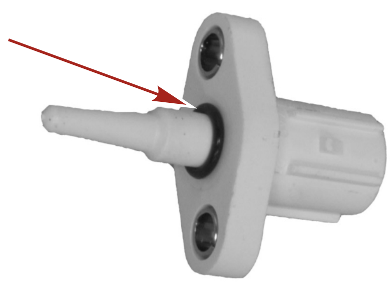


a - Sensor mounting screw (2)
b - Engine harness connector

13375

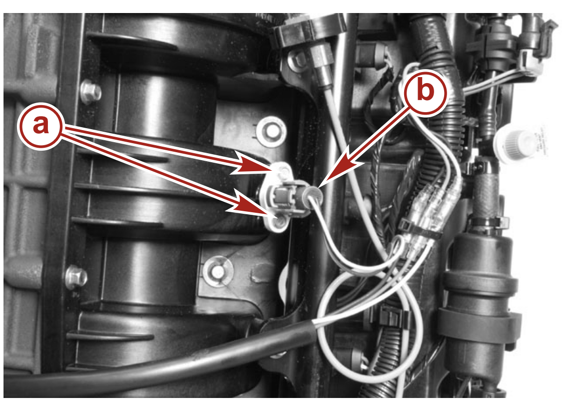
Manifold Air Temperature (MAT) Sensor Installation

1. Install a new O-ring onto the MAT sensor.



13378

2. Install the sensor on the intake manifold. Tighten the sensor mounting screws to the specified torque.
3. Connect the engine harness to the sensor.



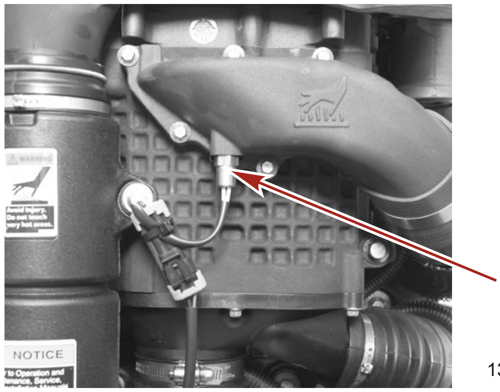
a - Sensor mounting screw (2)
b - Engine harness connector

13375

Description	Nm	lb-in.	lb-ft
Sensor mounting screw (M4 x 16)	1.7	15	

Supercharger Outlet Temperature Sensor

The supercharger outlet temperature sensor is a thermistor immersed in the boost pressure outlet stream. It is located in the front of the engine, at the base of the outlet duct. Low air temperature produces high resistance while high temperature causes low resistance. The PCM will reduce engine RPM and warn the helm of the high temperature.



13379

Supercharger Outlet Temperature Sensor Test

The CDS will determine the proper functioning of the supercharger outlet temperature sensor by providing a numerical readout of the sensor temperature before and after the engine is started. With the engine not running, the sensor temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in temperature.

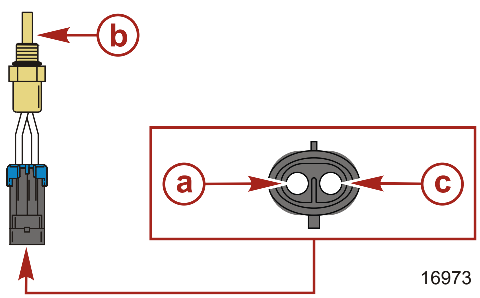
1. Start the engine and connect the CDS. If the sensor does not appear to be indicating a temperature change, shake or move the sensor harness and connector. If the temperature begins to change, look for a broken, loose, or corroded wire.

Computer Diagnostic System (CDS)	Order through SPX

2. Disconnect the engine harness connector from the sensor.
3. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins on the sensor, and loose, broken, or corroded wires at the engine harness connector.
4. The sensor can be tested with an ohmmeter. Disconnect the engine harness and remove the sensor from the supercharger.

DMT 2004 Digital Multimeter	91-892647A01

5. Immerse the sensor into a temperature controlled media. If the readings do not match those in the table, replace the sensor and retest.



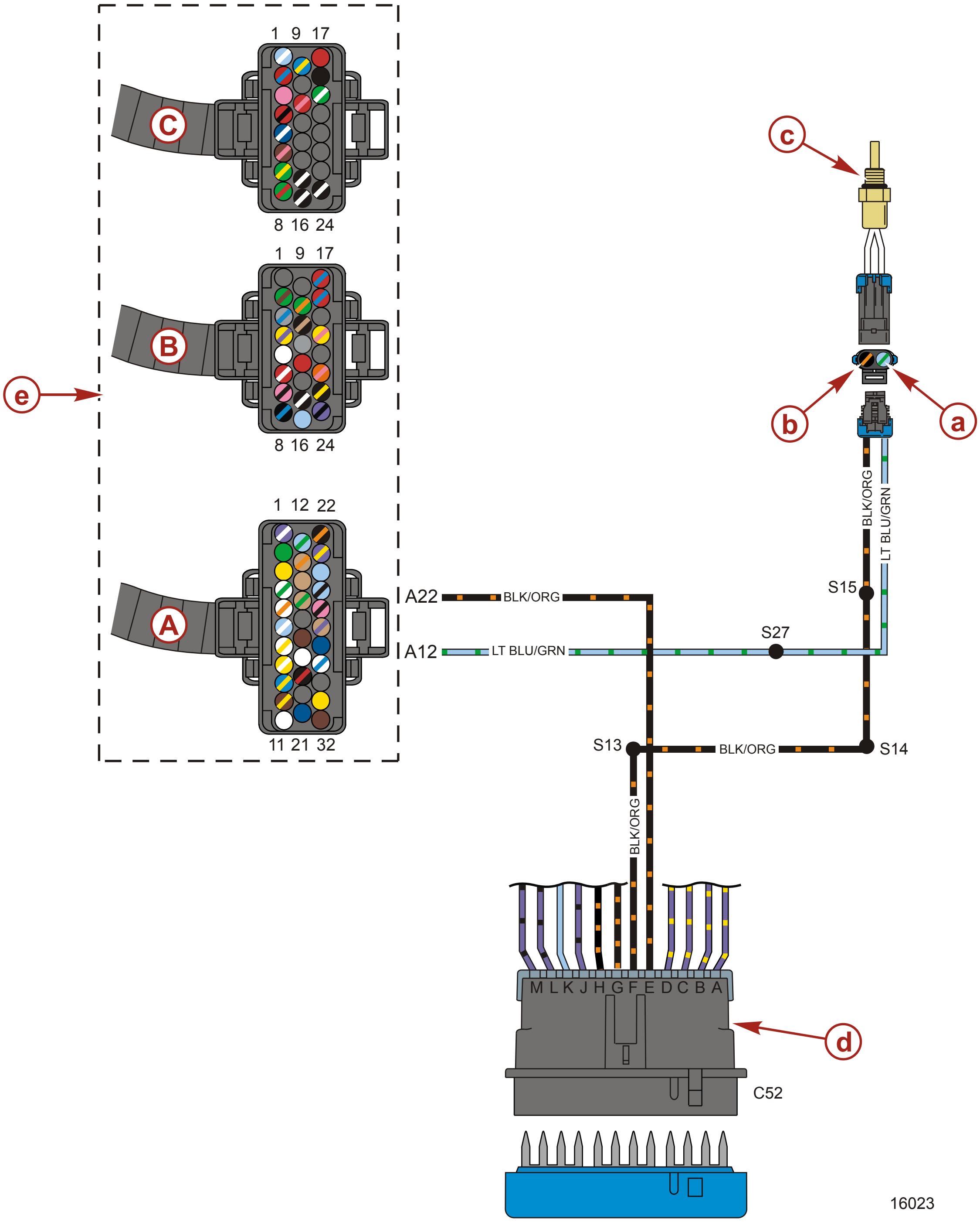
16973

a - Pin a (black/orange)
b - Supercharger outlet temperature sensor
c - Pin b (tan/green)

Supercharger Outlet Temperature Sensor Ohm Test	
Temperature	**Ω**
0 °C (32 °F)	32,600
50 °C (122 °F)	3,600
100 °C (212 °F)	678
145 °C (293 °F)	207

6. If the ohm check of the sensor indicates that the sensor is serviceable, perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

NOTE: All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, the connector, or between the connector and the splice point.



a - Pin a (light blue/green)
b - Pin b (black/orange)
c - Supercharger outlet temperature sensor
d - Splice saver
e - PCM

DMT 2004 Digital Multimeter	91-892647A01

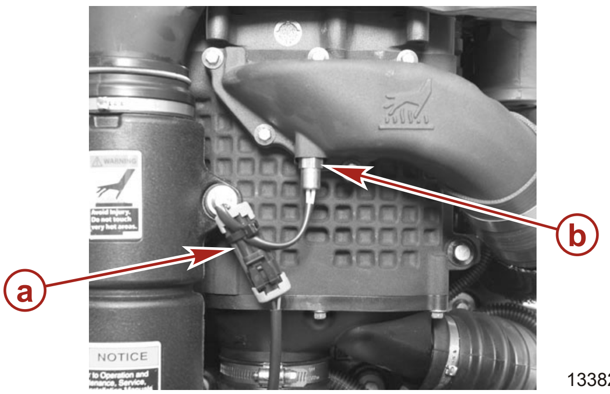
Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 12	Engine harness sensor connector (light blue/green)	Auto	Less than 1

7. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Computer Diagnostic System (CDS)	Order through SPX

Supercharger Outlet Temperature Sensor Removal

1. Disconnect the engine harness connector from the sensor.
2. Remove the temperature sensor from the supercharger outlet.



a - Engine harness connector
b - Temperature sensor

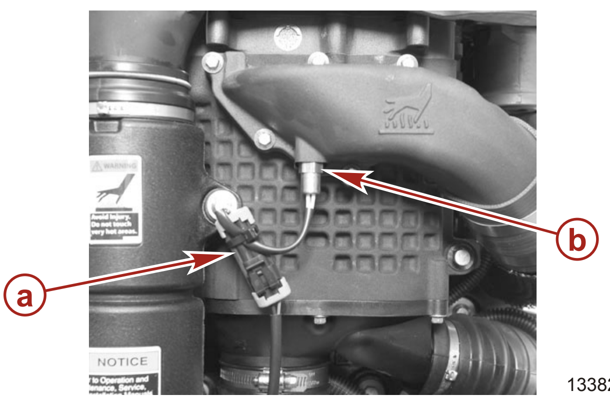
13382

Supercharger Outlet Temperature Sensor Installation

1. Install a new O-ring onto the temperature sensor.

13384

2. Install the temperature sensor onto the supercharger outlet. Tighten the temperature sensor to the specified torque.
3. Connect the engine harness to the sensor.



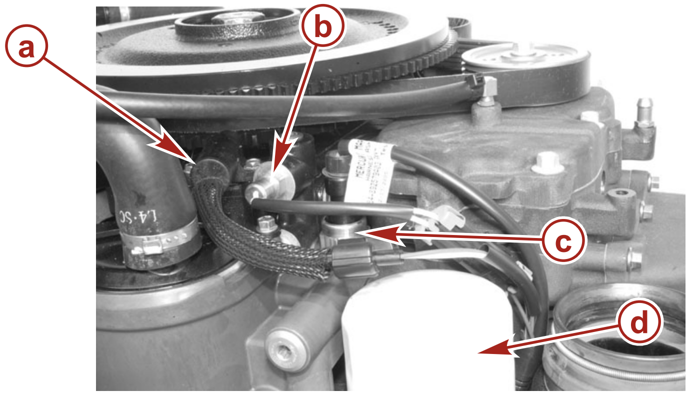
a - Engine harness connector
b - Temperature sensor

13382

Description	Nm	lb-in.	lb-ft
Temperature sensor	15	133	

Oil Pressure Sensor

The oil pressure sensor measures the engine oil pressure. It is located on the starboard side of the supercharger. In the event of low oil pressure, the PCM will limit engine power based on the amount of oil pressure available at a specific engine RPM.



13387

a - CPS
b - Oil temperature sensor
c - Oil pressure sensor
d - Oil filter

Oil Pressure Sensor Test

The CDS will determine the proper functioning of the oil pressure sensor by providing a numerical readout of the sensor after the engine is started.

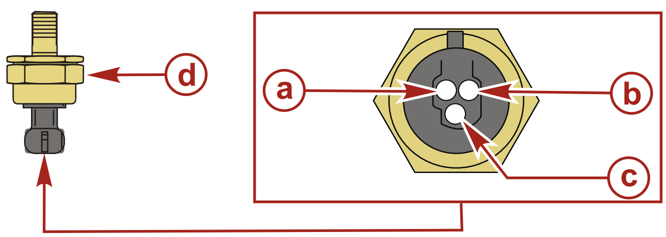
1. Connect the CDS to the engine. If the oil pressure sensor does not appear to be indicating a pressure change with the engine running at a normal operating temperature, shake or move the sensor harness and connector. If the pressure begins to change, look for broken, loose, or corroded wires.

Computer Diagnostic System (CDS)	Order through SPX

Normal Warm Operating Oil Pressure Gen I	
At idle	60–120 kPa (9–18 psi)
At wide-open throttle	300–450 kPa (44–65 psi)

Normal Warm Operating Oil Pressure Gen II	
At idle	90–190 kPa (13–28 psi)
At wide-open throttle	300–450 kPa (44–65 psi)

2. Disconnect the engine harness connector from the sensor.
3. Visually inspect the pins of the oil pressure sensor and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the oil pressure sensor and loose, broken, or corroded wires at the engine harness connector.
4. An ohm check of the oil pressure sensor can be made by measuring the resistance between pins A, B, and C. The normal resistance values for the oil pressure sensor at 21 °C (70 °F) are:



17006

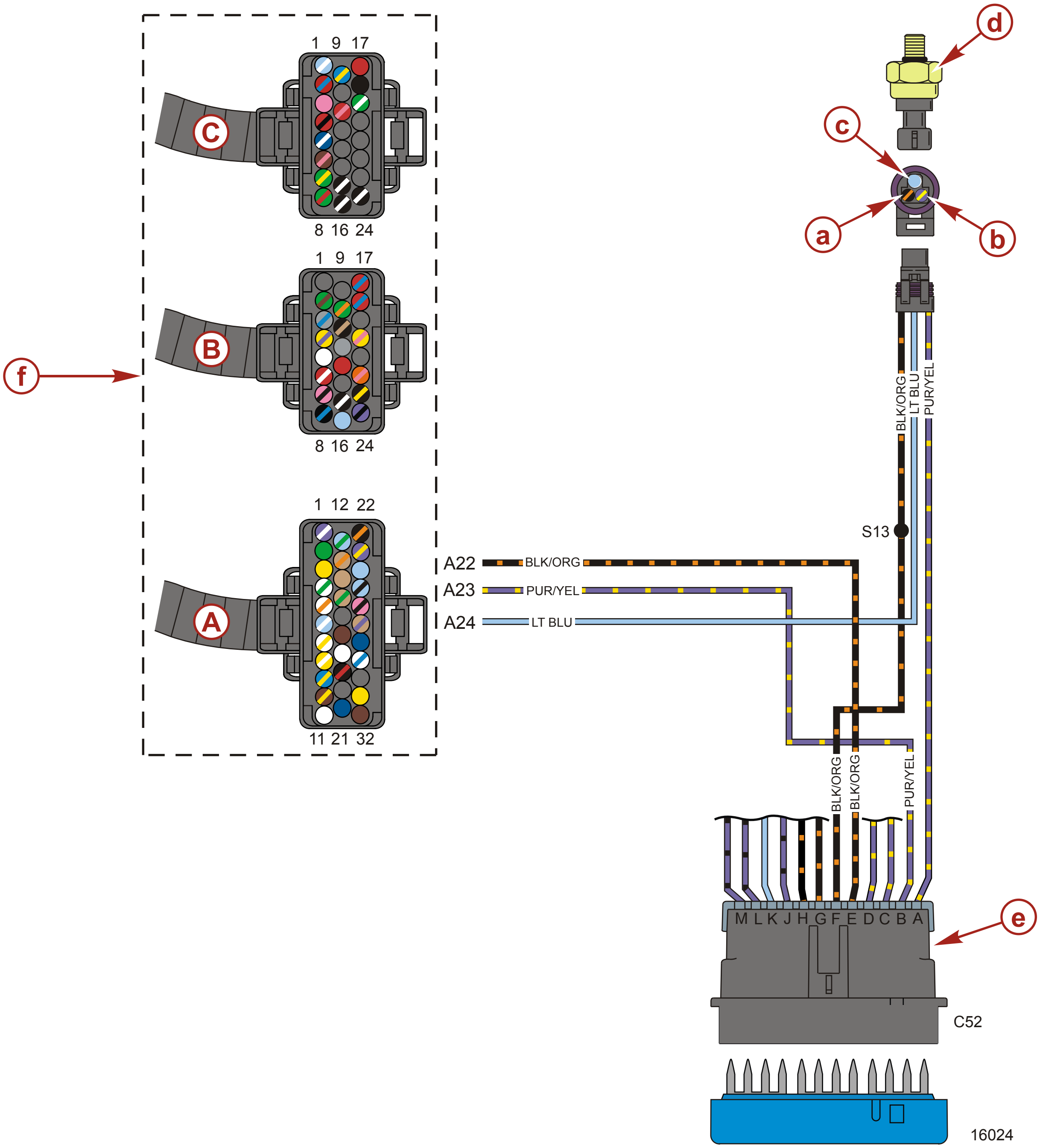
a - Pin a (black/orange)
b - Pin b (purple/yellow)
c - Pin c (light blue)
d - Oil pressure sensor

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (kΩ)
Red	**Black**		**At 21 °C (70 °F)**
a	b	Auto	78.4–145.6
a	c	Auto	182.0–338.0
b	a	Auto	78.4–145.6
b	c	Auto	100.8–187.2
c	a	Auto	182.0–338.0
c	b	Auto	100.8–187.2

5. If the ohm check of the oil pressure sensor indicates that the sensor is serviceable, perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

NOTE: All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or in between the connector and the splice point.



- a - Pin a (black/orange)
- b - Pin b (purple/yellow)
- c - Pin c (light blue)
- d - Oil pressure sensor
- e - Splice saver
- f - PCM

DMT 2004 Digital Multimeter	91-892647A01

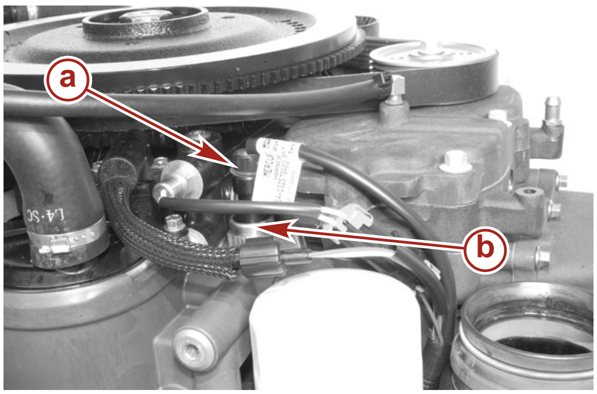
Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 23	Engine harness sensor connector (purple/yellow wire)	Auto	Less than 1
Connector A, pin 24	Engine harness sensor connector (light blue wire)	Auto	Less than 1

6. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Computer Diagnostic System (CDS)	Order through SPX

Oil Pressure Sensor Removal

1. Disconnect the engine harness connector from the oil pressure sensor.
2. Remove the oil pressure sensor from the supercharger.

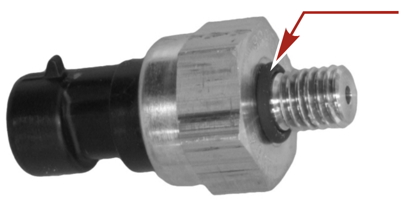


13388

a - Engine harness connector
b - Oil pressure sensor

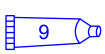
Oil Pressure Sensor Installation

1. Install a new O-ring onto the oil pressure sensor.



13393

2. Coat the threads of the sensor with Loctite 567 PST Pipe Sealant.

Tube Ref No.	Description	Where Used	Part No.
	Loctite 567 PST Pipe Sealant	Oil pressure sensor threads	92-809822

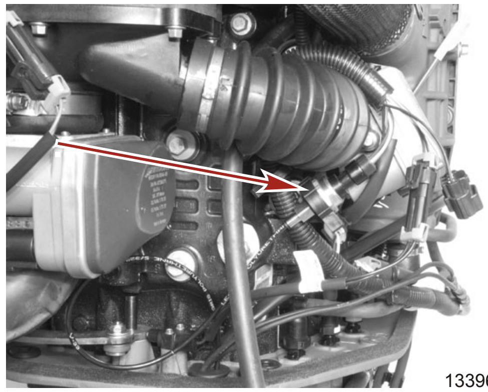
3. Install the oil pressure sensor onto the supercharger. Tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Oil pressure sensor	15	133	

4. Connect the sensor harness to the sensor.

Pitot Pressure Sensor

The pitot pressure sensor measures the force of the water at the front of the gear housing. The sensor converts this pressure to a voltage which is sent to the PCM. The PCM uses this voltage signal to determine boat speed. The pitot pressure sensor is located beneath the electronic boost control front tube on the port side of the engine.



13396

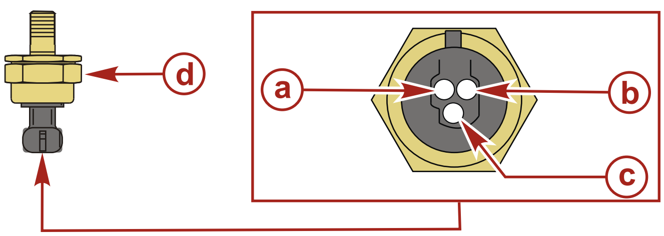
Pitot Pressure Sensor Test

The CDS will determine the proper functioning of the pitot pressure sensor by providing a numerical readout of the sensor after the engine is started and the boat is moving forward through the water.

1. With the engine running, the boat moving forward, and the CDS connected to the engine: if the pitot pressure sensor does not appear to be indicating a speed change, shake or move the sensor harness and connector. If the speed begins to change, look for a broken, loose, or corroded wires.

Computer Diagnostic System (CDS)	Order through SPX

2. Disconnect the engine harness connector from the sensor.
3. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
4. An ohm check of the pitot pressure sensor can be made by measuring the resistance between pins a, b, and c.



17006

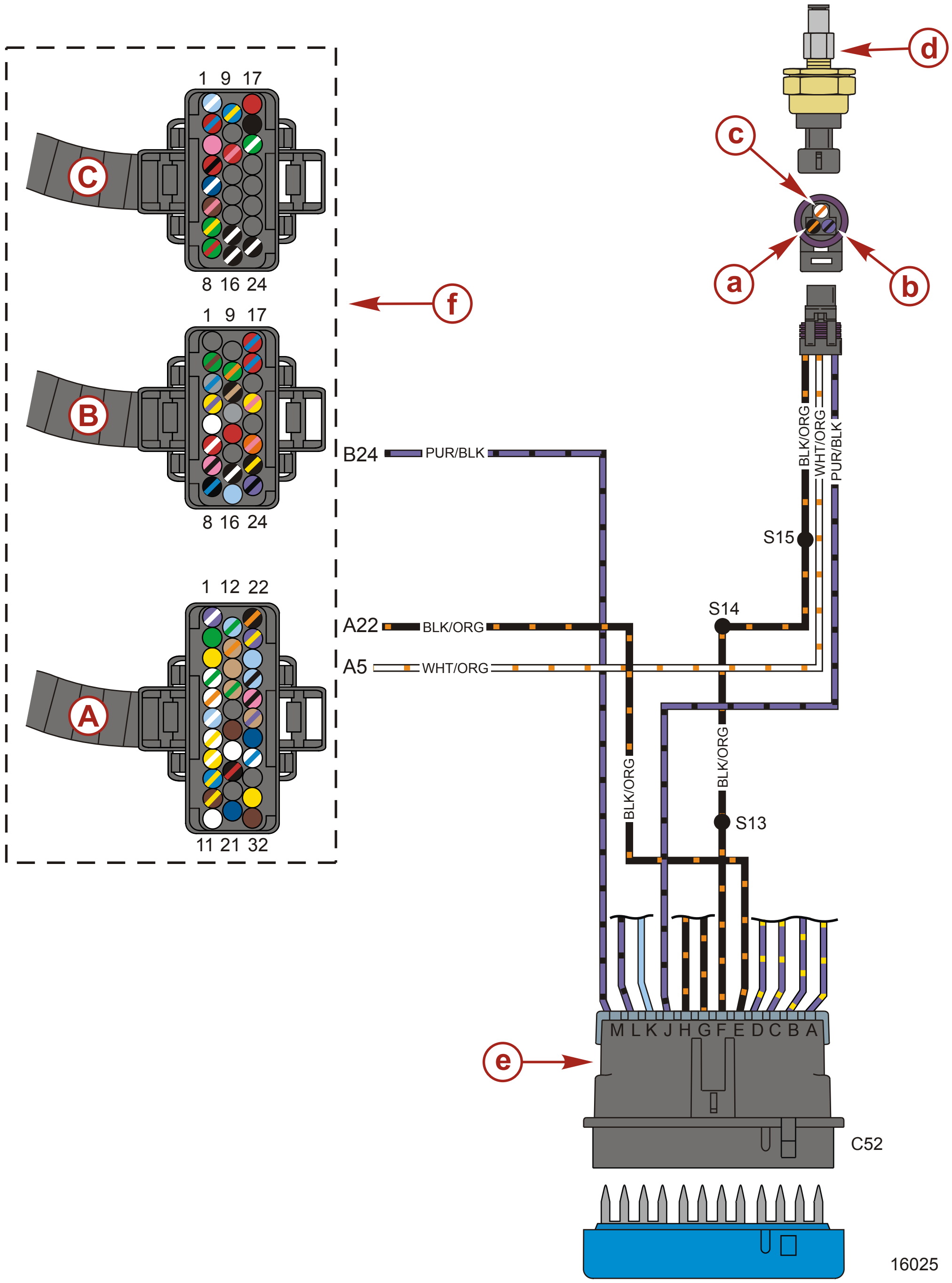
a - Pin a (black/orange)
b - Pin b (purple/black)
c - Pin c (white/orange)
d - Pitot pressure sensor

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (kΩ)
Red	**Black**		**At 21 °C (70 °F)**
a	b	Auto	78.4–145.6
a	c	Auto	182.0–338.0
b	a	Auto	78.4–145.6
b	c	Auto	100.8–187.2
c	a	Auto	182.0–338.0
c	b	Auto	100.8–187.2

5. If the ohm check of the pitot pressure sensor indicates that the sensor is serviceable, perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

NOTE: All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or between the connector and the splice point.



a - Pin a (black/orange)
b - Pin b (purple/black)
c - Pin c (white/orange)
d - Pitot pressure sensor
e - Splice saver
f - PCM

DMT 2004 Digital Multimeter	91-892647A01

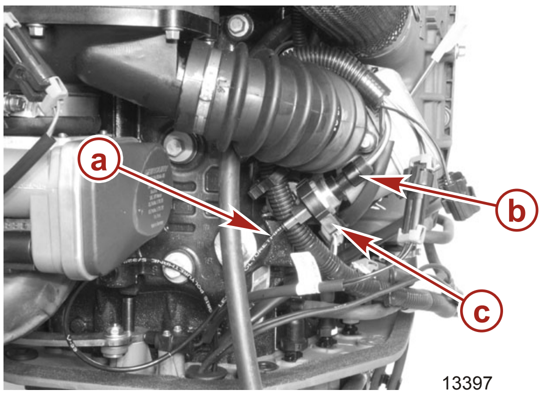
Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector B, pin 24	Engine harness sensor connector (purple/black wire)	Auto	Less than 1
Connector A, pin 5	Engine harness sensor connector (white/orange wire)	Auto	Less than 1

6. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Computer Diagnostic System (CDS)	Order through SPX

Pitot Pressure Sensor Removal

1. Disconnect the pitot tube from the sensor.
2. Disconnect the engine harness connector from the sensor.
3. Unlock the sensor retainer and remove the sensor.



13397

a - Pitot tube
b - Engine harness connector
c - Sensor retainer

4. Remove the sensor adapter from the pitot pressure sensor.

Pitot Pressure Sensor Installation

1. Install the sensor adapter to the pitot pressure sensor. Tighten the sensor adapter to ensure the adapter will not leak.

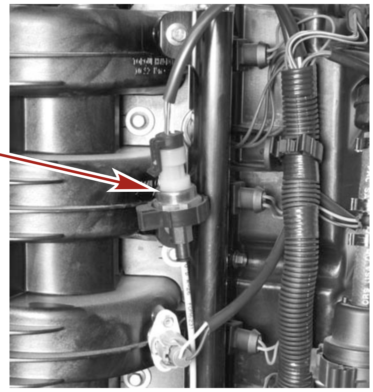
13401

a - Pitot pressure sensor
b - Sensor adapter

2. Secure the sensor with the retainer.
3. Connect the engine harness to the sensor.
4. Connect the pitot tube.

Block Water Pressure Sensor

The block water pressure sensor measures the amount of coolant being supplied by the water pump to the cylinder block. The sensor converts this pressure to a voltage which is sent to the PCM. The PCM will limit engine power if the coolant supply (water pressure) is insufficient at a given RPM. The block water pressure sensor is located on the aft side of the engine and is secured to the fuel injector harness with a cable tie.



13399

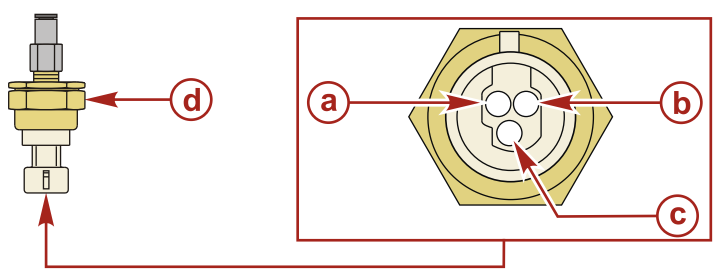
Block Water Pressure Sensor Test

The CDS will determine the proper functioning of the block water pressure sensor by providing a numerical readout of the sensor after the engine is started and engine RPM is varied.

1. With the engine running and the CDS connected to the engine, if the block water pressure sensor does not appear to be indicating a pressure change when engine RPM is varied, shake or move the sensor harness and connector. If the pressure begins to change, look for a broken, loose, or corroded wires.

Computer Diagnostic System (CDS)	Order through SPX

2. Disconnect the engine harness connector from the sensor.
3. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
4. An ohm check of the block water pressure sensor can be made by measuring the resistance between pins a, b, and c.



16596

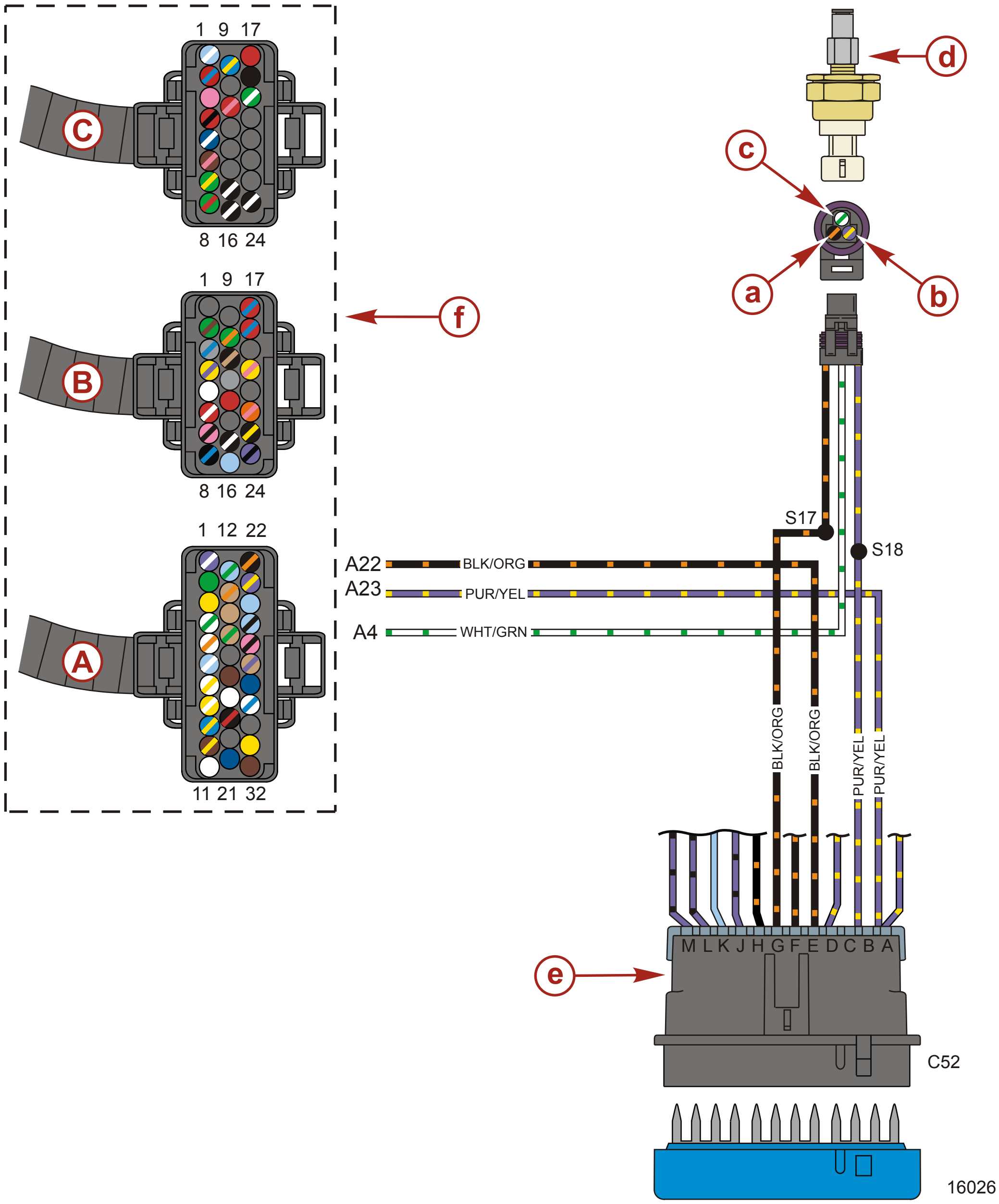
a - Pin a (black/orange)
b - Pin b (purple/yellow)
c - Pin c (white/green)
d - Block water pressure sensor

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (kΩ)
Red	**Black**		**At 21 °C (70 °F)**
a	b	Auto	78.4–145.6
a	c	Auto	182.0–338.0
b	a	Auto	78.4–145.6
b	c	Auto	100.8–187.2
c	a	Auto	182.0–338.0
c	b	Auto	100.8–187.2

5. Perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

NOTE: *All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or between the connector and the splice point.*



- **a -** Pin a (black/orange)
- **b -** Pin b (purple/yellow)
- **c -** Pin c (white/green)
- **d -** Block water pressure sensor
- **e -** Splice saver SP4
- **f -** PCM

DMT 2004 Digital Multimeter	91-892647A01

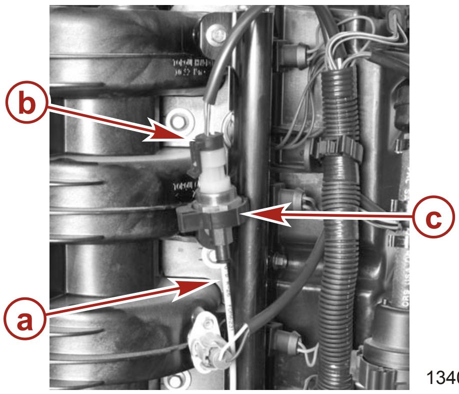
Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 23	Engine harness sensor connector (purple/yellow wire)	Auto	Less than 1
Connector A, pin 5	Engine harness sensor connector (white/green wire)	Auto	Less than 1

6. If the wiring is serviceable, the PCM can be tested using the CDS with the pinpoint guided diagnostic instructions. If the PCM is serviceable, replace the sensor.

Computer Diagnostic System (CDS)	Order through SPX

Block Water Pressure Sensor Removal

1. Remove the water pressure tube.
2. Disconnect the engine harness connector from the sensor.
3. Unlock the sensor retainer and remove the sensor.



13400

a - Water pressure tube
b - Engine harness connector
c - Sensor retainer

4. Remove the sensor adapter.

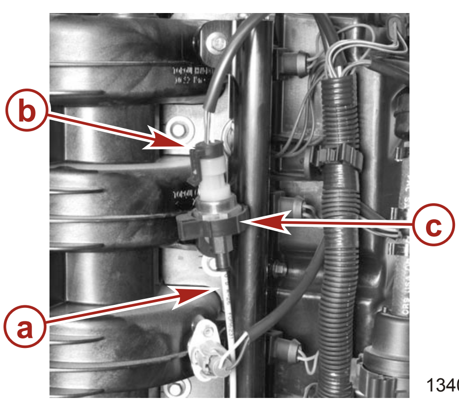
Block Water Pressure Sensor Installation

1. Install the sensor adapter to the block water pressure sensor. Tighten to ensure the sensor adapter will not leak.

13401

a - Block water pressure sensor
b - Sensor adapter

2. Install the block water pressure sensor into the sensor retainer.
3. Connect the engine harness to the sensor.
4. Install the water pressure tube to the sensor.

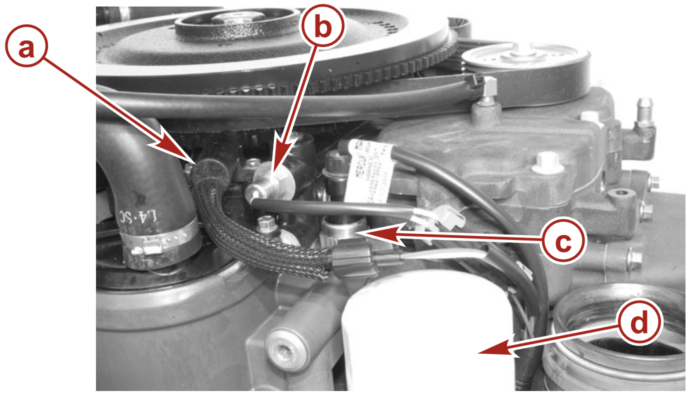


13400

a - Water pressure tube
b - Engine harness connector
c - Sensor retainer

Oil Temperature Sensor

The oil temperature sensor is located on the starboard side of the cylinder block, next to the CPS. It is a thermistor immersed in the engine oil passageway. It supplies the PCM with engine oil temperature information. The PCM adjusts the timing and the amount of fuel delivered according to the oil temperature in the cylinder block. Low oil temperature produces high resistance, while high temperature causes low resistance.



13387

- a - CPS
- b - Oil temperature sensor
- c - Oil pressure sensor
- d - Oil filter

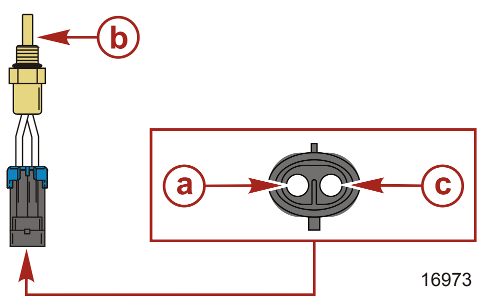
Oil Temperature Sensor Test

The CDS will determine the proper functioning of the oil temperature sensor by providing a numerical readout of the oil temperature before and after the engine is started. With the engine not running, oil temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in oil temperature to approximately 75–110 °C (167–230 °F). Outside air temperature and the temperature of the water that the engine is operating in will directly affect the engine oil temperature.

1. Start the engine and connect the CDS. If the oil temperature sensor does not appear to be indicating a temperature change, shake or move the sensor harness and connector. If the temperature begins to change, look for a broken, loose, or corroded wire.

Computer Diagnostic System (CDS)	Order through SPX

2. Disconnect the engine harness connector from the sensor.
3. Visually inspect the sensor pins and the wires to the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
4. The sensor can be tested with an ohmmeter. Disconnect the engine harness connector from the sensor and remove the sensor.
5. Immerse the tip of the sensor in a controlled temperature media. If the readings do not match those in the table, replace the sensor and retest.



16973

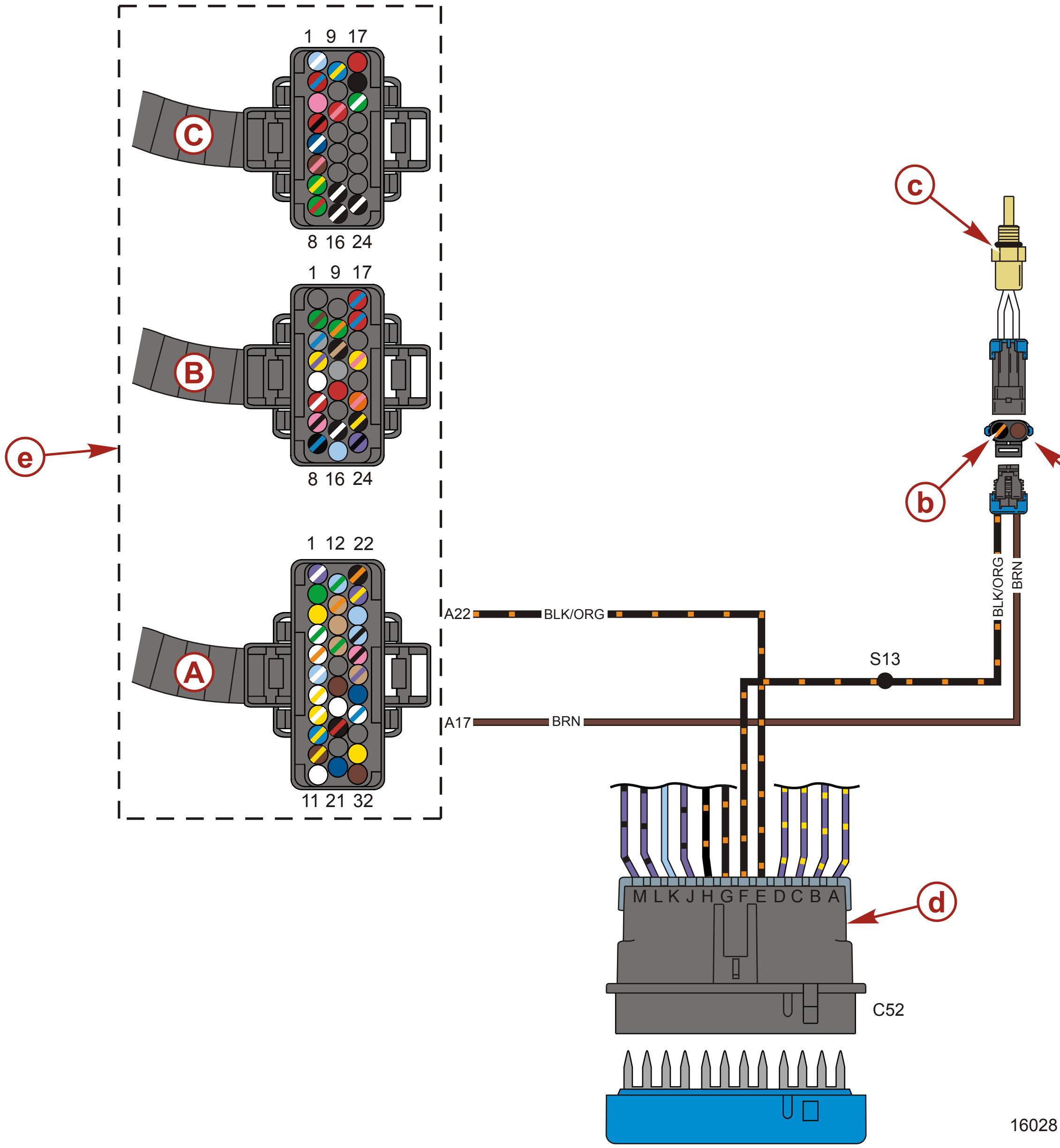
- a - Pin a (black/orange)
- b - Oil temperature sensor
- c - Pin b (tan/green)

DMT 2004 Digital Multimeter	91-892647A01

Oil Temperature Sensor Ohm Test	
Temperature	**Reading (kΩ)**
-10 °C (14 °F)	16.50–23.50
21 °C (70 °F)	10.65–11.95
38 °C (100 °F)	5.32–6.02
65 °C (150 °F)	1.90–2.20
95 °C (203 °F)	0.735–0.865

6. If the ohm check of the oil temperature sensor indicates that the sensor is serviceable, perform an ohm check of the sensor wiring between the sensor connector and the PCM as follows:

   ***NOTE:** All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or between the connector and the splice point.*



a - Pin A (brown)
b - Pin B (black/orange)
c - Oil temperature sensor
d - Splice saver SP5
e - PCM

DMT 2004 Digital Multimeter	91-892647A01

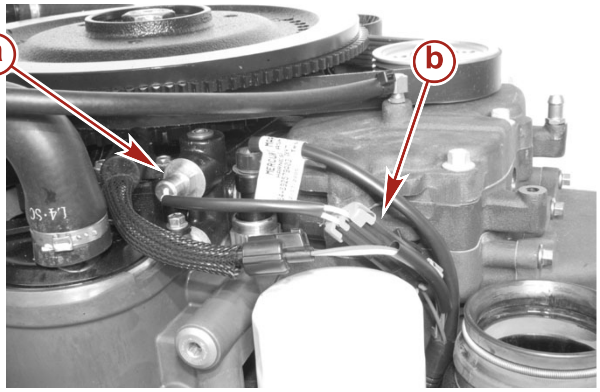
Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 17	Engine harness sensor connector (brown wire)	Auto	Less than 1

7. If the wiring is serviceable, replace the PCM and check the sensor function using the CDS.

Computer Diagnostic System (CDS)	Order through SPX

Oil Temperature Sensor Removal

1. Disconnect the engine harness connector from the sensor harness connector.
2. Remove the sensor from the cylinder block.



12156

a - Engine harness connector
b - Oil temperature sensor

Oil Temperature Sensor Installation

1. Install a new O-ring onto the oil temperature sensor.

13384

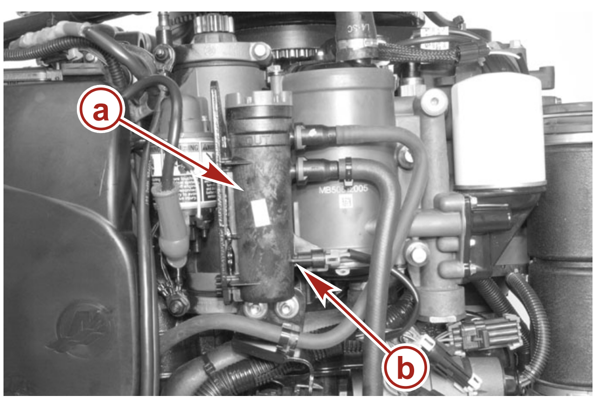
2. Install the oil temperature sensor onto the cylinder block. Tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Oil temperature sensor	15	133	

3. Connect the engine harness to the sensor harness connector.

Water in Fuel (WIF) Sensor

The water sensor is located in the fuel filter housing on the starboard side of the engine. The sensor has two probes that are highly conductive when water is present. The sensor is a normally open switch. Water completes a 5 volt negative reference to the PCM. The PCM will generate an error history and activate a warning horn to inform the operator. If SmartCraft gauges are installed, the PCM will flash a visual warning to the operator.

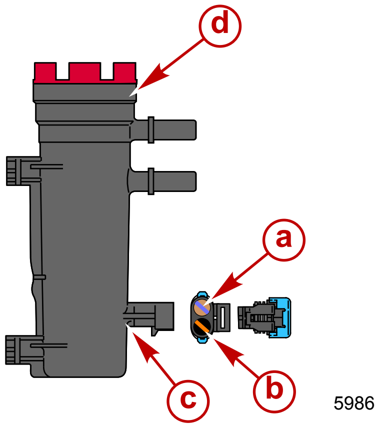


12196

a - Fuel filter assembly
b - Water in fuel sensor

Water in Fuel (WIF) Sensor Test

1. If the WIF warning horn activates, remove the fuel filter assembly from the engine and pour the contents into a clear container. If no water is present, disconnect the WIF sensor harness and perform a continuity check between the two sensor pins. There should be no continuity. If there is continuity, the sensor is defective and the fuel filter assembly must be replaced.



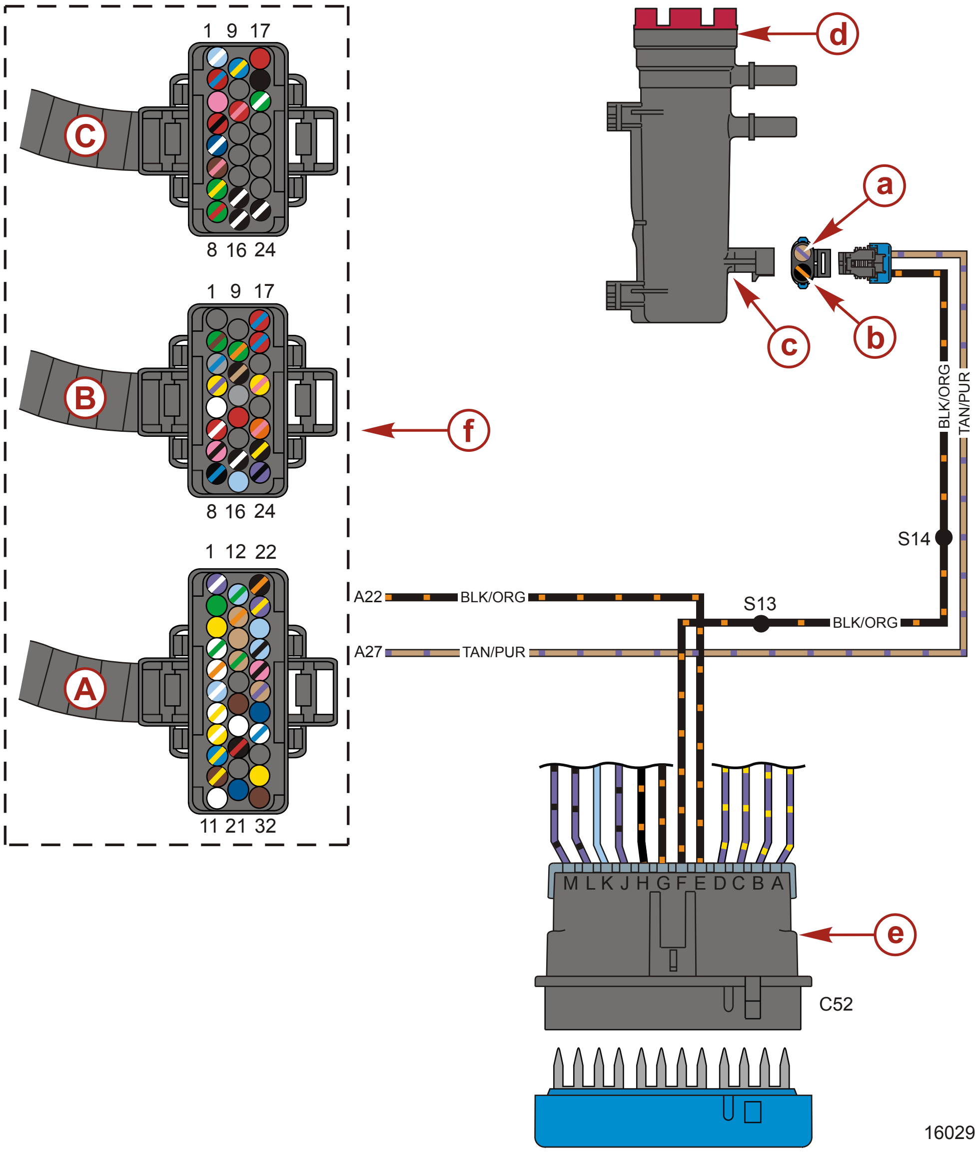
- a - Pin a (tan/purple)
- b - Pin b (black/orange)
- c - WIF sensor
- d - Fuel filter

DMT 2004 Digital Multimeter	91-892647A01

2. If the sensor is serviceable, perform a continuity check on the sensor harness between the sensor connector and the PCM. Check for shorts to ground.

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
PCM connector A, pin 22	Sensor connector, pin B	Auto	Less than 1
PCM connector A, pin 27	Sensor connector, pin A	Auto	Less than 1

***NOTE:** All sensor ground wires are spliced together and connect to the PCM at pin 22 of connector A. Unless there are multiple sensor failures, the most likely failure would be at the splice point, connector, or between the connector and the splice point.*



a - Pin a (tan/purple)
b - Pin b (black/orange)
c - WIF sensor
d - Fuel filter
e - Splice saver SP5
f - PCM

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Connector A, pin 22	Engine harness sensor connector (black/orange wire)	Auto	Less than 1
Connector A, pin 27	Engine harness sensor connector (tan/purple wire)	Auto	Less than 1

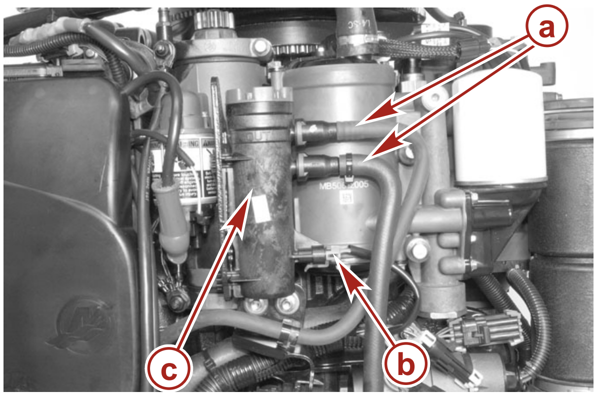
If the sensor harness is serviceable, replace the PCM.

Water in Fuel (WIF) Sensor Removal

***NOTE:** The WIF sensor is not replaceable as an individual component. It must be replaced as part of the fuel filter assembly.*

1. Disconnect the engine harness connector from the sensor.
2. Remove two fuel hoses from the fuel filter.

3. Slide the fuel filter assembly up and out of the retaining bracket.



12727

a - Fuel hoses
b - Engine harness connector
c - Retaining bracket

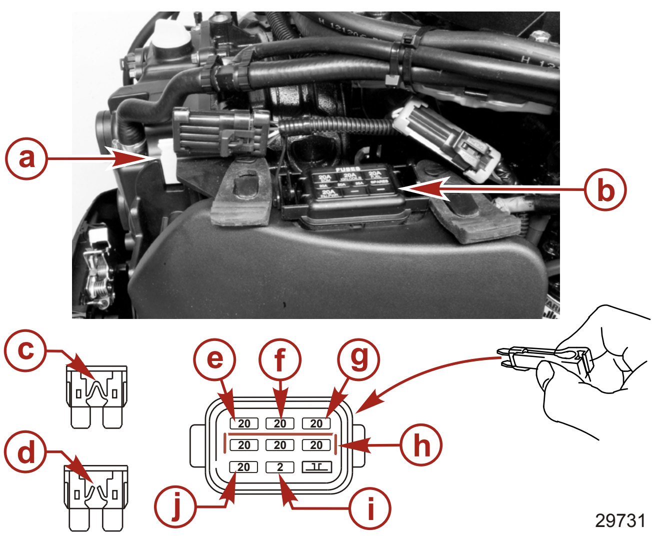
Water in Fuel (WIF) Sensor Installation

1. Slide the fuel filter assembly into the retaining bracket.
2. Connect the fuel hoses.
3. Connect the engine harness connector to the sensor.

Fuses

The electrical wiring circuits on the outboard are protected from overload by fuses in the wiring. If a fuse is blown, try to locate and correct the cause of the overload. If the cause is not found, the fuse may blow again.

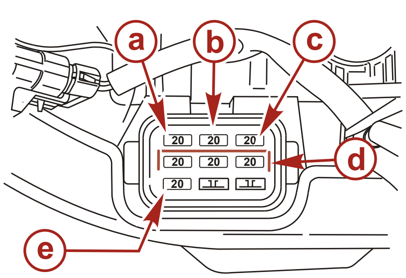
1. Remove the top cowl. Locate the fuse holder on the starboard side of the engine.
2. Remove the plastic cover from the fuse holder.
3. Remove the fuse puller from the fuse holder.
4. Remove the suspected blown fuse to determine if the silver colored band is broken.
5. Replace the fuse with a new fuse of the same amperage rating.



29731

Gen 1 and newer fuse holder

a - Fuse puller
b - Fuse holder
c - Good fuse
d - Blown fuse
e - Engine control module, start relay, and purge valve, "ECM" - 20 amp fuse
f - Ignition coils, "IGN. COILS" - 20 amp fuse
g - Fuel delivery, "FUEL" - 20 amp fuse
h - Spare fuses (3)
i - Diagnostic terminal - 2 amp fuse
j - Injector power and boost valve, "INJ. PWR." - 20 amp fuse



28776

Early model fuse holder

a - Engine control module and purge valve, "ECM" - 20 amp fuse
b - Ignition coils, "IGN. COILS" - 20 amp fuse
c - Fuel delivery, "FUEL" - 20 amp fuse
d - Spare fuses - 20 amp fuse
e - Injector power and boost valve, "INJ. PWR." - 20 amp fuse

Electrical

Section 2B - Charging and Starting System

Table of Contents

Charging and Starting Specifications

Charging and Starting Specifications	
Alternator output (regulated)	
Output at battery (at 1000 RPM)	37–44 A
Output at battery (at 3000 RPM)	53–69 A
Output at alternator (at 1000 RPM)	48–54 A
Output at alternator (at 3000 RPM)	65–72 A
Voltage set point	14.5 ± 0.25 volts
Regulator current draw[1]	
Ignition switch "OFF" (maximum)	1.0 mA
Ignition switch "ON"	350 mA
Starter draw (under load)	160 A
Starter draw (no load)	60 A
Minimum brush length	6.54 mm (0.25 in.)
Starting battery rating	
Required starting battery type	12 volt absorbed glass mat (AGM) battery
Required USA and Canada (SAE) starting battery type*	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 RC25 rating
Required international (EN) starting battery type*	975 minimum cold cranking amps (CCA) with a minimum of 65 ampere hour (Ah)

*Different test methods are used to determine cranking ratings in different parts of the world.

IMPORTANT: The battery selected must meet or exceed both required specifications:

- **USA and Canada (SAE rating)–Both MCA and RC25**
- **International (EN rating)–Both CCA and Ah**

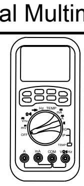
Boatbuilders who use batteries rated to SAE specifications must meet both the 800 marine cranking amps (MCA) and 135 RC25 specifications following SAE test procedures. If a boat is shipped anywhere in the world, a battery rating per SAE specifications is acceptable.

Boatbuilders who use batteries rated to EN specifications must meet both the 975 cold cranking amps (CCA) and 65 ampere hour (Ah) specifications following EN test procedures. If a boat is shipped anywhere in the world, a battery rating per EN specifications is acceptable.

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Alternator cable grounds	92- 25711 3
95	2-4-C with Teflon	Battery terminal bolts	92-802859A 1

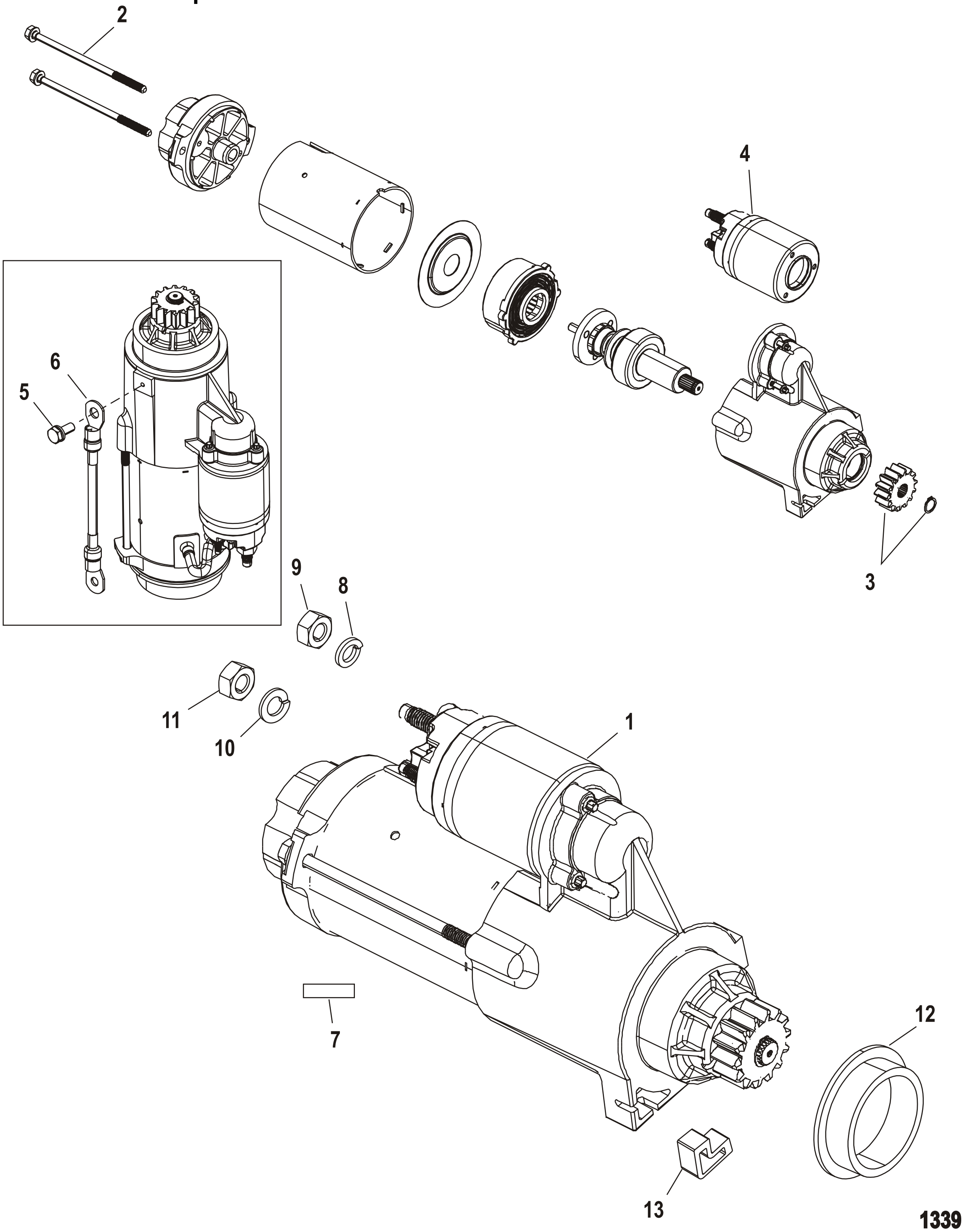
Special Tools

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.

1. All model alternator specifications require an amperage draw of less than 1.0 mA with the ignition key in the "OFF" position and an amperage draw of not more than 350.0 mA with key in the "ON" position.

Notes:

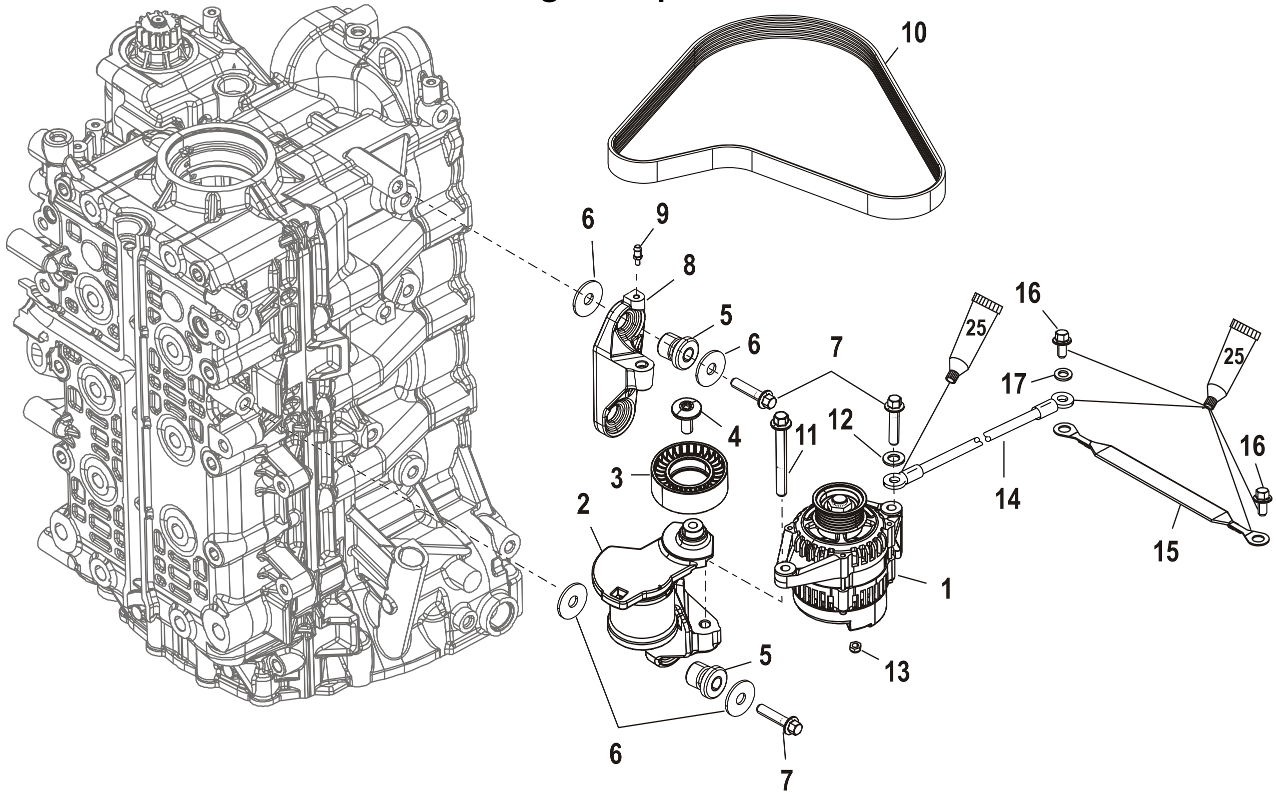
Starter Motor Components



Starter Motor Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Starter assembly			
2	2	Through bolt			
3	1	Gear kit			
4	1	Solenoid			
5	1	Bolt with washer (0.250-20 x 0.625)	9	80	
6	1	Cable			
7	1	Decal			
8	1	Lockwasher			
9	1	Nut (M5)	2.5	22	
10	1	Lockwasher			
11	1	Nut (M8)	9	80	
12	2	Collar			
13	1	Stop			

Alternator/Belt Tensioner Mounting Components



Alternator/Belt Tensioner Mounting Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	70 A alternator			
2	1	Belt tensioner			
3	1	Pulley			
4	1	Bolt	26		19.2
5	4	Mount			
6	8	Washer			
7	5	Bolt (M10 x 45)	47.5		35
8	1	Alternator bracket			
9	1	Pin			
10	1	Belt			
11	1	Bolt (M10 x 85)	47.5		35
12	1	Washer			
13	1	Nut (M6)	7	62	
14	1	Cable			
15	1	Braided cable			
16	2	Bolt (M6 x 16)	8	71	
17	1	Washer			

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Alternator cable grounds	92- 25711 3

Battery

Battery Cable Test

This test is used to determine if there is excessive resistance in the battery's positive or negative cables, or if the cable is sized properly to carry the necessary current needed to crank the engine at the proper RPM.

IMPORTANT: This test must be performed while the key switch is in the "START" position. Ignore any voltage readings taken without the circuit under load.

> **⚠ WARNING**
>
> **Moving parts can cause serious injury or death. Wear eye protection and keep hands, hair, and clothing away from moving parts when performing tests or checking adjustments on an operating engine.**

1. Perform a load test on the battery following the instructions supplied with the load tester. Ensure the battery is brought to a full charge after being tested.
2. With the key switch in the "START" position, measure the voltage across the battery posts, not the cable clamps. Record the voltage reading. If the voltage is less than 10 VDC, replace the battery.

   NOTE: The voltage reading in step 2 is the base voltage. The base voltage reading will be compared to the voltage readings obtained in the following steps.
3. With the key switch in the "START" position, measure the voltage from the battery positive post (not the cable clamp) to the starter post (the stud where the battery positive cable is connected). Record the voltage reading.
4. With the key switch in the "START" position, measure the voltage from the starter case to the battery negative post (not the cable clamp). Record the voltage reading.
5. If the voltage reading in step 3 was more than 1.0 VDC:
   a. Check the cable connections for tightness and corrosion.
   b. If the cable is tight and not corroded, replace the cable with a larger diameter cable.
6. If the voltage reading in step 4 was more than 1.0 VDC:
   a. Check the cable connections for tightness and corrosion.
   b. If the cable is tight and not corroded, replace the cable with a larger diameter cable.

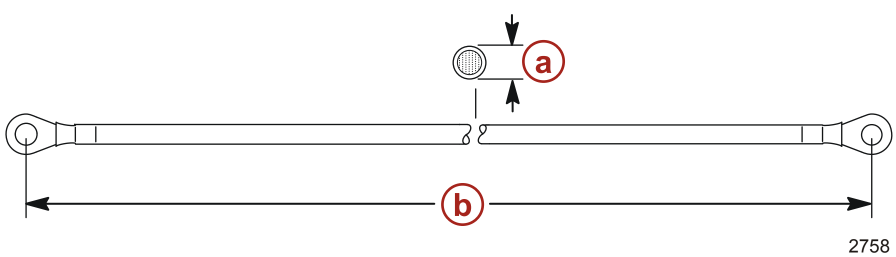
Resistance in the cables can cause a voltage drop and limit current to the starter. If corrosion is present, or if the starter is worn, there may not be enough amperage to turn the starter motor.

NOTE: If the voltage at the starter is less than 11 VDC, the engine may not start.

Battery Cable Size for Outboard DTS Models

IMPORTANT: Only use copper battery cables. Do not use aluminum cables for any outboard marine installations.

NOTE: If longer battery cables are required, the wire gauge size must increase. See the following chart for correct wire gauge size.



a - Wire gauge size
b - Battery cable length

Cable Length	Copper Battery Cable Wire Gauge Size Number (SAE)	Cable Length	Copper Battery Cable Wire Gauge Size Number (SAE)
	Verado and OptiMax DTS Engines		Verado and OptiMax DTS Engines
2.4 m (8 ft.)	-	**7.6 m (25 ft.)**	1
2.7 m (9 ft.)	-	**7.9 m (26 ft.)**	1/0
3.0 m (10 ft.)	-	**8.2 m (27 ft.)**	1/0
3.4 m (11 ft.)	-	**8.5 m (28 ft.)**	1/0
3.7 m (12 ft.)	4	**8.8 m (29 ft.)**	1/0
4.0 m (13 ft.)	2	**9.1 m (30 ft.)**	1/0

Cable Length	Copper Battery Cable Wire Gauge Size Number (SAE)	Cable Length	Copper Battery Cable Wire Gauge Size Number (SAE)
	Verado and OptiMax DTS Engines		Verado and OptiMax DTS Engines
4.3 m (14 ft.)	2	**9.4 m (31 ft.)**	1/0
4.6 m (15 ft.)	2	**9.8 m (32 ft.)**	1/0
4.9 m (16 ft.)	2	**10.1 m (33 ft.)**	2/0
5.2 m (17 ft.)	2	**10.4 m (34 ft.)**	2/0
5.5 m (18 ft.)	2	**10.7 m (35 ft.)**	2/0
5.8 m (19 ft.)	2	**11.0 m (36 ft.)**	2/0
6.1 m (20 ft.)	2	**11.3 m (37 ft.)**	2/0
6.4 m (21 ft.)	1	**11.6 m (38 ft.)**	2/0
6.7 m (22 ft.)	1	**11.9 m (39 ft.)**	2/0
7.0 m (23 ft.)	1	**12.2 m (40 ft.)**	2/0
7.3 m (24 ft.)	1		

Replacement Parts

⚠ 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.

IMPORTANT: Deep-cycle batteries are not suitable for use as engine starting batteries or for use as accessory batteries that are connected to high output engine charging systems. Deep-cycle battery life may be shortened by high output engine charging systems. Refer to individual battery manufacturer instructions for specific battery charging procedures and applications.

Recommended Battery

USA and Canada (SAE) specifications: A 12 volt marine starting battery with a minimum marine cranking amperage (MCA) rating of 800 amperes with a minimum reserve capacity rating of 135RC should be used.

International (EN) specifications: A 12 volt marine starting battery with a minimum cold cranking amperage (CCA) rating of 975 amperes with a minimum of 65 ampere hour (Ah) rating should be used.

IMPORTANT: For DTS products, each engine must be equipped with its own starting battery. If your boat application requires additional battery loads for boat accessories or marine electronics, it is recommended that an auxiliary battery or batteries be installed.

Battery Precautions

⚠ WARNING

An operating or charging battery produces gas that can ignite and explode, spraying out sulfuric acid, which can cause severe burns. Ventilate the area around the battery and wear protective equipment when handling or servicing batteries.

When charging batteries, an explosive gas mixture forms in each cell. Part of this gas escapes through holes in the vent plugs and may form an explosive atmosphere around the battery if ventilation is poor. This explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas and cause an internal explosion, which may shatter the battery.

The following precautions should be observed to prevent an explosion:

1. Do not smoke near batteries being charged or which have been charged very recently.
2. Do not break live circuits at terminals of batteries, because a spark usually occurs at the point where a live circuit is broken. Always be careful when connecting or disconnecting cable clamps on chargers. Poor connections are a common cause of electrical arcs which cause explosions.
3. Do not reverse polarity of battery terminal to cable connections.

Charging a Discharged Battery

⚠ WARNING

An operating or charging battery produces gas that can ignite and explode, spraying out sulfuric acid, which can cause severe burns. Ventilate the area around the battery and wear protective equipment when handling or servicing batteries.

The following basic rules apply to any battery charging situation:

1. Any battery may be charged at any rate (in amperes), or as long as spewing of electrolyte (from violent gassing) does not occur, and for as long as electrolyte temperature does not exceed 52 °C (125 °F). If spewing of electrolyte occurs, or if electrolyte temperature exceeds 52 °C (125 °F), charging rate (in amperes) must be reduced or temporarily halted to avoid damage to the battery.
2. Battery is fully charged when, over a 2 hour period at a low charging rate (in amperes), all cells are gassing freely (not spewing liquid electrolyte), and no change in specific gravity occurs. Full charge specific gravity is 1.260–1.275, corrected for electrolyte temperature with electrolyte level at 4.8 mm (3/16 in.) over plate, unless electrolyte loss has occurred (from age or overfilling), in which case, specific gravity reading will be lower. For most satisfactory charging, lower charging rates in amperes are recommended.
3. If, after prolonged charging, specific gravity of at least 1.230 on all cells cannot be reached, battery is not in optimum condition and will not provide optimum performance; however, it may continue to provide additional service, if it has performed satisfactorily in the past.
4. To check the battery voltage while cranking the engine with an electric starting motor at ambient air temperature of 23.8 °C (75 °F), place the red (+) lead of the tester on the positive (+) battery terminal and the black (–) lead of the tester on the negative (–) battery terminal. If the voltage drops below 10-1/2 volts while cranking, the battery is weak and should be recharged or replaced.

Winter Storage of Batteries

Battery companies are not responsible for battery damage, either in winter storage or in dealer stock, if the following instructions are not observed:

1. Remove battery from its installation as soon as possible and remove all grease, sulfate, and dirt from the top surface by running water over top of the battery. Be sure, however, the vent caps are tight beforehand and blow off all excess water thoroughly with compressed air. Check water level, making sure the plates are covered.
2. When adding distilled water to the battery, be extremely careful not to fill more than 4.8 mm (3/16 in.) above perforated baffles inside the battery. Battery solution or electrolyte expands from heat caused by charging. Overfilling the battery will cause the electrolyte to overflow (if filled beyond 4.8 mm [3/16 in.] above baffles).
3. Grease terminal bolts well with 2-4-C with Teflon and store the battery in a cool-dry place. Remove the battery from storage every 30–45 days, check the water level, and put on charge for 5 or 6 amps. Do not fast charge.

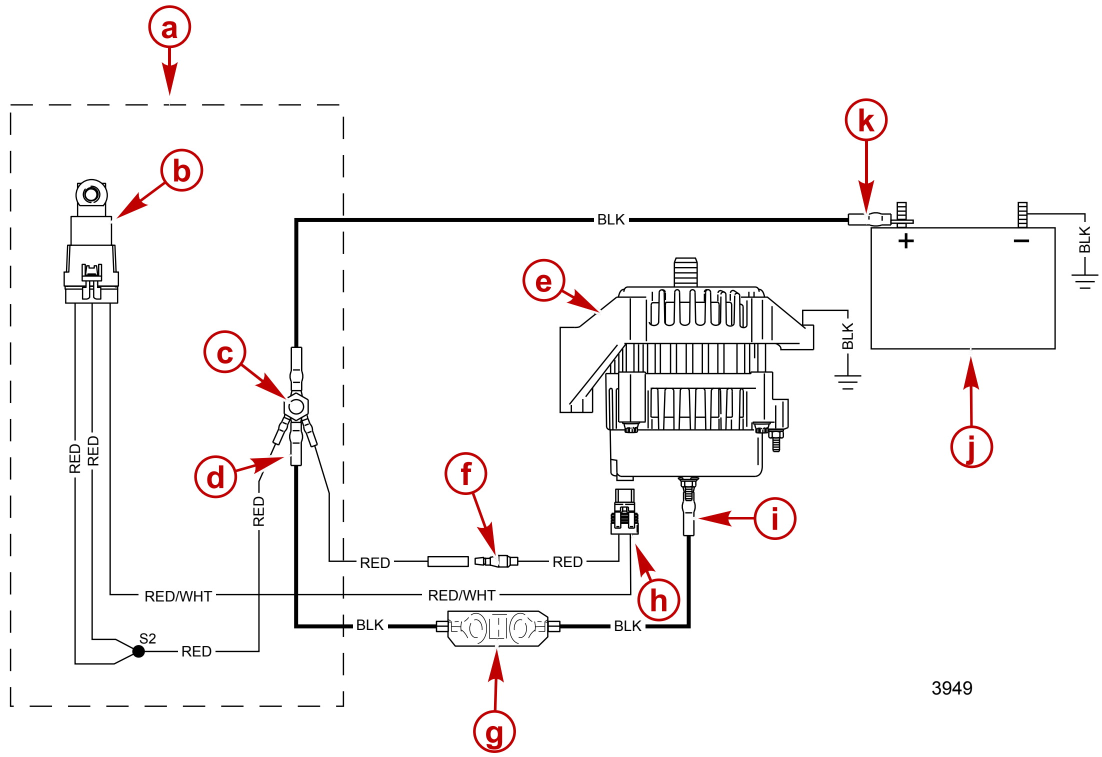
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Battery terminal bolts	92-802859A 1

4. If specific gravity drops below 1.240, check battery for reason and recharge. When gravity reaches 1.260, discontinue charging. To check specific gravity, use a hydrometer, which can be purchased locally.
5. Repeat preceding charging procedure every 30–45 days, as long as the battery is in storage, for best possible maintenance during inactive periods to ensure a good serviceable battery in spring. When ready to place the battery back in service, remove excess grease from the terminals (a small amount is desirable on terminals at all times), recharge again, as necessary, and reinstall the battery.

Alternator System

System Components

The charging system consists of the alternator, battery, 150 amp fusible link, main power relay, and wiring that connects these components.



a - Electrical box
b - Main power relay
c - Positive cable terminal
d - Black cable with red sleeve
e - 70 amp alternator
f - Alternator sense lead
g - 150 amp fusible link
h - Alternator excitation lead
i - Alternator output lead (black with red sleeve)
j - 12 VDC battery
k - Positive battery lead (black with red sleeve)

Precautions

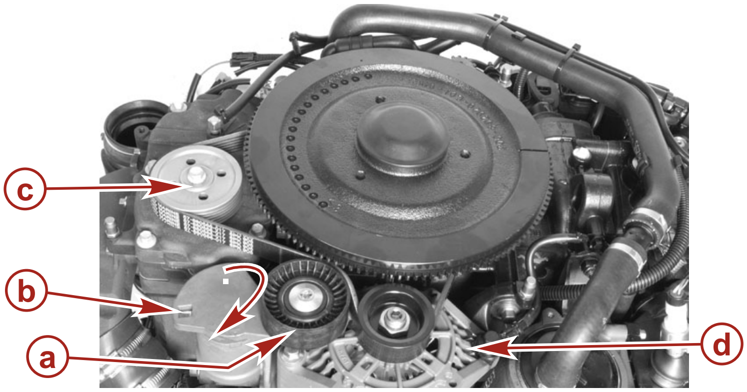
The following precautions must be observed when working on the alternator system. Failure to observe these precautions may result in serious damage to the alternator system.

1. Do not attempt to polarize the alternator.
2. Do not short across or ground any of the terminals on the alternator, except as specifically instructed.
3. Never disconnect the alternator output lead, regulator harness, or battery cables when the alternator is being driven by the engine.
4. Always remove the negative (–) battery cable from the battery before working on the alternator system.
5. When installing the battery, be sure to connect the negative (–) (grounded) battery cable to the negative (–) battery terminal and the positive (+) battery cable to the positive (+) battery terminal. Connecting the battery cables to the battery in reverse will result in blowing the 150 amp fusible link in the output lead of the alternator. The alternator will not be able to charge the battery and the battery will be quickly discharged if the engine is run.
6. When using a charger or booster battery, connect it in parallel with the existing battery (positive to positive; negative to negative).

Alternator and Supercharger Belt Tension Adjustment

IMPORTANT: The alternator and supercharger belt must be replaced if the belt has slipped on the pulley of the supercharger, alternator or belt tensioner, regardless of appearance.

Correct alternator and supercharger belt tension is maintained by a belt tensioner assembly.



13329

a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

Alternator Description

The alternator employs a rotor that is supported in two end frames by ball bearings, and is driven at 2.8 times engine speed. The rotor contains a field winding enclosed between two multiple-finger pole pieces. The ends of the field winding are connected to two brushes which make continuous sliding contact with the slip rings. The current (flowing through the field winding) creates a magnetic field that causes the adjacent fingers of the pole pieces to become alternate north and south magnetic poles.

The 3-phase stator is mounted directly over the rotor pole pieces and between the two end frames. It consists of three windings wound 120 degrees electrically out of phase on the inside of a laminated core.

The rectifier bridge contains six diodes which allows current to flow from ground, through the stator, and to the output terminal, but not in the opposite direction.

When current is supplied to the rotor field winding and the rotor is turned, the movement of the magnetic fields created induces an alternating current into the stator windings. The rectifier bridge changes this alternating current to direct current which appears at the output terminal. The diode trio is connected to the stator windings to supply current to the regulator and the rotor field during operation.

Voltage output of the alternator is controlled by a transistorized voltage regulator that senses the voltage at the battery, and regulates the field current to maintain alternator voltage for properly charging the battery. Current output of the alternator does not require regulation, as maximum current output is self-limited by the design of the alternator. As long as the voltage is regulated within the prescribed limits, the alternator cannot produce excessive current. A cutout relay in the voltage regulator also is not required, as the rectifier diodes prevent the battery from discharging back through the stator.

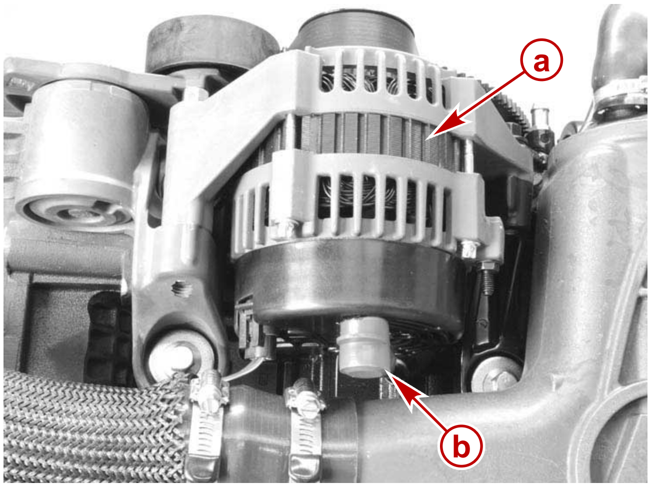
A small amount of current is supplied by the excitation circuit in the regulator to the rotor field to initially start the alternator charging. Once the alternator begins to produce output, field current is supplied solely by the diode trio.

The alternator is equipped with two fans which induce air flow through the alternator to remove heat created by the rectifier and stator.

Diagnosis of Alternator System on Engine

1. If the problem is an undercharged battery, verify the condition has not been caused by excessive accessory current draw or by accessories which have been accidentally left on.
2. Check the physical condition and state of charge of the battery. Battery must be at least 75% (1.230 specific gravity) fully charged to obtain valid results in the following tests. If not, charge the battery before testing the system.
3. Inspect the entire alternator system wiring for defects. Check all connections for tightness and cleanliness, particularly the battery cable clamps and battery terminals.

IMPORTANT: The black with red sleeve output lead from the alternator must be tight. A darkened red sleeve indicates the lead was loose and becoming hot. Verify output lead attaching nut is torqued to specification.

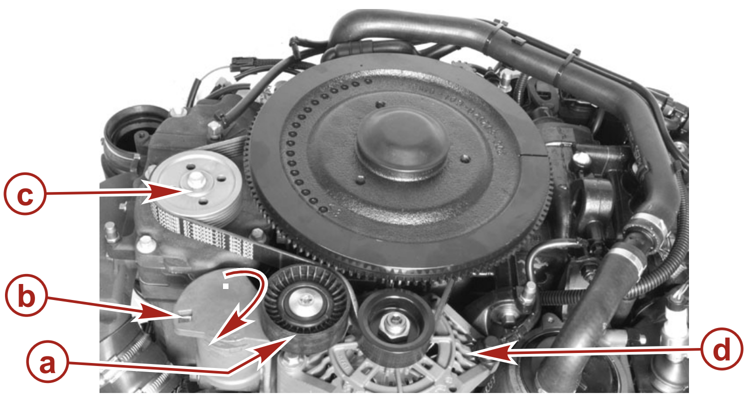


3888

a - Alternator
b - Output lead

Description	Nm	lb-in.	lb-ft
Nut	7	62	

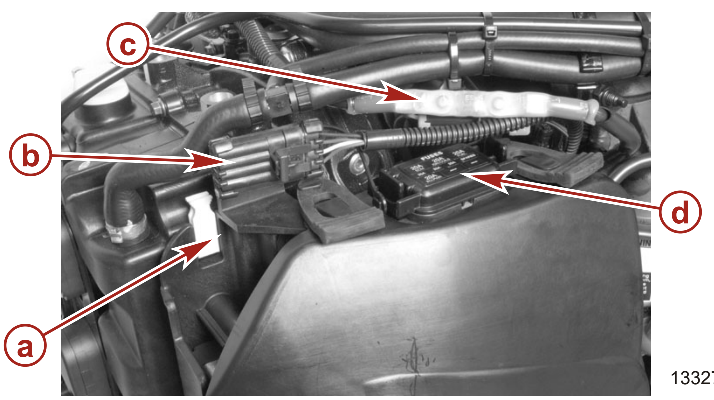
4. Check alternator drive belt for excessive wear, cracks, glazed surfaces, and fraying. Replace if necessary. Check belt tension.



13329

a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

5. Inspect the 150 amp fusible link located near the fuse holder on the top of the starboard side of the engine. If the fusible link is blown, check the battery leads for reversed polarity connection and replace the alternator black with red sleeved output lead.



13327

a - Fuse removal tool
b - Diagnostic terminal connector
c - 150 amp fusible link
d - Fuse holder

Alternator System Circuitry Test

Perform the following tests with a DMT 2004 digital multimeter to ensure that all of the circuits between the alternator and the other components within the charging system are in good condition.

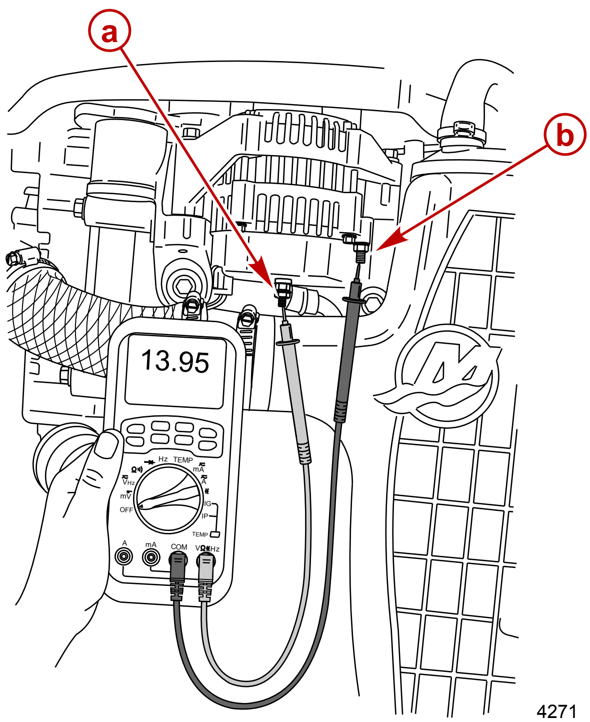
DMT 2004 Digital Multimeter	91-892647A01

1. Check the belt condition and tension.

2. Check wire connections at the alternator for tightness and absence of corrosion.
3. Check wire connections at the battery for tightness and absence of corrosion.
4. Check the battery condition. The battery should be fully charged.

Output Circuit

1. Connect the DMT positive (+) lead to the battery positive (+) post.
2. Connect the DMT negative (–) lead to the battery negative (–) post.
3. Supply cooling water to the engine.
4. Start the engine and increase engine speed to approximately 1300 RPM.
5. Observe the voltage reading.
6. If the reading is between 13.5 and 14.8 volts, switch the DMT to the AC volt position. A reading of 0.25 AC volts or less indicates the alternator diodes are fully functional. A reading above 0.25 AC volts indicates the diodes are faulty and the alternator must be replaced.
7. If the reading is below 13.5 volts:
    a. Connect the positive (+) DMT lead to the alternator output post.
    b. Connect the negative (–) DMT lead to the ground post on the alternator.
    c. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage and should not vary. If no reading is obtained or if the reading varies, inspect the wiring harness for loose connections, corrosion, breaks, or shorts. Repair or replace harness as required.
8. If reading is above 15 volts at the battery, the alternator is overcharging and must be replaced.

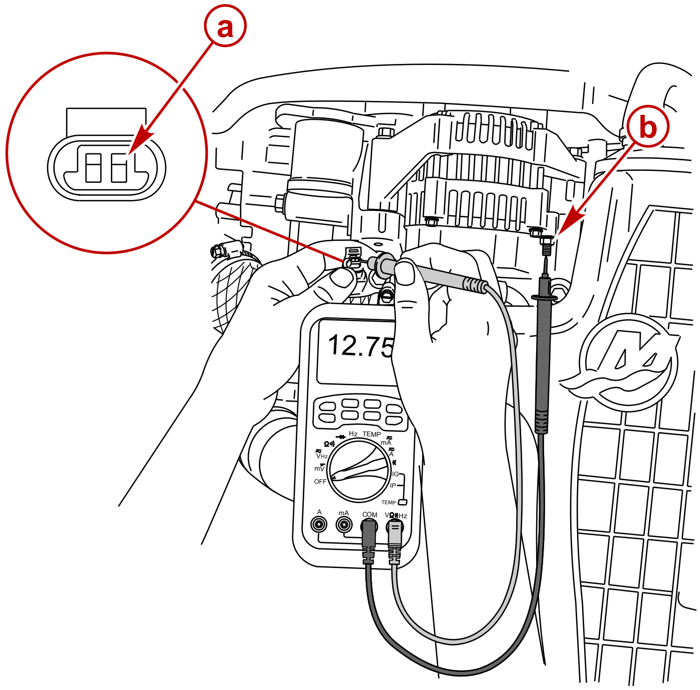


a - Alternator output post
b - Alternator ground post

Sensing Circuit

1. Unplug the red and red/white connector from the alternator.
2. Connect the positive (+) DMT lead to the red pin and the negative (–) DMT lead to the alternator ground post.

3. The DMT should indicate the battery voltage. If battery voltage is not present, check the red lead for loose or dirty connection or damaged wiring.



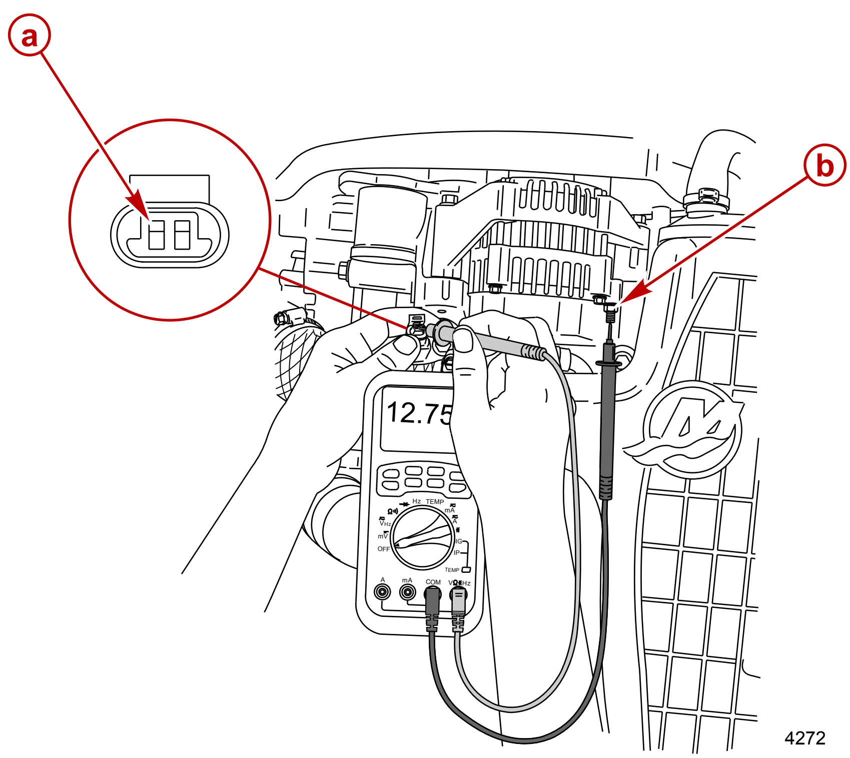
4273

a - Sensing circuit red lead
b - Alternator ground post

Excitation Circuit

NOTE: The ignition key must be in the "ON" position (engine not running). Battery voltage will be present at the red/white pin for approximately five seconds before the main power relay times out due to the engine not running. After main power relay times out, no voltage will be present.

1. Unplug the red and red/white connector from the alternator.
2. Connect the positive (+) DMT lead to the red/white pin and the negative (–) DMT lead to the alternator ground post.
3. The DMT should indicate battery voltage. If battery voltage is not present, check the red/white lead for loose or dirty connection or damaged wiring.



4272

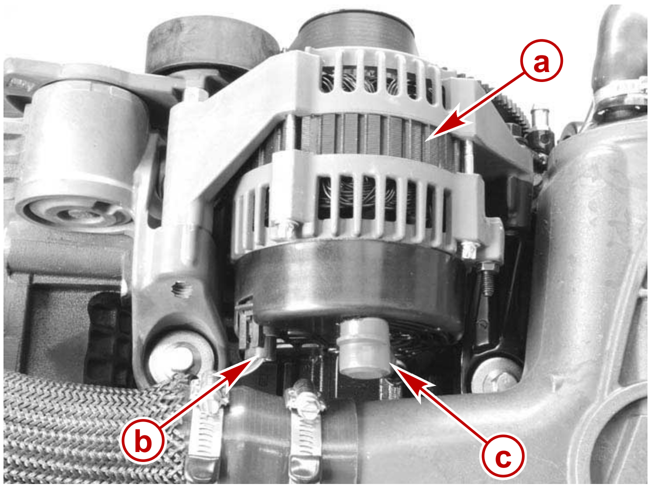
a - Excitation circuit red/white lead
b - Alternator ground post

Alternator 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.

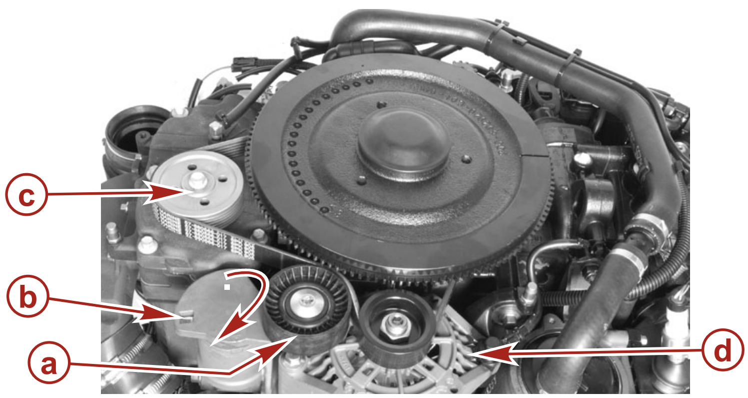
1. Disconnect battery leads from battery.
2. Remove flywheel cover. Refer to **Section 2A - Flywheel Cover**.
3. Disconnect output lead and sensing harness connector from alternator.



3881

a - Alternator
b - Sensing harness connector
c - Output lead

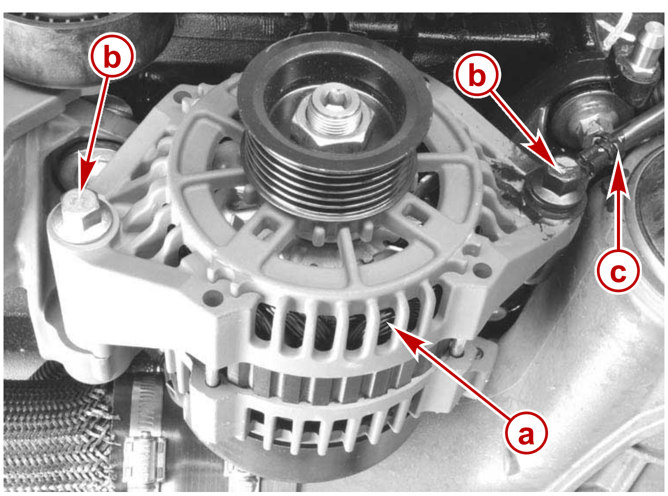
4. Use a breaker bar to release belt tension and remove alternator/supercharger belt.



13329

a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

5. Remove two screws securing alternator.

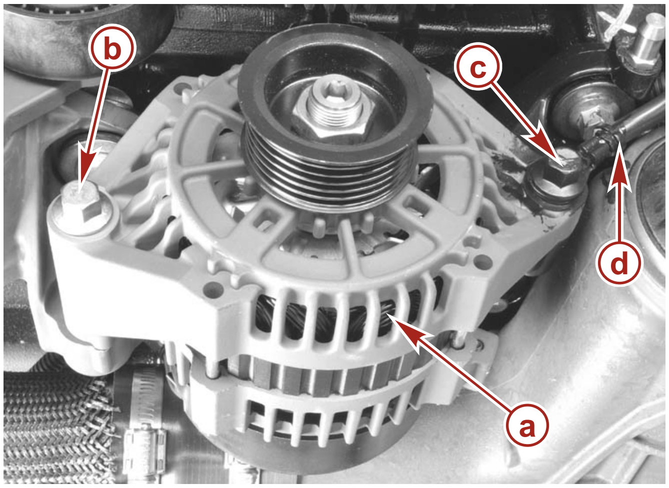


3882

a - Alternator
b - Screws
c - Ground lead

Alternator Installation

1. Install M10 x 45 alternator mounting screw through the ground lead eyelet.
2. Install M10 x 85 alternator mounting screw.
3. Tighten alternator mounting screws to specified torque.

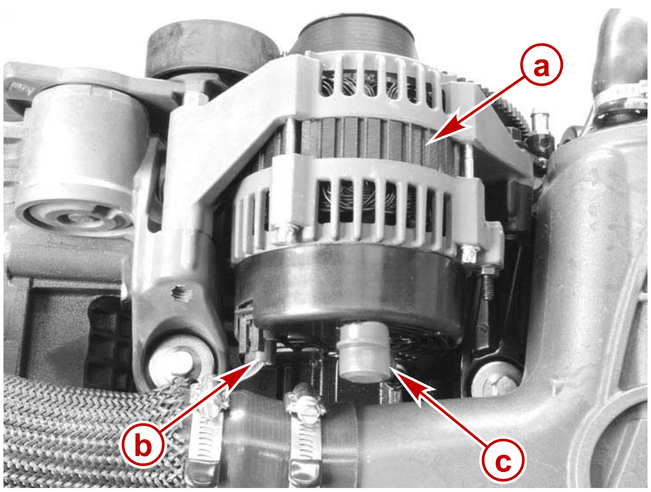


5770

a - Alternator
b - Alternator mounting screw (M10 x 85)
c - Alternator mounting screw (M10 x 45)
d - Ground lead

Description	Nm	lb-in.	lb-ft
Alternator mounting screw (M10 x 85)	47.5		35
Alternator mounting screw (M10 x 45)	47.5		35

4. Connect sensing harness to alternator.
5. Secure output lead to alternator with nut. Torque nut to specification.

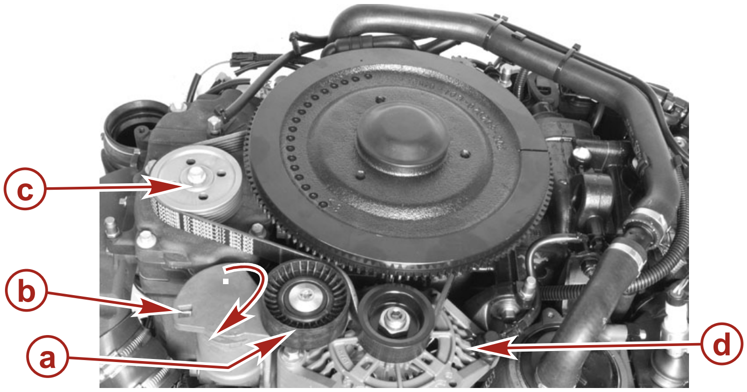


3881

a - Alternator
b - Sensing harness
c - Output lead

Description	Nm	lb-in.	lb-ft
Output lead nut	7	62	

6. Reinstall alternator/supercharger belt. Use breaker bar to release belt tensioner to ease installation.



13329

a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

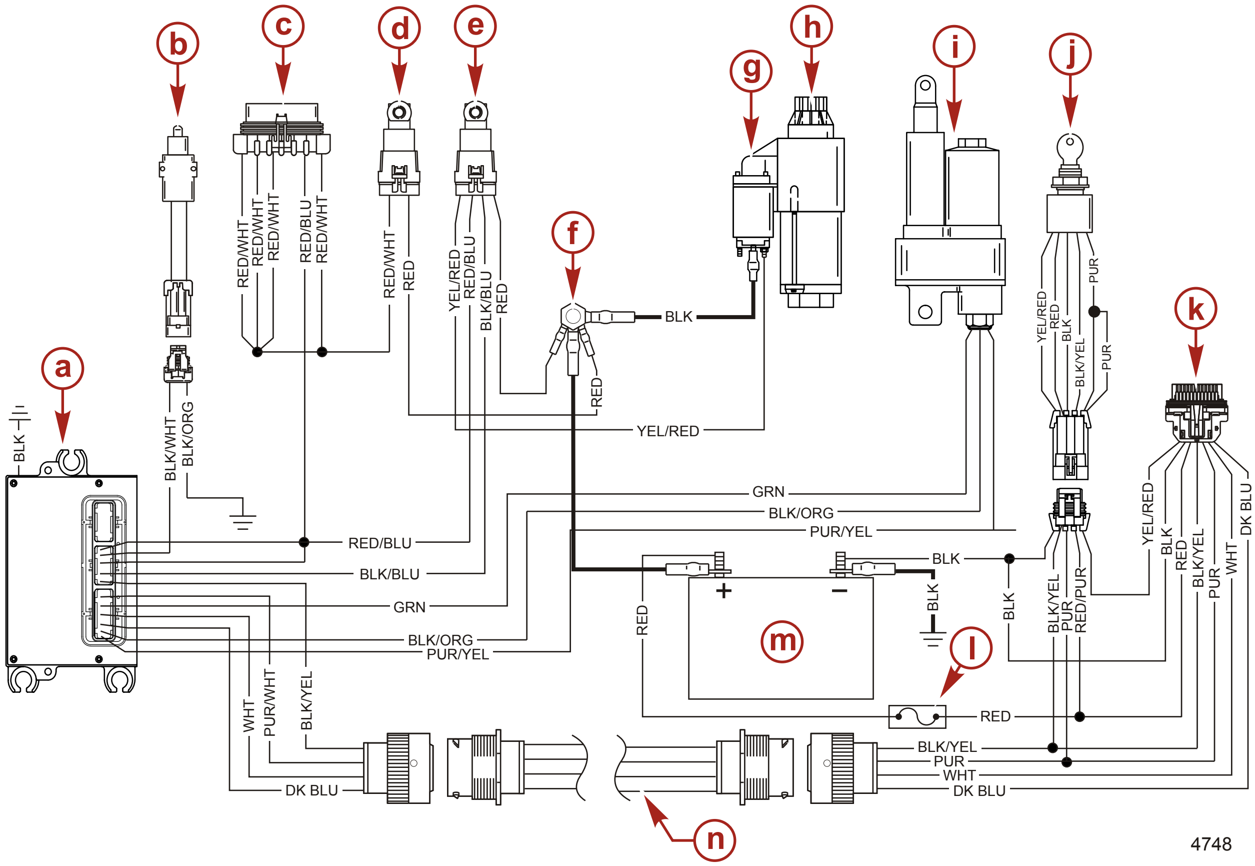
7. Reinstall flywheel cover. Refer to **Section 2A - Flywheel Cover**.

Starter System

Starter Motor Amp Draw

Starter Motor (part number 50-892339)	
No load amp draw	60 amp
Normal amp draw	160 amp

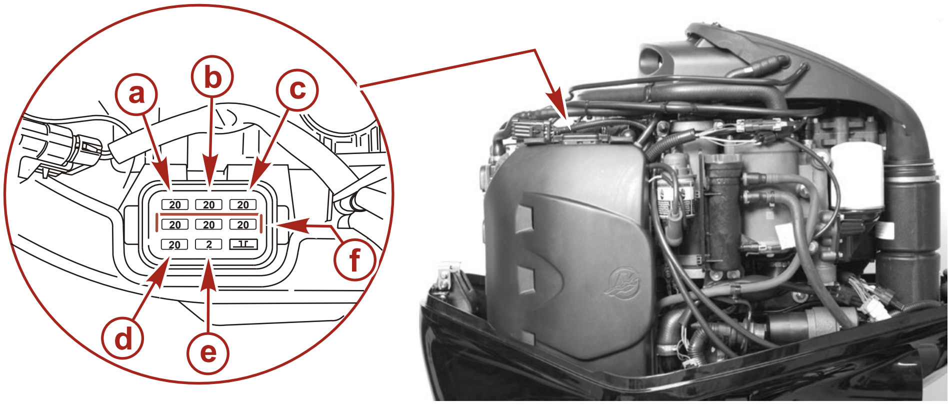
Starter System Components



a - Propulsion control module (PCM)
b - Neutral start switch
c - Fuse holder
d - Main power relay
e - Start relay
f - Positive battery cable terminal
g - Starter solenoid
h - Starter motor
i - Shift actuator
j - Ignition switch
k - Command module connector
l - 5 amp fuse (digital power and shift)
m - 12 VDC battery
n - 14 pin data harness

Starting System Test

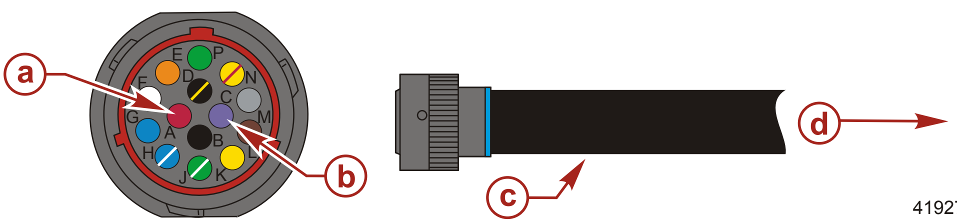
1. Inspect the 20A fuse labeled "ECM" in the fuse holder. This fuse protects the PCM, start relay, and associated wiring.



41926

a - PCM and starter relay - 20A fuse "ECM" (red/white and red/blue)
b - Ignition coils- 20A fuse "IGN.COILS" (red/white and red/yellow)
c - Fuel pumps- 20A fuse "FUEL" (red/white and red/pink)
d - Injector power- 20A fuse "INJ.PWR" (red/white and red orange)
e - Diagnostic- 2A fuse "—" (red and red/orange) (S/N 1B381782 and above)
f - Spare fuses

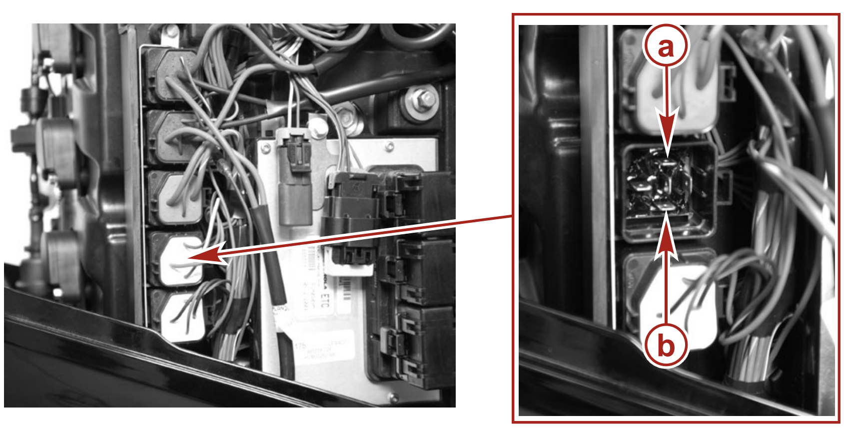
2. Inspect the 5A DTS fuse located near the engine starting battery. This fuse protects the CAN harness and key switch related wiring.
3. The battery must deliver a minimum of 11 VDC to the starter. Perform a load test on the battery following the instructions supplied with the load tester.
4. Inspect all power and ground connections at the battery, starter solenoid, starter relay, starter motor, and the engine wiring harness connector for tightness and corrosion. Clean or repair as necessary.
5. Disconnect the engine wiring harness connector and check for continuity between pins **C** (purple) and **A** (red/purple) going through-the-hull wiring with the key switch in the "START" position. If the circuit is interrupted, investigate the hull wiring for the possible cause: key switch, lanyard switch, and repair as needed. If the circuit is complete, proceed to the next step.



41927

a - Pin A (red)
b - Pin C (purple)
c - 14 pin CAN data harness
d - To helm

6. Remove the engine harness connector from the starter relay.
7. Measure the resistance between relay terminal 86 (black/blue lead), and terminal 85 (red/blue lead). Replace the relay if resistance is not within specification.

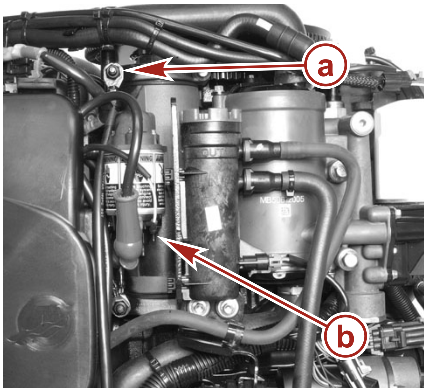


13426

a - Terminal 86 (black/blue)
b - Terminal 85 (red/blue)

Starter Relay	
Resistance	80–100 ohms

8. With the key switch in the "START" position, the starter drive should engage the engine flywheel. If not, measure the resistance between the yellow/red terminal on the starter solenoid and engine ground. If resistance is not within specification, the starter solenoid is defective and must be replaced.



13428

a - Ground screw
b - Yellow/red terminal

Starter Solenoid	
Resistance	0.4–0.8 ohms

9. If the starter drive audibly engages the engine flywheel, but the starter does not rotate, remove the starter and test the no-load amperage draw. If the amperage draw is not within the specification, replace the starter and/or starter solenoid assembly.

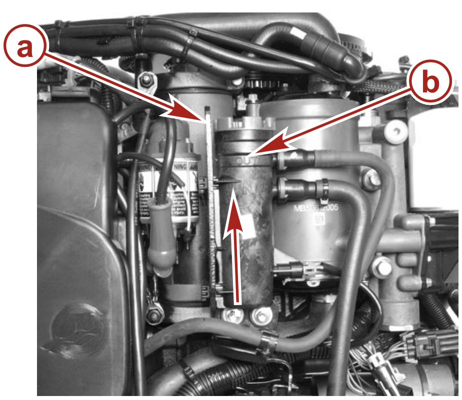
Starter	
No load amp draw	60–90 A

Starter 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 flywheel cover/air filter. Refer to **Section 2A - Flywheel Cover/Air Filter**.
3. Push up the fuel/water separator filter to disengage the filter from the retaining bracket.

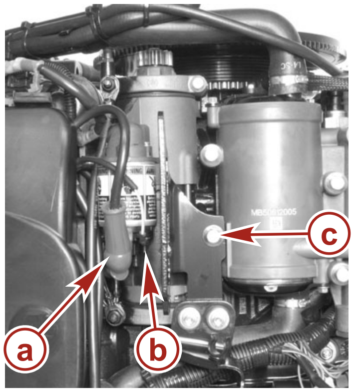


13430

a - Retaining bracket
b - Fuel/water separator filter

4. Remove black/red sleeved battery lead from the battery post inside the electrical box.
5. Remove yellow/red exciter lead from starter solenoid.

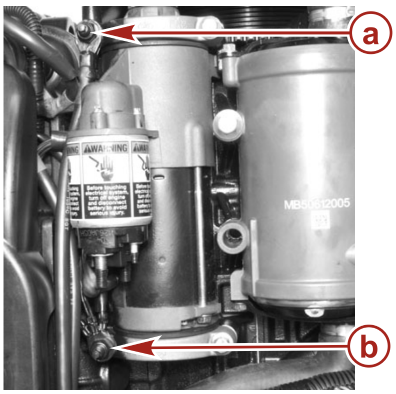
6. Remove the bolt securing the fuel/water separator filter retaining bracket to the integrated oil module.



13438

a - Black/red sleeved battery lead from the battery post
b - Yellow/red exciter lead
c - Retaining bracket bolt

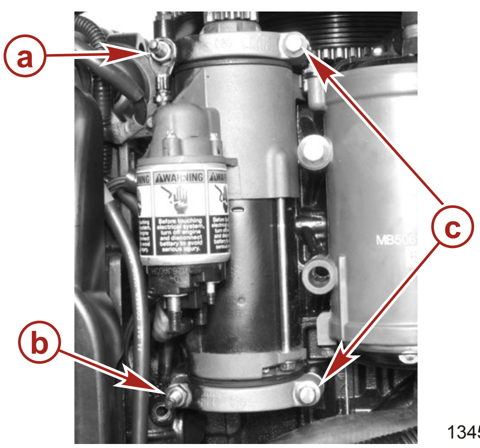
7. Remove the nut securing the battery ground lead to the upper starter mounting stud.
8. Remove the nut securing three ground terminals to the lower starter mounting stud.



13449

a - Nut securing battery lead
b - Nut securing three ground terminals

9. Remove the nut securing the starter ground lead to the upper starter mounting stud.
10. Remove the nut on the lower mounting stud.
11. Remove the two bolts securing the starter mounting brackets to the cylinder block.



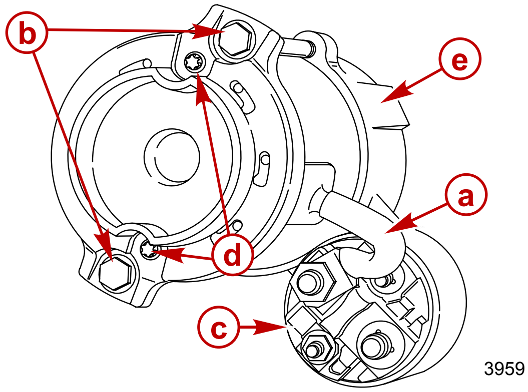
13450

a - Nut securing starter ground lead
b - Nut on lower mounting stud
c - Bolt (2)

Starter Disassembly

1. Remove the brush lead from the starter solenoid.

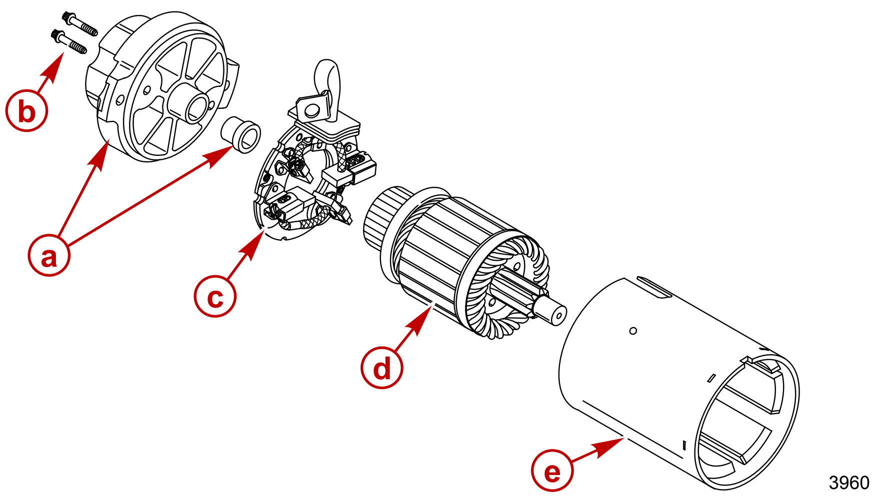
2. Remove the two through bolts.



- a - Brush lead
- b - Through bolts (2)
- c - Starter solenoid
- d - Brush plate screws
- e - Drive housing

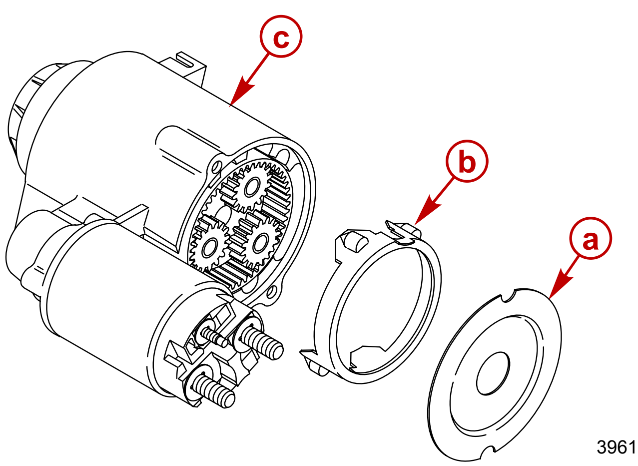
3. Remove the end frame, field frame, and armature from the drive housing.

NOTE: Permanent magnets inside the field frame will hold the armature inside the field frame.



- a - End frame and bearing
- b - Brush plate screws (2) (Snap On® E6 Torx socket)
- c - Brush plate assembly
- d - Armature
- e - Field frame

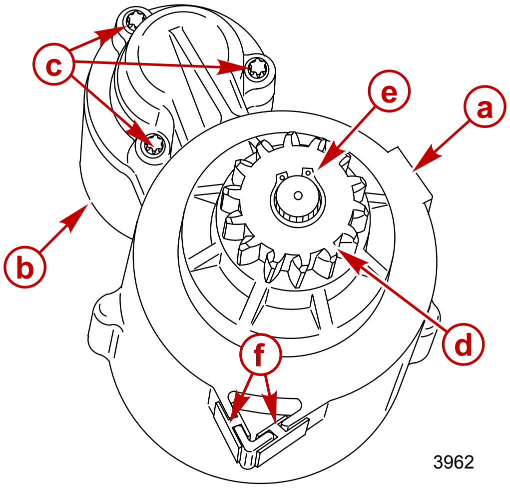
4. Remove the shield and cushion from the drive housing.



- a - Shield
- b - Cushion
- c - Drive housing

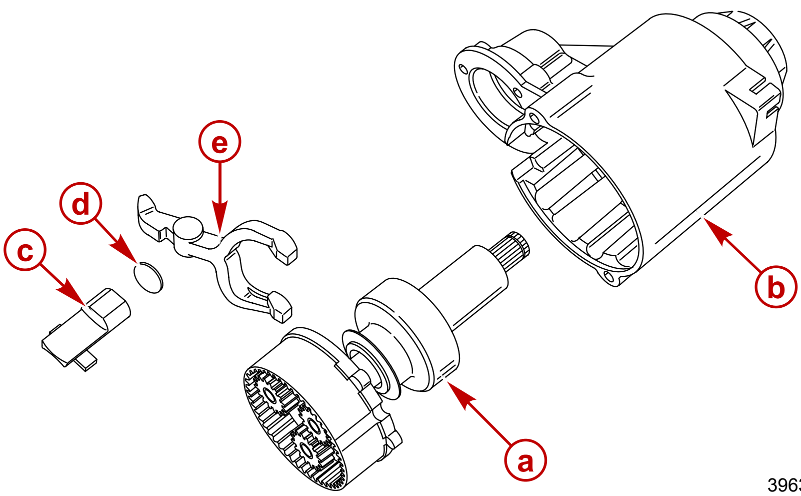
5. Remove the three screws securing the starter solenoid to the drive housing. Remove the starter solenoid from the drive housing.
6. Remove the snap ring from the planetary gear and clutch assembly.

7. Remove the pinion gear from the planetary gear and clutch assembly.



a - Drive housing
b - Starter solenoid
c - Screws (3) (Snap On® E6 Torx socket)
d - Pinion gear
e - Snap ring
f - Bumpers

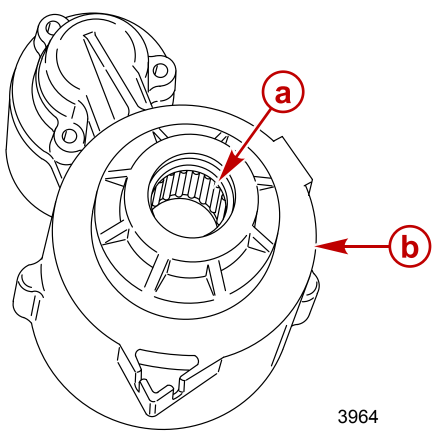
8. Remove the plug, metal disc, solenoid arm, planetary gear and clutch assembly from the drive housing.



a - Planetary gear and clutch assembly
b - Drive housing
c - Plug
d - Metal disc
e - Solenoid arm

9. Inspect the drive housing needle bearing for roughness. If the drive housing bearing is worn or damaged, the drive housing bearing can be removed using an appropriate mandrel.

   ***NOTE:** If the drive housing bearing has spun in the drive housing bore, the drive housing must be replaced.*



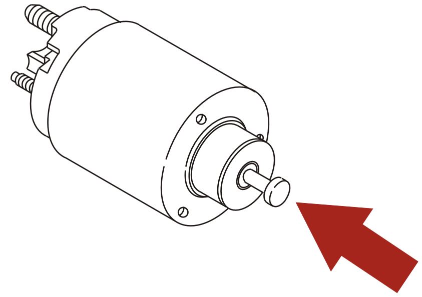
a - Needle bearing
b - Drive housing

Cleaning and Inspection

IMPORTANT: Do not use a grease dissolving solvent to clean the electrical components, planetary gears and clutch assembly. Grease dissolving solvents will damage the electrical components insulation and wash the lubrication out of the planetary gears and clutch assembly. Use clean rags and compressed air to clean the components.

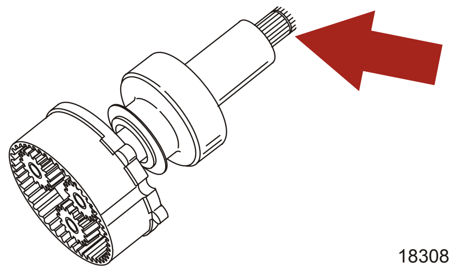
1. Test the overrunning clutch assembly. The clutch assembly should turn freely in the overrunning direction and must not slip in the cranking direction.
2. Inspect the pinion gear teeth for wear.

3. Push the starter solenoid actuating plunger into the starter solenoid. When released, the starter solenoid actuating plunger should return to a fully extended position.



18282

4. Inspect the area where the pinion gear contacts the planetary gear and clutch assembly.

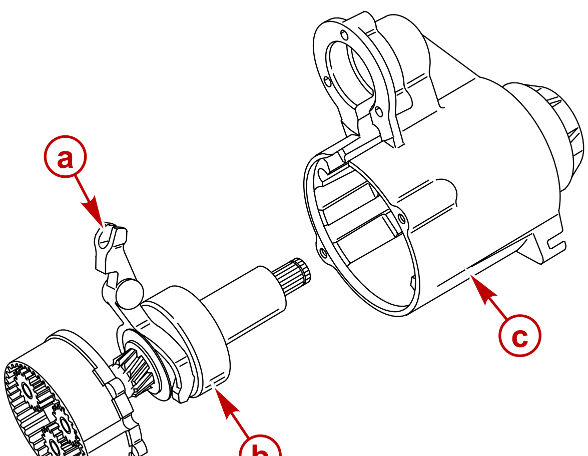


18308

5. Check that the bearings roll freely. If any roughness is felt, replace the bearing.
6. Inspect planetary gear assembly. Planetary gears must mesh easily and roll freely without binding.

Starter Reassembly

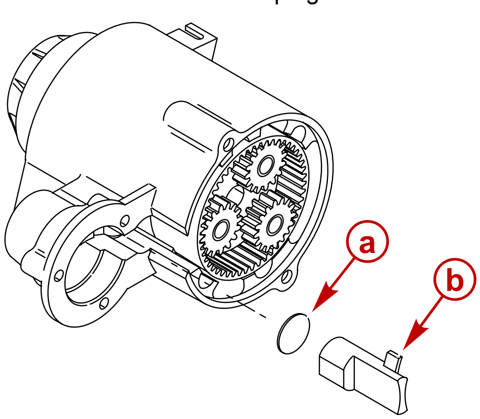
1. Install the solenoid arm with the planetary gear and clutch assembly, into the drive housing.



3966

a - Solenoid arm
b - Planetary gear and clutch assembly
c - Drive housing

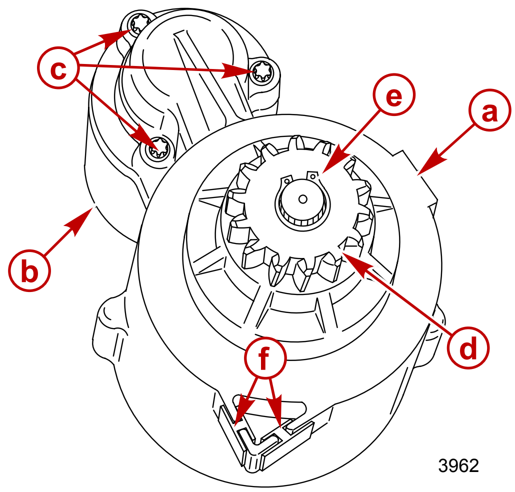
2. Install the metal disc and plug into the drive housing.



3967

a - Metal disc
b - Plug

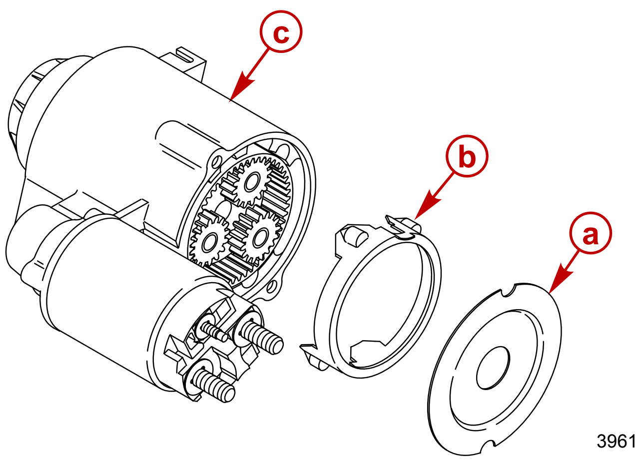
3. Attach the solenoid arm to the starter solenoid. Install the starter solenoid onto the drive housing. Secure the starter solenoid to the drive housing with three screws. Tighten the screws to the specified torque.
4. Install the pinion gear and secure with a snap ring.
5. Install the rubber bumpers onto the drive housing.



a - Drive housing
b - Starter solenoid
c - Screws (3) (Snap On® E6 Torx socket)
d - Pinion gear
e - Snap ring
f - Bumpers

Description	Nm	lb-in.	lb-ft
Solenoid mounting screw (3)	4.5	40	

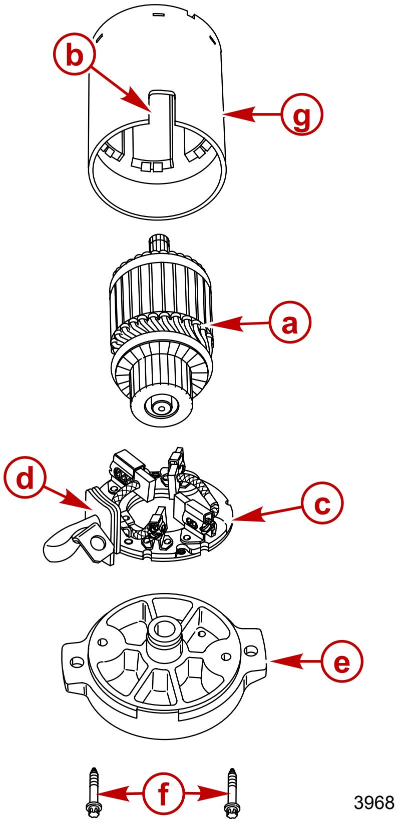
6. Install the cushion and shield onto the drive housing.



a - Shield
b - Cushion
c - Drive housing

7. Install the field frame over the armature.
8. Hold the brushes back and slide the brush plate assembly onto the armature while aligning the brush plate lead grommet with the slot in the field frame.
9. Install the end frame and secure the brush plate assembly to the end frame with two screws. Tighten the brush plate screws to the specified torque.

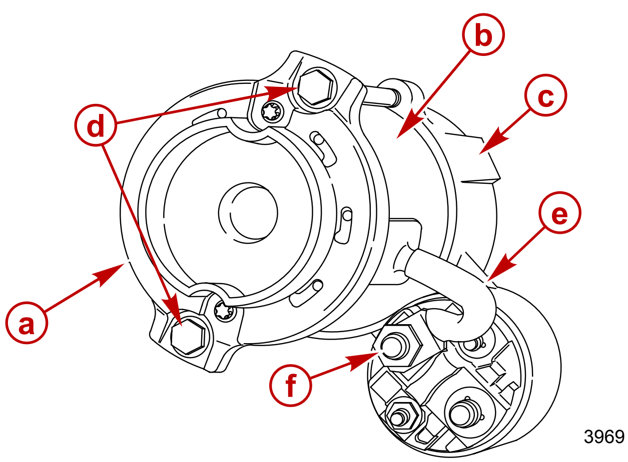
NOTE: Prior to installing the field frame assembly into the drive housing, align the slot in the field frame with the plug in the drive housing.



a - Armature
b - Field frame grommet slot
c - Brush plate assembly
d - Brush lead grommet
e - End frame
f - Brush plate screws (2)
g - Field frame plug slot

Description	Nm	lb-in.	lb-ft
Brush plate screw (2)	3.4	30	

10. Install the field frame and end frame onto the drive housing.
11. Install the two through bolts. Tighten the through bolts to the specified torque.
12. Install the brush lead onto the starter solenoid. Secure the brush lead to the starter solenoid with a nut. Tighten the nut to the specified torque.



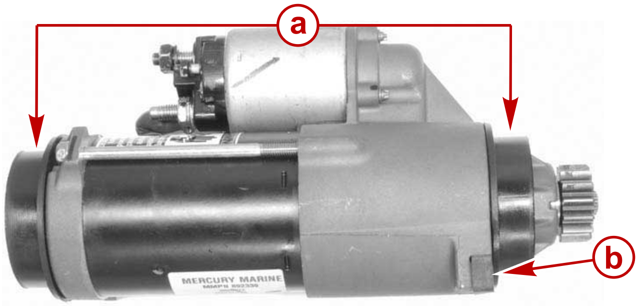
a - End frame
b - Field frame
c - Drive housing
d - Through bolts (2)
e - Brush lead
f - Nut

Description	Nm	lb-in.	lb-ft
Through bolt (2)	12.5	110	
Nut	6	55	

Starter Installation

1. Ensure the starter collars are on the starter end caps.

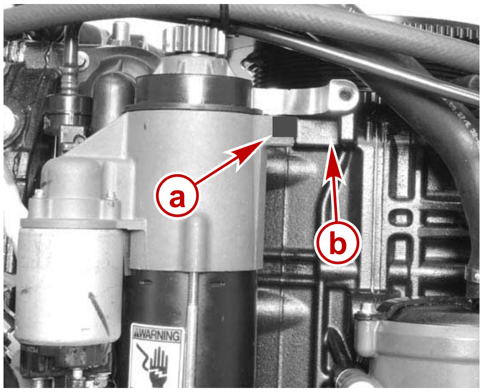
2. Ensure the starter bumpers are on the upper end cap.



3955

a - Starter collar
b - Starter bumpers

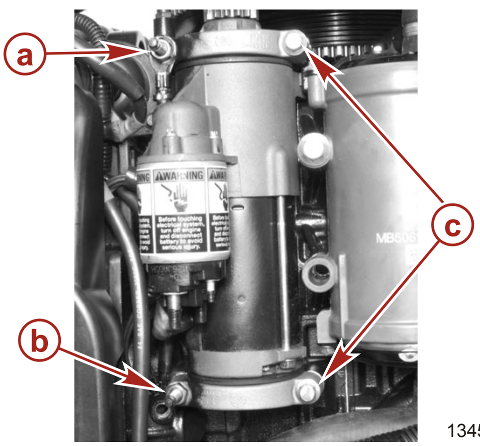
3. Place the starter onto the cylinder block starter mounting boss with the starter bumper facing the starter stop boss.



3956

a - Starter bumper
b - Starter stop boss

4. Install the starter mounting brackets onto the mounting studs.
5. Install the starter ground lead to the upper starter mounting stud. Secure with a M8 non-locking nut. Tighten nut to the specified torque.
6. Secure the lower mounting bracket to the mounting stud with a M8 non-locking nut. Tighten nut to the specified torque.
7. Install two M8 x 40 mounting bolts to the starter mounting bracket. Tighten bolts to the specified torque.



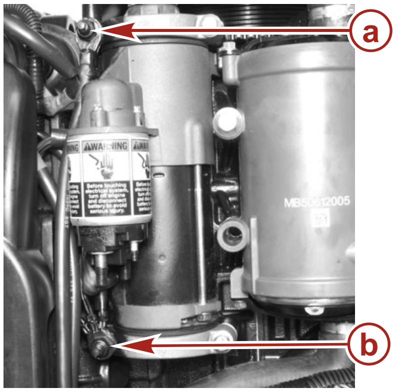
13450

a - Nut securing starter ground lead
b - Nut on lower mounting stud
c - Bolt (2)

Description	Nm	lb-in.	lb-ft
Nut (M8)	17	150.4	
Bolt (M8 x 40)	17	150.4	

8. Install the battery negative cable to the upper starter mounting stud. Secure with a M8 locking nut. Tighten nut to the specified torque.

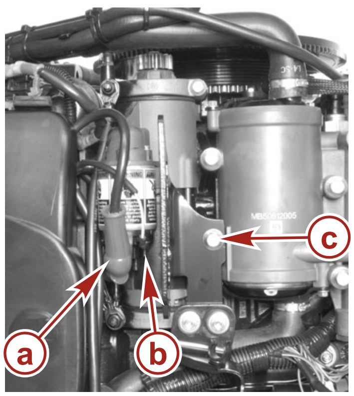
9. Install three ground terminals to the lower starter mounting stud. Secure with a M8 locking nut. Tighten nut to the specified torque.



13449

a - Nut securing battery negative cable
b - Nut securing three ground terminals

10. Install the power cable from the battery post inside the electrical box to the starter solenoid. Secure power lead with a lockwasher and nut. Tighten nut to the specified torque.
11. Install the starter exciter wire to the starter solenoid. Secure exciter wire with a lockwasher and nut. Tighten nut to the specified torque.
12. Secure the fuel/water separator bracket to the IOM with a bolt. Tighten bolt to the specified torque.



13438

a - Power cable
b - Exciter wire
c - Bolt

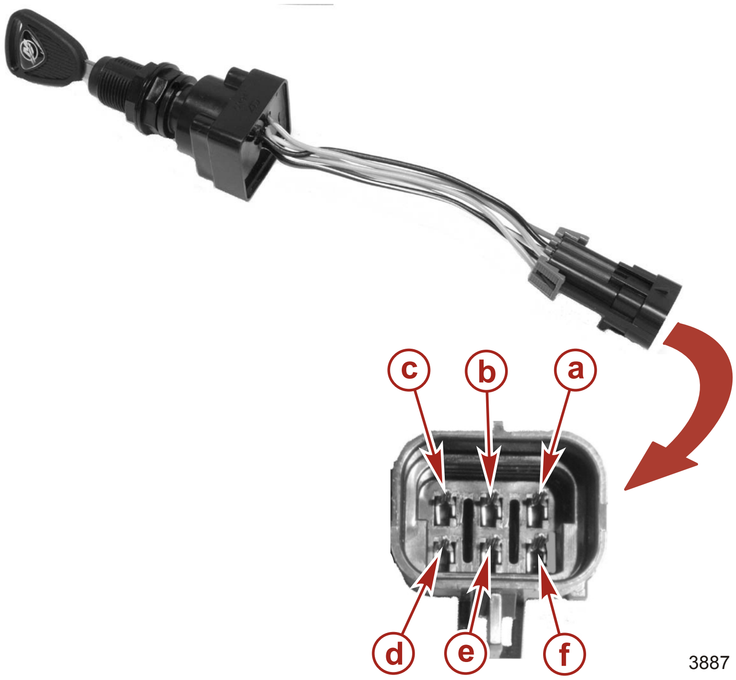
Description	Nm	lb-in.	lb-ft
Power cable nut	10	88.5	
Exciter wire nut	2.5	22	
Bolt	17	150.4	

13. Install the fuel/water separator filter assembly to the bracket.

Key Switch Test (Four Position)

1. Disconnect the key switch from the command module harness.
2. Set ohmmeter on R x 1 scale for the following tests.

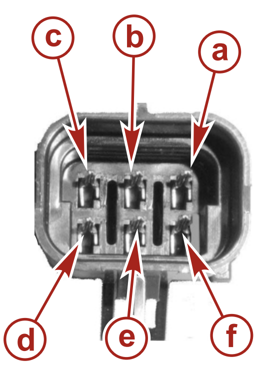
3. If meter readings are other than specified in the following tests, verify that switch and not wiring is faulty. If wiring checks OK, replace switch.



a - Pin A - Red
b - Pin B - Black
c - Pin C - Purple/white
d - Pin D - Purple
e - Pin E - Black/yellow
f - Pin F - Yellow/red

Key Position	Continuity should be indicated at the following points:	
Off	B	E
Accessories	A	C
Run	A	D
Start	A	F
	F	D
	A	D

Key Switch Test (Three Position)



a - Pin A
b - Pin B
c - Pin C
d - Pin D
e - Pin E
f - Pin F

Ref. No.	Pin	Wire Color	Description
a	A	Red	12 volts
b	B	Black	Ground
c, d	C, D	Purple	Run
e	E	Black/yellow	Off
f	F	Yellow/red	Start

Meter Test Leads		Key Position	Reading (Ω)
Red	Black		
Pin B	Pin E	Off	Continuity
Pin A	Pin F	Run	Continuity
Pin A	Pin C, D		
Pin A	Pin F	Start	Continuity
Pin F	Pin C, D		Continuity
Pin A	Pin C, D		Continuity

Notes:

Electrical

Section 2C - Timing, Synchronizing, and Adjusting

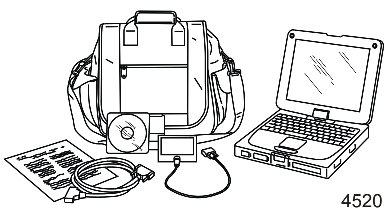
2
C

Table of Contents

Ignition Specifications

Ignition Specifications	
Full throttle RPM	
135/150/175/200 hp	5800–6400
Idle RPM (all models)	650
Ignition type	Digital inductive
Spark plug type	NGK ILFR6G or NGK ILFR6GE
Spark plug gap	0.8 mm (0.031 in.)
Spark plug hex size	16 mm
Spark plug torque	27 Nm (20 lb-ft)
Spark plug hole size	14 mm
Firing order	1-3-4-2
Ignition timing at idle	Approximately 2° ATDC; PCM controlled
Ignition timing at WOT	PCM controlled
PCM overspeed limiter	Activates at 6500 RPM

Special Tools

Computer Diagnostic System (CDS)	Order through SPX
 4520	Monitors all electrical systems for proper function, diagnostics, and calibration purposes. For additional information, pricing, or to order the Computer Diagnostic System contact: SPX Corporation 28635 Mound Rd. Warren, MI 48092 or call: USA - 1-800-345-2233 Canada - 800-345-2233 Europe - 49 6182 959 149 Australia - (03) 9544-6222

Idle Timing Adjustment (All Models)

Idle timing is not adjustable. Idle timing is controlled by the propulsion control module (PCM). Idle timing can be monitored with the computer diagnostic system (CDS) through the PCM.

Computer Diagnostic System (CDS)	Order through SPX

Maximum Timing Adjustment (All Models)

Maximum timing is not adjustable. Maximum timing is controlled by the propulsion control module (PCM). Maximum timing can be monitored with the computer diagnostic system (CDS) through the PCM.

Computer Diagnostic System (CDS)	Order through SPX

Idle Speed Adjustment (All Models)

Engine idle speed is not adjustable. The parameters affecting idle speed can be checked and monitored by the computer diagnostic system (CDS).

Computer Diagnostic System (CDS)	Order through SPX

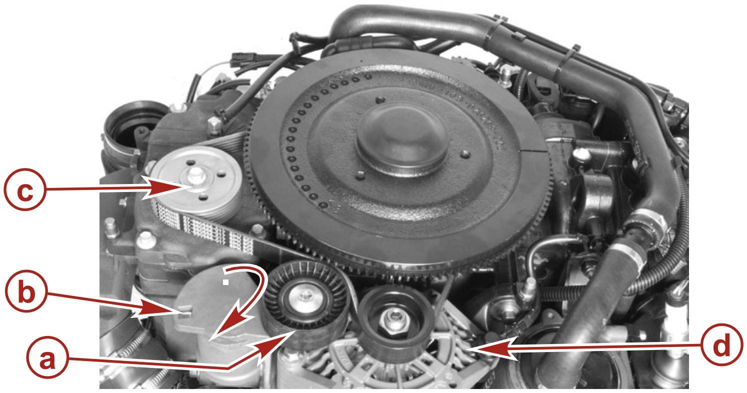
Throttle Adjustment (All Models)

All throttle inputs are relayed electronically from the helm to the engine. There are no mechanical linkages or adjustments to be made or checked.

Alternator and Supercharger Belt Tension Adjustment

IMPORTANT: The alternator and supercharger belt must be replaced if the belt has slipped on the pulley of the supercharger, alternator or belt tensioner, regardless of appearance.

Correct alternator and supercharger belt tension is maintained by a belt tensioner assembly.



13329

a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

Notes:

Electrical

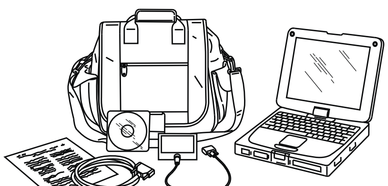
Section 2D - Digital Throttle and Shift

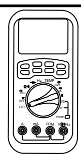
Table of Contents

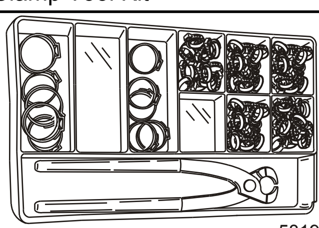
Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
80	SAE Engine Oil 30W	Shift link bushings	Obtain Locally
		Shift link bushing	
91	Engine Coupler Spline Grease	Wear sleeve, shift slide rail, shift slider bushing, bell crank, bushings	92-802869A 1
		Bell crank spacers	
		Bell crank bushing	
		ESC bushing and bell crank bushing rubber washer	
		Bell crank slider bushing	
		Shift slider rail	

Special Tools

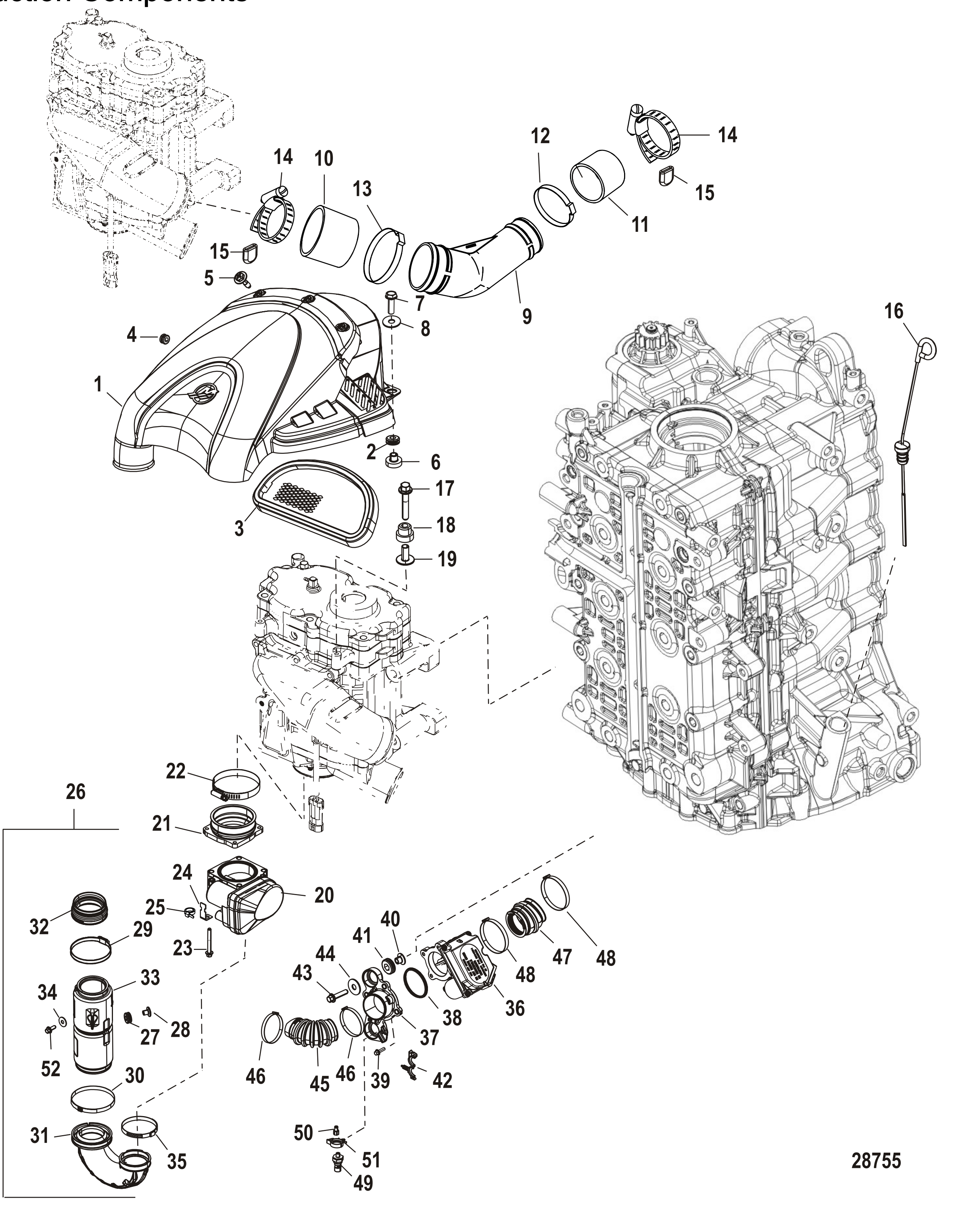
Computer Diagnostic System (CDS)	Order through SPX
 4520	Monitors all electrical systems for proper function, diagnostics, and calibration purposes. For additional information, pricing, or to order the Computer Diagnostic System contact: SPX Corporation 28635 Mound Rd. Warren, MI 48092 or call: USA - 1-800-345-2233 Canada - 800-345-2233 Europe - 49 6182 959 149 Australia - (03) 9544-6222

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

Hose Clamp Tool Kit	91-803146A2
 5819	Aids in the installation of high pressure (Oetiker ®) hose clamps.

Notes:

Induction Components

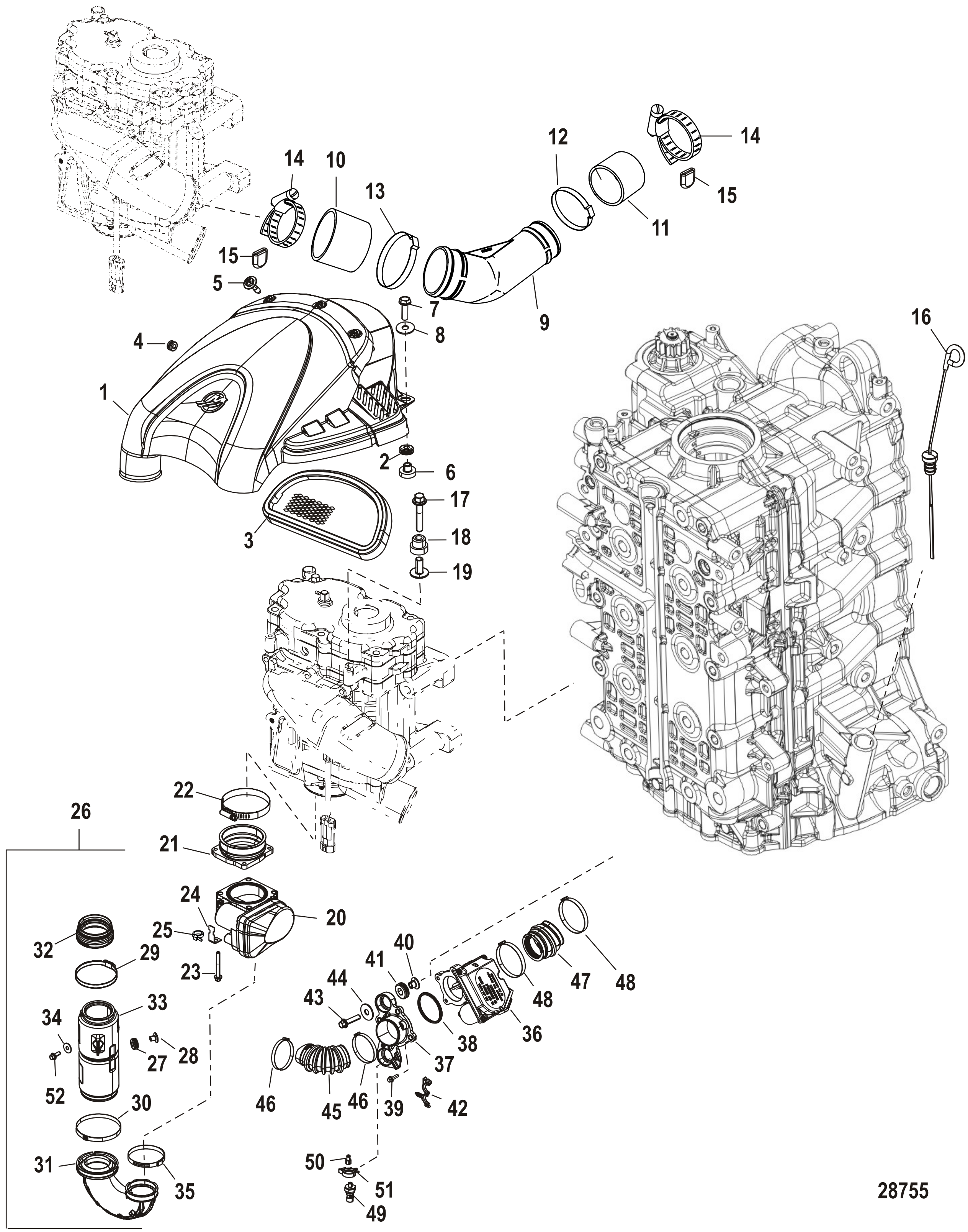


Induction Components

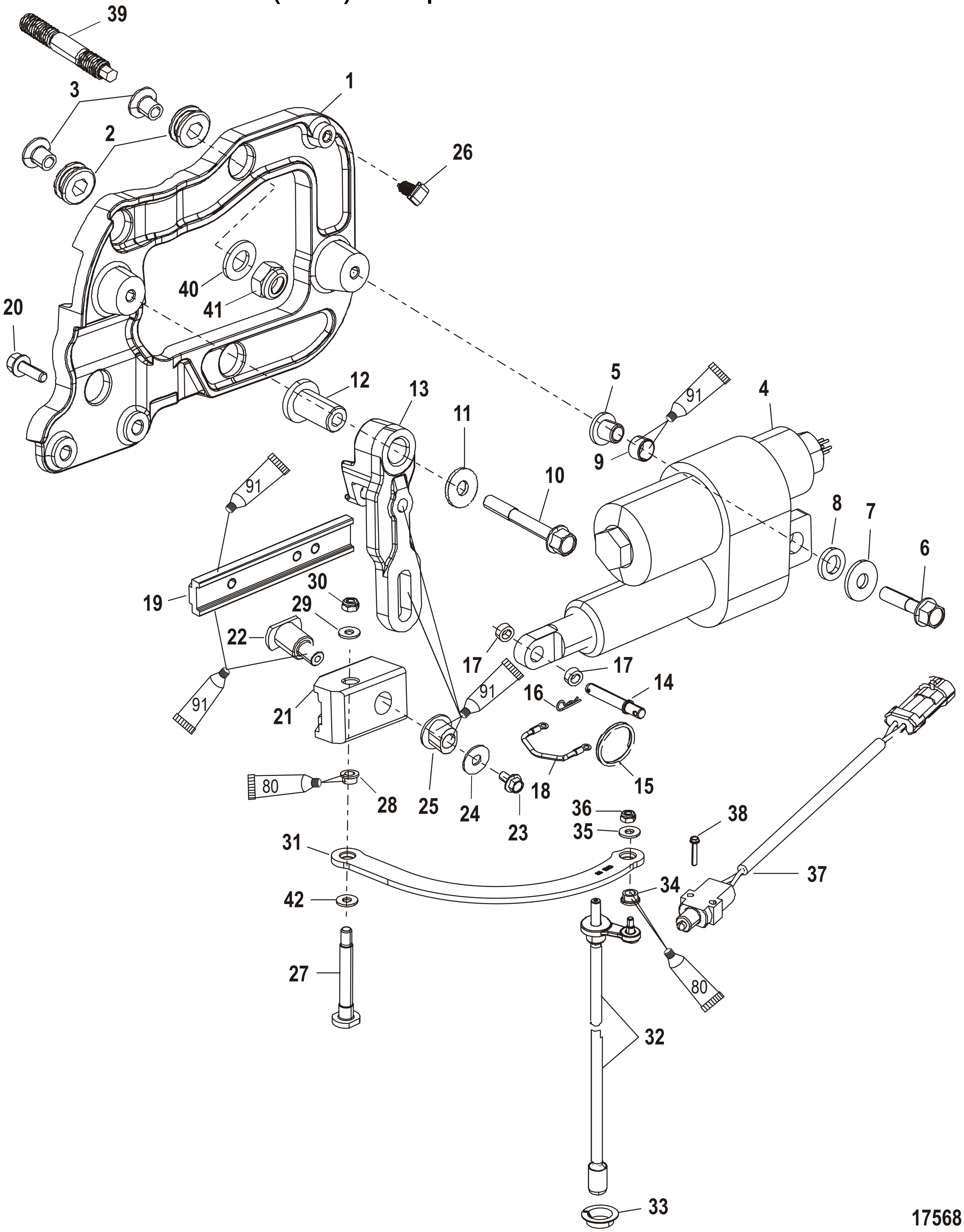
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Upper intake assembly			
2	2	Grommet			
3	1	Filter			
4	1	Fuel vent hose grommet			
5	3	Screw	6	53	
6	2	Bushing			
7	2	Bolt (M6 x 25)	8	71	
8	2	Washer			
9	1	Outlet tube			
10	1	Hose (65 mm inside diameter)			
11	1	Hose (60 mm inside diameter)			
12	1	Oetiker clamp (77 mm)			
13	1	Oetiker clamp (71 mm)			
14	2	Hose clamp	6.2	55	
15	2	Hose clamp end cover			
16	1	Oil dipstick			
17	1	Bolt (M6 x 20)	8	71	
18	1	Grommet			
19	1	Bushing			
20	1	Electronic throttle control (ETC)			
21	1	Isolator			
22	1	Clamp	6.2	55	
23	4	Bolt (M6 x 50)	11	97	
24	2	Bracket			
25	AR	Cable tie (8 in.)			
26	1	Lower intake assembly			
27	1	Grommet			
28	1	Bushing			
29	1	Oetiker clamp (84.5 mm)			
30	1	Oetiker clamp (96.5 mm)			
31	1	Inlet duct			
32	1	Coupler			
33	1	Resonator			
34	1	Washer			
35	1	Oetiker clamp (75.5 mm)			
36	1	Electronic boost control (EBC)			
37	1	EBC mount plate			
38	1	O-ring			
39	4	Screw (M6 x 20)	12	106	
40	2	Bushing			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
41	2	Grommet			
42	1	Clip			
43	2	Bolt (M8 x 35)	24	212	
44	2	Washer			
45	1	Hose			
46	2	Oetiker clamp (57.5 mm)			
47	1	Rear tube			
48	2	Oetiker clamp (62.0 mm)			
49	1	Pitot sensor			
50	1	Adapter fitting			
51	1	Clip			
52	1	Screw (M6 x 25)	7.5	66	

Induction Components



Electronic Shift Control (ESC) Components



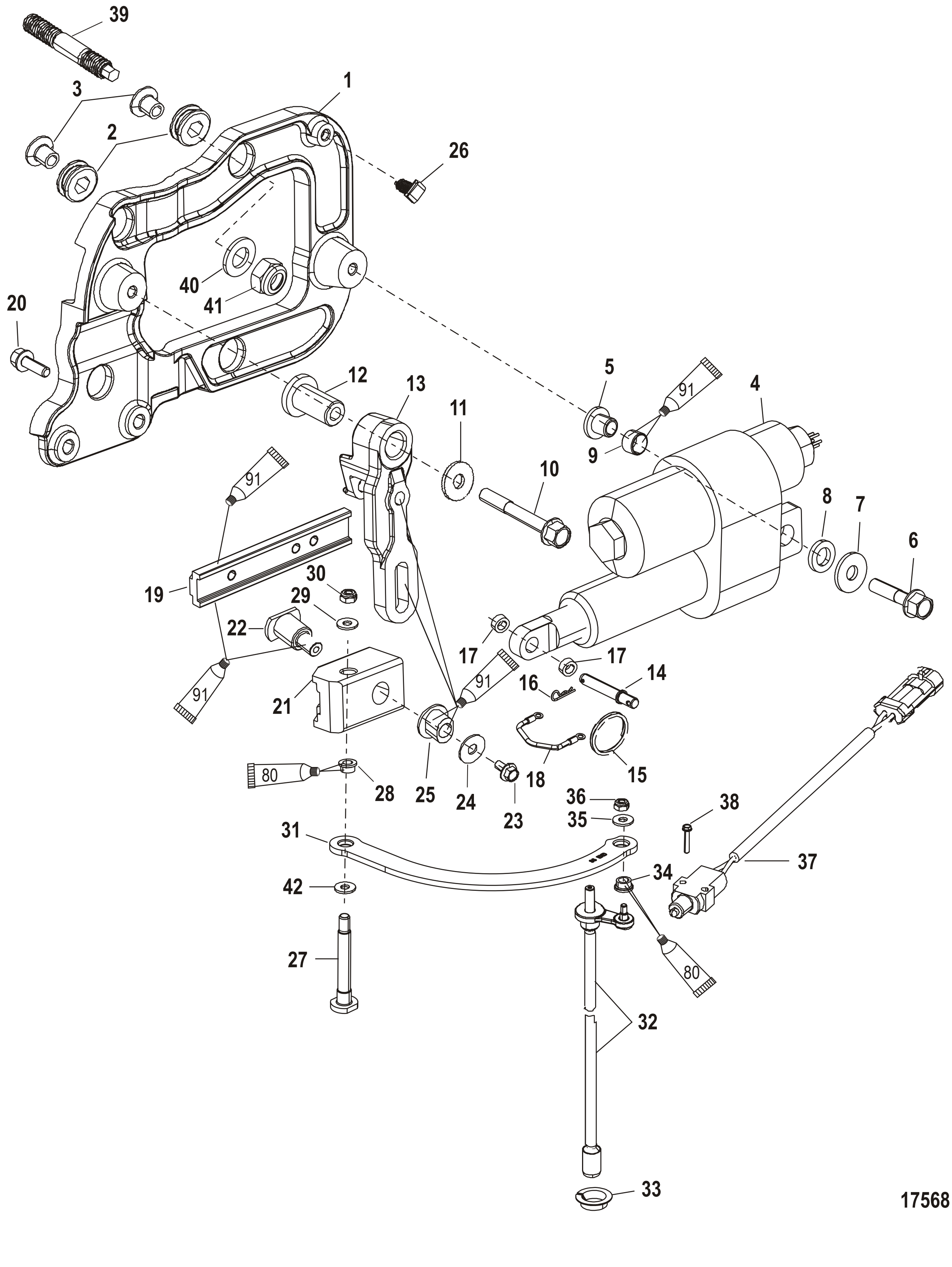
Electronic Shift Control (ESC) Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Shift bracket			
2	4	Grommet			
3	4	Bushing			
4	1	Shift actuator			
5	1	Bushing			
6	1	Bolt (M8 x 35)	20.3	180	
7	1	Washer			
8	1	Rubber washer			
9	1	Wear sleeve			
10	1	Bolt (M8 x 60)	27		20
11	1	Washer			
12	1	Bushing			
13	1	Bell crank			
14	1	Pin			
15	1	Split ring			
16	1	Cotter pin			
17	2	Spacer			
18	1	Cable assembly			
19	1	Shift slide rail			
20	2	Bolt (M8 x 25)	27		20
21	1	Shift slider			
22	1	Bushing			
23	1	Bolt (M5 x 10)	10	88.5	
24	1	Washer			
25	1	Bushing			
26	1	Clip			
27	1	Stud			
28	1	Bushing			
29	1	Washer			
30	1	Nut (M6)	6.2	55	
31	1	Shift link			
32	1	Shift shaft lever			
33	1	Bushing			
34	1	Bushing			
35	1	Washer			
36	1	Nut (M6)	5.6	50	
37	1	Shift switch			
38	2	Screw (M3.5 x 20)	2.3	20	
39	4	Stud (M8 x 50)	14.1	125	
40	4	Washer			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
41	4	Nut (M8)	20.3	180	
42	1	Washer			

Tube Ref No.	Description	Where Used	Part No.
80	SAE Engine Oil 30W	Shift link bushings	Obtain Locally
91	Engine Coupler Spline Grease	Wear sleeve, shift slide rail, shift slider bushing, bell crank, bushings	92-802869A 1

Electronic Shift Control (ESC) Components



Electronic Throttle Control (ETC)

The ETC is controlled through the PCM. The PCM receives information from the helm, based on the position of the throttle control handle/foot throttle. This information is sent to the PCM and the PCM activates the ETC motor to open or close the throttle valve. The two throttle valve position sensors in the ETC are also monitored by the PCM.

The ETC functions as an idle air control (IAC) valve. During hard deceleration, the ETC will remain open slightly until the engine RPM has stabilized, to eliminate engine stalling.

A built-in fail-safe is designed into the ETC. The ETC is spring-loaded to an off idle position to maintain engine RPM at approximately 1200 RPM in gear.

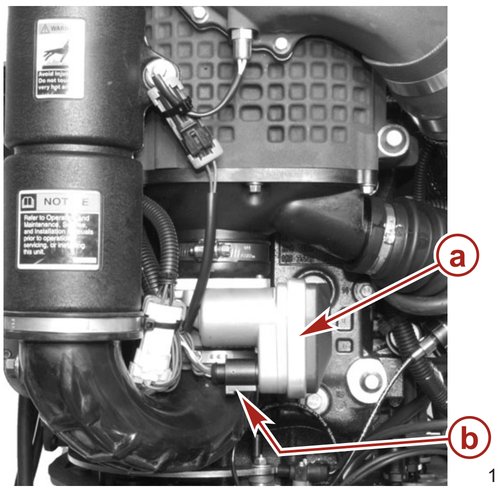
The ETC can be tested with the computer diagnostic system (CDS).

Computer Diagnostic System (CDS)	Order through SPX

The following step will assist you in determining if the failure is electrical or mechanical. Use the DMT 2004 digital multimeter to check for continuity or resistance.

DMT 2004 Digital Multimeter	91-892647A01

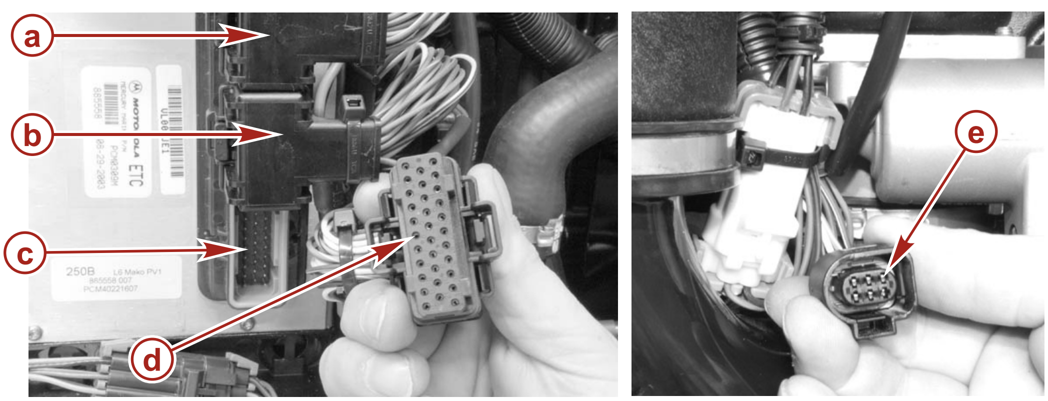
1. Disconnect the ETC harness connector from the ETC.



13618

a - ETC
b - ETC harness connector

2. Remove the electrical box cover.
3. Remove engine harness connector A at the PCM.
4. Check for continuity between the ETC harness connector pin, #1 and engine harness connector A, pin #6.

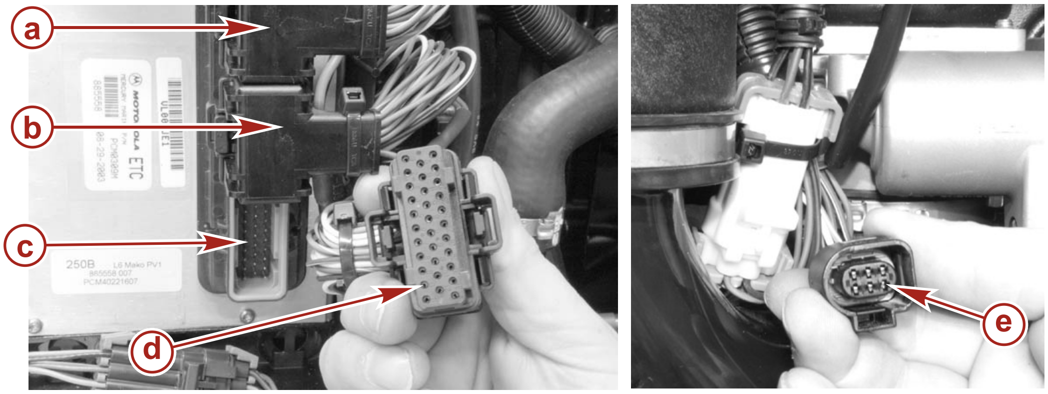


14492

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector A, pin #6
e - ETC harness connector pin, #1

5. If no continuity is found or there is high resistance, the engine harness must be replaced.
6. Check for continuity between ETC harness connector, pin #2 and engine harness connector A, pin #10.

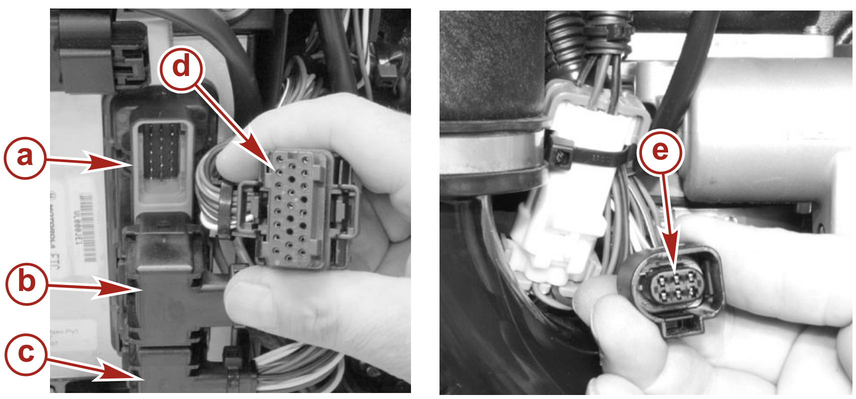
7. If no continuity is found or there is high resistance, check the vent canister switch (VCS). The VCS is normally closed.
8. If the VCS is closed and no continuity or high resistance is found, the engine harness must be replaced.



14494

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector A, pin #10
e - ETC harness connector, pin #2

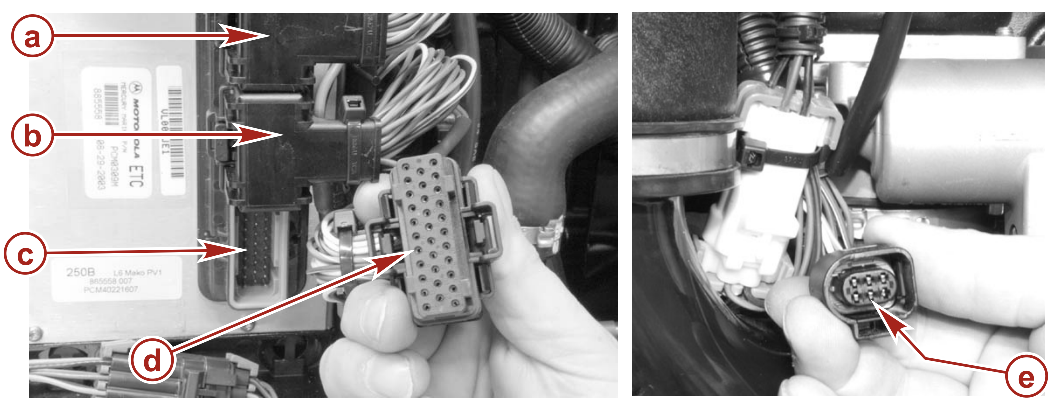
9. Remove engine harness connector C at the PCM.
10. Check for continuity between ETC harness connector, pin #3 and engine harness connector C, pin #2.



14497

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector C, pin #2
e - ETC harness connector, pin #3

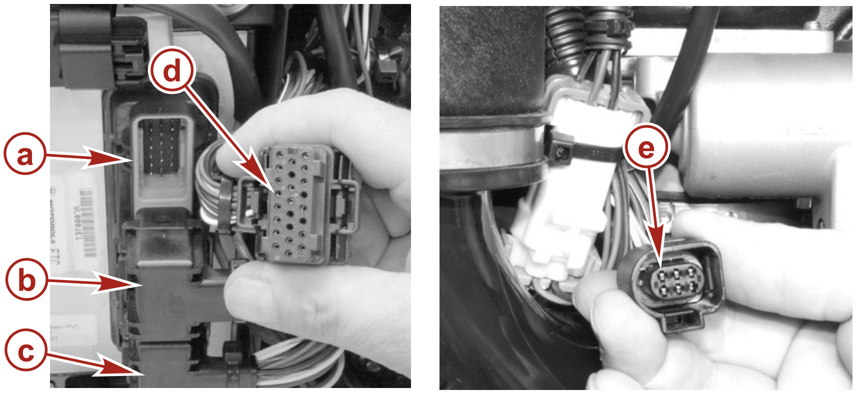
11. If no continuity is found or there is high resistance, the engine harness must be replaced.
12. Check for continuity between ETC harness connector, pin #4 and engine harness connector A, pin #7.



14499

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector A, pin #7
e - ETC harness connector, pin #4

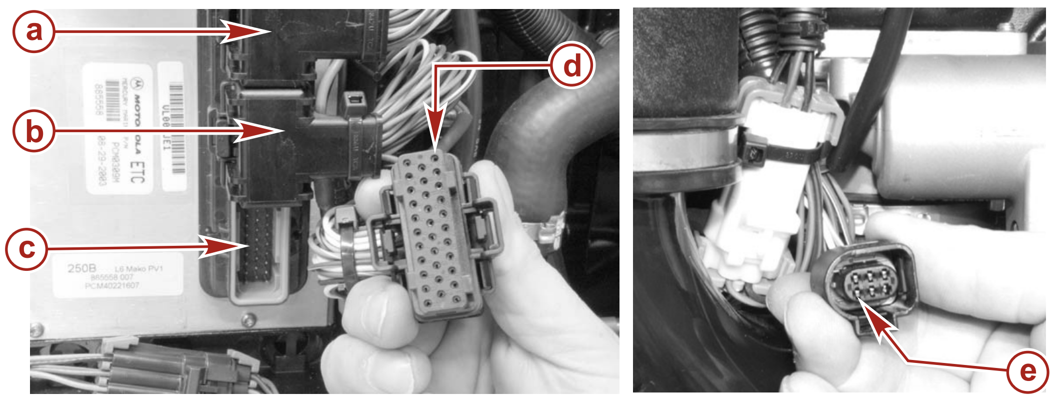
13. If no continuity is found or there is high resistance, the engine harness must be replaced.
14. Check for continuity between ETC harness connector, pin #5 and engine harness connector C, pin #4.



14498

- a - Engine harness connector C
- b - Engine harness connector B
- c - Engine harness connector A
- d - Engine harness connector C, pin #4
- e - ETC harness connector, pin #5

15. If no continuity is found or there is high resistance, the engine harness must be replaced.
16. Check for continuity between ETC harness connector pin, #6 and engine harness connector A, pin #22. This connection is a positive 5 V reference circuit from the PCM.



14500

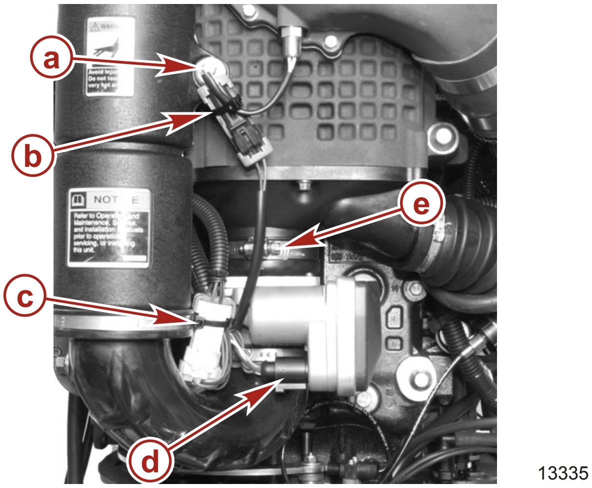
- a - Engine harness connector C
- b - Engine harness connector B
- c - Engine harness connector A
- d - Engine harness connector A, pin #22
- e - ETC harness connector, pin #6

17. If no continuity is found, there are multiple connections throughout the engine harness for this 5 V reference circuit. Refer to the wire diagrams to trace the wire harness.
18. If the pin continuity checks are good, the failure is mechanical.

Electronic Throttle Control (ETC) Removal

1. Remove the top cowl, lower chaps, port and starboard cowls. Refer to **Section 4A - Cowling Removal**.
2. Remove the flywheel cover. Refer to **Section 2A - Flywheel Cover**.
3. Disconnect the ETC harness connector from the electronic throttle control.
4. Remove the cable tie securing the electronic shift control harness connector to the ETC.
5. Loosen the hose clamp securing the ETC isolator to the supercharger.

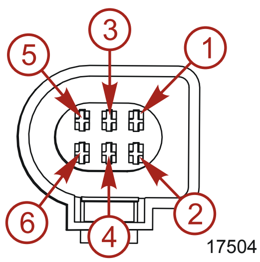
6. Remove the bolt securing the resonator to the supercharger.



a - Bolt securing resonator to supercharger
b - Cable tie securing supercharger temperature sensor connector
c - Cable tie securing the ESC connector and engine harness
d - ETC harness connector
e - Hose clamp securing ETC isolator

7. Remove the ETC assembly from the supercharger inlet.

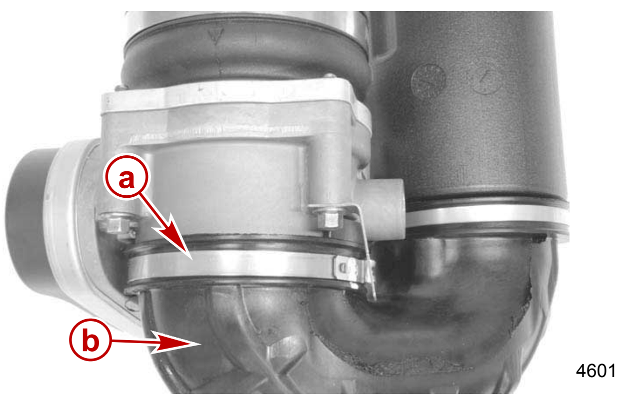
Electronic Throttle Control (ETC) Harness Connection Pin-Out



1 - Blue/white - TPI 1 voltage
2 - Purple/yellow - Transducer reference power
3 - Red/blue - Motor driver
4 - White/yellow - TPI 2 voltage
5 - Red/black - Motor driver
6 - Black/orange - Transducer ground

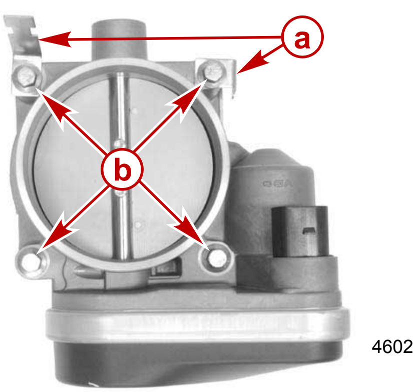
Electronic Throttle Control (ETC) Disassembly

1. Remove the hose clamp securing resonator boot to the ETC.



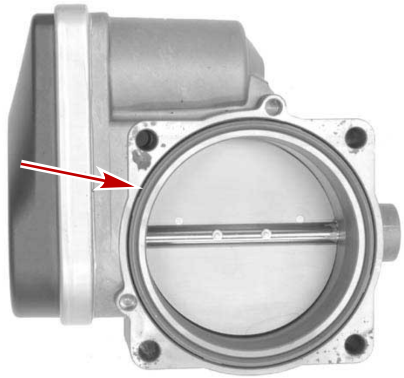
a - Hose clamp
b - Resonator boot

2. Remove the resonator boot.
3. Remove the four screws securing the isolator to the ETC. Do not lose the two harness support brackets.



a - Harness support brackets
b - Screws securing isolator to ETC

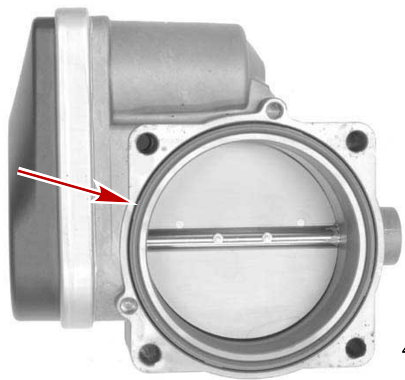
4. Remove isolator seal and inspect for damage.



4603

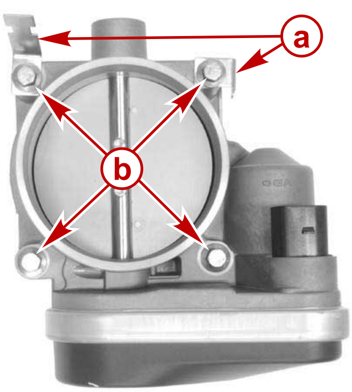
Electronic Throttle Control (ETC) Reassembly

1. Install the seal onto the ETC.



4604

2. Install the isolator onto the ETC.
3. Install the four isolator mounting screws. Ensure the harness support brackets are installed as shown.
4. Tighten the ETC screws to the specified torque.



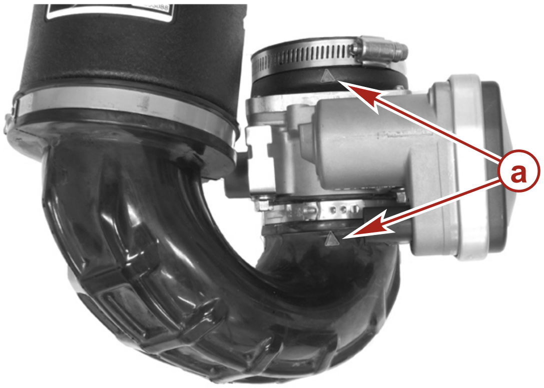
4602

a - Harness support brackets
b - Screws securing isolator to ETC

Description	Nm	lb-in.	lb-ft
Isolator screw (M6 x 50)	11	97	

5. Install a 75.5 mm diameter hose clamp onto the resonator boot.

6. Install the resonator boot onto the ETC. Ensure the alignment arrow of the resonator boot is aligned with the ETC isolator arrow before crimping the 75.5 mm diameter hose clamp with the hose clamp tool.



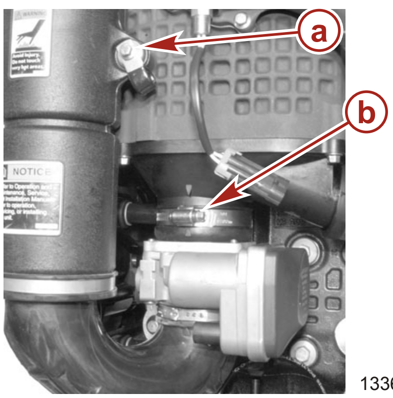
16520

a - Alignment arrows

Hose Clamp Tool Kit	91-803146A2

Electronic Throttle Control (ETC) Installation

1. Install a hose clamp onto the isolator.
2. Install the ETC assembly onto the supercharger.
3. Align the arrows on the supercharger and the ETC isolator.
4. Tighten the hose clamp to the specified torque.
5. Secure the resonator to the supercharger with a bolt, J-clamp, and washer.



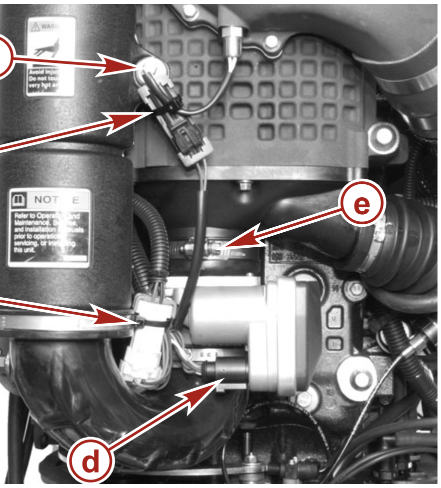
13364

a - Bolt, J-clamp, and washer
b - Hose clamp

Description	Nm	lb-in.	lb-ft
Bolt (M6 x 25)	7.5	66	
Hose clamp	6.2	55	

6. Connect the ETC harness connector to the ETC.
7. Connect the engine harness to the supercharger temperature sensor. Secure sensor connector to the J-clamp with a cable tie.

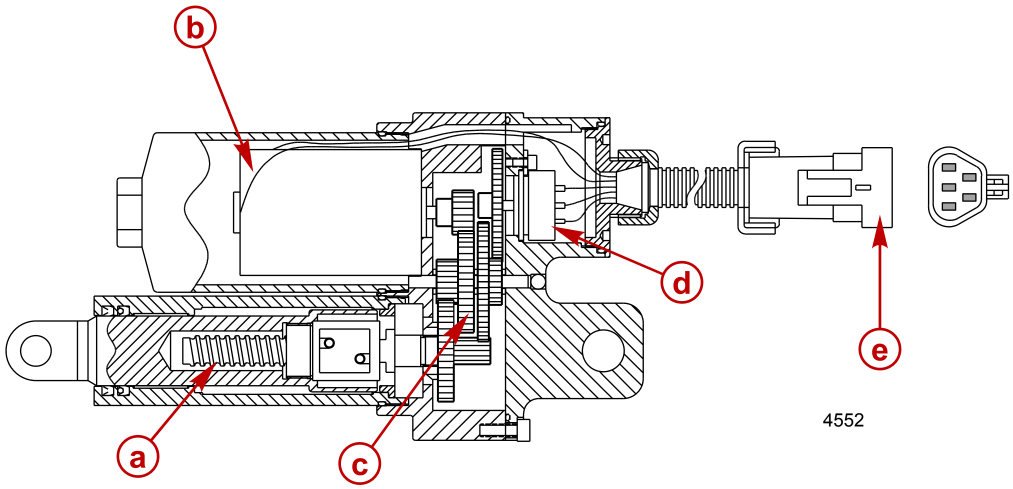
8. Secure the engine harness and ESC connector to the harness support bracket with a cable tie.



13335

- a - Bolt securing resonator to supercharger
- b - Cable tie securing supercharger temperature sensor connector
- c - Cable tie securing the ESC connector and engine harness
- d - ETC harness connector
- e - Hose clamp securing ETC isolator

Electronic Shift Control (ESC)



4552

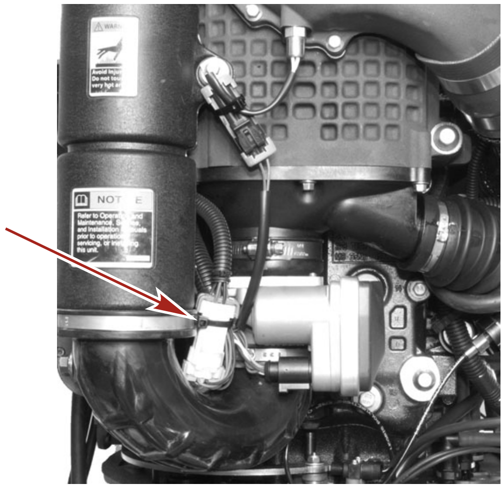
- a - Ball screw assembly
- b - Actuator motor
- c - Reduction gears
- d - Potentiometer
- e - Harness connection

The ESC/shift actuator is used to shift the engines gearcase into forward, neutral, and reverse gears without mechanical cables from the shift/throttle controls. The 12 VDC actuator motor rotates a ball screw assembly through reduction gears in the actuator. The screw shaft then extends or retracts the actuator shaft while at the same time the gear set rotates a potentiometer in the actuator. The potentiometer receives a reference voltage (5.0 volts) from the PCM, and its signal confirms the position of the actuator shaft.

Electronic Shift Control (ESC) Removal

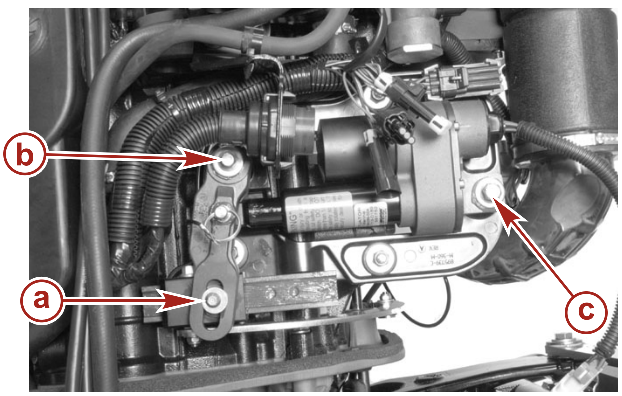
1. Remove lower chaps, port and starboard cowls. Refer to **Section 4A - Cowling Removal**.
2. Cut the cable tie securing the ESC harness connector to the harness support bracket.

3. Disconnect the engine harness from the ESC.



14517

4. Remove the bolt securing the bell crank to the shift slider.
5. Remove the bolt and washer securing the bell crank to the shift bracket.
6. Remove the bolt securing the ESC to the shift bracket.



13621

a - Bolt securing bell crank to shift slider
b - Bolt and washer securing bell crank to shift bracket
c - Bolt securing ESC to shift bracket

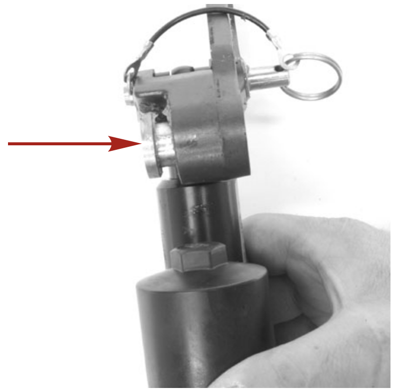
7. Remove the ESC.

   IMPORTANT: Do not allow the ESC piston to rotate more than 1/4 turn from the factory setting.

8. Remove the rubber washer and bushing from the ESC.

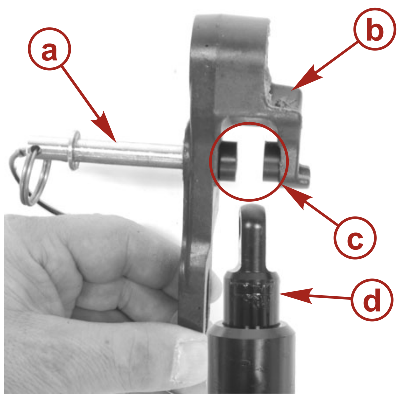
13626

9. Remove the bushing from the bell crank.



13627

10. Remove the cotter pin from the bell crank clevis pin.
11. Remove the clevis pin. Do not lose the spacers that are between the ESC piston and the bell crank.



13632

a - Clevis pin
b - Bell crank
c - Spacers (2)
d - ESC piston

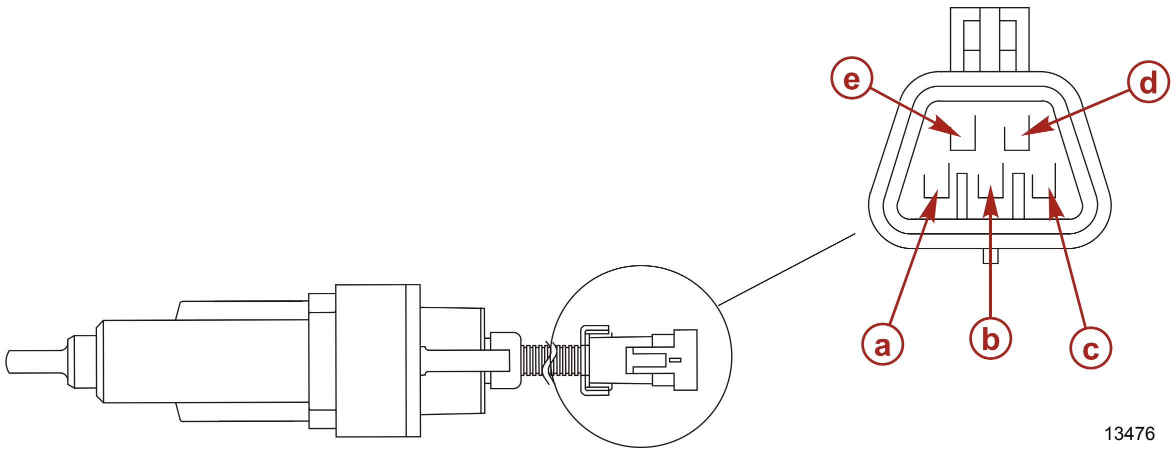
12. Secure the ESC piston with a cable tie.

4982

⚠ WARNING

To avoid serious injury or death from a collision resulting from a shifting malfunction, install cable ties through the electronic shift control piston to ensure that the piston does not rotate from the original factory position. Remove cable ties just prior to installation. Do not rotate the piston more than 1/4 turn after removing the cable ties. If the piston is accidentally rotated, contact Mercury Customer Service for recalibration.

Electronic Shift Control (ESC) Harness Connection Pin-Out



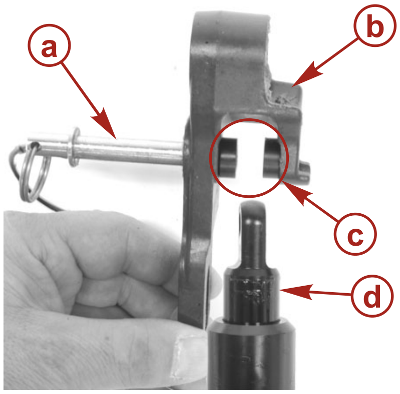
- a - Black/green - Transducer ground
- b - Green - Shift position input
- c - Red/green - Transducer power (5 volts)
- d - Black - Motor driver
- e - Red - Motor driver

Electronic Shift Control (ESC) Installation

⚠ WARNING
To avoid serious injury or death from a collision resulting from a shifting malfunction, install cable ties through the electronic shift control piston to ensure that the piston does not rotate from the original factory position. Remove cable ties just prior to installation. Do not rotate the piston more than 1/4 turn after removing the cable ties. If the piston is accidentally rotated, contact Mercury Customer Service for recalibration.

1. Remove cable tie from the ESC prior to installation.
2. Apply Engine Coupler Spline Grease to the spacers. Align the spacers with the clevis pin hole on the bell crank.

3. Align the ESC piston hole with the bell crank hole.

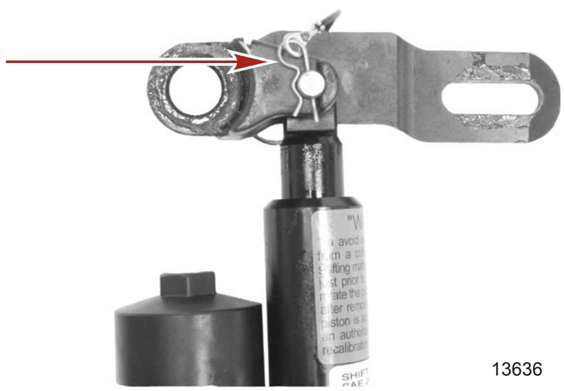


13632

a - Clevis pin
b - Bell crank
c - Spacer (2)
d - ESC piston

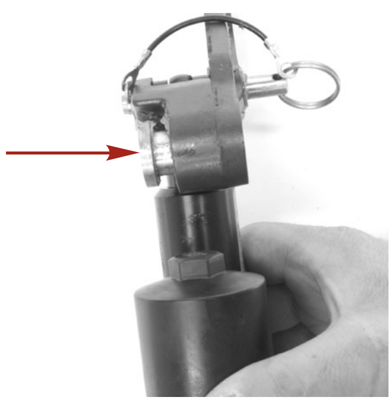
Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Bell crank spacers	92-802869A 1

4. Install the clevis pin and secure with a cotter pin.



13636

5. Lubricate the bell crank bushing with Engine Coupler Spline Grease and install into the bell crank.

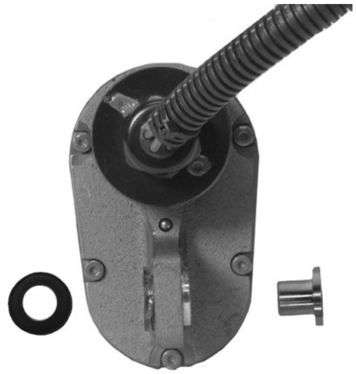


13627

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Bell crank bushing	92-802869A 1

6. Lubricate the ESC bushing with Engine Coupler Spline Grease.
7. Install the ESC bushing on the same side of the ESC as the bell crank bushing.

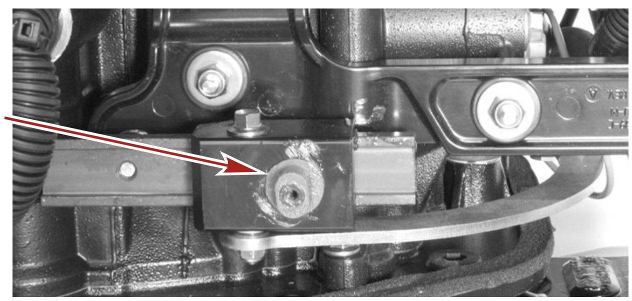
8. Lubricate the rubber washer with Engine Coupler Spline Grease and install onto the end of the ESC bushing protruding from the ESC.



13626

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	ESC bushing and bell crank bushing rubber washer	92-802869A 1

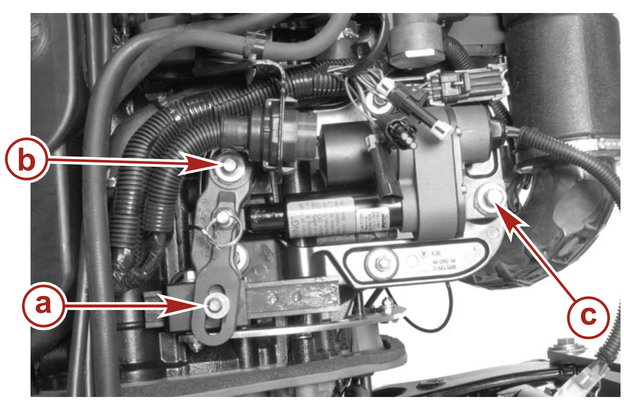
9. Lubricate the bell crank slider bushing with Engine Coupler Spline Grease.



13637

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Bell crank slider bushing	92-802869A 1

10. Install the ESC assembly with washers and bolts. Tighten bolts to the specified torque.
11. Connect the engine harness connector to the ESC.



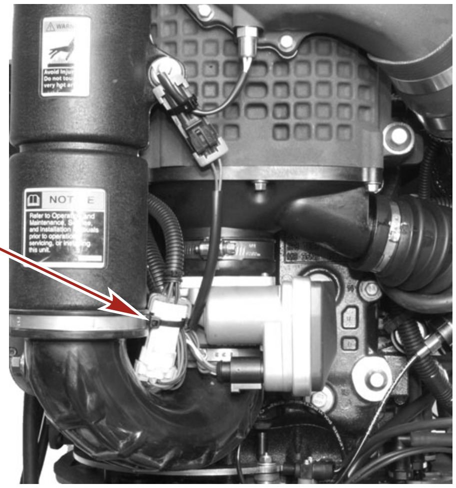
13621

- a - Bolt and washer securing bell crank to shift slider (M5 x 10)
- b - Bolt and washer securing bell crank to shift bracket (M8 x 60)
- c - Bolt and washer securing ESC to shift bracket (M8 x 35)

Description	Nm	lb-in.	lb-ft
Bolt (M5 x 10)	10	88.5	
Bolt (M8 x 60)	27		20
Bolt (M8 x 35)	20.3	180	

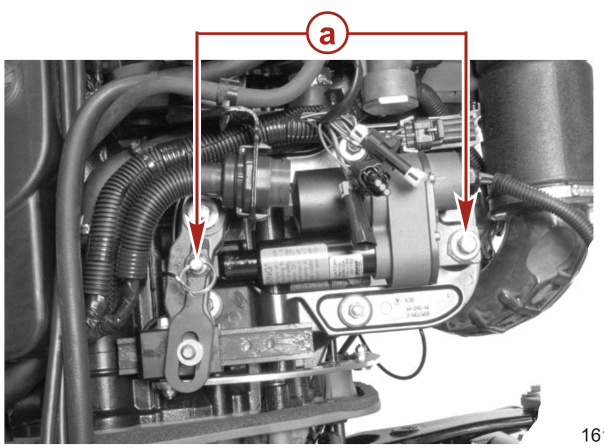
12. Connect the engine harness to the ETC.

13. Secure ESC harness connector and engine harness to the support bracket with a cable tie.



14517

14. Ensure the control handle is in neutral.
15. Turn the ignition key to the "ON" position.
16. Measure between the center of the piston clevis pin and the center of the ESC mounting bolt. The measurement must be 19.766 cm ± 1.0 mm (7-25/32 in. ± 1/32 in.).
17. If the measurement is not within specification, remove the clevis pin and rotate the piston to shorten or extend the length of the piston to achieve the measurement specification.



16126

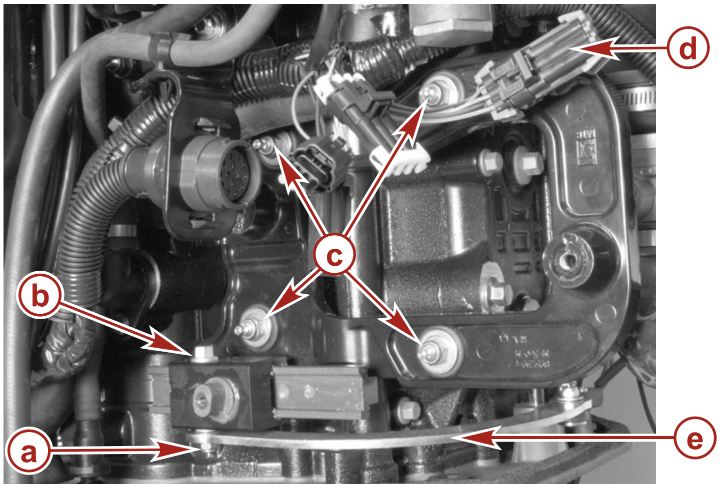
a - 19.766 cm ± 1.0 mm
(7.782 in. ± 0.040 in. or 7-25/32 in. ± 1/32 in.)

Electronic Shift Control (ESC) Bracket

ESC Bracket Removal

1. Remove the top cowl, lower chaps, port and starboard cowls. Refer to **Section 4A - Cowling Removal**.
2. Remove the ESC. Refer to **ESC Removal**.
3. Remove the boat harness connector from the ESC bracket.
4. Remove the nut, washer, and bolt securing the shift link to the shift slider.
5. Remove the four nuts and washers securing the ESC bracket to the cylinder block.

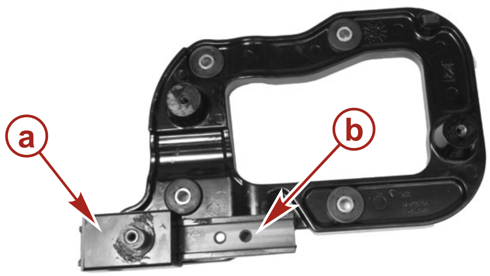
6. Remove the ESC bracket from the mounting studs.



13640

a - Nut and washer
b - Bolt
c - Nut and washer securing bracket (4 each)
d - Boat harness connector
e - Shift link

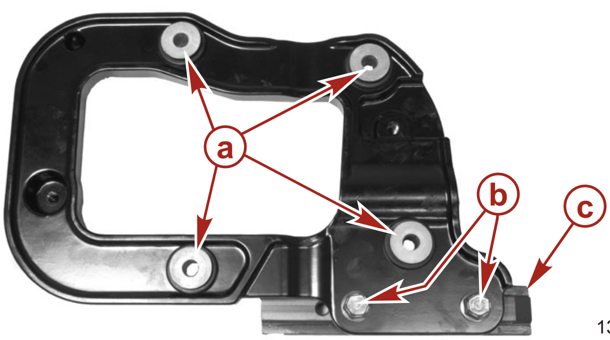
7. Remove the shift slider from the shift slider rail.



13641

a - Shift slider
b - Shift slider rail

8. Remove the bushings and rubber grommets from the shift bracket.
9. Remove the two bolts securing the shift slider rail to the shift bracket.
10. Remove the shift slider rail.



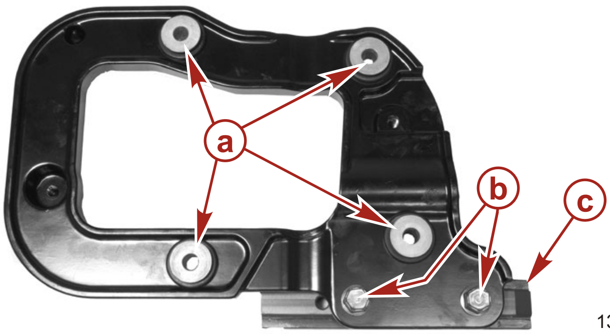
13647

a - Bushings and rubber grommets (4)
b - Bolts securing shift slider rail
c - Shift slider rail

ESC Bracket Installation

1. Install the shift slider rail to the ESC bracket. Secure with two M8 x 25 bolts. Tighten bolts to the specified torque.
2. Install the four rubber grommets into the ESC bracket.

3. Install the four bushings into the rubber grommets.

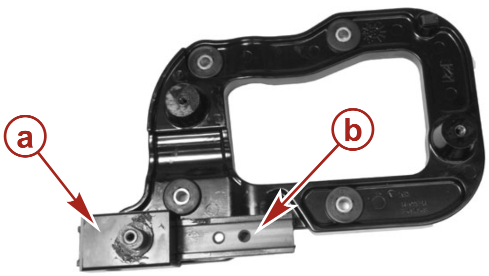


13647

a - Bushings and rubber grommets (4)
b - Bolts securing shift slider rail
c - Shift slider rail

Description	Nm	lb-in.	lb-ft
Bolt (M8 x 25)	27		20

4. Lubricate the shift slider rail with Engine Coupler Spline Grease.
5. Install the shift slider onto the shift slider rail. Ensure the long side of the shift slider is facing towards the rear of the shift bracket assembly.

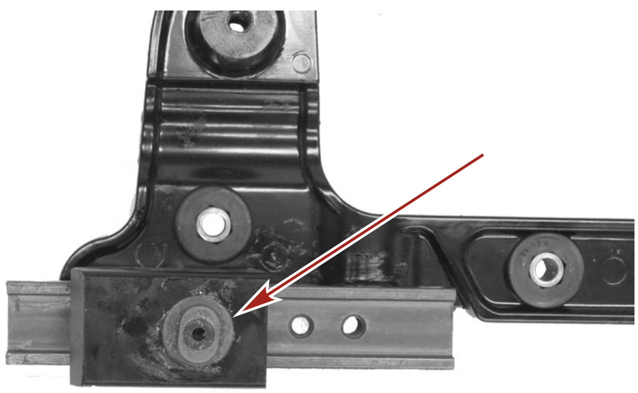


13641

a - Long side of the shift slider
b - Shift slider rail

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Shift slider rail	92-802869A 1

6. Lubricate the bell crank slider bushing with Engine Coupler Spline Grease and install on the shift slider.

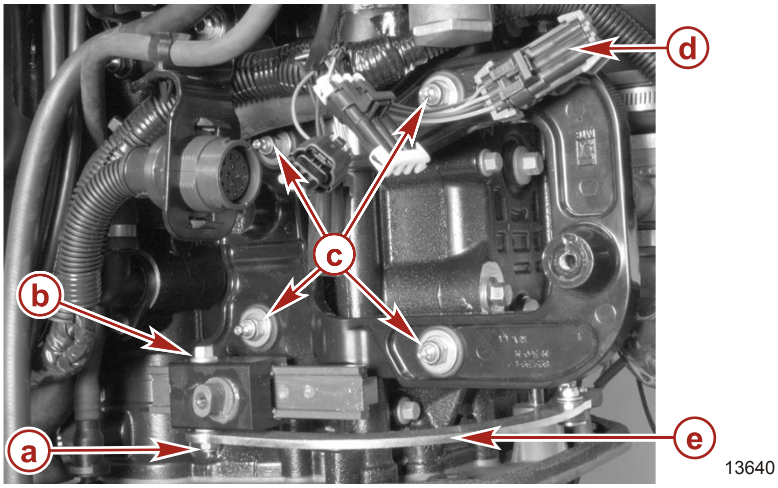


13649

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Bell crank slider bushing	92-802869A 1

7. Install the shift bracket onto the cylinder block studs.
8. Secure the shift bracket with four washers and nuts. Tighten nuts to the specified torque.
9. Lubricate the shift link bushing with SAE Engine Oil 30W.
10. Secure the shift link to the shift slider with a bolt, washer, and nut. Tighten the bolt and nut to the specified torque.

11. Attach the boat harness connector to the shift bracket.



a - Nut and washer (M6)
b - Bolt
c - Nut and washer securing bracket (4 each) (M8)
d - Boat harness connector
e - Shift link

Description	Nm	lb-in.	lb-ft
Nut, bolt (M6)	6.2	55	
Nut (M8)	20.3	180	

Tube Ref No.	Description	Where Used	Part No.
80	SAE Engine Oil 30W	Shift link bushing	Obtain Locally

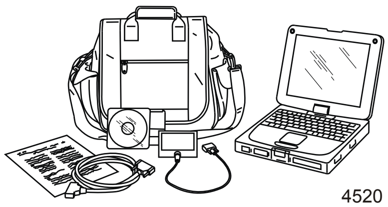
Notes:

Fuel System

Section 3A - Fuel System Operation

Table of Contents

Special Tools

Computer Diagnostic System (CDS)	Order through SPX
 4520	Monitors all electrical systems for proper function, diagnostics, and calibration purposes. For additional information, pricing, or to order the Computer Diagnostic System contact: SPX Corporation 28635 Mound Rd. Warren, MI 48092 or call: USA - 1-800-345-2233 Canada - 800-345-2233 Europe - 49 6182 959 149 Australia - (03) 9544-6222

Air Induction and Fuel Injection System

Air Induction System

Induction System Key Components

- Air filter
- Air attenuator
- Electronic throttle control (ETC)
- Supercharger
- Charge air cooler (CAC)
- Intake manifold
- Electronic boost control (EBC)

Air Flow

Fresh air enters the cowling and is drawn into the air filter where small airborne debris is filtered out. Air passing through the filter enters the air attenuator where the throttle noise of the engine is baffled for quiet operation. The air volume entering the engine is controlled by the electronic throttle control (ETC).

The ETC with the assistance of the propulsion control module (PCM), meters the amount of air entering the system. The ETC is operated with an electric motor. The position of the ETC blade is monitored with two throttle position sensors (TPS). The ETC performs operations similar to an idle air control (IAC) valve. Should the ETC fail, the ETC blade is spring-loaded to return to off idle setting of about 1200 RPM in gear operation. After passing the ETC, the air enters the supercharger.

The supercharger is belt-driven from the crankshaft rotation. As the air passes the ETC it enters at the bottom of the supercharger where two close tolerance internal roots or vanes (one male, one female) rotate in opposite direction to compress and accelerate the air towards the exit port of the supercharger. The compressed and accelerated air has potentially risen in temperature beyond 80 °C (176 °F) and must be cooled before entering the combustion chamber. The supercharged air can increase two atmospheres 101.325 kPa (14.7 psi) above ambient barometric pressure during maximum boost. The supercharged air enters the charge air cooler (CAC).

The CAC is water-cooled and chills the supercharged air temperature significantly. Water pushed up from the lower unit, circulates through the CAC heat exchanger. Air passing over the CAC chills and increases the density of the supercharged air. The air which has passed the CAC enters the manifold where it enters the combustion chamber when the intake valve open.

The manifold runners allow the air to flow smoothly to the combustion chamber. Each runner has a single fuel injector controlled by the PCM. The fuel injector is unique and has two pintels or nozzles. The two pintel design allows for a better atomization of the fuel with the supercharged air. The pintels spray the fuel directly at the intake valves. Excess chilled air is recirculated (bypassed) back into the bottom of the supercharger (intake). The amount of recirculated chilled air is controlled by the electronic boost control (EBC) valve.

The EBC has a motor that operates the boost control valve and is controlled by the PCM. This valve is spring-loaded to the open position. The open position allows the excess air to be recirculated to the bottom of the supercharger. During hard acceleration, the PCM looks at the throttle position, manifold absolute pressure (MAP) sensor, manifold air temperature (MAT) sensor and engine RPM to determine the amount of valve closure needed to supply supercharged air to the engine. At 60% demand, the PCM will start to close the valve. There is no demand for supercharged air at idle or wide-open throttle. Tampering with the EBC will generate an error and subsequently will not develop the engine's rated horsepower.

Fuel Injection System

The Verado fuel injection system is a true multi-port timed injection. Fuel is injected into the cylinder head when the valves are open, one cylinder at a time. This type of injection gives the Verado a significant fuel efficiency and performance advantage over synchronous (batch timed) fuel injection engines.

The fuel delivery system, in conjunction with the ignition, is controlled by the propulsion control module (PCM). The PCM requires input information from multiple sensors to maintain optimum fuel injection volume (pulse width), fuel injection timing, amount of boost air pressure, and throttle position. The PCM converts the input signals from the various input sensors and sends digital instructions for the throttle and fuel injection timing/volume; positions the electronic boost control (EBC) valve, and the amount of engine timing.

The PCM also controls the modulation of the fuel lift pump after the fuel supply module (FSM) is initially filled. The modulation of the fuel lift pump is dependent on the demands of the engine and the subsequent amount of fuel consumption. The fuel lift pump is activated through the fuel pump ground circuit inside the PCM. While the engine is in operation, the PCM calculates how many grams of fuel is used at any RPM, and cycles the fuel lift pump according to the calculated fuel consumption. The fuel lift pump should never be at 100% duty cycle (constantly on). The fuel lift pump will always be an on/off cycle. The fuel lift pump will become disabled in the event of a FSM overflow. The PCM recognizes the FSM overflow with the activation of the vent canister switch (VCS).

Fuel pressure is also changing with engine demands. When the engine is under low or high demands the manifold absolute pressure (MAP) changes. The demands of the engine are known to the PCM by way of the MAP sensor digital signal change and throttle position. Fuel pressure will change in conjunction with the manifold absolute pressure change. A tube on the intake manifold is connected to the fuel pressure regulator inside the fuel supply module (FSM). The manifold pressure changes will push or pull the fuel pressure regulator diaphragm, changing the amount of fuel pressure in the fuel rail. The excessive pressure is released into the FSM.

Fuel injection volume is initially charted in the PCM when the system is activated by turning the key to the "ON" position. The PCM reads the MAP sensor in the intake manifold to determine the ambient barometric (BARRO) pressure. The PCM then looks at the cylinder block and air temperatures. The BARRO pressure, cylinder block, and air temperature readings are the base for all fueling strategies at start-up. Fuel strategy changes constantly during engine operation.

A supercharger is used to boost the air volume. Supercharged air loses density and must be cooled by passing through the charge air cooler (CAC) to increase the air density. The increased air density is forced into the combustion area creating a significant amount of usable horsepower. The amount of boost required for the engine to operate at maximum horsepower capacity is controlled by the PCM. The PCM closes the electronic boost control (EBC) valve to increase the amount of air forced into the combustion chamber. The amount of EBC valve closure is dependent on the demands of the engine based on the throttle position, MAP, and engine RPM.

The fuel is water-cooled. While the engine is running, water is pumped up to the powerhead by the water pump located in the lower unit. Water is pumped up to the engine via a water tube, passes through the adapter plate main water galley where it enters the powerhead, and is distributed to different locations. The water tube for cooling the fuel is connected to a ridged hose passing through the adapter plate, where it connects to a ridged hose attached to the fuel supply module (FSM). The water enters the FSM, passes through a coiled metal tube, and exits outside the FSM. The metal tube is completely submerged in fuel while the engine is in operation.

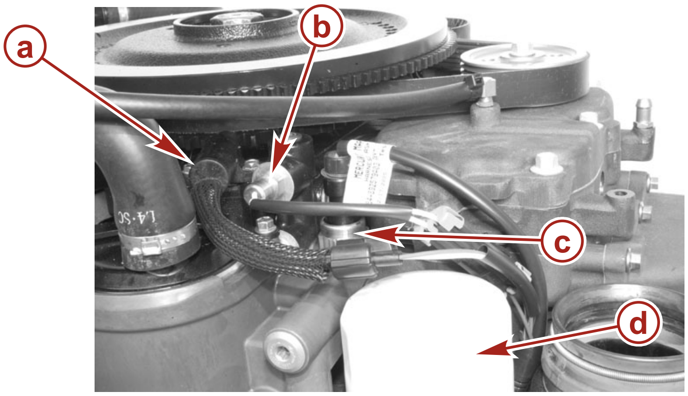
The neutral switch sends a signal to the PCM indicating when it is in neutral. While in neutral, the PCM will limit the engine from an overrev RPM condition.

The electronic throttle control (ETC) is modulated by the PCM. The PCM converts digital position signals at the helm, and positions the ETC throttle plate accordingly. The ETC has two throttle position sensors (TPS). This redundancy ensures the accuracy of the throttle plate position, matching the digital position signal at the helm. The ETC also acts as an idle air control (IAC), increasing or decreasing the ETC plate opening, depending on the air temperature and engine temperature.

Powerhead Sensors

Crankshaft Position Sensor (CPS)

The crankshaft position sensor is located at the top of the cylinder block next to the flywheel. The sensor contains a magnet which is positioned next to the flywheel's lower ring gear. This ring gear has 54 teeth with six gaps (or missing teeth) at specific locations. The close proximity of the crankshaft position sensor magnet to the 54 teeth allows a magnetic field to be created each time a tooth passes the sensor. This field collapses and creates an AC voltage pulse. This AC pulse is sent to the propulsion control module (PCM). The timing and frequency of these pulses allows the PCM to regulate ignition and fuel injector timing. If the crankshaft position sensor fails, the engine will run rough or stop running.



13387

- a - Crankshaft position sensor
- b - Oil temperature sensor
- c - Oil pressure sensor
- d - Oil filter

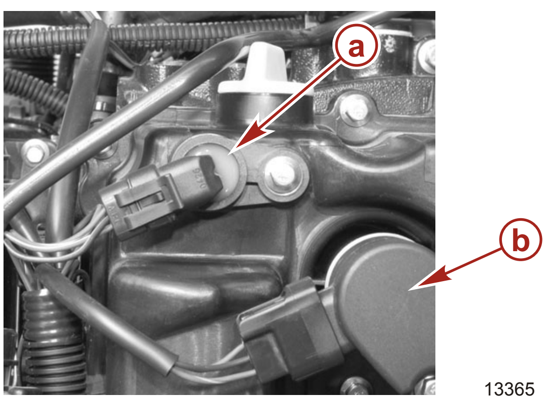
Refer to **Section 2A - Crankshaft Position Sensor (CPS)** for testing, removal, and installation.

Camshaft Position Sensor

The camshaft position sensor is located at the top of the valve cover. It supplies the PCM with timing and RPM information. When the camshaft position sensor is functioning, the PCM controls the fuel injection in a sequential, multi-port timing strategy. When the camshaft position sensor has failed, the PCM controls the fuel injection in a batch fire strategy. The engine may not start as quickly and the Guardian System will limit power to 75%. The PCM will generate and store a failure code when the camshaft position sensor fails.

A sequential firing strategy means the fuel injectors fire once per engine cycle (every two crankshaft revolutions). The fuel injection event is complete just before the intake valve closes. The ignition coils fire only once per engine cycle. Sequential firing is ideal for emissions, driveability, and slight horsepower advantages.

Batch fire strategy means the fuel injectors fire every revolution (1/2 the fuel needed per revolution/per cycle) and the coils also fire every revolution (wasted spark). This strategy does not consider the phase of the engine; i.e. whether a particular cylinder is on a compression or exhaust stroke. Batch fire engines do not require a camshaft position sensor.



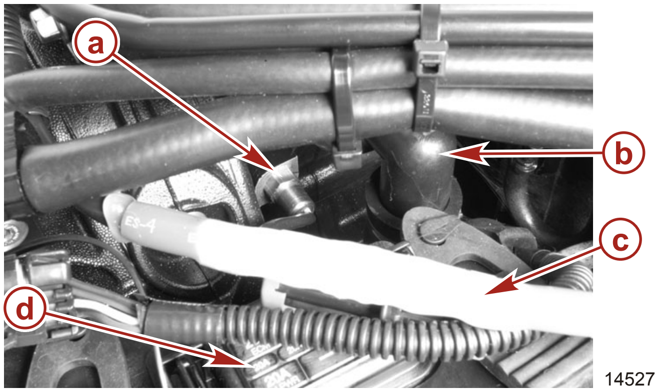
13365

- a - Camshaft position sensor (CPS)
- b - Ignition coil

Refer to **Section 2A - Camshaft Position Sensor** for testing, removal, and installation.

Cylinder Block Temperature Sensor

The cylinder block temperature sensor is located below the thermostat cover, behind the electrical box. It is a thermistor immersed in the engine coolant path. It supplies the PCM with engine temperature information. The PCM adjusts the timing and the amount of fuel delivered according to the water temperature in the cylinder block. Low coolant temperature produces high resistance, while high temperature causes low resistance.



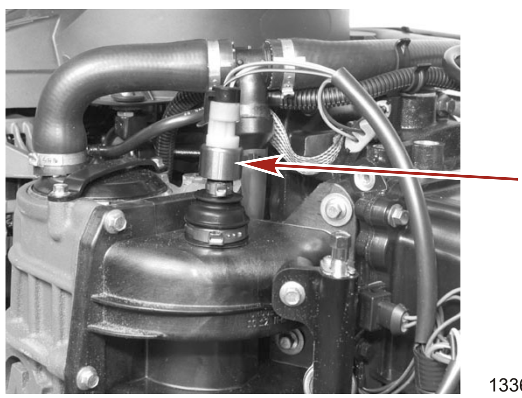
14527

a - Cylinder block temperature sensor
b - Thermostat housing
c - 150 amp fusible link
d - Fuse holder

Refer to **Section 2A - Cylinder Block Temperature Sensor** for testing, removal, and installation.

Manifold Absolute Pressure (MAP) Sensor

The manifold absolute pressure (MAP) sensor measures the changes in the intake manifold pressure. It is located at the top of the intake manifold. When the ignition key switch is turned "ON," the MAP sensor reads the ambient atmospheric pressure. This information is used by the PCM as an indication of altitude and is referred to as BARRO. The manifold absolute pressure will change as a result of engine load and speed changes.

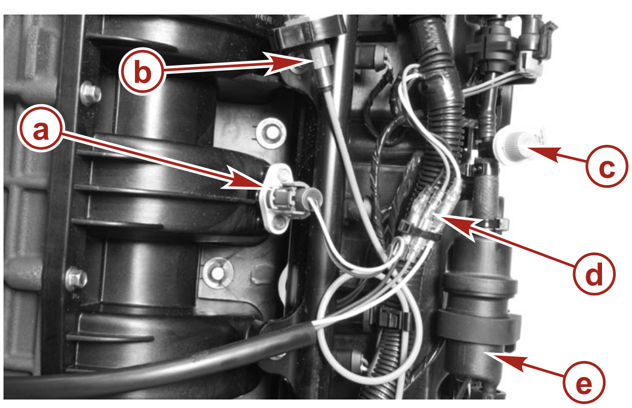


13369

Refer to **Section 2A - Manifold Absolute Pressure (MAP) Sensor** for testing, removal, and installation.

Manifold Intake Air Temperature (MAT) Sensor

The manifold intake air temperature sensor is a thermistor that controls a signal voltage to the PCM. It is located in the middle of the intake manifold close to the fuel rail. It informs the PCM of the air temperature inside the intake manifold. The PCM adjusts the fuel injection duration needed to run the engine at optimum efficiency according to the MAT information. When intake air is cold, the sensor resistance is high. As the air temperature rises, resistance lowers.



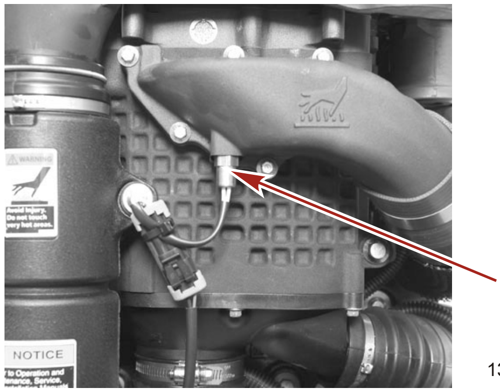
13374

a - MAT sensor
b - Block water pressure sensor
c - FSM vent cap
d - Trim position sensor bullet connectors
e - Vent canister float switch

Refer to **Section 2A - Manifold Intake Air Temperature (MAT) Sensor** for testing, removal, and installation.

Supercharger Outlet Temperature Sensor

The supercharger outlet temperature sensor is a thermistor immersed in the boost pressure outlet stream. It is located in the front of the engine, at the base of the outlet duct. Low air temperature produces high resistance while high temperature causes low resistance. The PCM will reduce engine RPM and initiate a warning at the helm.

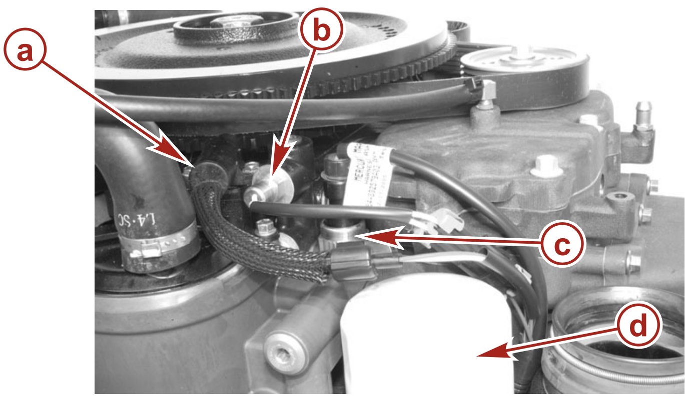


13379

Refer to **Section 2A - Supercharger Outlet Temperature Sensor** for testing, removal, and installation.

Oil Pressure Sensor

The oil pressure sensor measures the engine oil pressure. It is located on the starboard side of the supercharger. In the event of low oil pressure, the PCM will limit engine power based on the amount of oil pressure available at a specific engine RPM.



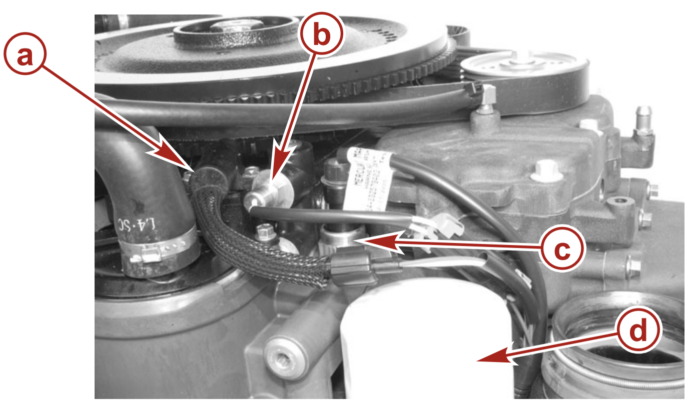
13387

- **a -** Crankshaft position sensor
- **b -** Oil temperature sensor
- **c -** Oil pressure sensor
- **d -** Oil filter

Refer to **Section 2A - Oil Pressure Sensor** for testing, removal, and installation.

Oil Temperature Sensor

The oil temperature sensor is located on the starboard side of the cylinder block, next to the crankshaft position sensor. It is a thermistor immersed in the engine oil passageway. It supplies the PCM with engine oil temperature information. The PCM adjusts the timing and the amount of fuel delivered according to the oil temperature in the cylinder block. Low oil temperature produces high resistance, while high temperature causes low resistance.



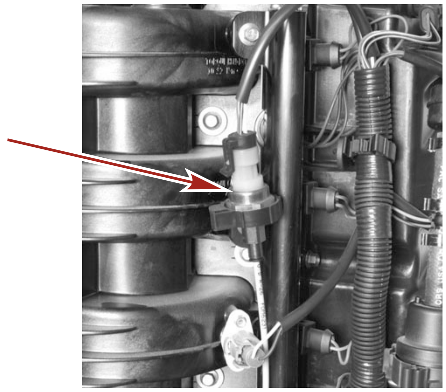
13387

- **a -** Crankshaft position sensor
- **b -** Oil temperature sensor
- **c -** Oil pressure sensor
- **d -** Oil filter

Refer to **Section 2A - Oil Temperature Sensor** for testing, removal, and installation.

Block Water Pressure Sensor

The cylinder block water pressure sensor measures the amount of coolant supplied by the water pump to the cylinder block. The sensor converts this pressure to a voltage which is sent to the PCM. The PCM will limit engine power if the coolant supply (water pressure) is insufficient at a given RPM. The cylinder block water pressure sensor is located on the aft side of the engine and is secured to the fuel rail with a clamp.

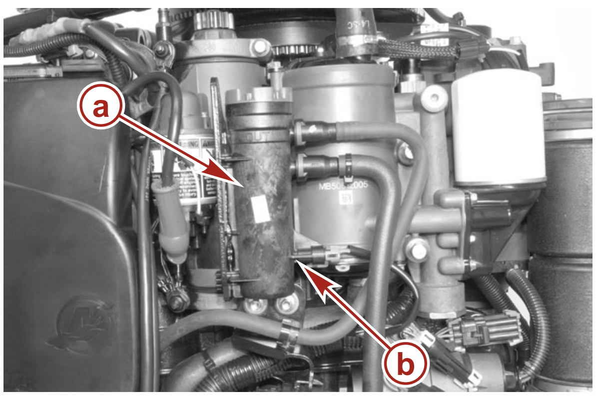


13399

Refer to **Section 2A - Block Water Pressure Sensor** for testing, removal, and installation.

Water in Fuel (WIF) Sensor

The WIF sensor is located in the fuel filter housing on the starboard side of the engine. The sensor has two probes that are highly conductive when water is present. The sensor is normally an open switch. Water completes a 5 volt negative reference to the PCM. The PCM will generate an error history and activate a warning horn to inform the operator. If SmartCraft gauges are installed, the PCM will flash a visual warning to the operator.



12196

a - Fuel filter assembly
b - Water in fuel sensor

Refer to **Section 2A - Water in Fuel (WIF) Sensor** for testing.

Fuel System

Fuel System Description

The components of the fuel system are:

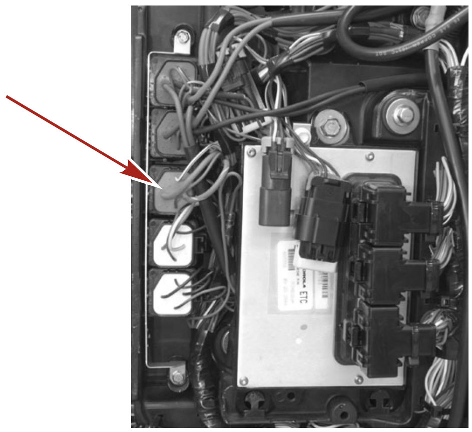
- Main power relay (MPR)
- Water sensor
- Propulsion control module (PCM)
- Fuel supply module (FSM)
- Fuel float switch
- Vent canister switch (VCS)
- Vent canister purge valve (VCPV)
- Fuel lift pump
- High-pressure fuel pump
- Fuel pressure regulator
- Fuel cooler
- Fuel injector

- Fuel rail pressure damper
- Supercharger

IMPORTANT: No external electric fuel pump is allowed by the US Coast Guard. The system does not require an external primer bulb. Using an external primer bulb will cause a warning horn to sound and cause a flooding condition.

Main Power Relay (MPR)

The main power relay (MPR) is located inside the electrical box on the starboard side of the engine. The MPR is controlled by the PCM. The MPR will remain active for approximately 15 minutes after the ignition key switch is turned to the "OFF" position. This allows for power trim operation when the key is in the "OFF" position. The main power relay supplies 12 volts to the power trim, power steering, fuel lift pump, high-pressure fuel pump, ignition pencil coils, fuel injectors, electronic shift control, electronic throttle control, electronic boost control, and alternator.



13484

Propulsion Control Module (PCM)

The PCM requires 8 VDC minimum to operate. If the PCM should fail, the engine will stop running. The inputs to the PCM can be monitored and tested by the computer diagnostic system (CDS).

Computer Diagnostic System (CDS)	Order through SPX

The PCM controls the following functions:

- Calculates the precise fuel and ignition timing requirements based on engine speed, throttle position, manifold absolute pressure (MAP), manifold air temperature (MAT), and cylinder block coolant temperature.
- Directly controls the ground circuit to: fuel injectors, ignition coil driver, ETC motor drive, EBC motor drive, ESC motor drive, main power relay activation, power steering pump, vent canister purge valve (VCPV), trim up, trim down, fuel lift pump, diagnostics, Engine Guardian, and tachometer link (analog tachometer output or link gauge driver).
- Indirectly controls the positive circuit to: fuel injectors, ignition coils, ETC motor drive, EBC motor drive, ESC motor drive, main power relay activation, VCPV, and high-pressure fuel pump.

The PCM operates in four modes: power off, stall, crank, and run. The PCM also provides for a smooth throttle response between varying throttle positions and engine loads. A warm-up mode is integrated with the run mode and disengaged after the engine accumulates a given amount of power or engine temperature.

Power off mode - With the ignition key switch "OFF," the PCM allows the trim system to function for up to 15 minutes. 12 VDC is available from the battery at the fuses, positive cable terminal in the electrical box, and at the alternator.

Stall mode - With the ignition key switch in the "RUN" position, the PCM is energized and provides power to the main power relay and the fuel pump relay for five seconds. It also provides 5 VDC power to the sensors. The PCM records barometric pressure from the MAP sensor, intake air temperature from the MAT sensor, and coolant temperature from the coolant temperature sensor. The PCM will use this information to establish a warm-up strategy that will control fuel delivery and engine speed during warm-up and idle.

Crank mode - The PCM controls all aspects of the starter including how long the starter is energized. When the ignition key switch is turned to the "START" position, the start relay is grounded through the PCM, energizing the starter solenoid. While the engine rotates, a pulse will be generated at the crankshaft position sensor which provides the PCM engine speed information. The PCM will then supply power to the fuel pump and ignition coils through the main power relay and the fuel pump relay.

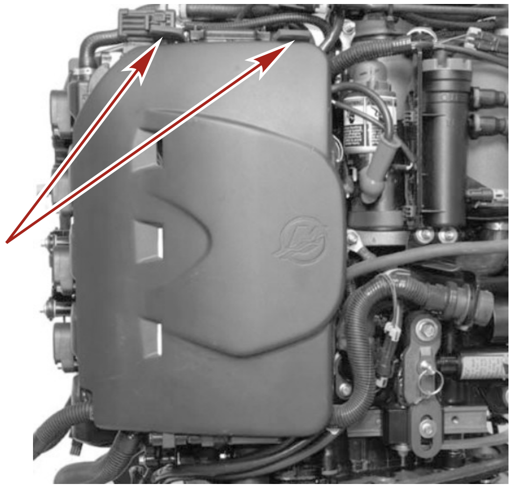
Run mode - At approximately 500 RPM, the PCM will transition to the run mode.

- The warm-up strategy will continue to adjust engine speed with the fuel injector pulse width and engine spark advance until the engine accumulates a given amount of power.
- The camshaft position sensor provides cylinder compression phasing information to the PCM for sequential fuel injection.

- The MAT sensor, TPS sensor, and MAP sensor are monitored to determine proper spark timing, boost control, and the fuel needs necessary to develop the amount of power asked for by the operator.

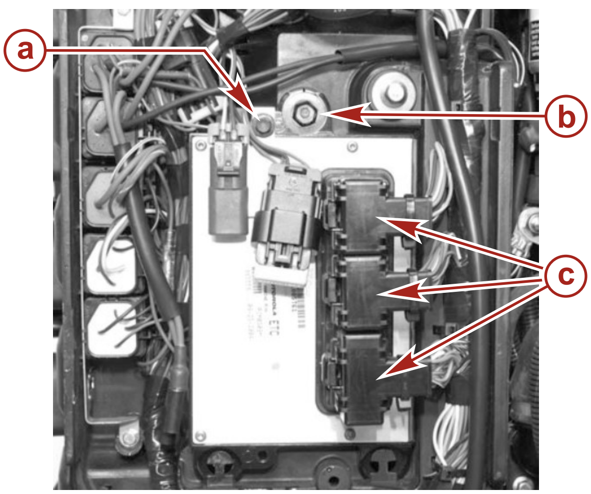
PCM Removal

1. Release the straps securing the electrical box cover.



13343

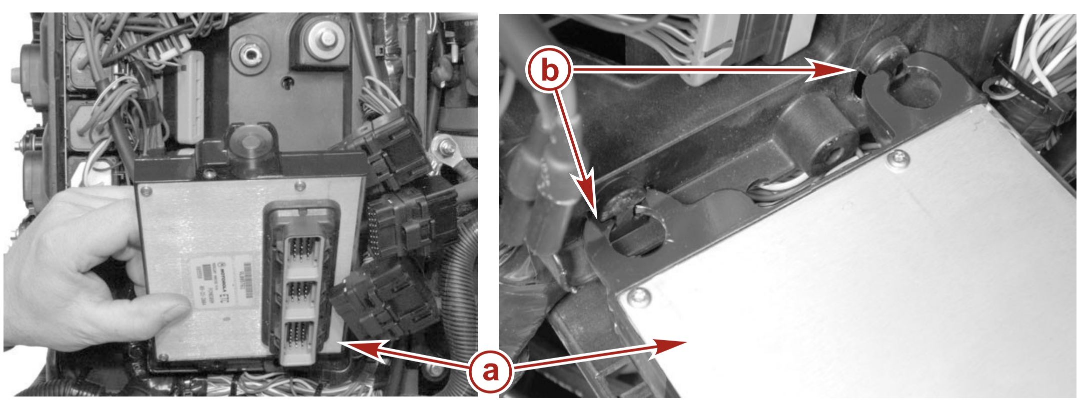
2. Lift the electrical box cover up to remove it from the electrical box.
3. Remove the bolt securing the bracket for the terminator resistors.
4. Disconnect the three harness connectors.
5. Remove the bolt securing the PCM to the electrical box.



13344

a - Bolt securing termination resistor bracket
b - Bolt securing PCM
c - Engine harness connectors

6. Carefully tilt the top of the PCM out to disengage the PCM from the electrical box lower PCM mounts.

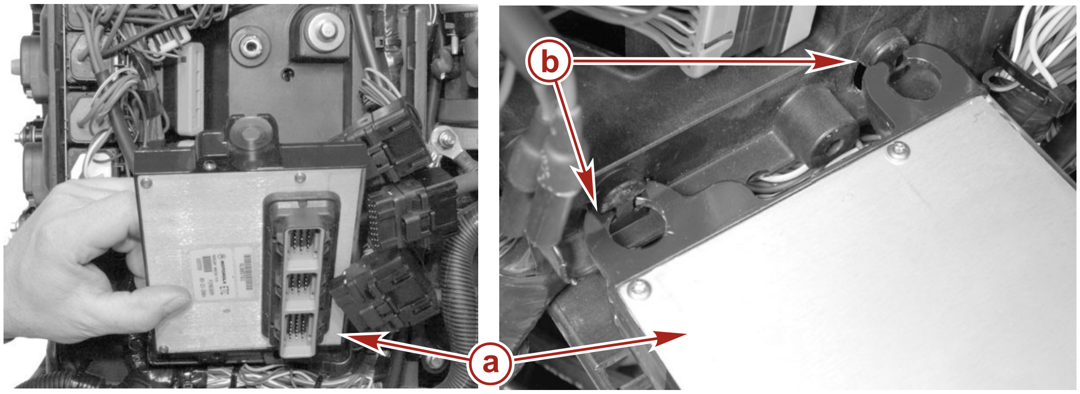


13345

a - PCM
b - Electrical box lower PCM mounts

PCM Installation

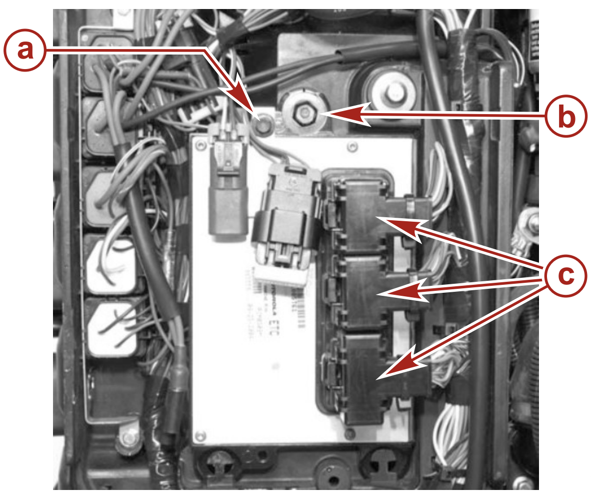
1. Align the PCM with the electrical box lower PCM mounts.
2. Install the PCM onto the electrical box.
3. Carefully tilt the PCM up to align the threaded mounting hole.



13345

a - PCM
b - Electrical box lower PCM mounts

4. Secure the PCM with a bolt. Tighten bolt to the specified torque.
5. Install the three engine harness connectors into the PCM.
6. Secure the bracket for the termination resistors with a bolt and tighten to the specified torque.

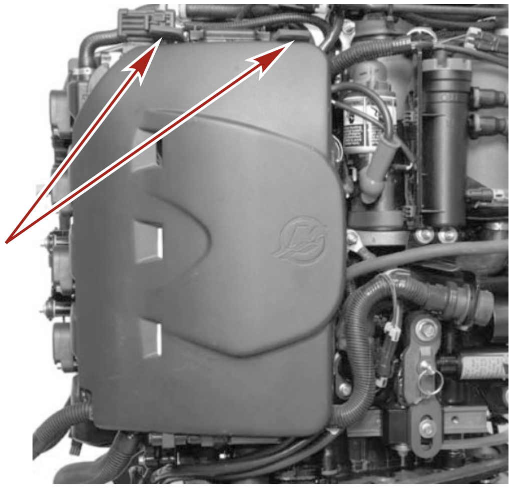


13344

a - Bolt securing termination resistor bracket
b - Bolt securing PCM
c - Engine harness connectors

Description	Nm	lb-in.	lb-ft
Bolt securing PCM (M8 x 13)	9	80	
Bolt securing termination resistor bracket (M6 x 14)	6	53	

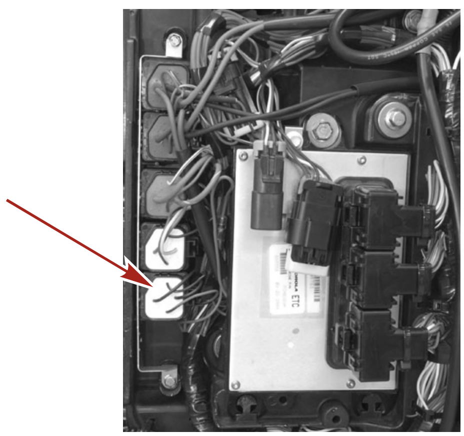
7. Install the electrical box cover and secure with straps.



13343

High-Pressure Fuel Pump Control Relay

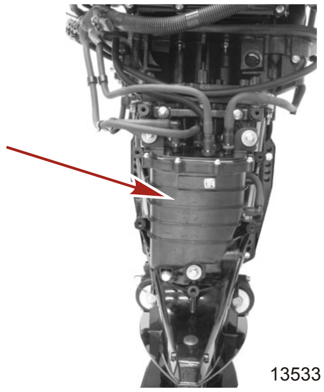
The engine wire harness has a fifth relay for high-pressure fuel pump control. It is located next to the PCM. The incorporation of the high-pressure fuel pump control relay eliminates the possibility of pump damage when the key switch is turned to the "ON" position and the FSM is empty of fuel. The high-pressure fuel pump operation is controlled by the PCM. The PCM completes the ground connection of the high-pressure fuel pump through the high-pressure fuel pump control relay. The power for the high-pressure fuel pump is supplied by the main power relay. A 20 amp fuse is in line with the power wire to the high-pressure fuel pump. The PCM programmed logic for the high-pressure fuel pump, limits the initial fuel pump use at key "ON" for five seconds. After the initial five seconds, the high-pressure fuel pump will not be active until engine RPM is recognized by the PCM.



13511

Fuel Supply Module (FSM)

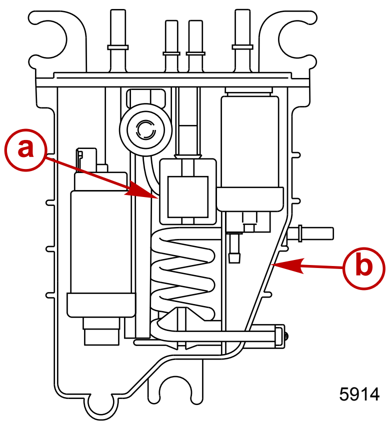
The fuel supply module contains the fuel lift pump, high-pressure fuel pump, fuel level float switch, fuel pressure regulator, and a fuel cooler. The FSM is mounted aft and outside of the driveshaft housing, directly below the lower adapter plate. There is no needle and seat controlling the amount of fuel entering the FSM. The filling of the FSM is controlled by the fuel level float switch inside the FSM. This switch is only for filling the FSM during the initial ignition key "ON." After the FSM is recognized as full, the PCM modulates the fuel lift pump to fill the FSM.



13533

Fuel Float Switch

The fuel float switch is a reed type switch sending an open or closed (off or on) signal to the PCM. The float has a magnet in it. As the fuel level increases in the FSM, the float will rise causing the magnet to open the reed switch sending the off signal to the PCM.

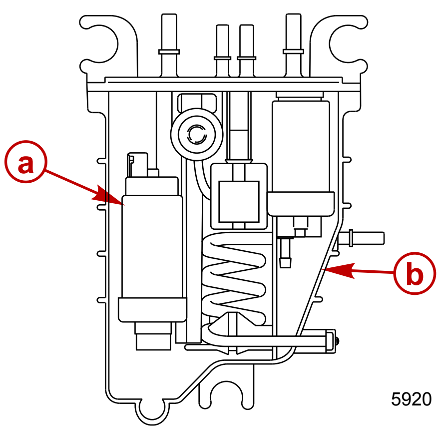


5914

a - Fuel float switch
b - Fuel supply module

High-Pressure Fuel Pump

When the ignition key is turned "ON," the high-pressure fuel pump is active for five seconds after the PCM initiates the main power relay. After the first five seconds, the high-pressure fuel pump will not run until the PCM recognizes engine RPM. The PCM does not have the logic to detect the high-pressure fuel pump operation. In the event of a high-pressure fuel pump failure, no fault will be generated, but the engine will not run. The high-pressure fuel pump sends the fuel through a 20 micron fuel filter, into the bottom of the fuel rail. There is an internal regulation of the high-pressure pump of 689.5 kPa (100 psi). The fuel rail pressure is controlled by a fuel pressure regulator.



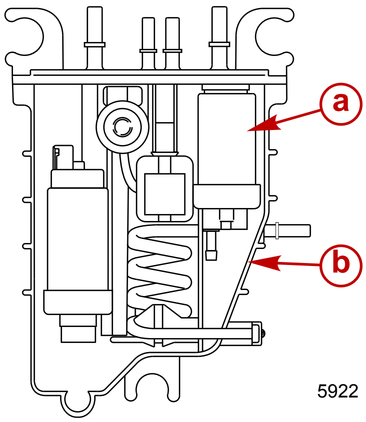
5920

a - High-pressure fuel pump
b - Fuel supply module

Fuel Lift Pump

Fuel is pulled from the fuel tank, by the fuel lift pump located inside the FSM. The fuel lift pump is activated with 12 volts through the main power relay when the key is turned to the "ON" position. The grounding of the fuel lift pump is completed in the PCM. The PCM circuit grounding of the fuel lift pump is dependent upon three conditions.

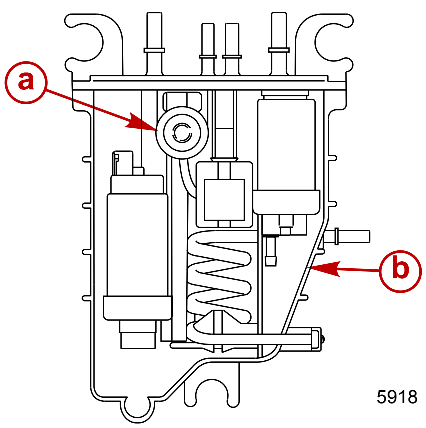
- **Condition one**: if there is no change in the fuel float switch signal during the first time an engine is put into service.
- **Condition two**: after a predetermined programmed time limit, the PCM will open the grounding circuit.
- **Condition three**: when the fuel float switch and the vent canister float switch are closed, the PCM grounds the return electrical lead completing the circuit of the fuel lift pump.



a - Fuel lift pump
b - Fuel supply module

Fuel Pressure Regulator

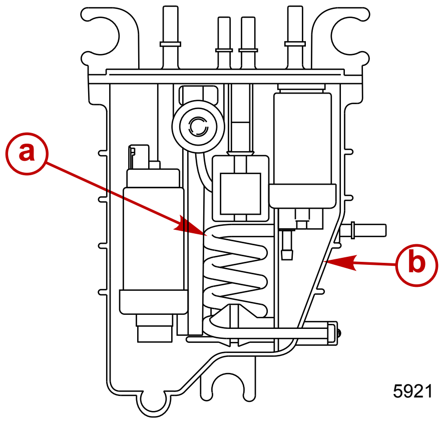
The fuel pressure regulator, located inside the fuel supply module, controls the amount of fuel pressure required for the engine to run efficiently. The fuel pressure regulator changes the pressurization of the fuel depending on the demands of the engine. The air pressure changes in the intake manifold to a higher or lower pressure during RPM changes. These manifold absolute pressure changes are linked to the fuel pressure regulator. The changes which take place at the fuel pressure regulator are managed by a hose that is connected to the intake manifold integrated air/fuel module. The air pressure change that is positive or negative on the fuel pressure regulator diaphragm, increases or decreases the amount of fuel that is dumped back into the FSM.



a - Fuel pressure regulator
b - Fuel supply module

Fuel Cooler

The fuel cooler receives its supply of water from the filtered water outlet on the upper adapter plate. The water outlet removes large debris from the water supply. The water is then directed with a preformed hose down to the FSM fuel cooler inlet. The fuel cooler is a metal line with several wound coils to help cool the fuel. After the water has passed through the fuel cooler it is dumped immediately outside of the FSM.

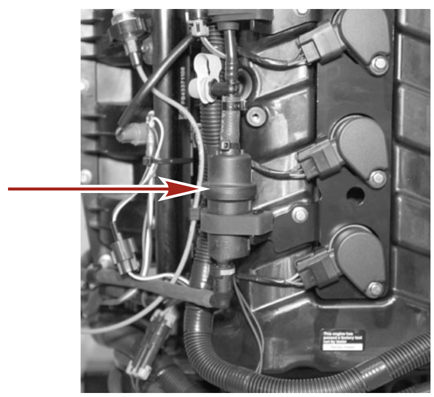


5921

a - Fuel cooler
b - Fuel supply module

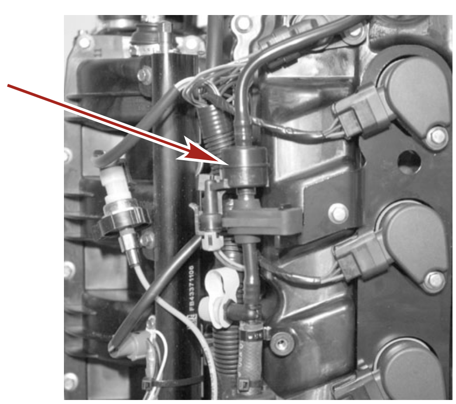
Vent Canister Switch (VCS)

The vent canister switch (VCS) is located on the port side of the spark plugs. The VCS is an on/off signal to the PCM. The VCS is normally closed, completing a 5 volt reference from the PCM. The VCS will open during a fuel supply module overflow condition. A open VCS will cause the PCM to close the vent canister purge valve.


13500

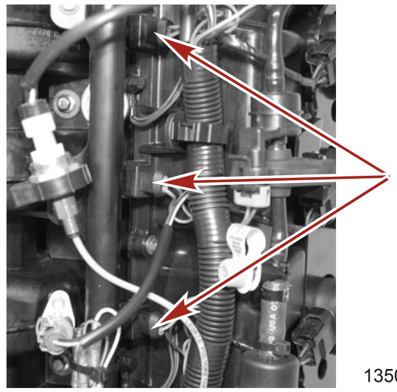
Vent Canister Purge Valve (VCPV)

The vent canister purge valve is located to the port side of the spark plugs. The vent canister purge valve is closed when the engine is not running. This prevents the FSM fuel vapors from building up in the cowl. When the engine is running, the PCM completes the ground circuit of the purge valve, opening the valve to allow fuel vapors from the FSM to be vented into the air filter inside the flywheel cover. This allows the fuel vapors to be burned in the combustion chamber. The VCPV is modulated off and on by the PCM.


13502

Fuel Injector

The fuel injector is an electrically operated spring-loaded solenoid, which delivers a metered amount of fuel into the intake manifold runner, just ahead of the intake valve. The injectors are electrically charged as the key switch is set to the "RUN" position. The PCM controls the injection by completing the ground circuit, lifting the solenoid, which allows high-pressure fuel to flow. The PCM then opens the ground circuit allowing the spring to close the injector and stop the fuel flow. The fuel injector is not serviceable. There are two separate split streams of fuel aimed at the intake valves for better atomization of the fuel. An injector filter is located on the fuel inlet side of the injector. The filter is not replaceable but can be cleaned of debris.

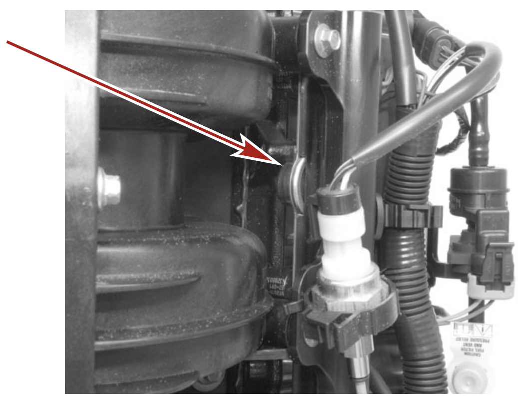


13504

Fuel Rail Pressure Damper

The fuel rail pressure damper is located on the fuel rail assembly. It is designed to reduce fuel pressure changes caused by pulses generated by the fuel injectors opening and closing. The fuel rail pressure damper contains a spring on the dry side of the diaphragm. This spring positions the diaphragm against the diaphragm seat when the engine is not running and there is no fuel pressure present.

While the fuel pressure reaches normal operating range, the fuel pressure will compress the spring and the diaphragm will move slightly away from the normal position. Any fuel pressure spikes will be equalized with the pressure of the spring pushing on the diaphragm, which helps maintain a constant pressure within the fuel system.

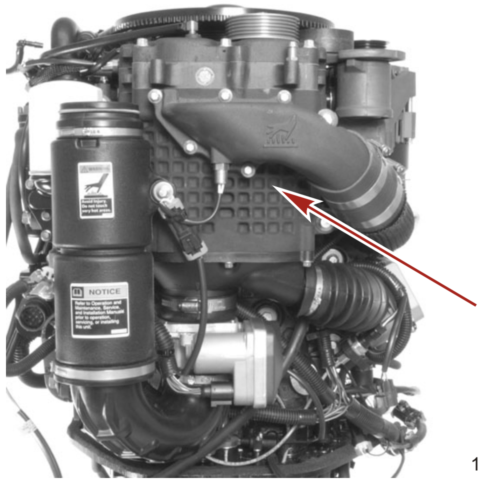


13506

Supercharger

Description

The supercharger is a crankshaft belt-driven positive displacement true air compressor. It delivers increased air density and pressures up to two atmospheres 101.35 kPa (14.7 psi) of boost to the intake manifold. The added density and pressure increases the horsepower. It is located on the front of the engine.



13485

The supercharger uses horsepower from the crankshaft. This loss of horsepower is minimal and is outweighed by the supercharger horsepower gains at full load. A bypass, called an electronic boost control valve, diverts air from the intake manifold back into the supercharger during idle speeds. Little or no boost is present during idle speeds.

When air is compressed, its ambient temperature rises and loses density. A cooler air intake charge results in more available horsepower due to the increase of air density. The charge air cooler located inside the intake manifold, minimizes the heat added to the charged air by transferring the heat to seawater before the charge reaches the combustion chamber.

Compression Sequence

1. **Inlet phase** - The supercharger has two helix rotors that spin opposite of each other. The helix rotors do not contact each other. As the lobes on the rotors mesh at the inlet ports, air is captured and moved toward the discharge ports.
2. **Compression phase** - As captured air cells are moved toward the discharge ports, the space between the lobes progressively decrease, resulting in compression and an increase in the air temperature.
3. **Discharge phase** - The compressed air cells are moved to the discharge port and passes through the intercooler in the intake manifold. The bypass valve will close when there is a demand for boost. The bypass valve is controlled by the PCM.

Fuel System

Section 3B - Troubleshooting and Diagnostics

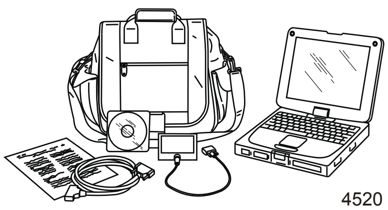
Table of Contents

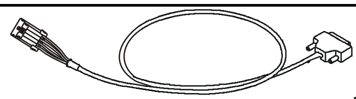
3
B

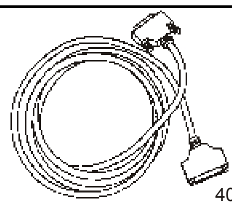
Lubricant, Sealant, Adhesives

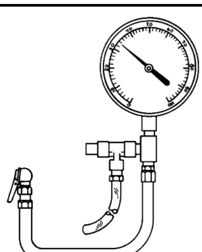
Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Grounds and ring terminals	92- 25711 3

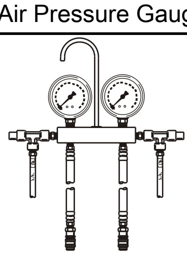
Special Tools

Computer Diagnostic System (CDS)	Order through SPX
 4520	Monitors all electrical systems for proper function, diagnostics, and calibration purposes. For additional information, pricing, or to order the computer diagnostic system contact: SPX Corporation 28635 Mound Rd. Warren, MI 48092 or call: USA - 1-800-345-2233 Canada - 800-345-2233 Europe - 49 6182 959 149 Australia - (03) 9544-6222

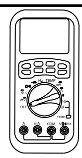
Adapter Harness	84-822560A13
 5826	Data link harness between engine and computer diagnostic system (CDS).

Extension Cable	84-825003A 1
 4012	Data link extension harness (3.05 m [10 ft.]) between the adapter harness and the Digital Diagnostic Terminal or Computer Diagnostic System (CDS).

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.

Digital Pressure Meter	91-892651A01
 5786	Connects to the fuel system/manifold and can be used in conjunction with Computer Diagnostic System (CDS).

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.

Using the Computer Diagnostic System (CDS)

The propulsion control module (PCM) is designed that if a sensor fails, the PCM will compensate so the engine does not go into an overrich condition. Because of this, disconnecting a sensor for troubleshooting purposes may have no noticeable effect.

IMPORTANT: Any sensor that is disconnected while the engine is running will be recorded as a fault in the PCM "Fault History." Use the CDS to view and clear the fault history when troubleshooting/repair is completed.

The computer diagnostic system (CDS) has been developed specifically to help technicians diagnose and repair Mercury Marine two and four cycle engines.

Computer Diagnostic System (CDS)	Order through SPX

Attach the diagnostic cable to the PCM diagnostic connector and plug in the software. You will be able to monitor sensors and PCM data values including status switches. The PCM program can help diagnose intermittent engine problems. It will record the state of the engine sensors and switches for a period of time and then can be played back to review the recorded information.

Adapter Harness	84-822560A13
Extension Cable	84-825003A 1

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

Troubleshooting without CDS

Troubleshooting without the CDS is limited to checking resistance on some of the sensors.

Typical failures usually do not involve the PCM. Most likely at fault are the connectors, set-up, and mechanical wear.

- 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.

  NOTE: *PCM's are capable of performing a cylinder misfire test to isolate problem cylinders. Once a suspect cylinder is located, an output load test on the ignition coil or fuel injector can be performed using the CDS.*
- Any sensor or connection can be disconnected and reconnected while the engine is operating without damaging the PCM. Disconnecting the crankshaft position sensor will stop the engine.

  IMPORTANT: Any sensor that is disconnected while the engine is running will be recorded as a fault in the PCM Fault History. Use the CDS to view and clear the fault history when troubleshooting/repair is completed.
- If all cylinders exhibit similar symptoms, the problem is with a sensor or harness input to the PCM.
- If the problem is speed related or intermittent, it is probably a connector or contact related. Inspect the connectors for corrosion, loose wires, or loose pins. Secure the connector seating. If dielectric compound was used to protect the wire connections, the dielectric compound must be removed.
- Inspect the harness for obvious damage: pinched wires, chafing.
- Secure grounds and all connections involving ring terminals. Coat grounds and ring terminals with Liquid Neoprene.

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Grounds and ring terminals	92- 25711 3

- Check the fuel pump connections and the fuel pump pressure.

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.

Fuel Component Troubleshooting and Diagnostics

Anti-Siphon Valves

While anti-siphon valves may be helpful from a safety standpoint, they clog with debris, they may be too small, or they may have too heavy a spring. The pressure drop across these valves can, and often does, create operational problems and/or powerhead damage by restricting fuel to the fuel lift pump and, subsequently, the high-pressure fuel pump. Some symptoms of restricted (lean) fuel flow, which could be caused by use of an anti-siphon valve, are:

- Severe fuel rail pressure fluctuation
- Loss of fuel pump pressure
- High speed surging
- Outboard cuts out or hesitates upon acceleration
- Outboard runs rough
- Outboard quits and cannot be restarted
- Outboard will not start
- Vapor lock

Since any type of anti-siphon device must be located between the outboard fuel inlet and fuel tank outlet, a simple method of checking if such a device (or bad fuel) is a problem source, is to operate the outboard with a separate fuel supply which is known to be good, such as a remote fuel tank.

If, after using a separate fuel supply, it is found that the anti-siphon valve is the cause of the problem, there are two solutions to the problem; either 1) replace the anti-siphon valve with one that has a lighter spring tension, or 2) replace it with a solenoid-operated fuel shut off valve.

Referencing Fuel Pressure Readings

The fuel rail pressure reading will vary according to whether the intake manifold is under vacuum during idle, or under pressure when the demands of the engine load are highest. This change from vacuum to pressure variance, and the subsequent changes of the fuel pressure reading, is maintained by a reference hose connection at the intake manifold to the fuel pressure regulator inside the fuel supply module (FSM).

During slow throttle advancement to WOT, the propulsion control module (PCM) determines the demands of the engine are light based on the manifold absolute pressure (MAP) reading, throttle position, and engine RPM; and will not close the boost control valve. The manifold remains in a vacuum state. During quick throttle advancement to WOT, the PCM determines the demands of the engine are high based on the MAP reading change, the throttle position, and what the engine RPM is in relation to the throttle position; and closes the boost control valve to change the manifold from a vacuum state to a pressurized state.

When the manifold is in a pressurized state, air is forced into the combustion chamber as the valves open. More fuel is needed to have a correct stoichiometric air to fuel ratio (14.7:1). The additional air pressure, is transferred to the fuel pressure regulator via the reference line. This reference line, connected to the fuel pressure regulator inside the FSM, applies the additional pressure from the manifold to the fuel pressure regulator diaphragm. The additional pressure on the fuel pressure regulator diaphragm changes the pressure needed to unseat the fuel pressure regulator, increasing the amount of fuel pressure in the fuel rail.

The fuel pressure regulator is factory set to open at 350 ± 32 kPa (50.76 ± 4.64 psi). Fuel pressure is less than regulator set pressure when there is a vacuum in the engines intake manifold (less than barometric pressure), and is more than regulator set pressure when there is boost pressure in the engines intake manifold (higher than barometric pressure).

Fuel Pressure Calculations, Engine Running

When calculating the fuel pressure at different points of engine RPM, a simple formula can be used to determine what the fuel pressure should approximately be; **(MAP - Baro) + regulator set point**.

The following examples are with an ambient barometric pressure of 101 kPa (14.65 psi).

If the intake manifold absolute pressure is below the barometric pressure (vacuum), and the CDS displays 32 kPa (4.64 psi), the formula appears as:

- **kPa**: 32 - 101 = –69 + 350 = 281. The calculated fuel pressure reading is 281 kPa.
- **psi**: 4.64 - 14.65 = –10.1 + 50.76 = 40.76. The calculated fuel pressure reading is 40.76 psi.

If the intake manifold absolute pressure is above the barometric pressure (boost) and the CDS displays 191 kPa (27.70 psi), the formula appears as:

- **kPa**: 191 - 101 = 90 + 350 = 440. The calculated fuel pressure reading is 440 kPa.
- **psi**: 27.70 - 14.65 = 13.05 + 50.76 = 63.81. The calculated fuel pressure reading is 63.81 psi.

Fuel Lift Pump

The fuel lift pump can be tested with the CDS.

Computer Diagnostic System (CDS)	Order through SPX

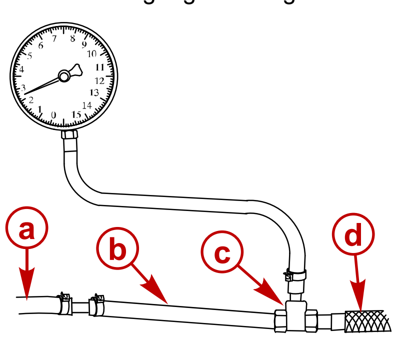
The fuel lift pump is pulse width modulated (PWM) by the ground side of the pump through the PCM. The positive side is powered through the main power relay (MPR). The fuel lift pump PWM is dependent on the vent canister switch (VCS) and the FSM float level switch state.

There are four possible dependencies for the PWM.

- When the ignition key switch is in the "ON" position, the fuel lift pump will run for approximately 45 seconds. A "Key UP Lift Pump Time Out" is generated after the 45 seconds with no fault code stored.
- FSM Low, VCS Low, Fuel Mass Level: The fuel lift pump will run when the FSM float switch is low (full), or the PCM has determined the engine has consumed approximately 150 grams of fuel. If the FSM float switch has not changed after 180 seconds have expired, a "Lift Pump Time Out" fault is set and the fuel lift pump will be turned off. This is only functional when the engine is running.
- FSM High, VCS Low: The fuel lift pump is turned off. No fault is set.
- FSM Low, VCS High: The fuel lift pump is turned off, the vent canister purge valve (VCPV) is closed, and a "Vent Switch High" fault is set. Possible cause is a faulty fuel float level switch, fuel in the line between the VCS and the VCPV which can be eliminated by opening the purge vent Schrader valve (under the green cap).
- FSM High, VCS High: The fuel lift pump is turned off, VCPV is closed, and a "Vent Switch High" fault is set.
  - If the PCM does not see a fuel lift pump (open circuit) a "Fuel Pump CKT" fault is set.
  - If the FSM fuel float switch sticks in the up position (FSM full, lift pump turned off), no fault is set and the engine will run out of fuel.

Testing Fuel Lift Pump 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 engine.
8. Observe clear fuel line for air bubbles.
9. The vacuum gauge reading should be within the listed specification when the pump is active.



4439

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

Fuel Lift Pump Vacuum	
Sea level (maximum)	10.2 kPa (3.00 Hg)

High-Pressure Fuel Pump

High-Pressure Fuel Pump	
Fuel pressure, engine not running	350 ± 32 kPa (50.7 ± 4.6 psi)
Fuel pressure, engine running	Pressure dependent on manifold vacuum/pressure

The high-pressure fuel pump can be tested for operation electrically with the CDS.

Computer Diagnostic System (CDS)	Order through SPX

The high-pressure fuel pump power comes from the main power relay (MPR) and is grounded through the engine wire harness.

There is no logic in the PCM to know if the high-pressure fuel pump is functioning or not. No fault will be set if the high-pressure fuel pump fails and the engine will not run.

1. Connect a fuel pressure gauge to the fuel rail Schrader valve.

Fuel Pressure Gauge Kit	91-881833A03
Dual Fuel/Air Pressure Gauge Kit	91-881834A 1
Digital Pressure Meter	91-892651A01

2. With the CDS, run the fuel pump load test.
3. The fuel pressure gauge should read 350 ± 32 kPa (50.7 ± 4.6 psi) when the pump is running, engine not running.
4. If there is little or no pressure reading on the gauge, ensure the FSM has enough fuel to supply the high-pressure fuel pump.

Vent Canister Switch (VCS)

The vent canister switch (VCS) is controlled by the PCM. The PCM supplies 5 V to the VCS. The VCS is normally closed or low when the FSM is empty of fuel. The VCS can be checked with an ohmmeter while it is still mounted on the engine or with the CDS.

DMT 2004 Digital Multimeter	91-892647A01
Computer Diagnostic System (CDS)	Order through SPX

If the VCS sticks open or high, a fault "Vent Switch High" will be set, the vent canister purge valve (VCPV) will close, the lift pump will be turned off, and the engine will run out of fuel. The PCM will not turn on the fuel lift pump when the VCS fault is on or high. The VCS must be closed before the PCM will turn the lift pump on.

If the VCS sticks closed or low, and the FSM fuel level switch is functioning correctly, the engine will operate without faults or driveability issues. If the fuel supply module should overflow (a primer bulb or an electric primer pump will cause an overflow, a faulty fuel float level switch may cause an overflow) and the VCS sticks closed, a rich condition from unmetered fuel entering the air induction system at the air cleaner, may cause the engine to operate less than optimal.

Vent Canister Purge Valve (VCPV)

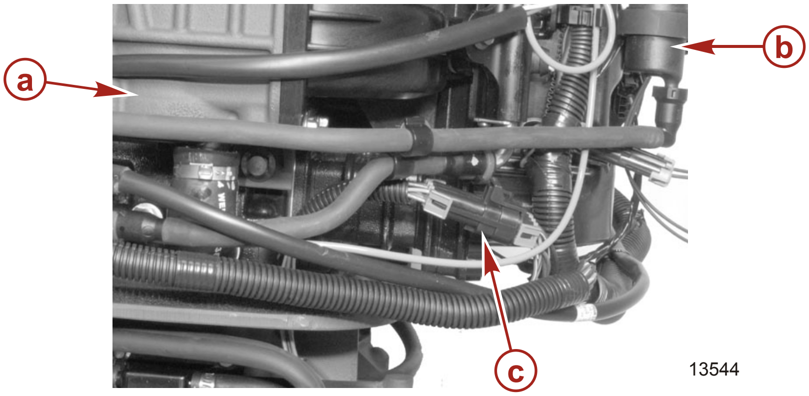
The VCPV is powered by the main power relay (MPR). The ground is pulse width modulated (PWM) by the PCM. The PWM is based on engine RPM.

The VCPV is normally closed. During initial start up, the VCPV remains closed until the engine RPM is stable is complete. The VCPV is then modulated (cycles open and closed) by the PCM.

- If the VCPV fails electrically or becomes unplugged while the engine is running, the valve will close. Since the VCPV is normally closed, the PCM has no logic to detect this failure.
- If the VCPV fails mechanically open, the PCM has no logic to detect this failure, no fault will be set. If the VCS fails low and the FSM overflows with fuel, the engine could have driveability issues due to unmetered fuel entering the air intake filter.

Fuel Supply Module (FSM)

The FSM is a modular component consisting of the fuel lift pump, high-pressure fuel pump, fuel level float switch, fuel pressure regulator, and the fuel cooler. The fuel lift pump and the high-pressure fuel pump can be tested with the CDS. The FSM harness connector is on the port side of the engine, near the charge air cooler.

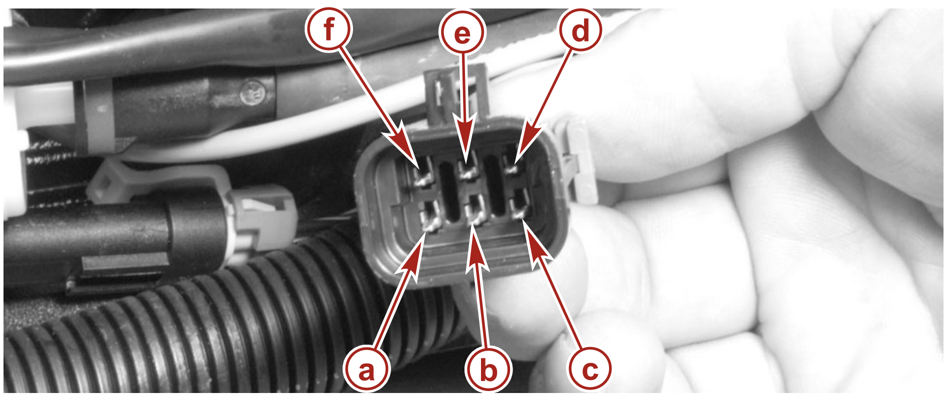


13544

a - Charge air cooler
b - Vent canister switch
c - FSM harness connector

Computer Diagnostic System (CDS)	Order through SPX

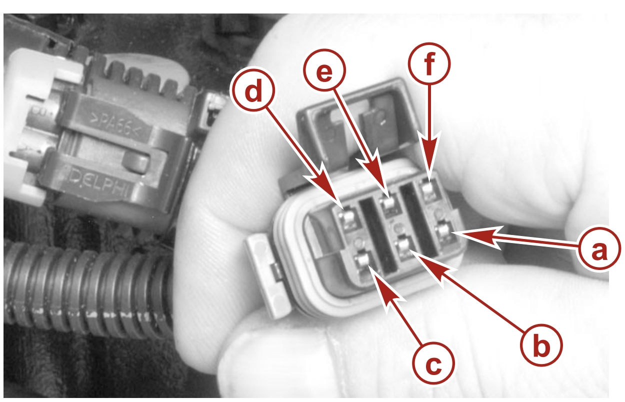
The following graphics show the FSM wire color - pin location and its purpose.



13653

FSM harness connector

a - Pin A, red wire, positive to high-pressure fuel pump
b - Pin B, orange wire, positive to fuel lift pump
c - Pin C, blue wire, ground to fuel float level switch
d - Pin D, black wire, ground to high-pressure fuel pump
e - Pin E, brown wire, ground to fuel lift pump
f - Pin F, purple wire, positive 5 V to fuel float level switch



13656

FSM engine harness connector

a - Pin A, red/pink wire, positive to high-pressure fuel pump
b - Pin B, red/pink wire, positive to fuel lift pump
c - Pin C, blue/yellow wire, fuel float level switch ground inside PCM
d - Pin D, black wire, ground to high-pressure fuel pump
e - Pin E, pink/black wire, fuel lift pump ground inside PCM
f - Pin F, purple/yellow wire, positive 5 V to fuel float level switch from PCM

Electronic Throttle Control (ETC)

The ETC is controlled through the PCM. The PCM receives information from the helm, based on the position of the throttle control handle/foot throttle. This information is sent to the PCM and the PCM activates the ETC motor to open or close the throttle valve. The two throttle valve position sensors in the ETC are also monitored by the PCM.

The ETC functions as an idle air control (IAC) valve. During hard deceleration, the ETC will remain open slightly until the engine RPM has stabilized, to eliminate engine stalling.

A built in fail-safe is designed into the ETC. The ETC is spring-loaded to an off idle position to maintain engine RPM at approximately 1200 RPM in gear.

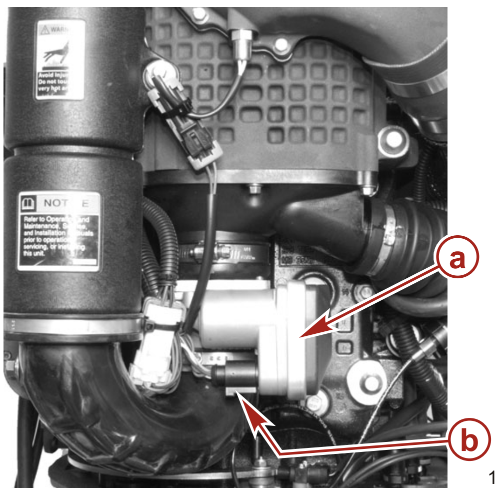
The ETC can be tested with the CDS.

Computer Diagnostic System (CDS)	Order through SPX

The following step will assist you in determining if the failure is electrical or mechanical. Use the DMT 2004 digital multimeter to check for continuity or resistance.

DMT 2004 Digital Multimeter	91-892647A01

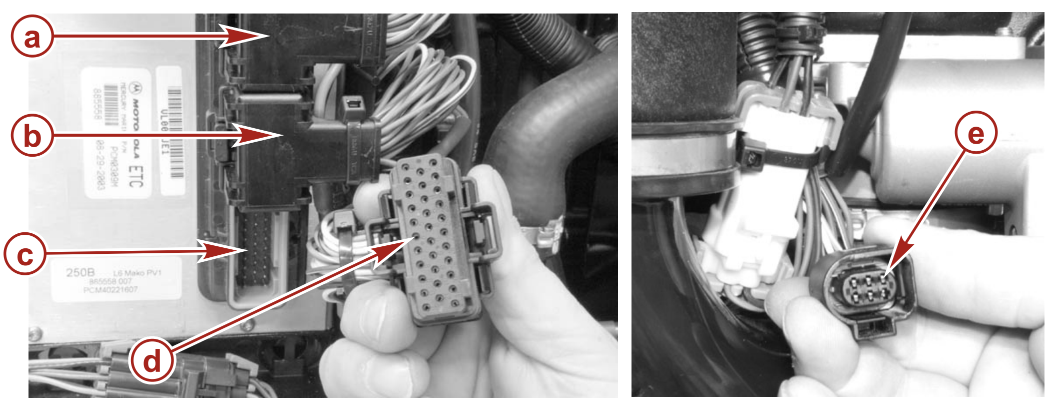
1. Disconnect the ETC harness connector from the ETC.



13618

a - ETC
b - ETC harness connector

2. Remove the electrical box cover.
3. Remove engine harness connector A at the PCM.
4. Check for continuity between ETC harness connector, pin #1 and engine harness connector A, pin #6.

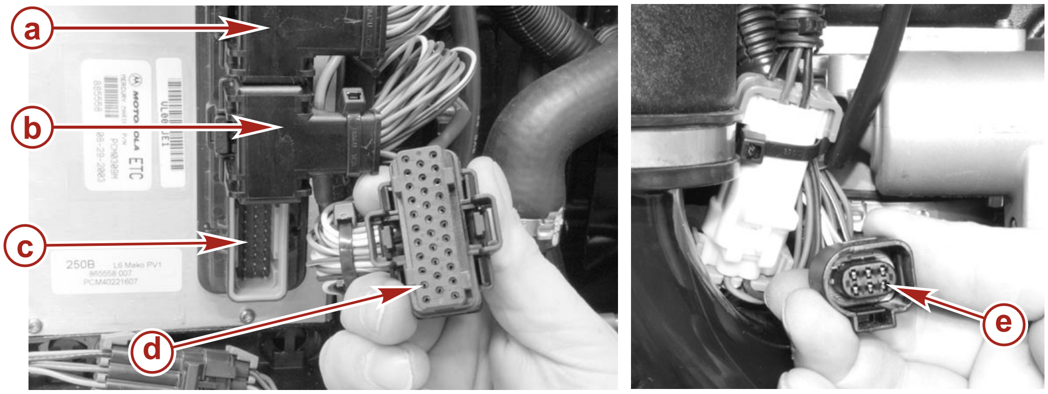


14492

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector A, pin #6
e - ETC harness connector, pin #1

5. If no continuity is found or there is high resistance, the engine harness must be replaced.
6. Check for continuity between ETC harness connector, pin #2 and engine harness connector A, pin #10.
7. If no continuity is found or there is high resistance, check the vent canister switch (VCS). The VCS is normally closed.

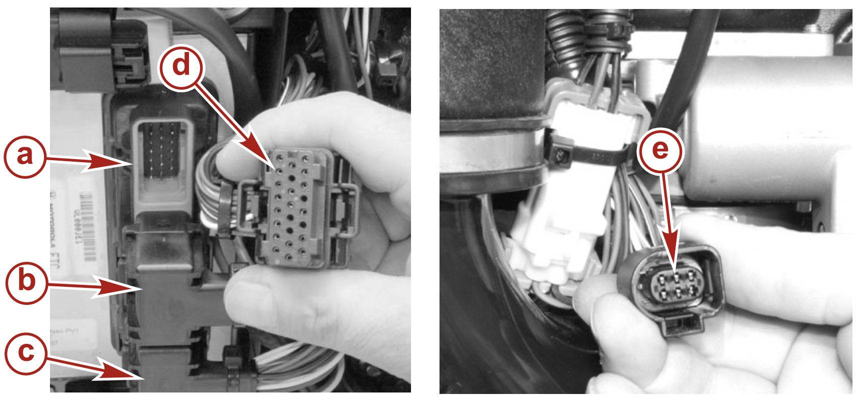
8. If the VCS is closed and no continuity or high resistance is found, the engine harness must be replaced.



14494

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector A, pin #10
e - ETC harness connector, pin #2

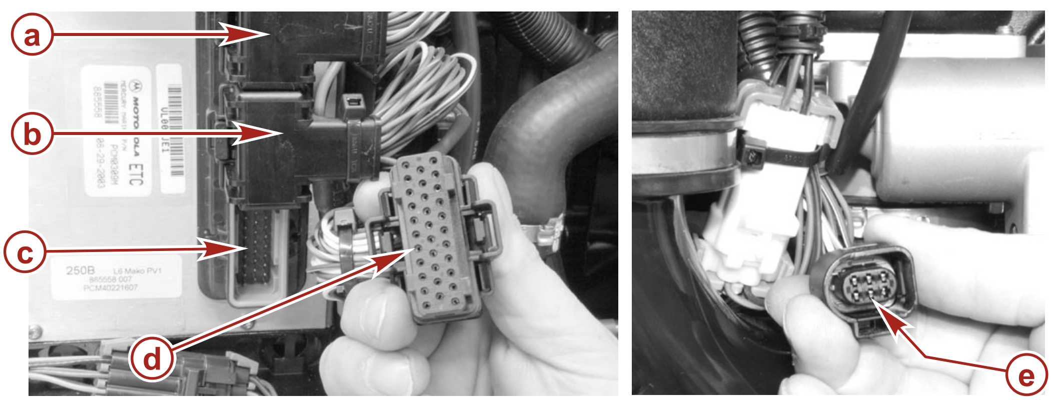
9. Remove engine harness connector C at the PCM.
10. Check for continuity between ETC harness connector, pin #3 and engine harness connector C, pin #2.



14497

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector C, pin #2
e - ETC harness connector, pin #3

11. If no continuity is found or there is high resistance, the engine harness must be replaced.
12. Check for continuity between ETC harness connector, pin #4 and engine harness connector A, pin #7.

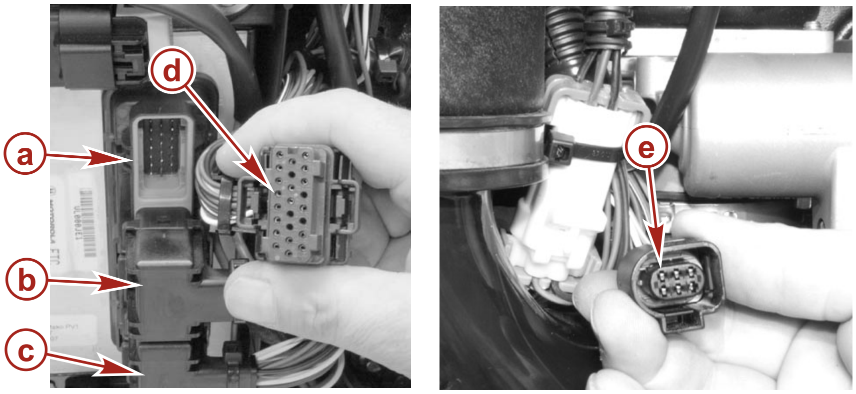


14499

a - Engine harness connector C
b - Engine harness connector B
c - Engine harness connector A
d - Engine harness connector A, pin #7
e - ETC harness connector, pin #4

13. If no continuity is found or there is high resistance, the engine harness must be replaced.

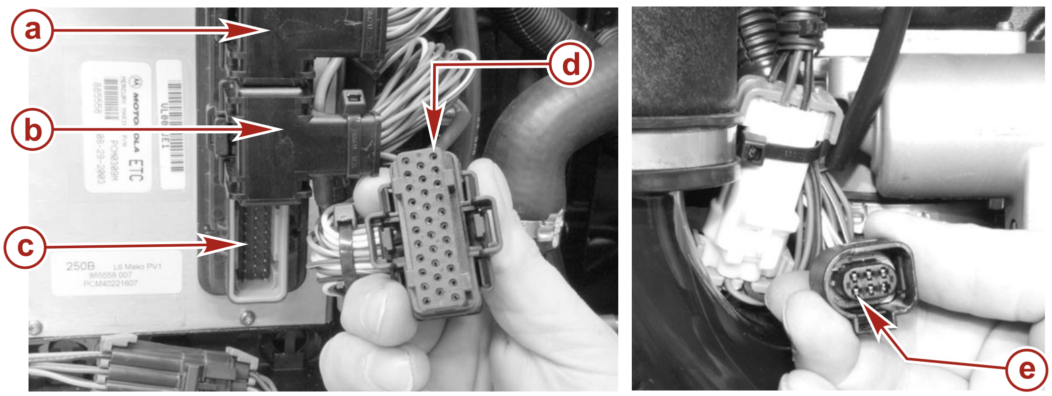
14. Check for continuity between ETC harness connector, pin #5 and engine harness connector C, pin #4.



14498

- **a -** Engine harness connector C
- **b -** Engine harness connector B
- **c -** Engine harness connector A
- **d -** Engine harness connector C, pin #4
- **e -** ETC harness connector, pin #5

15. If no continuity is found or there is high resistance, the engine harness must be replaced.
16. Check for continuity between ETC harness connector, pin #6 and engine harness connector A, pin #22. This connection is a positive 5 V reference circuit from the PCM.



14500

- **a -** Engine harness connector C
- **b -** Engine harness connector B
- **c -** Engine harness connector A
- **d -** Engine harness connector A, pin #22
- **e -** ETC harness connector, pin #6

17. If no continuity is found, there are multiple connections throughout the engine harness for this 5 V reference circuit. Refer to the wire diagrams to trace the wire harness.
18. If the pin continuity checks are good, the failure is mechanical.

Electronic Boost Control (EBC)

The EBC is controlled through the PCM. The PCM receives data from several sensors to help determine the amount of boost needed for the engine to perform efficiently. The PCM activates the EBC valve motor to close or open. The EBC valve is normally open.

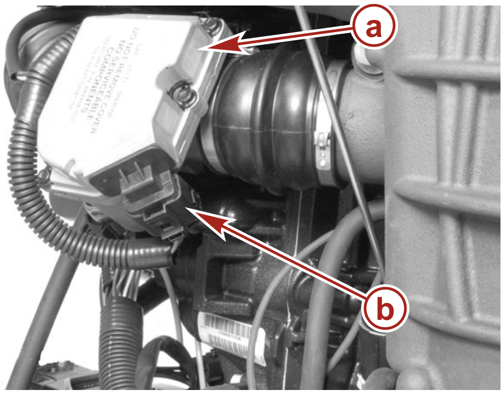
The EBC can be tested with the computer diagnostic system (CDS).

Computer Diagnostic System (CDS)	Order through SPX

The following steps will assist you in determining if the failure is electrical or mechanical. Use the DMT 2004 digital multimeter to check for continuity or resistance.

DMT 2004 Digital Multimeter	91-892647A01

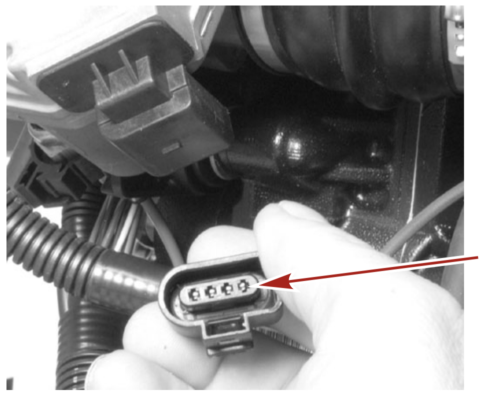
1. Remove the harness connector at the EBC.



13660

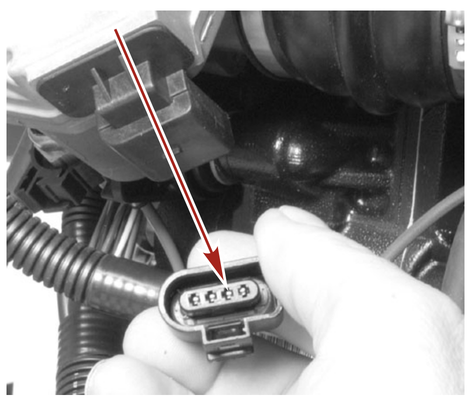
a - EBC
b - EBC engine harness connector

2. Check for continuity between the #1 pin and engine ground.



13663

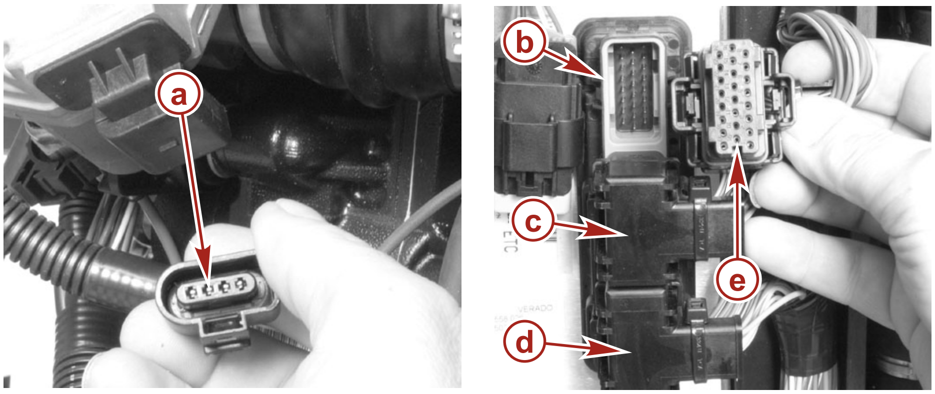
3. If continuity is not found or high resistance is present, the engine harness must be checked to determine if the harness is at fault or if there is a poor ground connection to the cylinder block. Refer to the wire diagrams to trace the wire harness and check the ground locations.
4. Connect the positive voltmeter lead to pin #2 and the negative voltmeter lead to a known good engine ground.
5. Turn the ignition key on. The main power relay (MPR) should be activated. Battery voltage should be at the #2 pin.



13664

6. If you have no voltage and the MPR did not activate, check the MPR fuse.
7. If the MPR activated and there is no battery voltage, a continuity test of the engine wire harness must be completed to determine the location of the open connection. Refer to the wire diagrams to trace the wire harness to the MPR.
8. Disconnect engine harness C at the PCM.

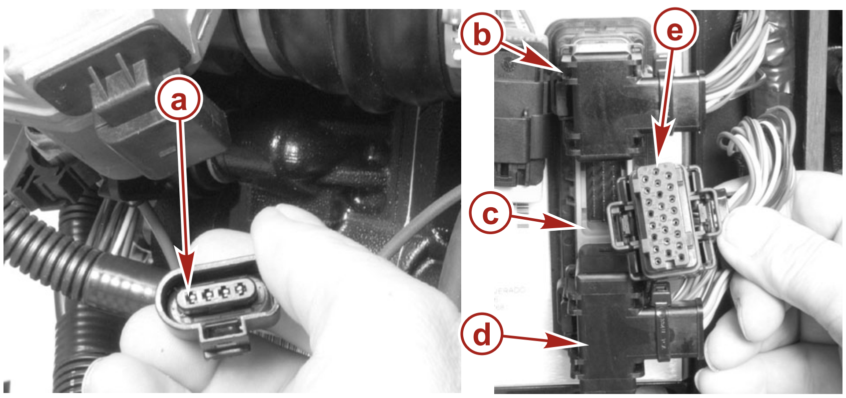
9. Check for continuity between EBC harness connector, pin #3 and engine harness connector C, pin #9. An open circuit indicates a repair or replacement of the engine harness is required.



13669

- **a -** EBC harness connector, pin #3
- **b -** Engine harness connector C
- **c -** Engine harness connector B
- **d -** Engine harness connector A
- **e -** Engine harness connector C, pin #9

10. Connect engine harness C to the PCM.
11. Disconnect engine harness B at the PCM.
12. Check the continuity between EBC harness connector, pin #4 and engine harness connector B, pin #16. An open circuit indicates a repair or replacement of the engine harness is required.



13672

- **a -** EBC harness connector, pin #4
- **b -** Engine harness connector C
- **c -** Engine harness connector B
- **d -** Engine harness connector A
- **e -** Engine harness connector B, pin #16

13. Connect engine harness connector B to the PCM. If no problems were found with the wire harness, the failure is mechanical.

Fuel System

Section 3C - Service Procedures

Table of Contents

3
C

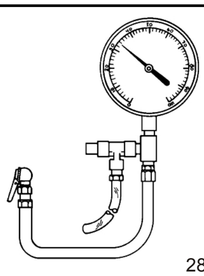
Fuel System Specifications

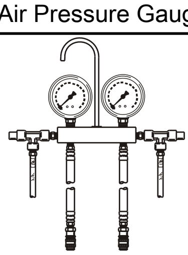
Fuel System Specifications	
Type of fuel	Automotive unleaded with a minimum pump posted octane rating of 87 (90 RON)
Approximate fuel pressure at idle	281–345 kPa (41–50 psi)
Fuel filtration	
Fuel inlet water separator	2 microns
High pressure	20 microns

Lubricant, Sealant, Adhesives

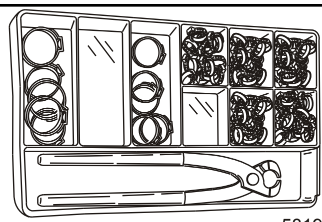
Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Oil pressure sensor threads	92-809822
66	Loctite 242 Threadlocker	FSM cover bolts	92-809821
		FSM mounting bolt threads	
		FSM shroud mounting bolt threads	
136	Lubriplate SPO 255	Fuel injector O-ring	Obtain Locally
		Schrader valve O-rings	
		Fuel inlet tube O-ring	
		Fuel injector O-ring, fuel damper O-ring	

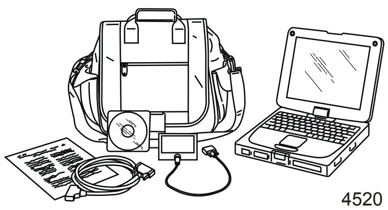
Special Tools

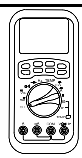
Fuel Pressure Gauge Kit	91-881833A03
 2807	Tests the fuel pump pressure; can be used to relieve fuel pressure.

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.

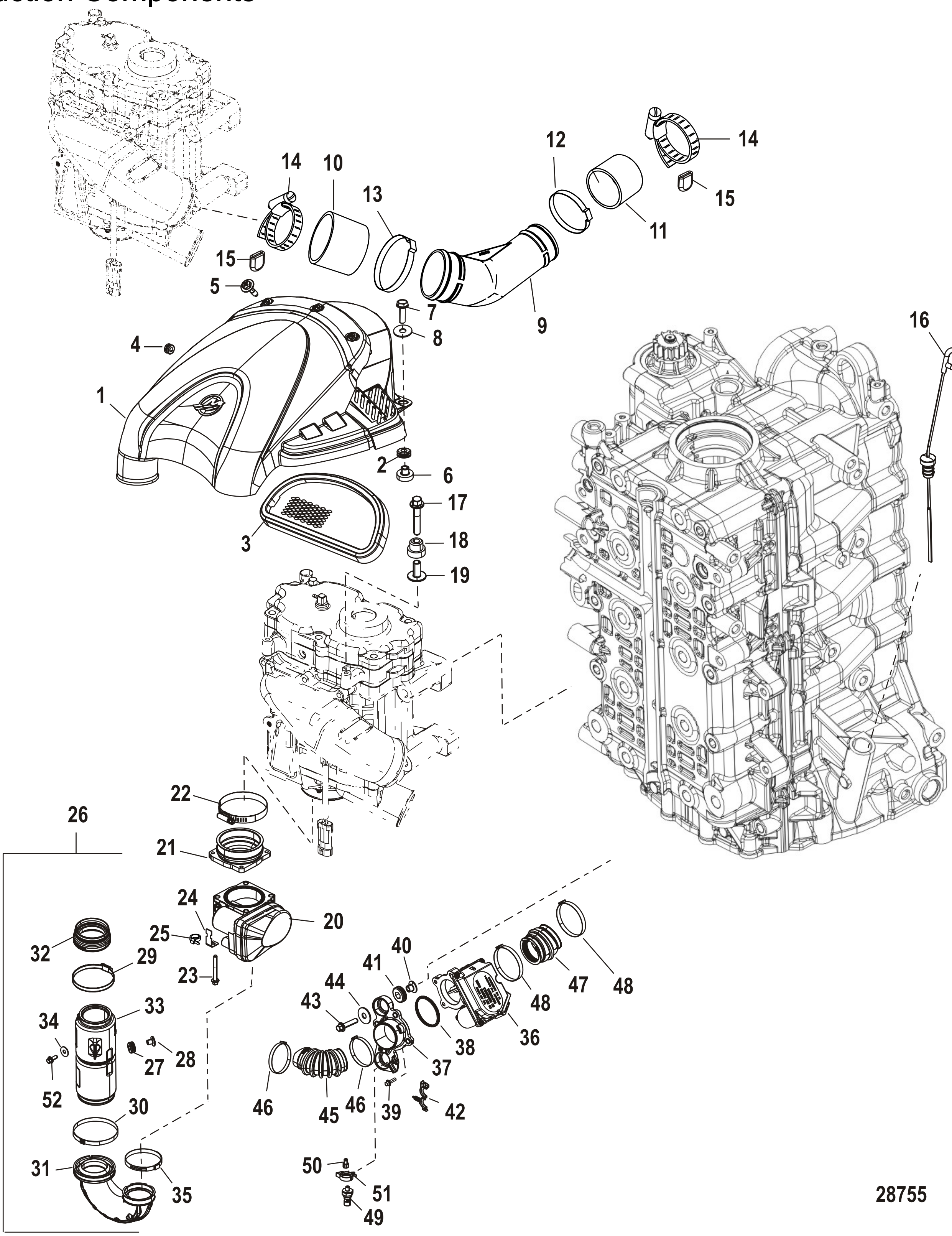
Digital Pressure Meter	91-892651A01
 5786	Connects to the fuel system/manifold and can be used in conjunction with Computer Diagnostic System (CDS).

Hose Clamp Tool Kit	91-803146A2
 5819	Aids in the installation of high pressure (Oetiker ®) hose clamps.

Computer Diagnostic System (CDS)	Order through SPX
 4520	Monitors all electrical systems for proper function, diagnostics, and calibration purposes. For additional information, pricing, or to order the Computer Diagnostic System contact: SPX Corporation 28635 Mound Rd. Warren, MI 48092 or call: USA - 1-800-345-2233 Canada - 800-345-2233 Europe - 49 6182 959 149 Australia - (03) 9544-6222

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.

Induction Components

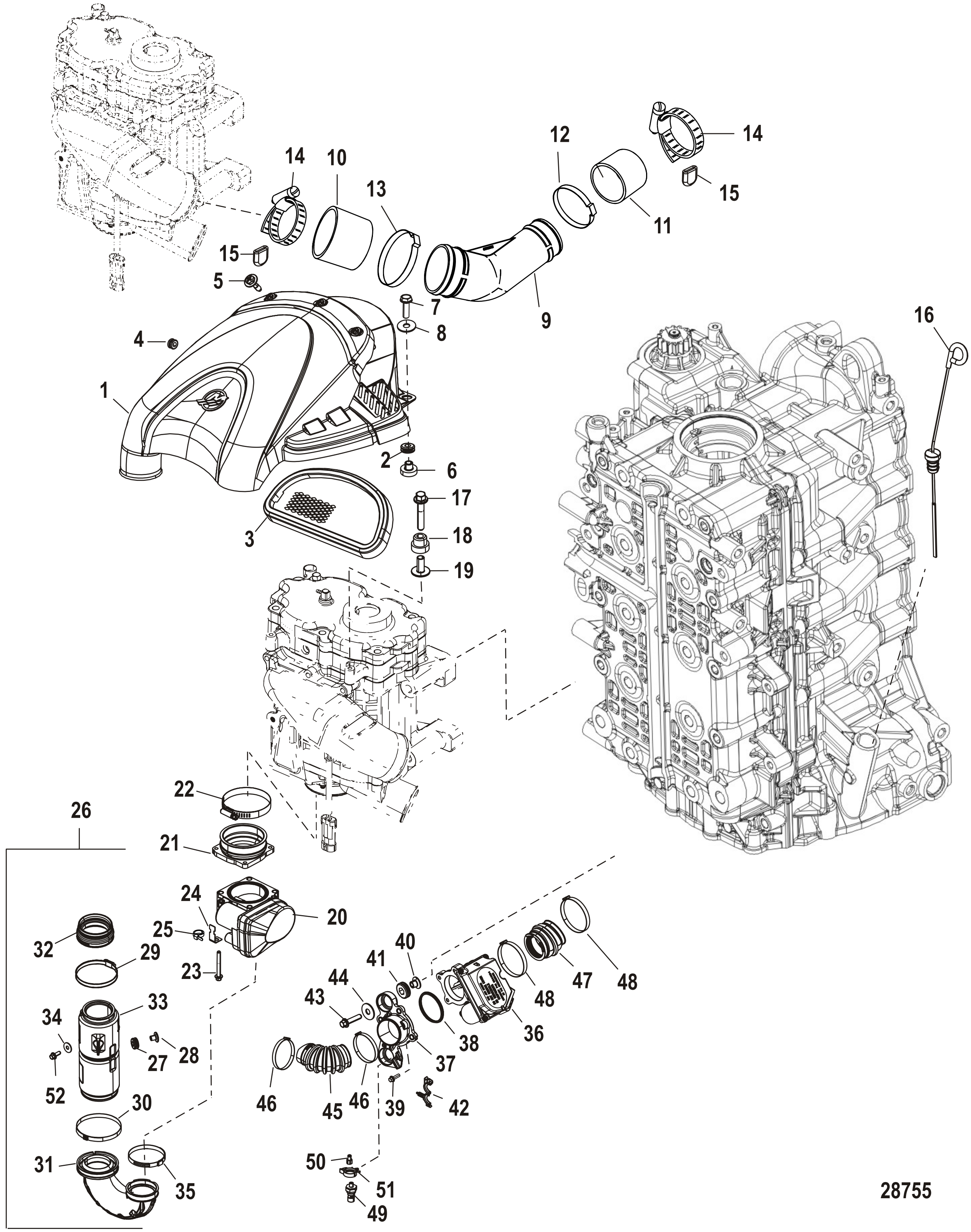


Induction Components

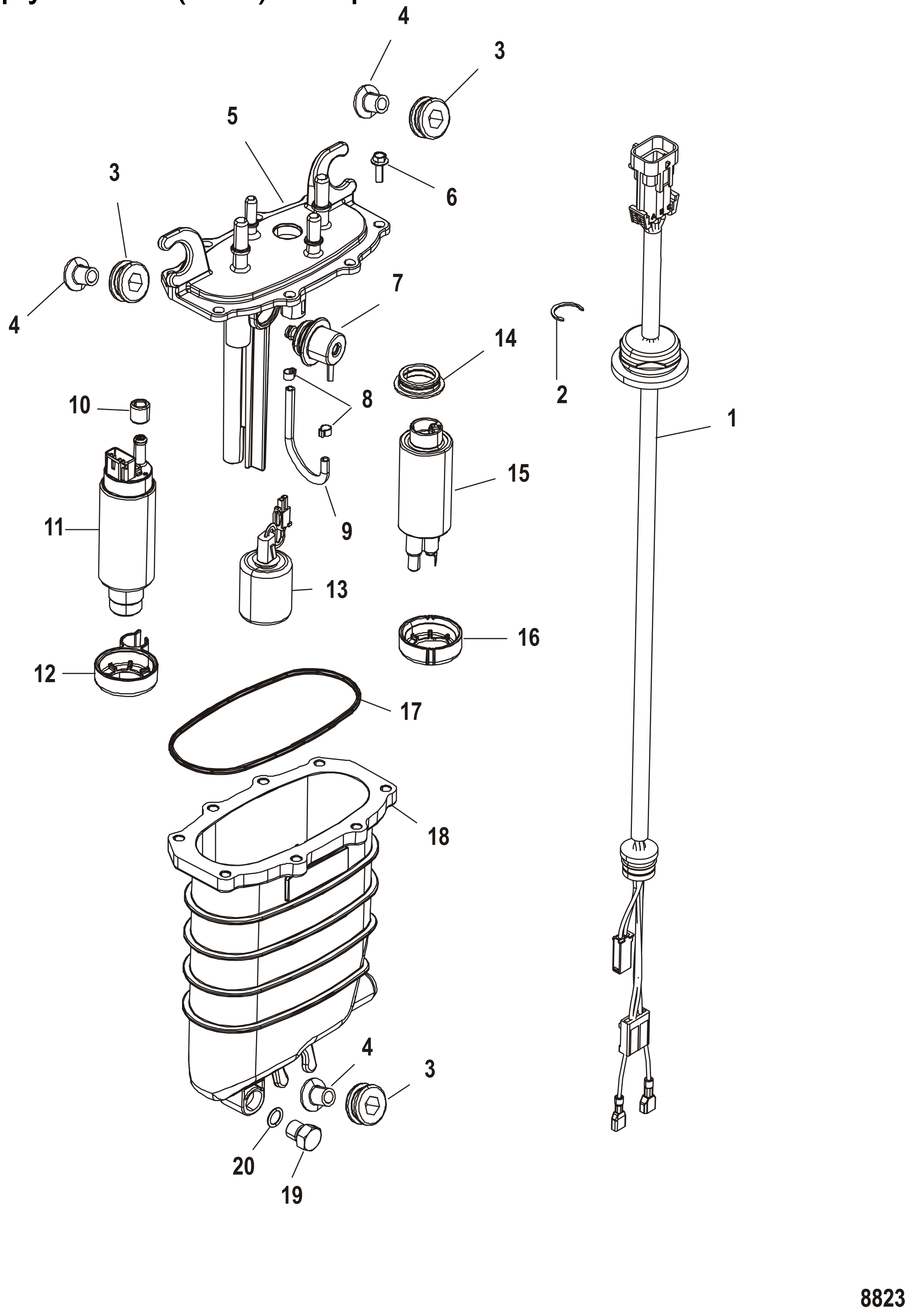
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Intake assembly (upper)			
2	2	Grommet			
3	1	Filter			
4	1	Fuel vent grommet			
5	3	Screw	6	53	
6	2	Bushing			
7	2	Bolt (M6 x 25)	8	71	
8	2	Washer			
9	1	Outlet tube			
10	1	Hose (65 mm inside diameter)			
11	1	Hose (60 mm inside diameter)			
12	2	Oetiker clamp (77 mm)			
13	1	Oetiker clamp (71 mm)			
14	2	Hose clamp	6.2	55	
15	2	Hose clamp cover			
16	1	Dipstick			
17	1	Bolt (M6 x 20)	8	71	
18	1	Grommet			
19	1	Bushing			
20	1	Electronic throttle control (ETC)			
21	1	Isolator			
22	1	Clamp	6.2	55	
23	4	Bolt (M6 x 50)	11	97	
24	2	Bracket			
25	AR	Cable tie			
26	1	Intake assembly (lower)			
27	1	Grommet			
28	1	Bushing			
29	1	Oetiker clamp (84.5 mm)			
30	1	Oetiker clamp (96.5 mm)			
31	1	Inlet duct			
32	1	Coupler			
33	1	Resonator			
34	1	Washer			
35	1	Oetiker clamp (75.5 mm)			
36	1	Electronic boost control (EBC)			
37	1	EBC mount plate			
38	1	O-ring			
39	4	Screw (M6 x 20)	12	106	
40	2	Bushing			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
41	2	Grommet			
42	1	Clip			
43	2	Bolt (M8 x 35)	24		18
44	2	Washer			
45	1	Hose			
46	2	Oetiker clamp (57.5 mm)			
47	1	Tube			
48	2	Oetiker clamp (62 mm)			
49	1	Pitot sensor			
50	1	Adapter fitting			
51	1	Clip			
52	1	Screw (M6 x 25)	7.5	66	

Induction Components



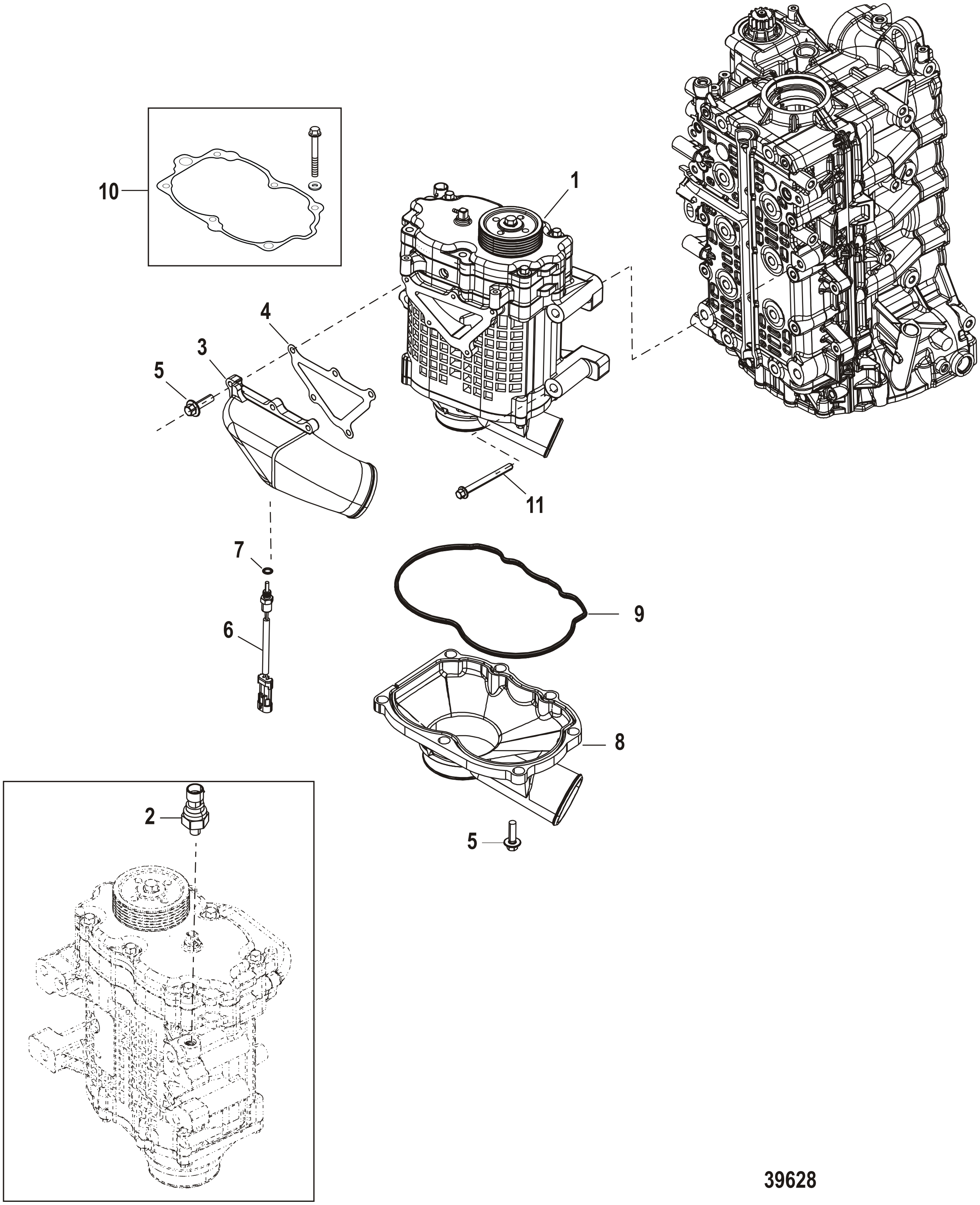
Fuel Supply Module (FSM) Components



Fuel Supply Module (FSM) Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Harness			
2	1	Clip			
3	3	Grommet			
4	3	Bushing			
5	1	Cover			
6	8	Bolt (M5 x 16 flange head)	5	45	
7	1	Regulator with O-ring			
8	2	Clamp			
9	1	Hose			
10	1	Seal			
11	1	High-pressure fuel pump			
12	1	Seal			
13	1	Float			
14	1	Seal			
15	1	Fuel lift pump			
16	1	Isolator			
17	1	Seal			
18	1	Housing			
19	1	Plug	5.7	50	
20	1	O-ring			

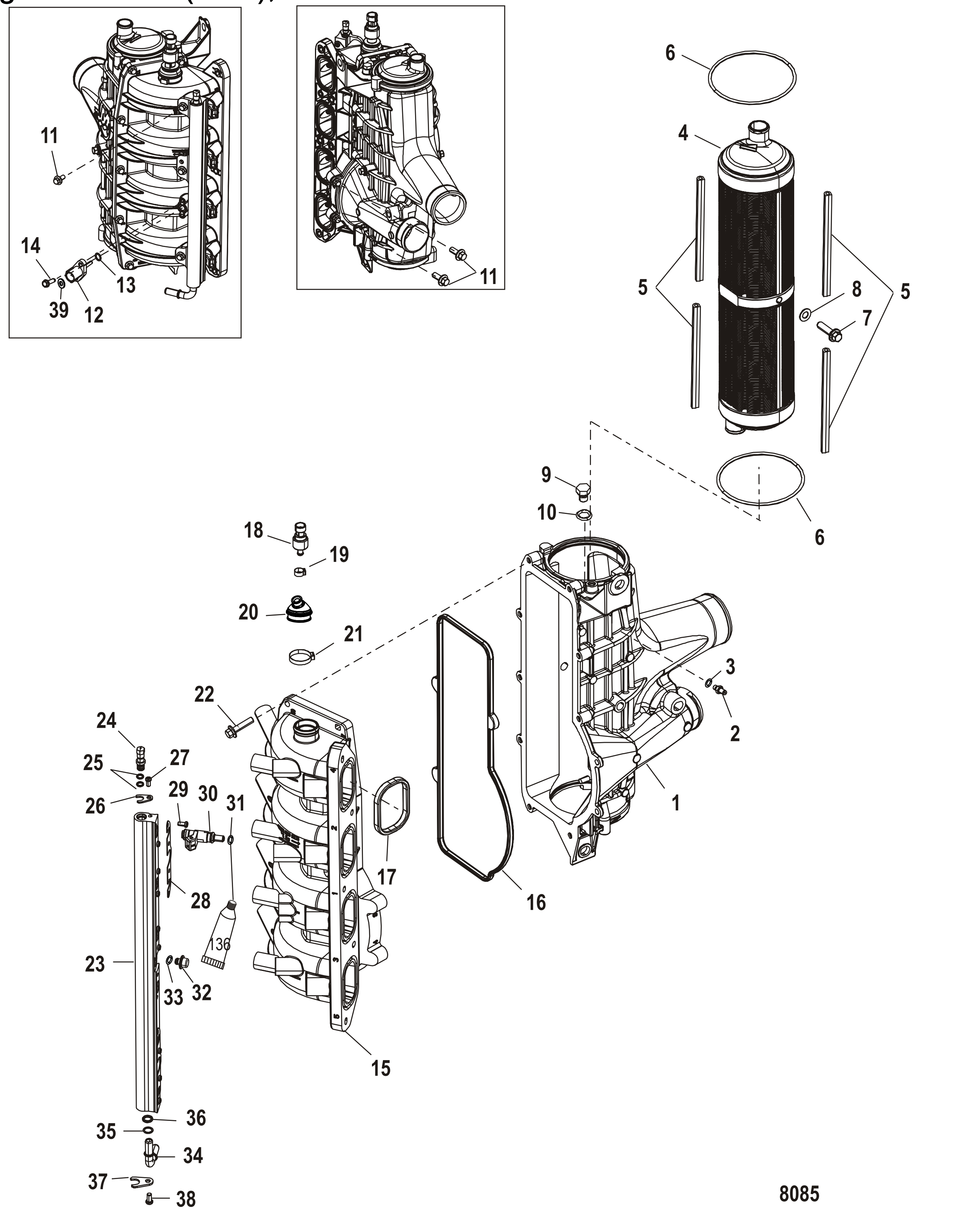
Supercharger Components



Supercharger Components

Ref. No.	Qty.	Description		Torque Nm	Torque lb-in.	Torque lb-ft
1	1	Supercharger				
2	1	Oil pressure sensor		15	133	
3	1	Outlet duct				
4	1	Gasket				
5	9	Bolt		8	71	
6	1	Temperature sensor		15	133	
7	1	O-ring				
8	1	Inlet duct				
9	1	Seal				
10	1	Bushing/gasket kit				
11	4	Bolt (M10 x 105)	First torque	15	133	
			Final torque	43		32

Charge Air Cooler (CAC), Intake Manifold

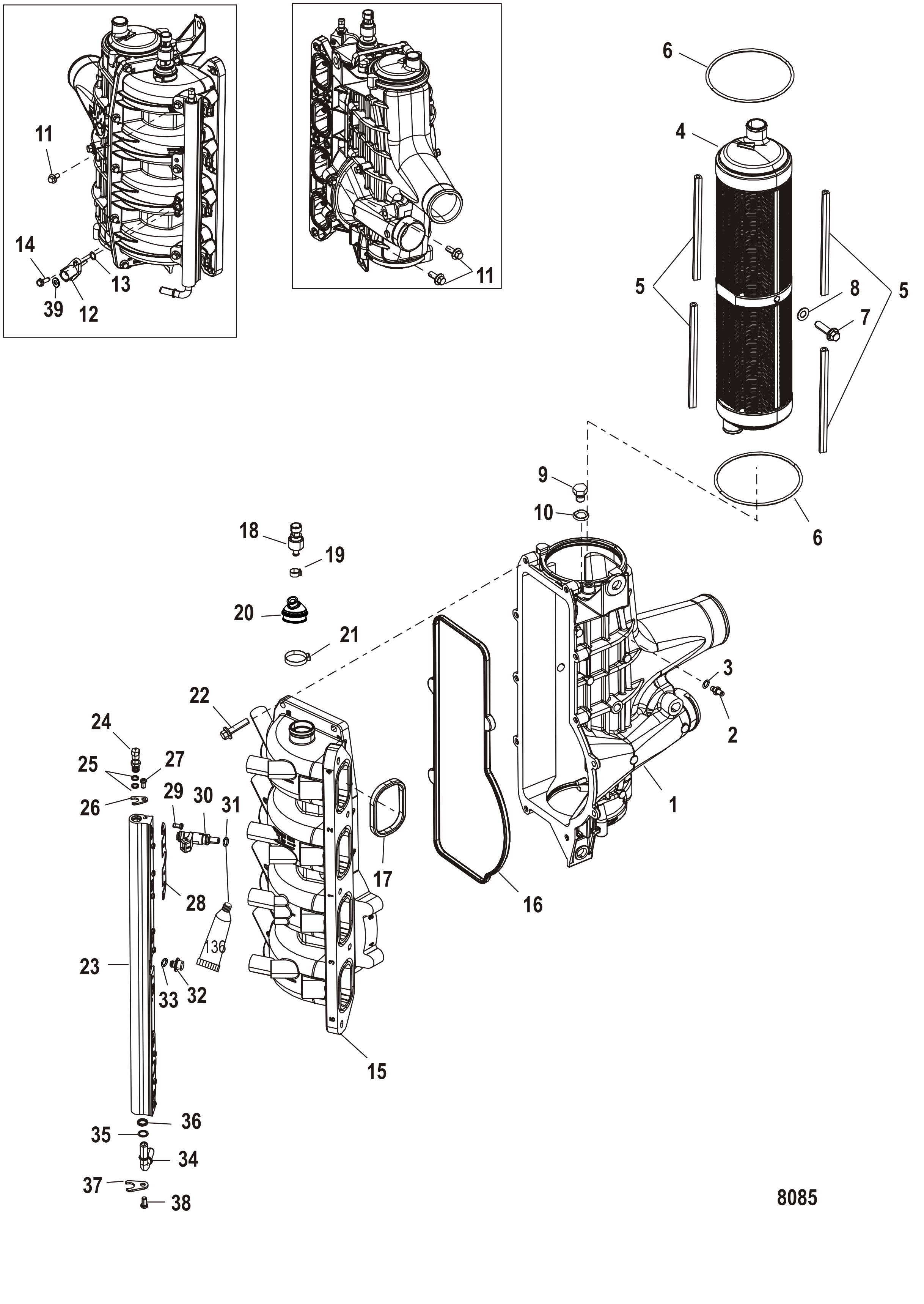


Charge Air Cooler (CAC), Intake Manifold

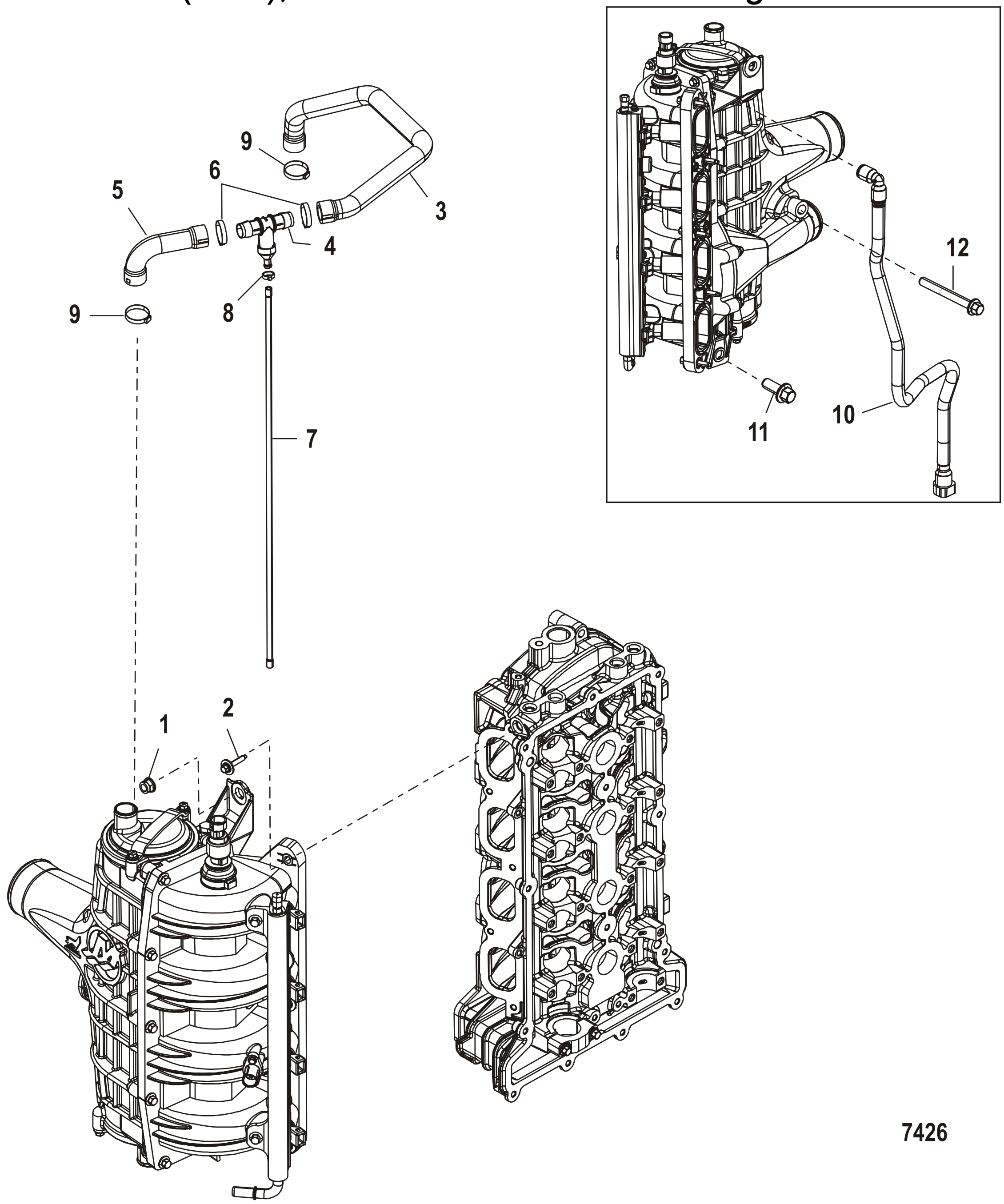
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	CAC assembly			
2	1	Fitting			
3	1	O-ring			
4	1	Stack assembly			
5	2	Seal kit			
6	2	O-ring			
7	4	Bolt (M6 x 18)	12	106	
8	2	Washer			
9	1	Fitting			
10	1	O-ring			
11	5	Bolt (M6 x 15)	7	62	
12	1	Manifold air temperature (MAT) sensor			
13	1	O-ring			
14	2	Screw (M4 x 16)	2	17.7	
15	1	Intake manifold assembly			
16	1	Seal			
17	4	Seal			
18	1	Manifold absolute pressure (MAP) sensor			
19	1	Oetiker clamp (15.7 mm)			
20	1	Boot			
21	1	Oetiker clamp (36.1 mm)			
22	9	Bolt (M6 x 25)	7	62	
23	1	Fuel rail			
24	1	Schrader valve			
25	2	O-ring			
26	1	Bracket			
27	1	Screw (M5 x 10)	6	53	
28	1	Bracket			
29	12	Screw (M5 x 10)	6	53	
30	4	Fuel injector			
31	4	O-ring			
32	1	Damper			
33	1	O-ring			
34	1	Fuel inlet tube			
35	1	Washer			
36	1	O-ring			
37	1	Bracket			
38	1	Screw (M5 x 10)	6	53	
39	1	Gasket			

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Fuel injector O-ring	Obtain Locally

Charge Air Cooler (CAC), Intake Manifold



Charge Air Cooler (CAC), Intake Manifold Hose Routing



Charge Air Cooler (CAC), Intake Manifold Hose Routing

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Nut (M10)	32.5		24
2	5	Bolt with washer	10	89	
3	1	Hose			
4	1	Flushing assembly fitting			
5	1	Hose			
6	2	Clamp (34.6 mm)			
7	1	Hose			
8	1	Cable tie			
9	2	Clamp (34.6 mm)			
10	1	Manifold reference hose			
11	1	Bolt (M10 x 30)	32.5		24
12	1	Bolt (M10 x 65)	32.5		24

Fuel Supply Module (FSM)

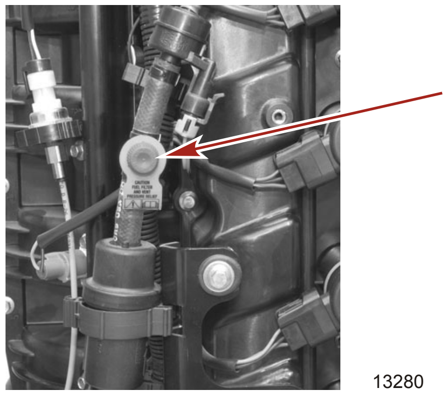
Fuel Supply Module (FSM) Removal

1. Disconnect the battery cables from the battery.
2. Remove the top cowl, lower chaps. Refer to **Section 4A - Cowling Removal**.

⚠ CAUTION

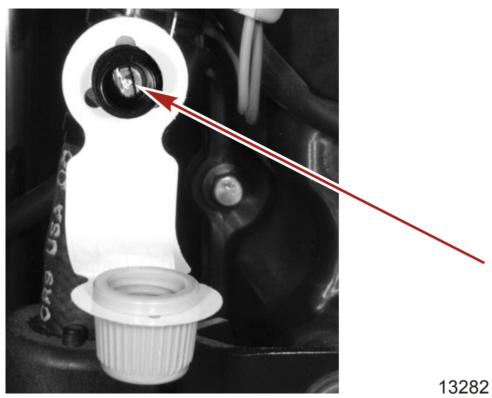
Failure to release pressure from the fuel system will result in fuel spraying out, which can cause a fire or explosion. Allow the engine to cool completely and release all fuel pressure before servicing any part of the fuel system. Always protect eyes and skin from pressurized fuel and vapors.

3. Remove the green cap to access the pressure relief valve for the FSM.



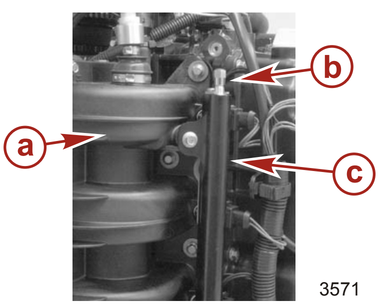
13280

4. Place a rag over the valve and press on the center of the valve to relieve any pressure inside the FSM.



13282

5. Attach a fuel pressure gauge to the fuel pressure valve on the fuel rail. Relieve the fuel pressure into an appropriate container.



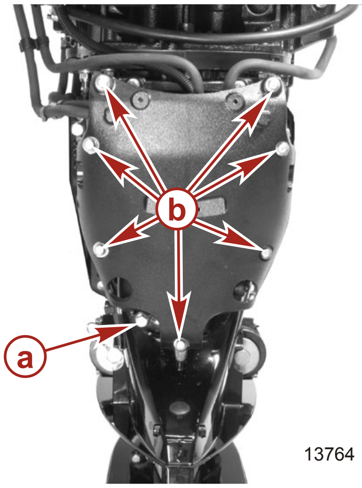
3571

a - Intake manifold
b - Fuel pressure valve
c - Fuel rail

Fuel Pressure Gauge Kit	91-881833A03
Dual Fuel/Air Pressure Gauge Kit	91-881834A 1
Digital Pressure Meter	91-892651A01

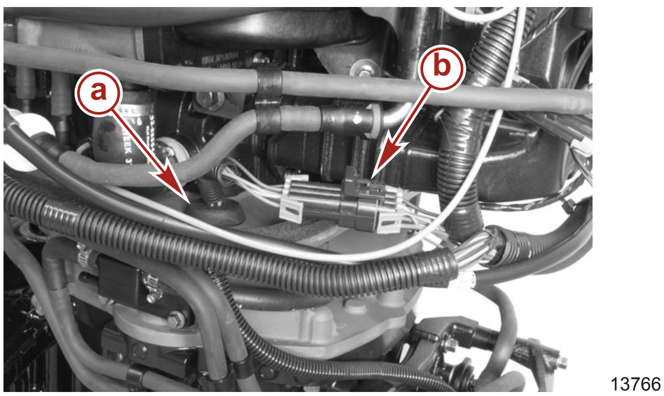
6. Remove seven bolts securing the FSM shroud to the driveshaft housing.

7. Remove the FSM plug and capture draining fuel into an appropriate container.



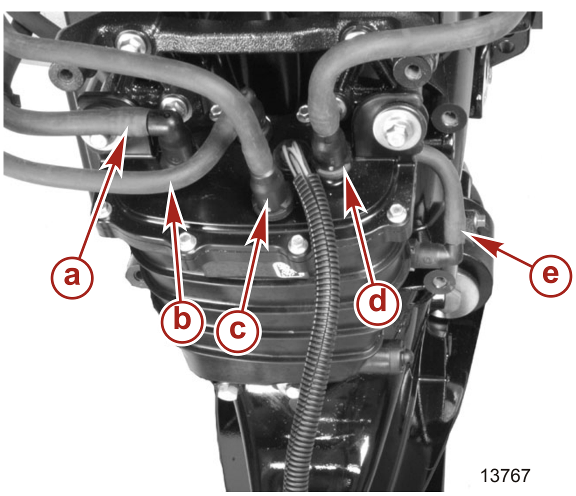
a - FSM plug
b - Bolts securing shroud

8. Disconnect the FSM harness from the engine harness.
9. Push the FSM harness grommet through the adapter plate.



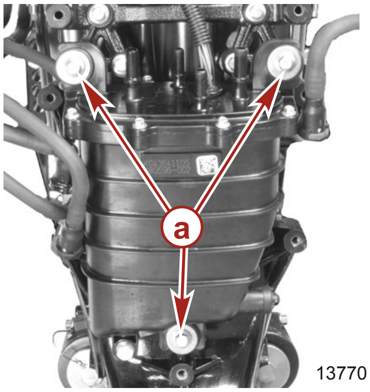
a - FSM harness grommet
b - FSM harness connector

10. Disconnect the fuel cooler line.
11. Disconnect the vent canister line.
12. Disconnect the fuel in line. Capture any fuel leaking from fuel line.
13. Disconnect the high-pressure fuel out line. Capture any fuel leaking from fuel line.
14. Disconnect the manifold reference line.



a - High-pressure fuel out line (10 mm red tab)
b - Manifold reference line (8 mm white tab)
c - Vent canister line (0.375 in. blue tab)
d - Fuel in line (10 mm red tab)
e - Fuel cooler line (8 mm blue tab)

15. Remove three bolts securing the FSM to the driveshaft housing.

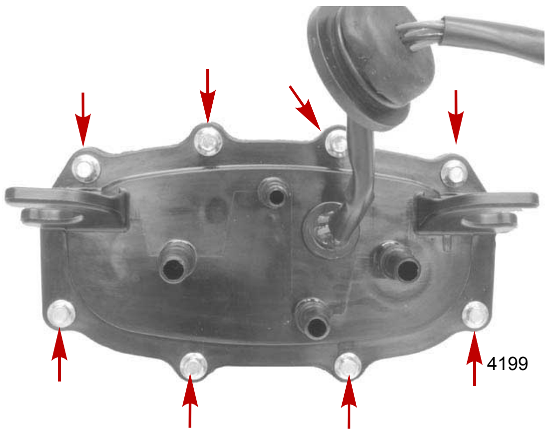


a - Bolts securing FSM (3)

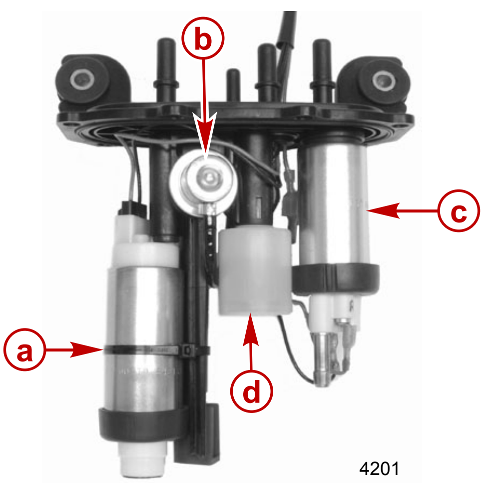
Fuel Supply Module Disassembly and Inspection

FSM Disassembly

1. Remove the bolts securing the FSM cover to the FSM housing. Remove the FSM cover.



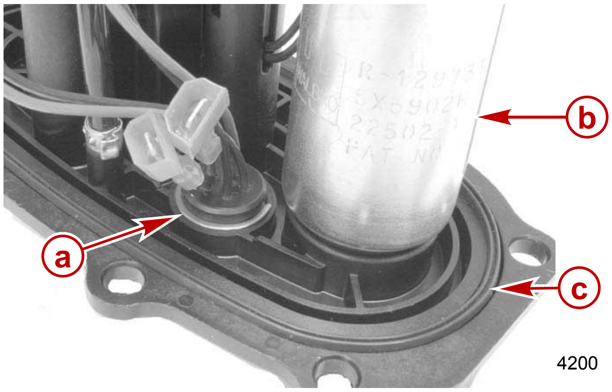
2. Cut cable tie securing fuel pump.
3. Disconnect the fuel lift pump, high-pressure fuel pump, and float switch from the FSM wire harness.



a - Cable tie securing high-pressure fuel pump
b - Fuel pressure regulator
c - Fuel lift pump
d - Float switch

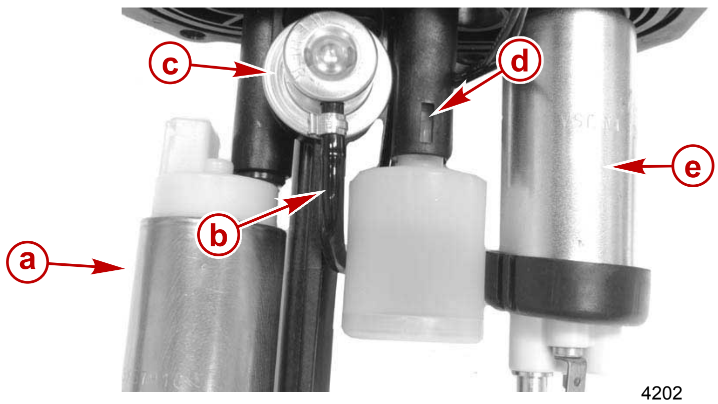
4. Remove the FSM cover gasket.

5. Remove the clip securing the FSM wire harness to the FSM cover. Remove the FSM wire harness from the FSM cover.



a - FSM wire harness clip
b - Fuel lift pump
c - FSM cover gasket

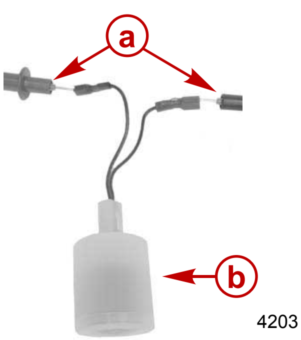
6. Push on the tabs to remove the float switch.
7. Pull on the high-pressure fuel pump to remove the pump from the FSM cover.
8. Pull the fuel lift pump to remove the pump from the FSM cover.
9. Remove the manifold reference hose from the fuel pressure regulator.
10. Pull the fuel pressure regulator off the FSM cover.



a - High-pressure fuel pump
b - Manifold reference hose
c - Fuel pressure regulator
d - Float switch tab
e - Fuel lift pump

FSM Inspection

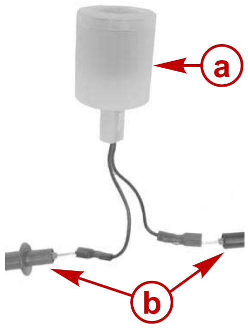
1. Visually check the float switch to ensure fuel has not leaked into the float.
2. Connect an ohmmeter to the float switch wires.
3. With the float switch in a normal operating position, wires facing up, there should be continuity. Replace the float switch if no continuity is found.



Normal operating position
a - Ohmmeter leads
b - Float switch in a normal operating position

Meter Test Leads		Meter Scale	Reading
Red	Black		
Float switch wire	Float switch wire	Ω	Continuity

4. Invert the float switch, wires facing down, there should be no continuity. Replace the float switch if there is continuity.



Inverted operating position

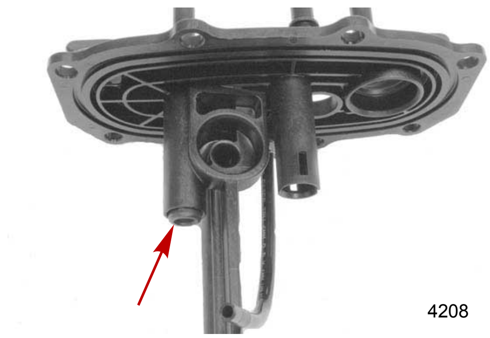
a - Float switch inverted
b - Ohmmeter leads

Meter Test Leads		Meter Scale	Reading
Red	Black		
Float switch wire	Float switch wire	Ω	No continuity

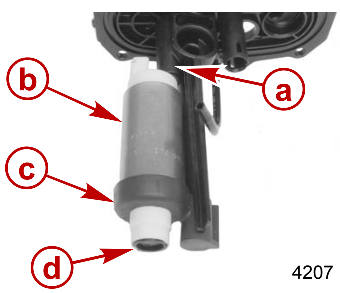
5. Remove the grommets on the high-pressure fuel pump.
6. Remove the grommets and screen on the fuel lift pump.
7. Inspect the screen for debris. Clean as needed.
8. Visually inspect the fuel pressure regulator. Replace the fuel pressure regulator if debris is found on the fuel pressure regulator screen.

Fuel Supply Module Assembly

1. Insert the small grommet into the FSM cover.



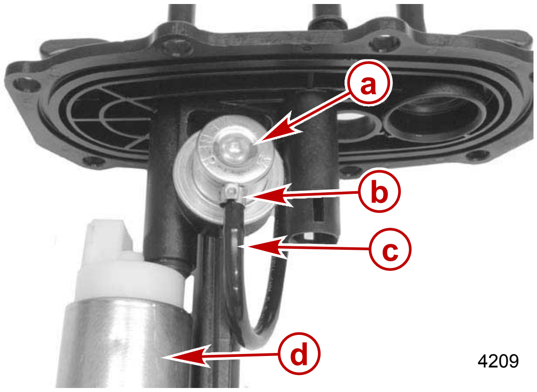
2. Install the high-pressure fuel pump.
3. Ensure the filter on the high-pressure fuel pump is clear of debris.



a - Grommet in FSM cover
b - High-pressure fuel pump
c - Isolator
d - Filter

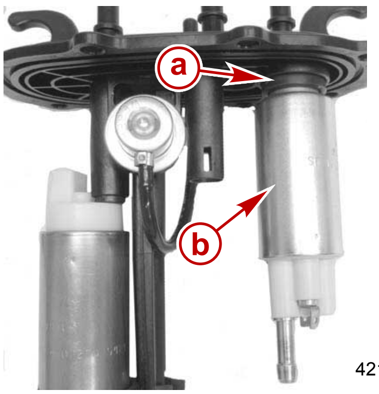
4. Install the fuel pressure regulator onto the FSM cover. Secure the manifold reference hose to the fuel pressure regulator.

NOTE: The fuel pressure regulator O-rings cannot be purchased separately.



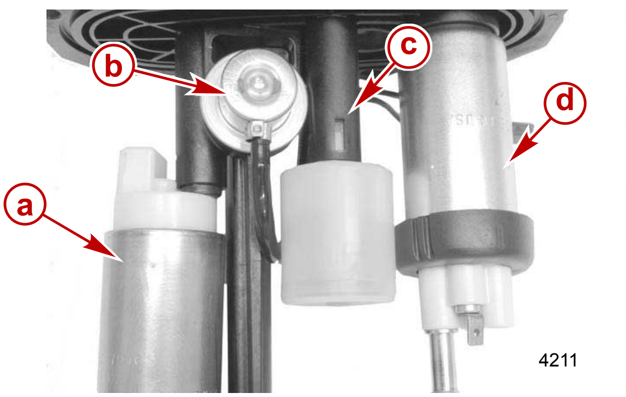
a - Fuel pressure regulator
b - Fuel pressure regulator hose clamp (6.5 mm)
c - Manifold reference hose
d - High-pressure fuel pump

5. Insert the lift pump grommet into the FSM cover.
6. Insert the fuel lift pump into the grommet. Ensure the fuel lift pump is fully seated into the grommet.



a - Fuel lift pump grommet
b - Fuel lift pump

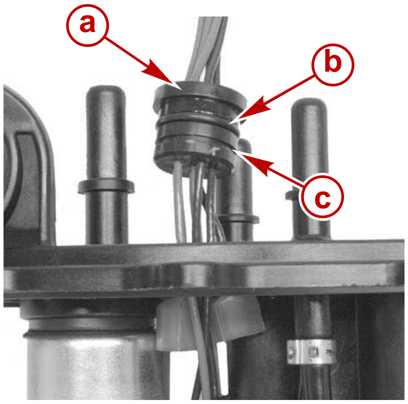
7. Guide the float switch wires into the slot on the FSM cover.
8. Align the float switch tabs with the FSM retaining holes.
9. Push the float switch completely into the FSM cover.



a - High-pressure fuel pump
b - Fuel pressure regulator
c - Float switch tab
d - Fuel lift pump

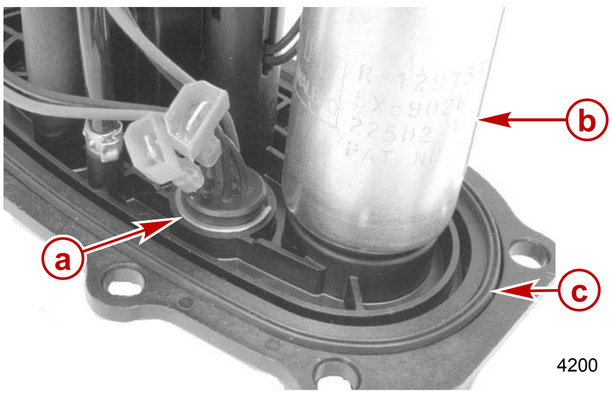
10. Ensure the O-ring on the FSM harness grommet is not damaged.
11. Guide the FSM harness connectors through the FSM cover.

12. Push the FSM harness grommet into the FSM cover until it bottoms out.



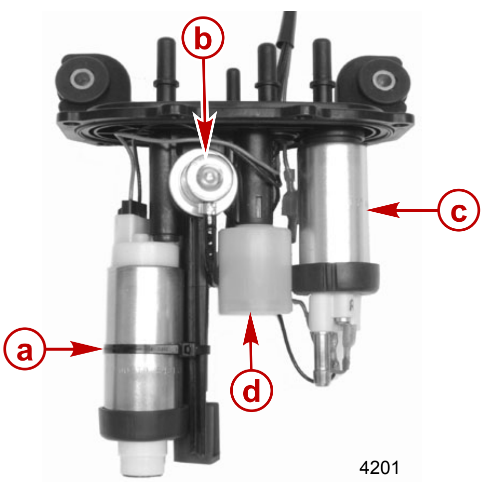
a - FSM harness grommet
b - O-ring
c - Grommet recess for retaining ring

13. Install the FSM harness grommet retaining ring.
14. Connect the high-pressure fuel pump harness.
15. Connect the fuel lift pump harness.
16. Connect the float switch harness.
17. Install the FSM cover gasket.



a - FSM wire harness clip
b - Fuel lift pump
c - FSM cover gasket

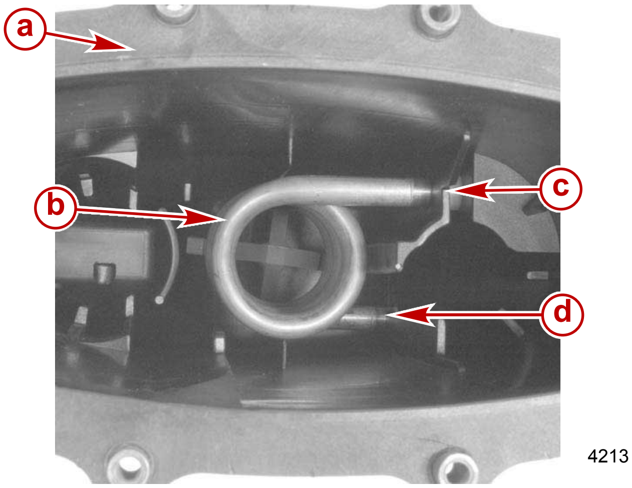
18. Secure fuel pump with a cable tie.



a - Cable tie securing high-pressure fuel pump
b - Fuel pressure regulator
c - Fuel lift pump
d - Float switch

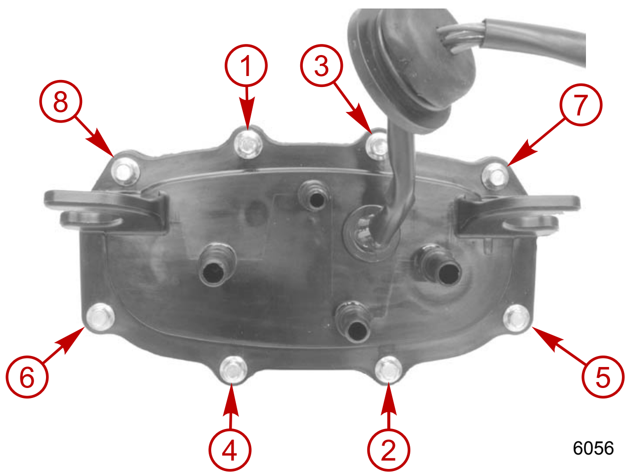
19. Inspect the fuel cooling coil inside the FSM housing for damage.

NOTE: *If damage to the fuel cooling coil is severe enough to cause water flow restriction, or if the coil is suspected of leaking water into the FSM, the fuel supply module housing must be replaced.*



a - FSM housing
b - Fuel cooler
c - Fuel cooler water inlet
d - Fuel cooler water exit

20. Install the FSM cover to the FSM housing.
21. Apply Loctite 242 Threadlocker to the FSM cover bolts.
22. Secure the FSM cover to the FSM housing. Tighten the FSM cover bolts in sequence to the specified torque.



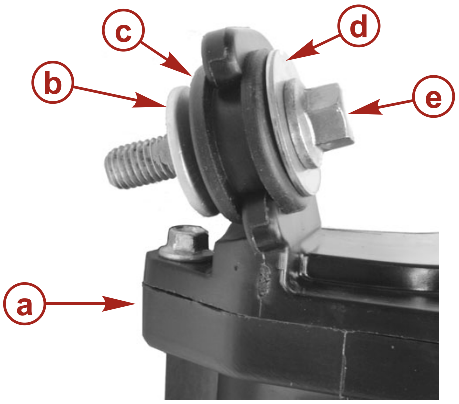
Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	FSM cover bolts	92-809821

Description	Nm	lb-in.	lb-ft
FSM cover bolt (M5 x 16 flange head)	5	45	

Fuel Supply Module (FSM) Installation

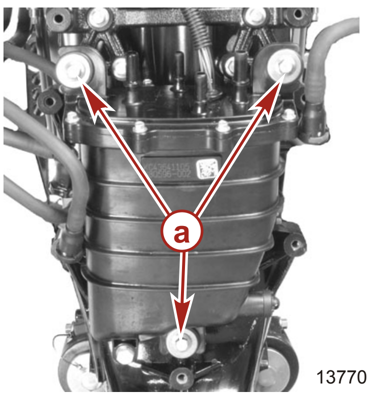
1. Install rubber grommets onto the FSM.
2. Insert bushings from the rear of the FSM, into the rubber grommets.
3. Install washer onto the FSM mounting bolts.

4. Insert FSM bolt/washer into each bushing.



- a - FSM assembly
- b - Bushing
- c - Grommet
- d - Washer
- e - Bolt

5. Apply Loctite 242 Threadlocker to the fuel supply module mounting bolt threads.
6. Install FSM onto the driveshaft housing. Tighten to the specified torque.



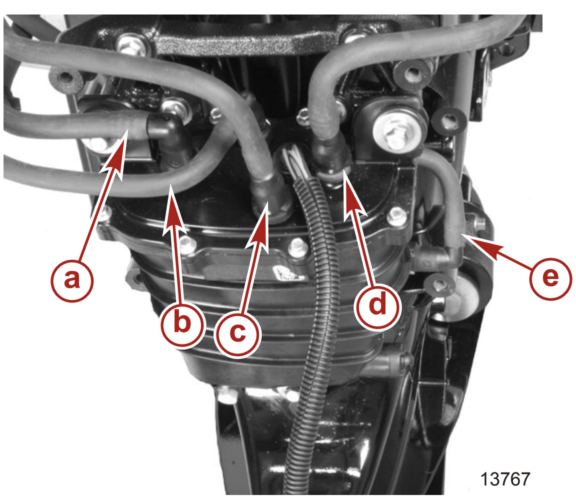
- a - FSM mounting bolts (3)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	FSM mounting bolt threads	92-809821

Description	Nm	lb-in.	lb-ft
FSM mounting bolts (M8 x 35) (3)	24		17.7

7. Connect the fuel out line, manifold reference line, fuel in line, vent canister line, and the fuel cooler line to the FSM.

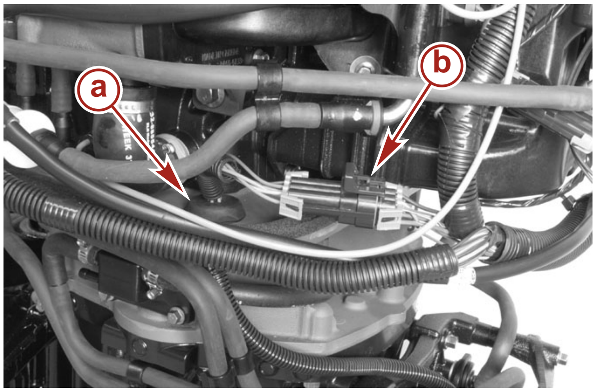
   ***NOTE:** The fuel lines at the FSM are preformed and only fit on the correct FSM port.*



- a - High-pressure fuel out line (10 mm red tab)
- b - Manifold reference line (8 mm white tab)
- c - Vent canister line (0.375 in. blue tab)
- d - Fuel in line (10 mm red tab)
- e - Fuel cooler line (8 mm blue tab)

8. Guide FSM harness connector through the adapter plate.
9. Push FSM wire harness grommet into the adapter plate.

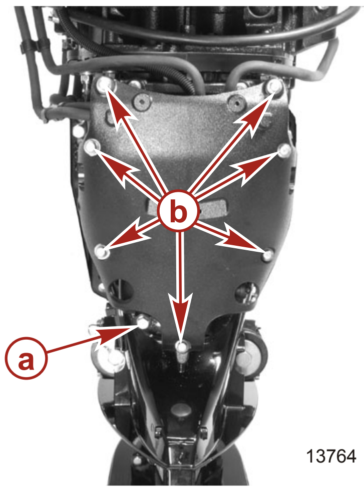
10. Connect the engine harness to the FSM harness.



13766

a - FSM harness grommet
b - FSM harness connector

11. Apply Loctite 242 Threadlocker to the seven shroud mounting bolt threads.
12. Install the FSM shroud. Tighten the FSM shroud bolts to the specified torque.



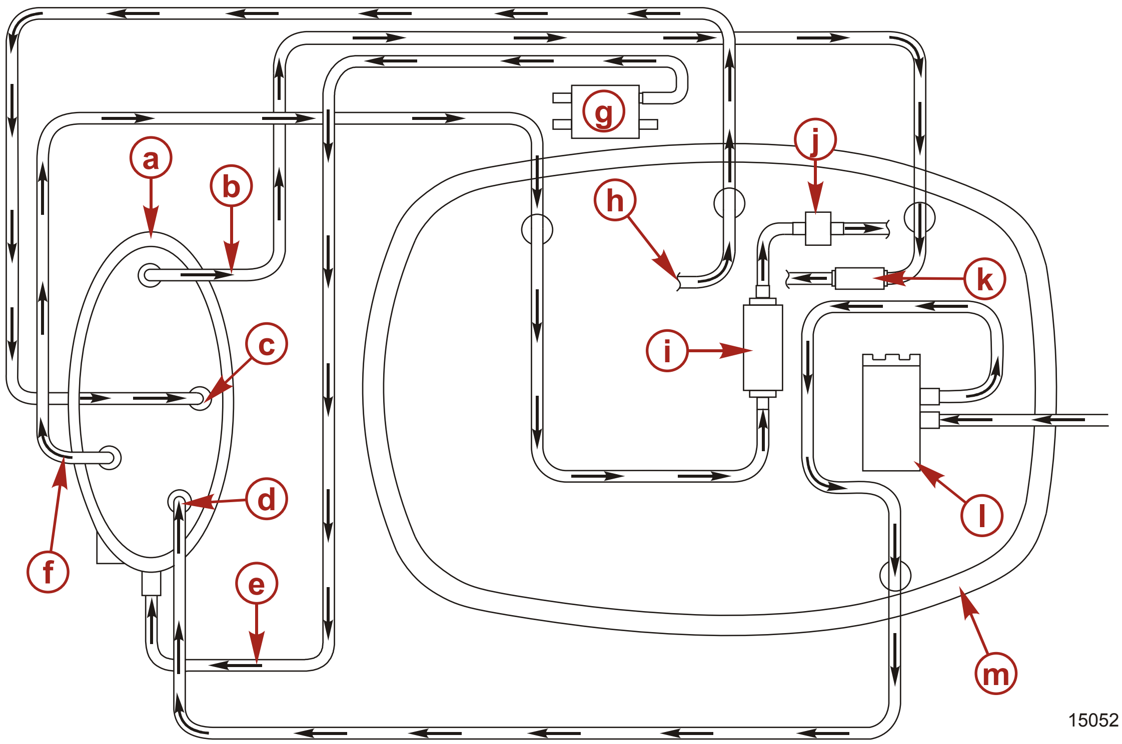
13764

a - FSM plug
b - Shroud mounting bolts (7)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	FSM shroud mounting bolt threads	92-809821

Description	Nm	lb-in.	lb-ft
FSM shroud mounting bolts (M8 x 40, M8 x 50, M8 x 75, M8 x 120)	24		17.7

Fuel Supply Module (FSM) Hose Routing Diagram L4 SC



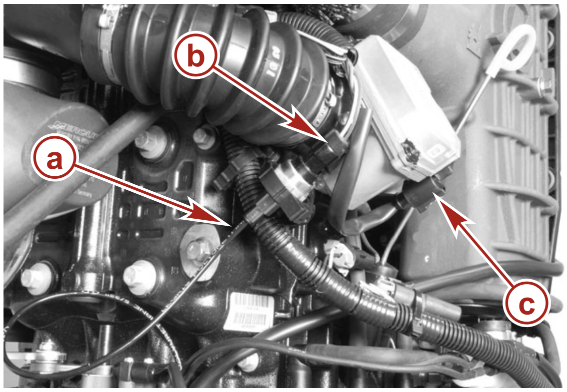
- a - FSM
- b - Fuel out
- c - Manifold reference
- d - Fuel in
- e - Water in
- f - To vent canister switch/vent canister purge valve
- g - Water manifold
- h - Manifold reference to intake manifold
- i - Vent canister float switch
- j - Vent canister purge valve
- k - 20 micron fuel filter
- l - 2 micron fuel filter/water separator
- m - Adapter plate

Electronic Boost Control (EBC)

Electronic Boost Control (EBC) Removal

1. Disconnect the EBC engine harness.
2. Disconnect the pitot sensor harness.

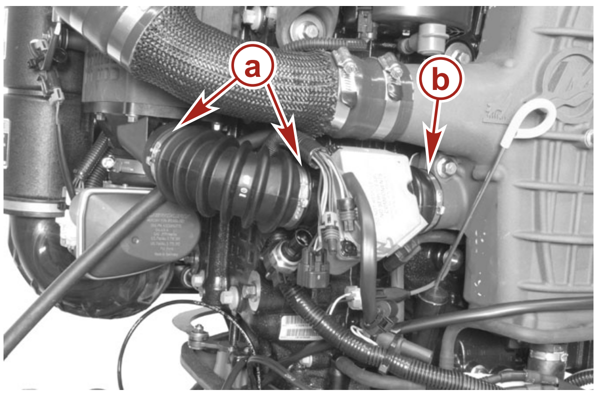
3. Disconnect the pitot sensor hose.



13860

a - Pitot sensor hose
b - Pitot harness connector
c - EBC harness connector

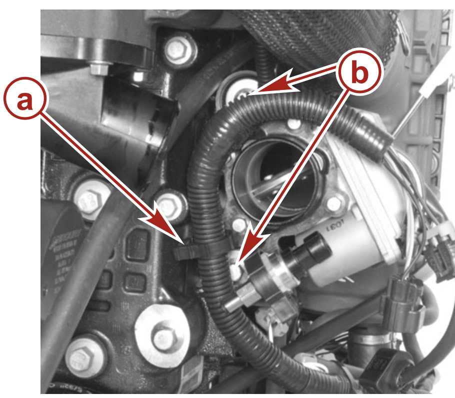
4. Remove the two hose clamps securing the EBC bypass tube to the intake duct and EBC.
5. Remove the hose clamp securing the CAC tube to the CAC.



13861

a - EBC bypass tube hose clamps
b - Hose clamp securing CAC tube

6. Remove the engine harness from the harness retainer.
7. Remove the two bolts securing the EBC mounting bracket to the cylinder block.

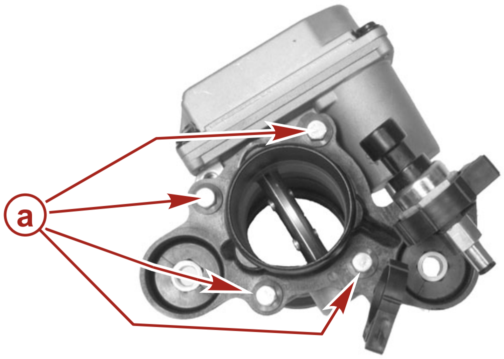


13862

a - Harness retainer
b - Bolt securing the EBC mounting bracket (2)

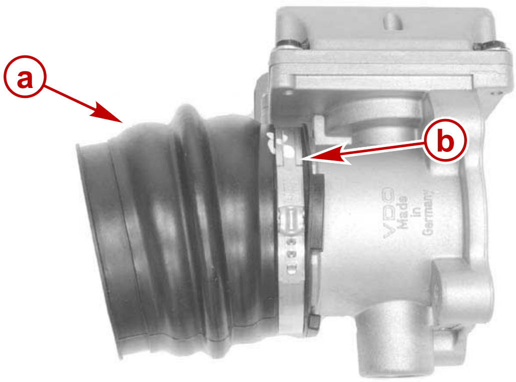
Electronic Boost Control Disassembly

1. Remove the four bolts securing the mounting bracket to the EBC.



a - Bolt securing mounting bracket (4)

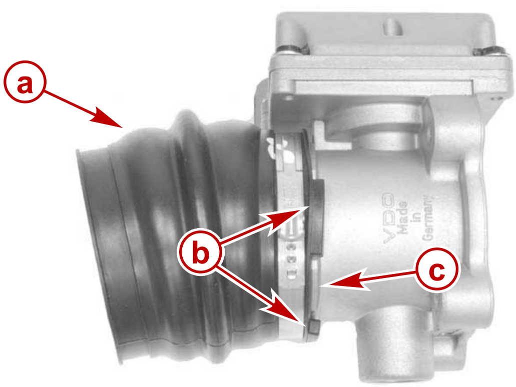
2. Remove the hose clamp securing the rear hose to the EBC.



a - Rear hose
b - Hose clamp

Electronic Boost Control (EBC) Assembly

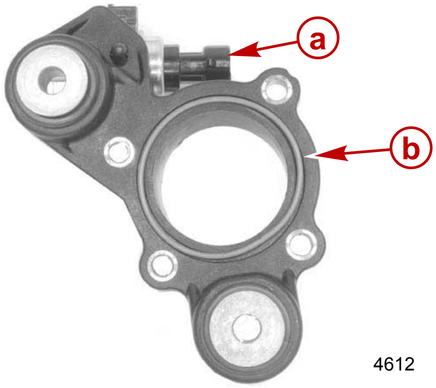
1. Place a 62.0 mm diameter hose clamp on the end of the rear hose that has a molded alignment key.
2. Install the rear hose onto the EBC. Ensure the hose molded key is in proper alignment with the cast key on the EBC.
3. Crimp the hose clamp with tool.



a - Rear hose
b - Hose molded key
c - Cast key on EBC

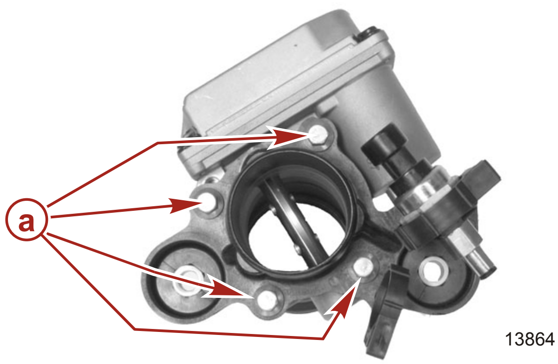
Hose Clamp Tool Kit	91-803146A2

4. Install a new O-ring onto the mounting bracket.



a - Pitot sensor
b - Mounting bracket O-ring

5. Install the mounting bracket onto the EBC.
6. Secure the mounting bracket to the EBC with four bolts. Tighten the mounting bracket bolts to the specified torque.

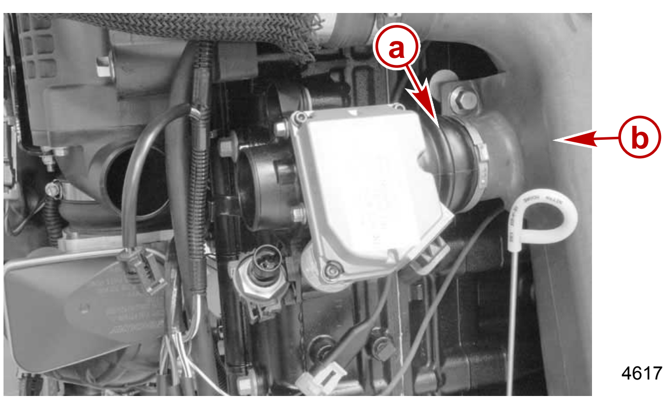


a - Bolt securing mounting bracket (4)

Description	Nm	lb-in.	lb-ft
Bolt (4) (M6 x 20)	12	106	

Electronic Boost Control (EBC) Installation

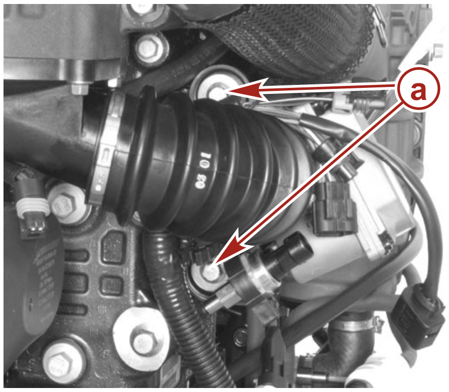
1. Install a 62.0 mm diameter hose clamp on the CAC tube.
2. Install the EBC assembly onto the CAC. Do not crimp the CAC tube hose clamp.



a - CAC tube
b - CAC

3. Install two 57.5 mm diameter hose clamps onto the bypass tube, one at each end.
4. Install the front tube onto the supercharger and the EBC mounting bracket at the same time. Ensure the bypass tube does not fold over when installing.

5. Align the EBC mounting bracket bolt holes with the cylinder block. Install the EBC mounting bracket bolts with washers. Tighten to the specified torque.

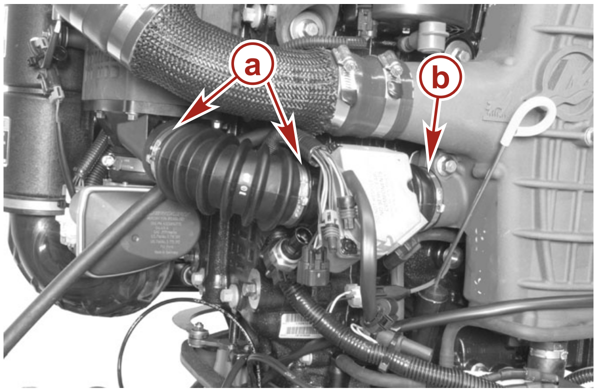


14607

a - EBC mounting bolts

Description	Nm	lb-in.	lb-ft
EBC bolt (2) (M8 x 35)	24	212	

6. Crimp the bypass tube and CAC tube clamps with the hose clamp tool.

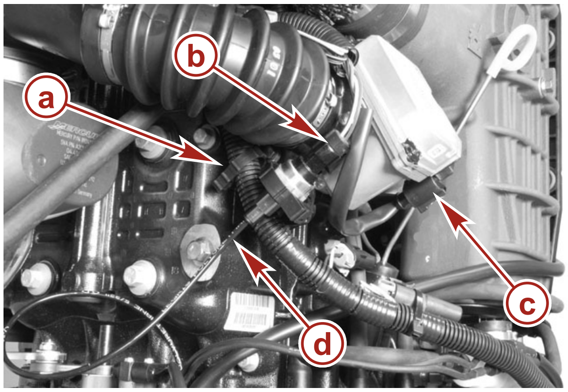


13861

a - EBC bypass tube hose clamps
b - Hose clamp securing CAC tube

Hose Clamp Tool Kit	91-803146A2

7. Connect the pitot harness to the pitot sensor.
8. Connect the EBC harness to the EBC.
9. Install the pitot hose into the pitot sensor.
10. Secure the engine wire harness to the EBC mounting bracket with clamp.



14608

a - Harness clamp
b - Pitot sensor harness connector
c - EBC harness connector
d - Pitot hose

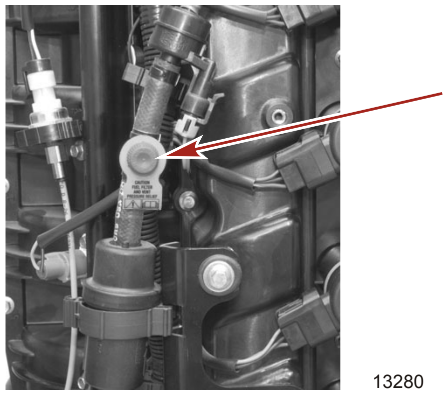
Fuel Rail

Fuel Rail Removal

⚠ CAUTION

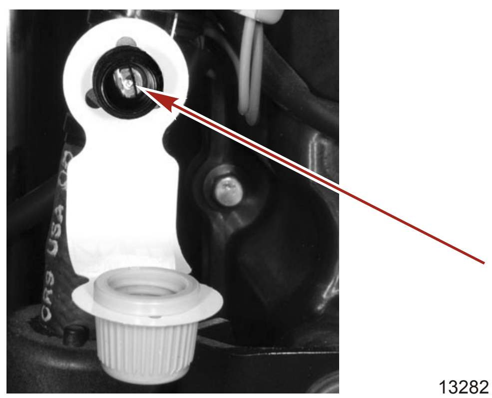
Failure to release pressure from the fuel system will result in fuel spraying out, which can cause a fire or explosion. Allow the engine to cool completely and release all fuel pressure before servicing any part of the fuel system. Always protect eyes and skin from pressurized fuel and vapors.

1. Remove the green cap to access the pressure relief valve for the FSM.



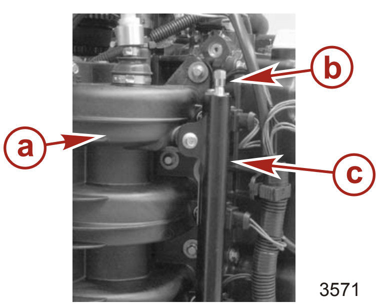
13280

2. Place a rag over the valve and press on the center of the valve to relieve any pressure inside the FSM.



13282

3. Attach a fuel pressure gauge to the fuel pressure valve on the fuel rail. Relieve the fuel pressure into an appropriate container.

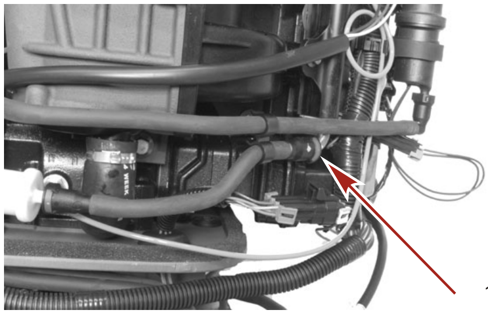


3571

a - Intake manifold
b - Fuel pressure valve
c - Fuel rail

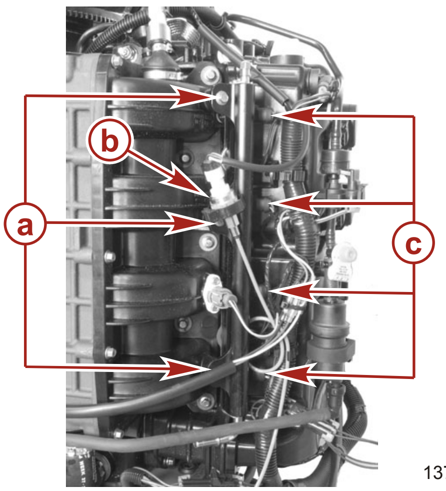
Fuel Pressure Gauge Kit	91-881833A03
Dual Fuel/Air Pressure Gauge Kit	91-881834A 1
Digital Pressure Meter	91-892651A01

4. Place a rag or shop towel under the high-pressure fuel line. Remove the fuel line. Dispose of fuel soaked rag/shop towel in an appropriate container.



13752

5. Remove the cylinder block water pressure sensor from the sensor retainer.
6. Remove the injector harness connector from the fuel injectors.
7. Remove the three bolts securing the fuel rail to the intake manifold.
8. Remove the fuel rail from the intake manifold.

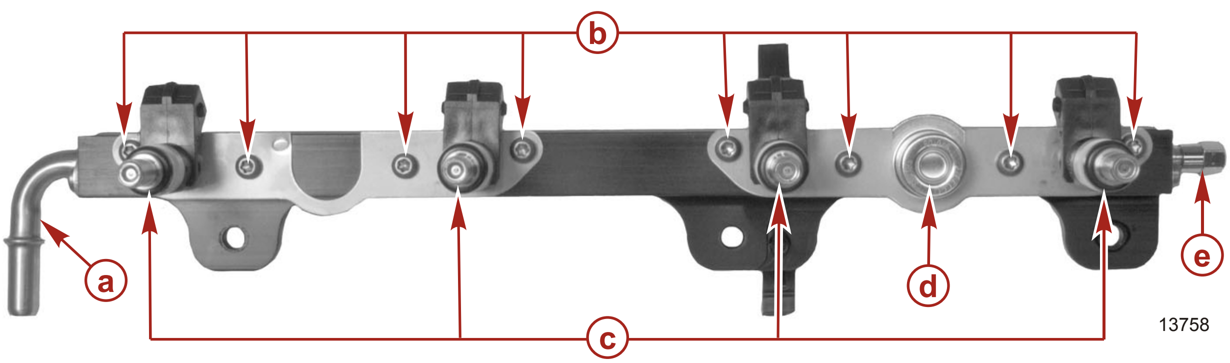


13753

a - Bolt (3)
b - Cylinder block water pressure sensor
c - Injector harness connectors

Fuel Rail Disassembly

1. Remove the T20 Torx screws securing the fuel injector retainers.
2. Remove the fuel injectors and damper.
3. Remove the T20 Torx screw securing the fuel inlet tube and Schrader valve to the fuel rail. Remove the fuel inlet tube and Schrader valve from the fuel rail.



13758

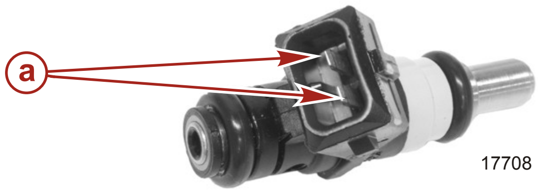
a - Fuel inlet tube
b - T20 Torx screw (8)
c - Fuel injector
d - Damper
e - Schrader valve

Fuel Injector Ohm Test

NOTE: A fuel injector test can be performed with the computer diagnostic system (CDS). The fuel injector is not polarity sensitive. An ohm test can be performed while the fuel injector is mounted to the fuel rail. It is not necessary to remove the fuel injector from the engine assembly when checking the resistance of the fuel injector.

Computer Diagnostic System (CDS)	Order through SPX

Use a digital ohmmeter to test the resistance of the fuel injector.



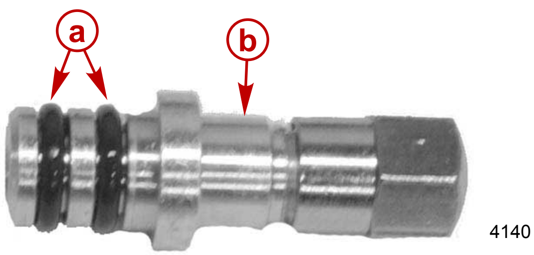
a - Fuel injector pins

DMT 2004 Digital Multimeter	91-892647A01

Fuel Injector	
Resistance at 21 °C (71 °F)	12 ± 0.5 ohms

Fuel Rail Assembly

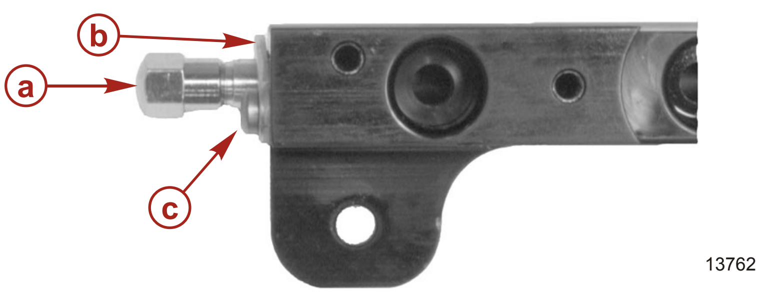
1. Use a solvent and compressed air to remove debris inside the fuel rail.
2. Install new O-rings onto the Schrader valve.
3. Lubricate the Schrader valve O-rings with SPO 255.



a - O-rings
b - Schrader valve

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Schrader valve O-rings	Obtain Locally

4. Install the Schrader valve to the fuel rail. Secure with retainer and T20 Torx screw. Tighten Torx screw to the specified torque.

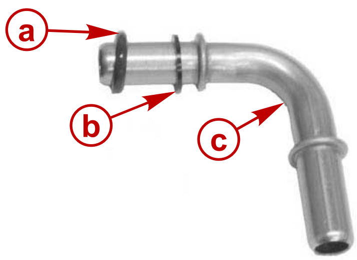


a - Schrader valve
b - Retainer
c - T20 Torx screw

Description	Nm	lb-in.	lb-ft
T20 Torx screw (M5 x 10)	6	53	

5. Install a washer and O-ring onto the fuel inlet tube. Lubricate with SPO 255.

NOTE: The fuel inlet is the same on both ends.



4151

a - O-ring
b - Washer
c - Fuel inlet tube

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Fuel inlet tube O-ring	Obtain Locally

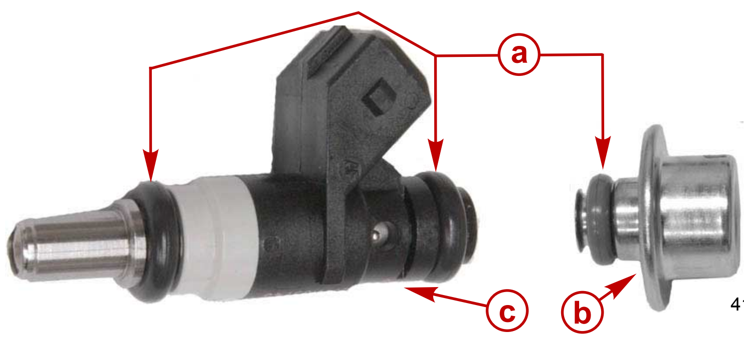
6. Install the fuel inlet tube to the fuel rail. Secure with retainer and T20 Torx screw. Tighten Torx screw to the specified torque.

13761

a - Fuel inlet tube
b - Retainer
c - T20 Torx screw

Description	Nm	lb-in.	lb-ft
T20 Torx screw (M5 x 10)	6	53	

7. Install new O-rings onto the fuel injectors and damper.
8. Lubricate the fuel injector and damper O-rings with SPO 255.



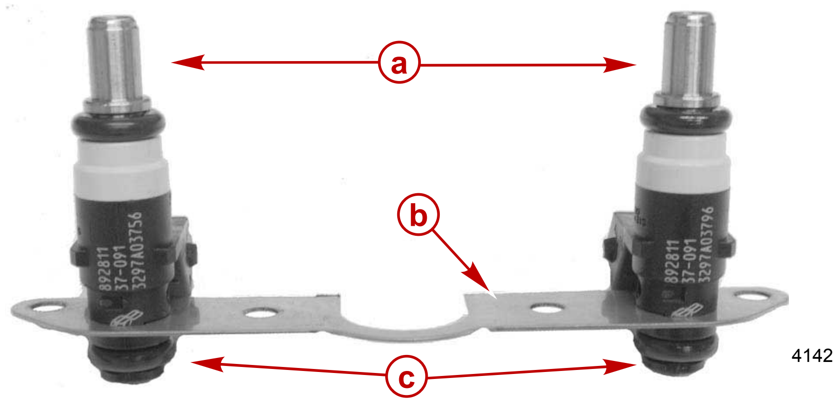
4138

a - O-rings
b - Damper
c - Fuel injector

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Fuel injector O-ring, fuel damper O-ring	Obtain Locally

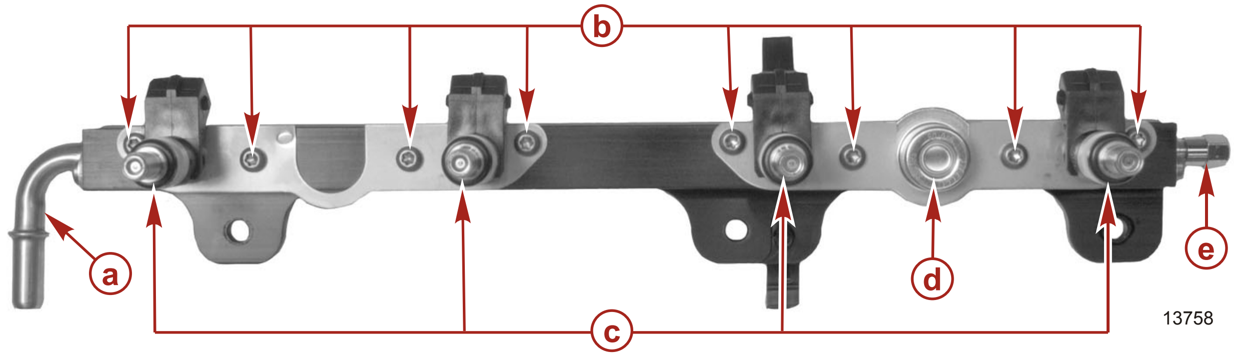
9. Install the damper onto the fuel rail.

10. Slide the fuel injector onto the fuel injector retainer bracket.



a - Manifold side of fuel injector
b - Fuel injector retainer bracket
c - Fuel rail side of fuel injector

11. Install fuel injectors onto fuel rail.
12. Secure fuel injector retainer bracket with T20 Torx screws.



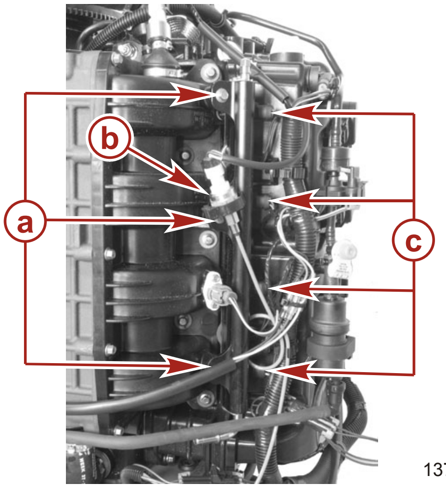
a - Fuel inlet tube
b - T20 Torx screw (8)
c - Fuel injector
d - Damper
e - Schrader valve

Description	Nm	lb-in.	lb-ft
T20 Torx screw (M5 x 10)	6	53	

Fuel Rail Installation

1. Install the fuel rail assembly onto the intake manifold.
2. Secure the fuel rail assembly to the intake manifold with three bolts. Tighten the fuel rail bolts to the specified torque.
3. Connect the fuel injector harness to the injectors.

4. Secure the cylinder block water pressure sensor to the fuel rail with retainer.

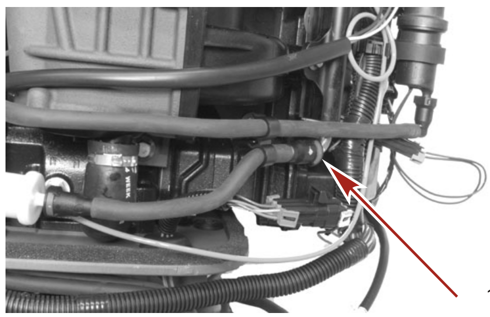


13753

- a - Bolts (3) (M6 x 15)
- b - Cylinder block water pressure sensor
- c - Fuel injector harness connectors

Description	Nm	lb-in.	lb-ft
Fuel rail bolt (3) (M6 x 15)	10	89	

5. Connect the high-pressure fuel line to the fuel rail fuel inlet.



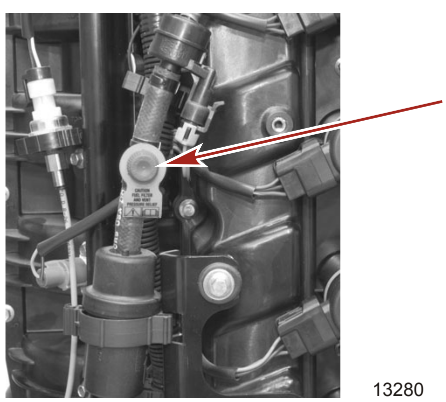
13752

6. Prime the fuel system and inspect for fuel leaks.

Charge Air Cooler (CAC) - Intake Manifold

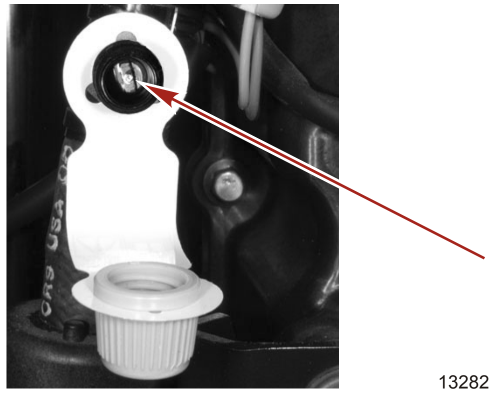
Charge Air Cooler (CAC) - Intake Manifold Removal

1. Disconnect the battery.
2. Remove all the cowls. Refer to **Section 4A - Cowling Removal**.
3. Remove the green cap to access the pressure relief valve for the FSM.



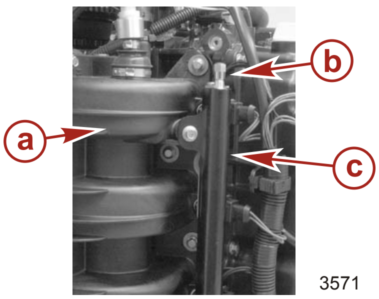
13280

4. Place a rag over the valve and press on the center of the valve to relieve any pressure inside the FSM.



13282

5. Attach a fuel pressure gauge to the fuel pressure valve on the fuel rail. Relieve the fuel pressure into an appropriate container.

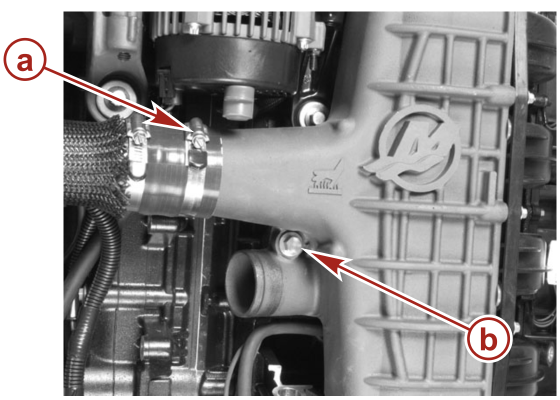


3571

a - Intake manifold
b - Fuel pressure valve
c - Fuel rail

Fuel Pressure Gauge Kit	91-881833A03
Dual Fuel/Air Pressure Gauge Kit	91-881834A 1
Digital Pressure Meter	91-892651A01

6. Remove the EBC. Refer to **Electronic Boost Control**.
7. Remove the fuel rail and MAT sensor harness connector. Refer to **Fuel Rail**.
8. Loosen the hose clamp securing the inlet tube to the CAC.
9. Remove the bolt securing the front of the CAC to the cylinder block.

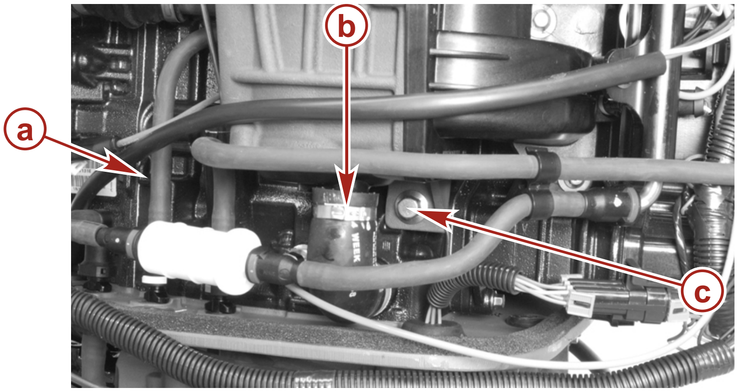


13936

a - Hose clamp
b - Bolt

10. Disconnect the manifold reference line at the adapter plate.
11. Remove the lower CAC hose clamp.

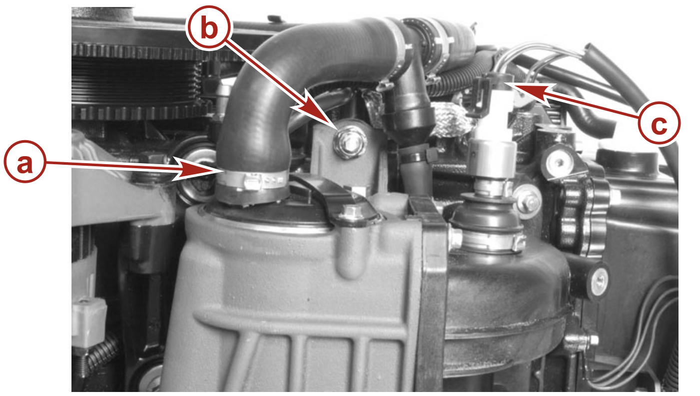
12. Remove the bolt securing the CAC to the cylinder block.



13937

a - Manifold reference line
b - Hose clamp (34.6 mm)
c - Bolt

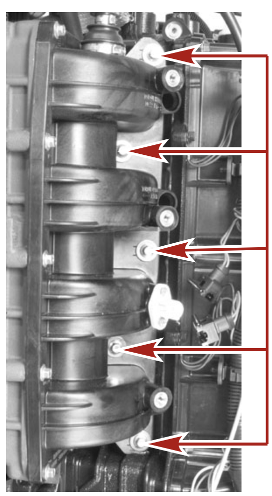
13. Remove the upper CAC hose clamp. Remove the hose from the CAC.
14. Remove the nut securing the CAC to the cylinder block.
15. Disconnect the MAP sensor harness connector.



13938

a - Hose clamp (34.6 mm)
b - Nut
c - MAP sensor harness connector

16. Remove the five bolts securing the intake manifold to the cylinder head.
17. Remove the CAC from the cylinder block/head and the lower CAC hose.

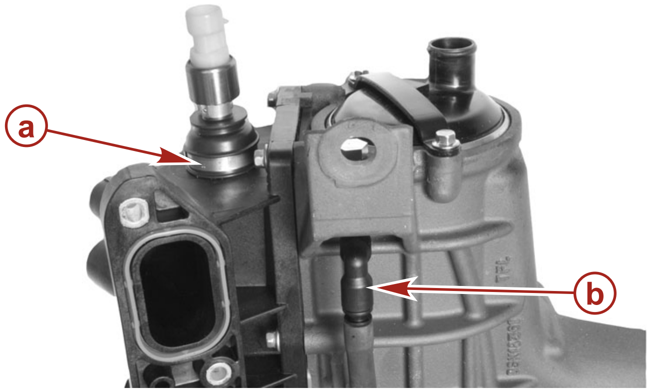


13939

Charge Air Cooler (CAC) - Intake Manifold Disassembly

1. Remove the hose clamp securing the MAP adapter boot. Remove the MAP sensor boot from the intake manifold.

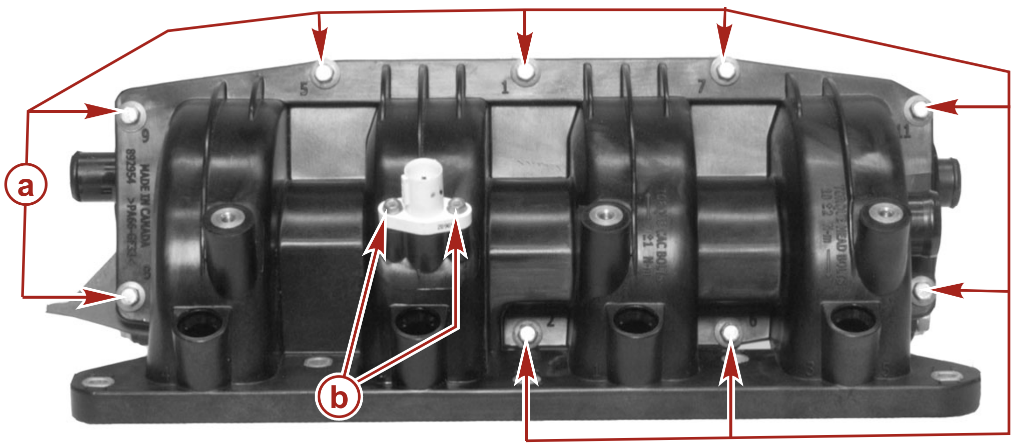
2. Remove the manifold reference line from the reference line fitting.



13940

a - Hose clamp
b - Manifold reference line

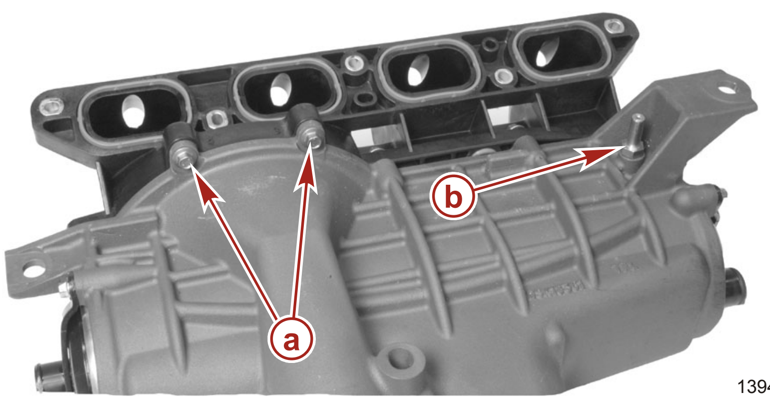
3. Remove the two screws securing the MAT sensor to the intake manifold. Remove the MAT sensor from the intake manifold.
4. Remove the nine bolts securing the intake manifold to the CAC.



13941

a - Intake manifold bolts (9)
b - Screws securing MAT (2)

5. Remove the two bolts securing the intake manifold to the CAC.
6. Remove the manifold reference fitting. Separate the intake manifold from the CAC.



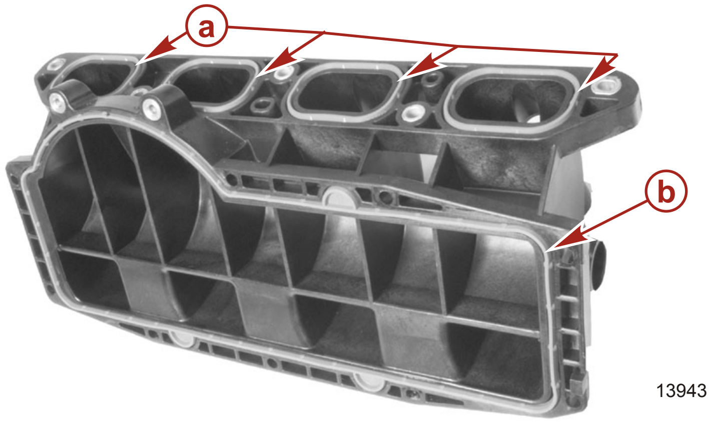
13942

a - Bolt (2)
b - Manifold reference fitting

Charge Air Cooler (CAC) - Intake Manifold Assembly

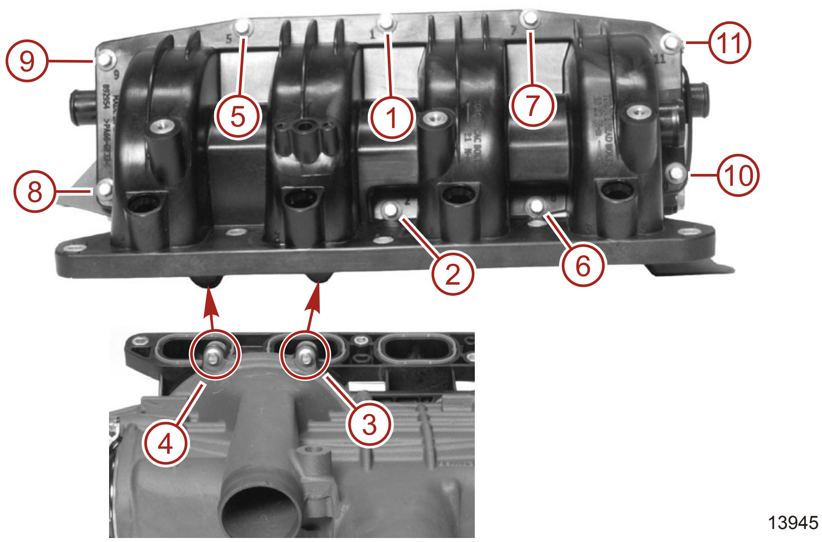
NOTE: The CAC is a nonserviceable component and must be replaced as an assembly if suspected of leaking or is severely fouled.

1. Install new intake manifold seals and CAC seal on the intake manifold.



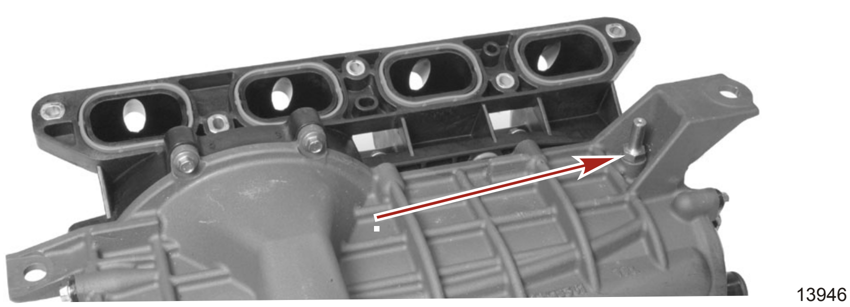
a - Intake manifold seal
b - CAC

2. Place the intake manifold onto the CAC.
3. Install all intake manifold bolts.
4. Tighten intake manifold bolts in the sequence shown to the specified torque.



Description	Nm	lb-in.	lb-ft
Intake manifold bolts (M6 x 15, M6 x 25)	7	62	

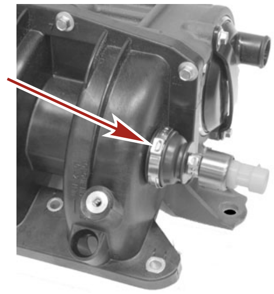
5. Install a new O-ring onto the manifold reference fitting and install the manifold reference fitting onto the CAC. Tighten the manifold reference fitting to the specified torque.



Description	Nm	lb-in.	lb-ft
Manifold reference fitting	8	71	

6. Install a 36.1 mm hose clamp on the MAP sensor boot.

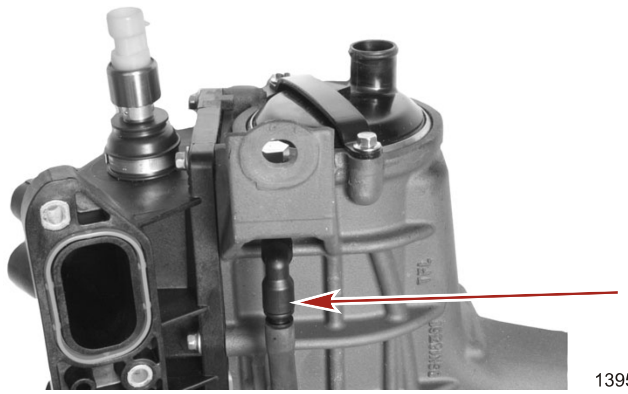
7. Install the MAP sensor boot to the intake manifold. Crimp the hose clamp with the hose clamp tool.



13948

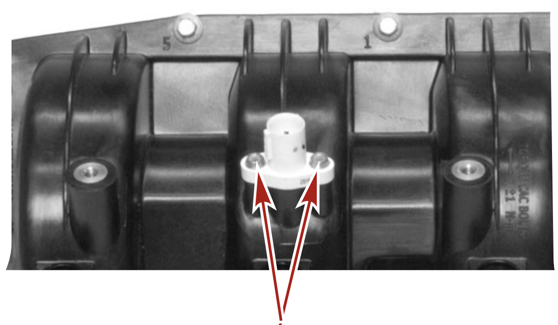
Hose Clamp Tool Kit	91-803146A2

8. Install the manifold reference hose.



13950

9. Install the MAT sensor. Secure with two screws. Tighten the MAT sensor screws to the specified torque.



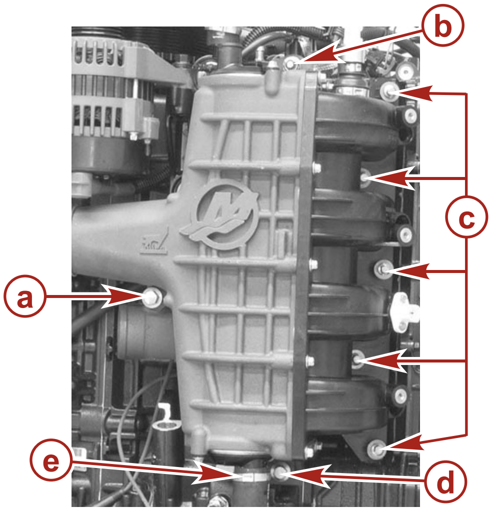
13947

Description	Nm	lb-in.	lb-ft
MAT sensor screws (M4 x 6)	2	18	

Charge Air Cooler (CAC) - Intake Manifold Installation

1. Install a 34.6 mm diameter hose clamp onto the lower CAC water hose.
2. Ensure a hose clamp is on the CAC inlet tube.
3. Insert the CAC lower water inlet into the lower CAC hose.
4. Carefully align the charged air inlet tube with the CAC.
5. Push the CAC onto the CAC inlet tube. The CAC should align with the upper CAC mounting stud.

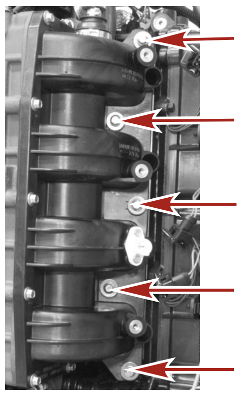
6. Install all the CAC mounting bolts and nut. Do not tighten bolts and nut.



14111

- a - Bolt (M10 x 65)
- b - Nut (M10)
- c - Bolt (M6 x 30)
- d - Bolt (M10 x 30)
- e - Hose clamp (34.6 mm)

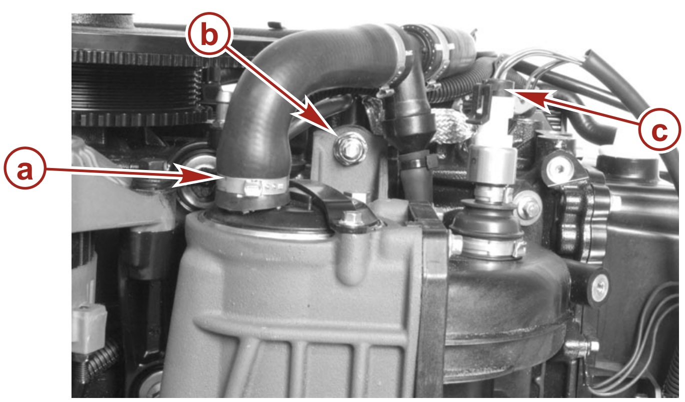
7. Tighten the CAC manifold bolts to the specified torque.



14107

Description	Nm	lb-in.	lb-ft
Charge air cooler manifold bolt	10	89	

8. Install a 34.6 mm hose clamp on the upper CAC hose.
9. Install the hose to the CAC and crimp the hose clamp with the hose clamp tool.
10. Connect the MAP sensor harness connector to the MAP sensor.
11. Tighten the nut securing the CAC to the mounting stud to specification.



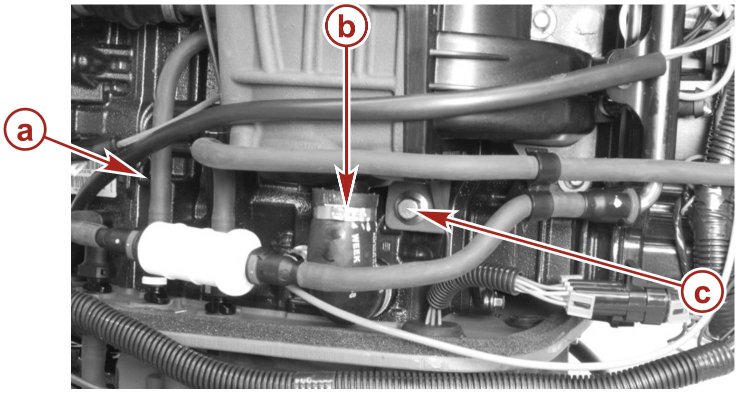
13938

- a - Hose clamp (34.6 mm)
- b - Nut
- c - MAP sensor harness connector

Description	Nm	lb-in.	lb-ft
Nut (M10)	32.5		24

Hose Clamp Tool Kit	91-803146A2

12. Install the manifold reference line to the manifold reference port on the adapter plate.
13. Crimp the hose clamp to secure the hose to the CAC with the hose clamp tool.
14. Tighten the bolt to the specified torque.



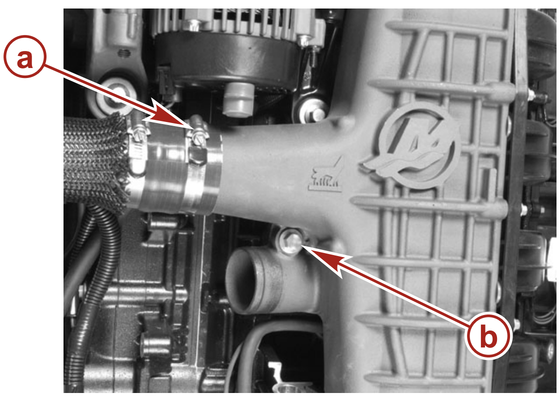
13937

a - Manifold reference line
b - Hose clamp (34.6 mm)
c - Bolt

Description	Nm	lb-in.	lb-ft
Bolt (M10 x 30)	32.5		24

Hose Clamp Tool Kit	91-803146A2

15. Tighten the hose clamp securing the inlet tube to the CAC to the specified torque.
16. Tighten the bolt securing the CAC to the cylinder block to the specified torque.



13936

a - Hose clamp
b - Bolt

Description	Nm	lb-in.	lb-ft
Hose clamp	6	53	
Bolt (M10 x 65)	32.5		24

17. Install the fuel rail. Refer to **Fuel Rail**.
18. Install the EBC. Refer to **Electronic Boost Control**.

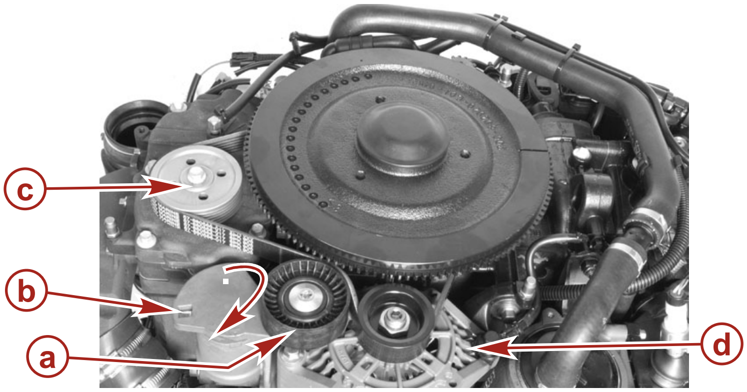
Supercharger Removal/Installation

Supercharger Removal

IMPORTANT: The accessory drive belt must be replaced if the belt has slipped on a seized alternator, seized tensioner pulley or a failed supercharger, regardless of the appearance of the belt.

1. Install a breaker bar into the supercharger/alternator belt tensioner.

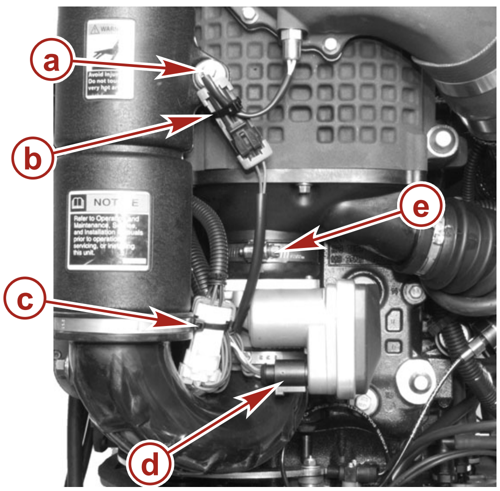
2. Release the belt tension and remove the belt from the alternator and supercharger.



13329

a - Belt tensioner
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

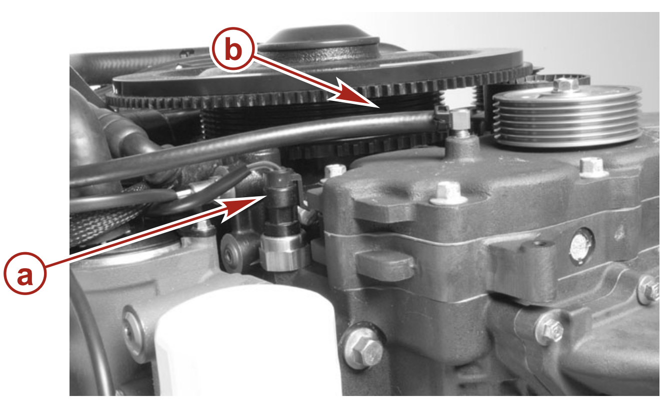
3. Cut the cable tie securing the outlet temperature sensor harness to the ETC resonator support bolt. Disconnect the sensor harness and remove the outlet temperature sensor.
4. Remove the bolt securing the ETC resonator assembly to the supercharger.
5. Loosen the hose clamp securing the ETC to the supercharger inlet duct.
6. Disconnect the ETC harness.
7. Remove the ETC/resonator assembly from the supercharger inlet.



13335

a - Bolts securing ETC resonator
b - Cable tie securing outlet temperature sensor
c - Cable tie securing ESC harness connector
d - ETC harness connector
e - Hose clamp securing ETC to supercharger

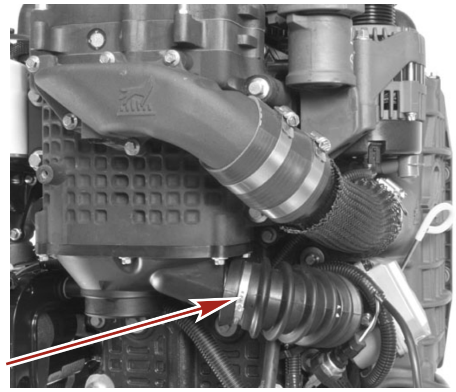
8. Remove the supercharger vent hose from the supercharger vent fitting.
9. Disconnect the oil pressure sensor harness.



13786

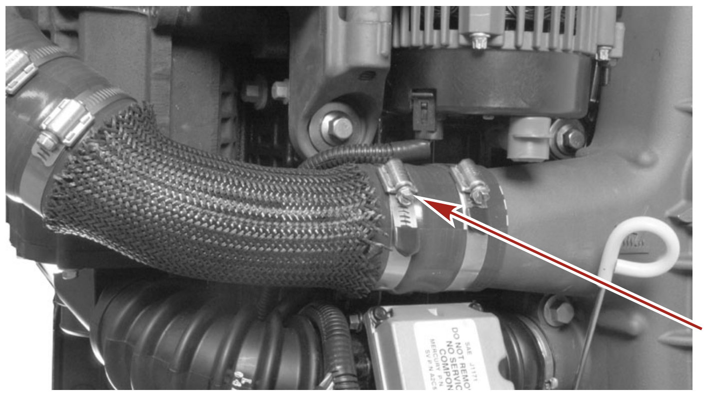
a - Oil pressure sensor harness
b - Supercharger vent hose

10. Remove hose clamp securing the bypass boot to the supercharger inlet duct.



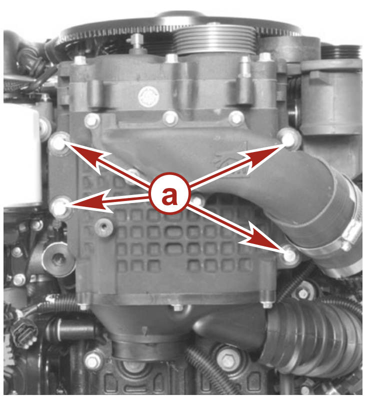
13790

11. Loosen the hose clamp securing the supercharger outlet tube to the CAC.



13791

12. Remove four bolts securing the supercharger to the cylinder block.
13. Pull the supercharger off the cylinder block.



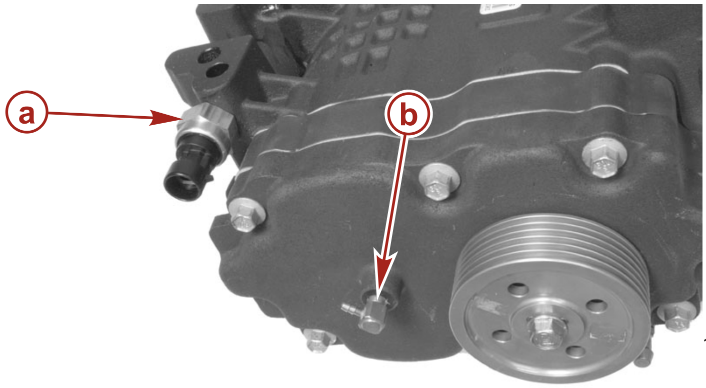
13792

a - Bolt securing supercharger (4)

Supercharger Disassembly/Assembly

Disassembly

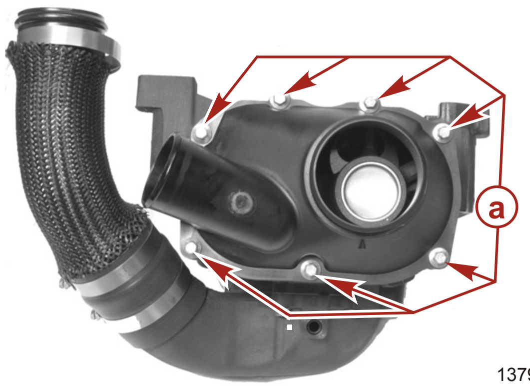
1. Remove the oil pressure sensor and the vent fitting from the supercharger.



13793

a - Oil pressure sensor
b - Vent fitting

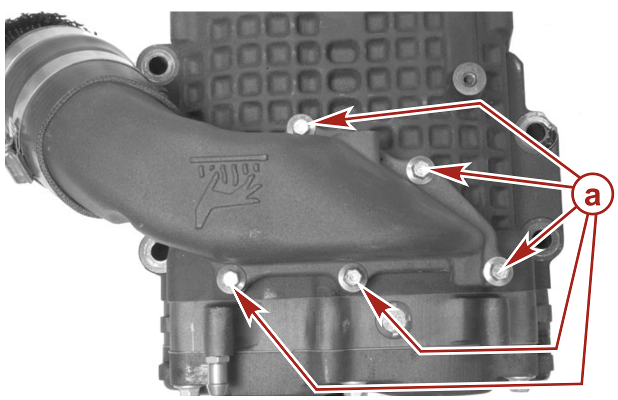
2. Remove seven bolts securing the inlet duct to the supercharger. Remove inlet duct.



13795

a - Bolt securing inlet duct (7)

3. Remove five bolts securing the outlet duct to the supercharger. Remove the outlet duct.

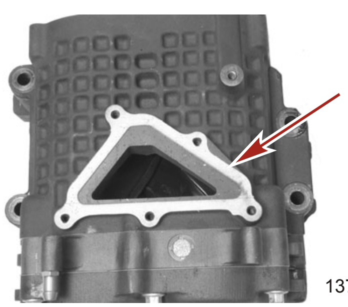


13797

a - Bolt securing outlet duct (5)

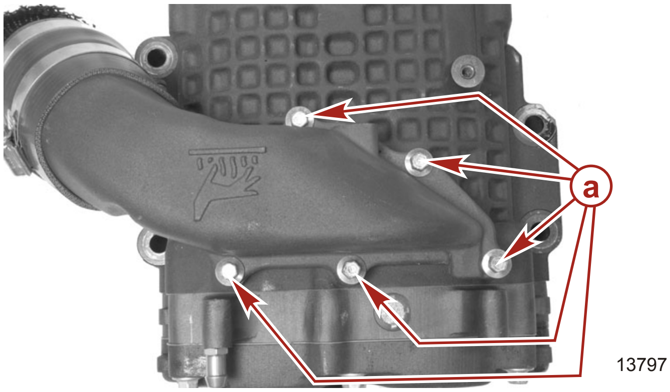
Assembly

1. Clean the mounting surface of the supercharger outlet port. Do not allow debris to enter the supercharger outlet area.
2. Install a new outlet duct gasket.



13798

3. Clean the mating surface of the outlet duct.
4. Install the outlet duct to the supercharger. Secure with five bolts. Tighten bolts to the specified torque.

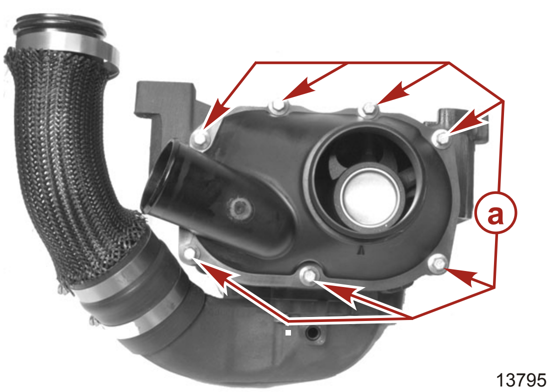


a - Bolt securing outlet duct (5)

Description	Nm	lb-in.	lb-ft
Bolt securing outlet duct	8	71	

5. Install a new O-ring seal onto the inlet duct.

6. Install inlet duct to the supercharger. Secure with seven bolts. Tighten bolts to the specified torque.

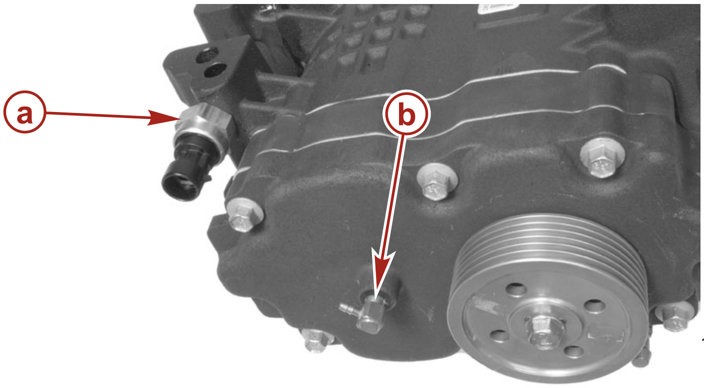


a - Bolt securing inlet duct (7)

Description	Nm	lb-in.	lb-ft
Bolt securing inlet duct (7)	8	71	

7. Apply Loctite 567 PST Pipe Sealant to the threads of the oil pressure sensor.
8. Install oil pressure sensor onto the supercharger. Tighten securely to ensure oil pressure sensor will not leak oil.

9. Install vent fitting onto supercharger. Tighten securely to ensure vent fitting will not leak.



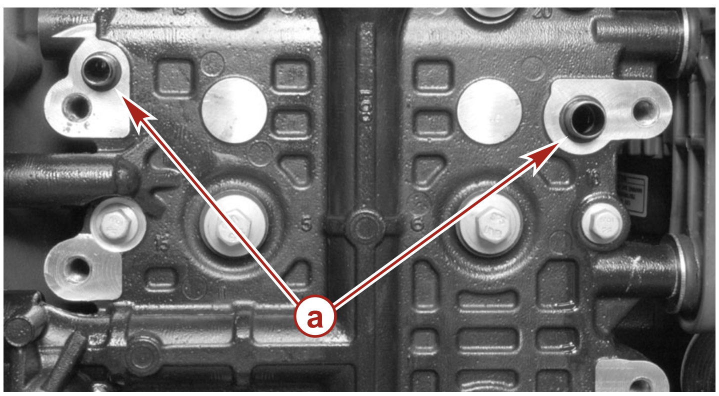
13793

a - Oil pressure sensor
b - Vent fitting

Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Oil pressure sensor threads	92-809822

Supercharger Installation

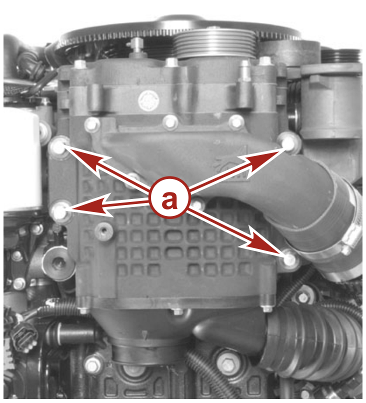
1. Install new O-rings onto the supercharger dowels.



13804

a - O-rings on supercharger dowels

2. Install a 57.5 mm diameter hose clamp on the bypass boot.
3. Ensure a hose clamp is on the supercharger outlet tube.
4. Install the supercharger inlet duct onto the bypass boot.
5. Align the supercharger outlet tube with the CAC.
6. Install the supercharger onto the supercharger dowels.
7. Secure the supercharger to the cylinder block with four bolts.
8. Tighten the supercharger bolts in two steps.

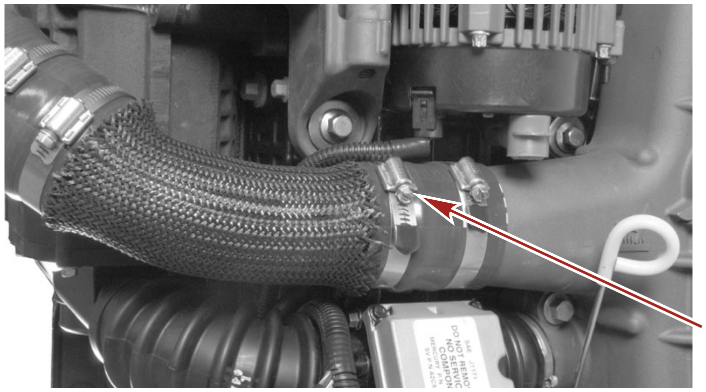


13792

a - Bolt securing supercharger (4)

Description		Nm	lb-in.	lb-ft
Bolt securing supercharger (4)	First torque	15	133	
	Final torque	43		32

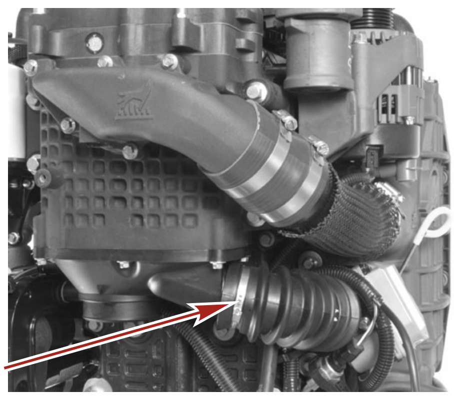
9. Secure the outlet tube to the CAC with the hose clamp. Tighten hose clamp to the specified torque.



13791

Description	Nm	lb-in.	lb-ft
Hose clamp	6	53	

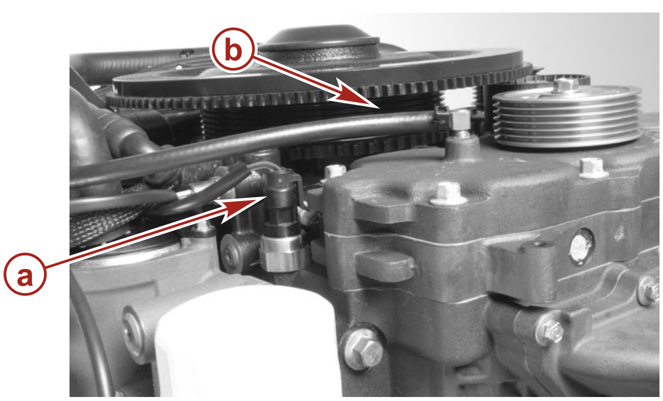
10. Secure the bypass boot to the inlet duct with a 57.5 mm clamp. Tighten clamp with the hose clamp tool.



13790

Hose Clamp Tool Kit	91-803146A2

11. Install the vent hose to the vent fitting. Secure with cable tie.
12. Connect the oil pressure sensor harness to the oil pressure sensor.



13786

a - Oil pressure sensor harness
b - Supercharger vent hose

13. Ensure a hose clamp is on the ETC isolator.
14. Install the ETC assembly onto the supercharger inlet duct. Tighten hose clamp to the specified torque.

Description	Nm	lb-in.	lb-ft
Hose clamp securing ETC	6.2	55	

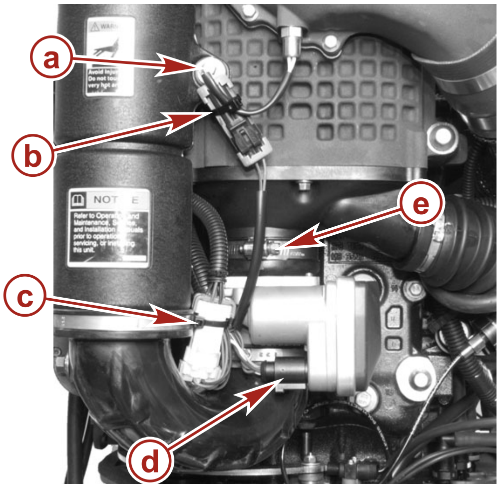
15. Secure the resonator to the supercharger with a bolt. Tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Resonator bolt (M6 x 20)	7.5	66	

16. Install a new O-ring onto the outlet temperature sensor.
17. Install the outlet temperature sensor onto the supercharger. Tighten outlet temperature sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
Outlet temperature sensor	10	89	

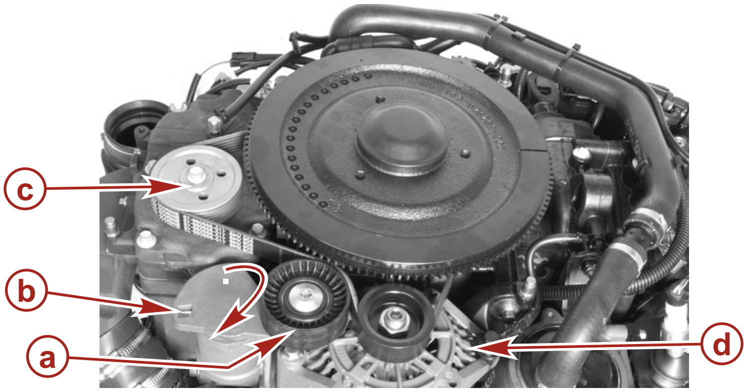
18. Connect the engine harness to the outlet temperature sensor and secure to the ETC resonator with a cable tie.
19. Connect the engine harness to the ETC. Secure the engine harness and ESC harness connector to the ETC bracket with a cable tie.



13335

a - Bolts securing ETC resonator
b - Cable tie securing outlet temperature sensor
c - Cable tie securing ESC harness connector
d - ETC harness connector
e - Hose clamp securing ETC to supercharger

20. Insert a breaker bar into the tensioner and compress the tensioner spring.
21. Guide the belt onto the alternator. Ensure the belt is centered on the alternator pulley.
22. Guide the belt onto the supercharger pulley. Ensure the belt is centered on the supercharger pulley.
23. Slowly release the tension to the belt.
24. Check the belt for proper belt alignment on the flywheel, alternator and supercharger.



13329

a - Belt tensioner
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

Fuel System

Section 3D - Emissions

Table of Contents

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. Emission 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

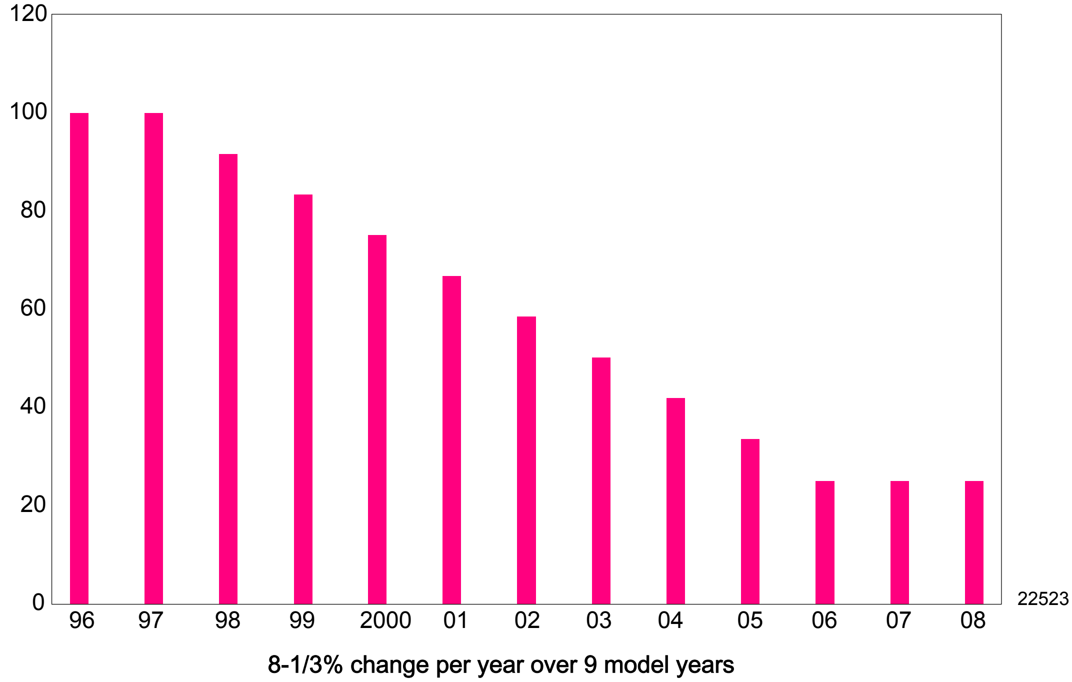
The reduction of exhaust emissions is accomplished by controlling the air/fuel ratio that goes into the combustion chamber and with adjusting the timing curve of the spark ignition, based on engine sensor information. A microprocessor is used to manage the fuel injection duration and adjust the ignition timing. These adjustments are made in a microsecond during all engine operations. Adjustments are established by predetermined values programmed into the microprocessor and are based on various sensor inputs to the microprocessor on the engine.

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. Enrichening the air/fuel ratio to decrease combustion temperatures and reduce NOx also increases HC and CO, as well as lowering fuel economy. 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.

Outboard Hydrocarbon Emissions Reduction



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 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 locations:

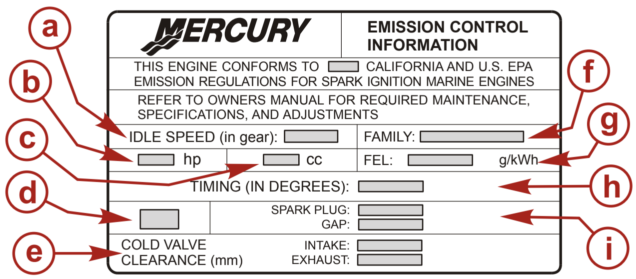
VIA U.S. POSTAL SERVICE:
Office of Mobile Sources Engine Programs and Compliance Division Engine Compliance Programs Group (6403J)
401 M St. NW
Washington, DC 20460,

VIA EXPRESS or COURIER MAIL:
Office of Mobile Sources Engine Programs and Compliance Division Engine Compliance Programs Group (6403J)
501 3rd St. NW
Washington, DC 20001,

EPA INTERNET WEB SITE: http:/www.epa.gov/omswww

Manufacturer's Certificate 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.

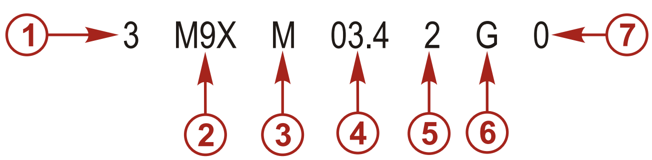


21096

- **a -** Idle speed
- **b -** Engine horsepower
- **c -** Piston displacement
- **d -** Date of manufacture
- **e -** Valve clearance (if applicable)
- **f -** Family number
- **g -** Maximum emissions output for the engine family
- **h -** Timing specifications
- **i -** Recommended spark plug and gap

Family Number

The following is an illustration of a typical family number and is not a representation of any one model.



21088

1. **1 -** Model year (3 = 2003)
2. **2 -** Manufacturer (Mercury Marine)
3. **3 -** Regulations (M = Marine)
4. **4 -** Engine displacement (decimal point = liters [03.4 = 3.4L]), (no decimal point = C.I. [0113 = 113 cubic inches])
5. **5 -** Technology type (1 = OB old tech, 2 = OB new tech, 3 = SportJet, 4 = OptiJet)
6. **6 -** Engine class (C = two-stroke, G = four-stroke)
7. **7 -** Product type (0 = all except, J = SportJet, E = EFI SportJet and 4-Strokes, 3 = OptiMax, H = high performance)

Service Replacement Certification Label

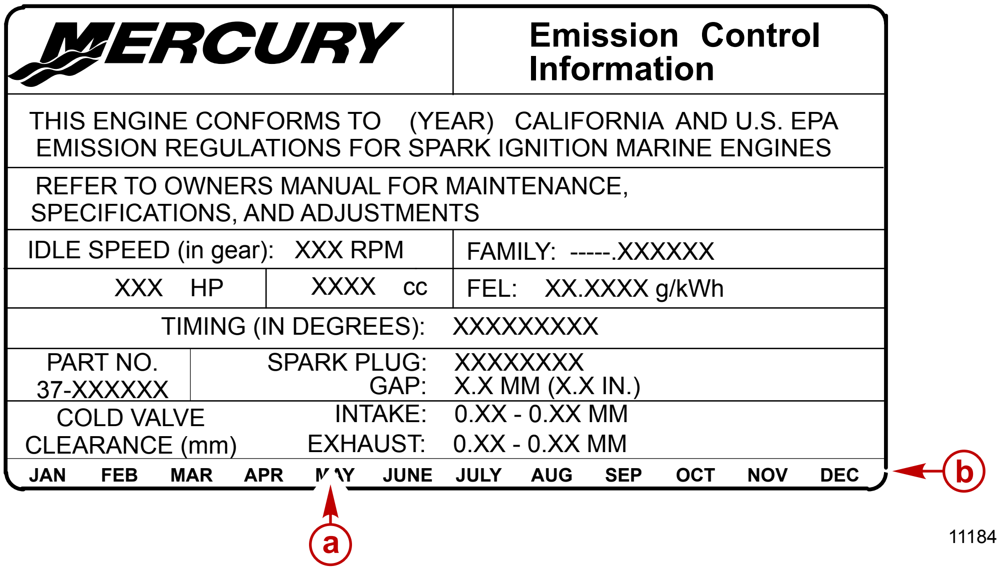
IMPORTANT: **By federal law, it is required that all 1998 and newer Mercury Marine outboards have a visible and legible emission certification label. If this label is missing or damaged, contact Mercury Marine Service for a replacement.**

Removal

Remove all remaining pieces of the damaged or illegible label. Do not install the 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.

Model	Model Year	Serial Number	Service Part Number
Mercury/Mariner 135/150/175 EFI FourStroke Verado	2005	1B227000–1B229688	37-879846
Mercury/Mariner 135/150/175 EFI FourStroke Verado	2006	1B229689–1B381781	37-898165A06
Mercury/Mariner 135/150/175 EFI FourStroke Verado	Gen 1	1B381782–1B517158	37-898165A07
Mercury/Mariner 135/150/175/200 EFI FourStroke Verado	Gen 2	1B517159 and above	37-898165A08

Notes:

Powerhead

Section 4A - Cylinder Block/Crankcase

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4
A

Cylinder Block/Crankcase Specifications

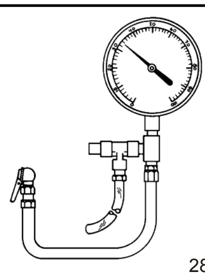
Cylinder Block/Crankcase Specifications	
Number of cylinders	4
Displacement	1.7 liters (105.6 CID)
Compression ratio	8.25:1
Standard bore	82.00 mm (3.228 in.)
Stroke	82.00 mm (3.228 in.)
Cylinder bore maximum taper (service)	0.0762 mm (0.003 in.)
Cylinder bore maximum out of round (service)	0.0762 mm (0.003 in.)
Cylinder block main bearing	65.997–66.013 mm (2.5982–2.5989 in.)
Crankshaft main bearing journal	59.985–60.001 mm (2.3616–2.3622 in.)
Crankshaft pin journal	49.982–50.00 mm (1.9678–1.968 in.)
Crankshaft end play	0.08–0.19 mm (0.003–0.007 in.)
Crankshaft runout	0.05 mm (0.002 in.)
Crankshaft main bearing oil clearance (without expansion)	0.014–0.042 mm (0.0005–0.0016 in.)
Crankshaft pin bearing oil clearance (without expansion)	0.020–0.050 mm (0.0008–0.0019 in.)
Connecting rod wrist pin bore diameter	22.005–22.014 mm (0.8663–0.8666 in.)
Connecting rod crankshaft pin diameter	53.000–53.018 mm (2.0866–2.0873 in.)
Piston skirt standard diameter	81.975 mm (3.2273 in.)
Piston wrist pin bore diameter	22.004–22.011 mm (0.8662–0.8665 in.)
Wrist pin diameter	21.997–22.000 mm (0.8660–0.8661 in.)
Top ring groove width	1.25 mm (0.049 in.)
Second ring groove width	1.23 mm (0.048 in.)
Third ring groove width	2.03 mm (0.080 in.)
Top ring thickness	1.19 mm (0.047 in.)
Second ring thickness	1.19 mm (0.047 in.)
Third ring thickness	1.98 mm (0.078 in.)
Top ring side clearance	0.04–0.08 mm (0.001–0.003 in.)
Second ring side clearance	0.04–0.08 mm (0.001–0.003 in.)
Third ring side clearance	0.05–0.17 mm (0.002–0.006 in.)
Top ring end gap	0.27–0.42 mm (0.010–0.016 in.)
Second ring end gap	0.42–0.62 mm (0.016–0.024 in.)
Oil ring end gap	0.2–0.7 mm (0.007–0.027 in.)

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Water and oil galley plugs	92-809822
		Cylinder block water pressure sensor adapter Legris fitting threads	
		Oil temperature sender threads	
25	Liquid Neoprene	Power stud and battery ground	92- 25711 3
		Engine harness ground, solenoid power lead nut, exciter wire nut	
		Alternator ground and battery charging lead	
		Cylinder head ground bolt, cylinder block ground bolt	
		Ignition coil grounds	
91	Engine Coupler Spline Grease	Driveshaft splines	92-802869A 1

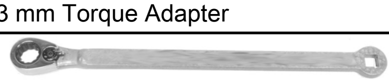
Tube Ref No.	Description	Where Used	Part No.
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Long main bearing bolt threads	Obtain Locally
135	Three Bond 1217F	Cylinder block cover	92-858005K02
136	Lubriplate SPO 255	Piston pin	Obtain Locally
		Cylinder block bearings	
		Connecting rod bearing	
		Crankpin	
		Crankshaft main bearings	
		Chain guide bolts	
		Lower CAC hose fitting O-ring and threads	
		Water dump adapter O-rings	
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Piston rings	92-858052K01
		Piston and rings, cylinder bore	
		Rod cap screw threads and head	
		Timing chain tensioner	
		Inside diameter of cylinder block crankshaft seal area	
		Inside diameter of crankshaft seal	

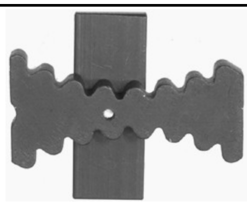
Special Tools

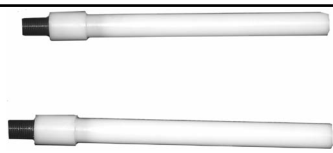
Fuel Pressure Gauge Kit	91-881833A03
 2807	Tests the fuel pump pressure; can be used to relieve fuel pressure.

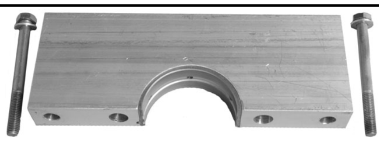
Digital Pressure Meter	91-892651A01
 5786	Connects to the fuel system/manifold and can be used in conjunction with Computer Diagnostic System (CDS).

Flywheel Puller/Lifting Ring	91-895343T02
 14869	Removes flywheel from engine. Used for lifting powerhead/engine.

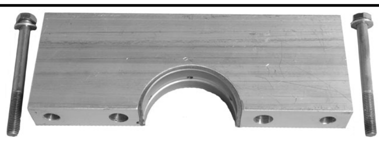
13 mm Torque Adapter	91-809905001
 4631	Aids in the removal and installation of powerhead nuts, and torquing nuts to specification.

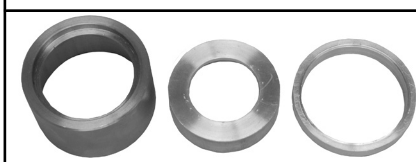
Cam Lock	91-896911A01
 5539	Prevents the intake and exhaust cam from turning while removing or installing cam retaining bolts.

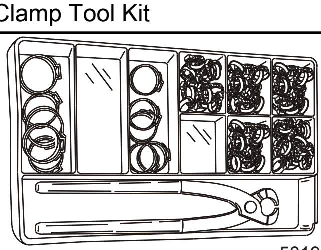
Rod Guide Dowel	Part number not available for this printing.
 4735	Prevents cylinder bore and crankshaft from damage while installing or removing connecting rod assembly.

Crankshaft Retainer	Part number not available for this printing.
 6191	Secures crankshaft to cylinder block while rotating block to install the cylinder head.

Ring Compressor	Part number not available for this printing
 4739	Compresses piston rings when installing the piston into the cylinder block.

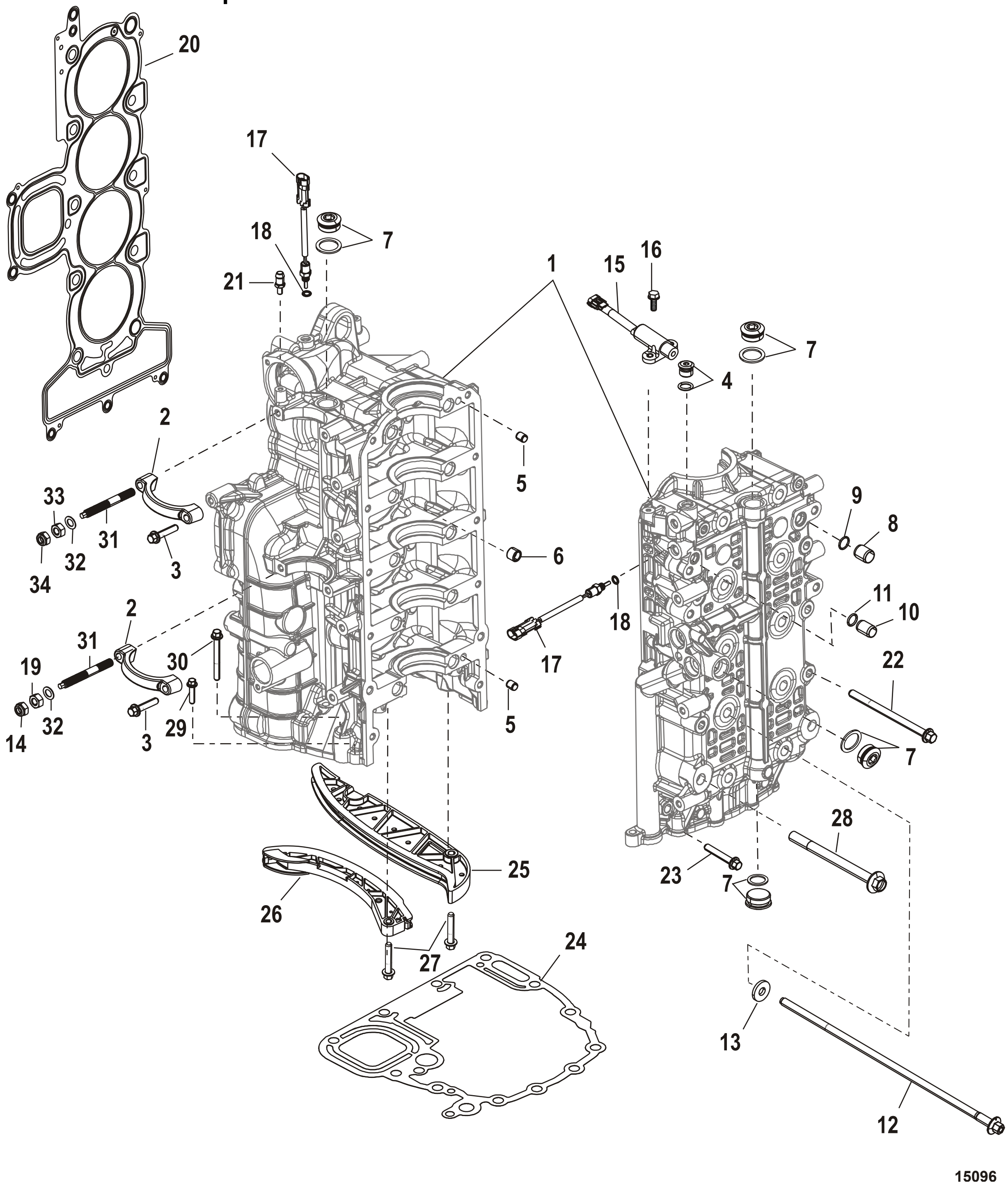
Crankshaft Retainer	Part number currently not available for this printing.
 6191	Secures crankshaft to cylinder block while rotating block to install the cylinder head.

Crankshaft Seal Installation Tool	Part number not available for this printing
 15499	Aids in the installation of the crankshaft seal.

Hose Clamp Tool Kit	91-803146A2
 5819	Aids in the installation of high pressure (Oetiker ®) hose clamps.

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.

Cylinder Block Components

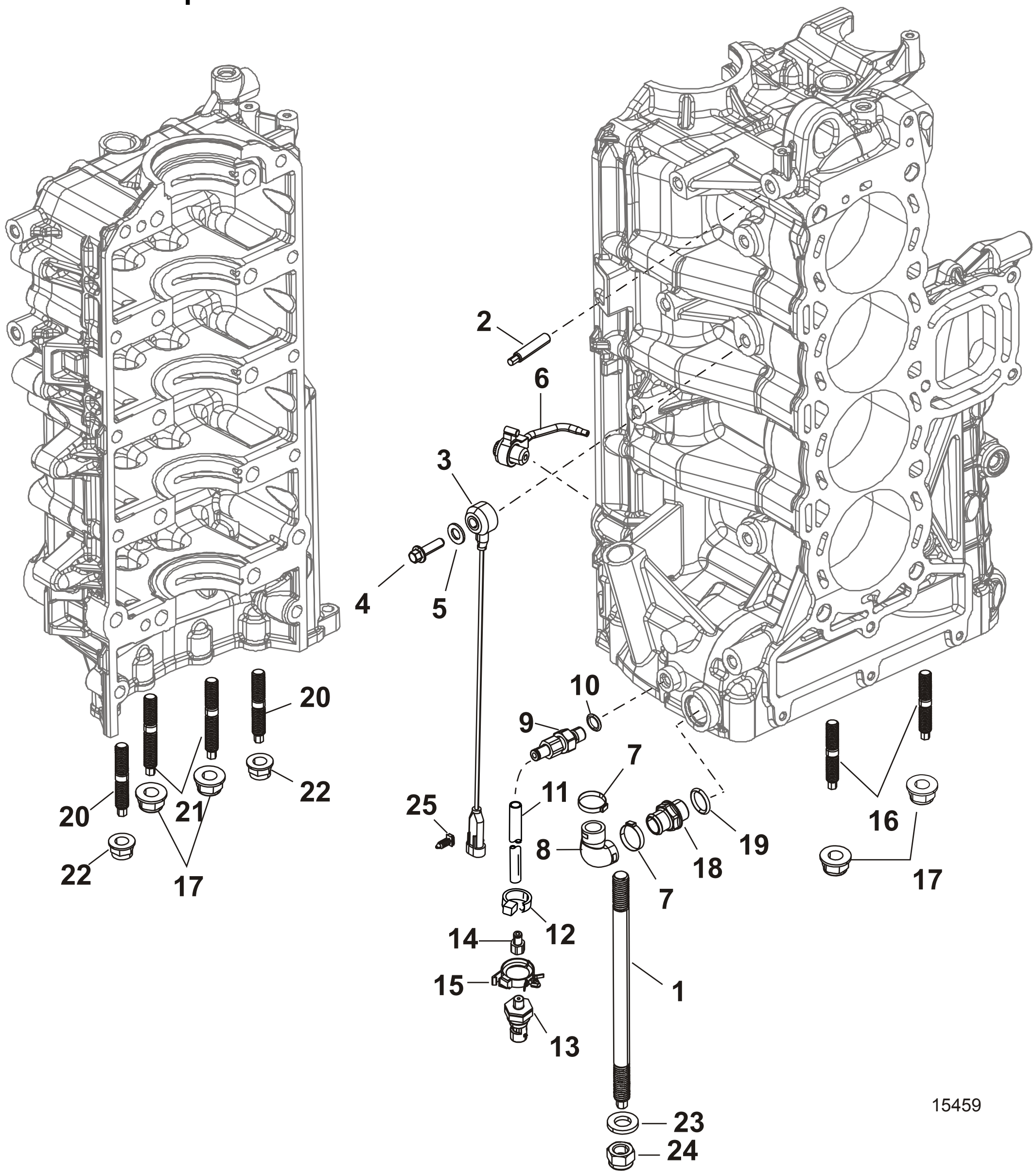


Cylinder Block Components

<table>
<tr><th rowspan="2">Ref. No.</th><th rowspan="2">Qty.</th><th rowspan="2" colspan="2">Description</th><th colspan="3">Torque</th></tr>
<tr><th>Nm</th><th>lb-in.</th><th>lb-ft</th></tr>
<tr><td>1</td><td>1</td><td colspan="2">Cylinder block assembly</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>2</td><td colspan="2">Bracket</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>2</td><td colspan="2">Bolt (M8 x 40)</td><td>17</td><td>150</td><td></td></tr>
<tr><td>4</td><td>2</td><td colspan="2">Plug (12 mm)</td><td>9</td><td>80</td><td></td></tr>
<tr><td>5</td><td>2</td><td colspan="2">Dowel pin</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>10</td><td colspan="2">Rubber dampener</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>4</td><td colspan="2">Plug (24 mm)</td><td>55</td><td></td><td>41</td></tr>
<tr><td>8</td><td>1</td><td colspan="2">Dowel pin (14 mm)</td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>1</td><td colspan="2">O-ring</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>1</td><td colspan="2">Dowel pin (11 mm)</td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>1</td><td colspan="2">O-ring</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">12</td><td rowspan="3">10</td><td rowspan="3">Bolt (M10 x 342)</td><td>First torque</td><td>27</td><td></td><td>20</td></tr>
<tr><td>Second torque</td><td>55</td><td></td><td>41</td></tr>
<tr><td>Final torque</td><td colspan="3">Turn additional 270°</td></tr>
<tr><td>13</td><td>10</td><td colspan="2">Washer</td><td></td><td></td><td></td></tr>
<tr><td>14</td><td>2</td><td colspan="2">Nut (M8)</td><td>25</td><td></td><td>18</td></tr>
<tr><td>15</td><td>1</td><td colspan="2">Crankshaft position sensor</td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>2</td><td colspan="2">Screw (M5 x 16)</td><td>5</td><td>45</td><td></td></tr>
<tr><td>17</td><td>2</td><td colspan="2">Temperature sensor</td><td>15</td><td>133</td><td></td></tr>
<tr><td>18</td><td>2</td><td colspan="2">O-ring</td><td></td><td></td><td></td></tr>
<tr><td>19</td><td>2</td><td colspan="2">Nut (M8)</td><td>25</td><td></td><td>18</td></tr>
<tr><td>20</td><td>1</td><td colspan="2">Head gasket</td><td></td><td></td><td></td></tr>
<tr><td>21</td><td>1</td><td colspan="2">Pin</td><td></td><td></td><td></td></tr>
<tr><td>22</td><td>8</td><td colspan="2">Bolt (M8 x 115)</td><td>35[1.]</td><td></td><td>26</td></tr>
<tr><td>23</td><td>2</td><td colspan="2">Bolt (M8 x 50)</td><td>35</td><td></td><td>26</td></tr>
<tr><td>24</td><td>1</td><td colspan="2">Gasket</td><td></td><td></td><td></td></tr>
<tr><td>25</td><td>1</td><td colspan="2">Fixed guide</td><td></td><td></td><td></td></tr>
<tr><td>26</td><td>1</td><td colspan="2">Movable guide</td><td></td><td></td><td></td></tr>
<tr><td>27</td><td>2</td><td colspan="2">Bolt (M8 x 45)</td><td>24</td><td></td><td>17.5</td></tr>
<tr><td>28</td><td>2</td><td colspan="2">Bolt (M10 x 120)</td><td>35</td><td></td><td>26</td></tr>
<tr><td>29</td><td>1</td><td colspan="2">Bolt (M8 x 35)</td><td>27</td><td></td><td>20</td></tr>
<tr><td>30</td><td>1</td><td colspan="2">Bolt (M8 x 75)</td><td>27</td><td></td><td>20</td></tr>
<tr><td>31</td><td>2</td><td colspan="2">Stud</td><td>10</td><td>89</td><td></td></tr>
<tr><td>32</td><td>1</td><td colspan="2">Washer</td><td></td><td></td><td></td></tr>
<tr><td>33</td><td>1</td><td colspan="2">Nut (M8)</td><td>17</td><td>150</td><td></td></tr>
<tr><td>34</td><td>1</td><td colspan="2">Nut (M8)</td><td>17</td><td>150</td><td></td></tr>
</table>

1. After #12 is fully tightened.

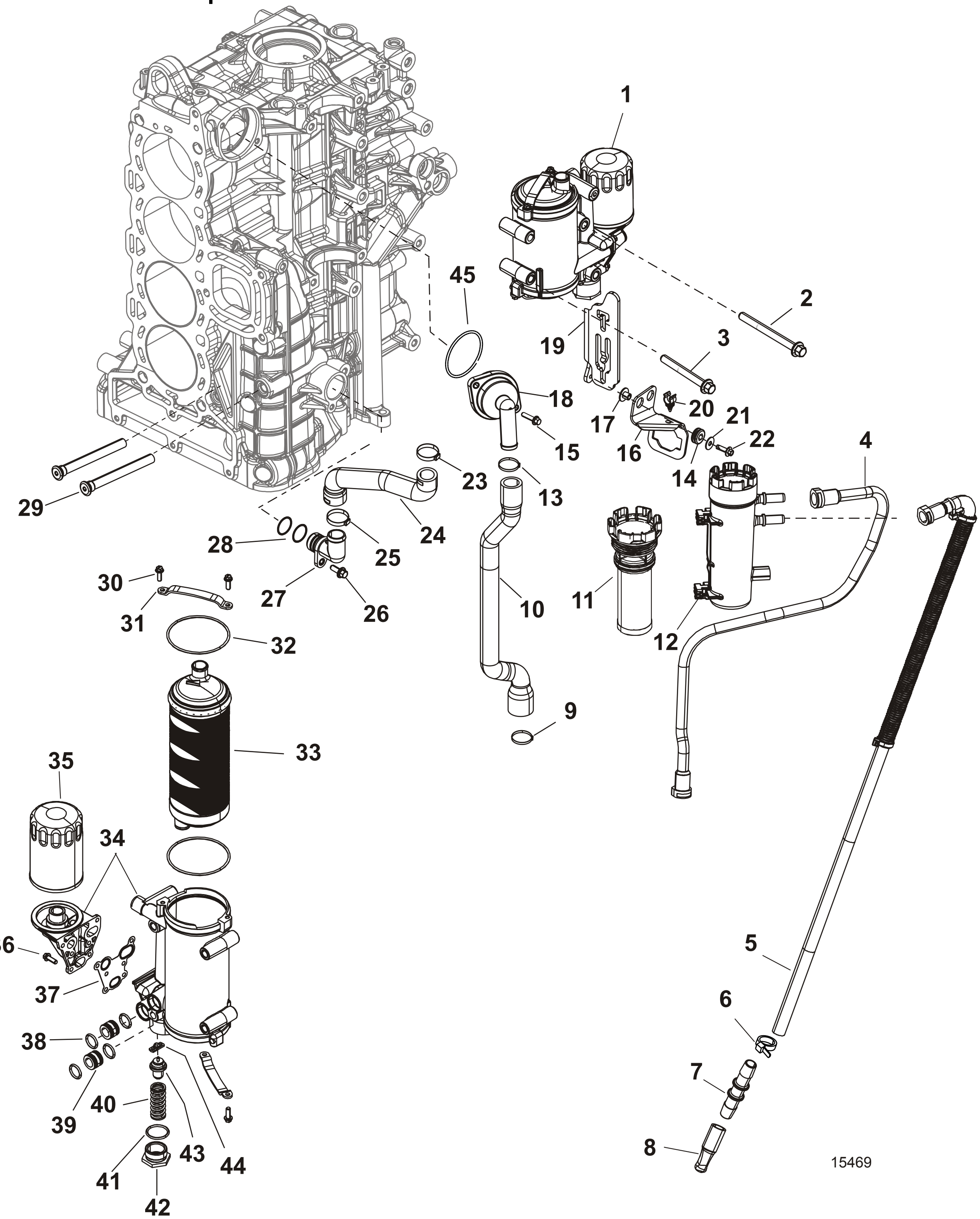
Cylinder Block Components - Port Side



Cylinder Block Components - Port Side

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	6	Stud (M10 x 175)	22.5		16.5
2	1	Stud (M10 x 50)	22.5		16.5
3	1	Knock sensor			
4	1	Bolt (M10 x 35)	20	177	
5	1	Washer			
6	4	Oil jet (S/N 1B517158 and below)	23		17
7	2	Clamp (34.6 mm)			
8	1	Hose			
9	1	Fitting assembly	17	150	
10	1	O-ring			
11	1	Tubing			
12	1	Cable tie			
13	1	Cylinder block water pressure sensor			
14	1	Adapter			
15	1	Clip			
16	2	Stud (M8 x 49)	10	89	
17	4	Nut (M8)	26		19
18	1	Fitting	16	142	
19	1	O-ring			
20	2	Stud (M10 x 54)	22.5		16.5
21	2	Stud (M8 x 55)	10	89	
22	2	Nut (M10)	61		45
23	6	Washer			
24	6	Nut (M10)	61		45
25	1	Clip			

Cylinder Block Component - Starboard Side

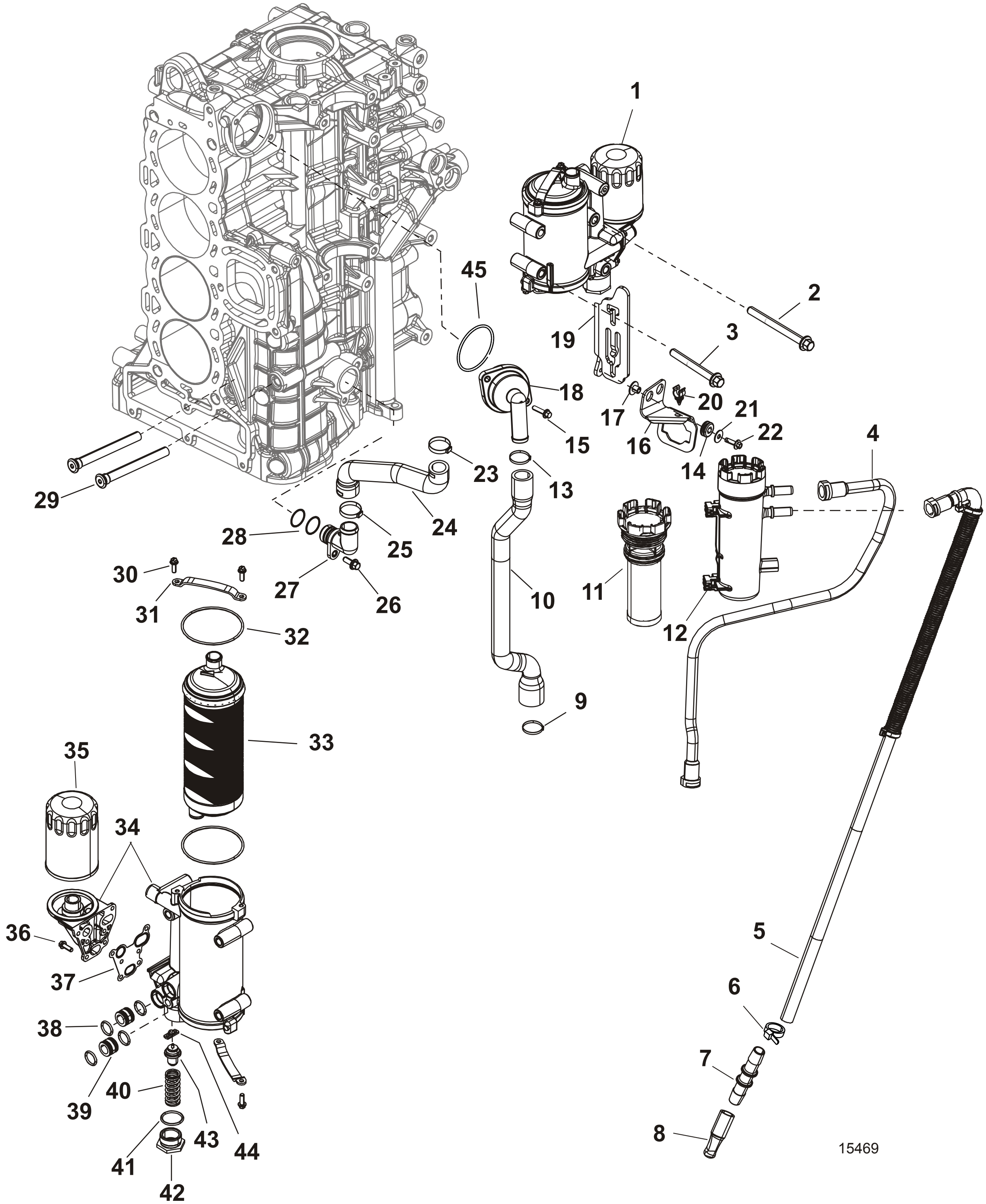


Cylinder Block Component - Starboard Side

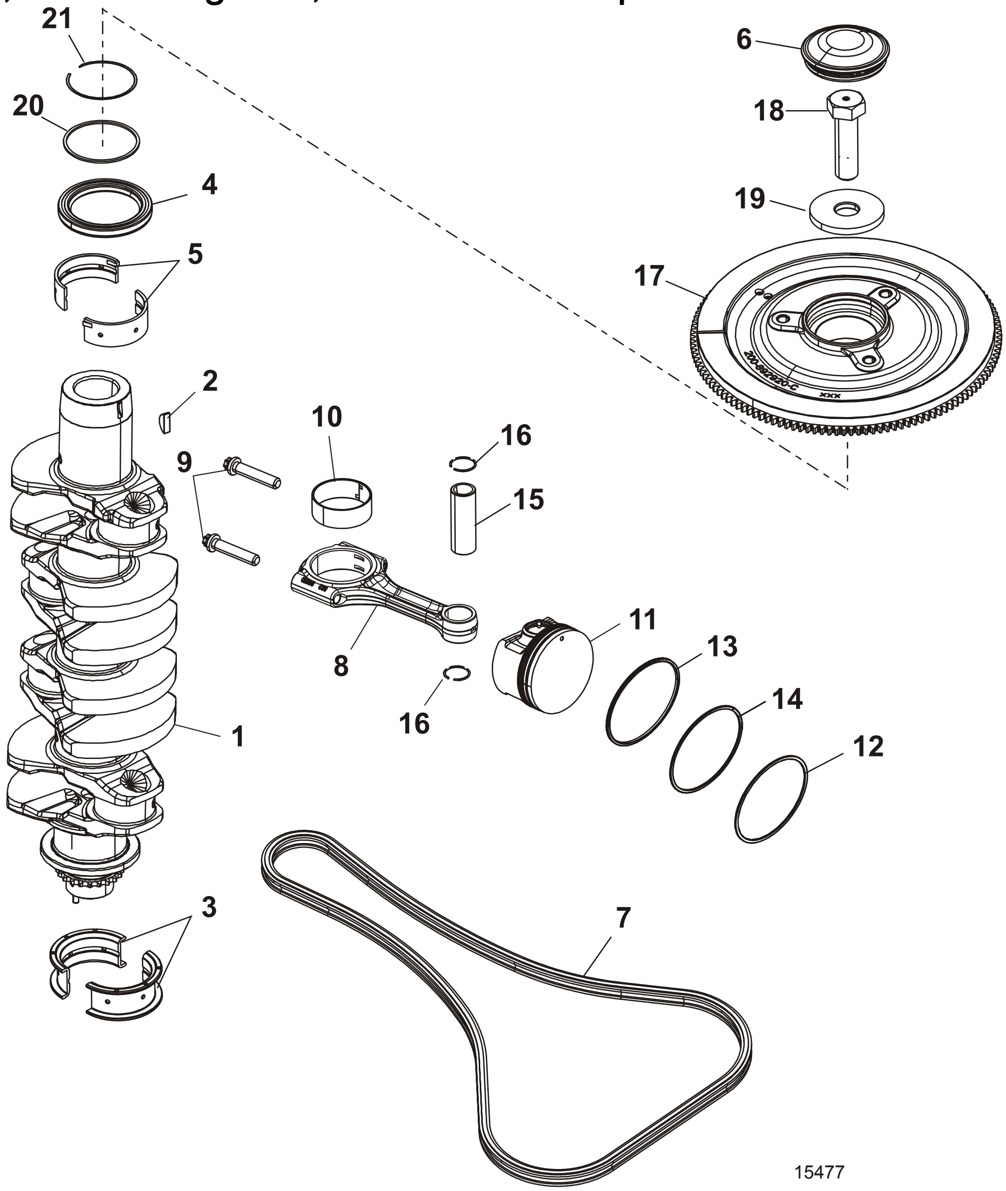
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Integrated oil module (IOM)			
2	1	Bolt (M10 x 105)	31		23
3	3	Bolt (M10 x 85)	31		23
4	1	Fuel hose (to lift pump)			
5	1	Fuel hose (fuel inlet)			
6	1	Cable tie			
7	1	Connector			
8	1	Grab tab			
9	1	Clamp (42.5 mm)			
10	1	Thermostat dump hose			
11	1	Fuel filter	7	62	
12	1	Filter housing			
13	1	Clamp (36.1 mm)			
14	2	Grommet			
15	2	Bolt (M6 x 25)	8	71	
16	1	Bracket			
17	2	Bushing			
18	1	Thermostat housing			
19	1	Bracket			
20	1	Clip			
21	2	Washer			
22	2	Bolt (M6 x 25)	8	71	
23	1	Clamp (34.6 mm)			
24	1	Hose			
25	1	Clamp (38.1 mm)			
26	1	Bolt (M6 x 16)	10	89	
27	1	Fitting			
28	2	O-ring			
29	2	Water deflector assembly	9	80	
30	4	Bolt (M6 x 18)	10	89	
31	2	Strap			
32	2	O-ring			
33	1	Tubestack			
34	1	IOM housing assembly			
35	1	Filter			
36	6	Bolt (M6 x 18)	10	89	
37	1	Gasket			
38	4	O-ring			
39	2	Dowel			
40	12	Spring			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
41	1	O-ring			
42	1	Thermostat retaining nut	24		17.5
43	1	Thermostat			
44	1	Brace			
45	1	Thermostat housing O-ring			

Cylinder Block Component - Starboard Side



Crankshaft, Connecting Rod, and Piston Components



Crankshaft, Connecting Rod, and Piston Components

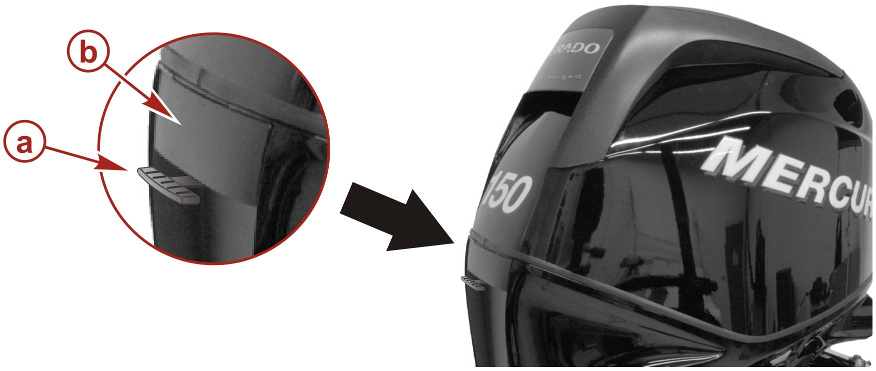
<table>
<tr><th rowspan="2">Ref. No.</th><th rowspan="2">Qty.</th><th rowspan="2" colspan="2">Description</th><th colspan="3">Torque</th></tr>
<tr><th>Nm</th><th>lb-in.</th><th>lb-ft</th></tr>
<tr><td>1</td><td>1</td><td colspan="2">Crankshaft</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>1</td><td colspan="2">Woodruff key</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>1</td><td colspan="2">Lower bearing</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>1</td><td colspan="2">Seal</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>4</td><td colspan="2">Main bearing</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>1</td><td colspan="2">Cap</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>1</td><td colspan="2">Timing chain</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>4</td><td colspan="2">Connecting rod</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">9</td><td rowspan="3">8</td><td rowspan="3">Bolt</td><td>First torque</td><td>15</td><td>133</td><td></td></tr>
<tr><td>Second torque</td><td>30</td><td></td><td>22</td></tr>
<tr><td>Final torque</td><td colspan="3">Turn additional 90° after second torque</td></tr>
<tr><td>10</td><td>4</td><td colspan="2">Connecting rod bearing</td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>4</td><td colspan="2">Piston</td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>4</td><td colspan="2">Top piston ring</td><td></td><td></td><td></td></tr>
<tr><td>13</td><td>4</td><td colspan="2">Oil piston ring</td><td></td><td></td><td></td></tr>
<tr><td>14</td><td>4</td><td colspan="2">Second piston ring</td><td></td><td></td><td></td></tr>
<tr><td>15</td><td>4</td><td colspan="2">Piston pin</td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>8</td><td colspan="2">Circlip</td><td></td><td></td><td></td></tr>
<tr><td>17</td><td>1</td><td colspan="2">Flywheel</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">18</td><td rowspan="2">1</td><td rowspan="2">Bolt</td><td>First torque</td><td>60</td><td></td><td>44.2</td></tr>
<tr><td>Final torque</td><td>180</td><td></td><td>132.8</td></tr>
<tr><td>19</td><td>1</td><td colspan="2">Washer</td><td></td><td></td><td></td></tr>
<tr><td>20</td><td>1</td><td colspan="2">Spacer</td><td></td><td></td><td></td></tr>
<tr><td>21</td><td>1</td><td colspan="2">Retaining ring</td><td></td><td></td><td></td></tr>
</table>

Cowling Removal and Installation (S/N 1B290194 and Below)

Top Cowl Removal and Installation

Top Cowl Removal

1. Unlock the top cowl by pushing down on the latch catch and pull up the cowl lock latch.
2. Lift up the rear of the cowl and disengage the front cowl hook. Lift the top cowl off of the engine.



15303

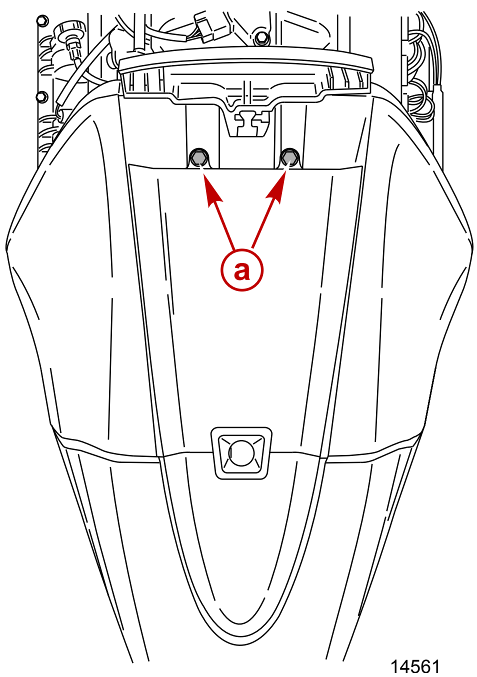
a - Latch catch
b - Cowl lock latch

Top Cowl Installation

1. Lower the top cowl over the engine. Bring the front of the cowl down first and engage the front cowl hook. Lower the cowl into its seated position with the bottom cowl.
2. Apply downward pressure on the back of the top cowl and secure in place by pushing in the cowl lock latch. Ensure the top cowl is securely fastened by pulling up on the back of the cowl.

Chap Removal

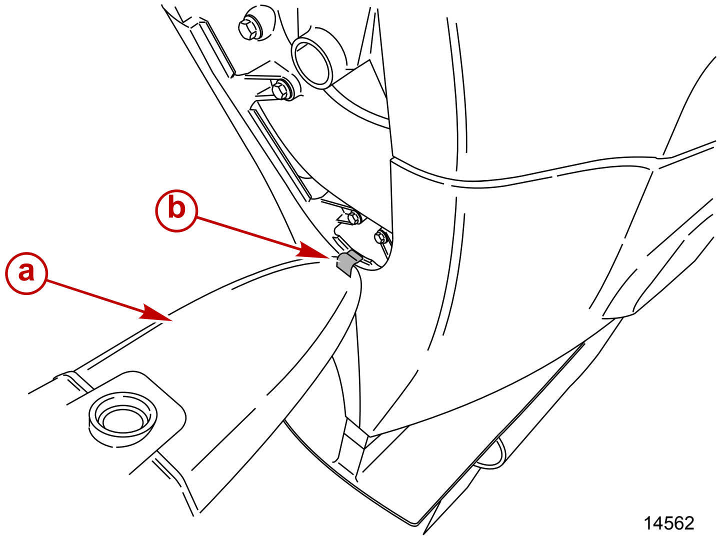
1. Remove top cowl.
2. Remove two screws securing center rear cover.



14561

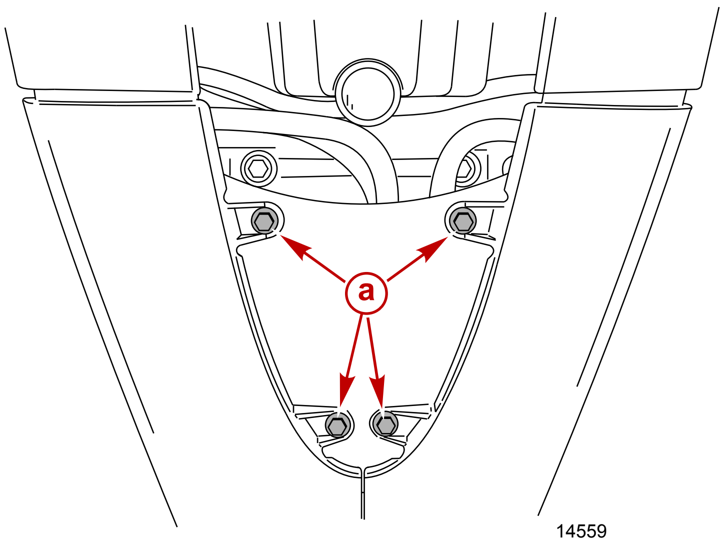
a - Screws

3. Remove center rear cover.



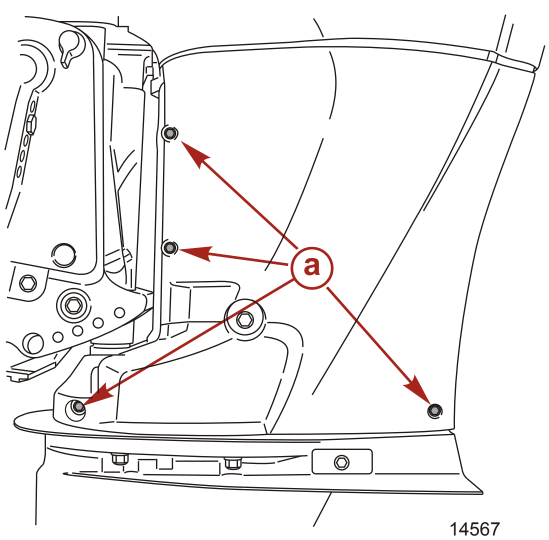
a - Center rear cover
b - Retaining tab

4. Remove the four rear chap attaching screws.



a - Screws

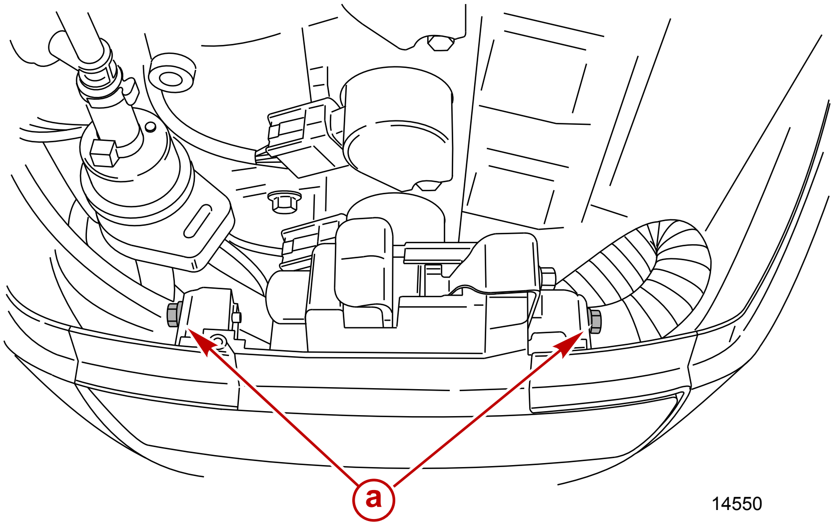
5. Remove the four screws from the side of each chap and remove the chaps.



a - Screws (4 each side)

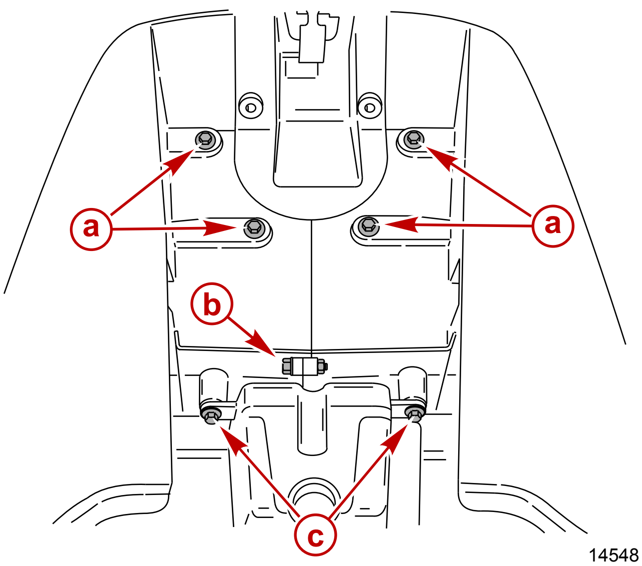
Pan Removal

1. Remove two screws and nuts securing aft end of pans.



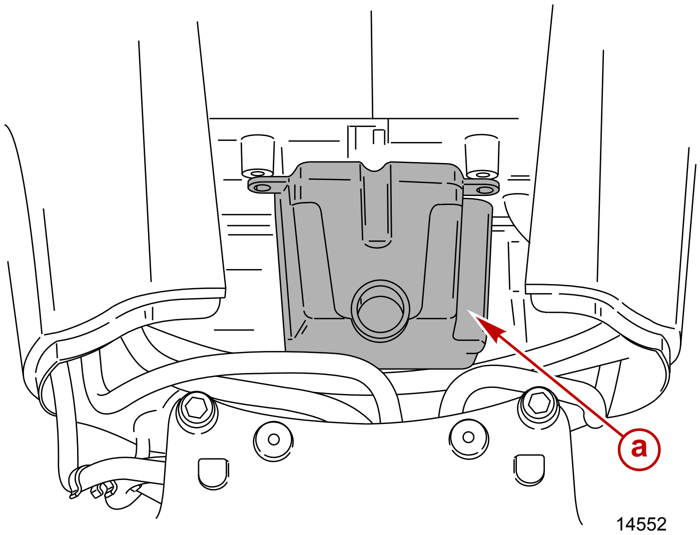
a - Screws and nuts

2. Remove four screws securing cowl latch to aft end of pans and remove latch.
3. Remove two screws securing muffler to pans.
4. Remove screw and nut securing aft end of pans together.



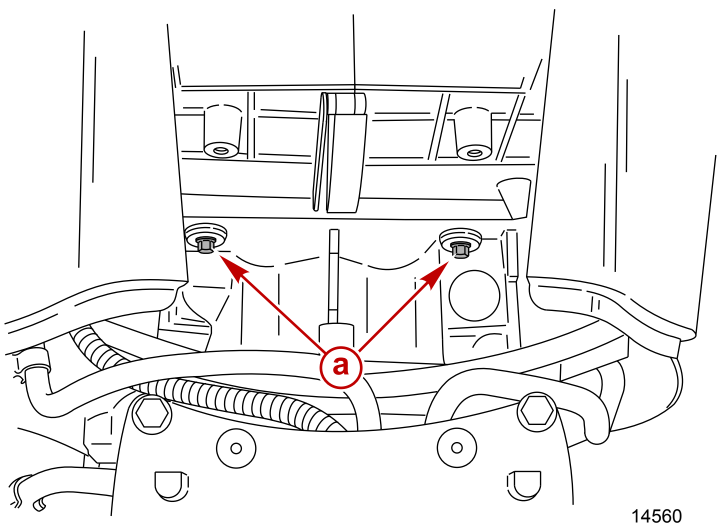
a - Cowl latch screws
b - Aft pan screw and nut
c - Muffler attaching screws

5. Remove muffler.



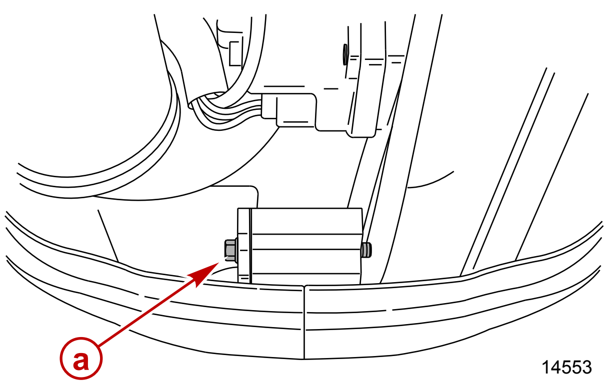
a - Muffler

6. Remove two screws securing aft end of pans.



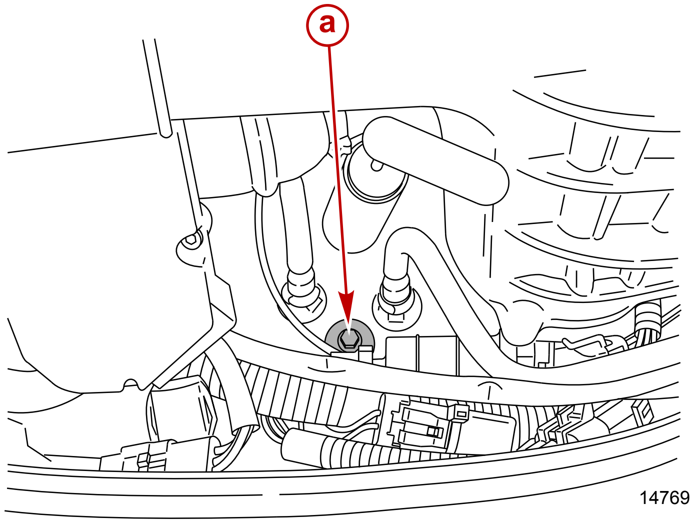
a - Screws

7. Remove front screw and nut securing pans together.



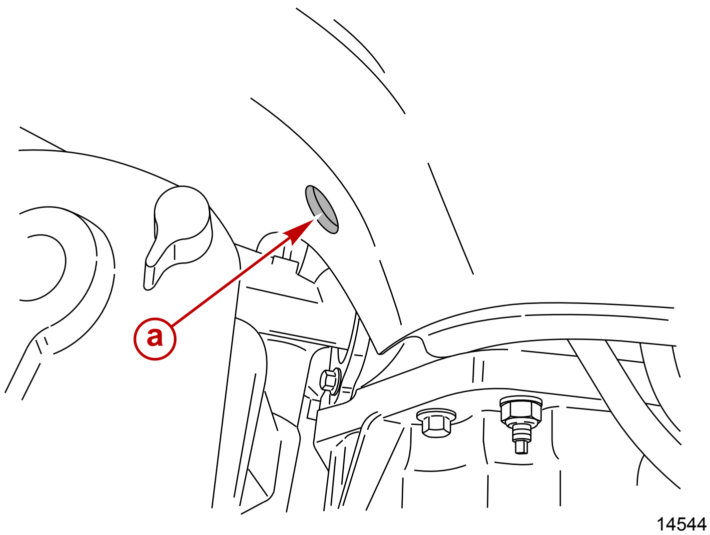
a - Screw and nut

8. Remove port pan top side screw.



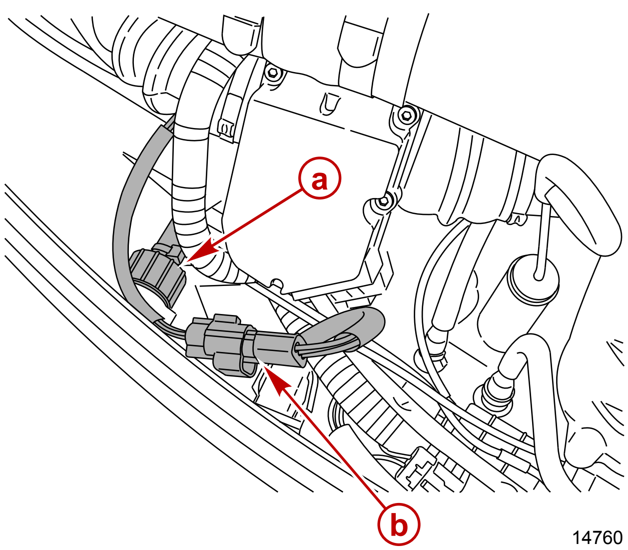
a - Top screw

9. Remove port pan front bottom screw.



a - Bottom screw

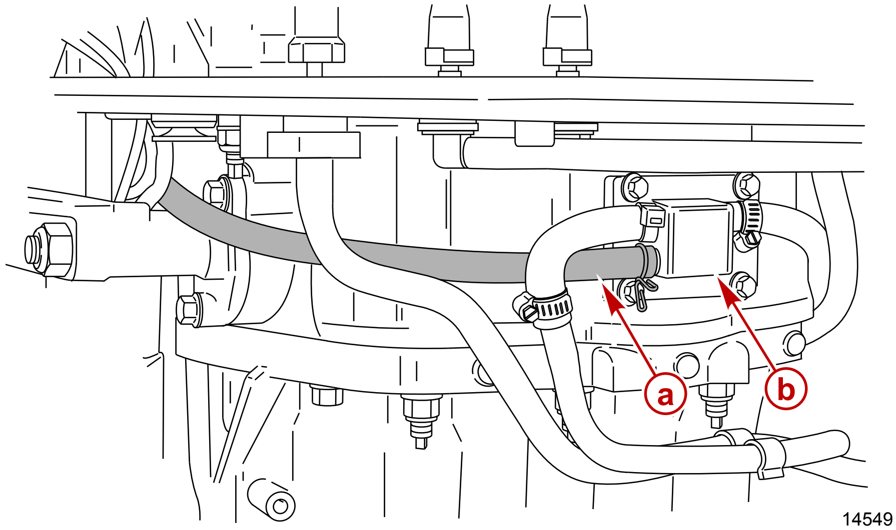
10. Unscrew water flush hose.
11. Disconnect tilt switch connector.



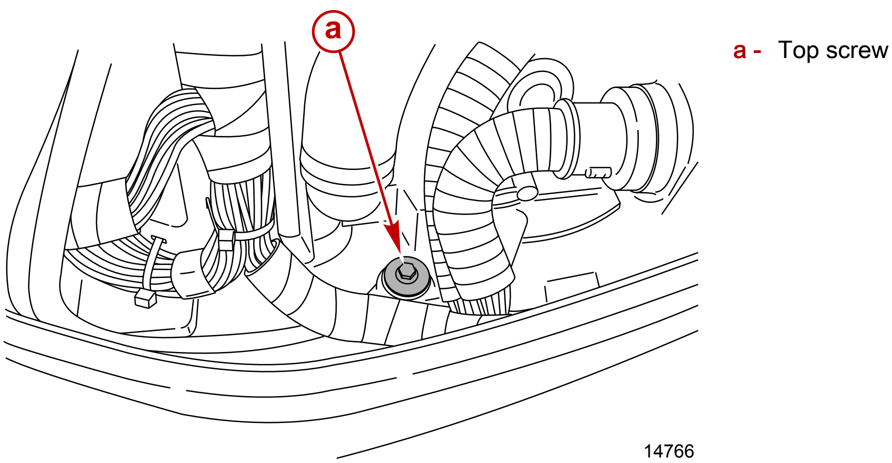
a - Water flush hose
b - Tilt switch connector

12. Remove port side pan.

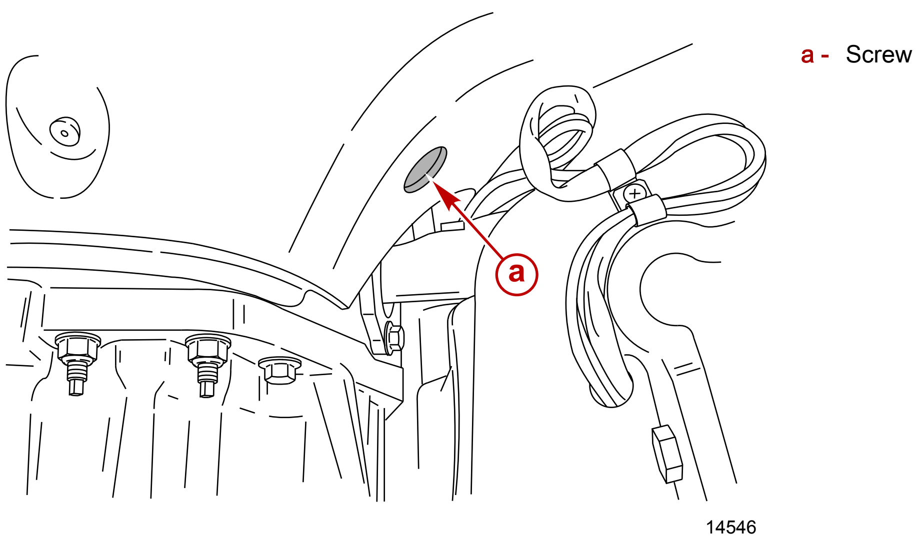
13. Remove tell-tale hose from manifold housing.



14. Remove starboard pan top screw.



15. Remove starboard pan front bottom screw.

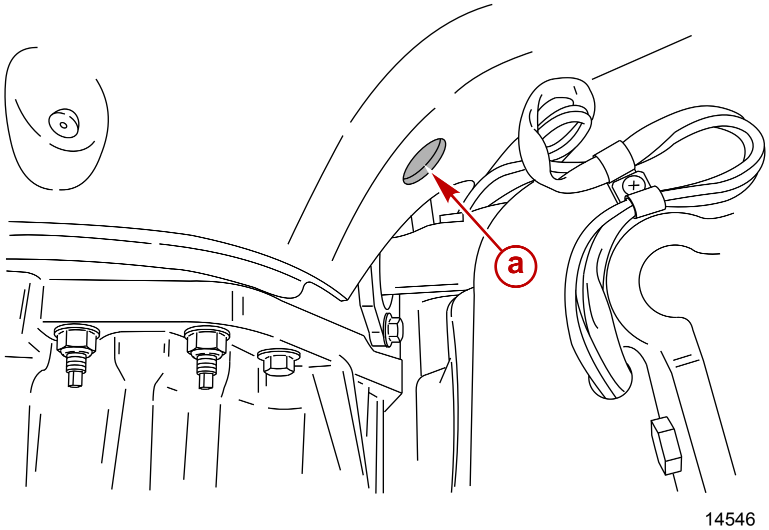


16. Remove starboard pan.

Pan Installation

1. Install starboard pan.
2. Route tell-tale hose behind shift shaft to manifold housing on port side of engine.

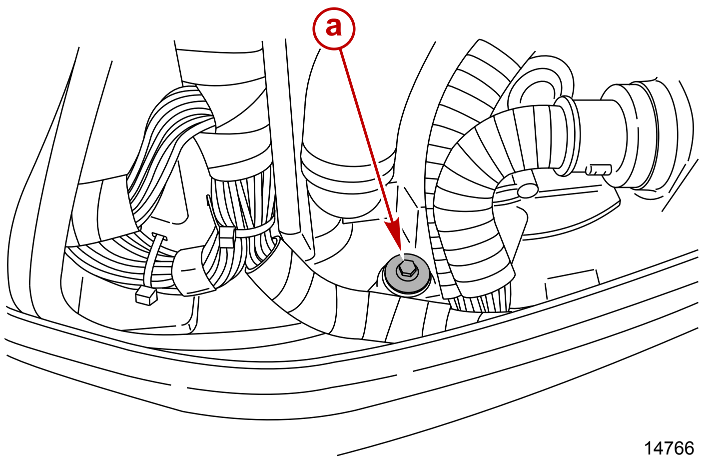
3. Install starboard pan front bottom screw.



a - Screw

Description	Nm	lb. in.	lb. ft.
Screw (M6)	10	89	

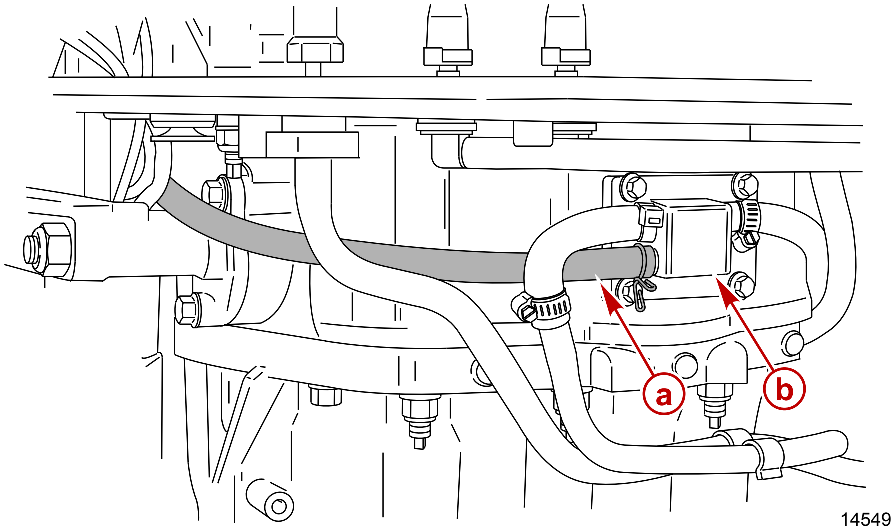
4. Install starboard pan top screw.



a - Screw

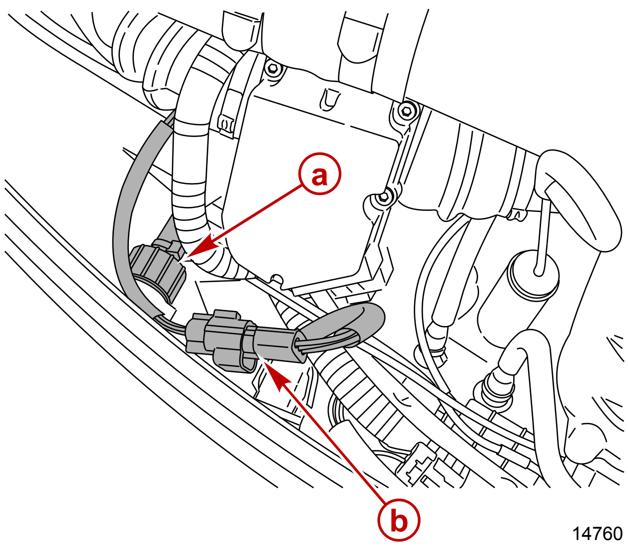
Description	Nm	lb. in.	lb. ft.
Screw (M6)	10	89	

5. Install tell-tale hose onto manifold housing.



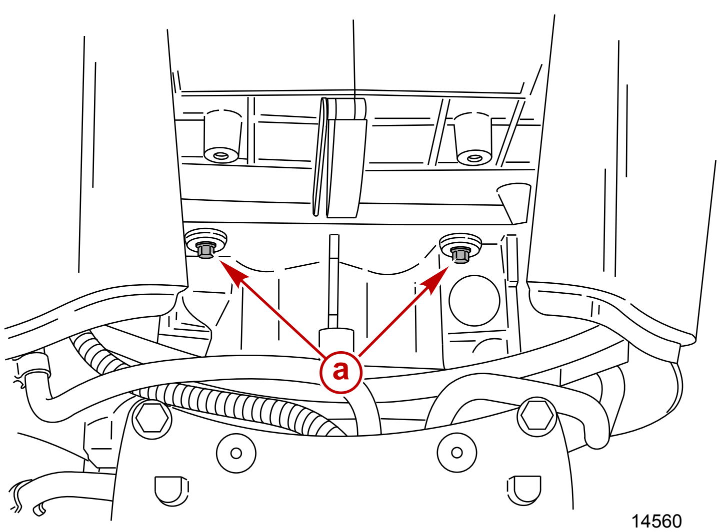
a - Tell-tale hose
b - Manifold housing

6. Install port side pan.
7. Connect water flush hose.
8. Connect tilt switch connector.



a - Water flush hose
b - Tilt switch connector

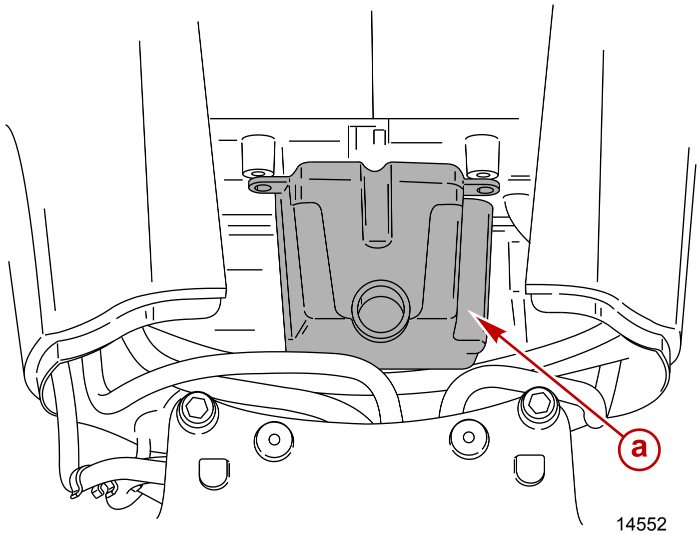
9. Install two screws securing aft end of pans.



a - Screws

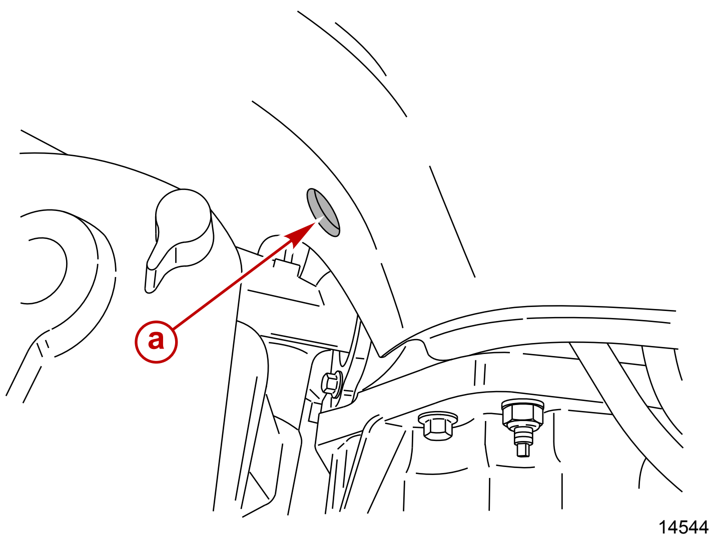
Description	Nm	lb. in.	lb. ft.
Screw (M6)	10	89	

10. Install muffler.



a - Muffler

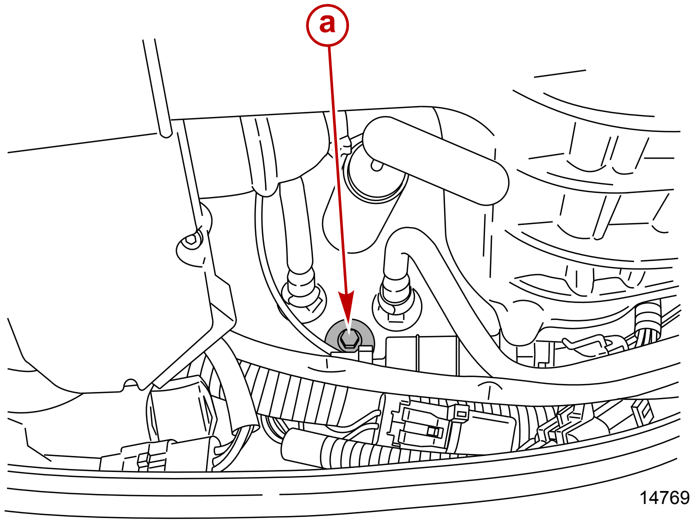
11. Install port pan front bottom screw.



a - Screw

Description	Nm	lb. in.	lb. ft.
Screw (M6)	10	89	

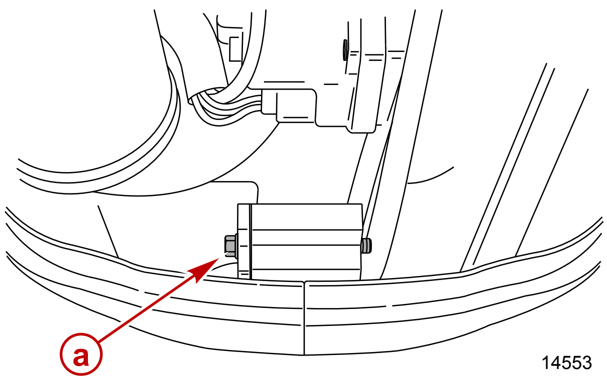
12. Install port pan top screw.



a - Screw

Description	Nm	lb. in.	lb. ft.
Screw	10	89	

13. Install front screw and nut securing pans together.

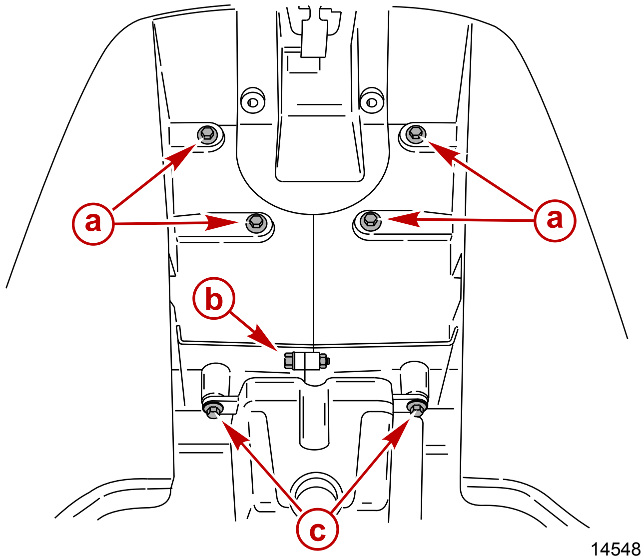


a - Screw and nut

Description	Nm	lb. in.	lb. ft.
Screw and nut (M6 x 55)	10	89	

14. Install two screws securing muffler. Torque screws to specification.
15. Install bottom screw and nut securing aft end of pans together. Torque screw to specification.

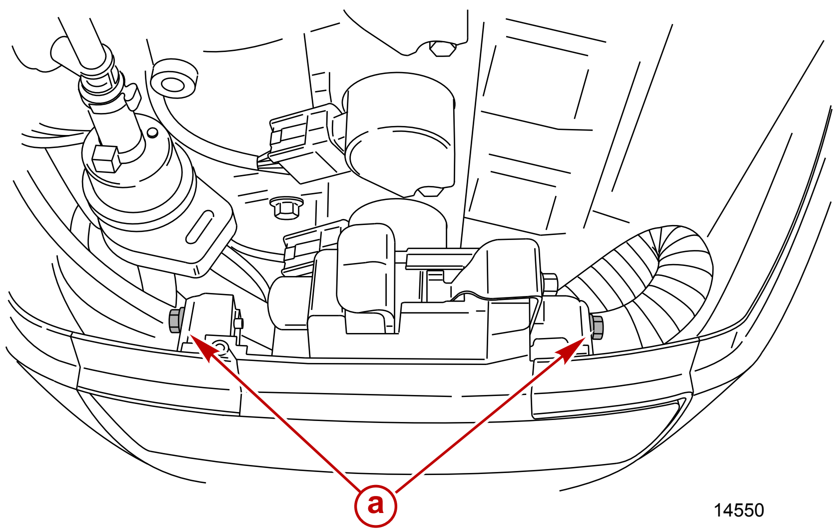
16. Install top cowl latch assembly and secure with four screws. Torque screws to specification.



a - Cowl latch screws (M6)
b - Screw and nut (M6 x 25)
c - Muffler attaching screws (M6 x 20)

Description	Nm	lb. in.	lb. ft.
Screw (M6)	6	53	
Screw and nut (M6 x 25)	10	89	
Screw (M6 x 20)	6	53	

17. Install two top screws and nuts securing aft end of pans together. Torque screws to specification.

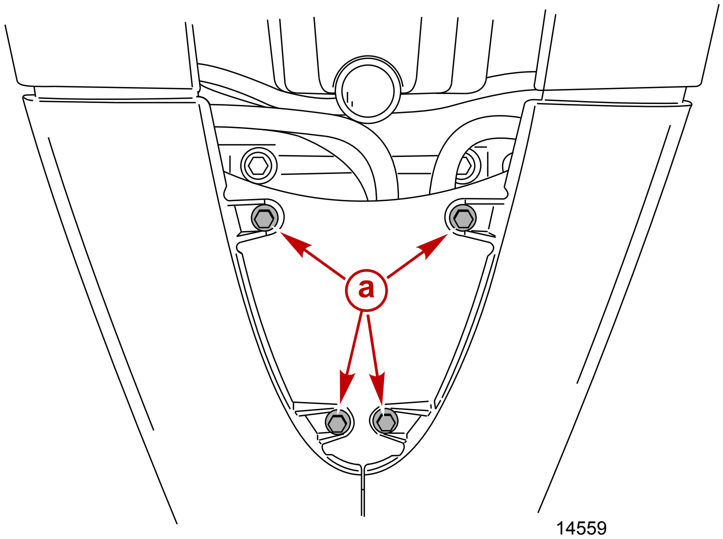


a - Screws and nut

Description	Nm	lb. in.	lb. ft.
Screws	10	88.5	

Chap Installation

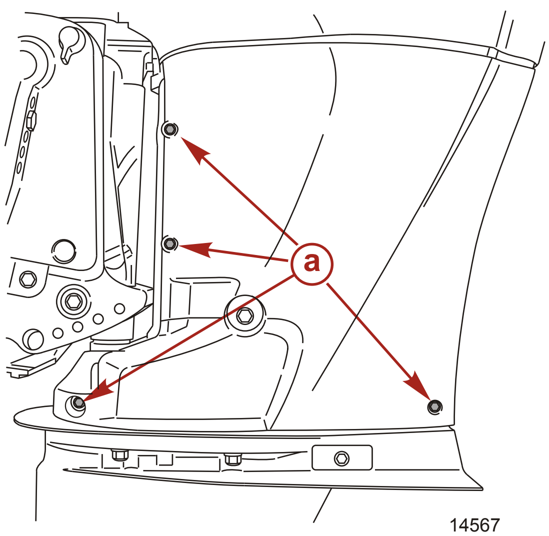
1. Install port and starboard chap onto driveshaft housing. Secure aft end of chaps with four attaching screws. Torque screws to specification.



a - Screws

Description	Nm	lb-in.	lb-ft
Screw	10	89	

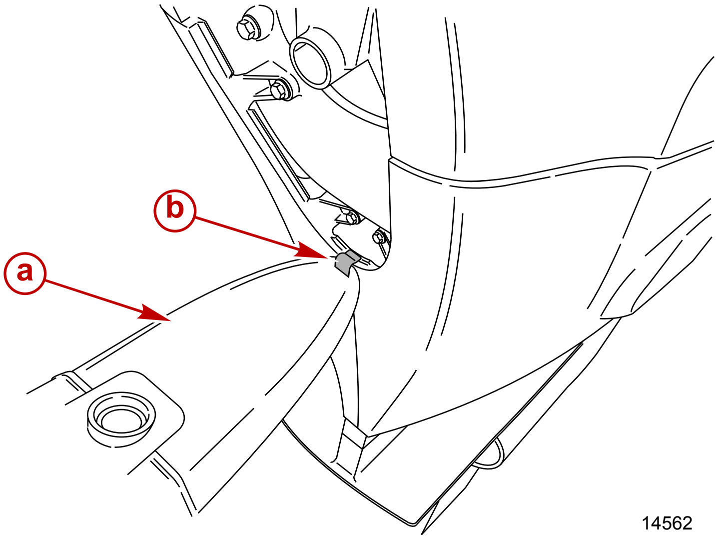
2. Secure sides of each chap with four attaching screws. Torque screws to specification.



a - Screws

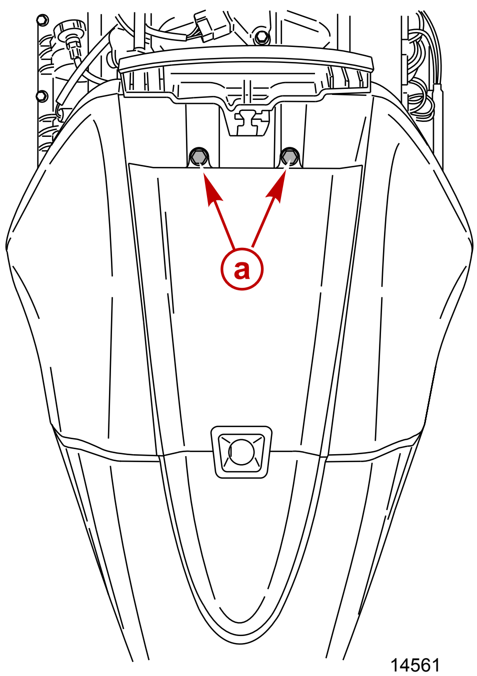
Description	Nm	lb-in.	lb-ft
Screw	10	89	

3. Install center rear cover positioning retaining tab into chaps.



a - Center rear cover
b - Retaining tab

4. Secure center rear cover with two screws. Torque screws to specification.



a - Screws

Description	Nm	lb-in.	lb-ft
Screw	10	89	

5. Install top cowl.

Cowling Removal and Installation (S/N 1B290195 and Above)

Top Cowl Removal and Installation

Removal

Unlock the top cowl by pulling out on the rear cowl latch. Lift the top cowl off the engine.

29767

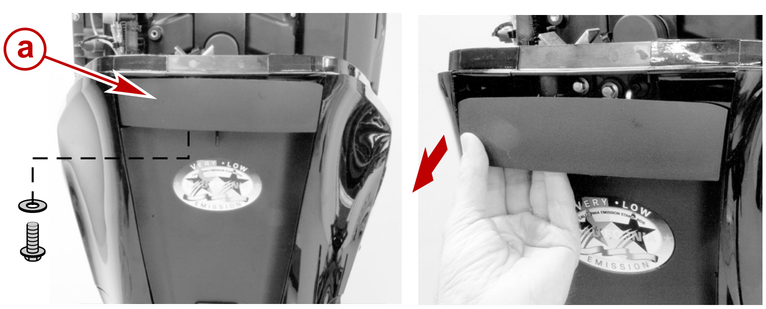
Installation

Bring the front of the cowl down first and engage the front cowl hook. Lower the cowl into the seated position and apply downward pressure to the back of the cowl to lock it in place. Ensure the cowl is securely fastened by trying to pull up on the back of the cowl.

29768

Rear Cover and Cowl Latch Removal

1. Remove the pivot screw and flat washer from the rear cowl latch.
2. Pull out and down on the rear corner of the latch to clear the rear cover. Remove the rear cowl latch.

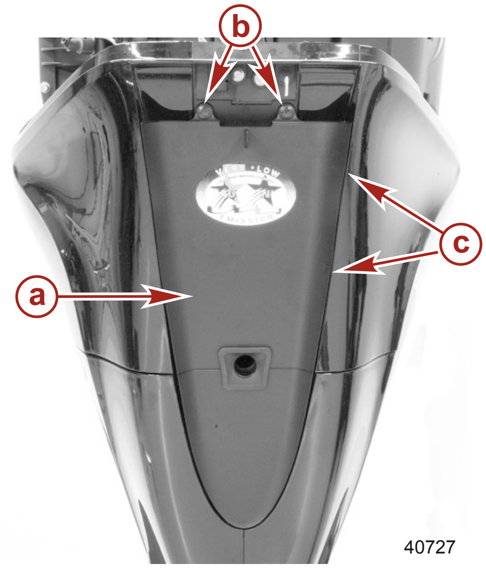


29740

a - Rear cowl latch handle

3. Remove the two screws securing the rear cover.

4. Locate the two arrows (pry points) on the rear cover. Use a thin blade screwdriver at these pry points and pry the cover off. Remove the rear cover.

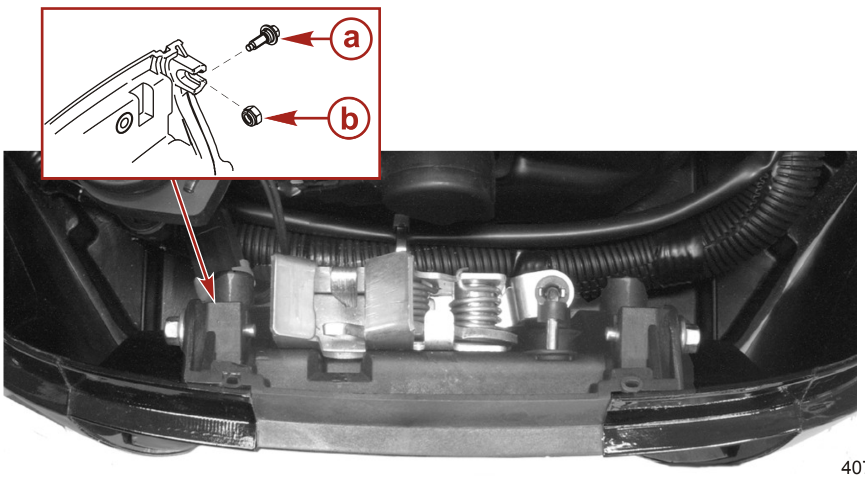


40727

a - Rear cover
b - Shoulder screw (M6 x 20)
c - Arrow (pry point)

5. Remove the two screws and locknuts securing the cowl latch.

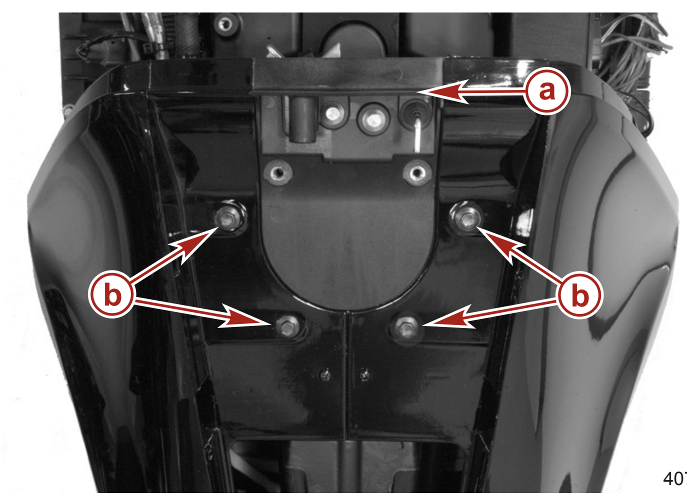
NOTE: The locknuts are loosely retained in a slot in the panel.



40728

a - Shoulder screw (M6 x 20 stainless) (2)
b - Locknut (2)

6. Remove the four screws securing the rear latch assembly. Remove the rear latch assembly.

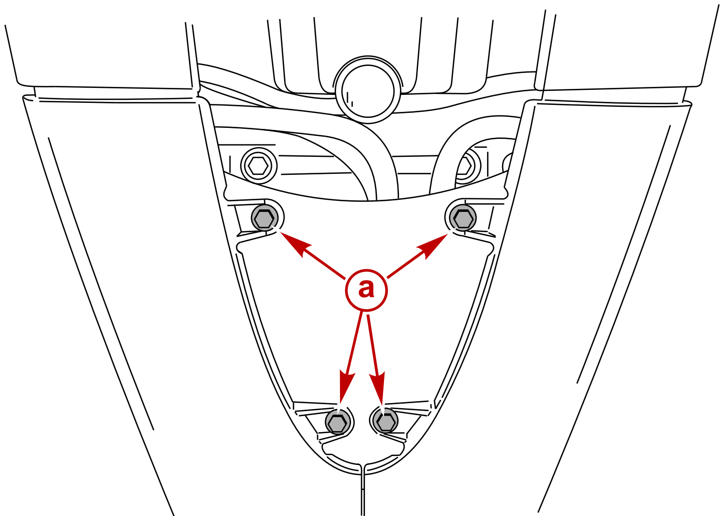


40729

a - Rear latch assembly
b - Shoulder screw (M6 x 20 black) (4)

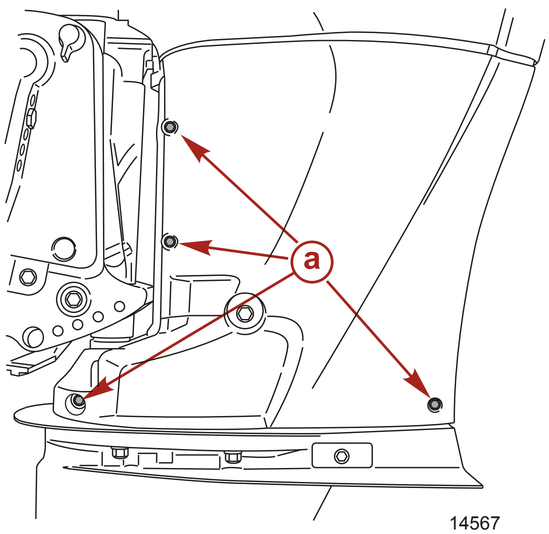
Chap Removal

1. Remove the four rear chap attaching screws.



a - Shoulder screw (M6 x 20 black) (4)

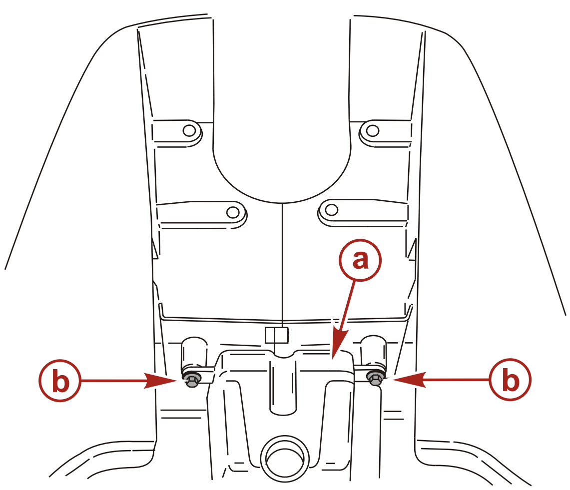
2. Remove the four screws from the side of each chap and remove the chaps.



a - Shoulder screw (M6 x 20 black) (4 each side)

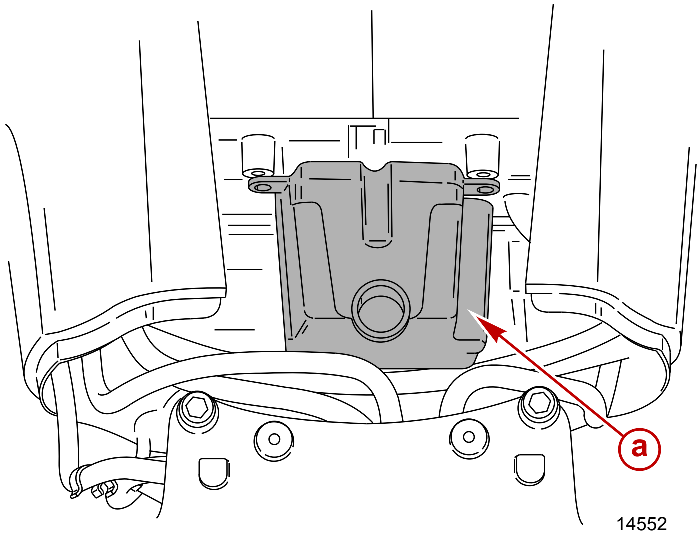
Pan Removal

1. Remove the two screws securing the muffler to the pans.



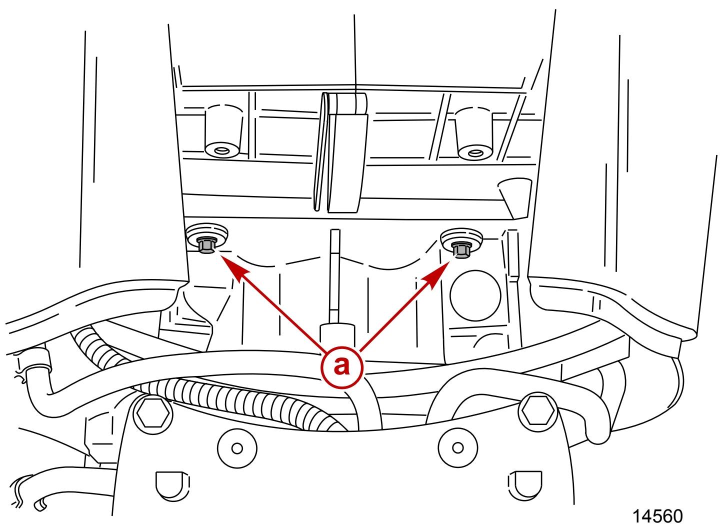
a - Muffler
b - Shoulder screw (M6 x 20 black) (2)

2. Remove the muffler.



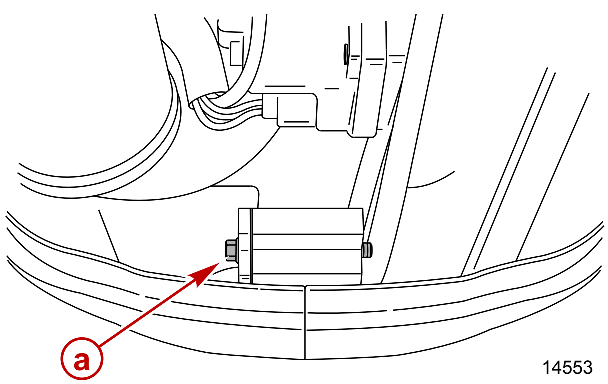
a - Muffler

3. Remove the two screws securing the aft end of the pans.



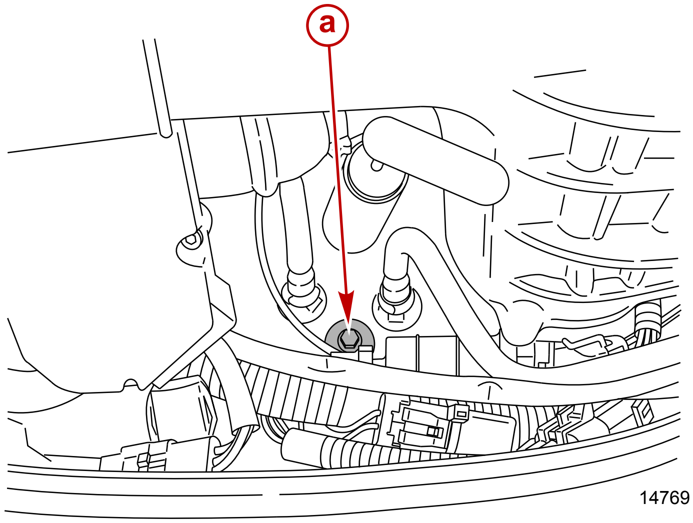
a - Shoulder screw (M6 x 35 stainless) (2)

4. Remove the front screw and locknut securing the pans together.



a - Screw and locknut (M6 x 55)

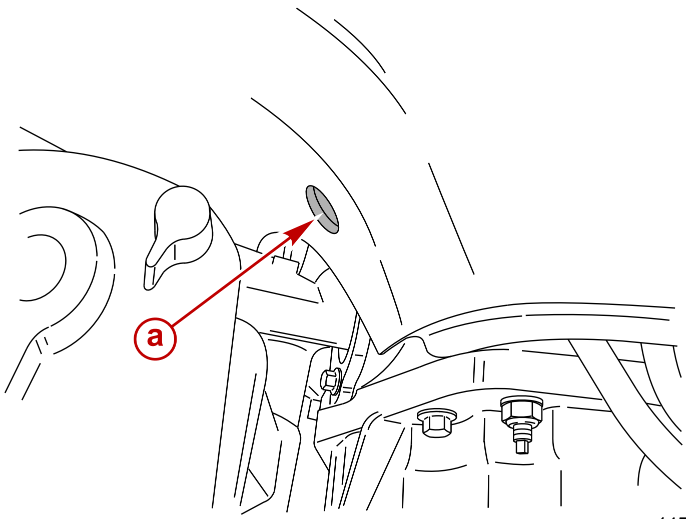
5. Remove the port pan top side screw.



14769

a - Screw (M6 x 35 stainless)

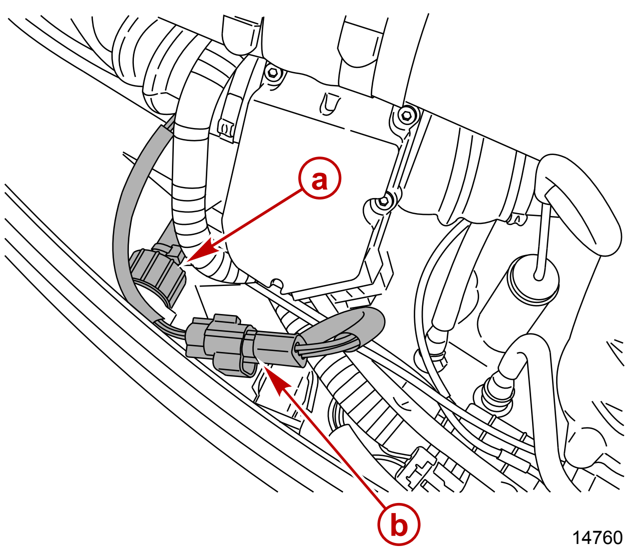
6. Remove the port pan front bottom screw.



14544

a - Screw (M6 x 35 stainless)

7. Unscrew the water flush hose.
8. Disconnect the tilt switch connector.

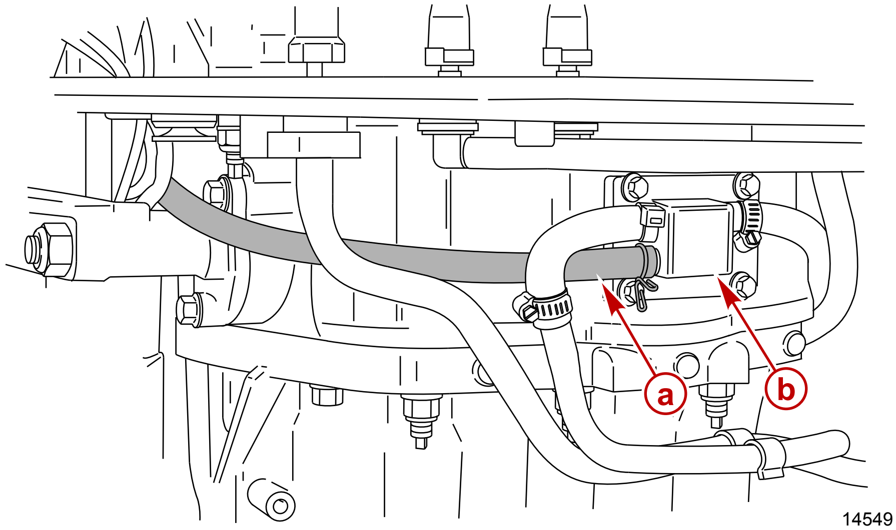


14760

a - Water flush hose
b - Tilt switch connector

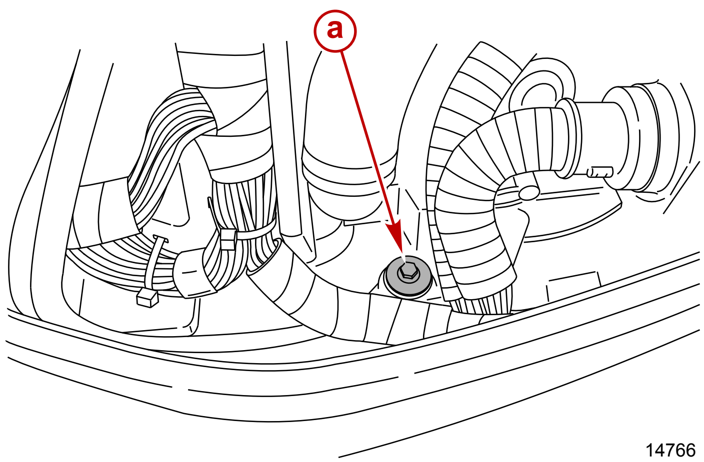
9. Remove the port pan.

10. Remove the tell-tale hose from the manifold housing.



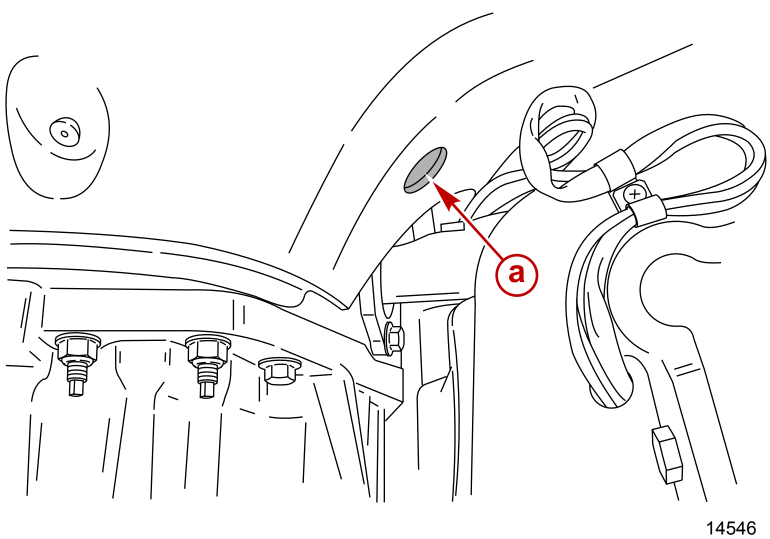
a - Tell-tale hose
b - Manifold housing

11. Remove the starboard pan top screw.



a - Screw (M6 x 35 stainless)

12. Remove the starboard pan front bottom screw.



a - Screw (M6 x 35 stainless)

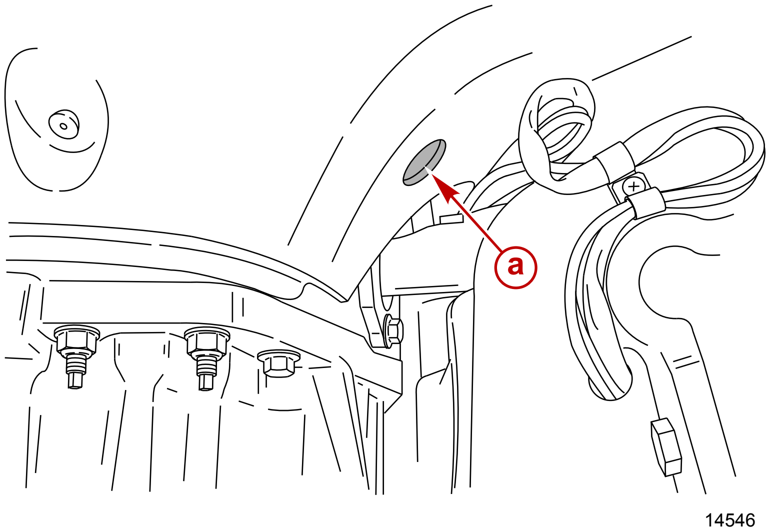
13. Remove the battery cables and fuel line through the grommet.
14. Remove the starboard pan.

Pan Installation

1. Route the rigging through the grommet in the starboard pan.
2. Install the starboard pan.

3. Route the tell-tale hose behind the shift shaft to the manifold housing.
4. Install the front bottom screw. Tighten the screw to the specified torque.

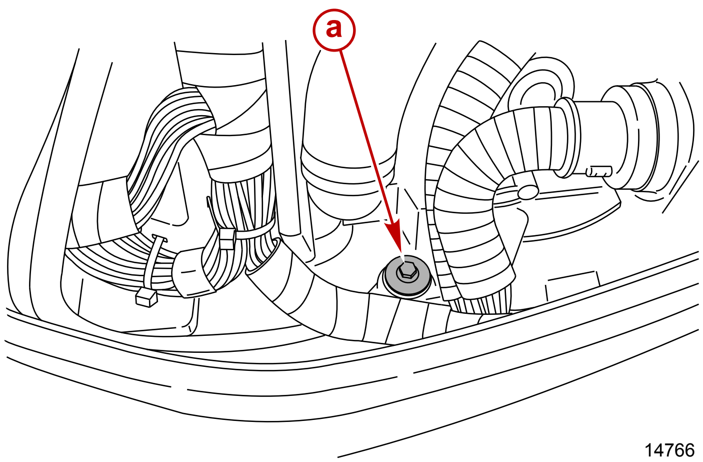
   IMPORTANT: Ensure the black plastic bushing is installed in the rubber grommet when installing each of the six screws securing the pan.



a - Screw (M6 x 35 stainless)

Description	Nm	lb-in.	lb-ft
Screw (M6 x 35 stainless)	10	89	

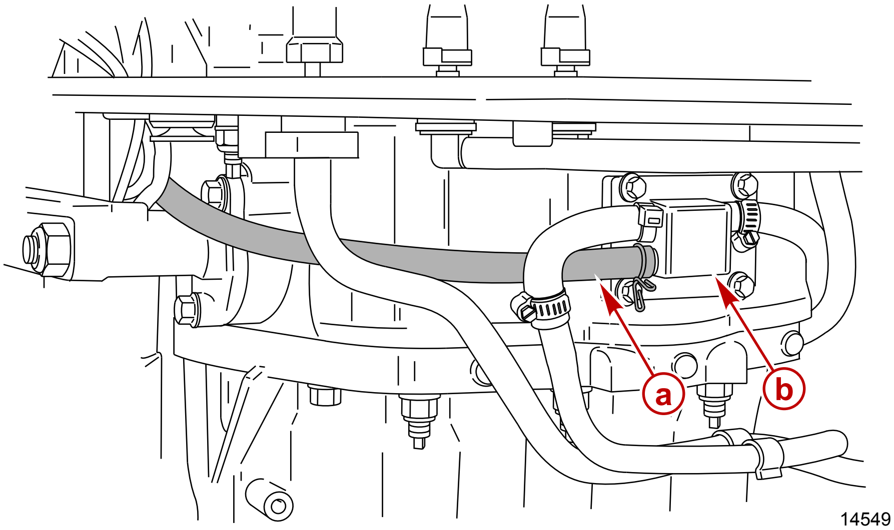
5. Install the top screw. Tighten the screw to the specified torque.



a - Screw (M6 x 35 stainless)

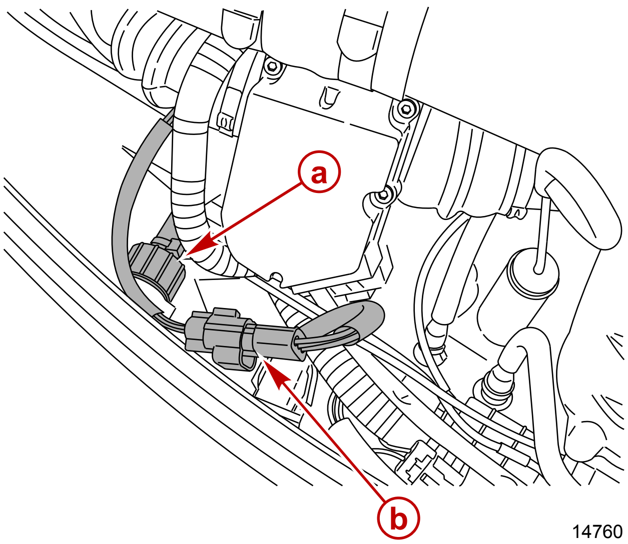
Description	Nm	lb-in.	lb-ft
Screw (M6 x 35 stainless)	10	89	

6. Install the tell-tale hose onto the manifold housing.



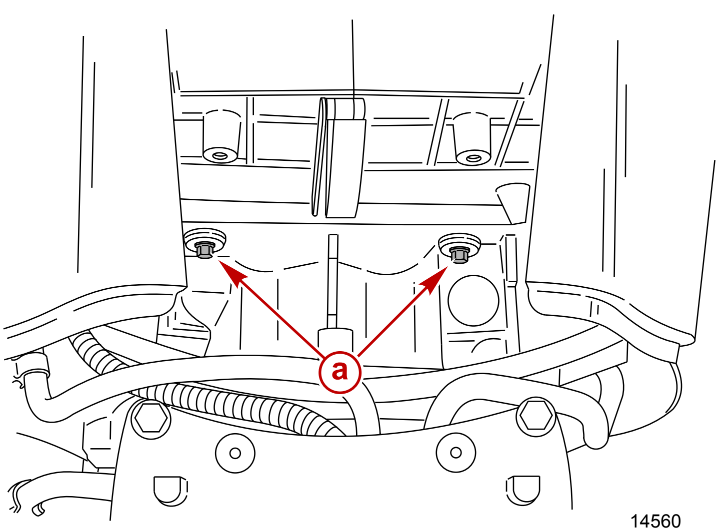
a - Tell-tale hose
b - Manifold housing

7. Install the port pan.
8. Connect the water flush hose and install it into the side of the pan.
9. Connect the tilt switch connector.



a - Water flush hose
b - Tilt switch connector

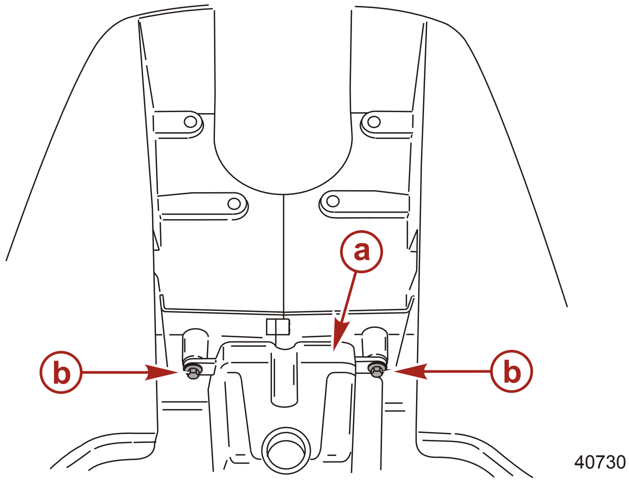
10. Install the shoulder screws securing the aft end of each pan. Tighten the screws to the specified torque.



a - Shoulder screw (M6 x 35 stainless) (2)

Description	Nm	lb-in.	lb-ft
Shoulder screw (M6 x 35 stainless)	10	89	

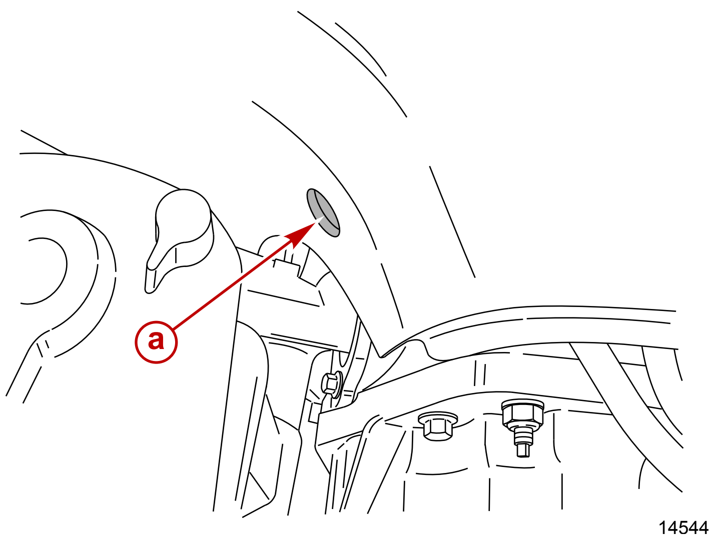
11. Install the muffler. Tighten the shoulder screws to the specified torque.



a - Muffler
b - Shoulder screw (M6 x 20 black) (2)

Description	Nm	lb-in.	lb-ft
Shoulder screw (M6 x 20 black)	10	89	

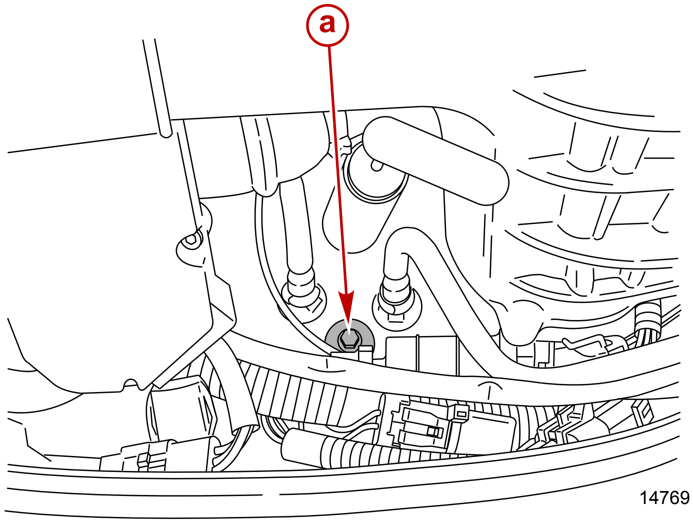
12. Install the port front bottom screw. Tighten the screw to the specified torque.



a - Screw (M6 x 35 stainless)

Description	Nm	lb-in.	lb-ft
Screw (M6 x 35 stainless)	10	89	

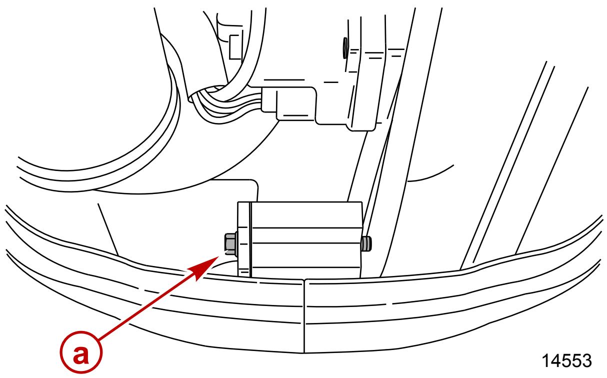
13. Install the pan top screw. Tighten the screw to the specified torque.



a - Screw (M6 x 35 stainless)

Description	Nm	lb-in.	lb-ft
Screw (M6 x 35 stainless)	10	89	

14. Install the front screw and locknut securing the pans together. Tighten the screw to the specified torque.



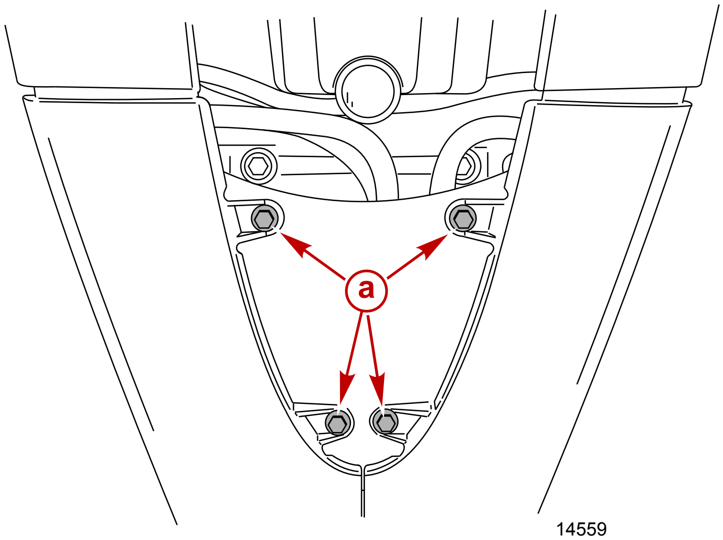
a - Screw and locknut (M6 x 55)

Description	Nm	lb-in.	lb-ft
Screw (M6 x 55)	10	89	

Chap Installation

1. Install the port and starboard chaps onto the driveshaft housing.

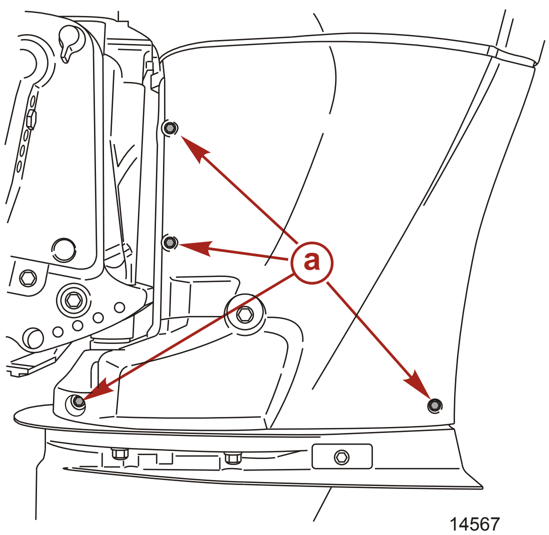
2. Secure the aft end with four shoulder screws. Tighten the shoulder screws to the specified torque.



a - Shoulder screw (M6 x 20 black) (4)

Description	Nm	lb-in.	lb-ft
Shoulder screw (M6 x 20 black)	10	89	

3. Secure each side with four shoulder screws. Tighten the shoulder screws to the specified torque.



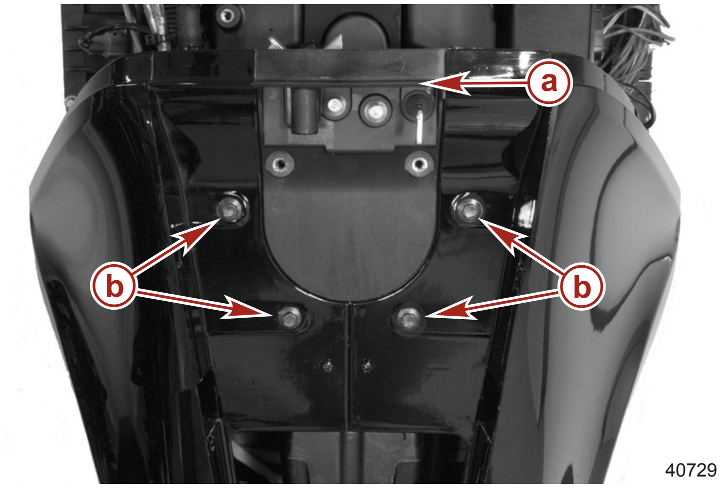
a - Shoulder screw (M6 x 20 black) (4 each side)

Description	Nm	lb-in.	lb-ft
Shoulder screw (M6 x 20 black)	10	89	

Rear Cover and Cowl Latch Installation

1. Install the rear latch assembly.

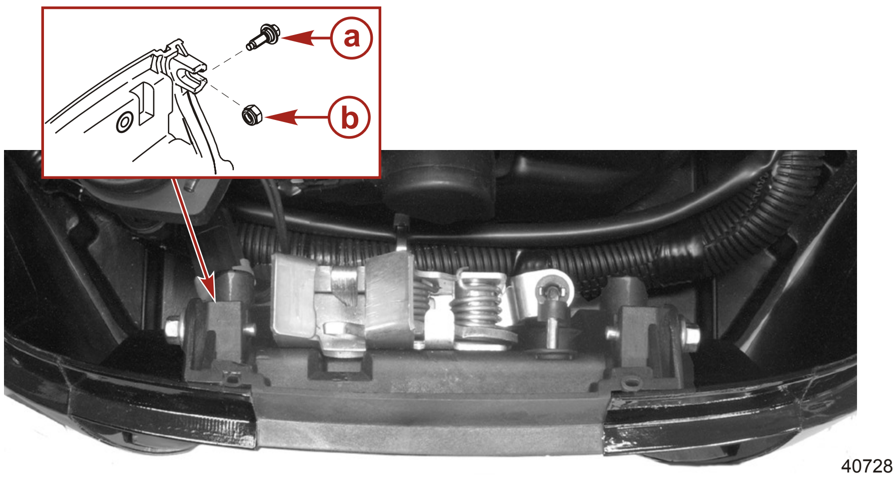
2. Install the four shoulder screws securing the rear latch assembly. Tighten the shoulder screws to the specified torque.



a - Rear latch assembly
b - Shoulder screw (M6 x 20 black) (4)

Description	Nm	lb-in.	lb-ft
Shoulder screw (M6 x 20 black) (4)	10	89	

3. Install the two screws and locknuts securing the cowl latch. Tighten the shoulder screws to the specified torque.

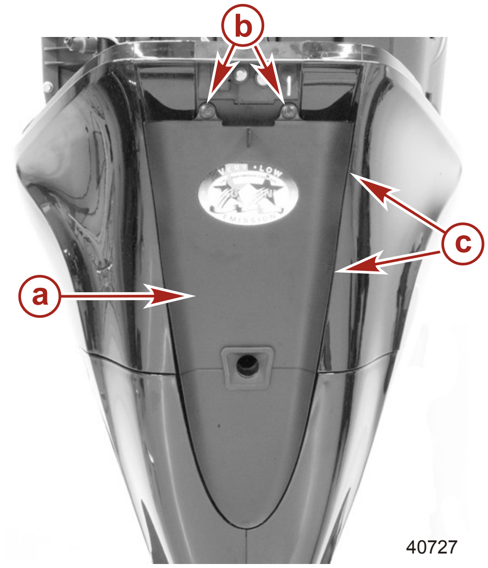


a - Shoulder screw (M6 x 20 stainless) (2)
b - Locknut (2)

Description	Nm	lb-in.	lb-ft
Shoulder screw (M6 x 20 stainless)	10	89	

4. Install the rear cover by inserting the tabs on the bottom and port side into the port pan/chaps and snap the rear cover into place.

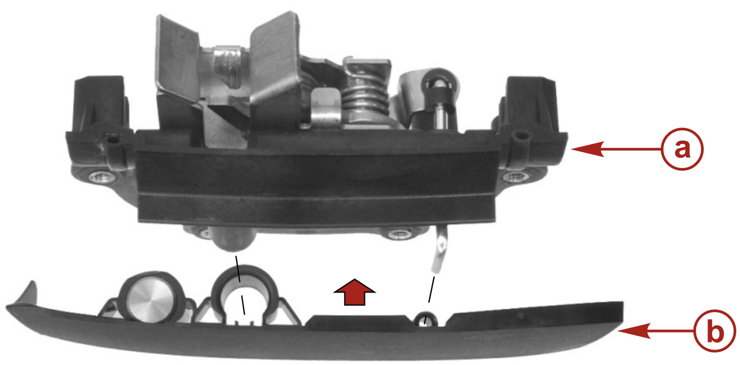
5. Secure the cover with two shoulder screws. Tighten the shoulder screws to the specified torque.



a - Rear cover
b - Shoulder screw (M6 x 20 black)
c - Arrow (pry point)

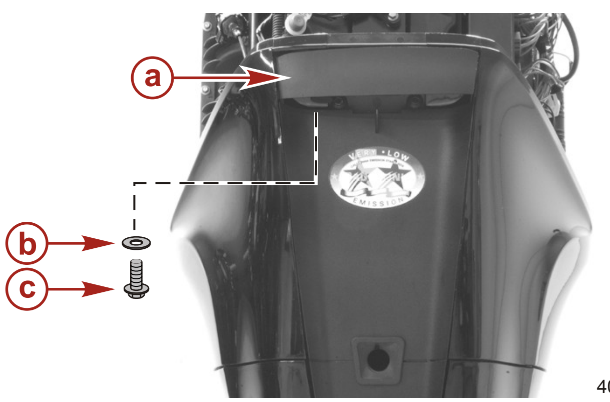
Description	Nm	lb-in.	lb-ft
Shoulder screw (M6 x 20)	10	89	

6. Install the handle onto the latch assembly.



Latch assembly shown uninstalled
a - Latch assembly
b - Handle

7. Install the pivot screw and washer securing the handle. Tighten the pivot screw to the specified torque.



a - Latch assembly
b - Washer
c - Pivot screw (M6 x 16 stainless)

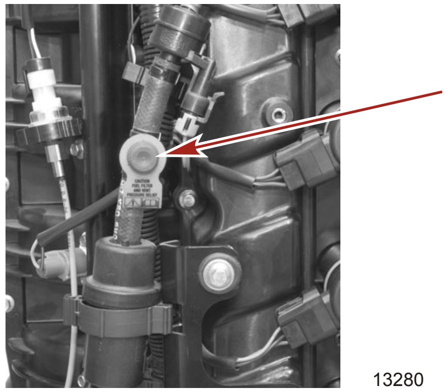
Description	Nm	lb-in.	lb-ft
Pivot screw	10	89	

Dressed Powerhead Removal

1. Drain the engine oil from the sump.
2. Disconnect the battery cables from the battery.

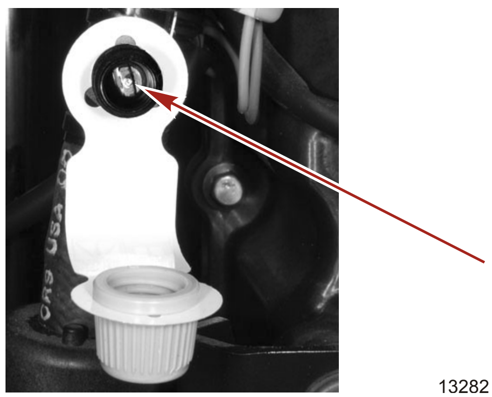
3. Remove all cowls. Refer to **Cowling Removal**.
4. Remove the flywheel cover. Refer to **Section 2A - Flywheel Cover**.
5. Remove the green cap to access the purge valve for the FSM pressure release.

⚠ 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.



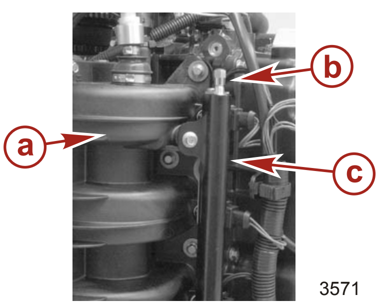
13280

6. Place a rag over the valve and press on the center of the valve to relieve any pressure inside the FSM.



13282

7. Attach a fuel pressure gauge to the fuel pressure valve on the fuel rail. Relieve the fuel pressure into an appropriate container.



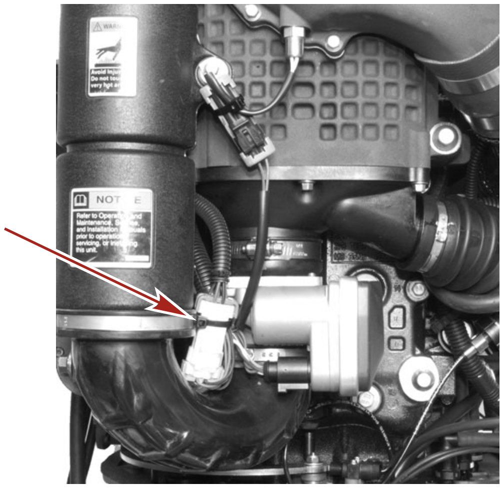
3571

a - Intake manifold
b - Fuel pressure valve
c - Fuel rail

Fuel Pressure Gauge Kit	91-881833A03
Digital Pressure Meter	91-892651A01

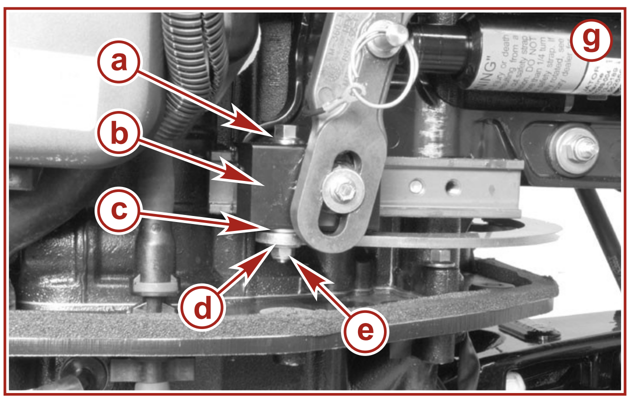
8. Cut the cable tie securing the ESC harness connector to the ETC bracket.

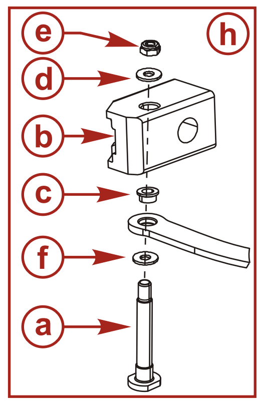
9. Disconnect the ESC harness from the engine harness connector.



14517

10. Push the shift slide aft to access the shift link bolt and nut.
11. Remove the shift link bolt, nut, washer, and bushing.

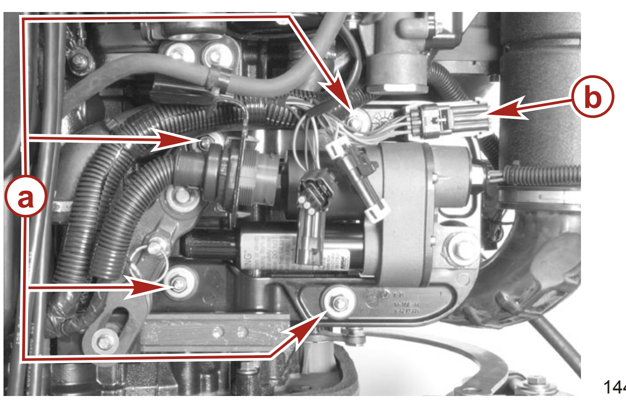




40915

- a - Shift link bolt
- b - Shift slide
- c - Bushing
- d - Washer (0.625 in. OD)
- e - Nut
- f - Washer (0.688 in. OD)
- g - Design I
- h - Design II

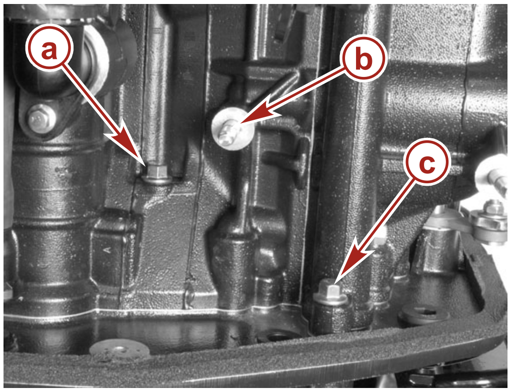
12. Push the shift slide aft to access one of the ESC bracket mounting nuts.
13. Slide the boat harness connector aft to remove it from the ESC bracket.
14. Remove the four nuts and washers securing the ESC bracket to the cylinder block. Remove the ESC bracket from the mounting studs.



14410

- a - Nuts and washers (4)
- b - Boat harness connector

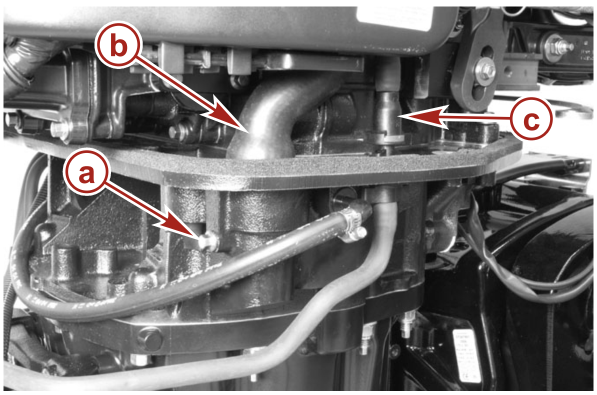
15. Remove the two bolts securing the powerhead to the adapter plate that were hidden by the ESC bracket assembly.



14415

a - Bolt (M8 x 75)
b - ESC mounting stud
c - Bolt (M8 x 35)

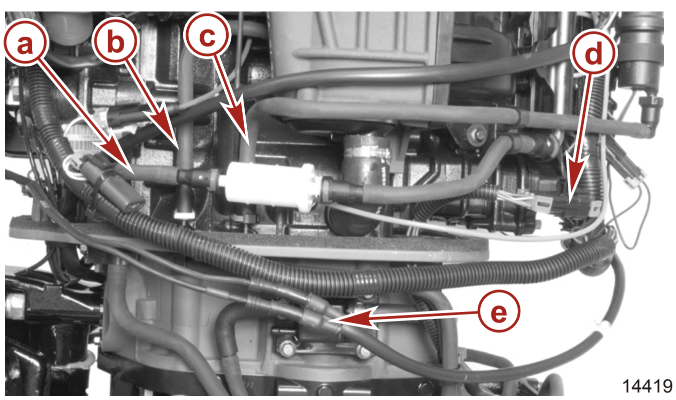
16. Loosen the bolt securing the powerhead water dump hose fitting to the adapter plate several turns. It is not necessary to remove this bolt.
17. Pull up on the powerhead water dump hose to dislodge the fitting from the adapter plate.
18. Disconnect the fuel delivery hose from the adapter plate.



14416

a - Bolt securing water dump hose adapter
b - Water dump hose
c - Fuel delivery hose

19. Disconnect the high-pressure fuel delivery hose from the adapter plate.
20. Disconnect the MAP reference hose from the adapter plate.
21. Disconnect the FSM purge hose from the adapter plate.
22. Disconnect the FSM harness.
23. Disconnect the trim motor wires from the engine wire harness bullet connectors.

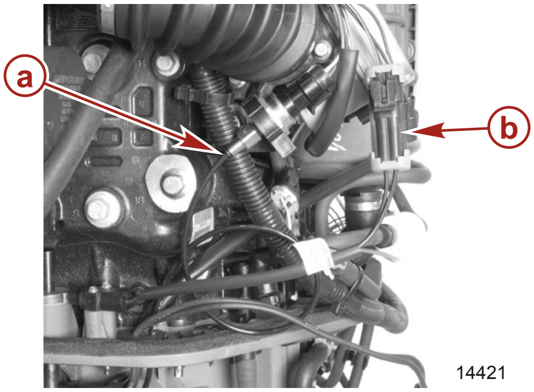


14419

a - High-pressure fuel delivery hose
b - MAP reference hose
c - FSM purge hose
d - FSM harness connector
e - Power trim motor bullet connectors

24. Disconnect the pitot hose from the pitot sensor.

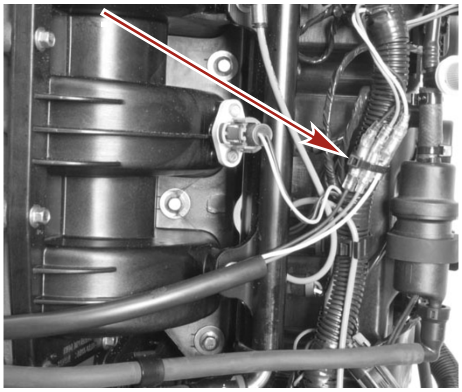
25. Disconnect the shift indicator harness from the engine harness.



14421

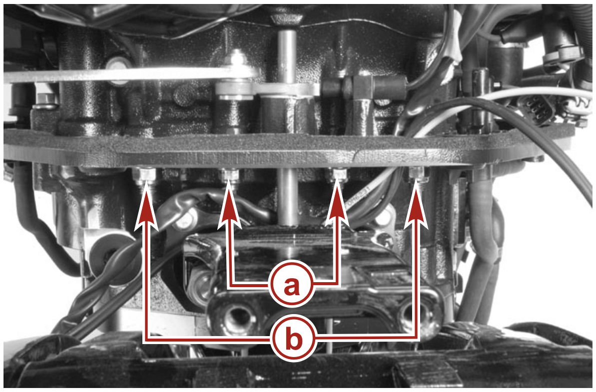
a - Pitot hose
b - Shift indicator harness connector

26. Cut the cable tie securing the trim position sensor wire bullet connectors. Disconnect the trim position sensor wire bullet connectors.



14422

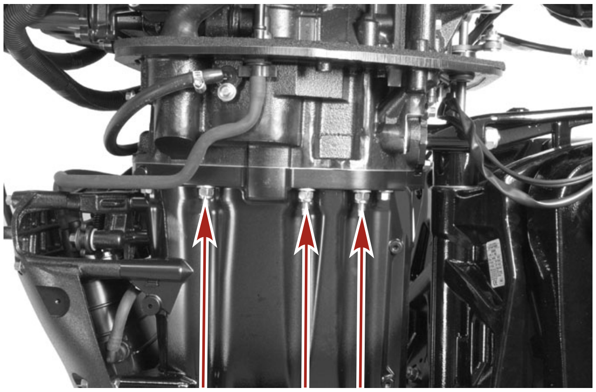
27. Remove the four flange locknuts securing the front of the powerhead assembly to the adapter plate.



14424

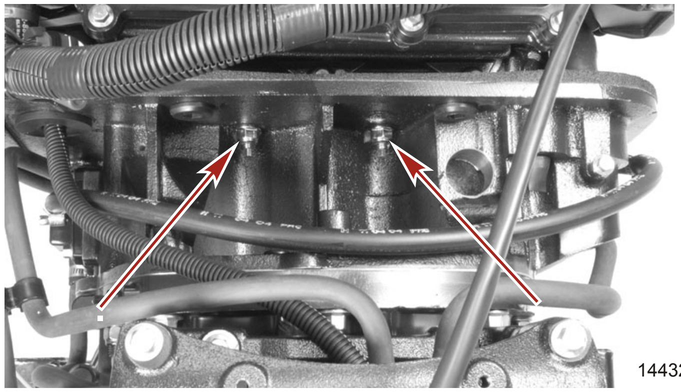
a - Flange locknut (M8)
b - Flange locknut (M10)

28. Remove the six locknuts and washers (3 each side) securing the powerhead to the adapter plate.



14427

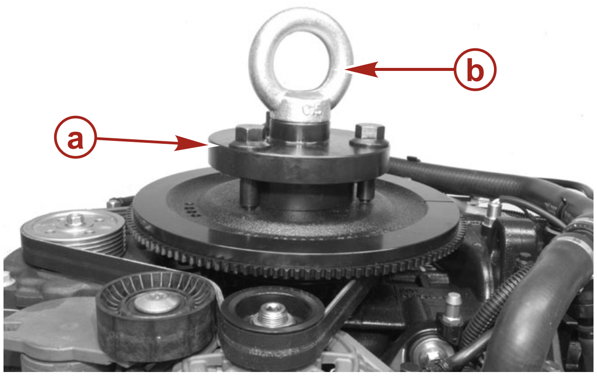
29. Remove the two aft flange locknuts securing the powerhead to the adapter plate.



14432

30. Install the lifting tool to the flywheel. Remove the powerhead from the adapter plate.

NOTE: While lifting the powerhead off the adapter plate, it may be necessary to gently rock the powerhead fore and aft to prevent the powerhead mounting studs binding in the adapter plate.



14433

a - Lifting base
b - Lifting eye

Flywheel Puller/Lifting Ring	91-895343T02

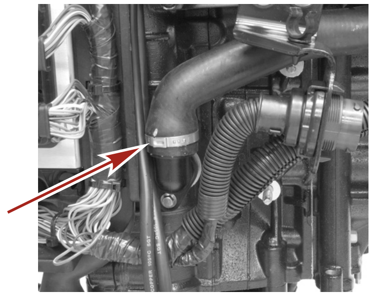
Removing Powerhead Components

IOM (Integrated Oil Module)

1. Push the water separating fuel filter up to disengage the filter housing from the filter mounting bracket.

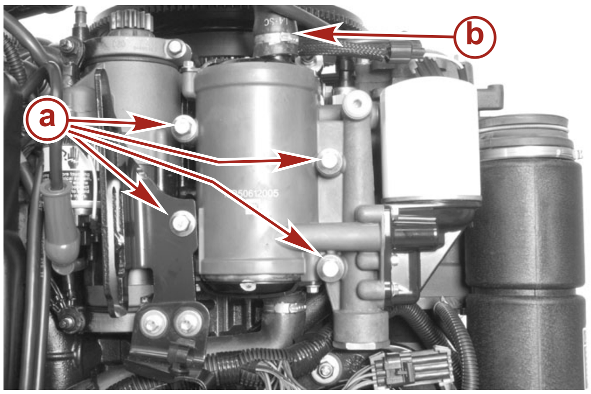
14614

2. Remove the clamp securing the lower IOM hose to the cylinder block fitting. Remove the hose from the fitting.



13755

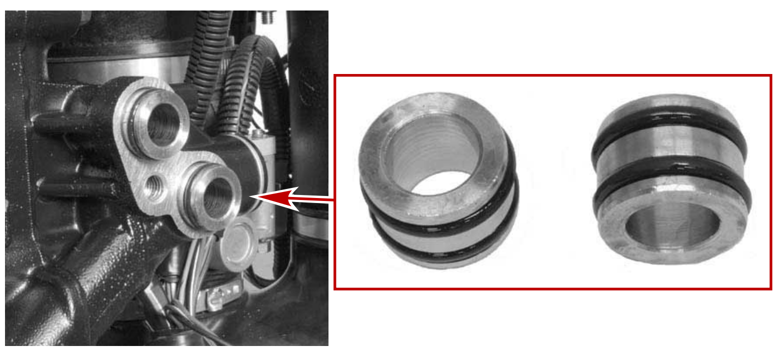
3. Remove the clamp securing the IOM top cooling hose. Remove the hose from the IOM.
4. Remove the four bolts securing the IOM to the cylinder block.



14619

a - Bolts (4)
b - Top cooling hose clamp

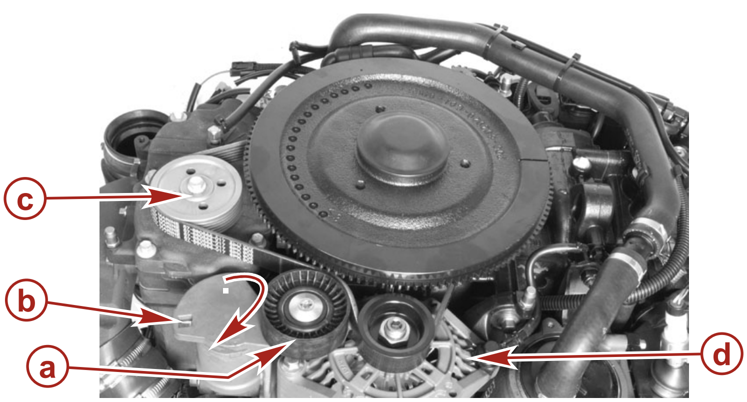
5. Pull the IOM off of the oil delivery and return dowels.
6. Remove the dowels from the cylinder block.
7. Remove the O-rings from the IOM dowels and discard the O-rings.



3772

Supercharger

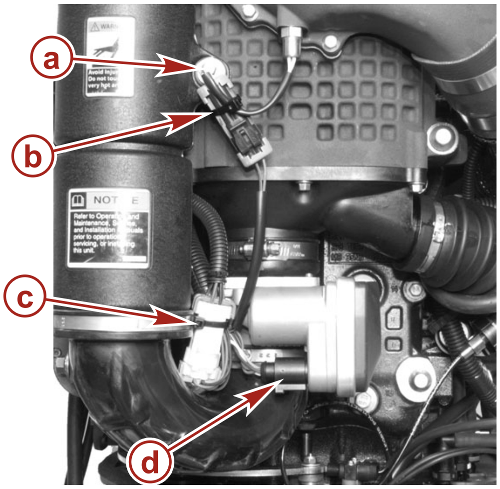
1. Install a breaker bar into the supercharger/alternator belt tensioner.
2. Release the belt tension and remove the belt from the alternator and supercharger.



13329

a - Belt tensioner
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

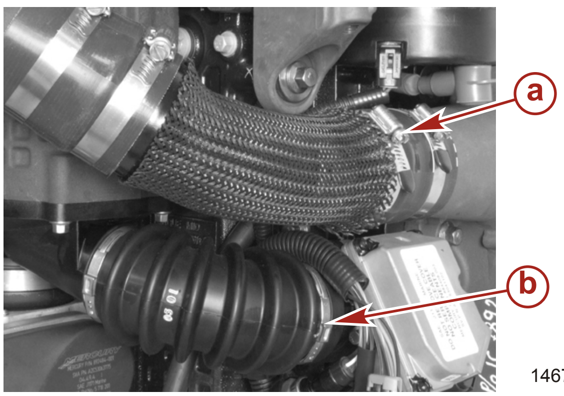
3. Cut the cable tie securing the outlet temperature sensor harness to the ETC resonator support bolt. Disconnect the sensor harness and remove the outlet temperature sensor.
4. Remove the bolt securing the ETC resonator assembly to the supercharger.
5. Loosen the hose clamp securing the ETC to the supercharger inlet duct.
6. Disconnect the ETC harness.



a - Bolt securing ETC resonator
b - Cable tie securing outlet temperature sensor
c - Cable tie securing ESC harness connector
d - ETC harness connector

14668

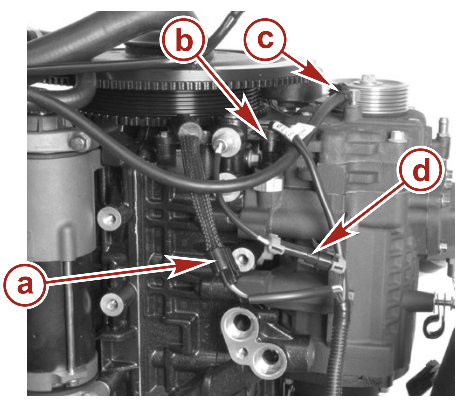
7. Loosen the hose clamp securing the inlet tube to the CAC.
8. Remove the hose clamp securing the bypass boot to the EBC.



a - Hose clamp securing inlet tube
b - Hose clamp securing bypass boot

14670

9. Remove the supercharger vent hose from the supercharger vent fitting.
10. Disconnect the CPS, oil temperature sensor, and oil pressure sensor harnesses.

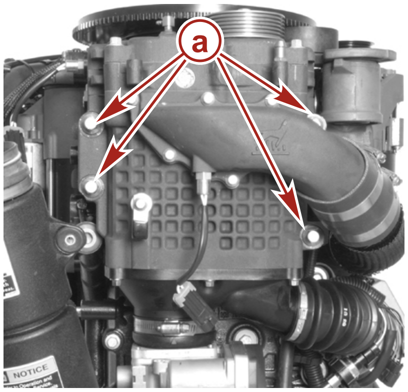


a - CPS harness connector
b - Oil pressure sensor harness connector
c - Supercharger vent hose
d - Oil temperature sensor connector

14672

11. Remove the four bolts securing the supercharger to the cylinder block.

12. Remove the supercharger assembly from the cylinder block, inlet tube, and ESC.

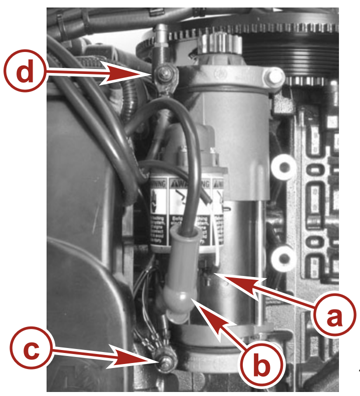


14673

a - Bolts (4)

Starter

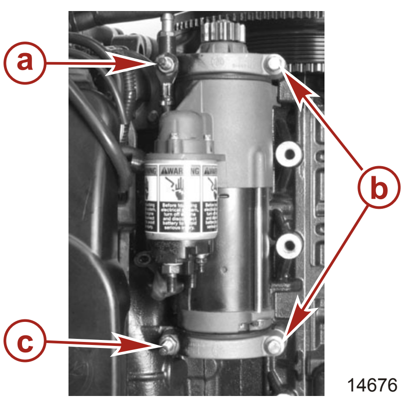
1. Remove the starter solenoid exciter wire.
2. Remove the starter solenoid battery cable.
3. Remove the nut securing the battery negative cable to the upper starter mounting stud. Remove the battery negative cable from the stud.
4. Remove the nut securing the three ground eyelets to the lower starter mounting stud. Remove the three ground leads from the stud.



14674

a - Solenoid exciter wire
b - Starter solenoid battery cable
c - Nut securing the three ground eyelets
d - Nut securing the battery negative cable

5. Remove the nut and washer securing the starter ground lead to the upper mounting stud.
6. Remove the two starter mounting bolts.
7. Remove the nut securing the starter mount.
8. Remove the starter from the cylinder block.



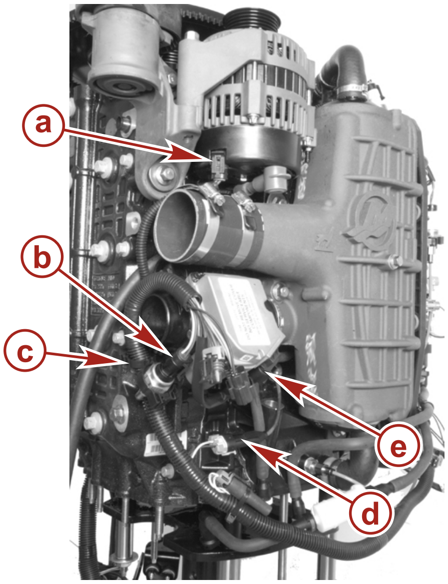
14676

a - Nut and washer securing starter ground lead
b - Bolts (2)
c - Nut securing starter mount

Charge Air Cooler (CAC) Removal

1. Remove the alternator exciter connector from the alternator.
2. Disconnect the speedometer harness connector.
3. Remove the engine wire harness assembly from the harness retaining clip.
4. Disconnect the knock sensor harness connector.

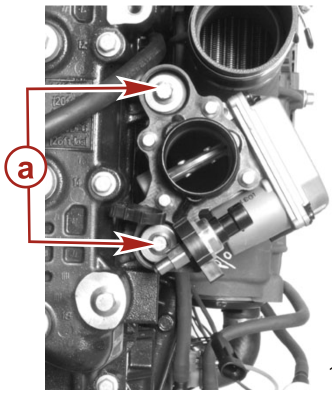
5. Disconnect the EBC harness connector.



14677

a - Alternator exciter connector
b - Speedometer sensor connector
c - Harness retaining clip
d - Knock sensor harness connector
e - EBC harness connector

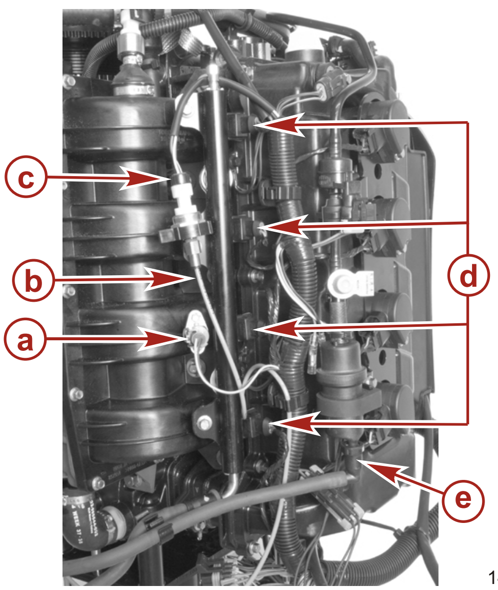
6. Remove two bolts and washers securing the EBC to the cylinder block.



14678

a - Bolt and washer (2)

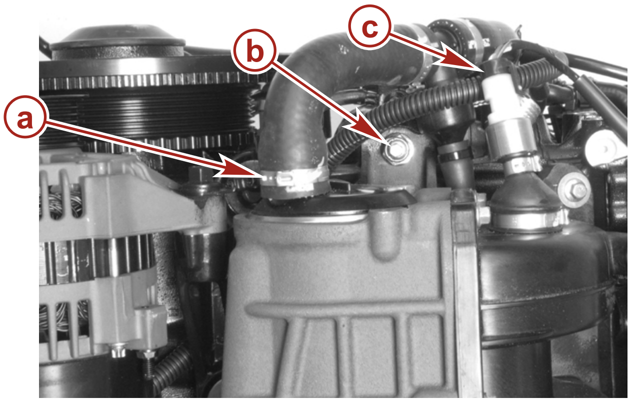
7. Disconnect the engine harness from the MAT sensor.
8. Remove the tubing from the block water pressure sensor.
9. Disconnect the engine harness from the block water pressure sensor.
10. Disconnect the engine harness from the fuel injectors.
11. Remove the FSM vent hose from the vent canister float switch.



14679

a - MAT sensor
b - Tubing
c - Block water pressure sensor
d - Fuel injector harness
e - FSM vent hose

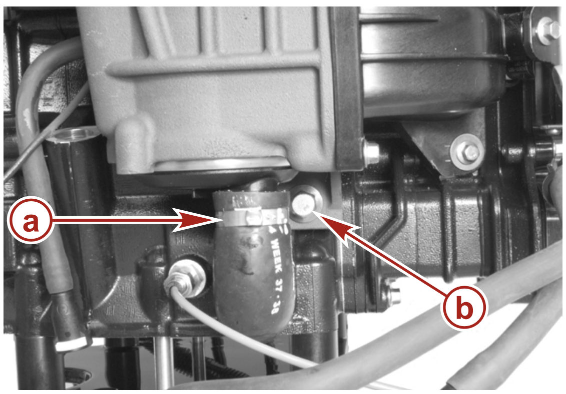
12. Remove the hose clamp securing the CAC upper hose.
13. Remove the nut securing the CAC to the mounting stud.
14. Disconnect the engine harness from the MAP sensor.



14692

a - Hose clamp securing upper hose
b - Nut securing CAC to mounting stud
c - MAP sensor connector

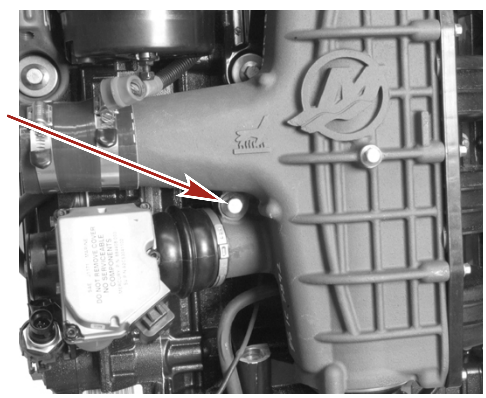
15. Remove the hose clamp securing the CAC lower hose.
16. Remove the bolt securing the CAC to the cylinder block.



14721

a - Hose clamp securing lower hose
b - Bolt securing CAC

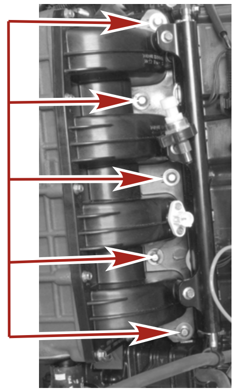
17. Remove the bolt securing the front of the CAC.



14722

18. Remove the bolts securing the manifold to the cylinder head.

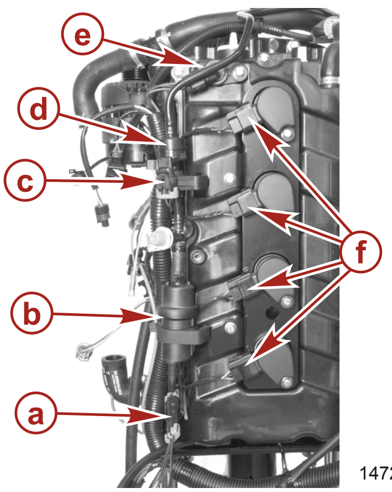
19. Remove the CAC assembly from the cylinder block and head.



14723

Wire Harness and Electrical Box

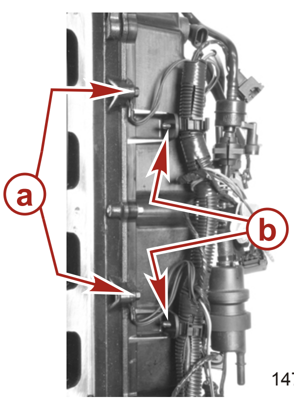
1. Disconnect the engine harness from the vent canister float switch.
2. Disconnect the engine harness from the vent canister purge valve.
3. Disconnect the engine harness from the cam position sensor.
4. Disconnect the engine harness from the ignition coils.



14725

a - Vent canister float switch connector
b - Vent canister float switch
c - Vent canister purge valve connector
d - Vent canister purge valve
e - Cam position sensor connector
f - Ignition coil harness connector

5. Use a pair of needle-nose pliers to collapse the retainer to remove the harness retainer from the valve cover.
6. Remove the bolts securing the ignition coil ground to the cylinder head.

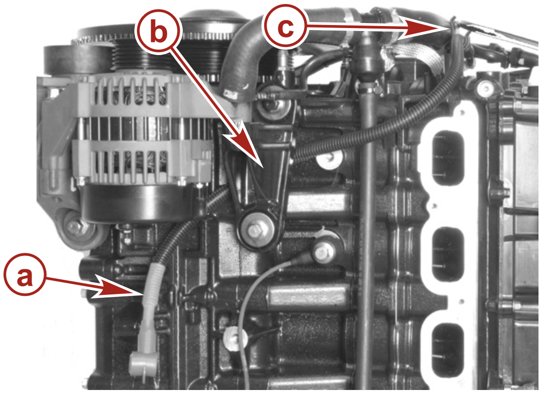


14726

a - Bolts securing grounds
b - Harness retainer

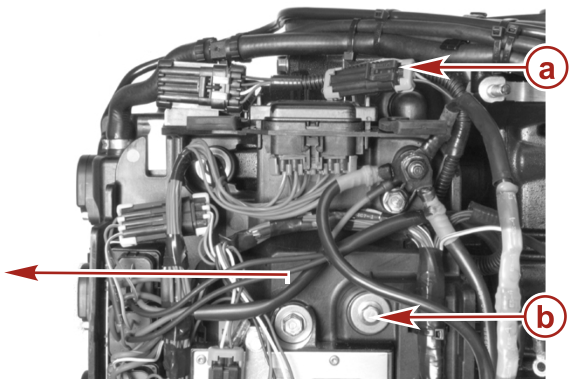
7. Remove the alternator charging wire from the alternator.
8. Pull the alternator charging wire from behind the alternator support bracket.

9. Remove the alternator charging wire from the support clip.



a - Alternator charging wire
b - Alternator support bracket
c - Support clip

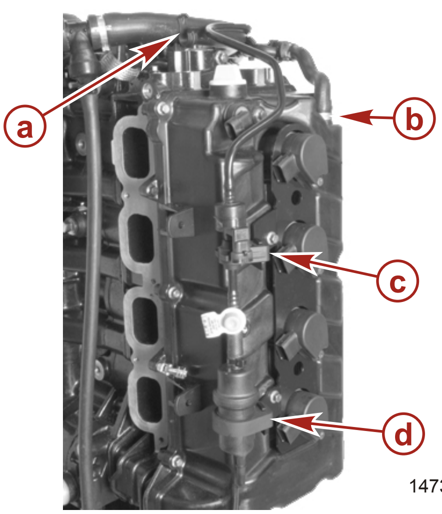
10. Disconnect the engine harness from the cylinder block temperature sensor.
11. Remove the bolt and washer securing the electrical box to the cylinder block.
12. Push the electrical box aft to disengage the electrical box from the support grommets.



a - Cylinder block temperature sensor connector
b - Bolt securing electrical box

FSM Vent Hose/Top Hose

1. Remove the hose clamp securing the ventilation hose to the valve cover.
2. Pull up on the vent canister float switch and the vent canister purge valve to remove them from the support brackets.
3. Remove the hose from the support clip.
4. Remove the hose assemblies from the cylinder block.

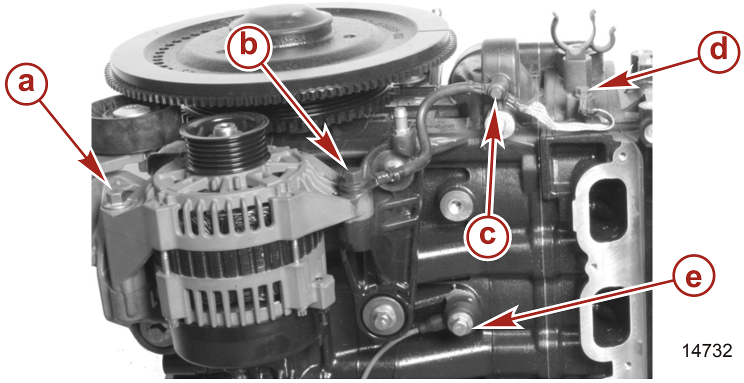


a - Hose support clip
b - Clamp securing ventilation hose
c - Vent canister purge valve
d - Vent canister float switch

Alternator/Support Bracket/Knock Sensor

1. Remove the bolt securing the alternator to the front support bracket.
2. Remove the bolt securing the alternator and ground wire to the rear support bracket. Remove the alternator.
3. Remove the bolt securing the alternator ground wire and ground strap to the cylinder block.

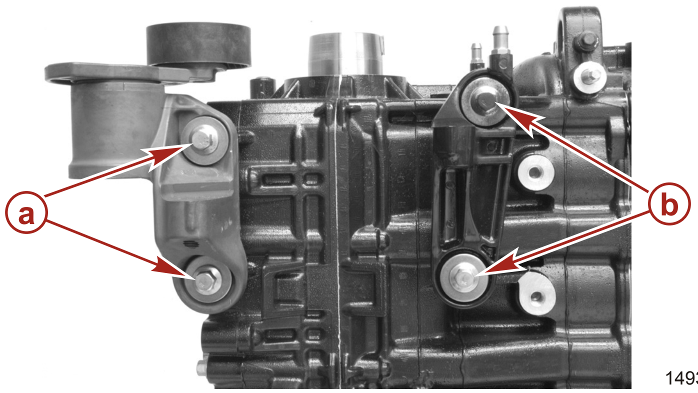
4. Remove the bolt securing the ground strap to the cylinder head.
5. Remove the bolt securing the knock sensor to the cylinder block.



14732

- a - Front alternator bolt
- b - Rear alternator bolt
- c - Bolt securing ground wire and strap
- d - Bolt securing ground strap
- e - Bolt securing knock sensor

6. Remove the two bolts securing the tensioner bracket to the cylinder block.
7. Remove the two bolts securing the alternator support bracket to the cylinder block.

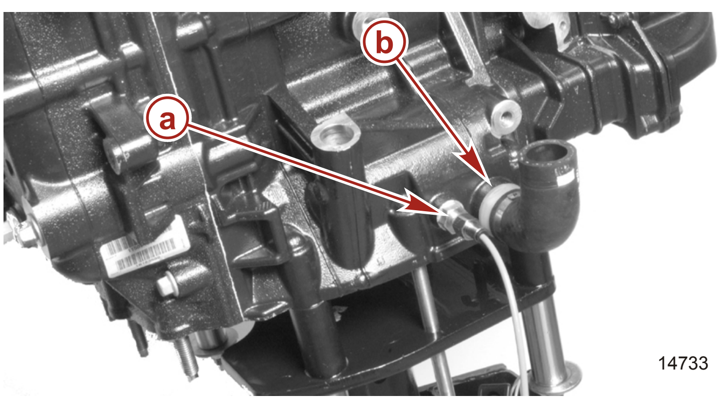


14930

- a - Bolts securing tensioner bracket
- b - Bolts securing support bracket

CAC Lower Hose Fitting/Block Water Pressure Sensor Adapter

1. Remove the block water pressure sensor adapter Legris from the cylinder block.
2. Remove the lower CAC hose fitting from the cylinder block.



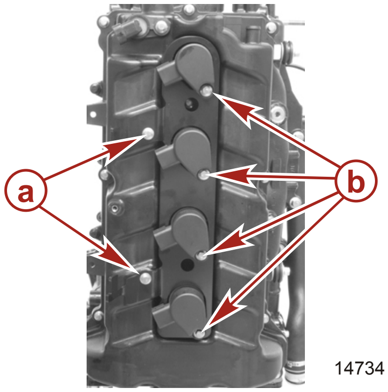
14733

- a - Water pressure sensor adapter Legris
- b - Lower CAC hose fitting

Ignition Coil/Support Bracket

1. Remove the bolts securing the ignition coils to the valve cover.
2. With a twisting motion, remove the ignition coils.

3. Remove the two bolts securing the ignition coil support bracket to the valve cover.

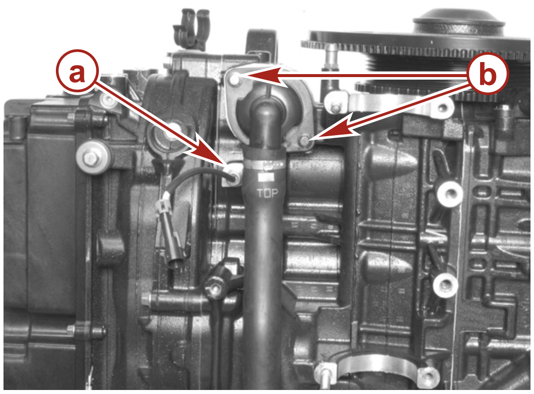


14734

a - Bolt securing ignition coil support bracket (2)
b - Bolts securing ignition coils

Thermostat Housing/Cylinder Block Water Temperature Sensor/Lower IOM Hose Fitting

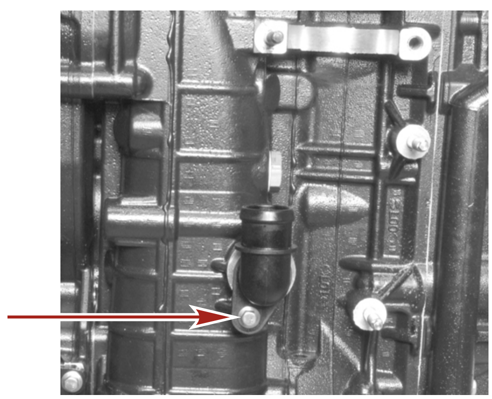
1. Remove the two bolts securing the thermostat housing to the cylinder block.
2. Remove the cylinder block water temperature sensor.



14735

a - Cylinder block water temperature sensor
b - Bolts securing thermostat housing

3. Remove the bolt securing the lower IOM hose fitting to the cylinder block and remove the lower IOM hose fitting.



14736

Powerhead Disassembly

Cylinder Head Removal

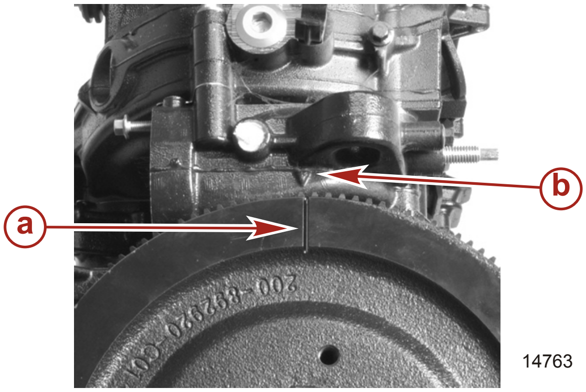
IMPORTANT: The removal and disassembly procedure of the cylinder head and cams must be strictly followed. Failure to follow the removal outline procedure may damage the valve train components.

IMPORTANT: Do not intermix the location of the valve train parts.

IMPORTANT: This engine is an interference valve train design. Do not rotate the crankshaft or cams when the timing chain is loose or removed from the cam gears unless advised to do so. Failure to adhere to this important information, will result in valve or piston damage.

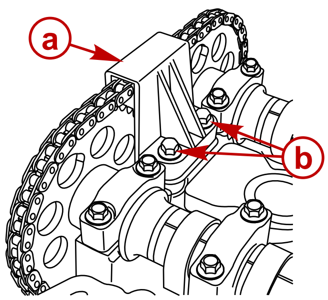
1. Remove the bolts securing the valve cover to the cylinder head.

2. Rotate the crankshaft with the flywheel so the timing marks are in alignment.



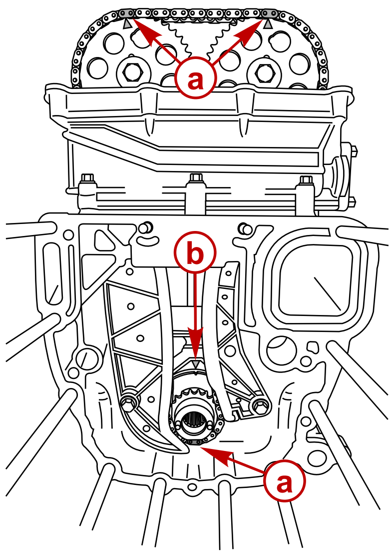
a - Flywheel timing mark
b - Cylinder block timing mark

3. Engines S/N 1B733388 and below: Remove the short span chain guide bolts. Remove the short span chain guide.



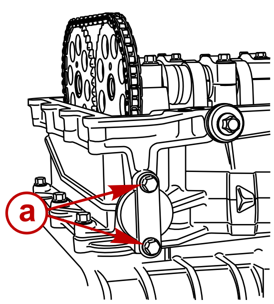
S/N 1B733388 and below
a - Short span chain guide
b - Short span chain guide bolts

4. Ensure the cam gear timing marks and the cylinder block timing marks are positioned as shown. If not, rotate the crankshaft one revolution. The timing marks should be aligned.



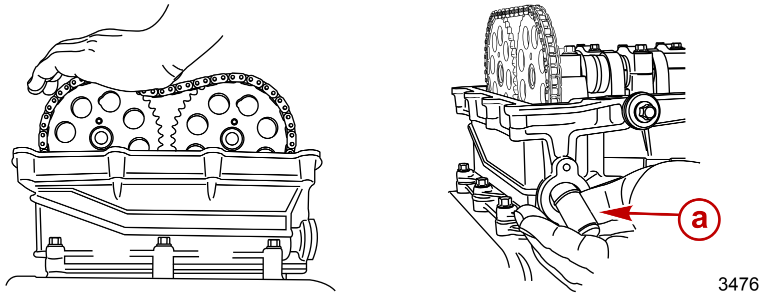
a - Timing chain anodized links
b - Cylinder block timing mark

5. Remove the cam tensioner cover bolts.



a - Cam tensioner cover bolts

6. Place your hand over the cam tensioner bore. With the heal of your other hand, press on the timing chain between the cam gears. This will assist to dislodge the tensioner from the cylinder head bore.



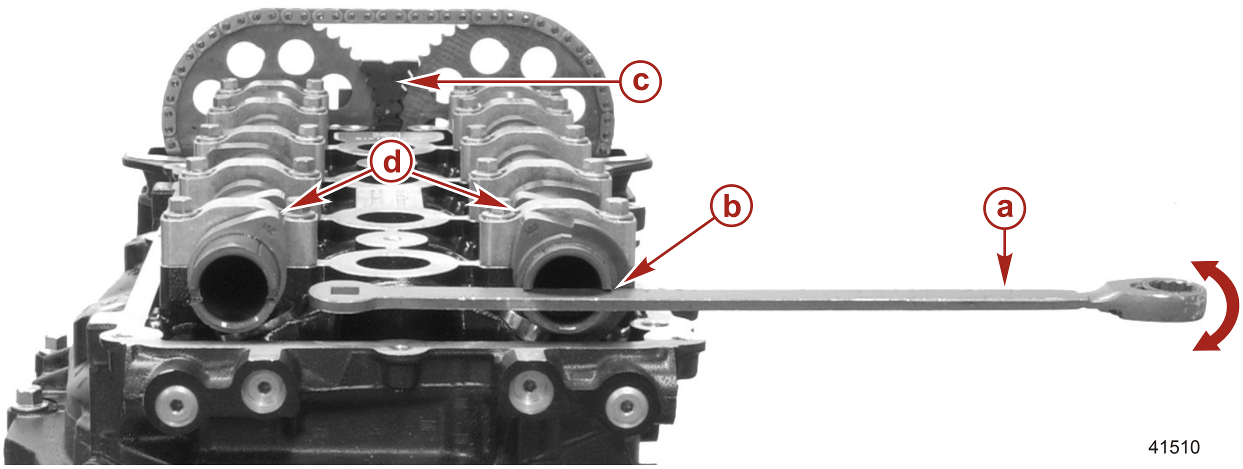
a - Cam tensioner

7. Install the cam lock between the intake and exhaust cam gears.

   NOTE: *The cams must be locked with a special tool to prevent loading of the cam gears and chain. Loading the cam gear and chain may damage the cam gear and chain.*

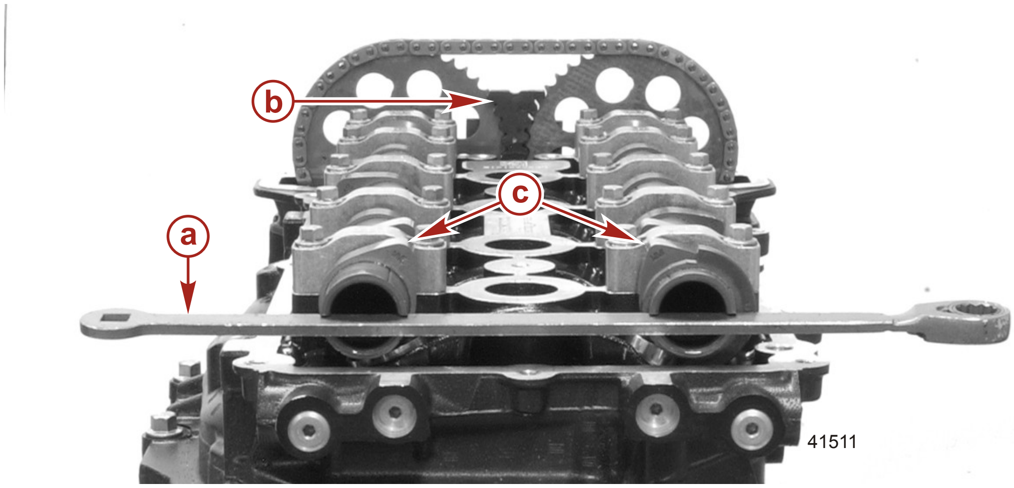
   NOTE: *When installing the cam lock, it may be necessary to rotate one of the cams slightly to align the cam lock with both cam gears.*

   a. Use the 13 mm torque adapter tool to rotate one of the camshafts while installing the cam lock between the cam gears.



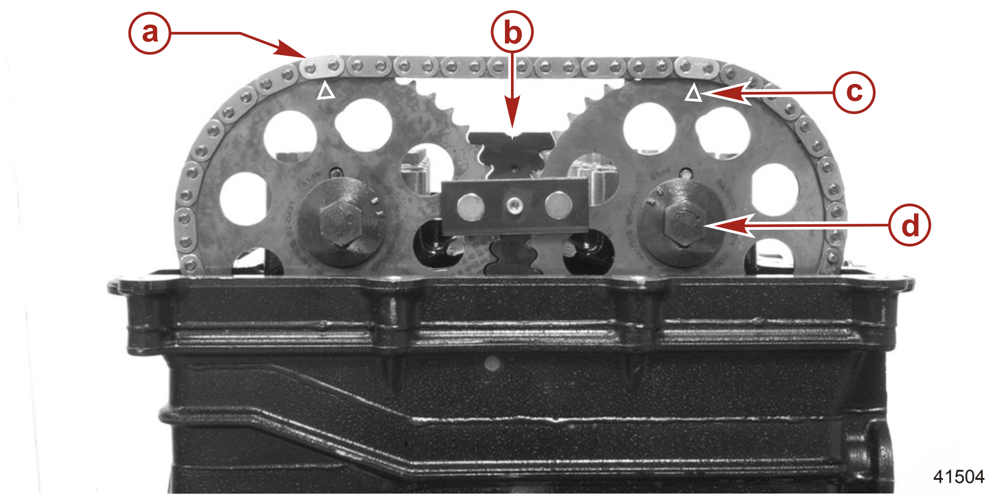
a - 13 mm torque adapter tool
b - Notch in camshaft
c - Cam lock tool installed
d - #1 cylinder camshaft lobes

b. When properly aligned, the 13 mm torque adapter fits in both camshaft notches and both #1 cylinder camshaft lobes are pointed away from the engine block.



a - 13 mm torque adapter tool
b - Cam lock tool installed
c - #1 cylinder camshaft lobes

c. The timing marks are aligned with the anodized links on the timing chain.



a - Timing chain anodized link
b - Cam lock
c - Cam gear timing mark
d - Cam gear retaining bolt (left-hand thread)

NOTE: If the anodizing is washed off the links, mark the links with an indelible marker to aid in the installation of the timing chain.

13 mm Torque Adapter	91-809905001
Cam Lock	91-896911A01

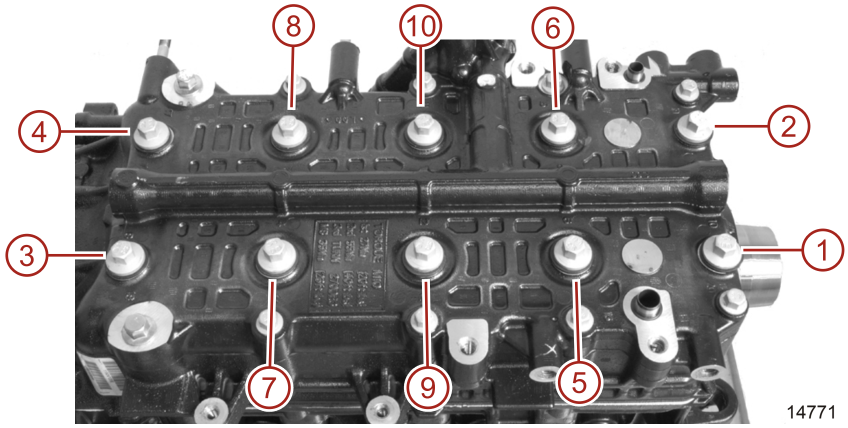
8. Loosen the cam gear retaining bolts.

   NOTE: The cam gear retaining bolts are left-hand thread.

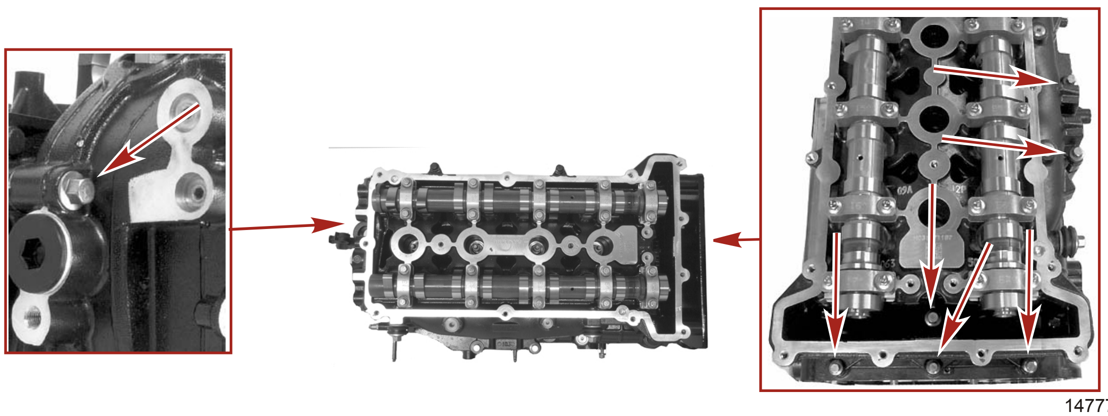
9. Remove the cam lock and cam gear retaining bolts.
10. Remove the cam gears. Allow the timing chain to drop into the cylinder block area.
11. In the sequence shown, loosen and remove the long main bolts.

    IMPORTANT: It is not necessary to remove the long main bolts when repairing the cylinder head only. If the cylinder block is to be disassembled, the long main bolts must be removed and replaced.

NOTE: The cylinder block has rubber dampeners for the long main bolts. The long main bolt threads will be difficult to pull past the dampeners. Unthread the long main bolts past the rubber dampeners.



12. Remove the cylinder head perimeter screws. Remove the cylinder head.

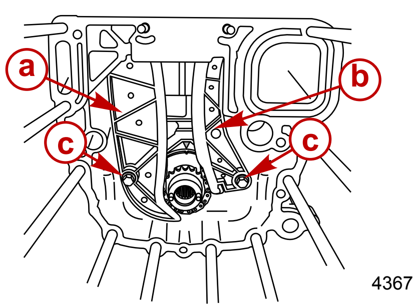


IMPORTANT: Do not set the cylinder head down on its deck. Damage to the valves may result. Set the cylinder head on pillow blocks to prevent damage to the valves.

Refer to **Section 4B - Cylinder Head Disassembly and Cleaning/Inspection/Repair**.

Crankcase and Crankshaft Disassembly/Removal

1. Remove the timing chain guide and tensioner.



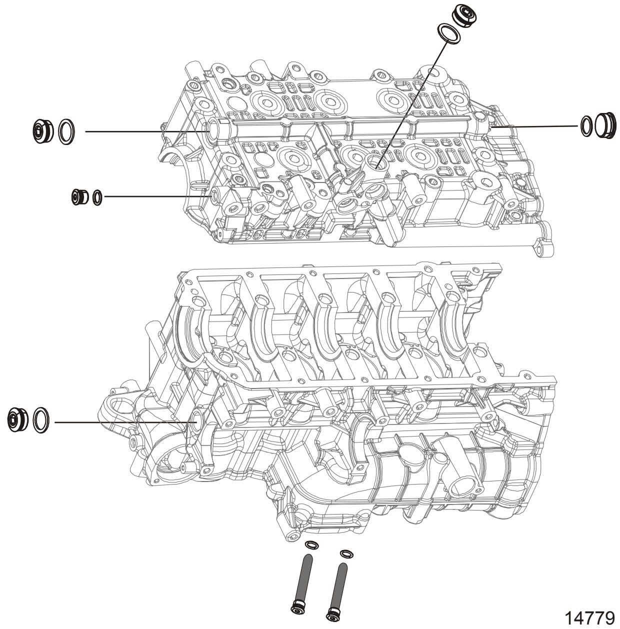
a - Timing chain guide
b - Timing chain tensioner
c - Timing chain tensioner and guide bolts

2. Remove the timing chain.

   NOTE: If the timing chain's three anodized links cannot be identified, a new chain must be installed.

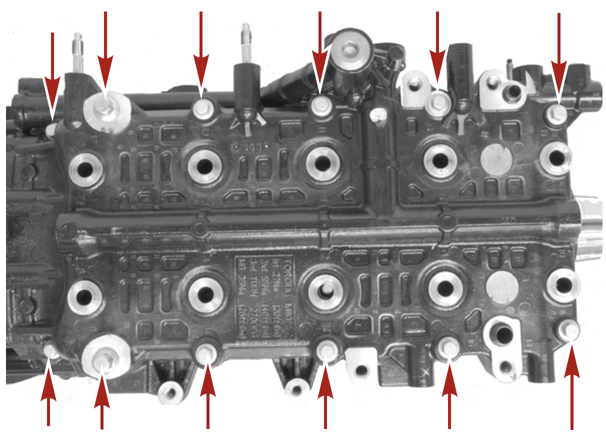
3. Remove all the anodized aluminum oil passage plugs from the crankcase cover and cylinder block.

NOTE: If any oil passage plugs or water galley plugs are difficult to remove, place a brass drift on the anodized plug and strike the brass drift lightly with a hammer to assist in breaking the plugs loose.



14779

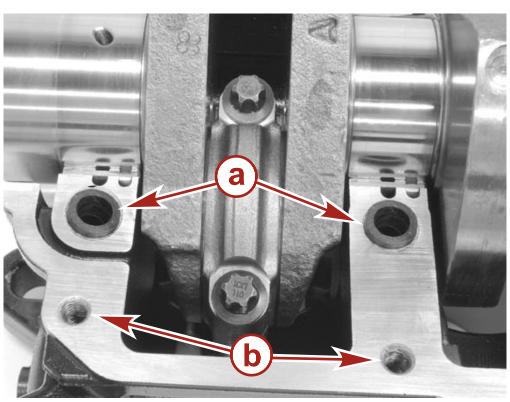
4. Remove the perimeter crankcase cover bolts.



14780

5. Pry the crankcase cover loose with two large screwdrivers. Lift the crankcase cover off of the cylinder block.
6. Mark all the connecting rod caps and rod locations with indelible marker or paint (example: 1, 2, 3, 4).

   IMPORTANT: Do not use a scribe or a metal punch on the connecting rod or rod cap for identification purpose. Using a scribe or metal punch will damage the connecting rod and may cause premature engine failure.
7. Remove the rubber dampeners.



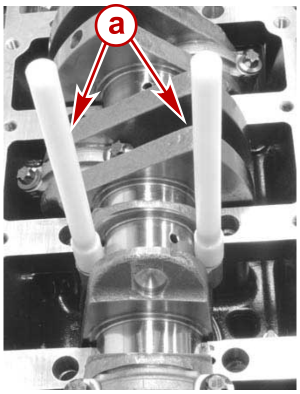
4486

a - Rubber dampeners
b - Crankcase cover perimeter bolt holes

8. Paint the rod cap bolts to identify them as used.

IMPORTANT: Rod cap bolts that have been torqued to specification, must not be used for reassembly.

9. Remove the rod cap bolts with a Torx #E-12. Remove the rod cap.
10. Install the rod guides to protect the crank pin and cylinder bore from damage.



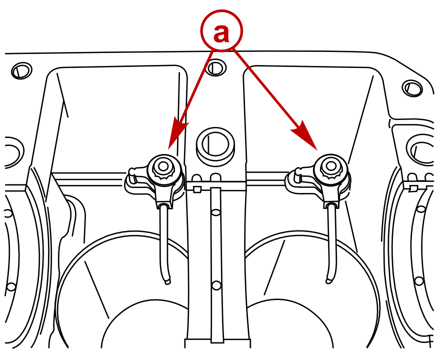
4834

a - Rod guide dowel

Rod Guide Dowel	Part number not available for this printing.

11. Push the connecting rod assembly out of the cylinder bore.
12. Mark the connecting rod up side orientation with an indelible marker or paint. **Do not use a scribe or punch for identification of the connecting rod orientation.**

    NOTE: The up side orientation of the connecting rod is the same orientation as the dot on the dome of the piston.
13. Install the rod cap to the connecting rod assembly. Ensure the rod cap fits perfect. Thread the rod cap screw into the connecting rod. Tighten the rod screws securely, but do not torque.
14. Remove the remaining connecting rod assemblies the same way.
15. Remove the crankshaft. Secure the crankshaft in a manner that will prevent damage.
16. S/N 1B517158 and below: Remove the piston cooling jets.

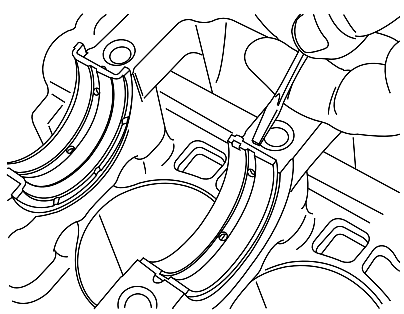


4368

a - Piston cooling jet

17. Remove the crankshaft main bearings from the cylinder block and crankcase cover.

    NOTE: A small screwdriver or awl will assist in removing the crankshaft main bearings.



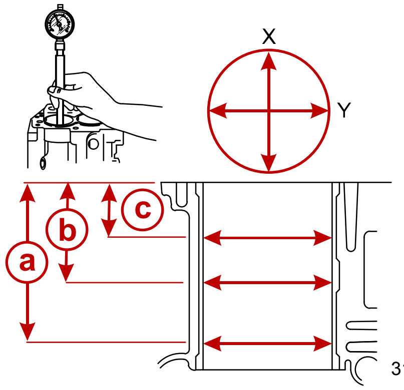
4369

Cleaning, Inspection, and Repair

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: 20 mm (0.8 in.), 60 mm (2.4 in.), and 100 mm (3.9 in.).



a - 100 mm (3.9 in.)
b - 60 mm (2.4 in.)
c - 20 mm (0.8 in.)

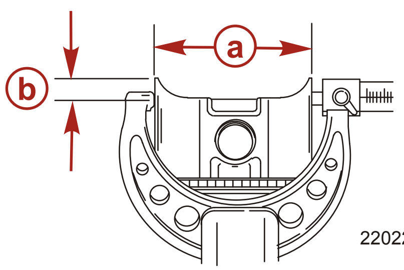
Cylinder Bore Specification	
Standard	82.0 mm (3.228 in.)
Out of round (production)	0.015 mm (0.0006 in.)
Out of round (service)	0.0762 mm (0.003 in.)
Taper (production)	0.015 mm (0.0006 in.)
Taper (service)	0.0762 mm (0.003 in.)

Measuring Piston

Inspect piston wall for wear or damage. Replace piston if necessary.

Piston Diameter

1. Measure the piston at a point 10 mm (0.394 in.) from the bottom, 90° to the piston pin. Replace piston if out of specification.



a - Piston diameter
b - Measure point 10 mm (0.394 in.)

Piston	
Diameter	81.975 mm (3.227 in.)

2. Measure piston to cylinder clearance. If out of specification, examine 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	0.06 mm (0.0024 in.)

Piston Ring Groove

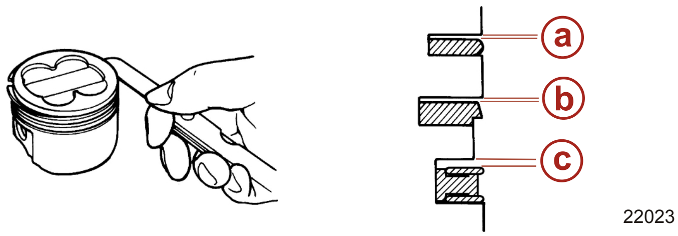
Measure piston ring groove. Replace the piston if out of specification.

a - Top ring groove
b - Middle ring groove
c - Oil ring groove

Piston Ring Groove	
Top "a"	1.25 mm (0.049 in.)
Middle "b"	1.23 mm (0.048 in.)
Oil "c"	2.03 mm (0.080 in.)

Piston Ring Side Clearance

Measure piston ring side clearance. Replace piston rings as a set if out of specification.



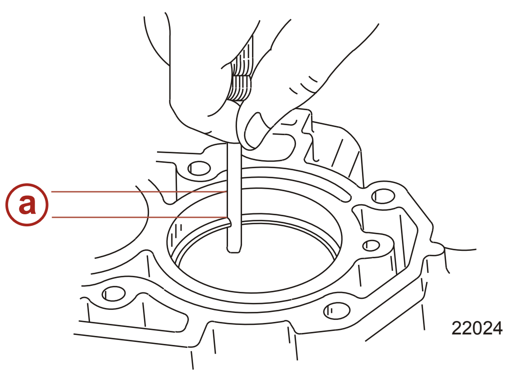
a - Top ring
b - Middle ring
c - Oil ring

Piston Ring Side Clearance	
Top "a"	0.04–0.08 mm (0.0015–0.0033 in.)
Middle "b"	0.04–0.08 mm (0.0015–0.0033 in.)
Oil "c"	0.05–0.17 mm (0.002–0.0066 in.)

Piston Ring End Gap

Measure piston ring end gap clearance. Replace piston rings as a set if out of specification.

NOTE: *Ring must be level for measurement. Push ring 25.4 mm (1.0 in.) into bore with crown of piston.*

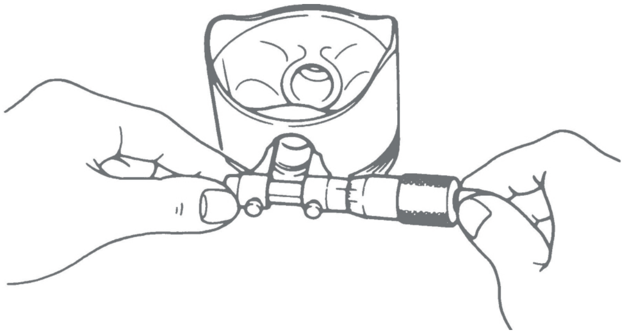


a - 25.4 mm (1.0 in.)

Piston Ring End Gap	
Top	0.27–0.42 mm (0.0106–0.0165 in.)
Middle	0.42–0.62 mm (0.016–0.024 in.)
Oil	0.20–0.70 mm (0.007–0.027 in.)

Piston Wrist Pin Diameter

Measure the piston pin bore diameter. Replace the piston if out of specification.

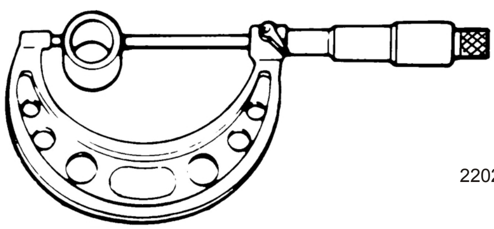


22025

Piston Pin	
Bore diameter	22.004–22.011 mm (0.8662–0.8665 in.)

Piston Pin

Measure the piston pin diameter. Replace the piston pin if out of specification.



22026

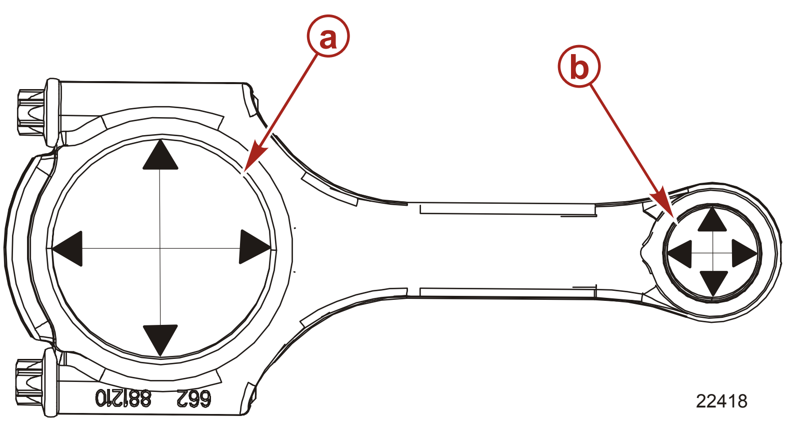
Piston Pin	
Diameter	21.997–22.0 mm (0.8660–0.8664 in.)

Measuring Connecting Rod

1. Ensure the rod cap fits perfect. Tighten the connecting rod cap bolts to the specified torque.

Description	Nm	lb-in.	lb-ft
Rod cap bolts	10	88	

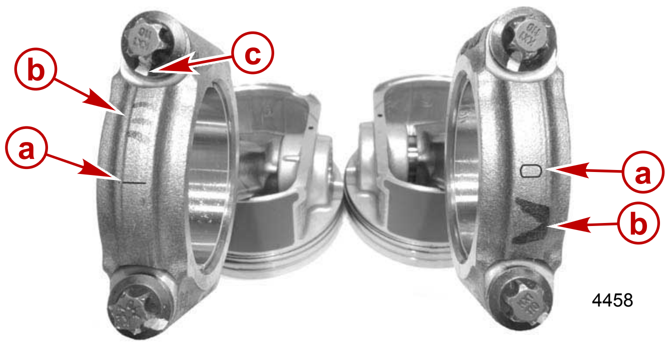
2. Measure the small (piston pin) and large (crankpin journal) ends of the connecting rod.



22418

a - Crankshaft journal end
b - Piston pin end

3. Compare the connecting rod crankpin journal measurement with the crankpin journal grade specifications listed in the following chart. If the connecting rod crankpin journal measurement does not match the stamped connecting rod crankpin journal grade, replace the connecting rod.



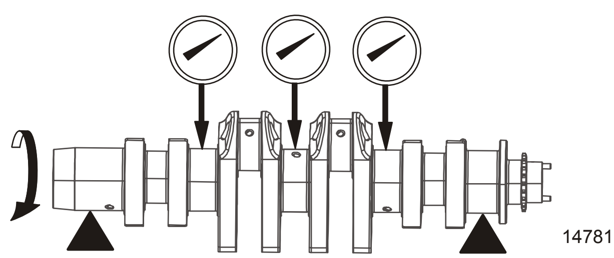
a - Stamped connecting rod crankpin journal grade
b - Marker indicating cylinder location
c - Paint on rod cap screw

Connecting Rod	
Piston pin	22.005–22.014 mm (0.8662–0.8665 in.)
Crankpin journal grade "I"	53.000–53.009 mm (2.0866–2.0869 in.)
Crankpin journal grade "0"	53.009–53.018 mm (2.0869–2.0873 in.)

Measuring Crankshaft

CRANKSHAFT RUNOUT

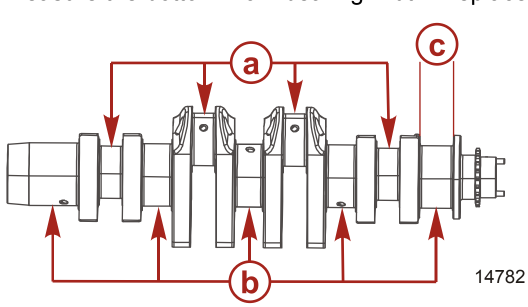
1. Thoroughly clean crankshaft and inspect bearing surfaces. Replace crankshaft if bearing surfaces are pitted, scored, or discolored.
2. Measure runout on all of the main bearing journals. Replace crankshaft if out of specification.
3. Clean oil holes in crankshaft.



Crankshaft	
Runout limit	0.05 mm (0.002 in.)

CRANKSHAFT MAIN BEARING AND CRANKPIN MEASUREMENT

1. Measure crankshaft journal diameter and crankpin diameter. Replace if out of specification.
2. Measure the bottom main bearing width. Replace if out of specification.



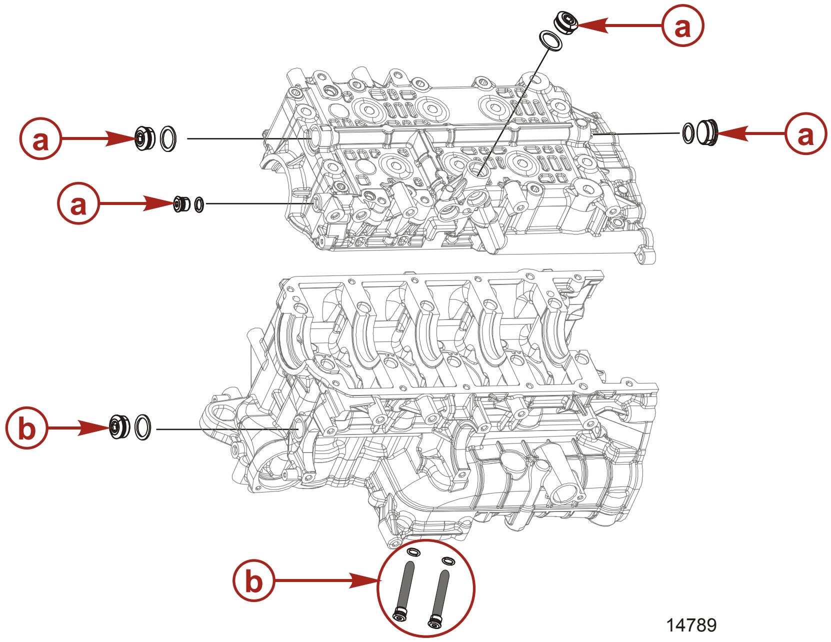
a - Crankpin journals
b - Main bearing journals
c - Bottom main bearing width

Crankshaft Journal Specifications		
Description	**Dimension**	**Grade**
Main bearing journal	59.993–60.001 mm (2.3619–2.3622 in.)	A
	59.985–59.993 mm (2.3616–2.3619 in.)	B
Crankpin journal	49.991–50.000 mm (1.9681–1.9685 in.)	C
	49.982–49.991 mm (1.9677–1.9681 in.)	D
Bottom main bearing width	31.4–31.6 mm (1.236–1.244 in.)	

Powerhead Assembly

Installing Water and Oil Galley Plugs

1. Install new O-rings onto the water and oil galley plugs.
2. Apply Loctite 567 Pipe Sealant on the threads of the water and oil galley plugs.
3. Install the water galley plugs. Tighten to the specified torque.
4. Install the oil galley plugs. Tighten to the specified torque.



a - Oil galley plugs
b - Water galley plugs

14789

Description		Nm	lb-in.	lb-ft
Water galley plugs	M24 x 2	50		36.8
	M12 x 1.5	9	80	
Oil galley plugs	M24 x 2	50		36.8
	M12 x 1.5	9	80	

Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Water and oil galley plugs	92-809822

Powerhead Preassembly Cleaning Recommendations

IMPORTANT: Any threaded hole or bolt with threadlocking compound that is contaminated with oil, must be thoroughly cleaned with a solvent to remove all traces of oil contamination. Failure to remove oil contamination will result in poor threadlocking compound adhesion.

Prior to assembling the powerhead, all threaded holes on the cylinder head and cylinder block must be cleared of threadlocking compound dust. Use compressed air to clear threadlocking compound dust.

Wash the cylinder block and crankcase cover with hot soapy water to remove debris and honing compound. Dry the cylinder block with compressed air. Failure to thoroughly clean the cylinder block of honing compound and/or debris will result in premature engine failure.

Crankshaft Bearings

The Gen 2 crankshaft bearings have an eccentric oil groove as part of the friction reduction package.

Models Covered	Serial Number or Year
Verado 135/150/175/200 Gen 2	1B517159 06/05/2007

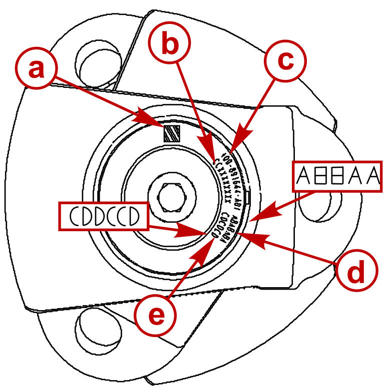
IMPORTANT: The eccentric crankshaft bearings do not backfit. Do not mix the bearings.

40655

a - Full oil groove - S/N 1B517158 and below
b - Eccentric oil groove - S/N 1B517159 and above

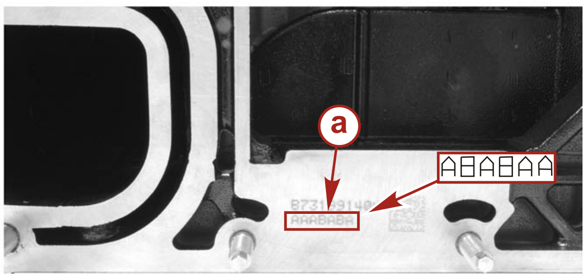
Selecting New Crankshaft Bearings

When replacing the crankshaft main bearings and crankpin bearings, select the suitable bearing from the bearing grade identifier located at the flywheel end of the crankshaft and on the bottom of the cylinder block.



5142

a - Bar code
b - Manufacture date
c - Part number
d - Main bearing journal grade
e - Crankpin journal grade



4423

a - Cylinder block main bearing journal grade

NOTE: When reading the main bearing journal grade on the crankshaft, the journal grade is in sequential order from J1 to J5 in a clockwise orientation.

NOTE: When reading the crankpin bearing journal grade on the crankshaft, the journal grade is in sequential order from P1 to P4 in a clockwise orientation.

NOTE: When reading the main bearing journal grade on the cylinder block, the journal grade is in sequential order from the top main bearing to the bottom thrust bearing.

Crankshaft Main Bearing Grade Selection

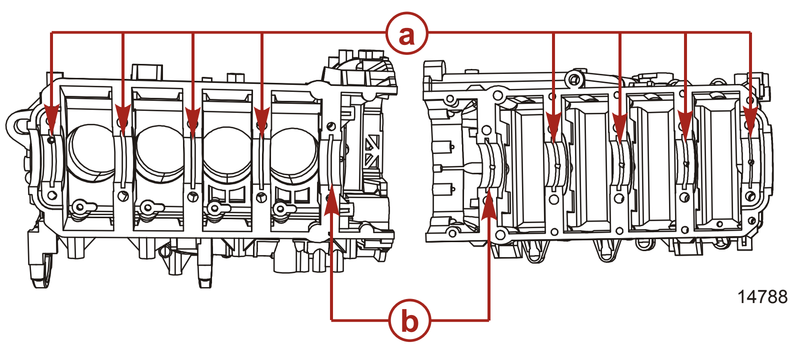
Crankshaft	
Main bearing oil clearance	0.014–0.042 mm (0.0005–0.0016 in.)

IMPORTANT: Ensure all mating surfaces, oil passages, water jackets, and cylinder bores are clean prior to assembling the powerhead. Always install new gaskets, seals, O-rings, piston ring, and wrist pin retaining clips. Replace torque to yield screws where advised to do so. Follow all advised lubrication during assembly.

1. Check the crankshaft journal size code and the cylinder block main bearing code.
2. Refer to the bearing selection chart to select the correct crankshaft main bearings.

   IMPORTANT: After selecting the correct bearing, install the bearing halves in the cylinder block and crankcase cover matching journal location to avoid mixing bearing sizes.

Crankshaft Journal Code	Cylinder Block Code	Bearing Color Selection
A	A	Green
A	B	Blue
A	C	White
B	A	Blue
B	B	White
B	C	Orange



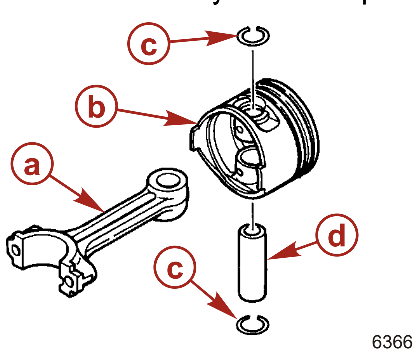
a - Main bearings
b - Main thrust bearing

3. Ensure debris is removed from the cylinder block and crankcase cover main bearing area, and install the selected main bearings.

Piston/Connecting Rod Assembly

1. Lubricate the piston pin with SPO 255.
2. Assemble the piston, connecting rod, piston pin, and new piston pin retaining clips.

   IMPORTANT: Always install new piston pin retaining clips.



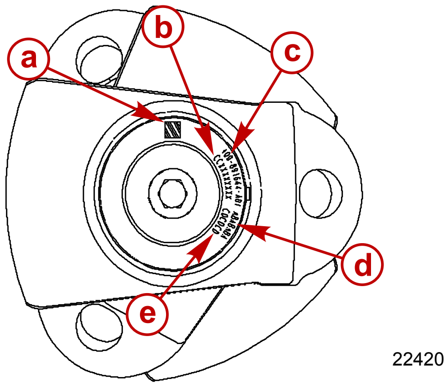
a - Paint on connecting rod
b - Piston
c - Piston pin retaining clip
d - Piston pin

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Piston pin	Obtain Locally

Connecting Rod Bearing Grade Selection

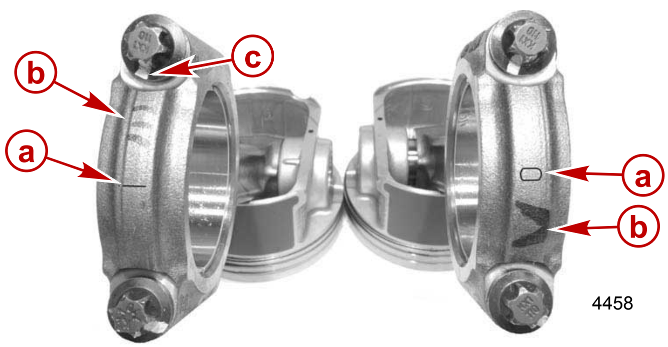
Connecting Rod	
Bearing oil clearance	0.020–0.050 mm (0.0008–0.0019 in.)

1. Check the crankpin journal size code on the flywheel end of the crankshaft.



- a - Bar code
- b - Manufacture date
- c - Part number
- d - Main bearing journal grade
- e - Crankpin journal grade

2. Check the journal code on the connecting rod cap.



- a - Stamped connecting rod crankpin journal grade
- b - Marker indicating cylinder location
- c - Paint on rod cap screw

Connecting Rod Specifications	
Piston pin	22.005–22.014 mm (0.8662–0.8665 in.)
Crankpin journal grade "I"	53.000–53.009 mm (2.0866–2.0869 in.)
Crankpin journal grade "0"	53.009–53.018 mm (2.0869–2.0873 in.)

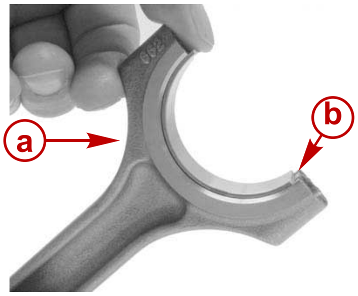
3. Refer to the bearing selection chart following, to select the correct crankshaft connecting rod bearings.

IMPORTANT: After selecting the correct bearing, install the bearing halves in the connecting rod and the matching connecting rod cap to avoid mixing bearing sizes.

Connecting Rod Journal Code	Crankshaft Pin Journal Code	Bearing Color Selection
I	C	Blue
I	D	White
0	C	White
0	D	Orange

4. Ensure the connecting rod bearing area is free of debris.

5. Install the locating tab of the upper half of the bearing into the slot on the connecting rod, and the locating tab of the lower half of the bearing into the slot on the connecting rod cap. Carefully push the bearing onto the connecting rod and connecting rod cap.



4389

a - Connecting rod
b - Connecting rod locating tab

Piston Ring Installation

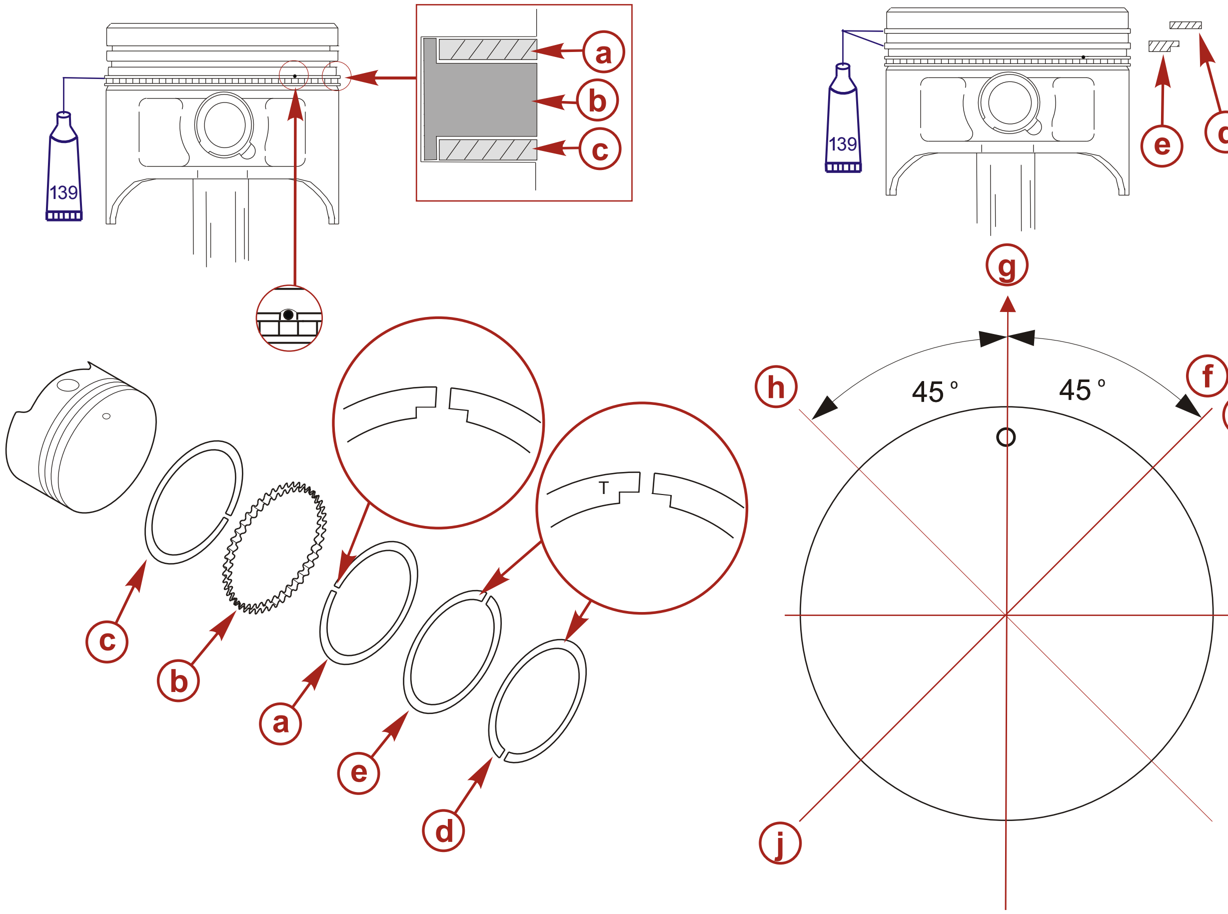
IMPORTANT: Do not reuse the original rings during reassembly. Always install new rings when rebuilding engine.

IMPORTANT: Use caution when installing piston rings to avoid scratching piston.

1. Apply Synthetic Blend 4-Stroke Outboard Oil 25W-40 engine oil to the piston ring grooves.
2. Install the oil ring spacer onto the lower ring groove of the piston.

   NOTE: *Ensure the oil ring spacer gap is properly orientated on the piston. The oil ring spacer cannot be rotated after the bottom and top oil control rings are installed.*
3. Install the bottom oil control ring.
4. Install the top oil control ring. The top oil ring uses a locating pin on the piston.
5. Install the second compression ring.
6. Install the top compression ring.
7. Position the piston ring gaps as shown.

NOTE: The second and top piston compression rings must be installed with the "T" side up. Spread rings just enough to slip over piston.



17806

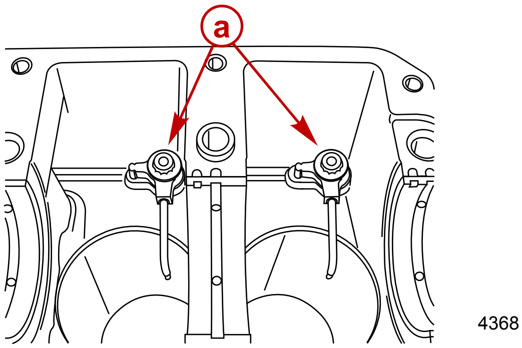
a - Top oil control ring
b - Oil ring spacer
c - Bottom oil control ring
d - Top compression ring
e - Second compression ring
f - Bottom compression ring gap
g - Oil ring spacer
h - Top oil control ring gap
i - Top compression ring gap
j - Second compression ring gap

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Piston rings	92-858052K01

Piston Assembly Installation

Models with Piston Cooling Jets - S/N 1B517158 and Below

Install the piston cooling jets. Tighten to the specified torque.



a - Piston cooling jets

Description	Nm	lb-in.	lb-ft
Piston cooling jet	23		17

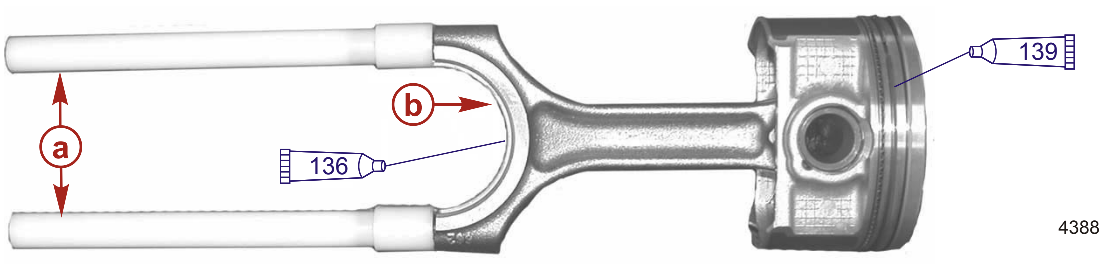
All Models

1. Lubricate the cylinder block bearings with Lubriplate SPO 255.
2. Place the crankshaft onto the cylinder block.
3. Install the crankshaft retainer onto one of the center main bearings. Tighten the retainer bolts securely.

Crankshaft Retainer	Part number not available for this printing.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Cylinder block bearings	Obtain Locally

4. Install the piston rod guide dowels onto the connecting rod assembly. Lubricate the piston and rings with Synthetic Blend 4-Stroke Outboard Oil 25W-40.
5. Lubricate the connecting rod bearing with Lubriplate SPO 255.
6. Lubricate the cylinder bore with Synthetic Blend 4-Stroke Outboard Oil 25W-40.



a - Piston rod guide dowel
b - Connecting rod bearing

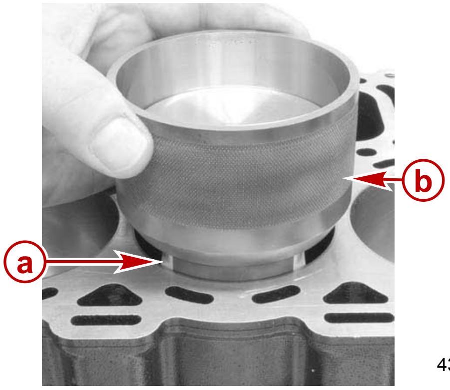
Rod Guide Dowel	Part number not available for this printing.

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Piston and rings, cylinder bore	92-858052K01
136	Lubriplate SPO 255	Connecting rod bearing	Obtain Locally

7. Slide the piston ring compressor over the piston so approximately 50% of the piston is showing below the ring compressor.

Ring Compressor	Part number not available for this printing

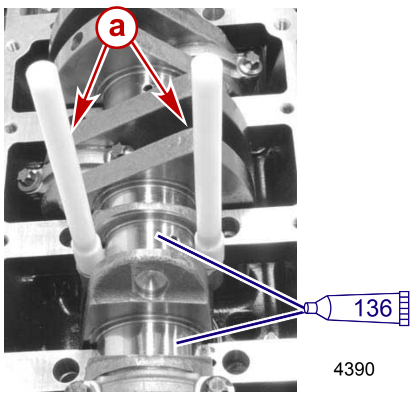
8. Insert the piston assembly into the cylinder bore. Ensure the dot on the piston is pointing towards the flywheel end of the crankshaft.
9. Ensure the ring compressor is fully seated on the cylinder block.



4393

a - Piston skirt
b - Ring compressor

10. Ensure the rod guide straddles the crankpin.
11. Push the piston assembly into the cylinder bore and onto the crankpin.
12. Remove the rod guides.
13. Lubricate the crankpin with Lubriplate SPO 255.



4390

a - Rod guide

Rod Guide Dowel	Part number not available for this printing.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Crankpin	Obtain Locally

14. Install the rod cap/bearing assembly.
15. Ensure the rod cap orientation is correct. The rod cap must fit perfect.
16. Lubricate the new rod cap screw threads and head with Synthetic Blend 4-Stroke Outboard Oil 25W-40.

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Rod cap screw threads and head	92-858052K01

17. Install new rod cap screws.
18. Torque the rod cap screws to 15 Nm (133 lb-in.). Then torque to 30 Nm (22 lb-ft).

    NOTE: After the second torque, paint a line on the rod cap screw parallel with the crankshaft. This will help distinguish when the rod cap screw has turned the additional 90°.
19. Turn the rod cap screw an additional 90° after the second torque.

Description		Nm	lb-in.	lb-ft
Connecting rod cap screw	**First torque**	15	133	
	Second torque	30		22
	Final torque	Turn additional 90°		

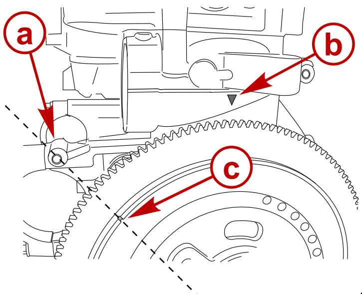
20. Install the remaining connecting rod assemblies using the same installation sequence.

Cylinder Head Installation

IMPORTANT: This engine utilizes an interference valve train design. Do not rotate the crankshaft or cams when the timing chain is loose or removed from the cam gears unless advised to do so. Failure to adhere to this caution may result in valve and/or piston damage.

IMPORTANT: The installation of the cylinder head must be strictly followed. Failure to follow the installation outline procedure may damage the valve train components.

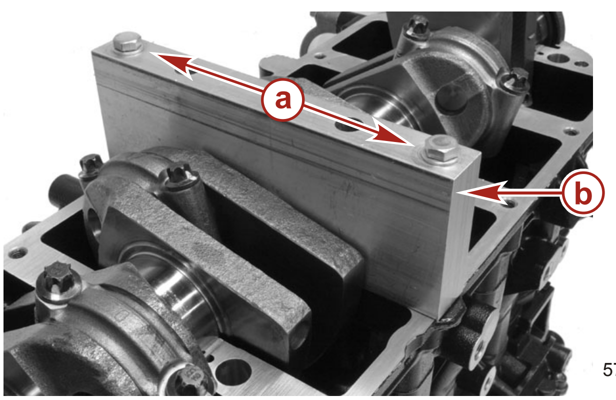
1. Install the flywheel key on the crankshaft and install the flywheel.
2. Install the flywheel retaining bolt and washer. Tighten the flywheel bolt until it is snug.
3. Rotate the engine so the flywheel timing mark aligns with the rear starter mount. This will allow sufficient piston to valve clearance to rotate the cams.



4035

a - Rear starter mount
b - Cylinder block timing mark
c - Flywheel timing mark

4. Install the crankshaft retainer on one of the center main bearings. Tighten the crankshaft retainer bolts securely.



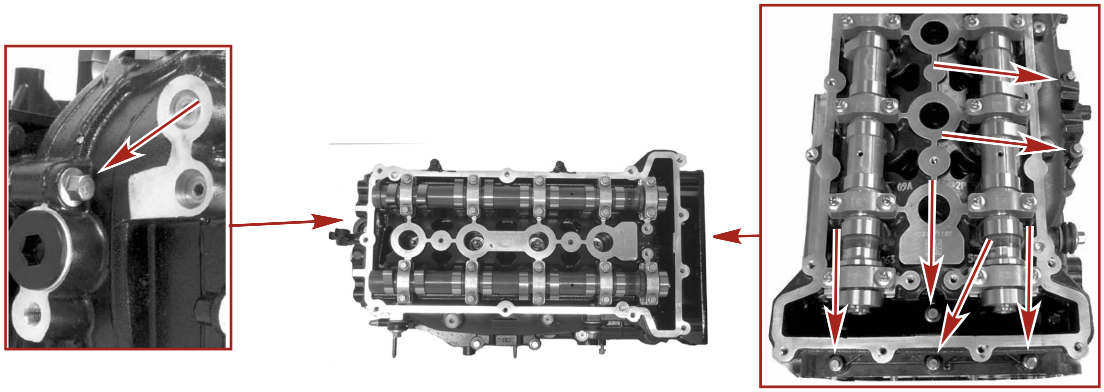
5755

a - Crankshaft retainer bolts
b - Crankshaft retainer

Crankshaft Retainer	Part number currently not available for this printing.

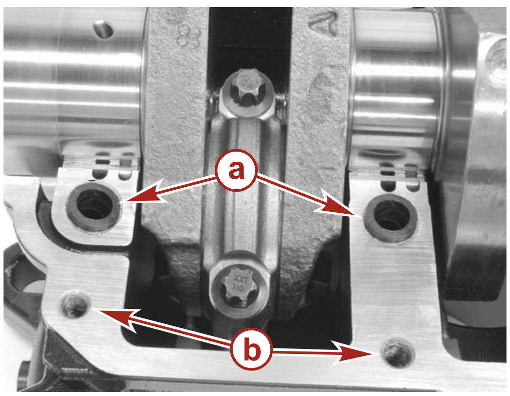
5. Rotate the cylinder block to install the head.
6. Place a new head gasket on the cylinder block.
7. Install the cylinder head to the cylinder block.

8. Install the cylinder head perimeter screws so they are snug. Do not tighten the cylinder head perimeter bolts.



14777

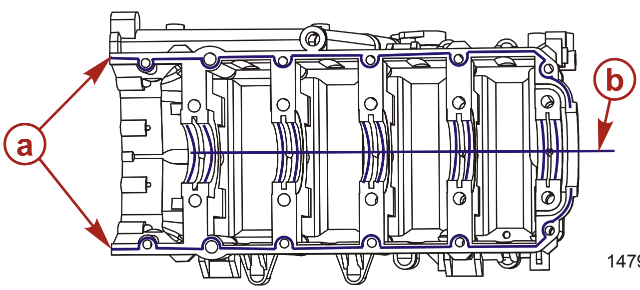
9. Rotate the cylinder block and remove the crankshaft retainer.
10. Install the rubber dampeners into the cylinder block. Ensure the dampeners are seated completely in the cylinder block.



4486

a - Rubber dampener seated
b - Crankcase cover perimeter bolt holes

11. Apply a 1 mm (0.040 in.) by 1 mm (0.040 in.) thin continuous bead of Three Bond 1217F around the cylinder block cover perimeter. Do not allow Three Bond 1217F to contact the main bearings.
12. Lubricate the crankshaft main bearings with Lubriplate SPO 255.



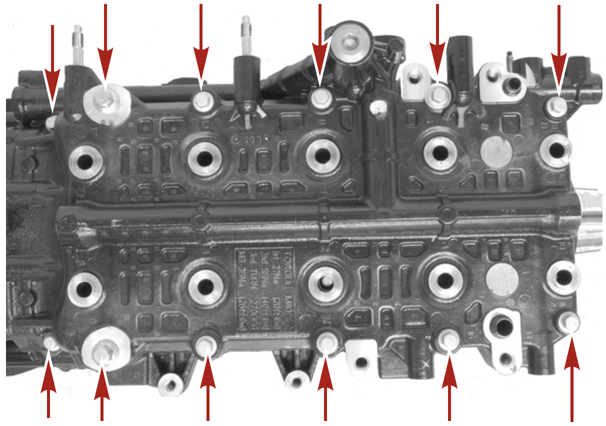
14790

a - Three Bond 1217F
b - Lubriplate SPO 255

Tube Ref No.	Description	Where Used	Part No.
135	Three Bond 1217F	Cylinder block cover	92-858005K02
136	Lubriplate SPO 255	Crankshaft main bearings	Obtain Locally

13. Carefully place the cylinder block cover onto the cylinder block.

14. Install the perimeter bolts, but do not tighten.



14780

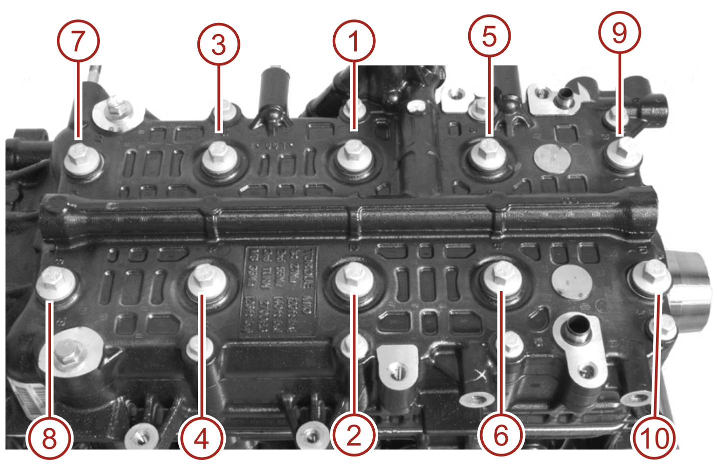
15. Lubricate the threads of the long main bearing bolts with molybdenum disulfide grease.

Tube Ref No.	Description	Where Used	Part No.
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Long main bearing bolt threads	Obtain Locally

16. Insert the long main bearing bolts into the cylinder block cover. Thread the long main bearing bolts into the rubber dampeners and into the cylinder head.

    NOTE: Do not force the long main bearing bolts past the cylinder block rubber dampeners. Forcing the long main bearing bolts past the cylinder block rubber dampeners may damage or fold the cylinder block rubber dampeners.

17. In the sequence listed on the cylinder block cover, tighten the long main bolts in three steps.
18. After the second torque is attained, mark all of the long main bolt heads with a line of paint, parallel to the crankshaft. This will help ensure the 270° turn is correctly attained.



14802

Description		Nm	lb-in.	lb-ft
Long main bolt	**First torque**	27		19.9
	Second torque	55		40.6
	Final torque	Turn additional 270° after 2nd torque is attained		

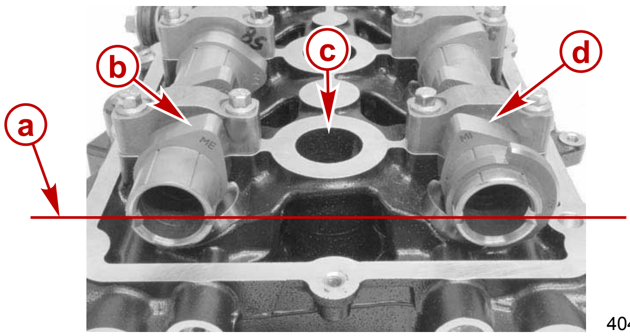
19. Tighten the cylinder block perimeter bolts in the order listed on the cylinder block to the specified torque.
20. Tighten the cylinder head perimeter bolts to the specified torque.

Description	Nm	lb-in.	lb-ft
Cylinder block perimeter bolts	35		25.8

Description		Nm	lb-in.	lb-ft
Cylinder head perimeter bolts	(M8 x 60)	28		20.6
	(M6 x 40)	11	97	

21. Check the valve lash clearance on all the valves. If the valve lash is not within specification, refer to **Section 4B - Valve Clearance and Adjustments.** If the valve lash is within specification, proceed with the next step.
22. Rotate the cams so the cam lobes for cylinder number one, intake and exhaust, points toward the spark plug coil.

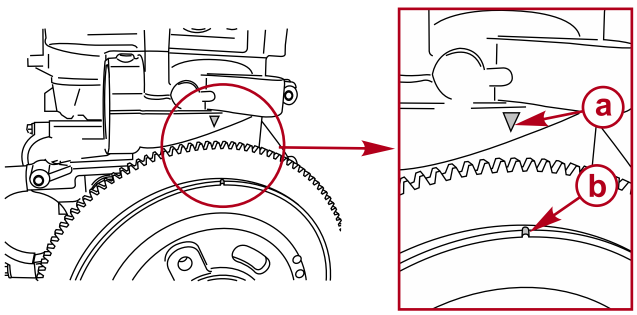
NOTE: The cams will be in correct alignment when the machined groove on the top of the cams are aligned.



4044

a - Machined groove on top of cams
b - Exhaust cam lobe position
c - #1 spark plug hole
d - Intake cam lobe position

23. Rotate the flywheel clockwise so the flywheel timing mark aligns with the arrow on the cylinder block.



3465

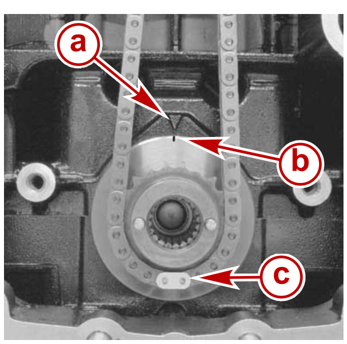
a - Timing mark on cylinder block
b - Timing mark on flywheel

Timing Chain

IMPORTANT: This engine utilizes an interference valve train design. Do not rotate the crankshaft or cams when the timing chain is loose or removed from the cam gears unless advised to do so. Failure to adhere to this caution may result in valve and/or piston damage.

IMPORTANT: The removal, disassembly, reassembly, and installation procedure of the head and cams must be strictly followed. Failure to follow the removal outline procedure may damage the valve train components.

1. Ensure the crankshaft timing mark is in alignment with the cylinder block timing mark.
2. Install the timing chain with the anodized link directly below the timing marks on the cylinder block and the crankshaft.

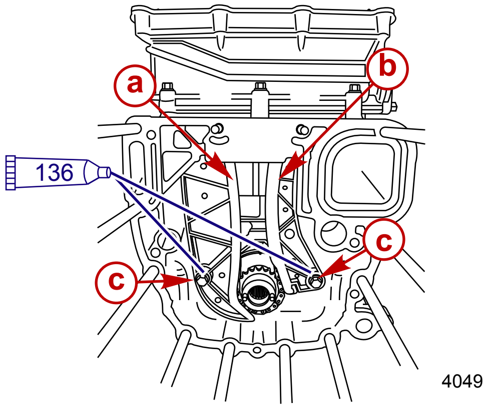


4047

a - Cylinder block timing mark
b - Crankshaft timing mark
c - Timing chain anodized link

3. Install the fixed chain guide and the movable chain guide to the cylinder block.
4. Lubricate the chain guide bolts with Lubriplate SPO 255.

5. Tighten the chain guide bolts to the specified torque.



a - Fixed chain guide
b - Movable chain guide
c - Chain guide retaining bolts

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Chain guide bolts	Obtain Locally

Description	Nm	lb-in.	lb-ft
Fixed and movable chain guide bolt	24		17.5

6. Install the cam gear on the intake cam. Retain the cam gear with the cam gear flange head bolt.

   IMPORTANT: Do not tighten the cam gear bolt.

   NOTE: The cam gear bolts are left-hand thread.

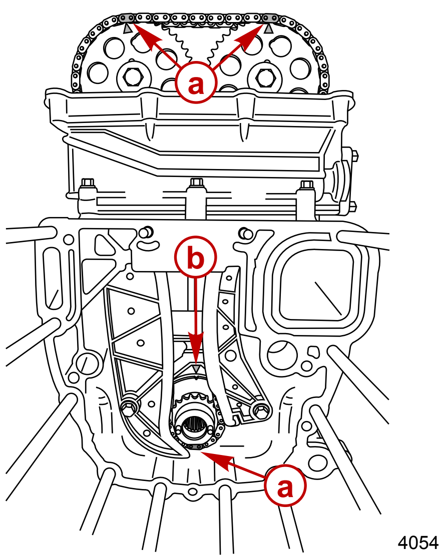
7. Install the timing chain on the intake cam gear. The anodized link of the timing chain must align with the timing mark on the cam gear. Rotating the crankshaft a few degrees may ease the installation of the timing chain/cam gear onto the cam. Secure with the cam gear retaining screw and washer.

   IMPORTANT: Do not tighten the cam gear bolt.

8. Place the exhaust cam timing gear in the chain, ensuring the timing mark on the cam gear and the anodized timing chain link are aligned. Install the cam gear with the timing chain onto the exhaust cam. Secure with the cam gear retaining screw and washer.

   IMPORTANT: Do not tighten the cam gear bolt.

9. Inspect the timing chain installation for correct alignment of the timing chain anodized links. Ensure the crankshaft timing mark and the cylinder block timing marks are in alignment.



a - Timing chain anodized links
b - Cylinder block timing mark

10. Install the cam lock.

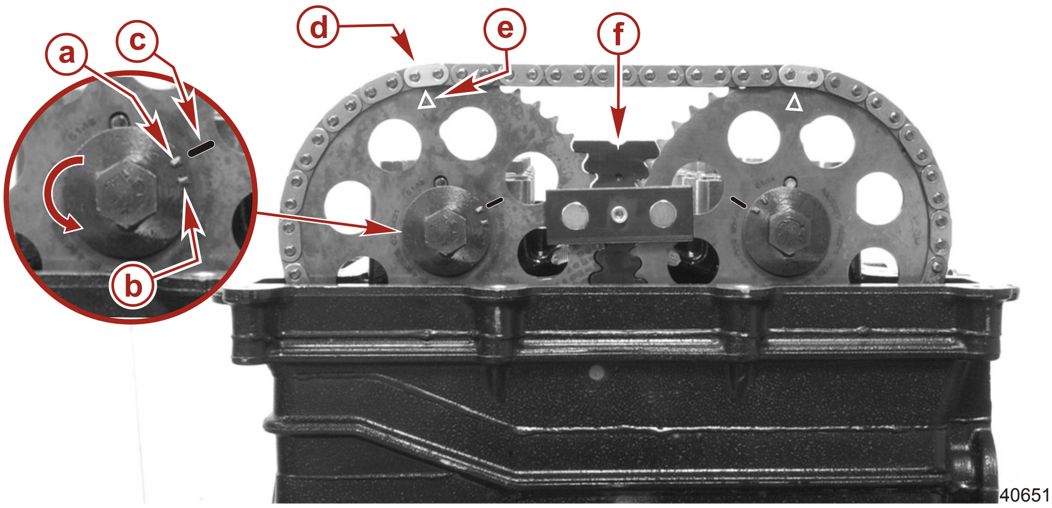
    NOTE: The cams must be locked with a special tool to prevent loading of the cam gears and chain. Loading the cam gear and chain may damage the cam gear and chain.

11. Each cam gear bolt should be tightened in two steps.

    NOTE: The cam gear bolts are left-hand thread.

a. Tighten the cam gear bolt to 45 Nm (33 lb-ft).

b. Paint an orientation line on the cam gear, in line with mark "a" on the cam gear flange head bolt. Turn the cam gear bolt until mark "b" on the cam gear flange head bolt aligns with the paint orientation line. This is the additional 20° turn after the first torque is attained.

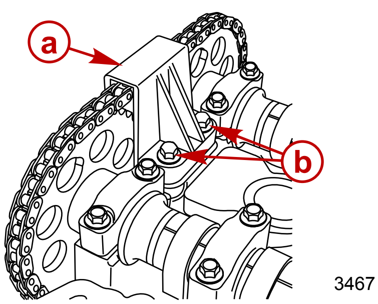


a - Mark "a"
b - Mark "b"
c - Painted orientation line
d - Anodized link
e - Cam gear timing mark
f - Cam lock

Description		Nm	lb-in.	lb-ft
Cam gear flange head bolt (M12 x 40) (left-hand thread)	**First torque**	45		33
	Final torque	Turn an additional 20° after the first torque is attained		

Cam Lock	91-896911A01

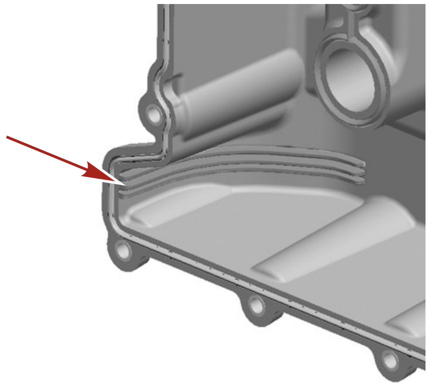
12. Remove the cam lock.
13. Engines S/N 1B733388 and below, when using the original cam cover: Install the short span chain guide. Tighten the short span chain guide bolts to the specified torque.



S/N 1B733388 and below
a - Short span chain guide
b - Short span chain guide bolts

Description	Nm	lb-in.	lb-ft
Short span chain guide bolt (M6 x 30)	10	89	

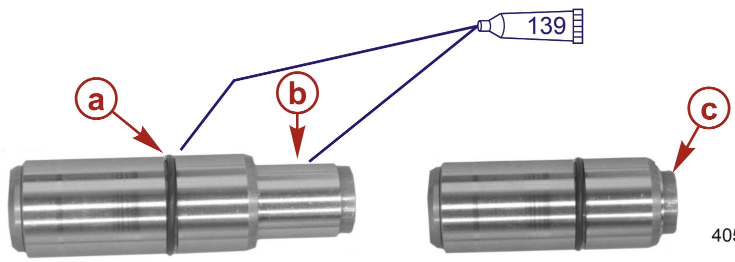
NOTE: Engines S/N 1B733389 and above incorporate a chain guide rib into the inside of the cam cover. The short span chain guide is not installed.



41512

NOTE: If a new style cam cover is installed on engines S/N 1B733388 and below, discard the short span chain guide and bolts.

14. Place a new O-ring on the timing chain tensioner assembly.
15. Compress the timing chain tensioner assembly and release the tensioner slowly. The tensioner should remain compressed.
16. Lubricate the timing chain tensioner with Synthetic Blend 4-Stroke Outboard Oil 25W-40.



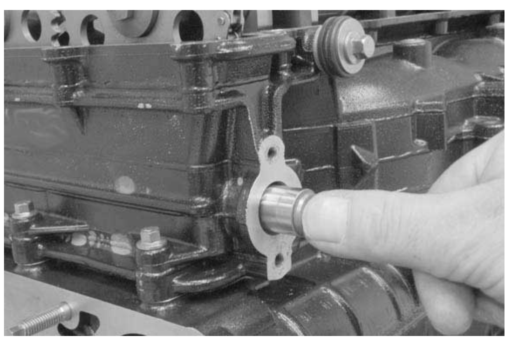
4056

a - O-ring
b - Tensioner extended
c - Tensioner compressed

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Timing chain tensioner	92-858052K01

17. Carefully push the timing chain tensioner assembly into the cylinder head.

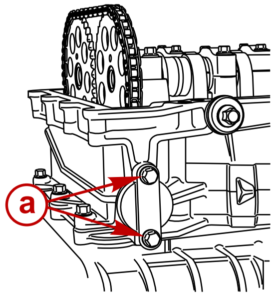
    NOTE: The timing chain tensioner O-ring will retain the timing chain tensioner in the cylinder head.



4057

18. Install a new O-ring onto the timing chain tensioner cover.

19. Tighten the chain tensioner cover bolts to the specified torque.

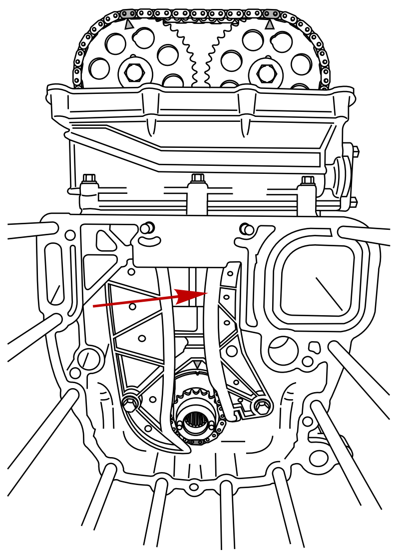


3471

a - Chain tensioner cover bolt

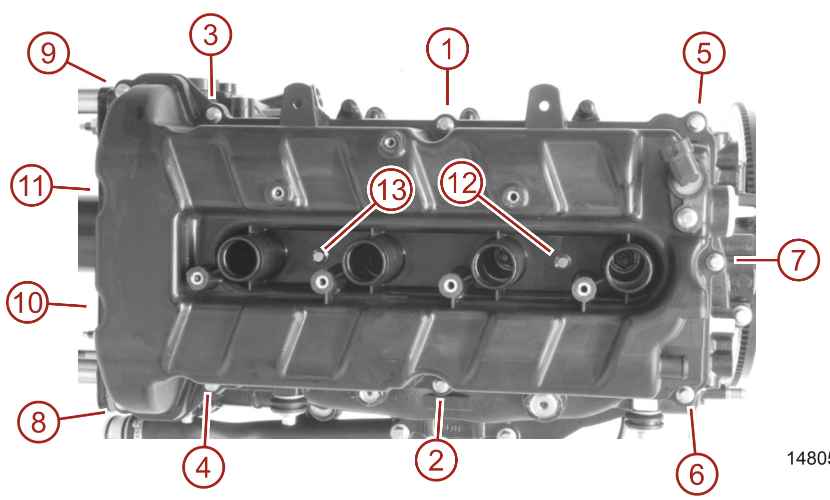
Description	Nm	lb-in.	lb-ft
Chain tensioner cover bolt (M6 x 25)	10	89	

20. Push on the movable chain guide towards the timing chain tensioner. The timing chain tensioner should expand and maintain proper timing chain tension.



4133

21. Install a new gasket on the valve cover.
22. Install the valve cover.
23. Install and lightly snug all the valve cover screws before tightening.
24. Tighten the valve cover screws to the specified torque, in the sequence shown.
25. After final valve cover screw has been torqued, check the center valve cover screws for proper torque.



14805

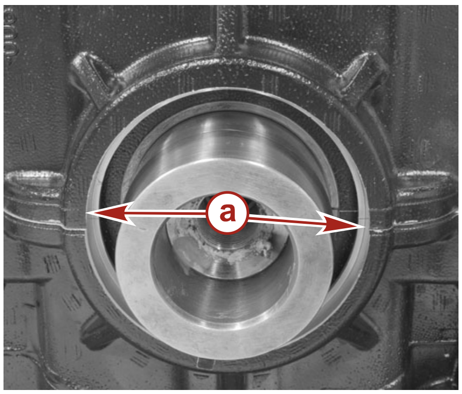
Description	Nm	lb-in.	lb-ft
Valve cover screw (M6 x 25)	10	89	

Installing Upper Crankshaft Seal

NOTICE

If the crankshaft's upper bore is contaminated prior to installation, the oil seal will not seat properly, leading to engine damage during operation. Ensure that the crankshaft's upper bore is completely clear of any oil or debris before installing the oil seal or other components.

1. Thoroughly clean the inside diameter of the cylinder block crankcase seal area.
2. Lightly lubricate the inside diameter of the cylinder block crankcase seal area with Synthetic Blend 4-Stroke Outboard Oil 25W-40.

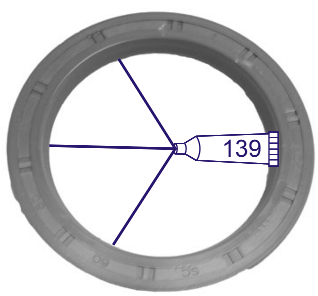


5856

a - Area to be lubricated

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Inside diameter of cylinder block crankshaft seal area	92-858052K01

3. Lightly lubricate the crankshaft seal inside diameter with Synthetic Blend 4-Stroke Outboard Oil 25W-40.

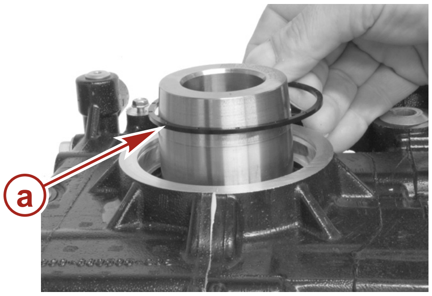


16027

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Inside diameter of crankshaft seal	92-858052K01

New Crankshaft Installation

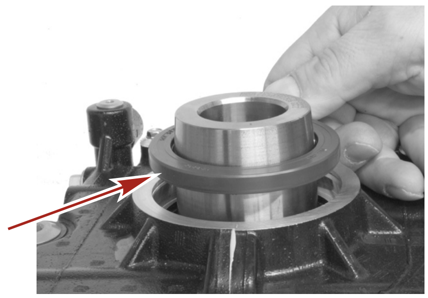
1. Place the seal spacer inside the seal bore area.



14806

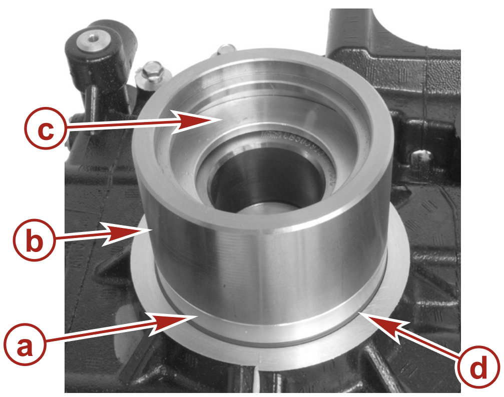
a - Seal spacer

2. Install the crankshaft seal into the cylinder block seal bore.



14807

3. Install the seal installation tool with the spacer and guide ring. Ensure the guide ring is seated on the crankshaft taper.

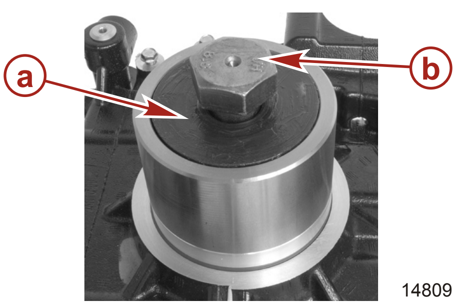


14808

a - Spacer
b - Seal installer
c - Guide ring
d - Seal

Crankshaft Seal Installation Tool	Part number not available for this printing

4. Install the flywheel washer and bolt. Tighten the flywheel bolt to the specified torque.

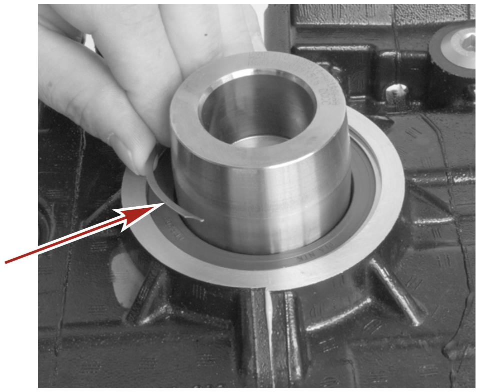


14809

a - Flywheel washer
b - Flywheel bolt

Description	Nm	lb-in.	lb-ft
Flywheel bolt	27		20

5. Remove the installation tool and install the retaining ring onto the cylinder block retaining ring groove.

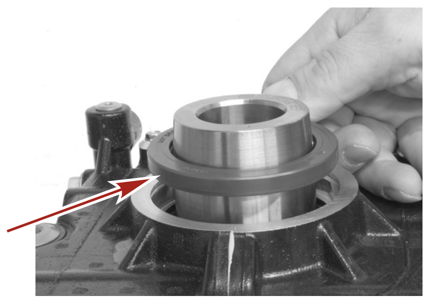


14818

Original Crankshaft Installation

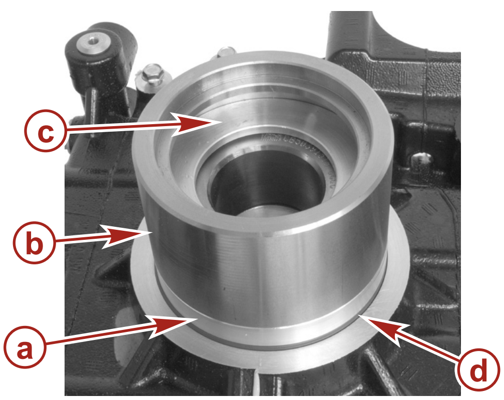
IMPORTANT: When using the original crankshaft in a replacement cylinder block, or reusing the original block and the original crankshaft, inspect the crankshaft seal area for a seal groove. If a seal groove is present, the crankshaft seal must be installed before the crankshaft seal spacer. If no seal groove is present, follow the installation instructions for a new crankshaft installation.

1. Install the crankshaft seal into the cylinder block seal bore.



14807

2. Install the seal installation tool with the spacer and guide ring. Ensure the guide ring is seated on the crankshaft taper.

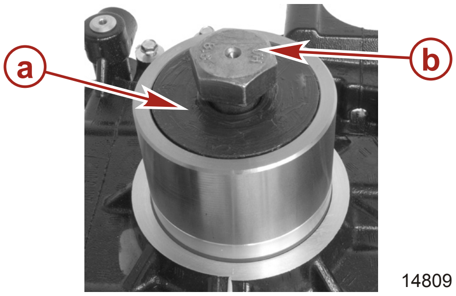


14808

a - Spacer
b - Seal installer
c - Guide ring
d - Seal

Crankshaft Seal Installation Tool	Part number not available for this printing

3. Install the flywheel washer and bolt. Tighten the flywheel bolt to the specified torque.

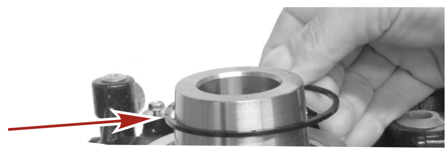


14809

a - Flywheel washer
b - Flywheel bolt

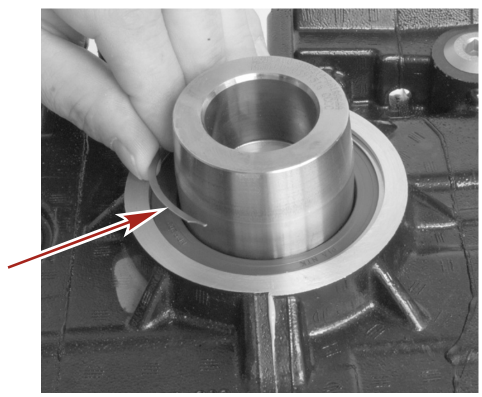
Description	Nm	lb-in.	lb-ft
Flywheel bolt	27		20

4. Install the seal spacer.



14829

5. Install the retaining ring onto the cylinder block retaining ring groove.



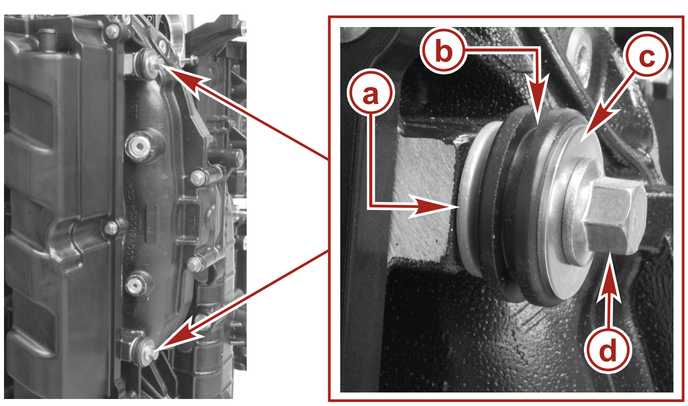
14818

Installing Powerhead Components

Electrical Box Support Grommet/Lower IOM Hose Fitting

Electrical Box Support Grommet

Install the electrical box bushing, grommet, washer, and bolt to the cylinder head. Tighten the bolt to the specified torque.



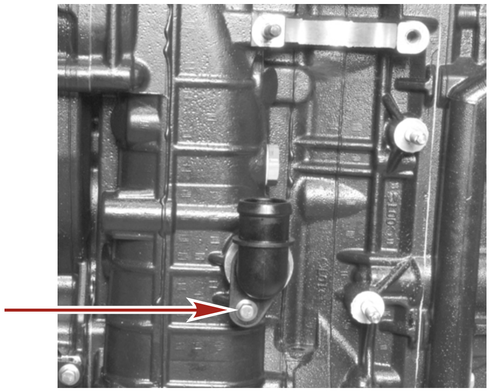
14909

a - Bushing
b - Grommet
c - Washer
d - Bolt

Description	Nm	lb-in.	lb-ft
Bolt (M8 x 35)	24	212	

Lower IOM Hose Fitting

1. Install new O-rings onto the lower IOM hose fitting.
2. Install lower IOM hose fitting onto the cylinder block and secure fitting with a bolt. Tighten bolt to the specified torque.



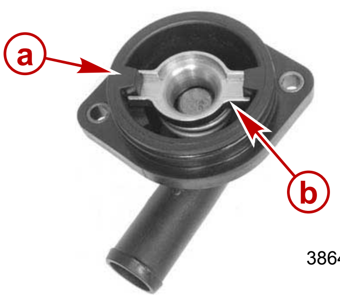
14736

Description	Nm	lb-in.	lb-ft
Bolt (M6 x 16)	10	89	

Thermostat Removal and Installation

Thermostat Removal

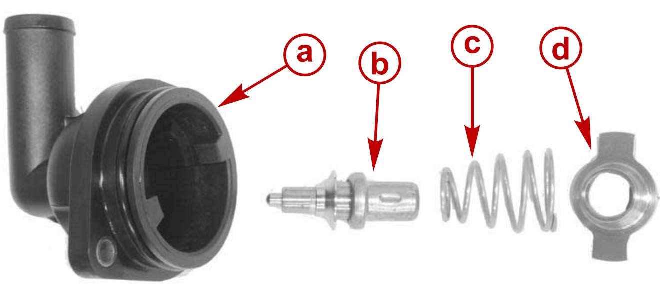
1. To remove the thermostat, push down on the thermostat retainer to disengage the thermostat retainer.
2. Turn the thermostat retainer to unlock.



3864

a - Thermostat retainer lock
b - Thermostat retainer

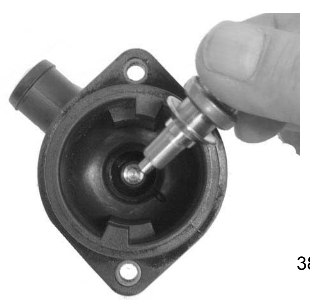
Installing Thermostat



3874

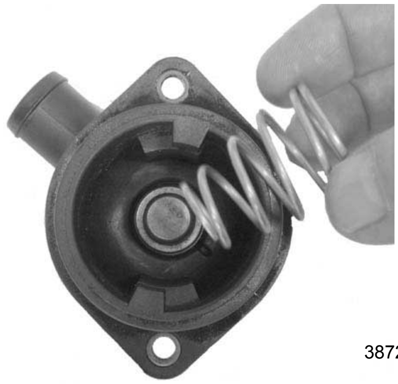
a - Thermostat housing
b - Thermostat
c - Thermostat spring
d - Thermostat retainer

1. Align the thermostat with the thermostat housing.



3871

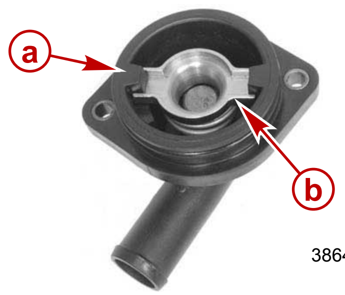
2. Install the thermostat spring. The small end of the spring is inserted first.



3872

3. Install the thermostat retainer onto the thermostat spring.
4. Push down on the thermostat retainer, turn the retainer and lock into the thermostat housing.

3873



3864

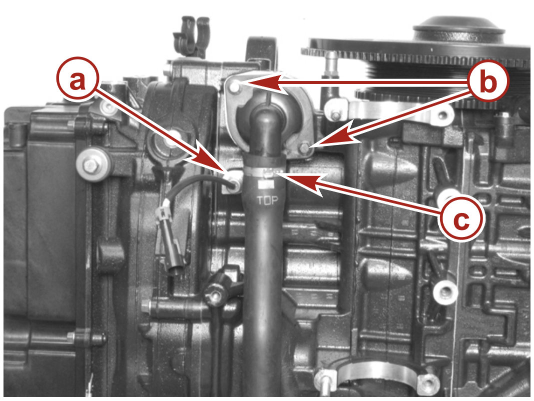
a - Thermostat retainer lock
b - Thermostat retainer

Thermostat Housing/Cylinder Block Water Temperature Sensor

1. Install a new O-ring onto the cylinder block water temperature sensor.

13384

2. Install the cylinder block water temperature sensor to the cylinder block. Tighten to the specified torque.
3. Install a new O-ring onto the thermostat housing.
4. Install the thermostat housing to the cylinder block. Secure with two bolts. Tighten bolts to the specified torque.
5. Install a 36.1 mm hose clamp to the thermostat dump hose.

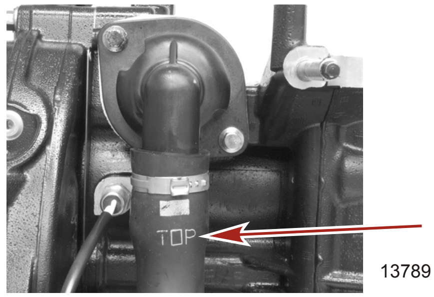


14610

a - Cylinder block water temperature sensor
b - Thermostat housing bolts
c - 36.1 mm hose clamp

Description	Nm	lb-in.	lb-ft
Cylinder block water temperature sensor	15	133	
Bolt (M6 x 25) (2)	8	71	

6. Install the thermostat dump hose to the thermostat housing. Orientate the thermostat dump hose so the word "TOP" faces out. Secure the thermostat dump hose to the thermostat housing with hose clamp tool.

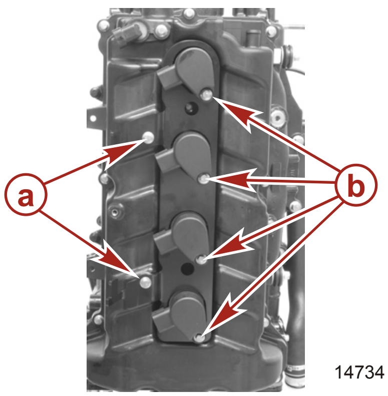


13789

Hose Clamp Tool Kit	91-803146A2

Ignition Coil Installation

1. Install the spark plugs. Tighten spark plugs to the specified torque.
2. Install the ignition coil support bracket and secure to the valve cover with two bolts. Do not tighten the bolts at this time.
3. Install the ignition coils and secure each ignition coil with a bolt. Tighten each ignition coil bolt to the specified torque.
4. Tighten the ignition coil support bracket bolts to the specified torque.



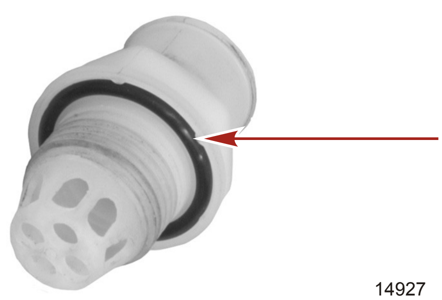
14734

a - Ignition coil support bracket bolts (2)
b - Ignition coil bolts (4)

Description	Nm	lb-in.	lb-ft
Spark plug	27		20
Bracket bolts (M6 x 16) (2)	8	71	
Coil bolts (M6 x 16) (4)	8	71	

Lower CAC Hose

1. Install a new O-ring onto the lower CAC hose fitting.


14927

2. Lubricate the O-ring and threads with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Lower CAC hose fitting O-ring and threads	Obtain Locally

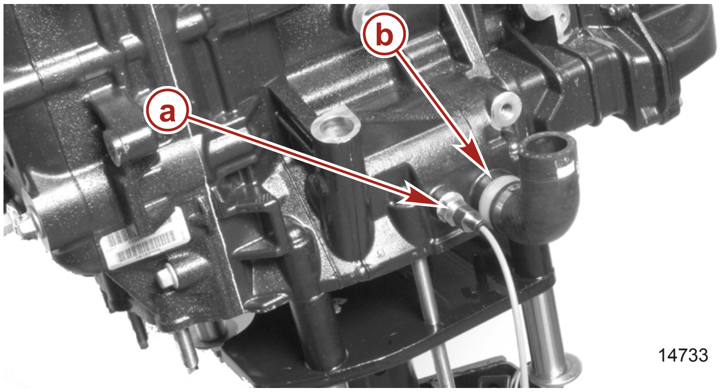
3. Install the lower CAC hose fitting onto the cylinder block and tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Lower CAC hose fitting	20	177	

4. Install a 34.6 mm hose clamp to the lower CAC hose.
5. Install the lower CAC hose to the fitting. Ensure the hose opening is towards the top of the cylinder block. Secure hose to the fitting with hose clamp tool.

Hose Clamp Tool Kit	91-803146A2

6. Install a new O-ring onto the water pressure sensor adapter Legris fitting.
7. Coat the threads of the Legris fitting with Loctite 567 PST Pipe Sealant.
8. Install the water pressure sensor adapter Legris fitting to the cylinder block. Tighten to specification.



a - Water pressure sensor adapter Legris fitting
b - Lower CAC hose fitting

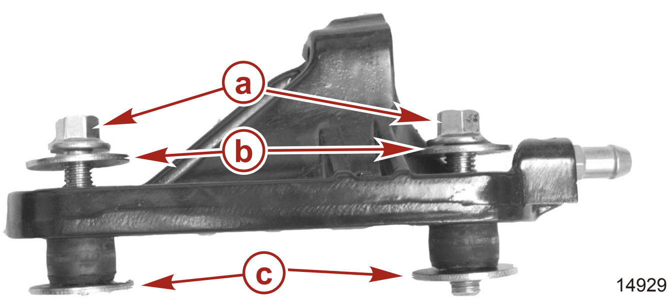
Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Cylinder block water pressure sensor adapter Legris fitting threads	92-809822

Description	Nm	lb-in.	lb-ft
Water pressure sensor adapter Legris fitting	15	133	

Alternator Support Brackets/Knock Sensor/Alternator

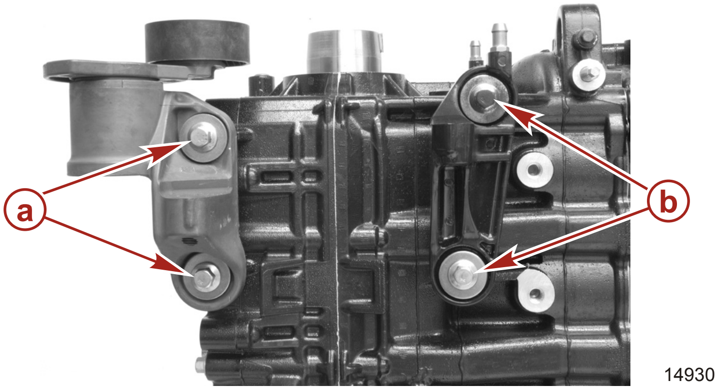
Alternator Support Brackets

1. Install a washer onto the four bolts.
2. Insert the bolts into the tensioner bracket and alternator support bracket.
3. Install washer on the bolts.



a - Bolt
b - Washer
c - Washer

4. Secure the brackets to the cylinder block. Tighten bolts to the specified torque.



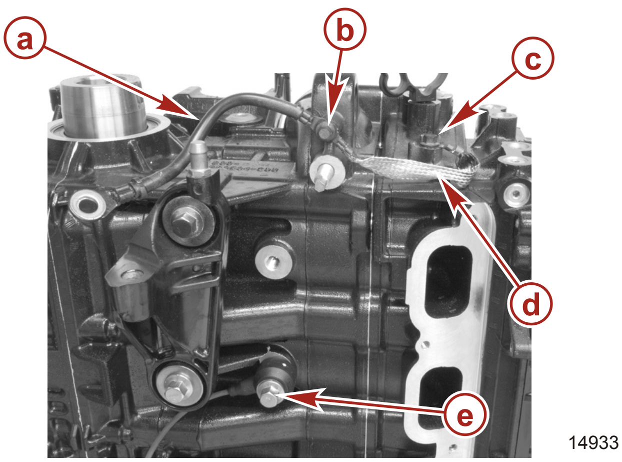
a - Tensioner bracket bolts
b - Support bracket bolts

Description	Nm	lb-in.	lb-ft
Bolts (M10 x 45) (4)	47.5		35

Knock Sensor/Alternator Ground Wires

IMPORTANT: The knock sensor retaining bolt/washer must be torqued to the specified limit. Failure to torque the knock sensor to the specified limit will result in inaccurate sensor monitoring of engine noise.

1. Install a washer onto the knock sensor bolt.
2. Install the bolt/washer onto the knock sensor.
3. Install the knock sensor to the cylinder block. Tighten to the specified torque.
4. Secure the braided ground strap to the cylinder head with a bolt.
5. Secure the other end of the braided ground strap and the alternator ground wire to the cylinder block.
6. Tighten the ground bolts to the specified torque.



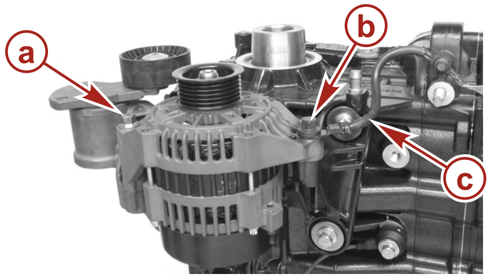
a - Alternator ground wire
b - Bolt securing alternator ground wire and braided ground strap to cylinder block
c - Bolt securing braided ground strap to cylinder head
d - Braided ground strap
e - Knock sensor bolt

Description	Nm	lb-in.	lb-ft
Knock sensor bolt (M10 x 35)	20	177	
Bolt securing ground strap and wire (M6 x 16) (2)	8	71	

Alternator

1. Secure the front of the alternator to the tensioner bracket with a bolt. Do not tighten bolt.
2. Insert the alternator mounting bolt through the eyelet of the alternator ground wire.
3. Secure the rear of the alternator with the bolt and ground wire.

4. Tighten the front and rear alternator mounting bolts to the specified torque.



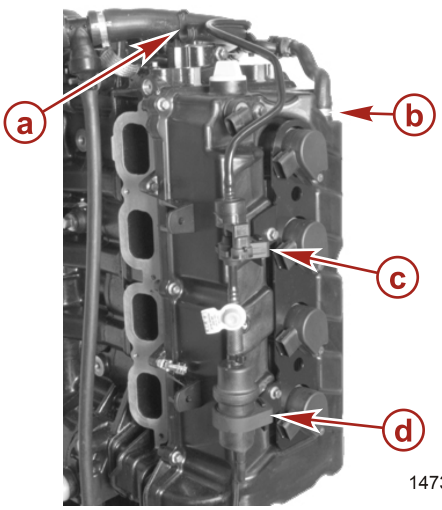
14935

a - Front alternator mounting bolt
b - Rear alternator mounting bolt
c - Alternator ground wire

Description	Nm	lb-in.	lb-ft
Front alternator mounting bolt (M10 x 85)	47.5		35
Rear alternator mounting bolt (M10 x 45)	47.5		35

FSM Vent Hose/Top Hose

1. Insert the vent canister float switch and vent canister purge valve rubber support grommets to the ignition coil support bracket.
2. Install a 22.6 mm hose clamp onto the ventilation hose.
3. Install the ventilation hose to the valve cover. Secure the ventilation hose to the valve cover with the hose clamp tool.
4. Place the top hose into the support bracket.



14730

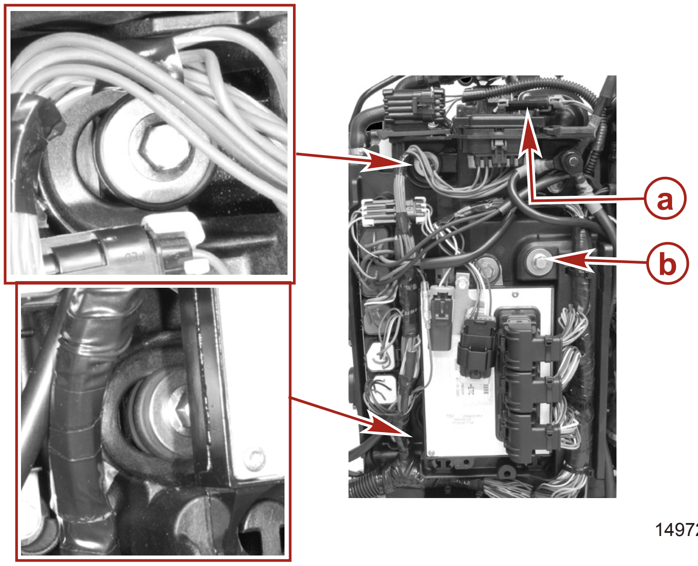
a - Hose support clip
b - 22.6 mm clamp securing ventilation hose
c - Vent canister purge valve
d - Vent canister float switch

Hose Clamp Tool Kit	91-803146A2

Electrical Box

1. Align the opening of the electrical box with the two electrical box grommets.
2. Secure the electrical box with a washer and bolt. Tighten the bolt to the specified torque.

3. Connect the cylinder block water temperature sensor to the engine harness.

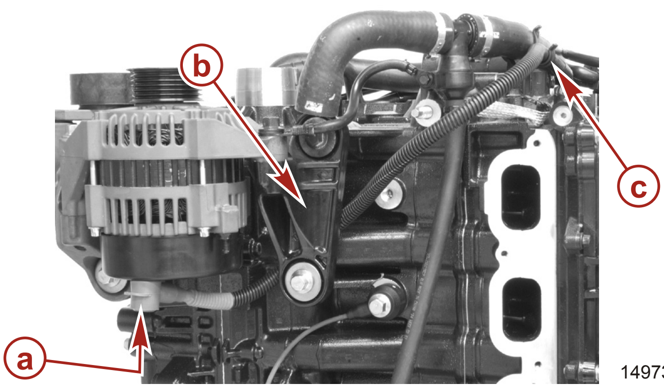


14972

a - Cylinder block water temperature sensor connector
b - Bolt and washer securing electrical box

Description	Nm	lb-in.	lb-ft
Bolt (M8 x 35)	24		17.7

4. Guide the alternator charging wire behind the rear alternator bracket.
5. Secure the alternator charging wire to the alternator with a nut. Tighten to the specified torque.
6. Install the alternator charging wire onto the support clip.



14973

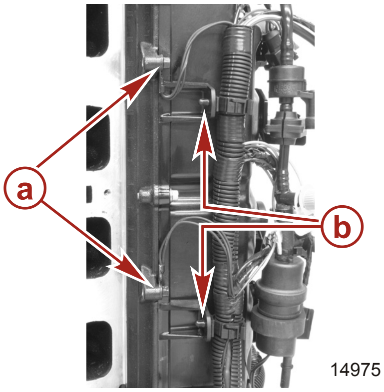
a - Nut securing alternator wire
b - Rear alternator bracket
c - Support clip

Description	Nm	lb-in.	lb-ft
Nut	7	62	

Injector/Coil Harness

1. Secure the two ignition coil grounds to the cylinder head with two bolts. Tighten bolts to the specified torque.

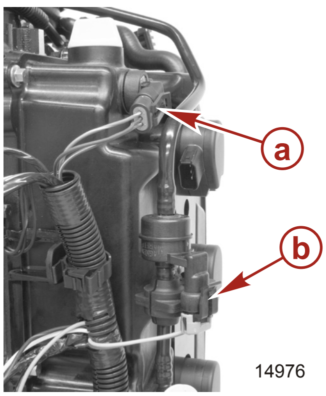
2. Secure the engine harness support clips to the valve cover.



a - Ignition coil grounds
b - Engine harness support clip

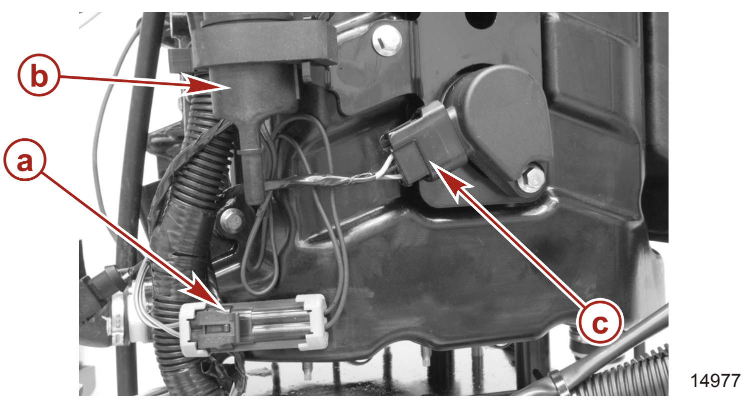
Description	Nm	lb-in.	lb-ft
Bolt (M6 x 12)	8	71	

3. Connect the cam position sensor harness to the engine harness.
4. Connect the engine harness to the vent canister purge valve.



a - Cam position sensor
b - Vent canister purge valve

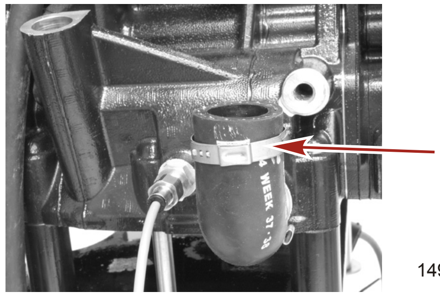
5. Connect the engine harness to the vent canister float switch.
6. Connect the engine harness to the ignition coils.



a - Vent canister float switch harness connector
b - Vent canister float switch
c - Engine harness ignition coil harness connector

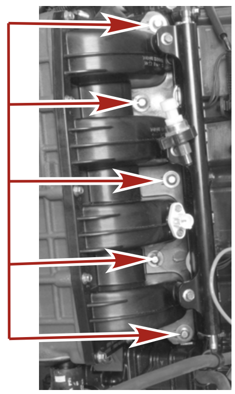
Charge Air Cooler

1. Install a 34.6 mm hose clamp on the lower CAC hose.



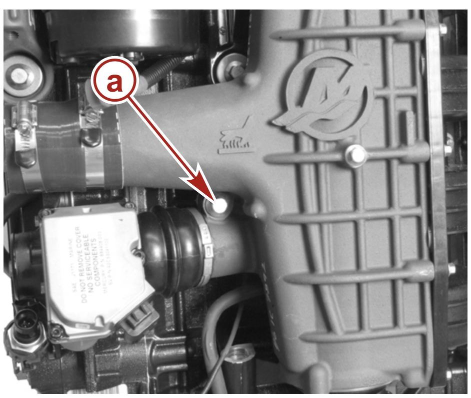
14982

2. Install new seals on the intake manifold.
3. Install the CAC onto the cylinder head. Secure the CAC to the cylinder head with five washers and bolts. Do not tighten the five bolts until all CAC mounting hardware is installed.



14723

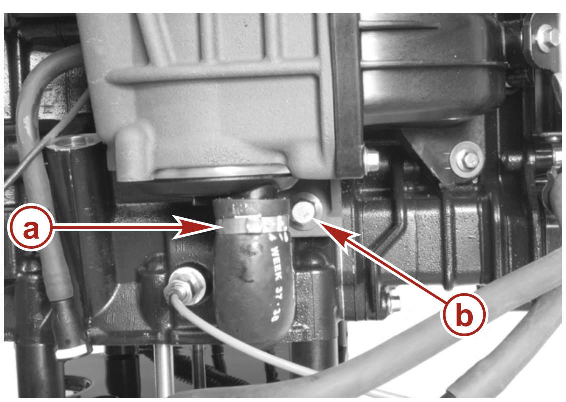
4. Install the bolt securing the front of the CAC. Do not tighten the bolt until all CAC mounting hardware is installed.



14990

a - Bolt securing front of CAC

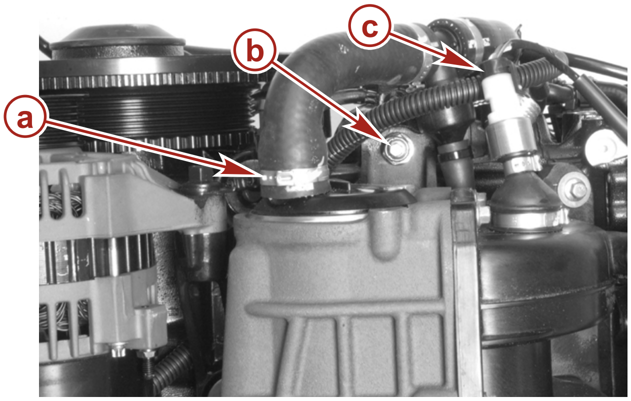
5. Install the lower CAC bolt. Do not tighten the bolt until all CAC mounting hardware is installed.
6. Secure the lower CAC hose to the CAC with the hose clamp tool.



14721

a - 34.6 mm hose clamp
b - Bolt (M10 x 30)

7. Secure the top of the CAC to the mounting stud with a nut. Do not tighten the nut until all CAC mounting hardware is installed.
8. Install a 34.6 mm hose clamp on the upper CAC hose. Secure the upper CAC hose to the CAC with the hose clamp tool.
9. Connect the engine harness to the MAP sensor.

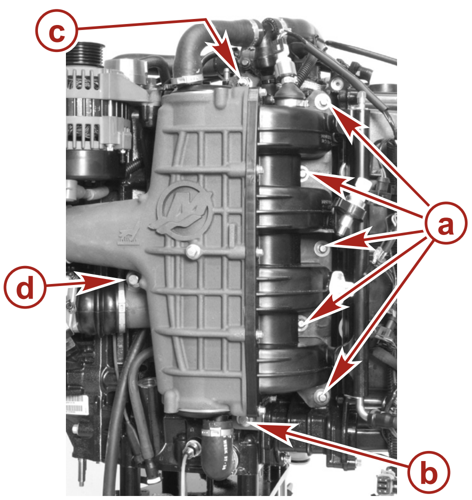


14692

a - 34.6 mm hose clamp
b - Nut (M10)
c - MAP sensor harness connector

Hose Clamp Tool Kit	91-803146A2

10. Tighten the five bolts with washers securing the intake manifold to the cylinder head to specification.
11. Tighten the bottom bolt securing the CAC to the cylinder block to specification.
12. Tighten the nut securing the CAC to the cylinder block to specification.
13. Tighten the front bolts securing the CAC to the cylinder block.

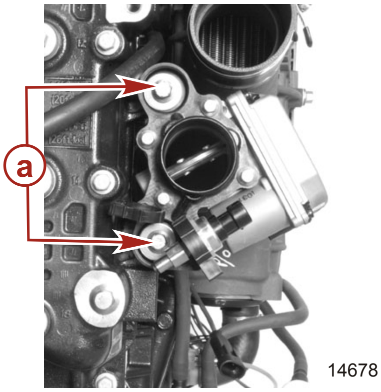


14993

a - Bolts with washers (M6 x 33) (5)
b - Bolt (M10 x 30)
c - Nut (M10)
d - Bolt (M10 x 65)

Description	Nm	lb-in.	lb-ft
Bolt (M6 x 32) (5)	10	89	
Bolt (M10 x 30)	32.5		24
Nut (M10)	32.5		24
Bolt (M10 x 65)	32.5		24

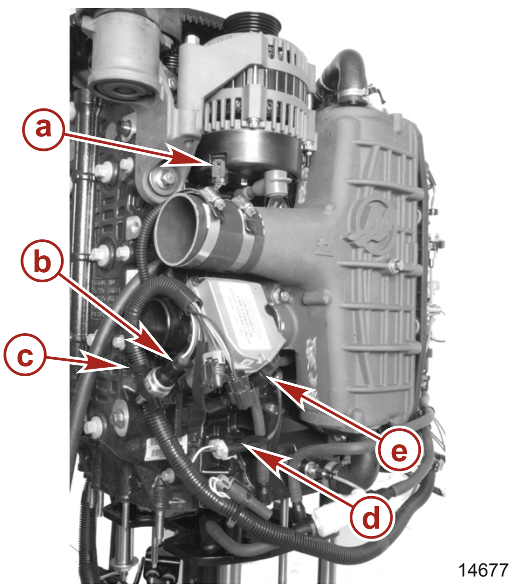
14. Secure the EBC to the cylinder block with two washers and bolts. Tighten to the specified torque.



a - Bolt and washer securing EBC

Description	Nm	lb-in.	lb-ft
Bolt (M8 x 35)	24	212	

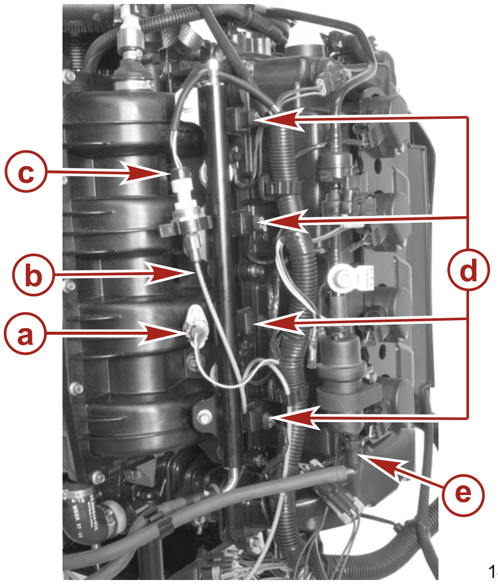
15. Connect the exciter wire harness to the alternator.
16. Connect the engine harness to the speedometer sensor.
17. Connect the engine harness to the EBC.
18. Connect the engine harness to the knock sensor.
19. Secure the engine harness to the EBC mount with the harness clip.



a - Exciter wire harness connector
b - Speedometer harness connector
c - Engine wire harness clip
d - Knock sensor harness connector
e - EBC harness connector

20. Connect the engine harness to the MAT sensor.
21. Connect the cylinder block water pressure tubing to the block water pressure sensor.
22. Connect the engine harness to the cylinder block water pressure sensor.

23. Connect the engine harness to the fuel injectors.

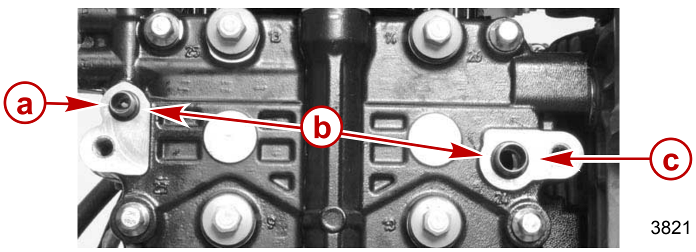


14679

a - MAT sensor
b - Cylinder block water pressure tubing
c - Cylinder block water pressure sensor
d - Fuel injector harness connectors
e - FSM vent hose

Supercharger Installation

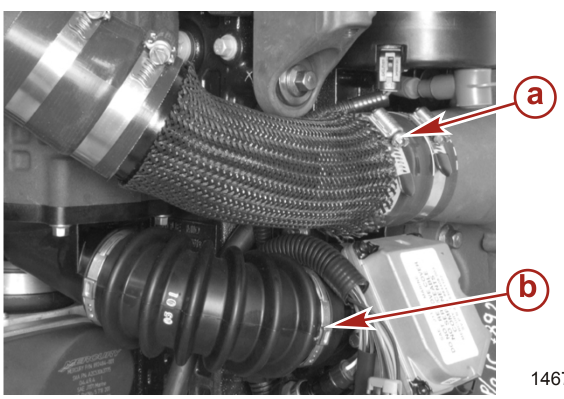
1. Install new O-rings onto the supercharger dowels.



3821

a - Oil delivery to supercharger
b - Supercharger dowel O-ring
c - Oil return from supercharger

2. Install a 57.5 mm hose clamp on the EBC bypass hose.
3. Insert the supercharger outlet to the CAC inlet hose. Do not tighten the hose clamp.
4. Guide the bypass hose onto the EBC. Do not tighten the hose clamp.

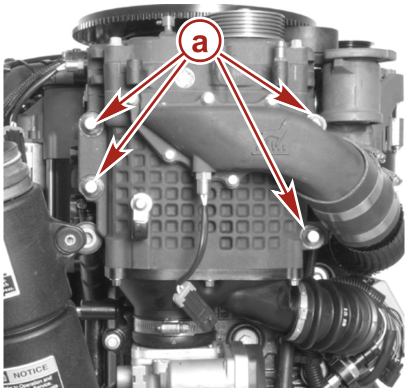


14670

a - Supercharger outlet hose clamp
b - EBC bypass hose clamp

5. Install the supercharger to the dowels.
6. Secure supercharger to the cylinder block with four bolts.
7. Tighten the four bolts to the initial torque.

8. Tighten the four bolts to the final torque level.



14673

a - Bolt (4)

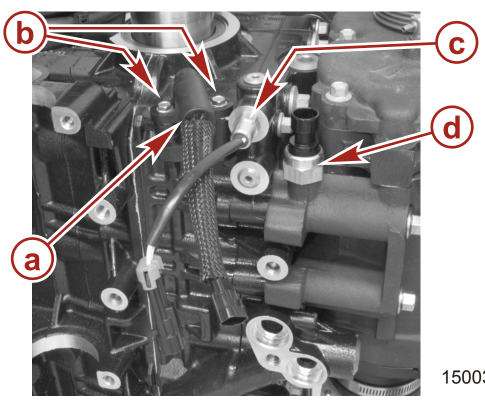
Description		Nm	lb-in.	lb-ft
Supercharger mounting bolt (M10 x 105)	**First**	15	133	
	Final	43		31.7

9. Tighten the supercharger outlet hose clamp to specification.
10. Tighten the EBC bypass hose clamp with the hose clamp tool.

Description	Nm	lb-in.	lb-ft
Supercharger outlet hose clamp	6.2	55	

Hose Clamp Tool Kit	91-803146A2

11. Install the CPS and secure with two screws. Tighten screws to the specified torque.
12. Install a new O-ring onto the oil temperature sender.
13. Cover the threads of the oil temperature sender with Loctite 567 PST Pipe Sealant.
14. Install oil temperature sender to cylinder block. Tighten to the specified torque.



15003

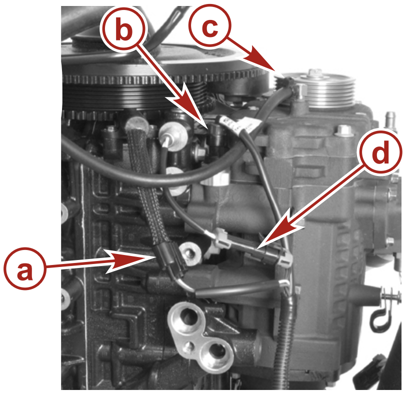
a - CPS
b - CPS screw (2)
c - Oil temperature sender
d - Oil pressure sender

Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Oil temperature sender threads	92-809822

Description	Nm	lb-in.	lb-ft
CPS screw (M5 x 16) (2)	5.08	45	
Oil temperature sender	15	133	

15. Connect the vent hose to the supercharger. Secure with a cable tie.

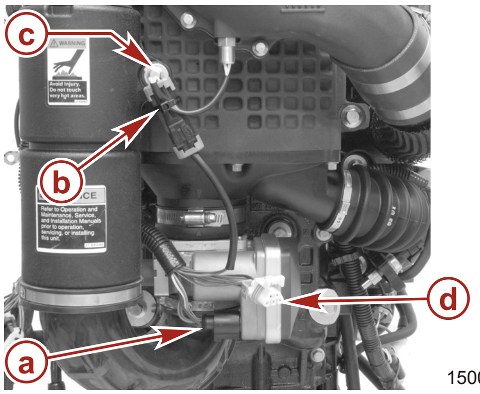
16. Connect the engine harness to the CPS, oil temperature sender, and the oil pressure sender.



15005

- a - CPS harness connector
- b - Oil pressure sensor harness connector
- c - Supercharger vent hose
- d - Oil temperature sensor harness connector

17. Connect the engine harness to the air temperature sensor on the supercharger.
18. Connect the engine harness to the ETC.
19. Secure the resonator to the supercharger with a bolt, washer, and P-clamp. Tighten the bolt to the specified torque.
20. Secure the air temperature sensor to the P-clamp with a cable tie.



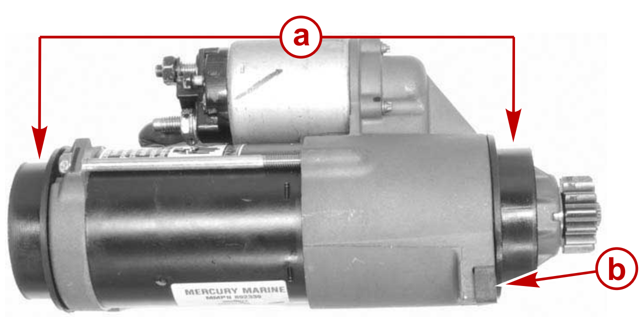
15006

- a - ETC harness connector
- b - Cable tie securing air temperature sensor
- c - Bolt securing resonator and P-clamp
- d - ESC harness connector

Description	Nm	lb-in.	lb-ft
Bolt securing resonator and P-clamp (M6 x 25)	7.5	66	

Starter Installation

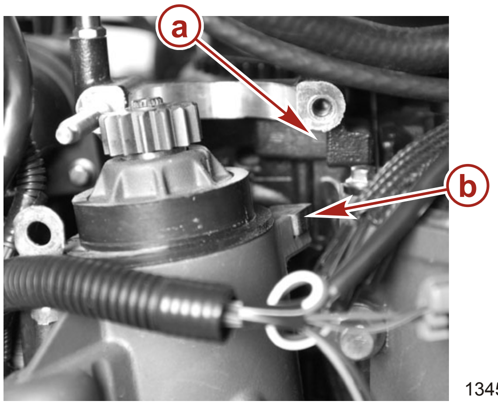
1. Ensure the bottom and top collars are on the starter end caps.
2. Ensure the starter stop is on the upper end cap.



3955

- a - Starter collar
- b - Starter stop

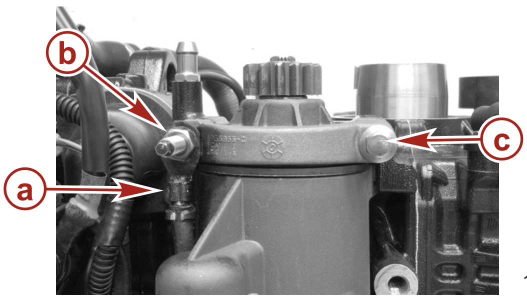
3. Place the starter onto the cylinder block with the starter stop facing the starter stop mounting boss.



13452

a - Starter stop mounting boss
b - Starter stop

4. Install the starter retainers onto mounting studs.
5. Install the starter ground lead to the upper mounting stud. Secure with a washer and M8 nonlocking nut. Tighten the nut to the specified torque.
6. Install the starter mount bolt. Tighten to the specified torque.

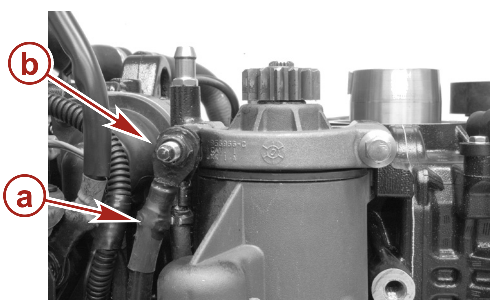


15014

a - Starter ground lead
b - Washer and nut (M8)
c - Bolt

Description	Nm	lb-in.	lb-ft
Nut (M8)	17	150.4	
Bolt (M8 x 40)	17	150.4	

7. Install the battery ground cable to the stud. Secure with a nut. Tighten the nut to the specified torque.



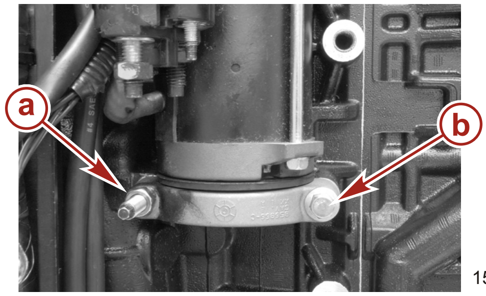
15015

a - Battery negative cable
b - Nut (M8)

Description	Nm	lb-in.	lb-ft
Nut (M8)	17	150.4	

8. Secure the lower starter mounting bracket to the lower mounting stud with a M8 nut. Tighten the nut to the specified torque.

9. Install the starter mount bolt. Tighten the bolt to the specified torque.

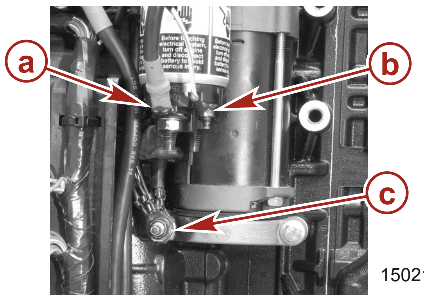


15016

a - Nut (M8)
b - Bolt

Description	Nm	lb-in.	lb-ft
Nut (M8)	17	150.4	
Bolt (M8 x 40)	17	150.4	

10. Install three ground eyelets to the stud. Secure with a nut. Tighten the nut to the specified torque.
11. Install the starter exciter wire. Secure with lockwasher and nut. Tighten the nut to the specified torque.
12. Install the power cable to the starter solenoid. Secure the power cable with a lockwasher and nut. Tighten the nut to the specified torque.



15021

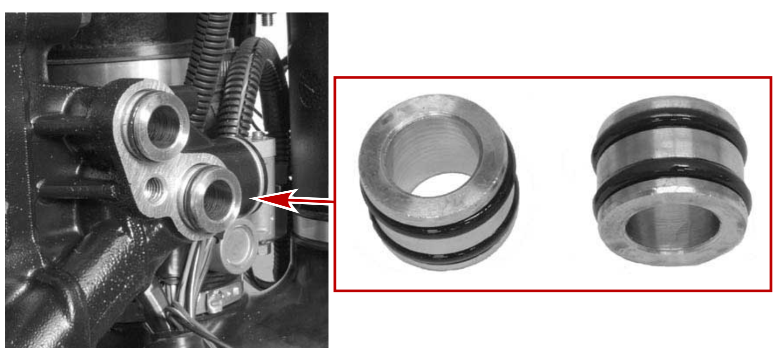
a - Power cable
b - Exciter wire
c - Nut (M8)

Description	Nm	lb-in.	lb-ft
Nut (M8)	17	150.4	
Power cable nut	10	88.5	
Exciter wire nut	2.5	22	

13. Slide the protection boot over the power cable and starter solenoid stud.

Integrated Oil Module (IOM)

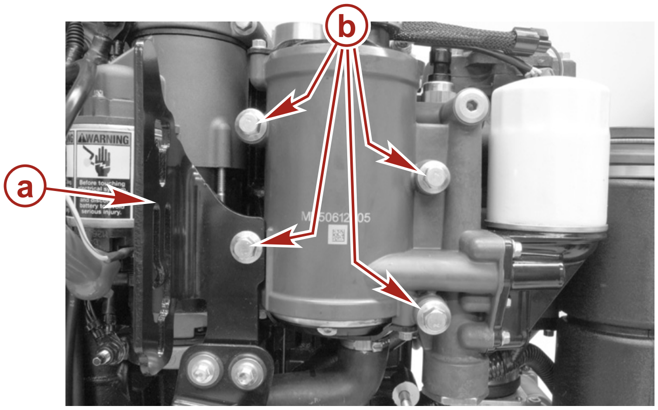
1. Install new O-rings on the IOM dowels.
2. Install the IOM dowels into the cylinder block.



3772

3. Align the IOM with the IOM dowels on the cylinder block.
4. Push the IOM onto the dowels and secure with three bolts. Do not tighten bolts.
5. Insert the fourth bolt through the fuel/water separating filter bracket.
6. Install bracket to the IOM.

7. Tighten the bolts to the specified torque.

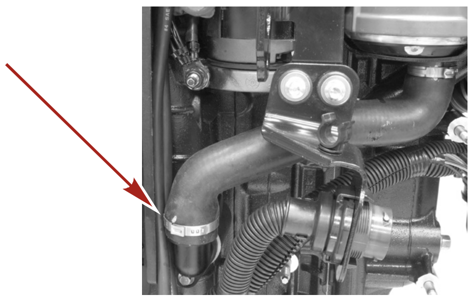


15029

a - Bracket
b - Bolts

Description	Nm	lb-in.	lb-ft
Bolts	31		23

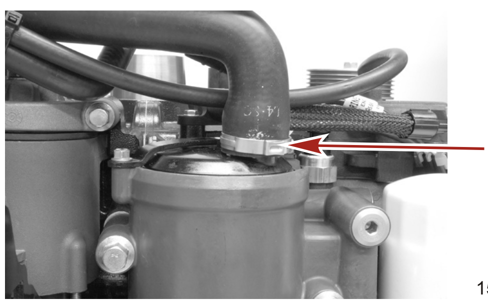
8. Install a 38.1 mm hose clamp on the bottom IOM hose.
9. Attach hose to the lower IOM cylinder block fitting.
10. Tighten the hose clamp with the hose clamp tool.



15031

Hose Clamp Tool Kit	91-803146A2

11. Install a 34.6 mm hose clamp on the upper IOM hose.
12. Install the hose to the IOM. Tighten the hose clamp with the hose clamp tool.



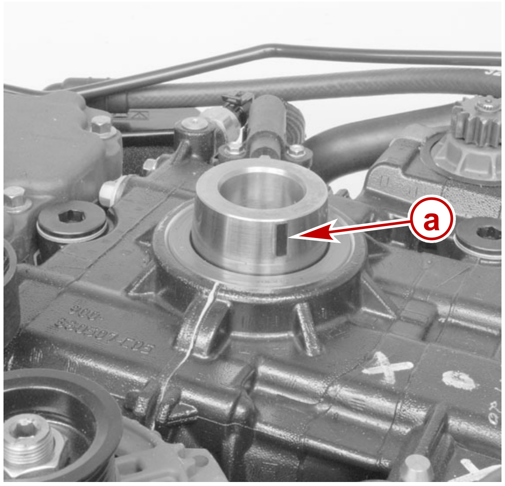
15032

Hose Clamp Tool Kit	91-803146A2

Flywheel and Alternator/Supercharger Belt Installation

IMPORTANT: Clean flywheel/crankshaft taper with solvent and assemble dry.

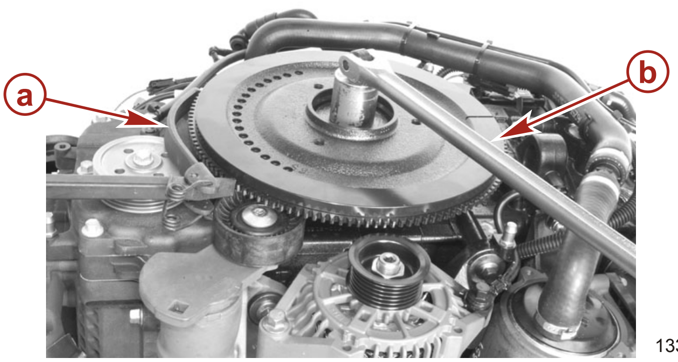
1. Install the flywheel key in the crankshaft.



5463

a - Flywheel key

2. Align the flywheel with the key and install the flywheel onto the crankshaft.
3. Secure the flywheel with bolt and washer. Use the flywheel holding tool to hold the flywheel and tighten the bolt to the specified torque.



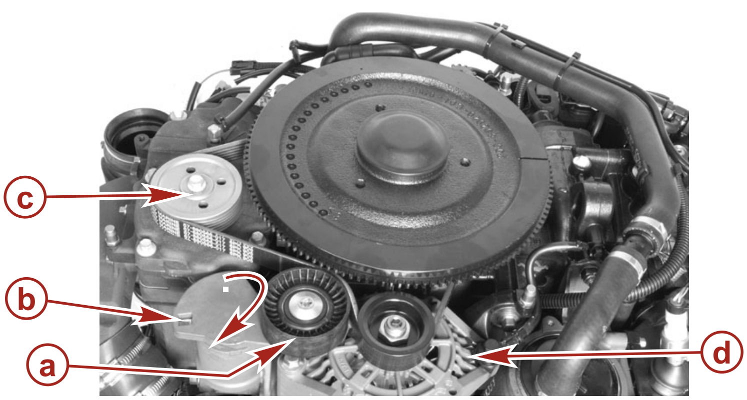
13341

a - Flywheel holding tool
b - Torque wrench

Flywheel Holding Tool	91-52344

Description		Nm	lb-in.	lb-ft
Flywheel bolt	**First torque**	60		44
	Final torque	180		133

4. Using the breaker bar in the tensioner release slot, install the alternator/supercharger belt.



13329

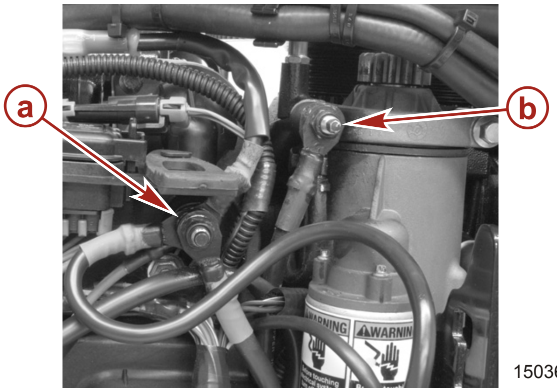
a - Tensioner pulley
b - Tensioner release slot
c - Supercharger pulley
d - Alternator

5. Install the flywheel cover.

After Servicing Engine

After servicing the engine, apply Liquid Neoprene to the following specific locations to reduce the possibilities of ignition, starting, or charging disruptive failures. These points of interest are most important to protect when the outboard is used in harsh environments such as saltwater.

- Battery ground and power stud in the electrical box

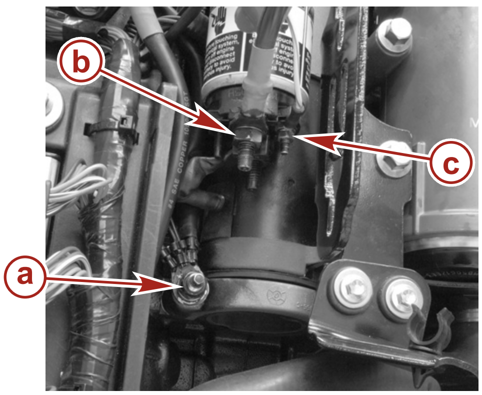


15036

a - Power stud
b - Battery ground

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Power stud and battery ground	92- 25711 3

- Harness ground, starter solenoid power lead, and exciter wire

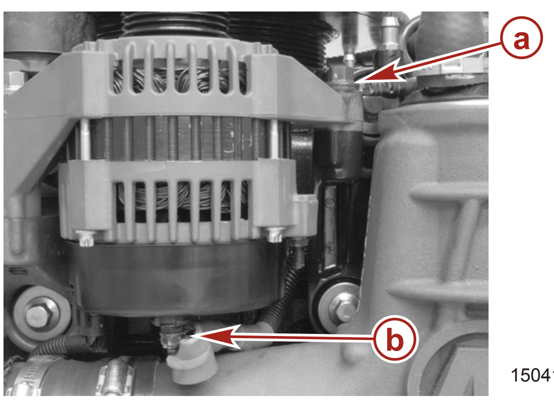


15037

a - Harness ground
b - Solenoid power lead
c - Exciter wire

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Engine harness ground, solenoid power lead nut, exciter wire nut	92- 25711 3

- Alternator battery charging lead and alternator ground

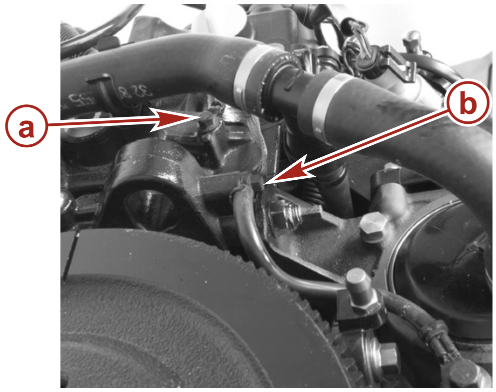


15041

a - Alternator ground
b - Alternator battery charging lead

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Alternator ground and battery charging lead	92- 25711 3

- Cylinder head and cylinder block ground bolts

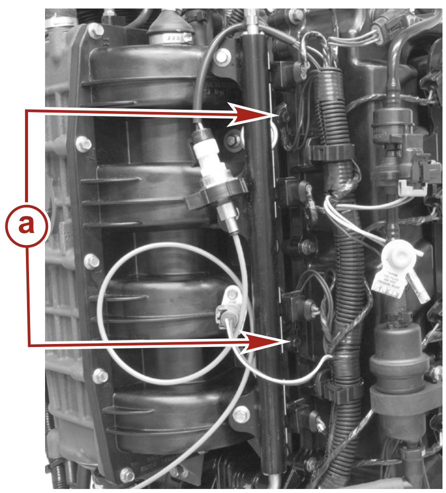


15039

a - Cylinder head ground bolt
b - Cylinder block ground bolt

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Cylinder head ground bolt, cylinder block ground bolt	92- 25711 3

- Ignition coil grounds on cylinder head



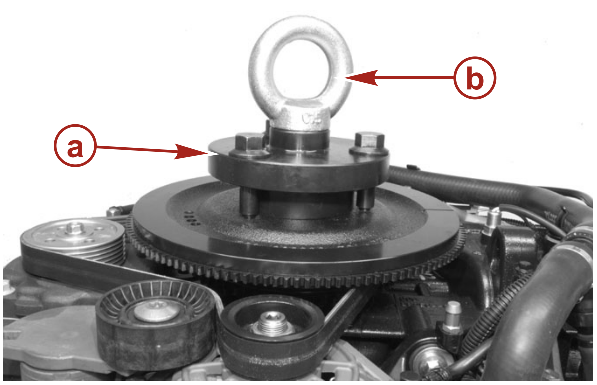
15040

a - Ignition coil grounds

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Ignition coil grounds	92- 25711 3

Dressed Powerhead Installation

1. Ensure the flywheel timing mark points toward the timing mark on the cylinder block.
2. Install the lifting tool onto the flywheel. Tighten the base bolts securely so they bottom out on the flywheel.
3. Thread the lifting eye onto the lifting base securely so it bottoms out on the lifting base.

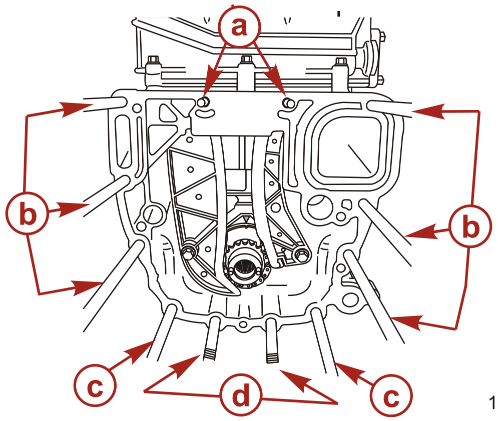


14433

a - Lifting base
b - Lifting eye

Flywheel Puller/Lifting Ring	91-895343T02

4. Install the six (M10 x 175) long powerhead mounting studs, two (M10 x 54) studs, two (M8 x 55) studs, and two (M8 x 49) studs to the powerhead. Tighten the powerhead mounting studs to the specified torque.



15480

a - Stud (2) (M8 x 49)
b - Stud (6) (M10 x 175)
c - Stud (2) (M10 x 54)
d - Stud (2) (M8 x 55)

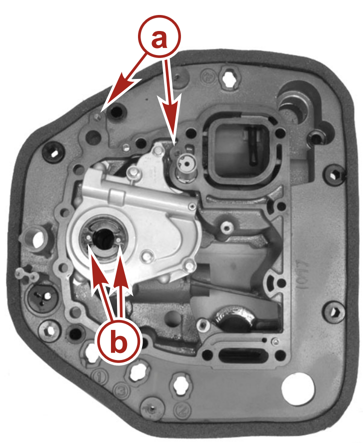
Description	Nm	lb-in.	lb-ft
M10 studs	22.5	200	16.5
M8 studs	10	89	

5. Place a new powerhead gasket on the adapter plate.
6. Lubricate the driveshaft splines with Engine Coupler Spline Grease.

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Driveshaft splines	92-802869A 1

7. Turn the oil pump drive gear so the drive pins point fore and aft.
8. Use a cotton swab to remove all the oil that may have accumulated in two of the adapter plate threaded mounting holes.

IMPORTANT: Remove all traces of oil in the two adapter plate threaded mounting holes. Failure to remove the oil will damage the adapter plate during the torquing of the powerhead to the adapter plate.



14792

a - Remove oil from threaded holes
b - Drive pins point fore and aft

9. Install the O-rings onto the water dump hose fitting.
10. Lubricate the O-rings with Lubriplate SPO 255.

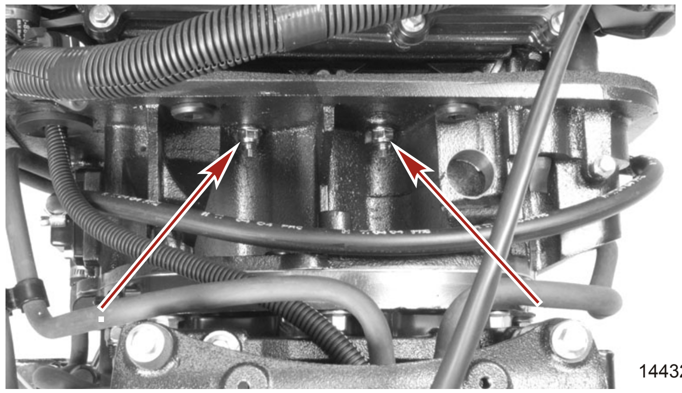
14796

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Water dump adapter O-rings	Obtain Locally

11. Carefully lower the powerhead onto the adapter plate while aligning the powerhead mounting studs with the adapter plate holes.

    NOTE: It may be necessary to gently rock the powerhead once the powerhead mounting studs are partially through the adapter plate.

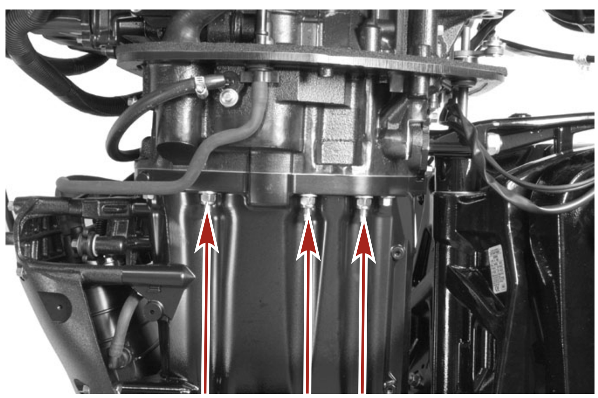
12. Install the two aft powerhead flange locknuts. Do not torque to specification until all powerhead mounting nuts and bolts are installed.



14432

Description	Nm	lb-in.	lb-ft
Aft flange locknut securing powerhead (M8)	26		19

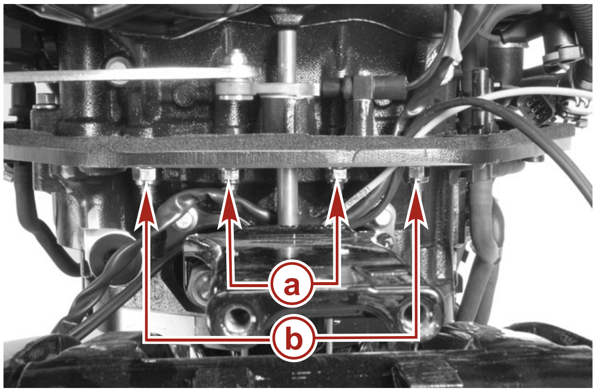
13. Install the six washers and locknuts (3 each side). Do not torque to specification until all powerhead mounting nuts and bolts are installed.



14427

Description	Nm	lb-in.	lb-ft
Locknut (M10)	61		45

14. Install the four flange locknuts in the front of the powerhead. Do not torque to specification until all powerhead mounting nuts and bolts are installed.

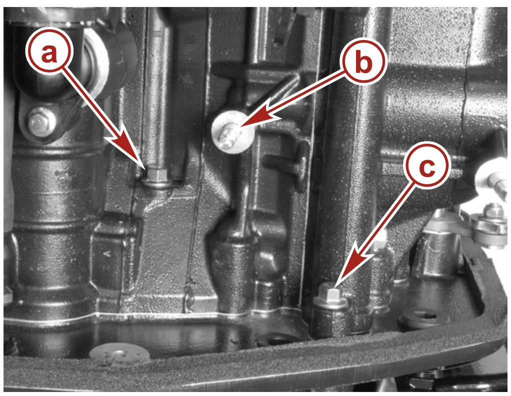


14424

a - Flange locknut (M8)
b - Flange locknut (M10)

Description	Nm	lb-in.	lb-ft
Flange locknut (M8)	26		19
Flange locknut (M10)	61		45

15. Install the two upper bolts on the starboard side of the block. Do not torque to specification until all powerhead mounting nuts and bolts are installed.



14415

a - Bolt (M8 x 75)
b - ESC mounting stud
c - Bolt (M8 x 35)

Description	Nm	lb-in.	lb-ft
Bolt (M8 x 75)	27		20
Bolt (M8 x 35)	27		20

16. Use the torque adapter to tighten the 13 mm hex locknuts securing the powerhead to the adapter plate/driveshaft housing.

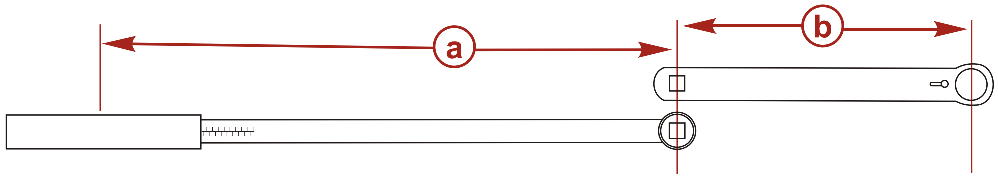
13 mm Torque Adapter	91-809905001

IMPORTANT: You must calculate the torque value of the nuts securing the powerhead to the adapter plate when using an extension tool.

a. On beam type torque wrenches, measure from the square drive to the fulcrum (pivot) point of the handle. Follow steps d through g.
b. On electronic digital type torque wrenches, measure from the square drive to the center of the handle. Follow steps d through g.
c. On click-stop or dial type torque wrenches, adjust the torque wrench to the specified torque. Determine the effective length from the square drive to the center of the handle. Follow steps d through k.
d. Measure tool extension from the center of the square drive to the center of the nut drive. Tool 91-809905001 is 30.48 cm (12 in.).
e. Add the torque wrench length and the tool length to find the sum.
f. Divide the sum by the torque wrench length to find the quotient.
g. Divide the torque specification by the quotient. This is the torque specification for the nut or bolt.
h. Adjust the torque wrench to reflect the new torque calculation.
i. For greater accuracy, redetermine the effective length of the torque wrench and the extension tool with the new torque calculation.

j. Compute for the corrected torque setting.

k. Adjust the torque wrench to reflect the second new torque calculation. This is the final torque specification for the aft nut when using a click-stop or dial type torque wrench.

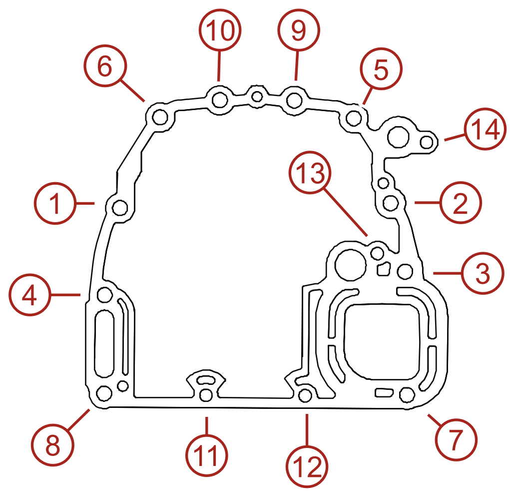


4754

a - Torque wrench length

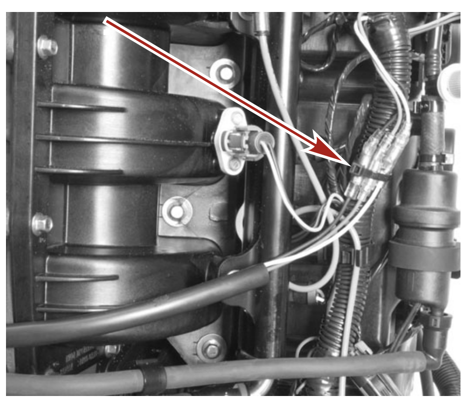
b - Tool extension

17. Use the torque sequence shown in the following graphic illustration, after all the nuts and bolts that secure the powerhead to the adapter plate are installed.



5341

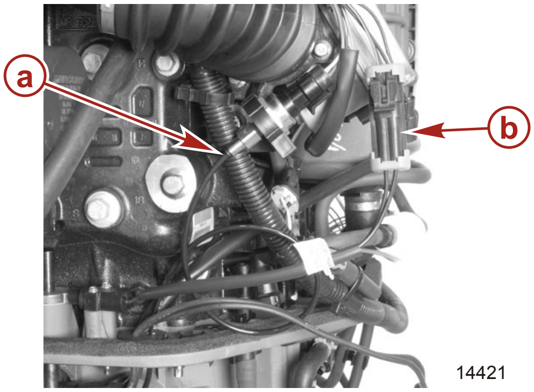
18. Tighten all of the powerhead mounting bolts and nuts to the proper torque level.
19. Connect the trim position sensor wire bullet connectors with the engine harness. Secure the bullet connectors to the wire harness convoluted tubing.



14422

20. Connect the shift indicator to the engine harness.

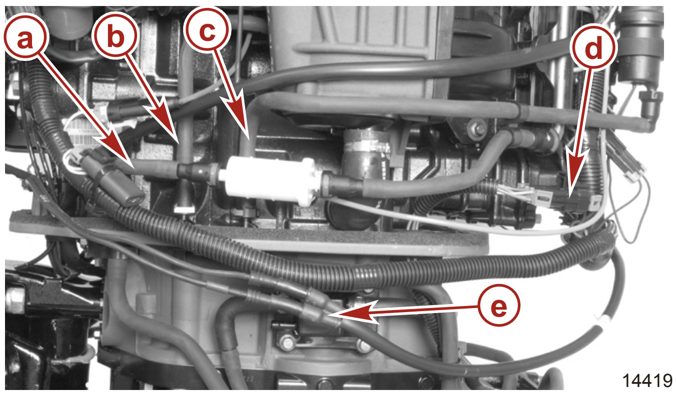
21. Install the pitot hose to the pitot sensor.



14421

a - Pitot hose
b - Shift indicator harness connector

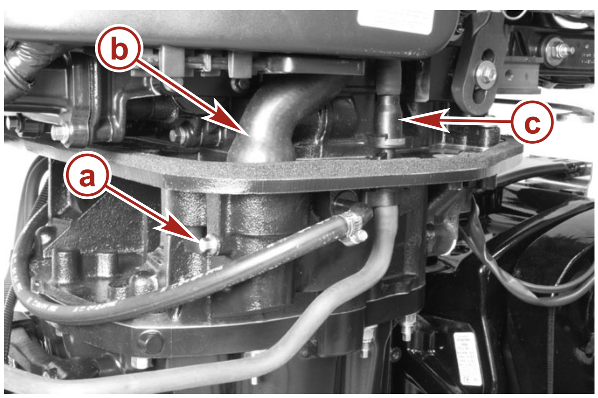
22. Connect the high-pressure fuel delivery hose to the adapter plate.
23. Connect the MAP reference hose to the adapter plate.
24. Connect the FSM purge hose to the adapter plate.
25. Connect the FSM harness.



14419

a - High-pressure fuel delivery hose
b - MAP reference hose
c - FSM purge hose
d - FSM harness connector
e - Power trim motor bullet connectors

26. Push the water dump hose adapter into the adapter plate. Ensure the water dump hose adapter is fully inserted into the adapter plate.
27. Tighten the bolt securing the water dump hose fitting to the specified torque.
28. Connect the fuel delivery hose to the adapter plate.



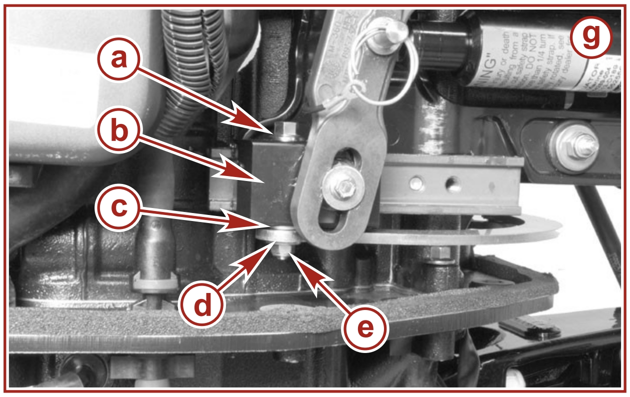
14416

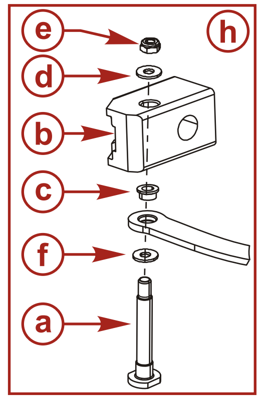
a - Bolt securing water dump hose fitting
b - Water dump hose
c - Fuel delivery hose

Description	Nm	lb-in.	lb-ft
Bolt (M6 x 16)	10	89	

29. Install the ESC bracket to the cylinder block ESC mounting studs. Do not install the washers and locknuts at this point.

30. Secure the shift link to the shift slide with the shift link bolt, nut, washers, and bushing. Tighten the shift link bolt and nut to the specified torque.



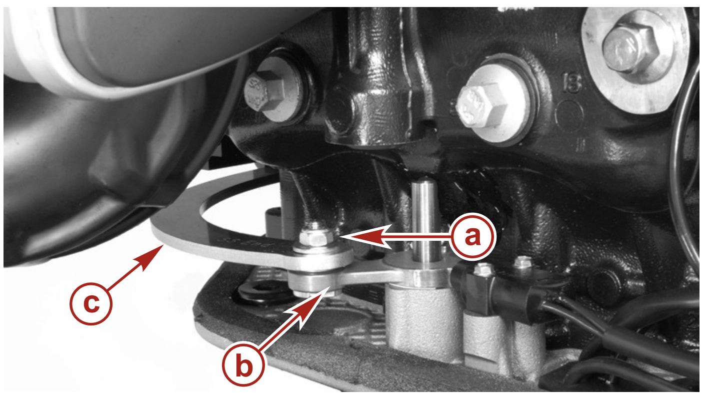


40915

a - Shift link bolt
b - Shift slide
c - Bushing
d - Washer (0.625 in. OD)
e - Nut
f - Washer (0.688 in OD)
g - Design I
h - Design II

Description	Nm	lb-in.	lb-ft
Shift link bolt/nut	6	53	

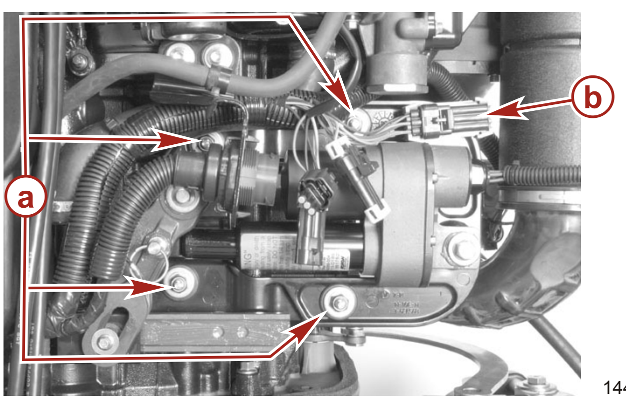
31. Remove the locknut and washer from the shift link and the shift shaft lever. Remove the shift link from the shift shaft lever.



41547

a - Locknut and washer
b - Shift shaft lever
c - Shift link

32. Push the shift slide aft to access one of the ESC bracket mounting studs.
33. Install four nuts and washers to secure the ESC bracket to the cylinder block. Tighten the nuts to the specified torque.
34. Install the boat harness connector to the ESC bracket.



14410

a - Nuts and washers (4)
b - Boat harness connector

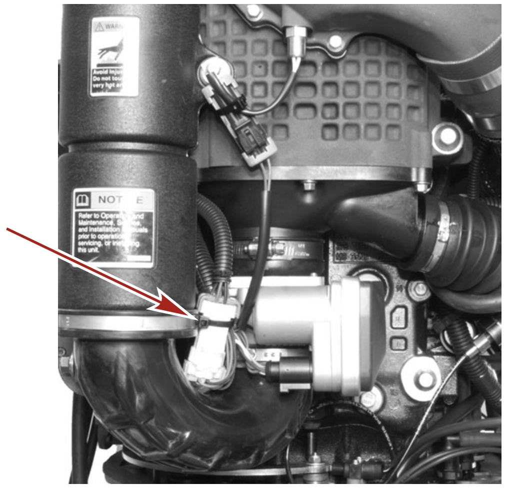
Description	Nm	lb-in.	lb-ft
Nut (M8)	20	177	

35. Install the shift link onto the shift shaft lever. Secure with a washer and locknut. Tighten the locknut to the specified torque.

Description	Nm	lb-in.	lb-ft
Shift shaft lever locknut (M6)	5.6	50	

36. Connect the ESC harness to the engine harness connector.

37. Secure the ESC harness connector to the ETC bracket with a cable tie.



14517

38. Connect the battery.
39. Prime the fuel system. Inspect for fuel leaks. Repair as needed.

Cowling Installation

Install the lower cowling and top cowl. Refer to **Cowling Removal and Installation**.

Engine Break-in Procedure

IMPORTANT: Failure to follow the engine break-in procedures can result in poor performance throughout the life of the engine and can cause engine damage. Always follow break-in procedures.

1. For the first two hours of operation, run the engine at varied throttle settings up to 4500 RPM or at three-quarter throttle, and at full throttle for approximately one minute every ten minutes.
2. For the next eight hours of operation, avoid continuous operation at full throttle for more than five minutes at a time.

Powerhead

Section 4B - Cylinder Head

Table of Contents

Cylinder Head Specifications

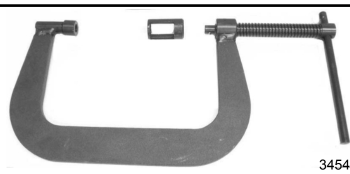
Cylinder Head Specifications	
Maximum deck warp	0.075 mm (0.003 in.)
Number of valves	16
Number of valves per cylinder	4
Number of cams	2
Cam bearing journal (intake and exhaust)	28.95 mm (1.140 in.)
Camshaft bearing cap ID	29.000–29.021 mm (1.1417–1.1425 in.)
Cam lobe	
Intake	42.50 mm (1.6732 in.)
Exhaust	43.55 mm (1.7145 in.)
Valve lash	
Intake	0.150–0.230 mm (0.0059–0.009 in.)
Exhaust	0.350–0.430 mm (0.0137–0.0169 in.)
Valve seat angles	30°, 45°, 60°
Valve spring free length	48.77 mm (1.920 in.)
Valve outside diameter	
Intake	32.0 ± 0.15 mm (1.259 ± 0.0059 in.)
Exhaust	27.2 ± 0.190 mm (1.0708 ± 0.0059 in.)
Valve face width (intake and exhaust)	2.25 mm (0.0886 in.)
Valve margin	
Intake	0.75 mm (0.0295 in.)
Exhaust	0.65 mm (0.0256 in.)
Valve guide bore ID (intake and exhaust)	6.00–6.016 mm (0.2362–0.2368 in.)
Valve stem diameter	
Intake	5.97 mm (0.235 in.)
Exhaust	5.96 mm (0.2346 in.)
Valve stem runout (maximum)	0.038 mm (0.0015 in.)
Valve stem to valve guide clearance	
Intake	0.03–0.046 mm (0.0011–0.0018 in.)
Exhaust	0.04–0.056 mm (0.0015–0.0022 in.)
Valve seat contact width (intake and exhaust)	2.25 mm (0.0886 in.)

Lubricants, Sealants, Adhesives

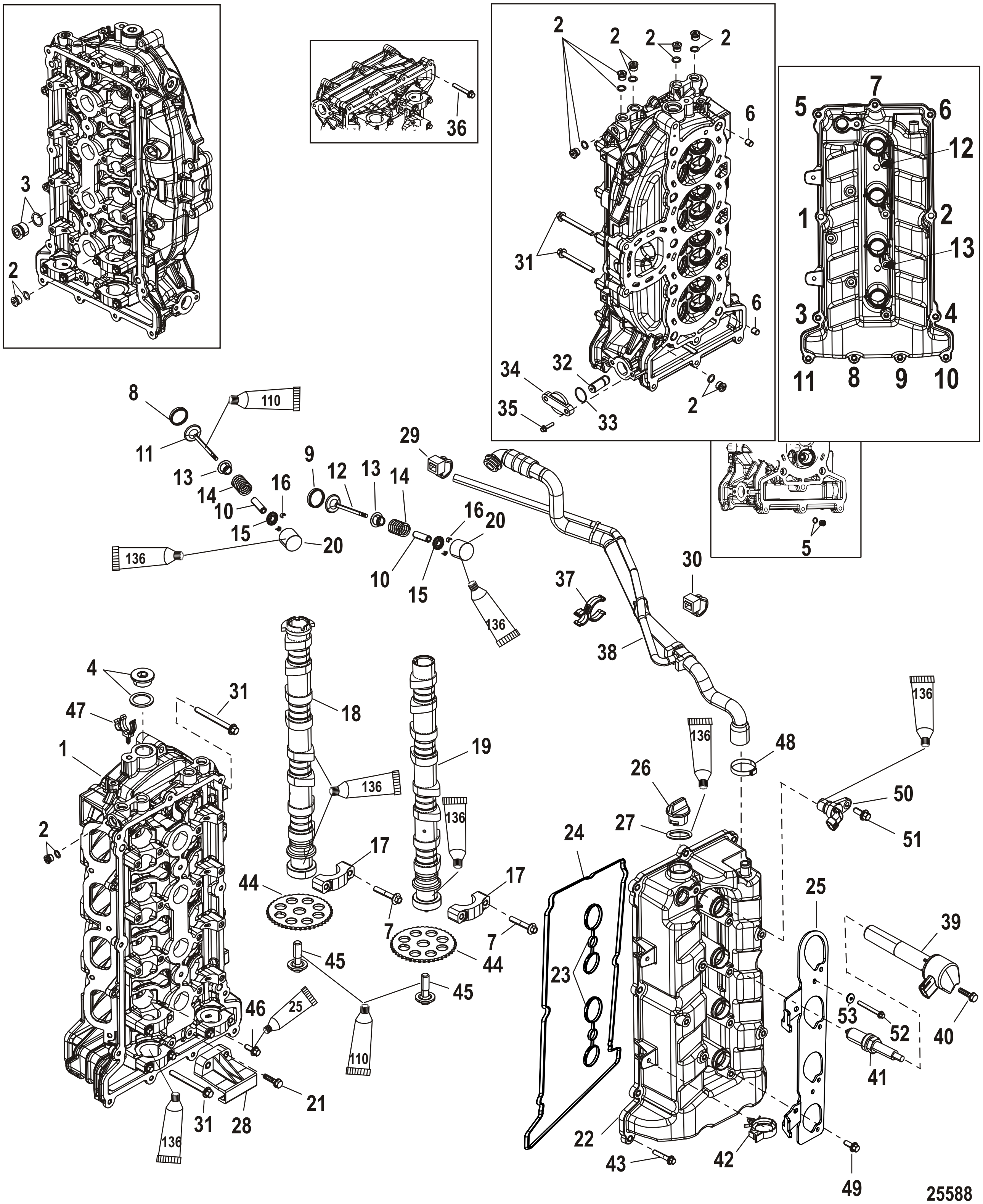
Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Oil and water galley plugs	92-809822
25	Liquid Neoprene	Cylinder head M6 x 12 bolt	92- 25711 3
95	2-4-C with Teflon	Installing valve spring retaining cotter	92-802859A 1
110	4-Stroke 10W-30 Outboard Oil	Valve stems, camshaft sprocket bolts	92-858045K01

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Camshaft lobes, sensor, and O-rings	Obtain Locally
		Valve bucket tappet outside diameter	
		Cam bearing	
		Cam journal	
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Valve guide seal	92-858052K01
		Valve stem	

Special Tools

Valve Spring Compressor	91-809494A 1
 3454	Removes and installs valve springs.

Cylinder Head Components



Cylinder Head Components

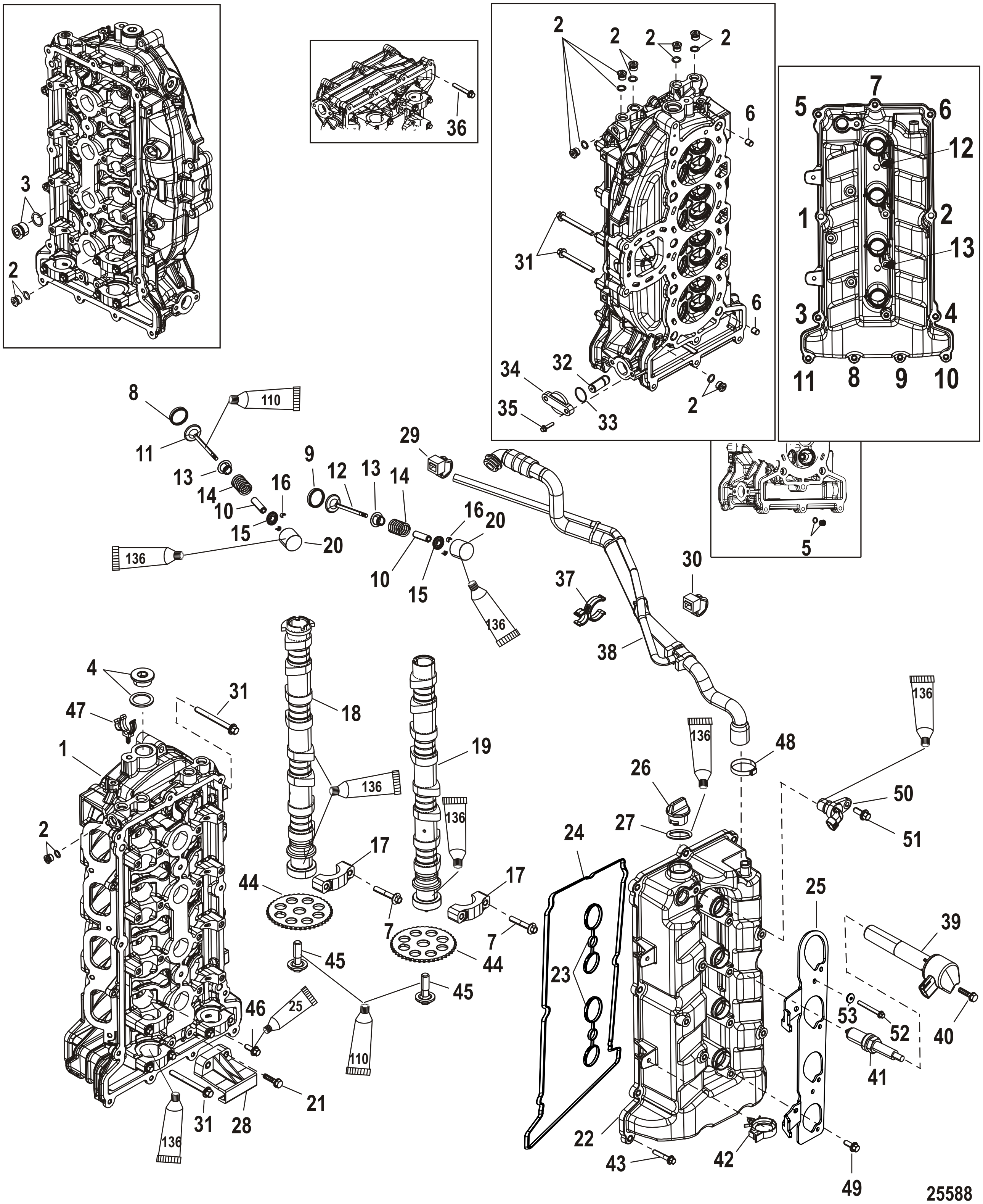
Ref. No.	Qty.	Description		Torque Nm	Torque lb-in.	Torque lb-ft
1	1	Cylinder head assembly				
2	8	Plug (12 mm)		9	80	
3	1	Plug (18 mm)		22		16
4	1	Plug (24 mm)		55		41
5	1	Plug (10 mm)		9	80	
6	2	Dowel pin (14 mm)				
7	20	Bolt (M6 x 36)	First torque	6	53	
			Final torque	12	106	
8	8	Intake seat				
9	8	Exhaust seat				
10	16	Guide				
11	8	Intake valve				
12	8	Exhaust valve				
13	16	Valve seal				
14	16	Spring				
15	16	Valve retainer				
16	32	Cotter key				
17	10	Cap				
18	1	Intake camshaft				
19	1	Exhaust camshaft				
20	16	Tappet				
21	2	Bolt (M6 x 30) (S/N 1B733388 and below)		10	89	
22	1	Valve cover (S/N 1B733388 and below)[1.]				
		Valve cover (S/N 1B733389 and above)				
23		Seal				
24		Seal				
25	1	Coil plate				
26	1	Oil plug				
27	1	O-ring				
28	1	Short guide (S/N 1B733388 and below)				
29	1	Cable tie				
30	2	Cable tie				
31	4	Bolt (M8 x 60)		28		21
32	1	Tensioner assembly				
33	1	O-ring				
34	1	Tensioner end cap				
35	2	Bolt (M6 x 25)		10	89	
36	3	Bolt (M6 x 40)		8	71	
37	1	Clip				

1. When replacing this camshaft cover with the new style camshaft cover incorporating a chain guide, discard the short span chain guide and bolts, items 21 and 28.

Ref. No.	Qty.	Description	Torque Nm	Torque lb-in.	Torque lb-ft
38	1	Breather hose			
39	4	Coil			
40	4	Bolt (M6 x 25)	10	89	
41	4	Spark plug	27		20
42	3	Clip			
43	13	Bolt (M6 x 25)	10	89	
44	2	Sprocket			
45	2	Left-hand bolt (M12 x 40) – First torque	45		33
		Final torque	Turn additional 20° after first torque is attained		
46	2	Bolt (M6 x 12)	8	71	
47	1	Clip			
48	1	Oetiker clamp (22.6 mm)			
49	2	Bolt (M6 x 12)	10	89	
50	1	Camshaft position sensor			
51	1	Bolt (M6 x 16) (included with camshaft cover)	8	71	
52	2	Bolt (M6 x 85) (included with camshaft cover)	15	133	
53	2	Washer			

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Camshaft lobes, sensor, and O-rings	Obtain Locally
110	4-Stroke 10W-30 Outboard Oil	Valve stems, camshaft sprocket bolts	92-858045K01
25	Liquid Neoprene	Cylinder head M6 x 12 bolt	92- 25711 3

Cylinder Head Components



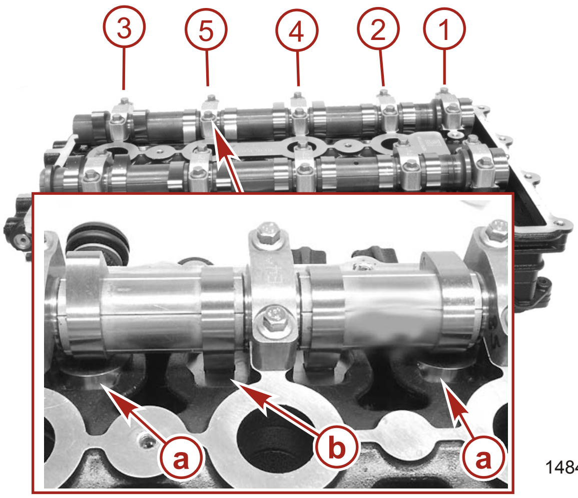
Cylinder Head Disassembly

Cam Removal

IMPORTANT: The removal and disassembly procedure of the head and cams must be strictly followed. Failure to follow the removal outline procedure may damage the valve train components and/or cylinder head.

1. Starting with the cam cap that is farthest away from the cam lobes that are engaging the valve bucket, and working towards the cam lobe that is engaging the valve bucket, release the pressure on the cam caps one quarter (1/4) turn at a time. Continue with the sequence and release the pressure one quarter (1/4) turn at a time until all tension on the cam caps is released. Refer to the following graphic.

NOTICE
Improperly loosening cam cap bolts will damage the cam cap, cam cap guides, cam cap-to-cylinder head mating surface, or cam. Do not release the tension from the cam cap screws more than one quarter turn at a time, alternating as you go.



14840

a - Cam lobe not engaging valve bucket
b - Cam lobe engaging valve bucket

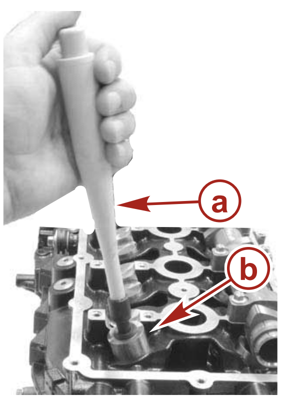
NOTE: All cam caps are marked in chronological sequence starting from the top with number 1 and working down to number 5. The cam caps also have a direction arrow pointing to the top of the head.

2. Remove the cam caps.
3. Lift the cam out of the cylinder head cam bearing.

Valve Removal

1. Clean the surface of the valve buckets with a solvent to remove any oil residue. With an indelible magic marker, write on the top of the valve bucket its location: E1, E2, E3, I1, I2, I3, etc.
2. Remove the valve bucket tappet with a vacuum assisted valve lashing tool. Obtain the vacuum assisted valve lashing tool locally. Do not use a magnet to remove the valve bucket tappets.

   IMPORTANT: Do not intermix the location of the valve train parts. The valve bucket tappets have different dimensions to correct for proper valve lash clearance. Note the location of the valve bucket tappets and valves.



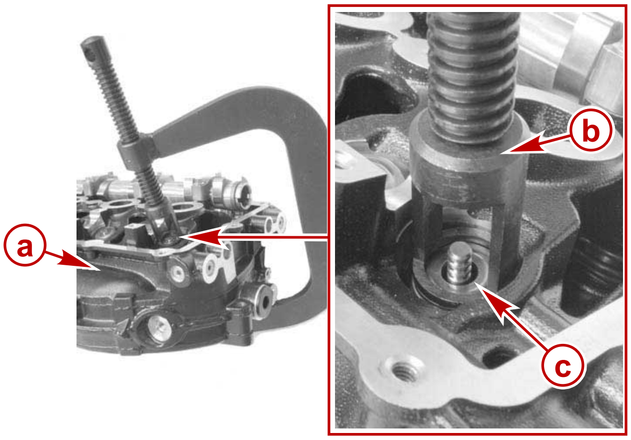
14842

a - Vacuum assisted valve lashing tool
b - Valve bucket tappet

3. Use a valve spring compressor to collapse the valve spring to remove the valve spring cotters.

   NOTE: Do not damage the cylinder head valve bucket tappet bore when using the valve spring compressor.

IMPORTANT: Do not intermix the valves and the location where they were removed.

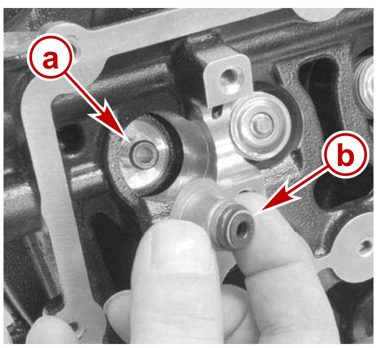


4018

a - Cylinder head
b - Valve spring compressor
c - Valve stem

Valve Spring Compressor	91-809494A 1

4. Release the valve spring compressor.
5. Remove the valve.
6. Remove and discard the valve guide seal.



4019

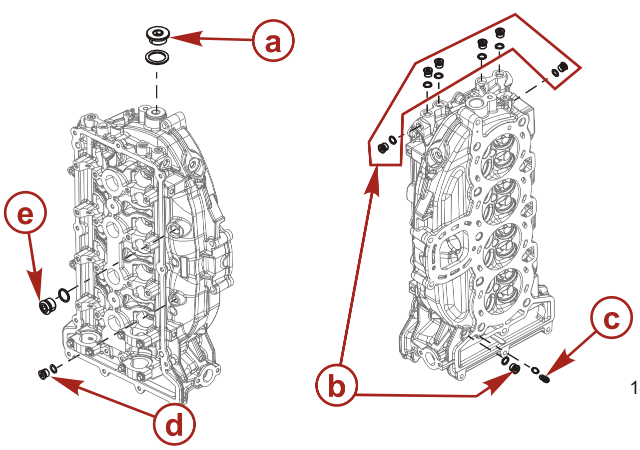
a - Valve guide
b - Valve guide seal

NOTE: Do not reuse valve guide seals after the valve has been removed.

Cylinder Head Galley Plug Removal

1. Remove all of the oil and water galley plugs from the cylinder head.

   NOTE: It may be necessary to lightly tap on the galley plugs with a brass drift and hammer to break the galley plug seal.
2. Remove the O-rings from the oil and water galley plugs and discard the galley plug O-rings.



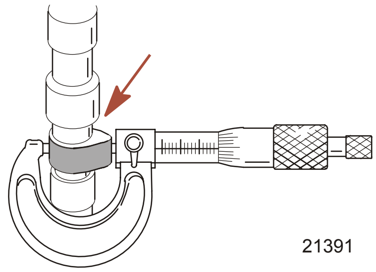
14832

a - Oil galley plug
b - Oil galley plugs
c - Water galley plug
d - Water galley plug
e - Water galley plug

Cleaning/Inspection/Repair

Camshaft

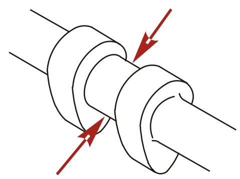
1. Measure the camshaft lobe at its valve open (maximum valve lift). Replace the camshaft if the dimensions are out of specification.



21391

Camshaft Lobe Specifications	
Intake camshaft	42.50 mm (1.6732 in.)
Exhaust camshaft	43.55 mm (1.7145 in.)

2. Measure all of the camshaft bearing journals with a micrometer. Replace the camshaft if the journal dimensions are out of specification.



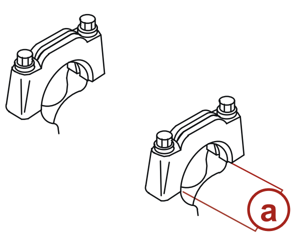
21393

Camshaft Bearing	
Journal outer diameter	28.950 mm (1.140 in.)

3. Install the camshaft bearing caps in their correct location. Tighten the camshaft bearing screws to the specified torque.

Description		Nm	lb-in.	lb-ft
Camshaft bearing cap screw	First torque	6	53	
	Final torque	12	106	

4. Measure the inside dimension of the camshaft bearing cap. Replace the cylinder head if the dimension is out of specification.



21395

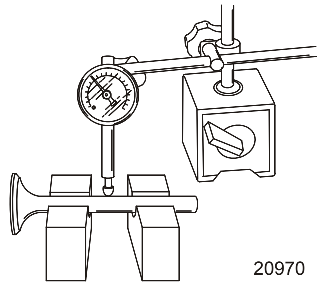
a - Camshaft bearing cap inside dimension

Camshaft Bearing Cap	
Inside diameter	29.000–29.021 mm (1.1417–1.1425 in.)

Valves

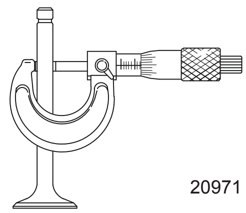
1. Inspect valves for damage/warpage. Replace if necessary.

2. Measure valve stem runout. Replace valves if out of specification.


20970

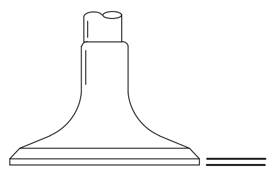
Valve Stem	
Runout	0.038 mm (0.0015 in.) maximum

3. Measure the valve stem diameter. Replace valves if out of specification.


20971

Valve Stem Diameter	
Intake	5.970 mm (0.2350 in.)
Exhaust	5.960 mm (0.2346 in.)

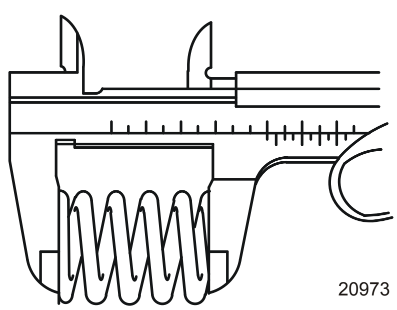
4. Measure margin thickness. Replace valve if out of specification.


20972

Valve Margin Thickness	
Intake	0.750 mm (0.0295 in.)
Exhaust	0.650 mm (0.0256 in.)

Valve Springs

Check free length of each spring. Replace valve springs if out of specification.


20973

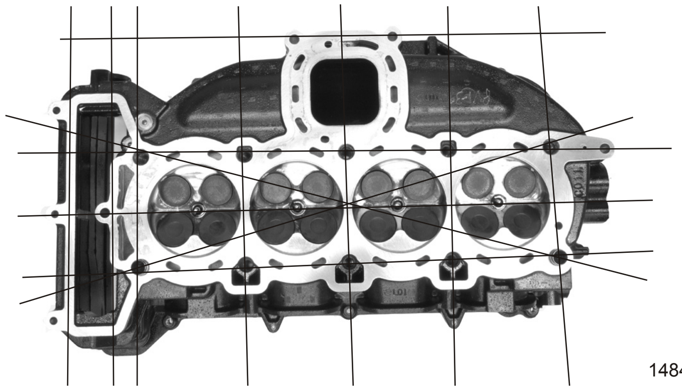
Valve Spring	
Free length	48.77 mm (1.920 in.)

Cylinder Head

1. Inspect the cylinder head for mineral deposits/corrosion in the water passageways, clean any deposits/corrosion observed.

2. Inspect the cylinder head for carbon deposits in combustion chamber. Use round scraper to clean away deposits. Be careful not to scratch or remove cylinder head material.
3. Measure cylinder head warpage. Replace cylinder head if out of specification.

NOTE: Use a straight edge and a thickness gauge to inspect cylinder head for warpage.

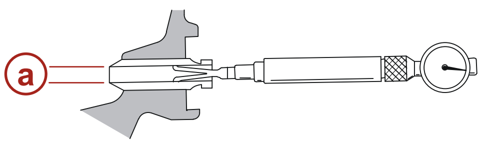


14844

Cylinder Head	
Maximum deck warp	0.075 mm (0.003 in.)

Valve Guides

Measure the valve guide bore with a valve guide bore gauge. If valve guide wear is out of specification, replace the valve guide.



20975

a - Valve guide bore

Valve Guide Bore	
Intake and exhaust	6.00–6.016 mm (0.2362–0.2368 in.)

VALVE GUIDE REPLACEMENT

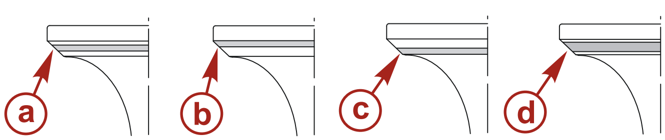
NOTE: Inexperienced personnel should not attempt to replace the valve guide. A reputable engine machine shop will have the tools to replace the valve guides and ream the guides to proper tolerance.

IMPORTANT: The valve guide must be removed and installed at room temperature. Use a pneumatic impact hammer to remove and install the valve guide.

Valve Stem to Valve Guide Clearance	
Intake	0.03–0.046 mm (0.0011–0.0018 in.)
Exhaust	0.04–0.056 mm (0.0015–0.0022 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 manufacturer's 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.

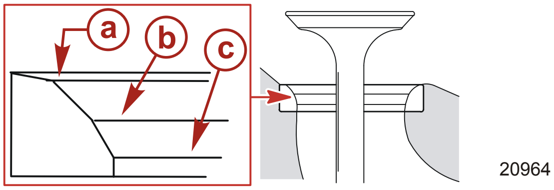


20969

a - Valve seat contact too narrow
b - Valve seat too high
c - Valve seat too low
d - Correct valve seat width

Valve Seat Contact Width	
Intake and exhaust	2.25 mm (0.0886 in.)

6. To reface a valve seat, use a 30°, 45°, and 60° valve seat cutting tool.

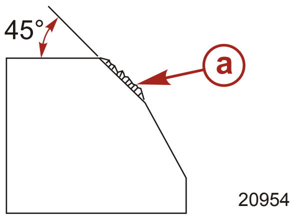


a - 30° angle
b - 45° angle
c - 60° angle

NOTE: When twisting cutter, keep an even downward pressure to prevent chatter marks.

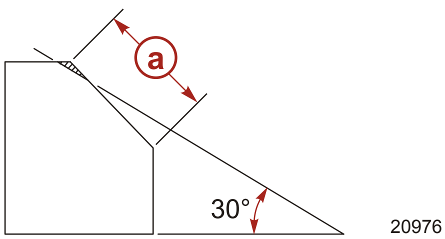
NOTE: After refacing the valve seat or replacing the valve and valve guide, the valve seat and valve face should be lapped.

7. Start with the 45° cutting tool to clean up any pitting or rough surface of the valve seat.



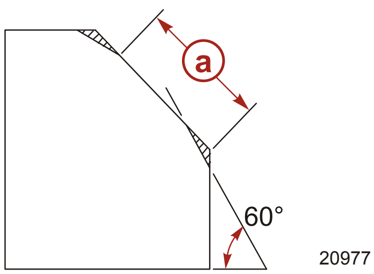
a - Rough surface of valve seat

8. Use the 30° cutting tool to adjust the contact width of the top edge of the valve seat.



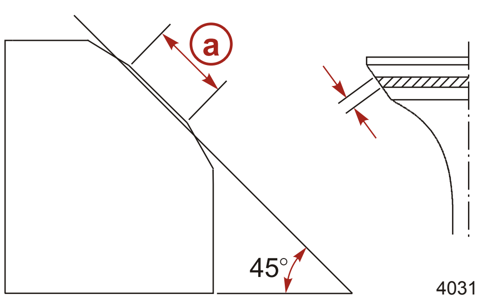
a - Previous contact width

9. Use the 60° cutting tool to adjust the contact width of the bottom edge of the valve seat.



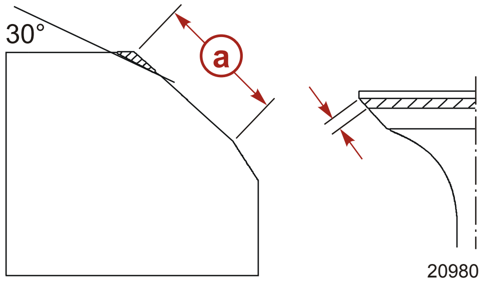
a - Previous contact width

10. If the valve seat contact area is too narrow and situated in the center of the valve face, use the 45° cutting tool to adjust its contact width.



a - Previous contact width

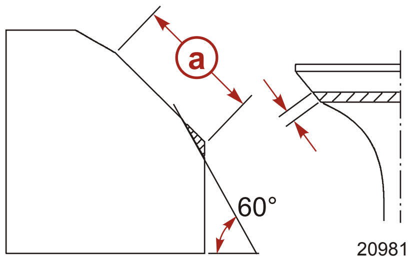
11. If the valve seat contact area is too narrow and situated near the top of the valve face, use the 30° cutting tool to cut the top edge of the valve seat. If necessary, use the 45° cutting tool to center the area of contact and set its width.



20980

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.



20981

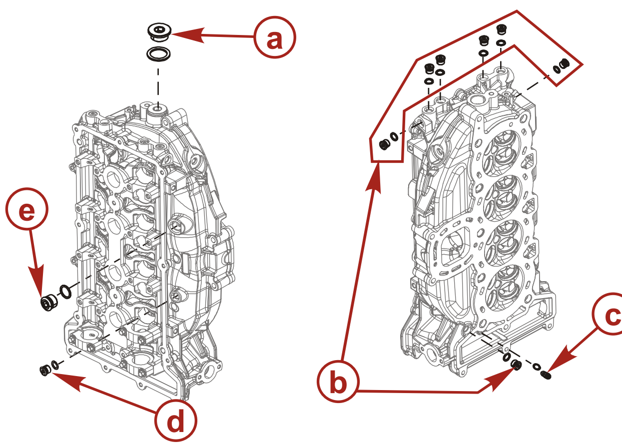
a - Previous contact width

13. After reconditioning the valve seat, the valve stem protrusion must be checked.

Cylinder Head Reassembly

Cylinder Head Galley Plug Installation

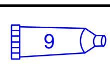
1. Install new O-rings on the oil and water galley plugs.
2. Seal the threads of the oil and water galley plugs with Loctite 567 PST Pipe Sealant.
3. Tighten the oil and water galley plug to the specified torque.



14832

a - Oil galley plug
b - Oil galley plugs
c - Water galley plug
d - Water galley plug
e - Water galley plug

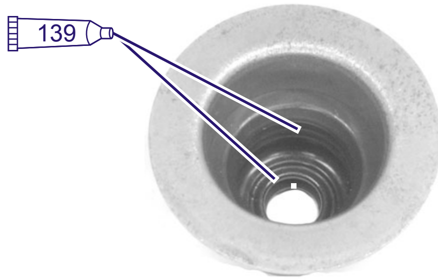
Description	Nm	lb-in.	lb-ft
Oil galley plug "a"	55		40.5
Oil galley plug "b"	9	80	
Water galley plug "c"	9	80	
Water galley plug "d"	9	80	
Water galley plug "e"	22		16.2

Tube Ref No.	Description	Where Used	Part No.
	Loctite 567 PST Pipe Sealant	Oil and water galley plugs	92-809822

Valves

IMPORTANT: The reassembly procedure of the cylinder head must be strictly followed. Failure to follow the assembly procedure may damage the valves, cam, or cylinder head.

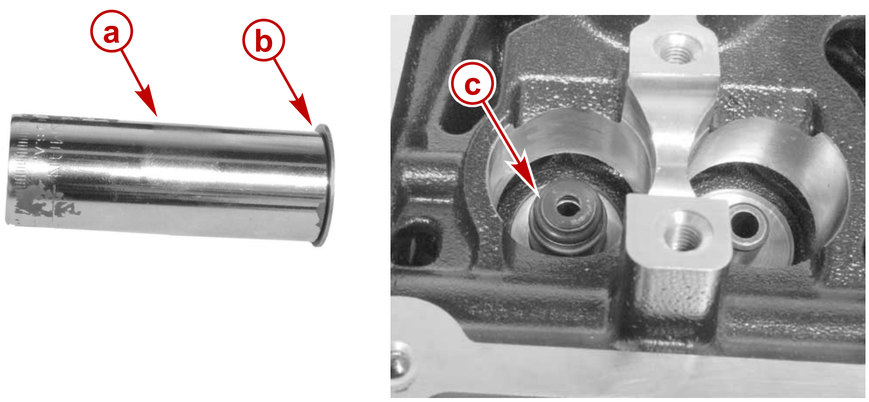
1. Lubricate valve guide seal with Synthetic Blend 4-Stroke Outboard Oil 25W-40.



4831

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Valve guide seal	92-858052K01

2. Insert the valve guide seal into a 17 mm (11/16 in.) deep well socket.
3. Install the valve guide seal onto the valve guide. Lightly push the valve guide seal with the socket until it is seated on the cylinder head.



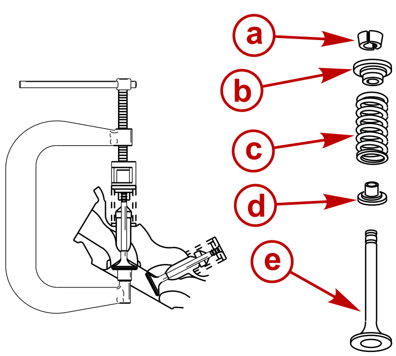
4832

a - 17 mm (11/16 in.) socket
b - Valve guide seal
c - Valve guide seal installed on valve guide

4. Lubricate the valve stem with Synthetic Blend 4-Stroke Outboard Oil 25W-40 and push valve through valve guide seal.
5. Place the valve spring and valve spring retainer over the valve stem.
6. Compress the valve spring with a valve spring compressor.

   NOTE: The valve springs can be installed in any direction.

   IMPORTANT: Use caution when compressing the valve spring. Do not damage the valve, valve spring retainer, or the cylinder head valve bucket tappet bore.



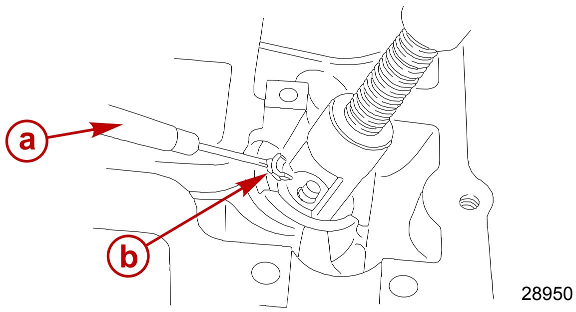
28952

a - Valve spring retaining cotter
b - Valve spring retainer
c - Valve spring
d - Valve guide seal
e - Valve (intake and exhaust)

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Valve stem	92-858052K01

Valve Spring Compressor	91-809494A 1

7. Place the valve spring retaining cotter onto the end of a small screwdriver. A small amount of 2-4-C with Teflon applied to the end of the screwdriver will help the valve spring retaining cotter to adhere to the screwdriver. Install the valve spring retaining cotter onto the valve stem.



a - Small screwdriver
b - Valve spring retaining cotter

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Installing valve spring retaining cotter	92-802859A 1

8. Release the valve spring compressor.
9. Continue to assemble all valves onto cylinder head.

Cams

1. Lubricate the valve bucket tappet outside diameter with SPO 255 and install in the same location it was removed from during disassembly.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Valve bucket tappet outside diameter	Obtain Locally

IMPORTANT: If the valve or the valve seat was replaced/refaced, or the cam and/or cylinder head was replaced, you must install the 2.996 mm (0.118 in.) valve bucket tappet as a starting point to ensure an accurate valve measurement lash clearance.

2. Lubricate all of the cylinder head cam bearing journals with SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Cam bearing	Obtain Locally

3. Carefully place either cam on the cylinder head cam journals. The intake cam location is on the port side. The exhaust cam is on the starboard side. Ensure the cam lobes for the top cylinder (number 1 cylinder) are facing away from the valves.

   NOTE: The intake cam is identified by the letters "MI" on the top side of all the cam lobes. The exhaust cam is identified by the letters "ME" on the top side of all the cam lobes.

4. Lubricate the cam journal with SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Cam journal	Obtain Locally

5. Install the cylinder head cam caps in their proper location.

   NOTE: All of the cylinder head cam caps are identified as to which side, intake (I) and exhaust (E), and to which journal the cap was removed from. The number one (1) cylinder head cam cap location is at the top of the cylinder head.

6. Tighten the cam cap screws one quarter (1/4) turn at a time.

   IMPORTANT: Maintain the cam parallel to the cylinder head cam journals while the cam caps are installed and tightened. Failure to keep the cam parallel to the cam journals, may damage the cylinder head, cam, or cam caps.

7. After all the cam caps are seated on the cylinder head, tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Cam cap screw	12	106	

8. Install the other cam following the same procedure.

9. Check the valve lash as described in the service manual section **Valve Clearance and Adjustments**.

Valve Clearance and Adjustments

Valve Clearance Measurement Steps

Valve Lash Clearance Specification	
Intake	0.150–0.230 mm (0.0059–0.009 in.)
Exhaust	0.350–0.430 mm (0.0137–0.0169 in.)

IMPORTANT: Accurate valve clearance measurements must be made on a cold engine at room temperature, with the cylinder head mated to the cylinder block and torqued to specification.

All of the cam caps must be at their torque specification prior to checking the valve lash measurement.

The valve lash measurement must be made with the cam lobe facing 180° from the valve bucket tappet.

1. Insert the feeler gauge between the cam and the valve bucket tappet. A slight drag on the feeler gauge will indicate the feeler gauge dimension measurement is accurate.

   NOTE: An offset feeler gauge will work best for checking the valve lash measurement. A straight feeler gauge will contact the cylinder head. This contact with the cylinder head may be misleading when checking the valve lash measurement.
2. Record the feeler gauge valve lash measurement and its location on all the valves.
3. If any of the valve lash measurements are out of specification, remove the cam as described in **Section 4B - Cylinder Head Disassembly**.

NOTE: It is not necessary to remove the cylinder head from the cylinder block to change the valve lash. The powerhead must be removed from the adapter plate when changing valve lash.

Changing Valve Clearance

IMPORTANT: The following procedure must be completed with the cylinder head mated to the cylinder block and torqued to specification. Failure to have the cylinder head mated and torqued to specification when changing the valve clearance will result with inaccurate formula measurements.

Valve Lash Clearance Specification	
Intake	0.150–0.230 mm (0.0059–0.009 in.)
Exhaust	0.350–0.430 mm (0.0137–0.0169 in.)

1. If the valve lash clearance is out of valve lash clearance specification, remove the valve bucket tappet and measure its height. Record your measurement of the valve bucket tappet dimension.

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2. Add the valve bucket tappet height measurement and the feeler gauge valve lash measurement.
3. Subtract the specified valve lash clearance from the sum of the valve bucket tappet height measurement/feeler gauge valve lash measurement. This is the valve bucket tappet height measurement you need to install.

EXAMPLE

If the removed valve bucket tappet height is 2.996 mm (0.118 in.), the feeler gauge valve lash measurement is 0.30 mm (0.012 in.), and the specified valve lash clearance is 0.20 mm (0.008 in.) then the formula will appear like:

Metric measurement: 2.996 + 0.30 - 0.20 = 3.096 mm. New valve bucket tappet height measurement is 3.096 mm.

English measurement: (0.118 + 0.012 - 0.008 = 0.122 in.). New valve bucket tappet height measurement is 0.122 in.

NOTE: Photocopy the following table for additional valve clearance measurement work sheets.

MEASUREMENT TABLE								
INTAKE (cold) 0.150–0.230 mm (0.0059–0.009 in.)					EXHAUST (cold) 0.350–0.430 mm (0.0137–0.0169 in.)			
Cylinder	Valve Bucket Tappet Height	Feeler Gauge Valve Lash Measurement	Specified Clearance	New Valve Bucket Tappet Height	Valve Bucket Tappet Height	Feeler Gauge Valve Lash Measurement	Specified Clearance	New Valve Bucket Tappet Height
#1								
#2								
#3								
#4								
#5								
#6								

Powerhead

Section 4C - Lubrication

Table of Contents

Lubrication System Specifications

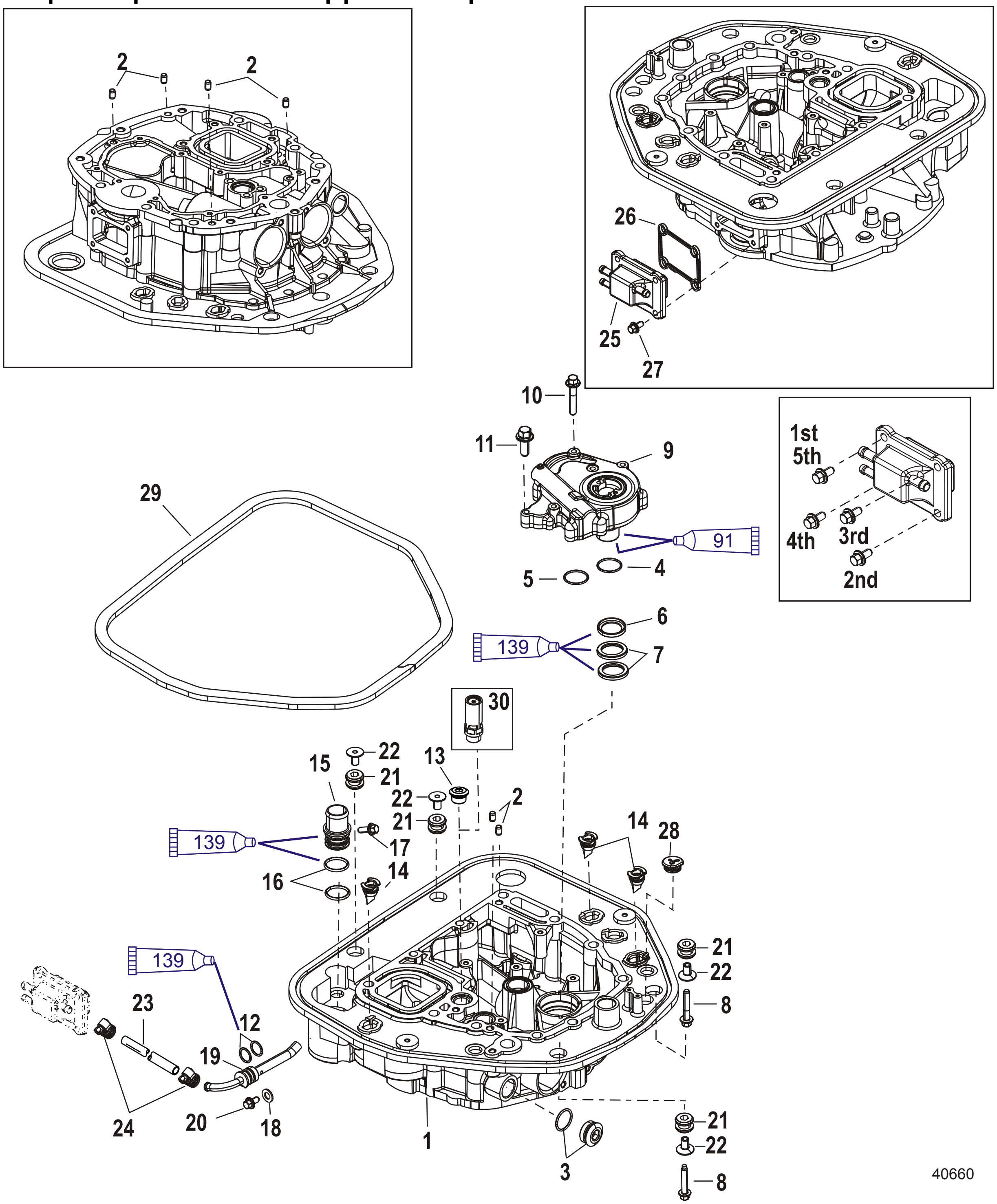
Lubrication System Specifications	
Engine capacity with filter replacement	6 liters (6.3 US qt)
Oil filter	P/N 35-896546T
Gen I oil pressure (warm) (S/N 1B517158 and below)	
at 650 RPM	Minimum 50 kPa (7 psi)
at 6000 RPM	Minimum 220 kPa (32 psi)
at 650 RPM (typical range)	60–120 kPa (9–18 psi)
at 6000 RPM (typical range)	300–450 kPa (44–65 psi)
Gen II oil pressure (warm) (S/N 1B517159 and above)	
at 650 RPM	Minimum 35 kPa (5 psi)
at 6000 RPM	Minimum 200 kPa (29 psi)
at 650 RPM (typical range)	90–190 kPa (13–28 psi)
at 6000 RPM (typical range)	300–450 kPa (44–65 psi)
IOM thermostat opening temperature	62 °C (144 °F)

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Oil pump mounting screw	92-809821
91	Engine Coupler Spline Grease	Oil pump drive gear hub	92-802869A 1
		Engine driveshaft	
		Oil pump driven shaft	
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Dump fitting and O-rings, driveshaft seals, cooling jet O-rings	92-858052K01
		Oil pump outer rotor	
		Priming the oil pump prior to oil pump installation	

Notes:

Oil Pump/Adapter Plate - Upper Components

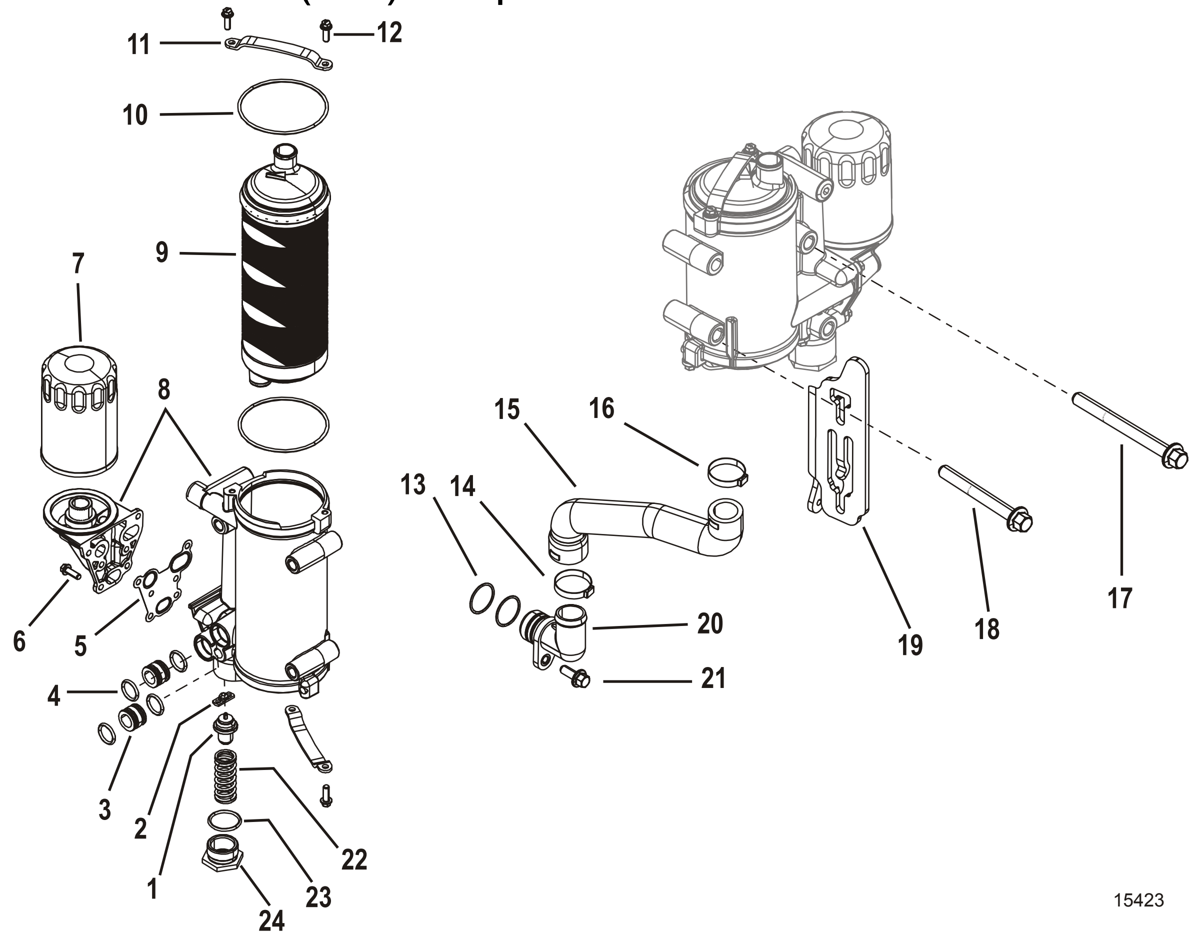


Oil Pump/Adapter Plate - Upper Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Adapter plate			
2	6	Dowel pin			
3	1	Plug	55		41
4	1	Inlet O-ring			
5	1	Outlet O-ring			
6	1	Oil seal			
7	2	Water seal			
8	4	Screw (M6)	10	89	
9	1	Oil pump assembly			
10	4	Bolt (M6 x 45)	10	89	
11	1	Bolt (M6 x 35)	10	89	
12	2	Cooling jet O-ring			
13	1	Plug (S/N 1B517159 and above)	40		30
14	3	Cowl drain			
15	1	Dump fitting assembly			
16	2	O-ring			
17	1	Screw (M6 x 12)	6	53	
18	1	Washer			
19	1	Cooling jet fitting			
20	1	Screw (M6 x 12)	6	53	
21	4	Grommet			
22	4	Bushing			
23	1	Tubing - 53 cm (21 in.)			
24	2	Worm gear clamp	3	27	
25	1	Manifold/strainer housing			
26	1	Seal			
27	4	Screw (M6 x 16)	Hand start and drive first screw snug. Drive remaining three screws in "X" pattern sequence to 6 Nm (53 lb-in.). Return to first screw and drive to torque.		
28	1	Grommet			
29	1	Adapter plate seal			
30	1	Pressure control valve (S/N 1B517158 and below)	40		30

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Oil pump drive gear hub	92-802869A 1
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Dump fitting and O-rings, driveshaft seals, cooling jet O-rings	92-858052K01

Integrated Oil Module (IOM) Components



Integrated Oil Module (IOM) Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Thermostat			
2	1	Brace			
3	2	Dowel			
4	4	O-ring			
5	1	Gasket			
6	6	Bolt (M6 x 18)	10	89	
7	1	Oil filter			
8	1	IOM housing assembly			
9	1	Tubestack			
10	2	O-ring			
11	2	Strap			
12	4	Bolt (M6 x 18)	10	89	
13	2	O-ring			
14	1	Clamp (38.1 mm)			
15	1	Hose			
16	1	Clamp (34.6 mm)			
17	1	Bolt (M10 x 105)	31		23
18	3	Bolt (M10 x 85)	31		23
19	1	Bracket			
20	1	Fitting			
21	1	Bolt (M6 x 16)	10	89	
22	1	Spring			
23	1	O-ring			
24	1	Thermostat retaining nut			

Engine Guardian System

The Engine Guardian System monitors the critical sensors on the engine for any early indications of problems. The system will respond to a problem by emitting a continuous beep and/or reducing engine power in order to provide engine protection.

If Guardian System has been activated, reduce throttle speed. The problem will need to be identified and corrected, if possible. The system must be reset before the engine will operate at higher speeds. Moving the throttle lever back to the idle position will reset the system.

Low Oil Pressure, Engine Guardian

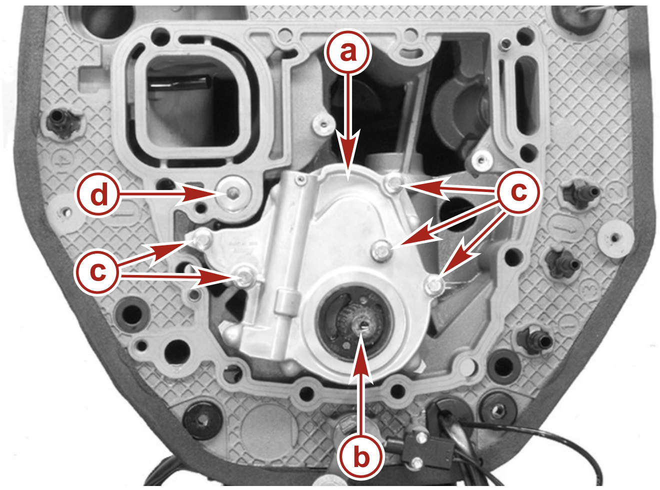
When the PCM receives digital information that the engine oil pressure is below a predetermined value at any given RPM, the Engine Guardian System will sound a continuous horn and reduce the engine RPM. The amount of RPM reduction is dependent on the amount of oil pressure.

Oil Pump

Oil Pump Removal

NOTE: The powerhead must be removed to access the oil pump.

1. Remove the powerhead. Refer to **Section 4A - Powerhead Removal**.
2. Remove the five 8 mm hex bolts securing the oil pump to the adapter plate.



40906

- a - Oil pump
- b - Driveshaft
- c - Oil pump mounting bolts (M8 hex)
- d - Plug (S/N 1B517159 and above)

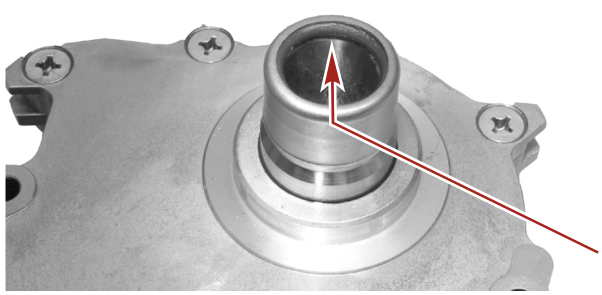
NOTE: The pressure control valve and the piston cooling jets were removed from the engine as part of a friction reduction package. The valve was replaced with a plug. Starting serial number for the installation of the plug is 1B517159.

3. Lift the oil pump off the adapter plate.

Oil Pump Disassembly

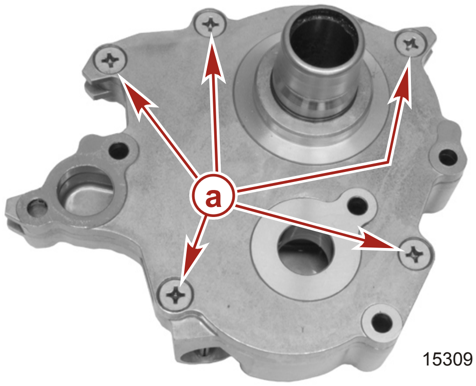
IMPORTANT: The oil pump assembly is a nonserviceable component. Ensure all other engine components relating to maintaining proper oil pressure, are inspected prior to the disassembly of the oil pump. The oil pump generally will not be the source of low oil pressure problems.

1. Remove the driveshaft O-ring seal from the oil pump driven shaft.



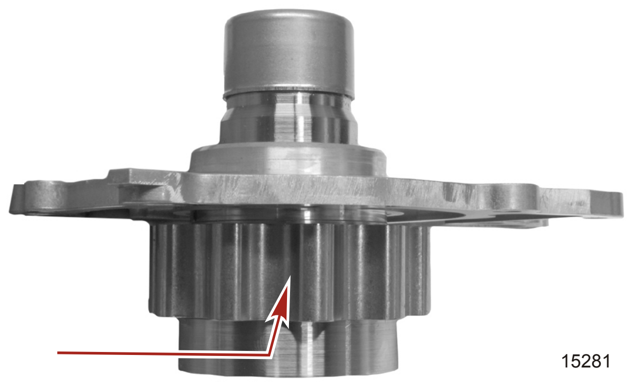
15275

2. Remove the five screws securing the oil pump cover to the oil pump housing.

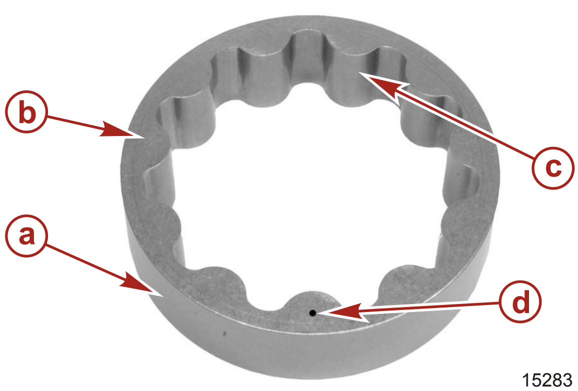


a - Oil pump cover screw (5)

3. Remove the oil pump cover.
4. Clean the inner rotor and shaft with a solvent.
5. Inspect the inner rotor for damage. If the oil pump inner rotor shows signs of excessive wear or embedded particles, replace the oil pump.



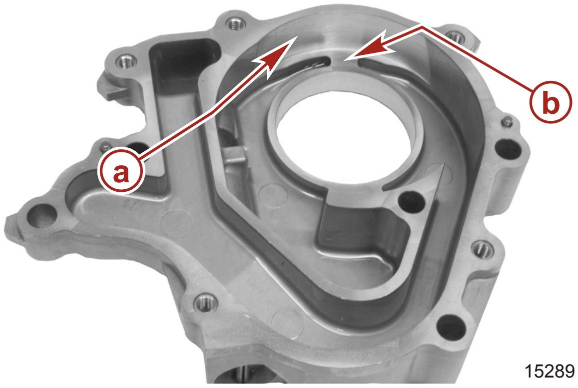
6. Remove the outer rotor from the oil pump housing.
7. Clean the outer rotor with solvent.
8. Inspect the top and bottom surfaces, the outside diameter, and the inner diameter of the rotor for damage, scoring, or embedded particles. If any part of the outer rotor is damaged or has embedded particles, replace the oil pump.



a - Rotor outer diameter
b - Top/bottom surface of rotor
c - Rotor inside diameter
d - Rotor orientation identification mark

9. Inspect the outer rotor housing for scoring or embedded particles.
10. Inspect the area between the suction and pressure sides of the oil pump housing.

11. Replace the oil pump assembly if damage or embedded particles are found.

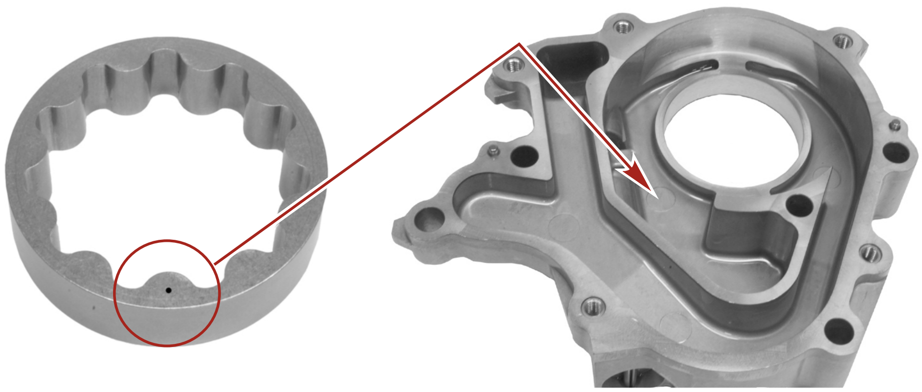


15289

a - Critical area where outer rotor contacts oil pump housing
b - Critical area between suction and pressure sides of housing

Oil Pump Assembly

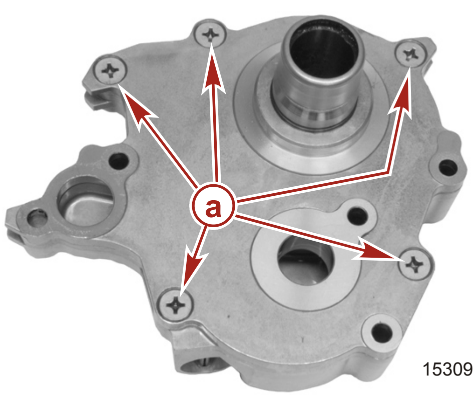
1. Lubricate the oil pump outer rotor with Synthetic Blend 4-Stroke Outboard Oil 25W-40 engine oil.
2. Install the outer rotor into the oil pump housing with the rotor orientation identification mark facing towards the oil pump housing.



15291

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Oil pump outer rotor	92-858052K01

3. Install the oil pump cover assembly onto the oil pump housing. Ensure to align the inner rotor with the outer rotor during the oil pump cover installation.
4. Install the oil pump cover screws. Tighten the oil pump cover screws to the specified torque.

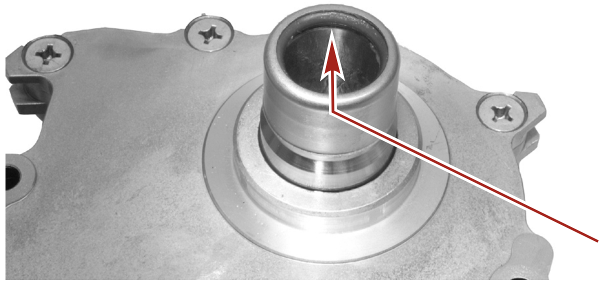


15309

a - Oil pump cover screw (5)

Description	Nm	lb-in.	lb-ft
Oil pump cover screw	10	89	

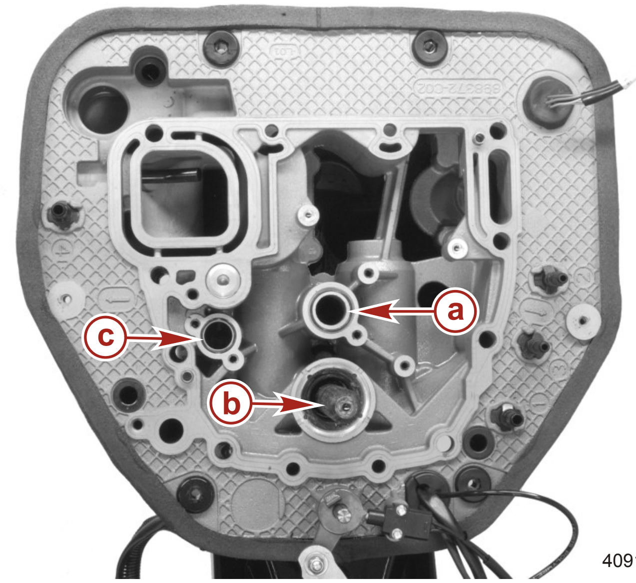
5. Install a new driveshaft O-ring seal into the oil pump assembly.



15275

Oil Pump Installation

1. Lubricate the driveshaft with Engine Coupler Spline Grease.
2. Install O-rings into the oil pump inlet port and the oil pump pressure port O-ring groove in the adapter plate.

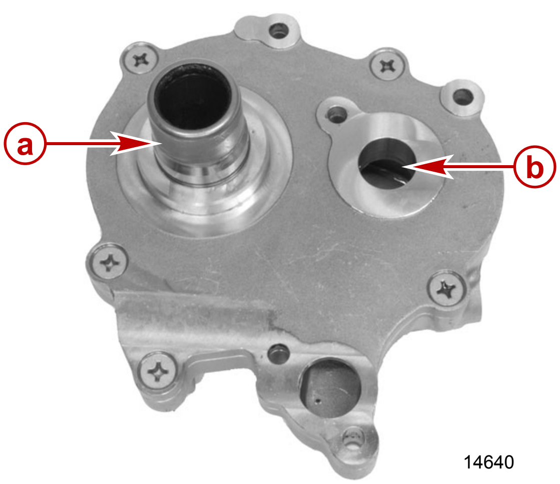


40910

a - Oil pump inlet port
b - Driveshaft
c - Oil pump pressure port

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Engine driveshaft	92-802869A 1

3. Lubricate the oil pump by pouring 5 ml (1 teaspoon) of Synthetic Blend 4-Stroke Outboard Oil 25W-40 into oil pump inlet port.
4. Rotate the oil pump driven shaft to distribute the oil throughout the oil pump.
5. Lubricate the inside and outside of the oil pump driven shaft with Engine Coupler Spline Grease.

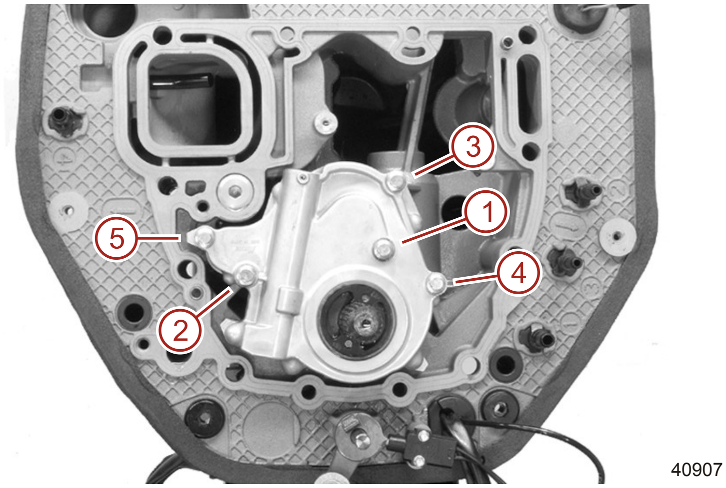


14640

a - Oil pump driven shaft
b - Oil pump inlet port

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Oil pump driven shaft	92-802869A 1
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Priming the oil pump prior to oil pump installation	92-858052K01

6. Install the oil pump assembly onto the adapter plate.
7. Apply a small amount of Loctite 242 Threadlocker to the oil pump mounting screws.
8. Install the oil pump mounting screws and tighten in the sequence shown to the specified torque.



Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Oil pump mounting screw	92-809821

Description	Nm	lb-in.	lb-ft
Oil pump mounting screw (M6 x 45) (4) (M8 hex)	10	89	
Oil pump mounting screw (M6 x 35) (1) (M8 hex)			

Integrated Oil Module (IOM)

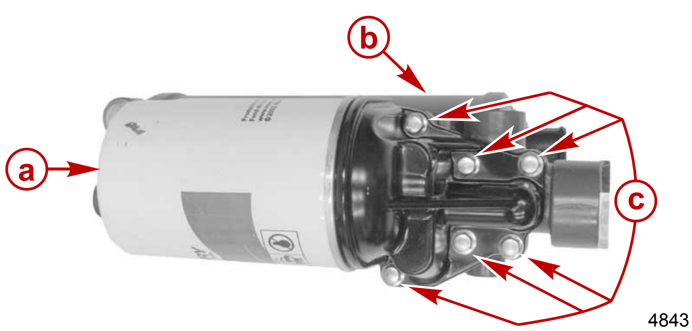
IOM Removal

Refer to **Section 4A - Removing Powerhead Components**.

IOM Disassembly

IMPORTANT: The tubestack portion of the IOM is nonserviceable. The IOM should be replaced as an assembly if fouled, damaged, or blockage is suspected.

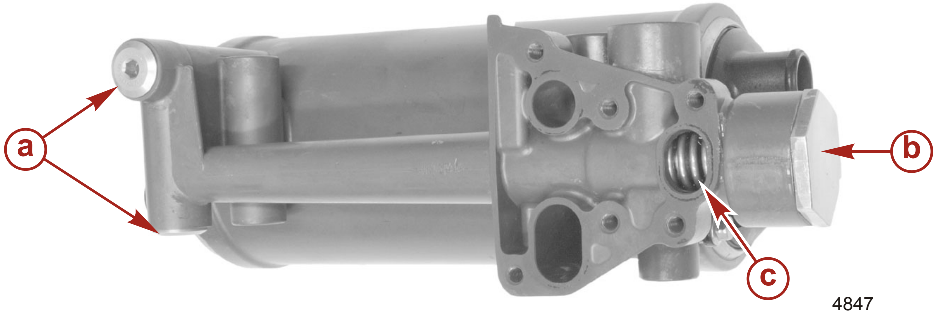
1. Remove the oil filter.
2. Remove the six screws securing the oil filter adapter to the IOM.
3. Remove the oil filter adapter and gasket.



a - Oil filter
b - IOM
c - Screws securing oil filter adapter

4. Remove the galley plugs and discard the galley plug O-rings.

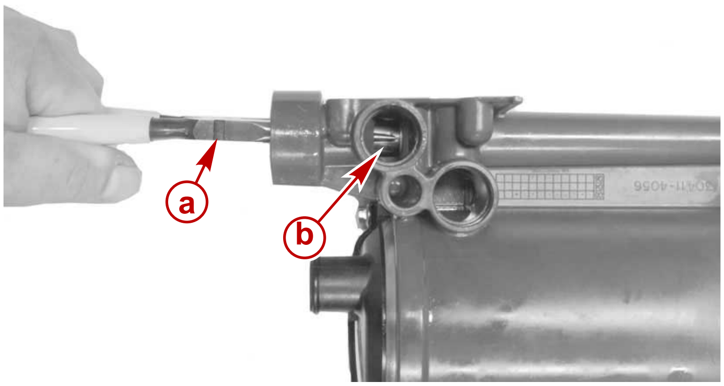
5. Remove the thermostat retaining nut.



4847

a - Galley plugs
b - Thermostat retaining nut
c - Thermostat spring

6. Remove the O-ring on the thermostat retaining nut and discard.
7. Remove the thermostat spring.
8. Use a needle-nose pliers to carefully remove the thermostat and thermostat brace.

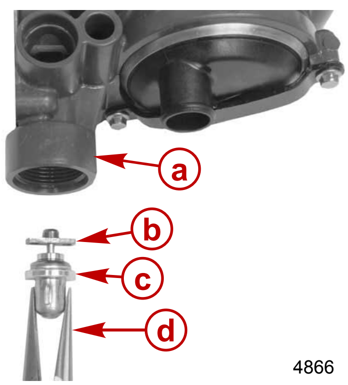


4849

a - Needle-nose pliers
b - Thermostat

IOM Assembly

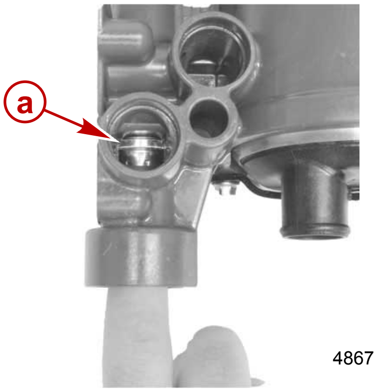
1. Install the thermostat brace onto the thermostat.
2. With a pair of needle-nose pliers, slide the thermostat with the brace into the IOM thermostat cavity until it is seated in the IOM.



4866

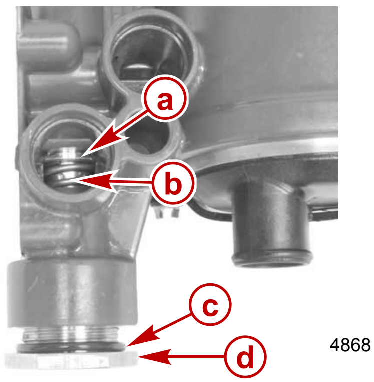
a - IOM
b - Thermostat brace
c - Thermostat
d - Needle-nose pliers

3. Check to ensure the thermostat brace has not fallen off the thermostat by pushing on the thermostat. The thermostat should spring back slightly when finger pressure is released.



a - Thermostat

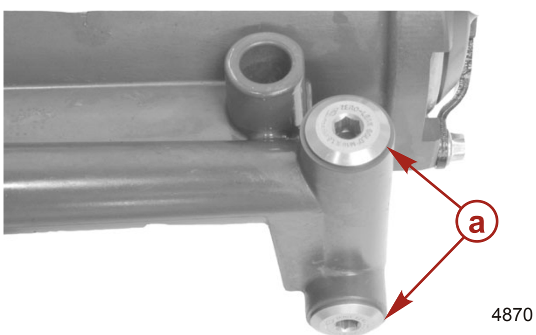
4. Install the thermostat spring.
5. Install a new O-ring onto the thermostat retaining nut. Install the thermostat retaining nut and tighten to the specified torque.



a - Thermostat
b - Thermostat spring
c - O-ring
d - Thermostat retaining nut

Description	Nm	lb-in.	lb-ft
Thermostat retaining nut	24		18

6. Install new O-rings onto the galley plugs.
7. Install galley plugs and tighten the galley plugs to the specified torque.

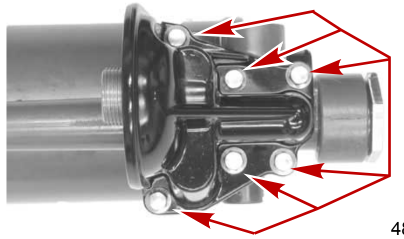


a - Galley plug

Description	Nm	lb-in.	lb-ft
Galley plug	22		16

8. Install a new gasket onto the IOM housing.

9. Install the oil filter adapter onto the IOM housing. Secure the oil filter adapter with six screws. Tighten the oil filter adapter screws to the specified torque.


4875

Description	Nm	lb-in.	lb-ft
Oil filter adapter screws (M6 x 18)	10	89	

10. After installing the IOM onto the powerhead, install a new oil filter.

IOM Installation

Refer to **Section 4A - Installing Powerhead Components**.

Notes:

Mid-Section

Section 5A - Clamp/Swivel Brackets and Driveshaft Housing

Table of Contents

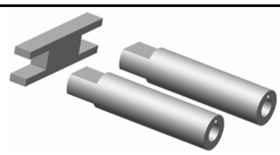
5
A

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
36	P80 Rubber Lubricant	Flush fitting assembly	Obtain Locally
66	Loctite 242 Threadlocker	Poppet cover screw threads	92-809821
		Lower mount clamp mounting screws and port side forward ground wire mounting screw	
		Spanner nut retainer screw	
		Fuel supply module mounting screw threads	
		FSM shroud mounting screw threads	
94	Anti-Corrosion Grease	Spanner nut threads	92-802867Q 1
95	2-4-C with Teflon	Swivel bushings, grease fittings, power trim cylinder striker plates	92-802859A 1
		Flush fitting plug O-ring	
		Swivel pin assembly	
		Swivel tube assembly	

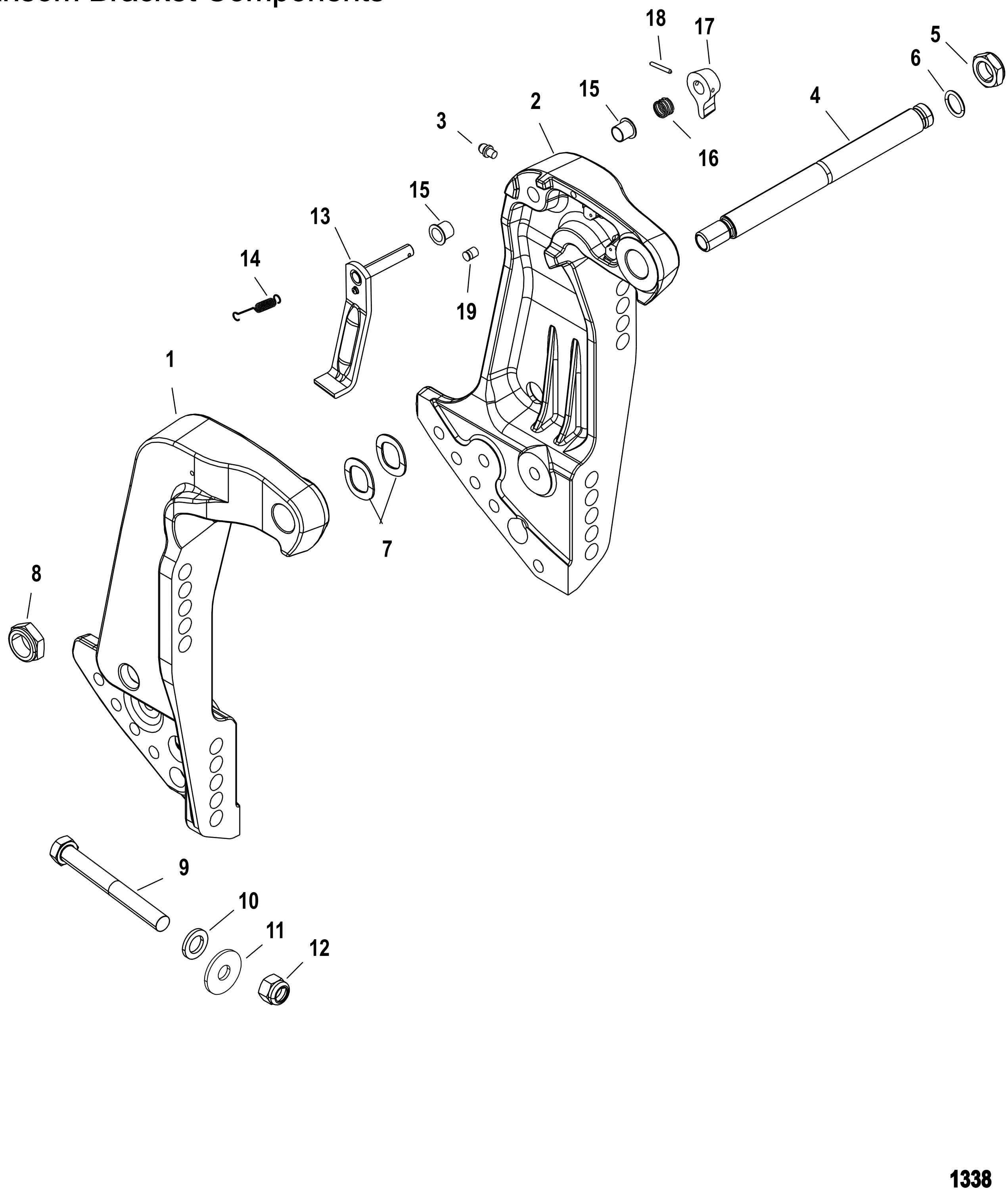
Special Tools

Spanner Nut Socket	91-897957T
 15638	Aids in the removal and installation of the upper mount spanner nut.

Upper Mount Alignment Tool	91-899015A01
 15639	Aligns upper mount for assembly with the swivel pin assembly.

Notes:

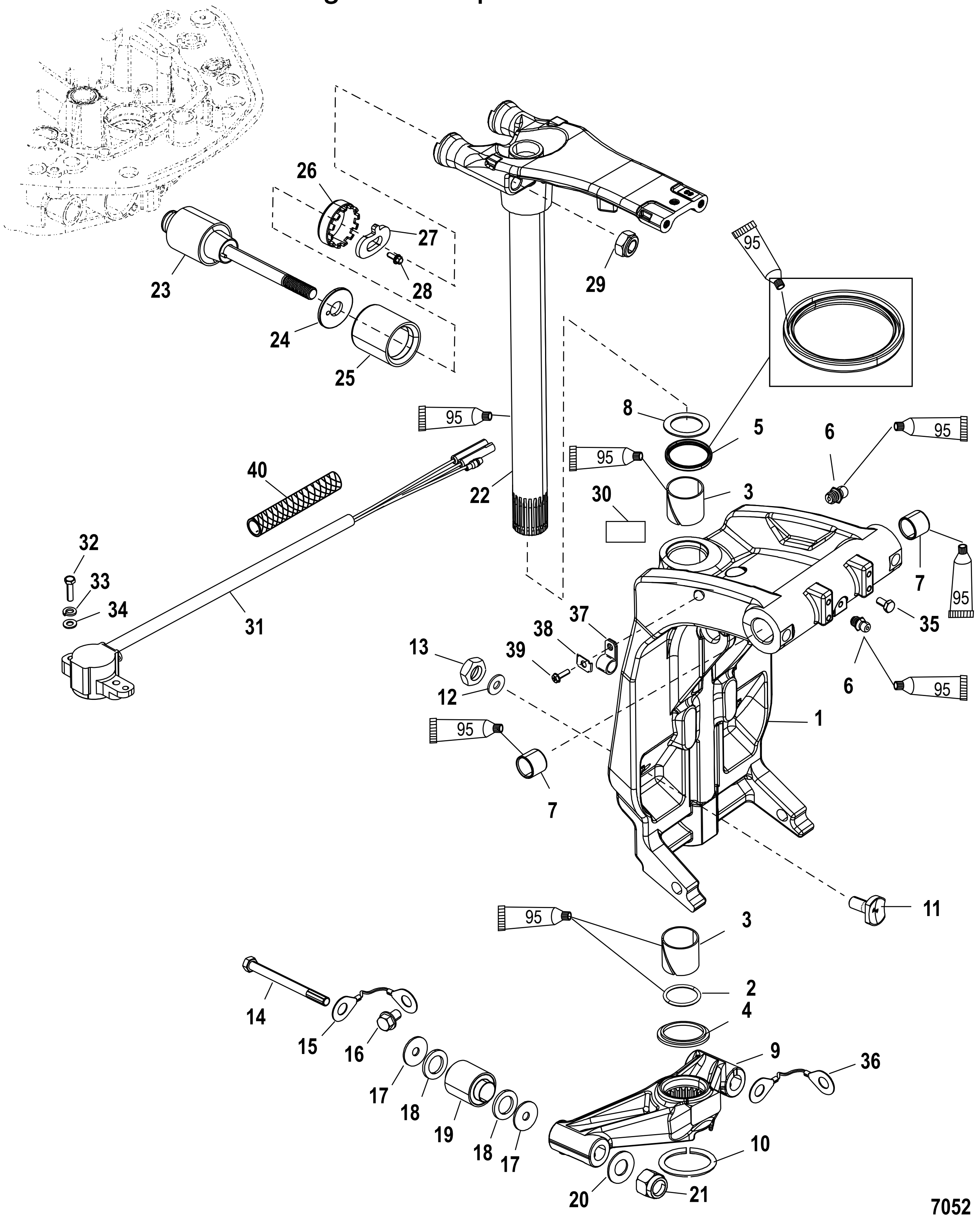
Transom Bracket Components



Transom Bracket Components

<table>
<tr><th rowspan="2">Ref. No.</th><th rowspan="2">Qty.</th><th rowspan="2" colspan="2">Description</th><th colspan="3">Torque</th></tr>
<tr><th>Nm</th><th>lb-in.</th><th>lb-ft</th></tr>
<tr><td>1</td><td>1</td><td colspan="2">Starboard transom bracket</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>1</td><td colspan="2">Port transom bracket</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>1</td><td colspan="2">Grease fitting</td><td>8.5</td><td>75</td><td></td></tr>
<tr><td>4</td><td>1</td><td colspan="2">Tilt tube</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>1</td><td colspan="2">Nut (1-14)</td><td>62</td><td></td><td>46</td></tr>
<tr><td>6</td><td>1</td><td colspan="2">O-ring</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>2</td><td colspan="2">Wave washer</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">1</td><td rowspan="2">Nut (7/8-14)</td><td>First torque</td><td>68</td><td></td><td>50</td></tr>
<tr><td>Final torque</td><td colspan="3">Then back off 1/4 turn</td></tr>
<tr><td>9</td><td>4</td><td colspan="2">Bolt (½-20 x 4.50 in.)</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>4</td><td colspan="2">Washer</td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>4</td><td colspan="2">Washer</td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>4</td><td colspan="2">Nut (½-20)</td><td></td><td></td><td></td></tr>
<tr><td>13</td><td>1</td><td colspan="2">Lever assembly</td><td></td><td></td><td></td></tr>
<tr><td>14</td><td>1</td><td colspan="2">Tension spring</td><td></td><td></td><td></td></tr>
<tr><td>15</td><td>2</td><td colspan="2">Nyliner bushing</td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>1</td><td colspan="2">Compression spring</td><td></td><td></td><td></td></tr>
<tr><td>17</td><td>1</td><td colspan="2">Knob</td><td></td><td></td><td></td></tr>
<tr><td>18</td><td>1</td><td colspan="2">Groove pin</td><td></td><td></td><td></td></tr>
<tr><td>19</td><td>1</td><td colspan="2">Pin</td><td></td><td></td><td></td></tr>
</table>

Swivel Bracket and Steering Arm Components

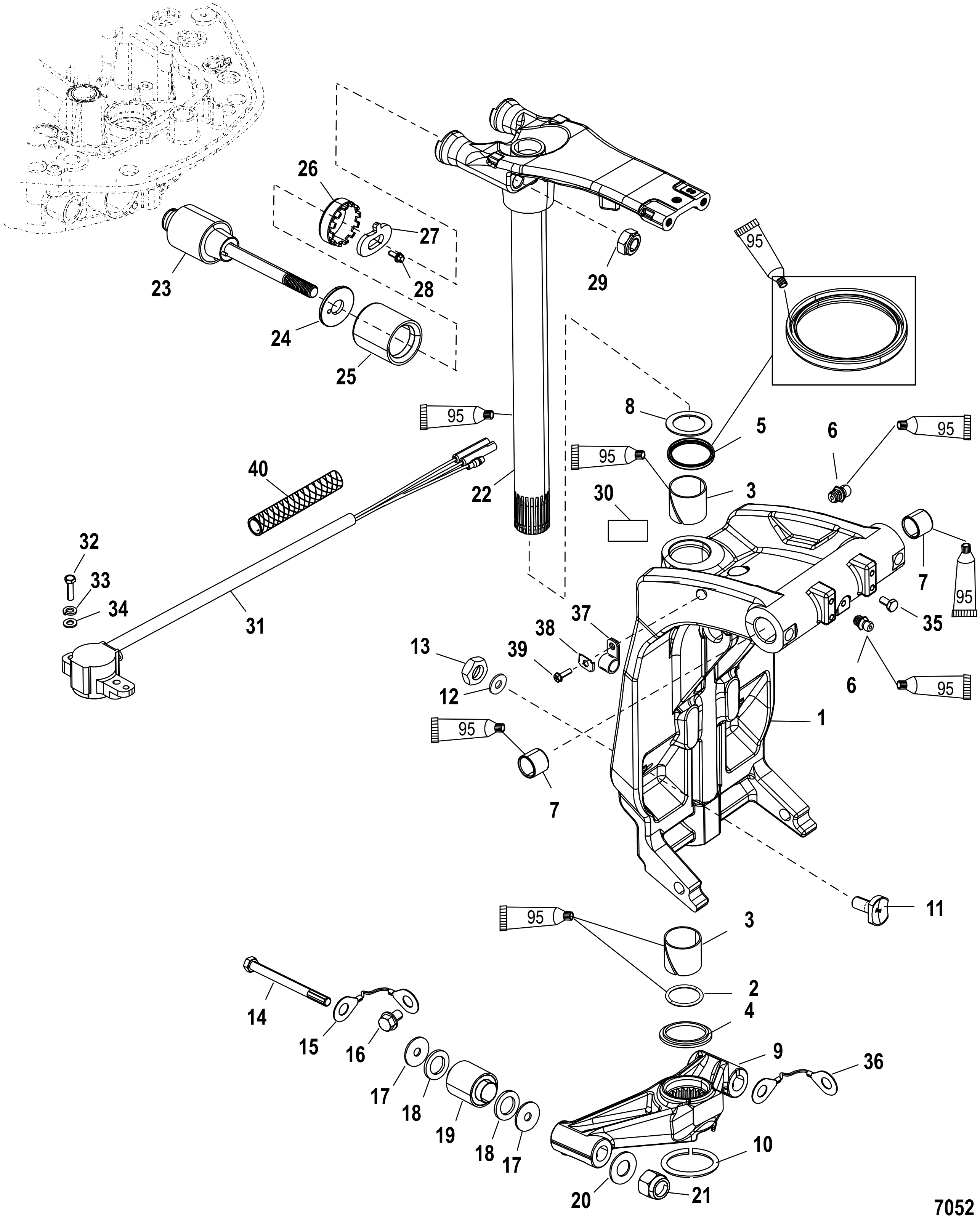


Swivel Bracket and Steering Arm Components

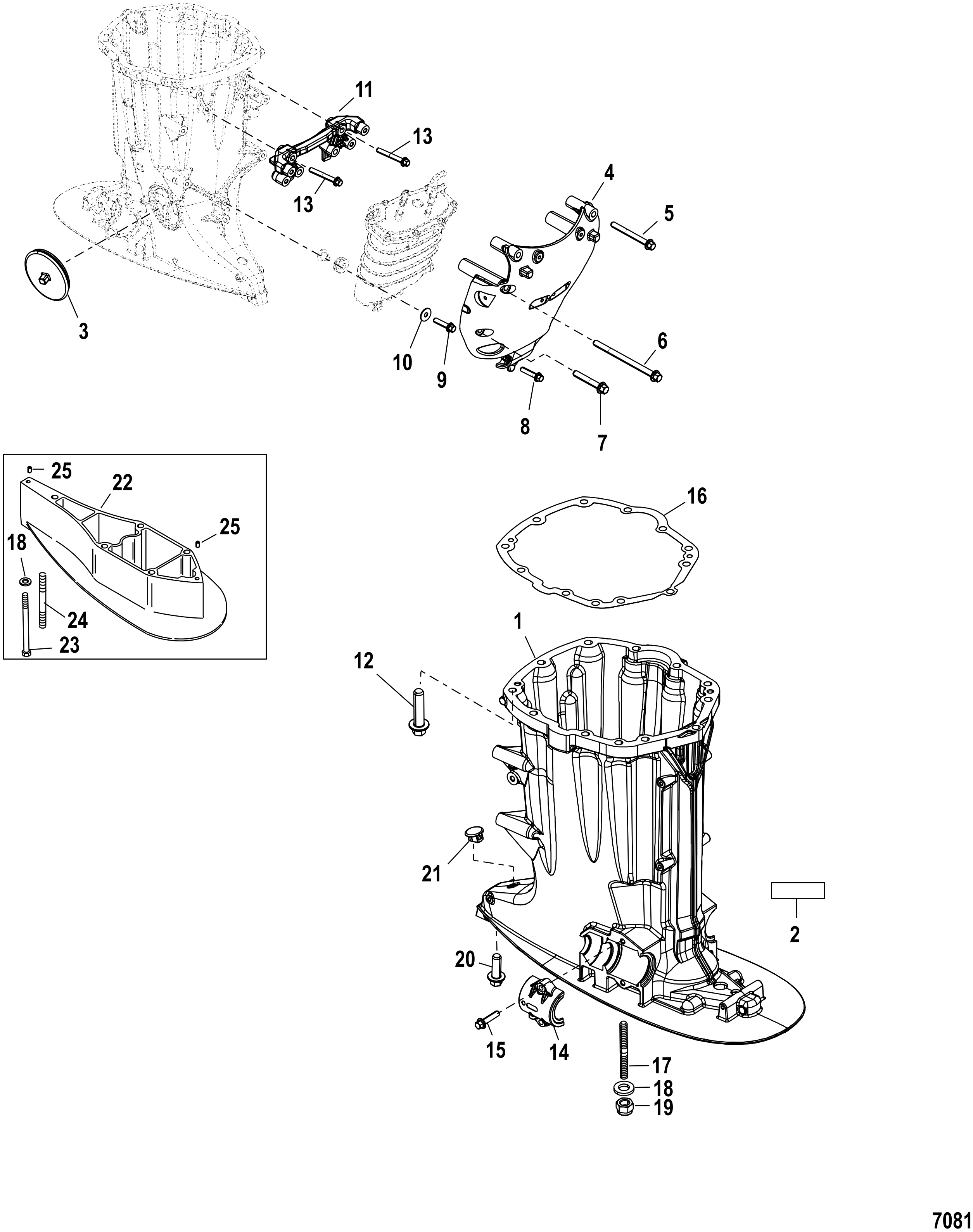
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Swivel bracket			
2	1	O-ring			
3	2	Bushing			
4	1	Spacer			
5	1	Oil seal			
6	2	Grease fitting	8.5	75	
7	2	Bushing			
8	1	Thrust washer			
9	1	Bottom yoke			
10	1	Retaining ring			
11	2	Striker plate			
12	2	Lockwasher			
13	2	Nut (0.375-24)	30.5		22.5
14	2	Bolt (M14 x 175)			
15	2	Ground wire assembly			
16	1	Screw (0.250-20 x 0.375 in.)			
17	4	Washer			
18	4	Washer			
19	2	Lower mount			
20	2	Washer			
21	2	Nut (M14)	122		90
22	1	Swivel pin assembly			
23	2	Upper mount assembly			
24	2	Snubber washer			
25	2	Retainer sleeve			
26	2	Spanner nut	270		200
27	2	Retainer			
28	2	Screw (M6 x 20)	10	89	
29	2	Nut (M14)	122		90
30	1	Serial decal			
31	1	Trim position sensor			
32	2	Screw (#10-24 x 0.750 in.)	1.7	15	
33	2	Lockwasher			
34	2	Washer			
35	2	Screw (0.250-28 x 0.500 in.)			
36	1	Ground wire assembly			
37	1	J-clip			
38	1	C-washer			
39	1	Screw (#10-16 x 0.600 in.)			
40	1	Conduit (40.6 cm [16 in.])			

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Swivel bushings, grease fittings, power trim cylinder striker plates	92-802859A 1

Swivel Bracket and Steering Arm Components



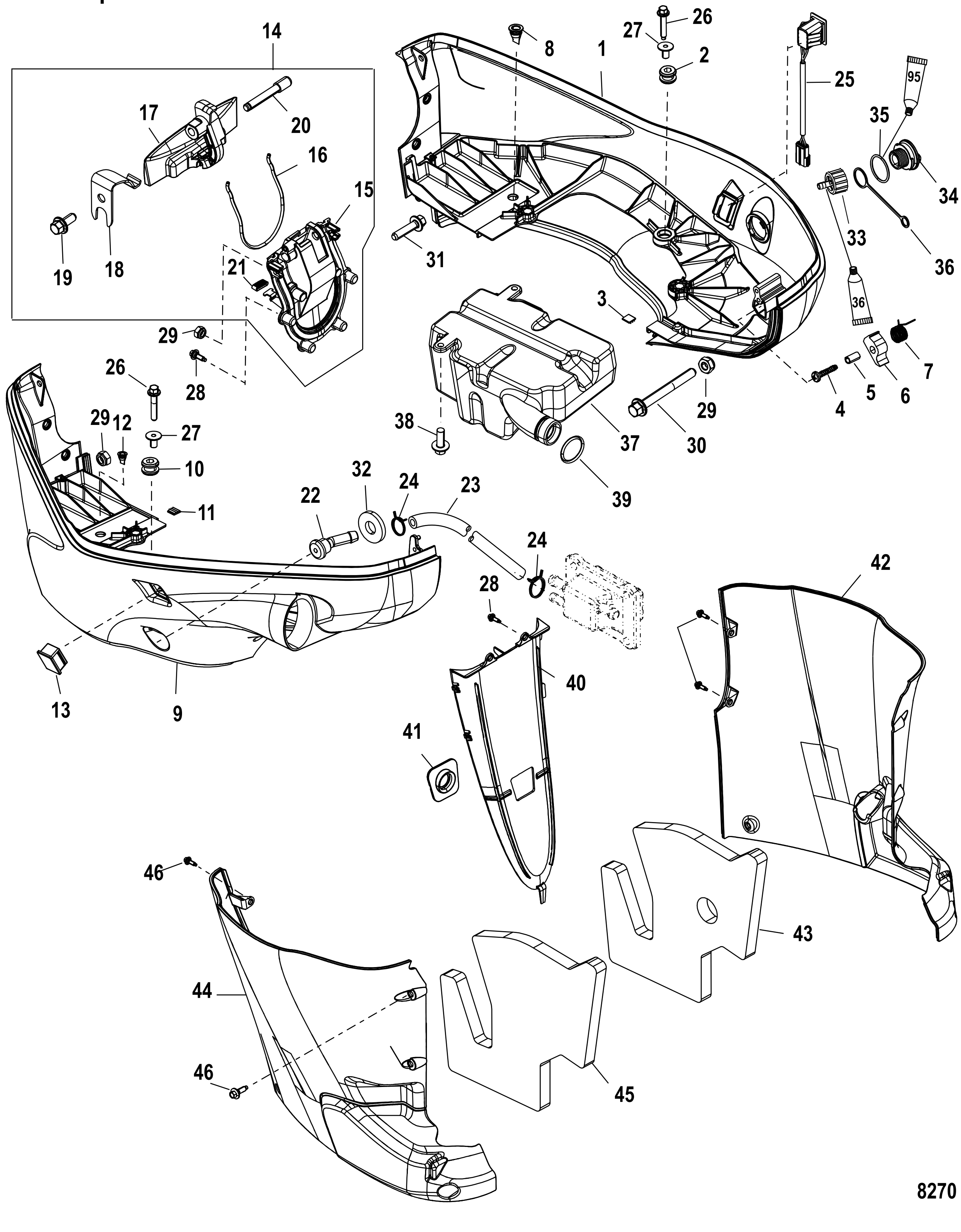
Driveshaft Housing Components



Driveshaft Housing Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Driveshaft housing			
2	1	Oil drain decal			
3	1	Grommet			
4	1	Fuel supply module shroud			
5	2	Screw (M8 x 75)	24		17.7
6	2	Screw (M8 x 120)	24		17.7
7	2	Screw (M8 x 50)	24		17.7
8	1	Screw (M8 x 40)	24		17.7
9	3	Screw (M8 x 35)	24		17.7
10	3	Washer			
11	1	Bracket			
12	5	Screw (M10 x 40)	47.5		35
13	4	Screw (M8 x 50)	24		17.7
14	2	Lower mount clamp			
15	4	Screw (M8 x 35)	27		20
16	1	Gasket			
17	4	Stud (M12 x 52)	30		22
18	4 or 5	Washer			
19	4	Nut (M12)	61		45
20	1	Screw (M12 x 35) (Long)	75		55.3
21	1	Rubber plug			
22	1	Spacer (X-Long)			
23	1	Screw (M12 x 160) (X-Long)	75		55.3
24	4	Stud (M12 x 179) (X-Long)	30		22
25	2	Dowel pin (0.375 x 0.625 in.) (X-Long)			

Cowl Components



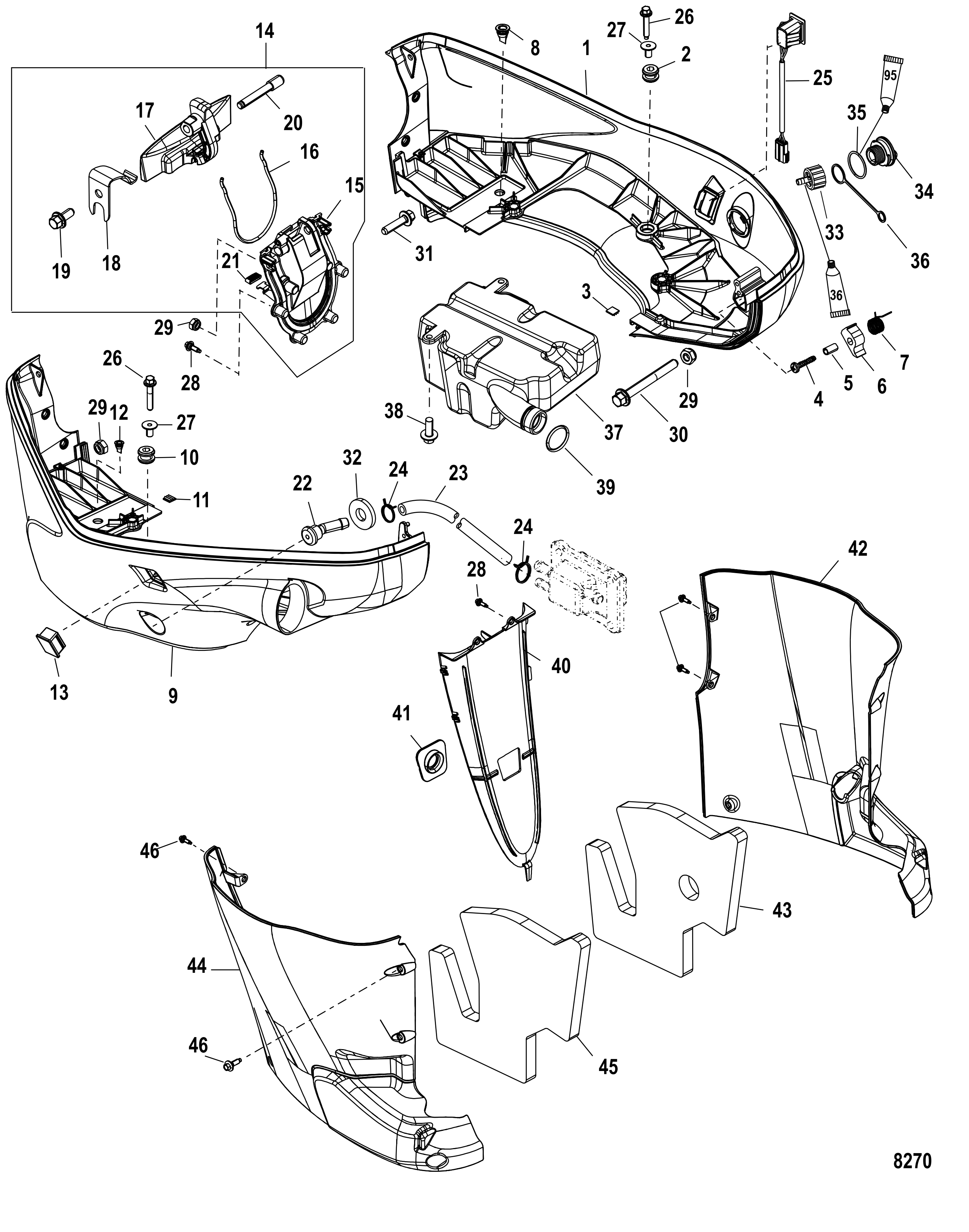
Cowl Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Port pan assembly			
2	1	Grommet			
3	1	Front seal			
4	1	Screw			
5	1	Spacer			
6	1	Pawl			
7	1	Spring			
8	1	Cowl drain			
9	1	Starboard pan assembly			
10	1	Grommet			
11	1	Back seal			
12	1	Cowl drain			
13	1	Plug			
14	1	Latch assembly			
15	1	Access panel assembly			
16	1	Seal			
17	1	Rail latch lever assembly			
18	1	Spring			
19	1	Screw			
20	1	Lever pin			
21	1	Latch button			
22	1	Fitting			
23	1	Tubing (53.3 cm [21 in.])			
24	2	Clamp (20.3 cm [8 in.])			
25	1	Trim switch			
26	2	Screw (M6 x 20)	10	89	
27	2	Bushing			
28	8	Screw (M6)	6	53	
29	4	Nut (M6)			
30	1	Screw (M6 x 55)	10	89	
31	1	Screw (M6 x 25)	10	89	
32	1	Spacer			
33	1	Flush fitting assembly			
34	1	Flush fitting plug			
35	1	O-ring			
36	1	Tether			
37	1	Exhaust plenum			
38	2	Screw (M6 x 20)	6	53	
39	1	O-ring			
40	1	Rear cover assembly			

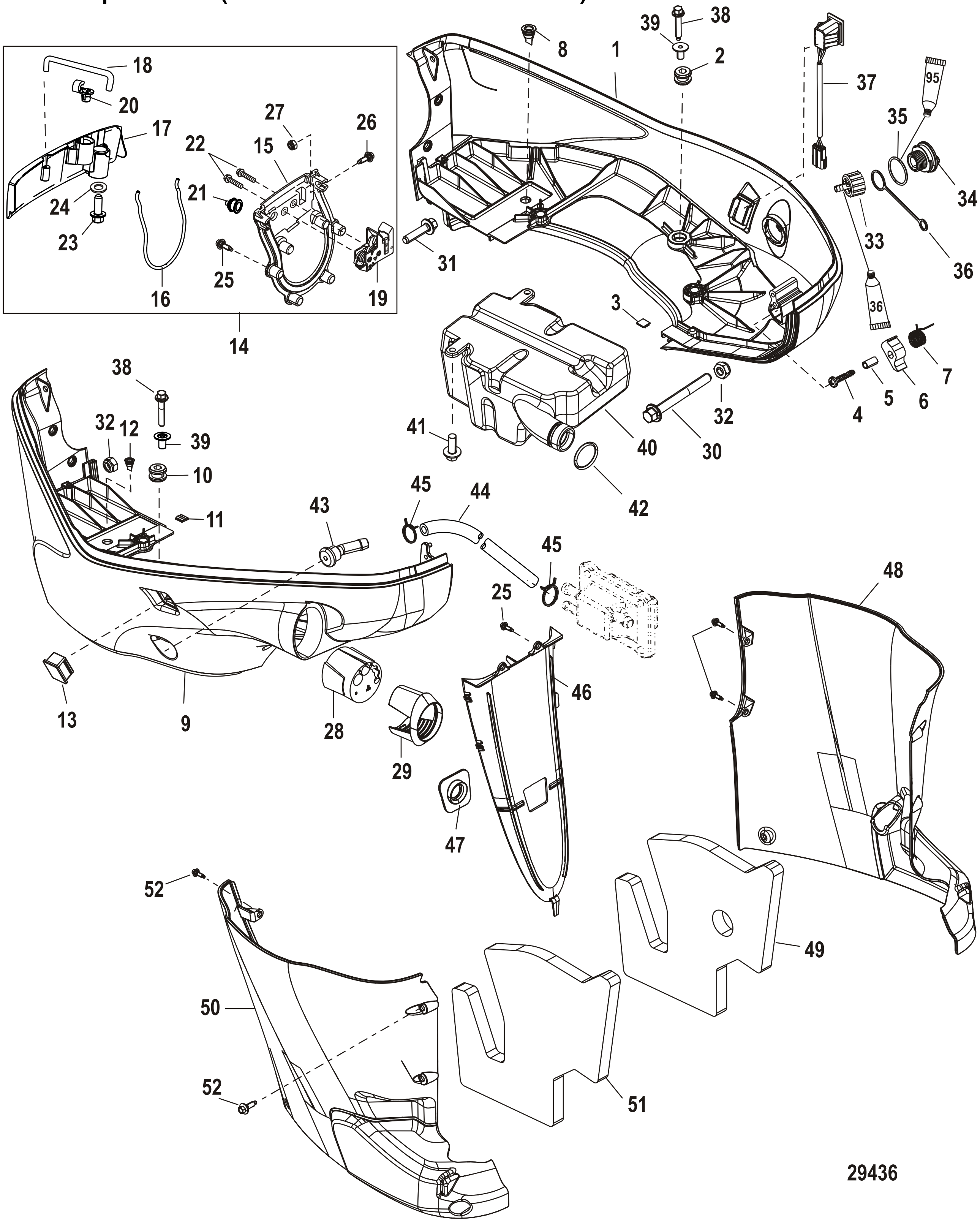
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
41	1	Idle exhaust boot			
42	1	Port chap assembly			
43	1	Port sound blanket			
44	1	Starboard chap assembly			
45	1	Starboard sound blanket			
46	12	Screw (M6)	10	89	

Tube Ref No.	Description	Where Used	Part No.
36	P80 Rubber Lubricant	Flush fitting assembly	Obtain Locally
95	2-4-C with Teflon	Flush fitting plug O-ring	92-802859A 1

Cowl Components



Cowl Components (S/N 1B517159 and Above)



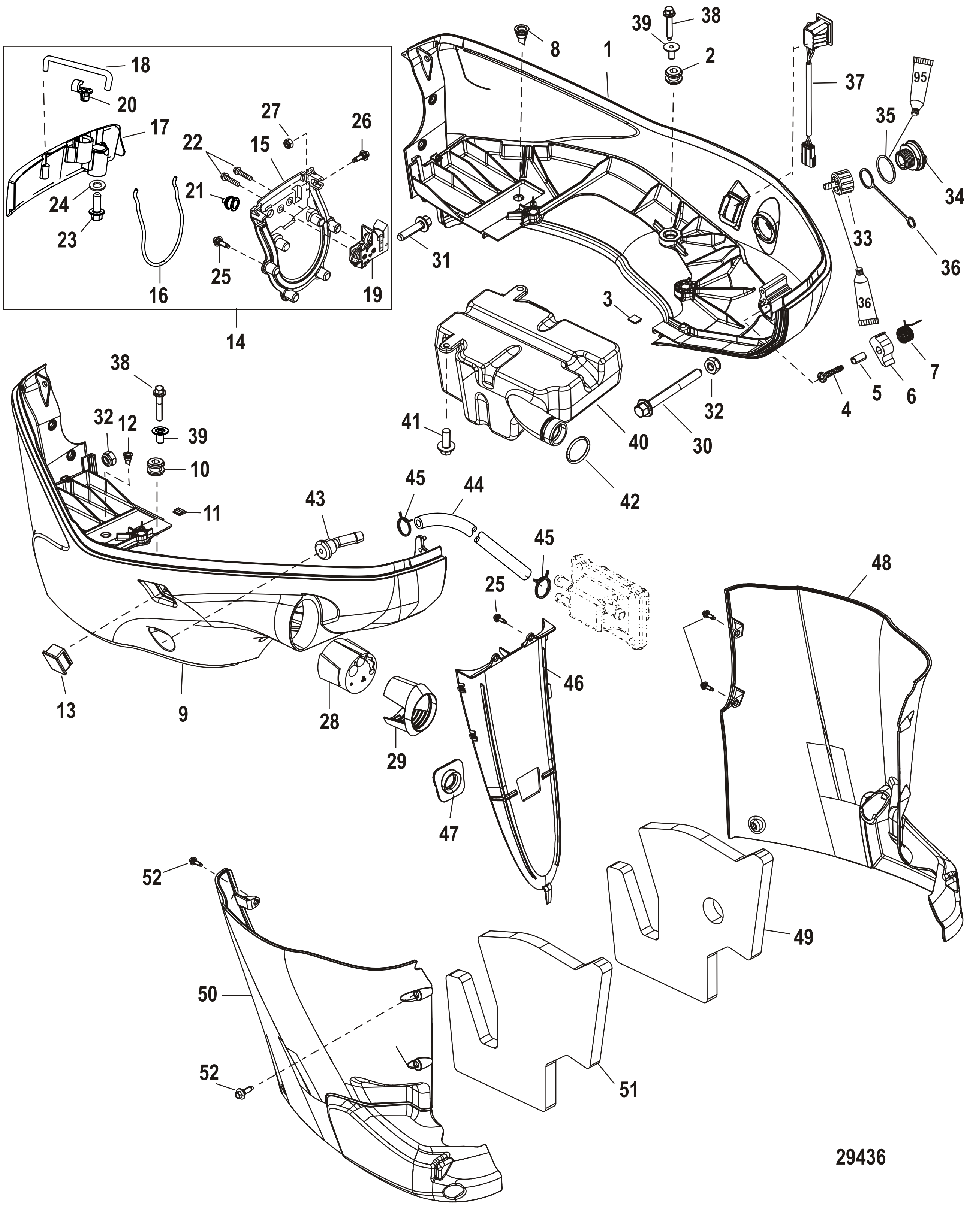
Cowl Components (S/N 1B517159 and Above)

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Port pan assembly (S/N 1B701486 and below)			
		Port pan assembly (S/N 1B701487 and above)			
2	1	Grommet			
3	1	Front seal			
4	1	Screw (S/N 1B701486 and below)			
5	1	Spacer (S/N 1B701486 and below)			
6	1	Pawl (S/N 1B701486 and below)			
7	1	Spring (S/N 1B701486 and below)			
8	1	Cowl drain			
9	1	Starboard pan assembly (S/N 1B701486 and below)			
		Starboard pan assembly (S/N 1B701487 and above)			
10	1	Grommet			
11	1	Back seal			
12	1	Cowl drain			
13	1	Plug			
14	1	Latch assembly			
15	1	Access panel assembly			
16	1	Seal			
17	1	Handle			
18	1	Link			
19	1	Rear latch assembly			
20	1	Retainer			
21	1	Seal			
22	2	Screw (M6 x 25) (stainless)	10	89	
23	1	Screw (M6 x 16) (stainless)	10	89	
24	1	Washer (0.225 x 0.620 x 0.030)			
25	6	Shoulder screw (M6)			
26	2	Screw (M6)	6	53	
27	2	Nut (M6)			
28	1	Adapter			
29	1	Grommet			
30	1	Screw (M6 x 55)	6	53	
31	1	Screw (M6 x 25)			
32	2	Nut (M6)	6	53	
33	1	Flush fitting assembly	10	89	
34	1	Flush fitting plug			
35	1	O-ring			
36	1	Tether			
37	1	Trim switch			
38	2	Screw (M6 x 35) (stainless)	10	89	

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
39	2	Bushing			
40	1	Exhaust plenum			
41	2	Shoulder screw (M6 x 20)	6	53	
42	1	O-ring			
43	1	Fitting			
44	1	Tubing (53.3 cm [21 in.])			
45	2	Clamp (20.3 cm [8 in.])			
46	1	Rear cover assembly			
47	1	Idle exhaust boot			
48	1	Port chap assembly			
49	1	Port sound blanket			
50	1	Starboard chap assembly			
51	1	Starboard sound blanket			
52	12	Shoulder screw (M6) (black)	10	89	

Tube Ref No.	Description	Where Used	Part No.
36	P80 Rubber Lubricant	Flush fitting assembly	Obtain Locally
95	2-4-C with Teflon	Flush fitting plug O-ring	92-802859A 1

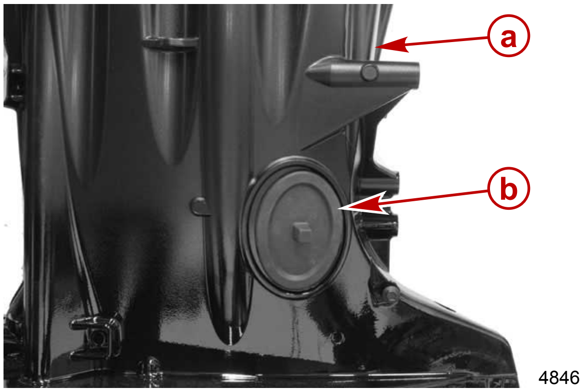
Cowl Components (S/N 1B517159 and Above)



Water Poppet Removal/Installation

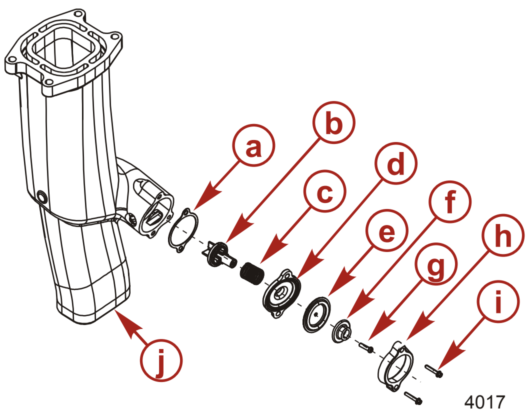
Removal and Disassembly

1. Remove the lower chaps. Refer to **Section 4A - Cowling Removal.**
2. Remove the grommet in the driveshaft housing to access the water poppet.



a - Port side of driveshaft housing
b - Water poppet grommet

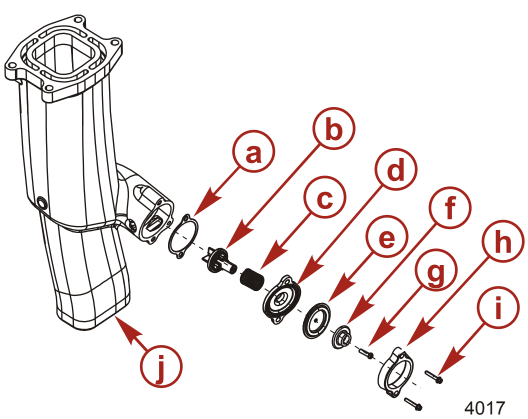
3. Remove the two screws from the poppet cover and remove the cover.
4. Remove the retainer and poppet assembly.
5. Remove the retaining screw from the poppet assembly.
6. Inspect the components and replace as required.
7. Remove the gasket and clean the gasket surfaces of the exhaust tube and poppet retainer.



a - Gasket
b - Poppet
c - Spring
d - Retainer
e - Diaphragm
f - Washer
g - Retaining screw (10-16 x 0.750 in.)
h - Poppet cover
i - Poppet cover screw (2) (M6 x 35)
j - Exhaust tube

Reassembly and Installation

1. Assemble the poppet, spring, retainer, diaphragm, and washer. Install a retaining screw through the components into the poppet. Drive the screw tight.
2. Install a new gasket on the clean surface.
3. Apply Loctite 242 Threadlocker to the poppet cover screw threads.
4. Install two screws through the poppet cover and assemble in the exhaust tube. Tighten the screws to the specified torque.

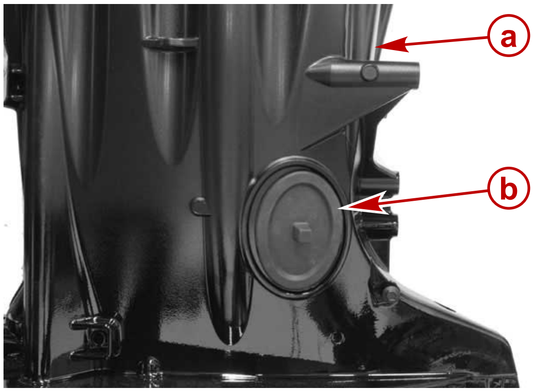


a - Gasket
b - Poppet assembly
c - Spring
d - Retainer
e - Diaphragm
f - Washer
g - Retaining screw (10-16 x 0.750 in.)
h - Poppet cover
i - Poppet cover screw (2) (M6 x 35)
j - Exhaust tube

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Poppet cover screw threads	92-809821

Description	Nm	lb-in.	lb-ft
Poppet cover screw	5	44	

5. Install the grommet in the driveshaft housing.



4846

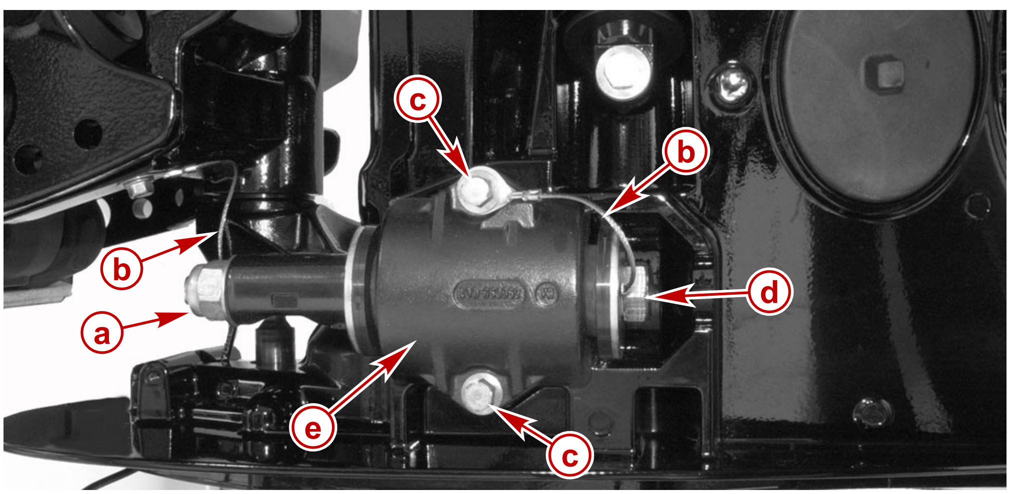
a - Port side of driveshaft housing
b - Water poppet grommet

6. Install the lower chaps. Refer to **Section 4A - Cowling Installation.**

Lower Mounts

Removal

1. Remove lower chaps. Refer to **Section 4A - Cowling Removal.**
2. Remove the port lower mount locknut and bolt.
3. Remove the two screws securing the port lower mount to the driveshaft housing.
4. Remove the ground wire and port mount clamp.
5. Remove the lower mount from the driveshaft housing.

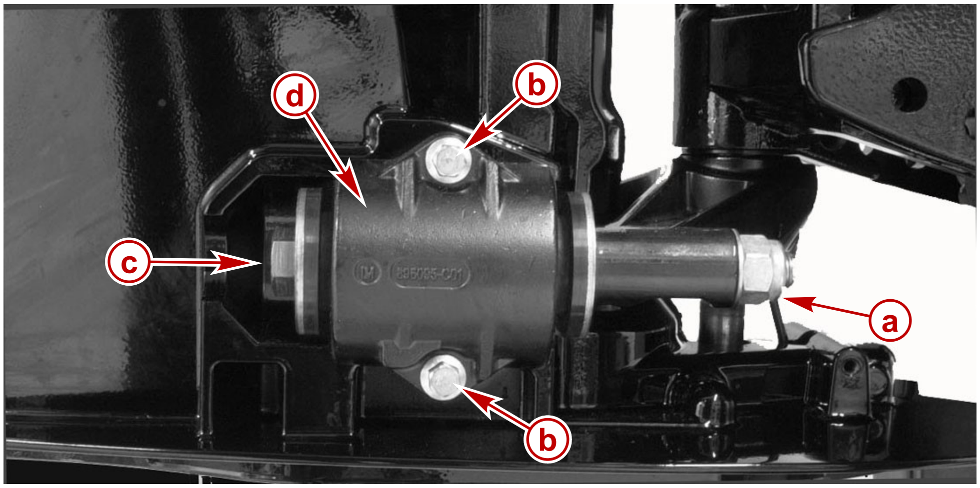


14888

a - Port lower mount locknut
b - Ground wire
c - Lower mount clamp retaining screw (M8 x 35)
d - Lower mount bolt (M14 x 175)
e - Port lower mount clamp

6. Remove the starboard lower mount nut and bolt.
7. Remove the two screws securing the starboard lower mount to the driveshaft housing. Remove the mount clamp.

8. Remove the starboard lower mount from the driveshaft housing.

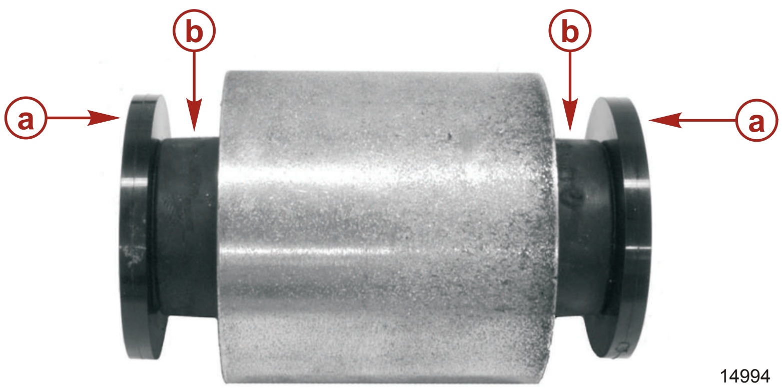


14889

a - Lower mount nut
b - Lower mount clamp retaining screw (M8 x 35)
c - Starboard lower mount bolt (M14 x 175)
d - Starboard lower mount clamp

Installation

1. Assemble the two rubber washers on the rubber bushing of each lower mount.

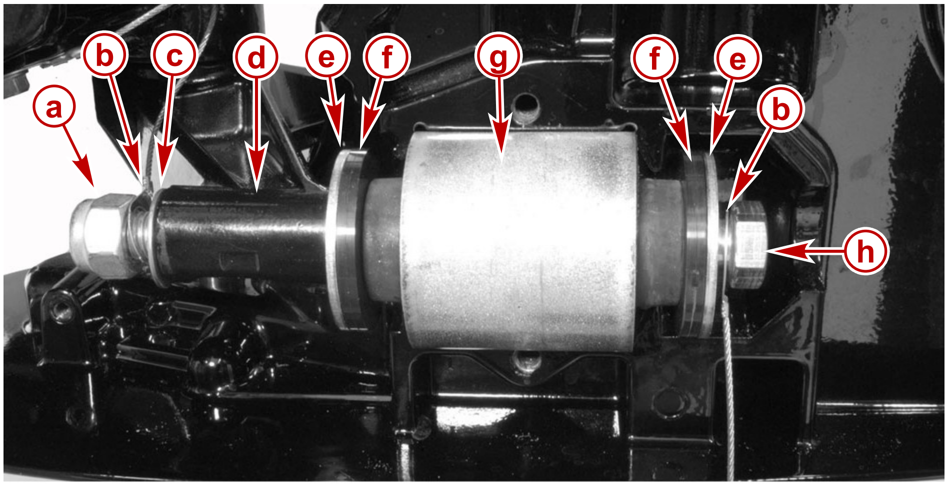


14994

a - Rubber washer
b - Rubber bushing

2. Assemble a steel washer and ground wire (ground wire port side only) to each end of the lower mount.
3. Partially install the lower mount bolt through the washers and lower mount.
4. Pull bottom yoke away from driveshaft housing and install the lower mount assembly into the mount cavity in the driveshaft housing.
5. Push the bolt completely through the lower mount and bottom yoke.

6. Partially install locknut on bolt.

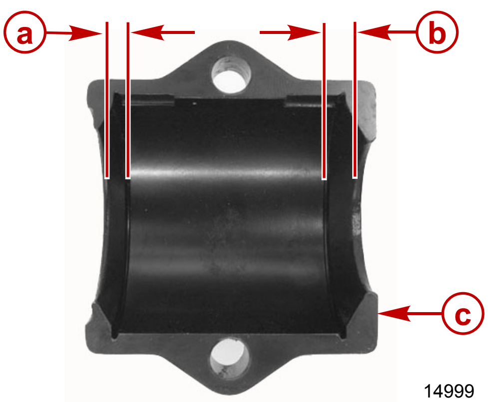


14995

a - Lower mount locknut
b - Ground strap (2) (port side only)
c - Washer
d - Yoke
e - Steel washer
f - Rubber washer
g - Lower mount
h - Lower mount bolt

7. Place the mount clamp over the lower mount on the driveshaft housing with the small chamfer towards the front.

   IMPORTANT: Ensure the small chamfer of the lower mount clamp faces the front of the engine.



14999

a - Small chamfer
b - Large chamfer
c - Lower mount clamp

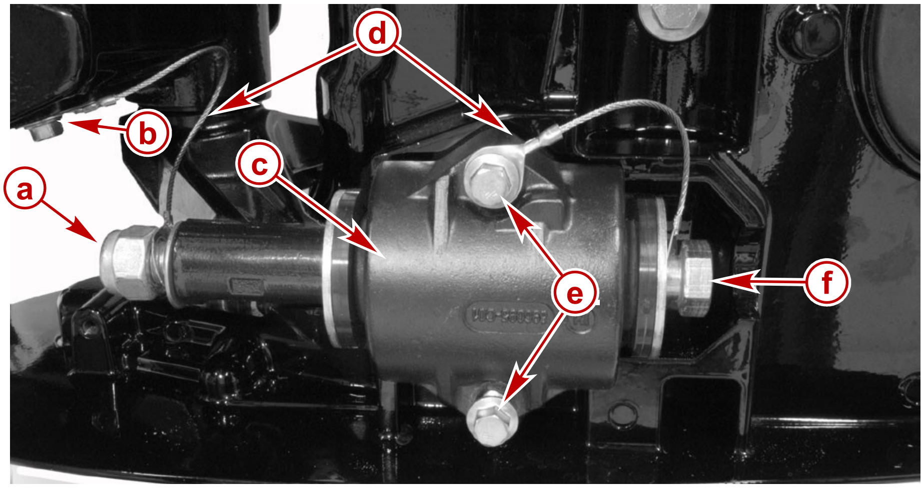
8. Apply Loctite 242 Threadlocker to the lower mount clamp mounting screws and port side forward ground wire mounting screw.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Lower mount clamp mounting screws and port side forward ground wire mounting screw	92-809821

9. Install a screw with ground wire (ground wire port side only) to top clamp mounting hole. Install screw to bottom clamp mounting hole. Tighten screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Lower mount clamp mounting screws	27		20

10. Tighten locknut on lower mount bolt to the specified torque.



14996

a - Lower mount assembly locknut
b - Forward ground strap attaching screw (port side only)
c - Lower mount clamp
d - Ground strap (2) (port side only)
e - Lower mount clamp screws
f - Lower mount bolt

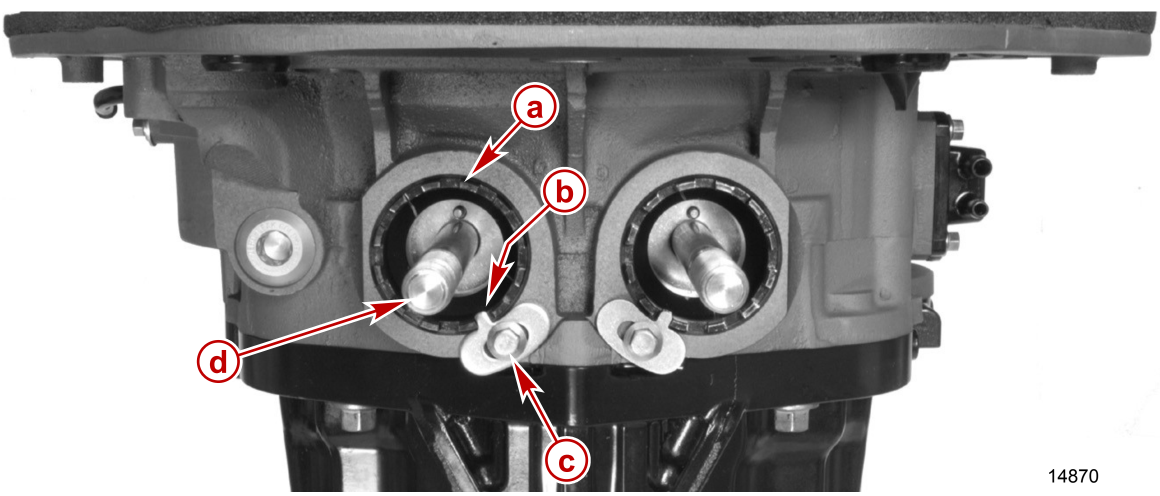
Description	Nm	lb-in.	lb-ft
Lower mount bolt and locknut	122		90

11. Repeat the installation procedure for the starboard side lower mount.
12. Install chaps. Refer to **Section 4A - Cowling Installation.**

Upper Mounts

Removal

1. Remove the powerhead. Refer to **Section 4A - Powerhead Removal.**
2. Remove the driveshaft housing from the transom/swivel brackets. Refer to **Driveshaft Housing and Swivel Bracket Disassembly,** following.
3. Remove the screw and retainer from each upper mount assembly.
4. Remove the spanner nut securing each upper mount assembly in the adapter plate.
5. Remove the upper mount assembly from the adapter plate.

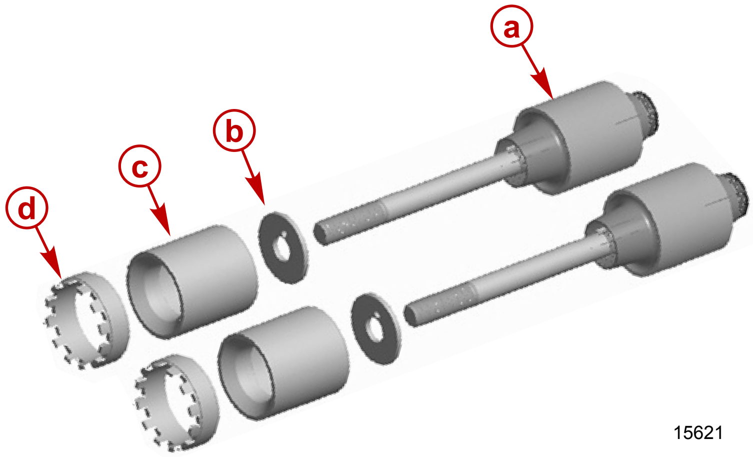


14870

a - Spanner nut (2)
b - Retainer (2)
c - Retainer screw (M6 x 20) (2)
d - Upper mount assembly (2)

Spanner Nut Socket	91-897957T

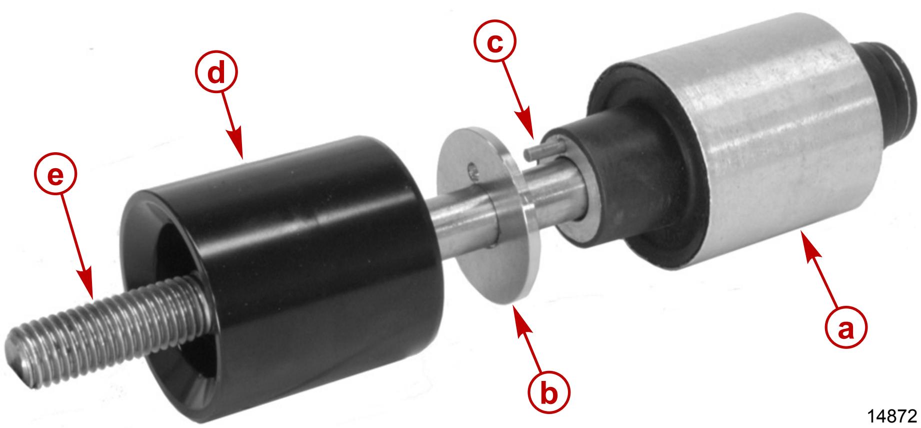
6. Inspect components for wear. Replace as required.



a - Upper mount assembly
b - Washer
c - Retainer sleeve
d - Spanner nut

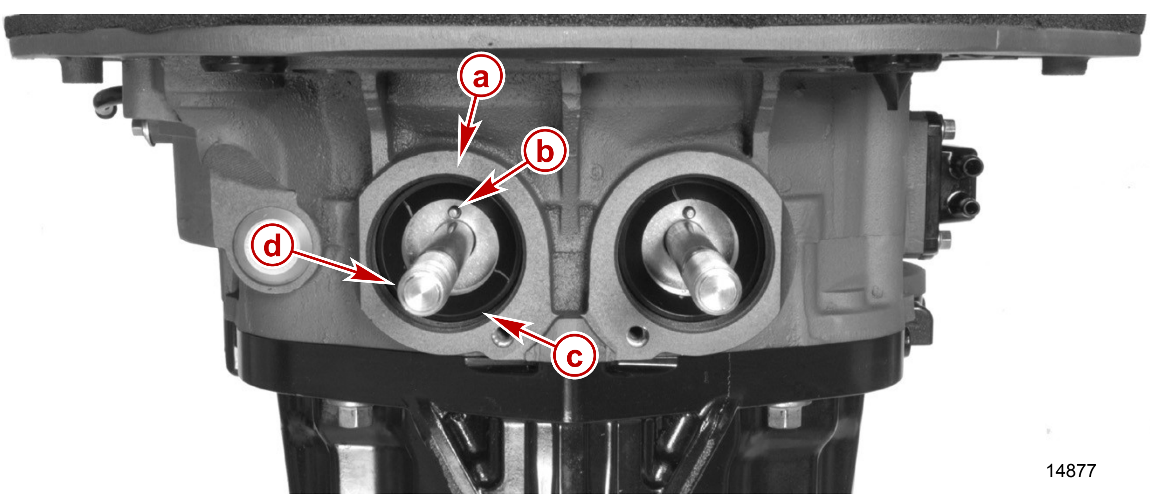
Installation

1. Assemble the washer over the locating pin on the rubber mount of the upper mount.
2. Assemble the retainer sleeve on the upper mount assembly bolt. The chamfered end of the sleeve faces away from the rubber mount.



a - Upper mount assembly
b - Snubber washer
c - Locating pin
d - Retainer sleeve
e - Upper mount assembly bolt

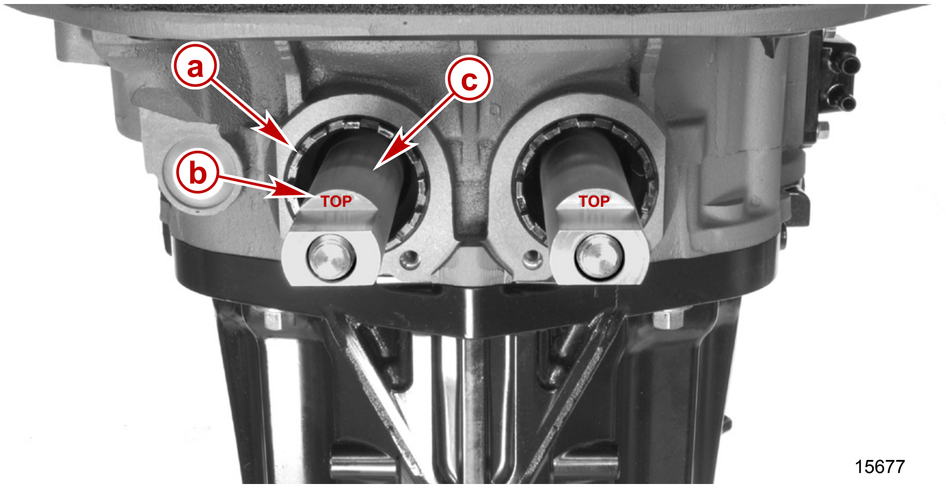
3. Install the upper mount components into the upper mount cavity in the adapter plate.
4. Ensure the snubber washer and locating pin are aligned as shown.



a - Adapter plate upper mount cavity (2)
b - Anti-rotation pin (2)
c - Retainer sleeve (2)
d - Upper mount assembly (2)

5. Apply Anti-Corrosion Grease to the spanner nut threads. Install the spanner nut in the adapter plate.
6. Install an upper mount alignment tool alignment cylinder over each upper mount anti-rotation pin.

NOTE: Each alignment cylinder is marked with "TOP" indicating the location of the alignment pin hole on opposite end.



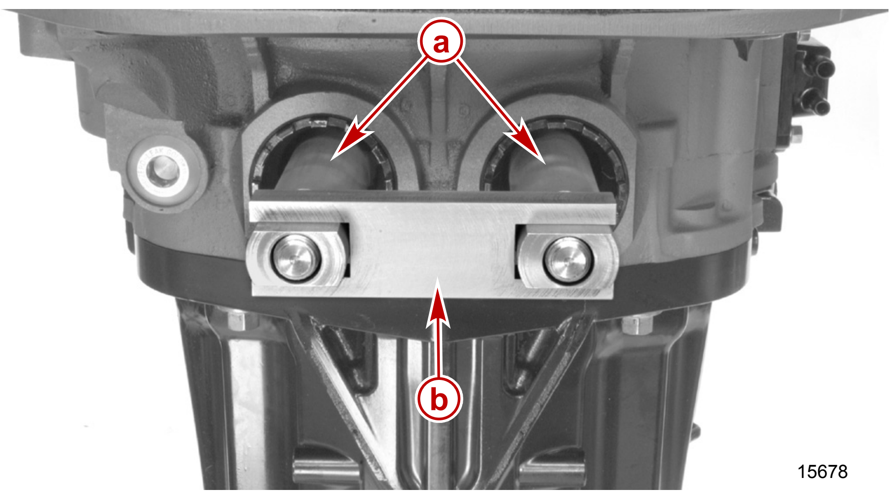
15677

a - Spanner nut
b - Top of alignment cylinder
c - Alignment cylinder

Tube Ref No.	Description	Where Used	Part No.
94	Anti-Corrosion Grease	Spanner nut threads	92-802867Q 1

Upper Mount Alignment Tool	91-899015A01

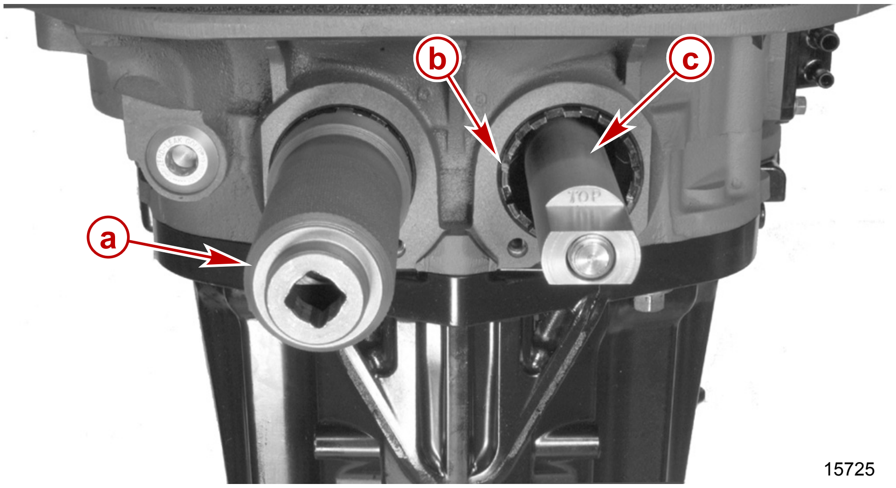
7. Position the alignment bridge over the flats on the alignment cylinders.
8. Tighten the spanner nut by hand.



15678

9. Remove the alignment tool bridge.
10. Using the spanner nut socket, tighten each spanner nut to the specified torque.

11. Remove the spanner nut socket and check alignment using the alignment tool bridge.

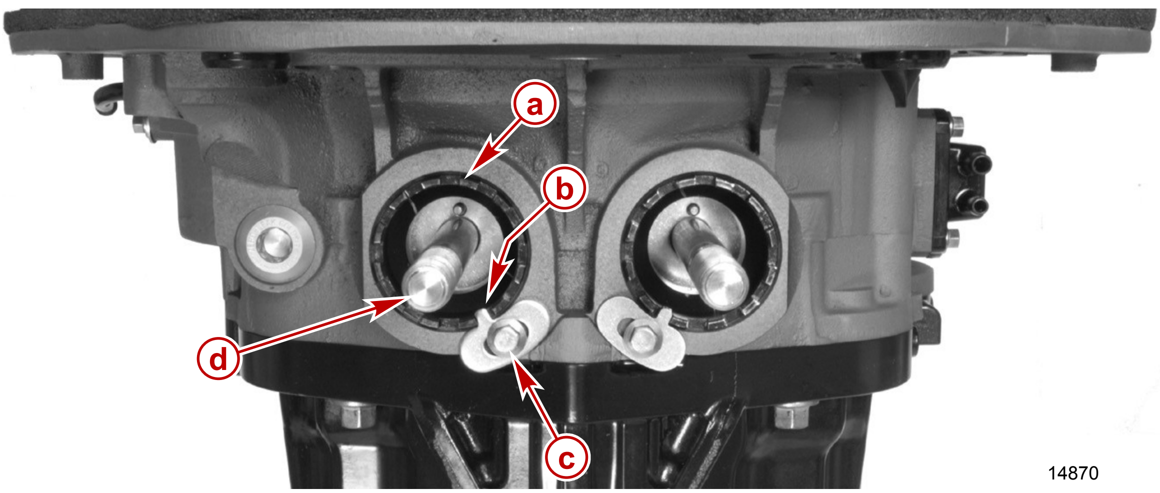


a - Spanner nut socket
b - Spanner nut
c - Alignment cylinder

Spanner Nut Socket	91-897957T

Description	Nm	lb-in.	lb-ft
Upper mount spanner nut	271		200

12. Remove the special tools.
13. Install retainer so tab aligns with notch on spanner nut.
14. Apply Loctite 242 Threadlocker to the retainer screws. Install screw and tighten to the specified torque.



a - Spanner nut (2)
b - Tab on retainer aligned with notch (2)
c - Retainer screw (2)
d - Upper mount assembly (2)

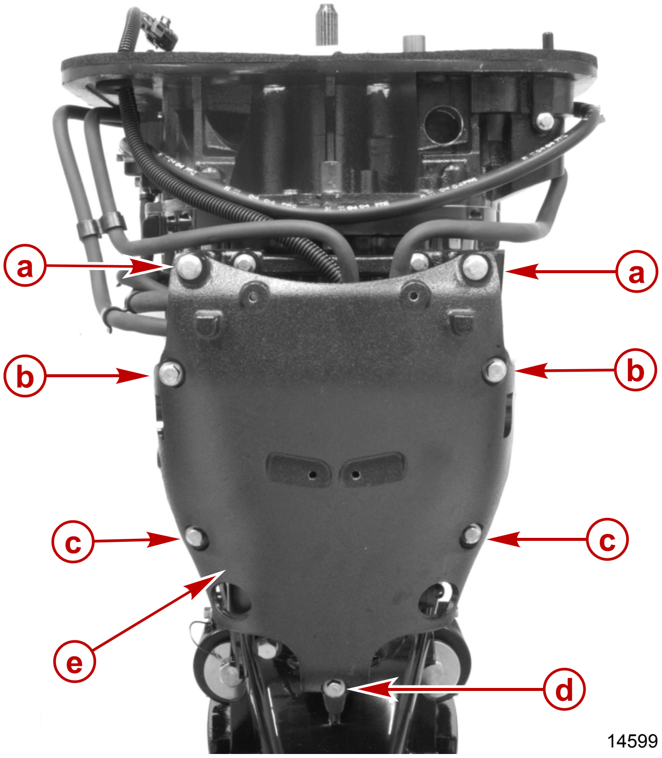
Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Spanner nut retainer screw	92-809821

Description	Nm	lb-in.	lb-ft
Spanner nut retainer screw	6	53	

Fuel Supply Module (FSM)

Removal

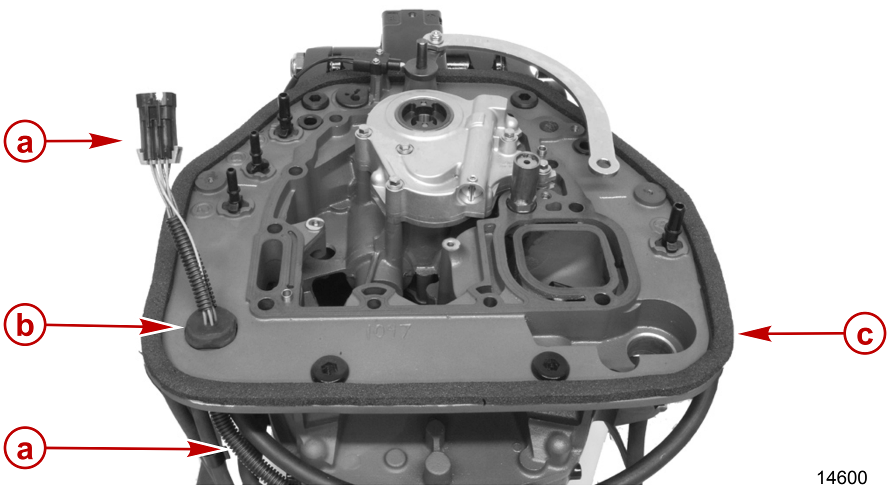
1. Remove the seven screws securing the fuel supply module shroud to the driveshaft housing.



14599

a - Shroud attaching screw (M8 x 75)
b - Shroud attaching screw (M8 x 120)
c - Shroud attaching screw (M8 x 50)
d - Shroud attaching screw (M8 x 40)
e - Fuel supply module shroud

2. Push the fuel supply module harness grommet through the adapter plate. Pull the harness down through the hole in the adapter plate flange.

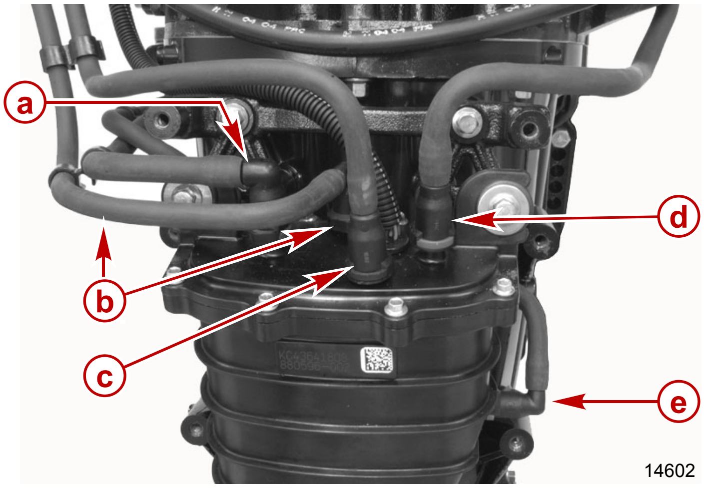


14600

a - Fuel supply module harness
b - Fuel supply module harness grommet
c - Adapter plate

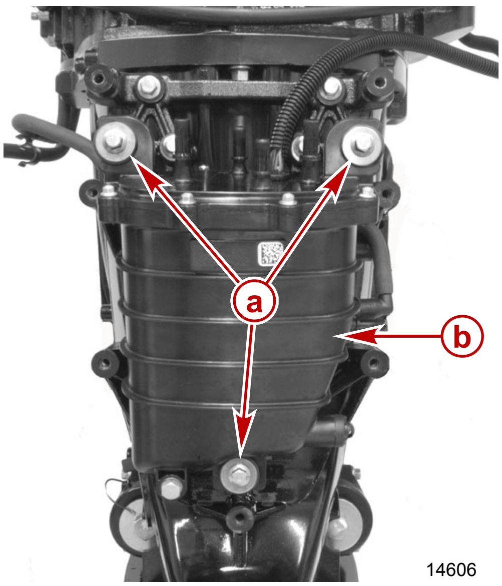
3. Remove the four hoses on top of the fuel supply module and one hose on the starboard side.

NOTE: Fuel may be present in fuel lines. Use a proper container to capture fuel.



a - High-pressure fuel outlet (10 mm red tab)
b - Manifold reference to fuel pressure regulator (5/16 in. white tab)
c - Vent to vent canister switch (3/8 in. white tab)
d - FSM fuel inlet from fuel filter/water separator (10 mm red tab)
e - Water cooling inlet hose (8 mm blue tab)

4. Remove the three screws securing the fuel supply module to the driveshaft housing.



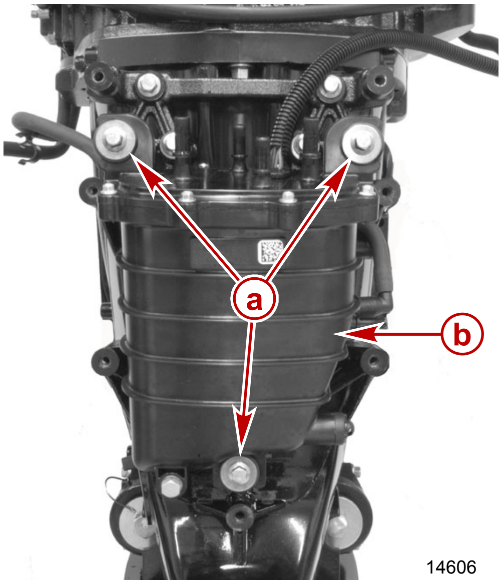
a - Fuel supply module mounting screws
b - Fuel supply module

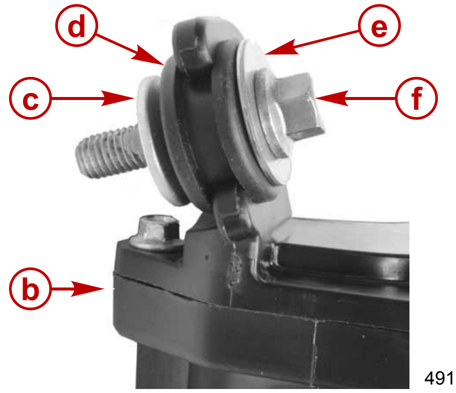
5. Remove the fuel supply module from the driveshaft housing.

Installation

1. Apply Loctite 242 Threadlocker to the three fuel supply module mounting screw threads.
2. Route the water cooling inlet hose to the starboard side of the driveshaft housing, behind the FSM.

3. Loosely attach the fuel supply module to the driveshaft housing with three screws, washers, grommets, and bushings.

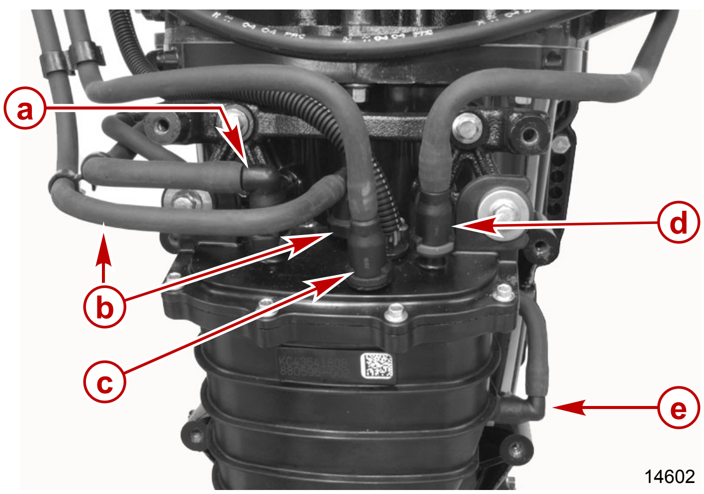




a - Fuel supply module mounting hardware
b - Fuel supply module
c - Bushing (3)
d - Grommet (3)
e - Washer (3)
f - Mounting screw (M8 x 35) (3)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Fuel supply module mounting screw threads	92-809821

4. Connect the fuel outlet line, manifold reference line, fuel inlet line, vent canister line, and the fuel cooler line.



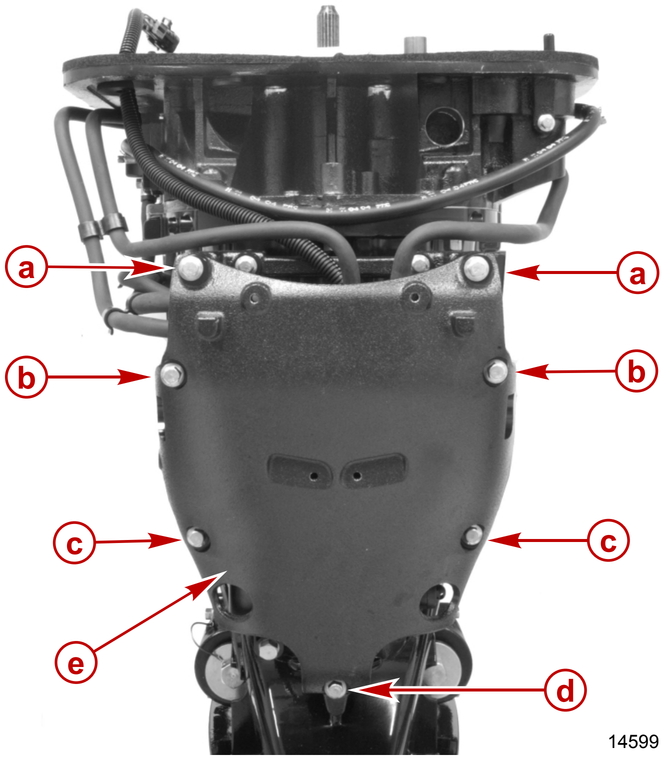
a - High-pressure fuel outlet (10 mm red tab)
b - Manifold reference to fuel pressure regulator (5/16 in. white tab)
c - Vent to vent canister switch (3/8 in. white tab)
d - FSM fuel inlet from fuel filter/water separator (10 mm red tab)
e - Water cooling inlet hose (8 mm blue tab)

5. Tighten the three fuel supply module mounting screws to the specified torque.

Description	Nm	lb-in.	lb-ft
FSM mounting screws	24		17.7

6. Apply Loctite 242 Threadlocker to the seven fuel supply module shroud mounting screw threads.

7. Assemble the fuel supply module shroud to the driveshaft housing. Secure with the seven screws. Tighten screws to the specified torque.



a - Shroud attaching screw (M8 x 75)
b - Shroud attaching screw (M8 x 120)
c - Shroud attaching screw (M8 x 50)
d - Shroud attaching screw (M8 x 40)
e - Fuel supply module shroud

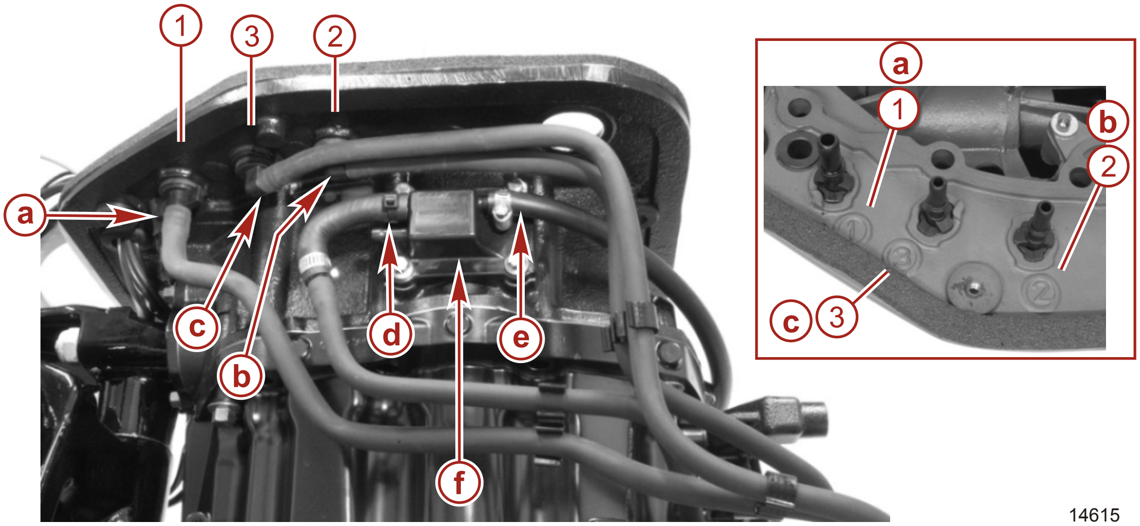
Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	FSM shroud mounting screw threads	92-809821

Description	Nm	lb-in.	lb-ft
Fuel supply module shroud mounting screws	24		17.7

8. Install the fuel supply module harness and grommet in the adapter plate.

Hoses Routing

Port Side

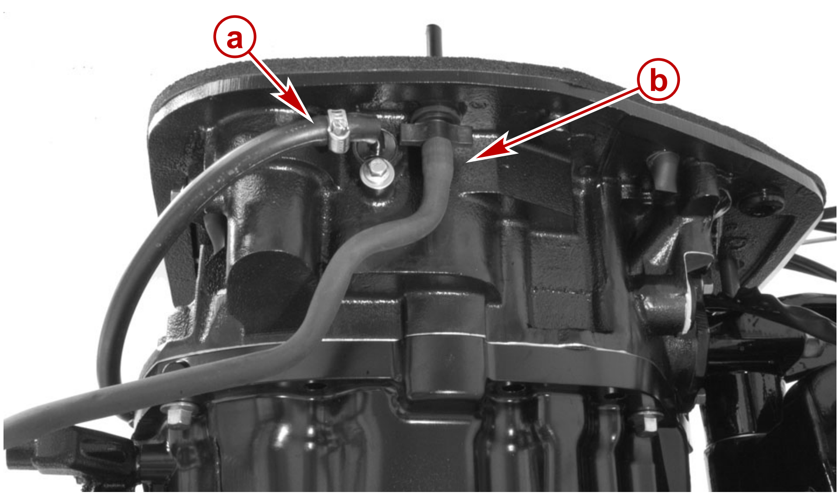


14615

1 - Hose reference   2 - Hose reference   3 - Hose reference

- **a -** FSM high-pressure fuel outlet hose (10 mm red tab)
- **b -** Vent to canister switch hose (3/8 in. white tab)
- **c -** Manifold reference hose (5/16 in. white tab)
- **d -** FSM water cooling inlet hose (8 mm blue tab)
- **e -** Hose - to cooling jet
- **f -** Water manifold

Starboard Side



14617

- **a -** Hose - to cooling jet
- **b -** FSM fuel inlet hose (10 mm red tab)

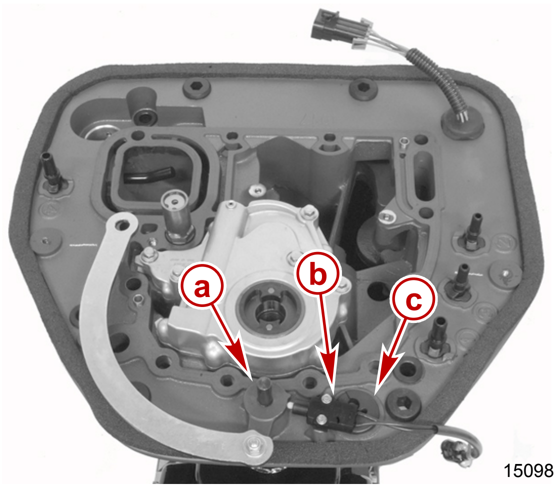
Hose Connections

1. To remove the hose connectors from the adapter plate, rotate the hose/connector counterclockwise to align the tab with the slot in the adapter plate and pull each hose down through adapter plate.
2. To install hoses, align the tab with the slot in the adapter plate and rotate the hose/connector clockwise.

Driveshaft Housing and Swivel Bracket Disassembly

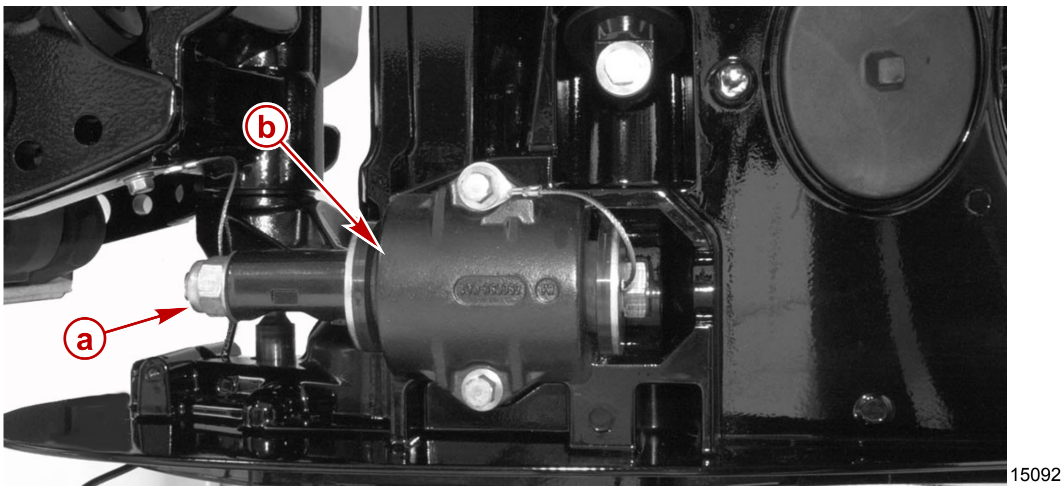
1. Remove the powerhead. Refer to **Section 4A - Powerhead Removal**.
2. Remove the gearcase housing. Refer to **Section 6A - Gearcase Removal**.
3. Remove the shift shaft assembly from the adapter plate/driveshaft housing by pulling straight up on the shaft.

4. Remove the power trim harness and water tube from the adapter plate.



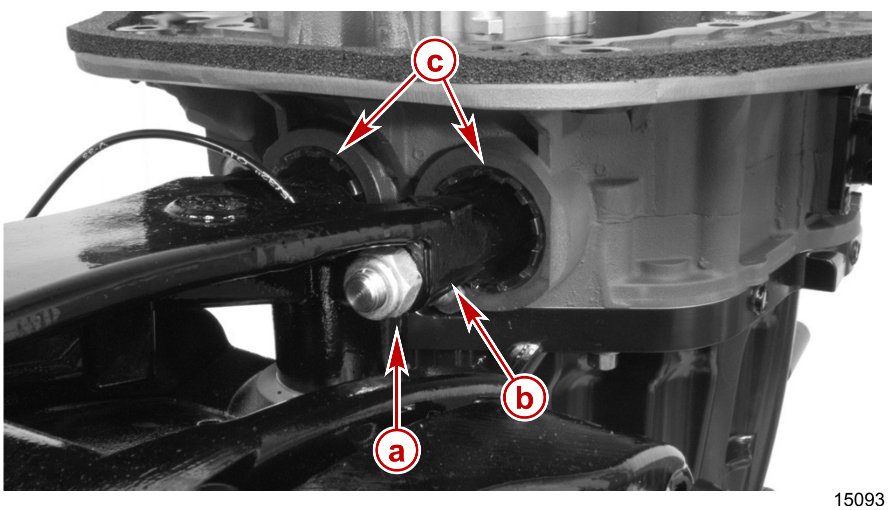
a - Shift shaft assembly
b - Neutral switch
c - Power trim harness and water tube

5. Remove the lower mount nut securing each lower mount to the driveshaft housing.



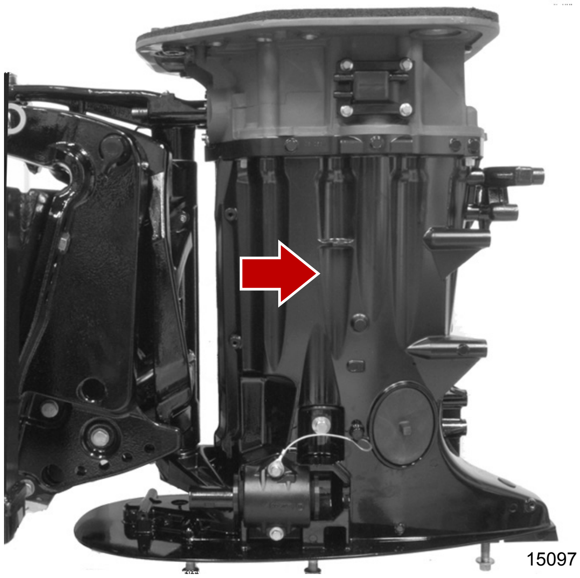
a - Lower mount nut
b - Lower mount assembly (port side shown)

6. Remove the upper mount nut securing each lower mount to the adapter plate.



a - Upper mount nut (2)
b - Swivel bracket
c - Upper mount assembly

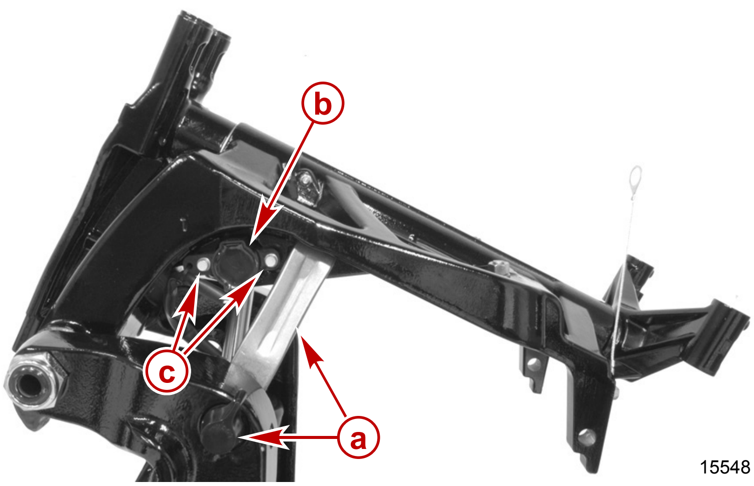
7. Pull the driveshaft housing/adapter plate away from the swivel bracket assembly.



Transom/Swivel Bracket

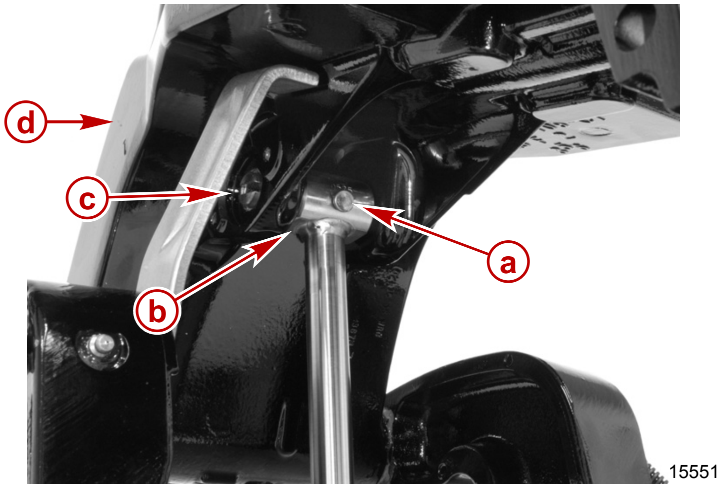
Disassembly

1. Remove the steering cylinder assembly. Refer to **Section 8A or 8B - Steering Cylinder Removal.**
2. Trim to full up position. Engage the tilt lock lever.
3. Remove the two screws securing the trim position sensor to the port transom bracket. Remove the trim position sensor.



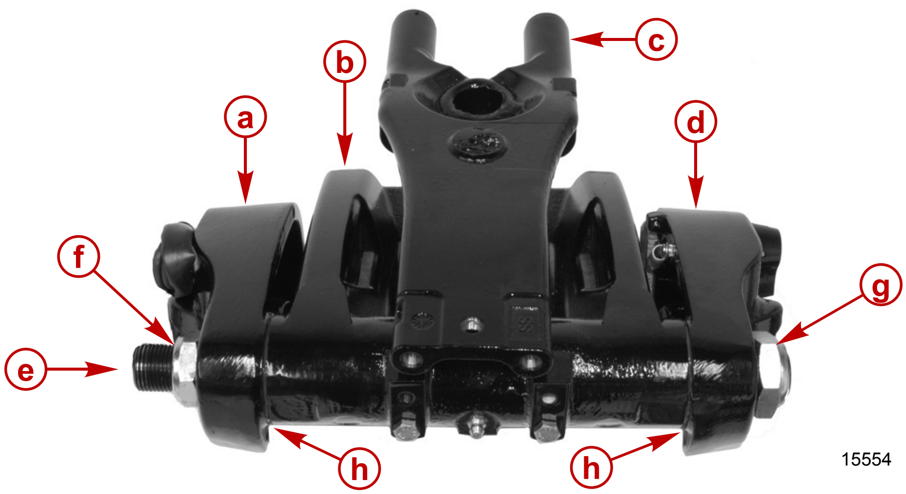
a - Tilt lock
b - Trim sensor
c - Trim sensor mounting screw

4. Remove the trilobe pin from the upper tilt shaft.



a - Trilobe pin
b - Tilt cylinder rod eye
c - Upper tilt pin
d - Swivel bracket assembly

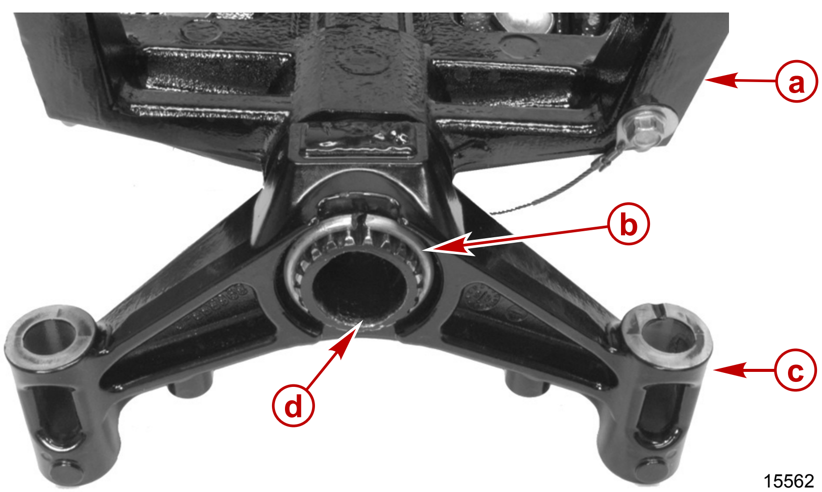
5. Remove the 1-1/4 in. hex nut on the tilt tube.
6. Support the swivel bracket while removing the tilt tube from the transom bracket/swivel bracket assembly.
7. Remove the swivel bracket and wave washers.



a - Starboard transom bracket
b - Swivel bracket
c - Swivel pin assembly
d - Port transom bracket
e - Tilt tube
f - 1-1/4 in. hex locknut
g - 1-3/8 in. hex locknut
h - Wave washer

Swivel Bracket/Pin Disassembly

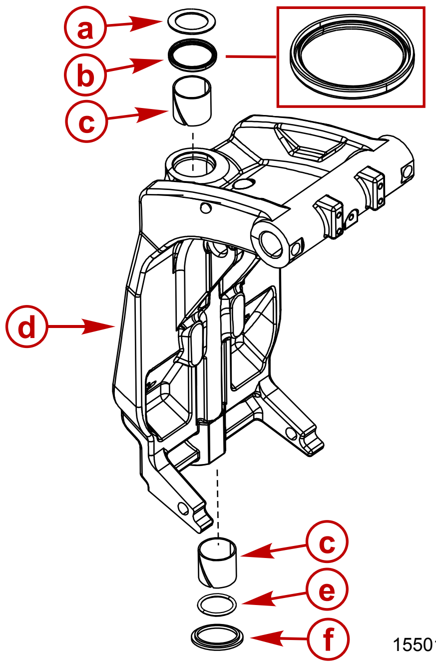
1. Remove the retaining ring on the bottom of the swivel pin assembly.



a - Swivel bracket
b - Retaining ring
c - Bottom yoke
d - Swivel pin

2. Remove the swivel pin assembly from the swivel bracket.
3. Remove the thrust washer and seal from the top of the swivel bracket.

4. Remove the spacer and O-ring from the bottom of the swivel bracket.
5. Remove old grease from the swivel bracket bore and clean the bore.
6. Inspect the bushings in each end of the swivel bracket. Replace if required.

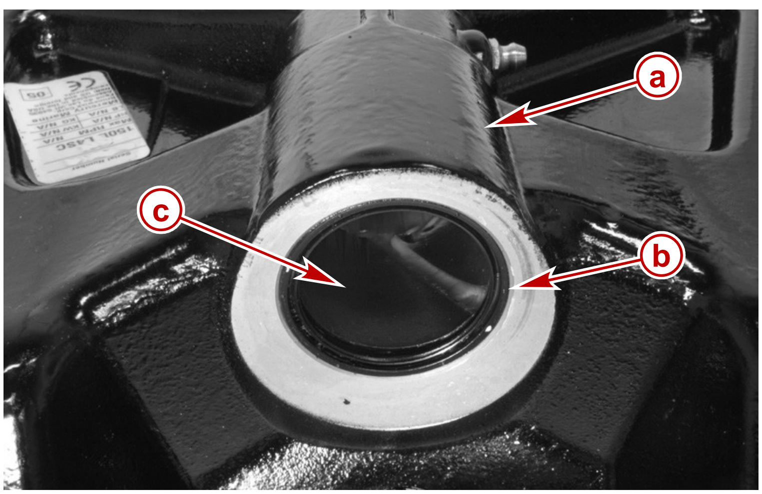


15501

a - Thrust washer
b - Seal
c - Bushing
d - Swivel bracket
e - O-ring
f - Spacer

Swivel Bracket/Pin Assembly

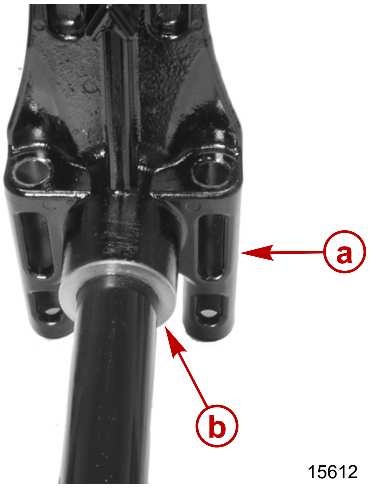
1. Install a new seal, spring side up (out), in the top of the swivel bracket.



15563

a - Swivel bracket
b - Seal
c - Bushing

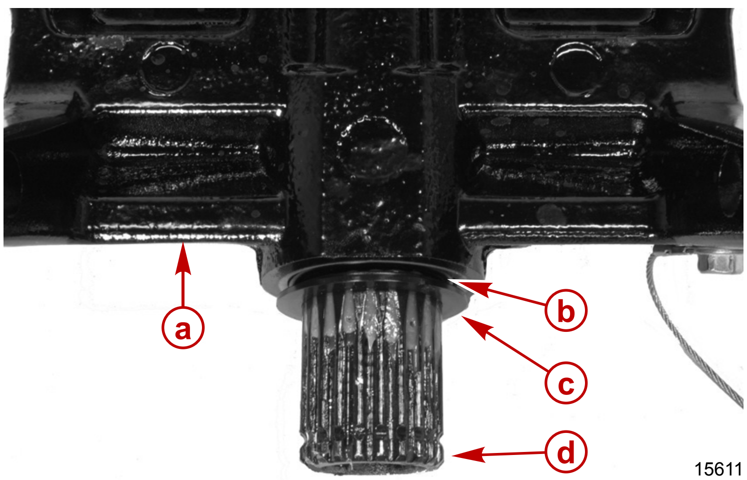
2. Install the thrust washer on the swivel pin.



a - Swivel pin assembly
b - Thrust washer

15612

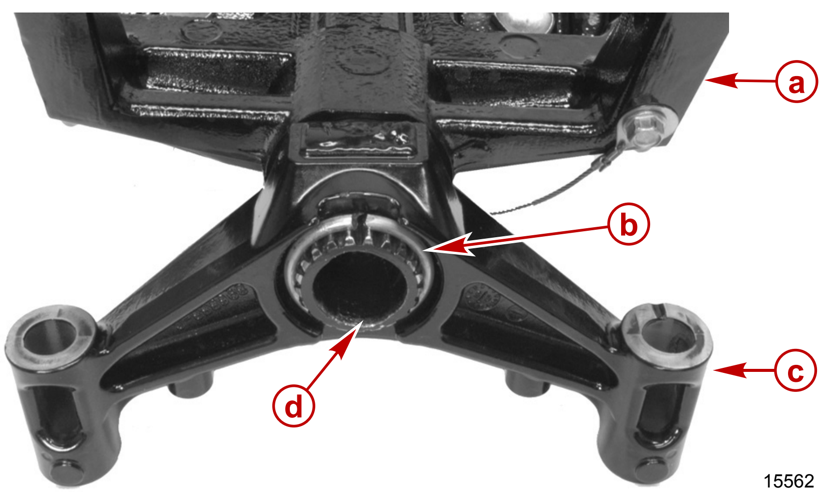
3. Install the O-ring in the bottom of the swivel bracket.
4. Install the swivel pin assembly in the swivel bracket.
5. Install the spacer, flat side down (out), over the swivel pin and into the swivel bracket.



a - Swivel bracket
b - O-ring
c - Spacer
d - Swivel pin

15611

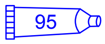
6. Align the bottom yoke mount with the upper mount on the swivel pin and assemble the bottom yoke on the swivel pin.
7. Using a suitable mandrel, install the retaining ring in the groove on the swivel pin.



a - Swivel bracket
b - Retaining ring
c - Bottom yoke
d - Swivel pin

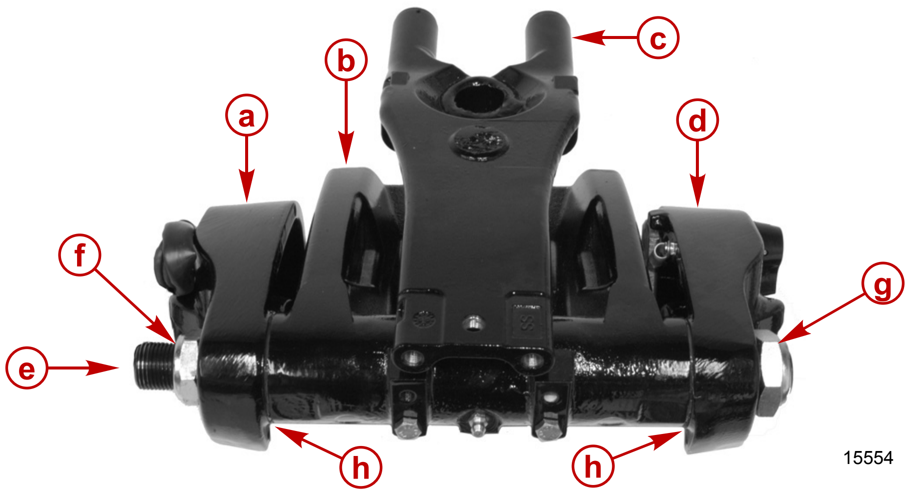
15562

8. Lubricate the swivel pin assembly through the grease fitting in the swivel bracket.

Tube Ref No.	Description	Where Used	Part No.
 95	2-4-C with Teflon	Swivel pin assembly	92-802859A 1

Transom/Swivel Bracket Assembly

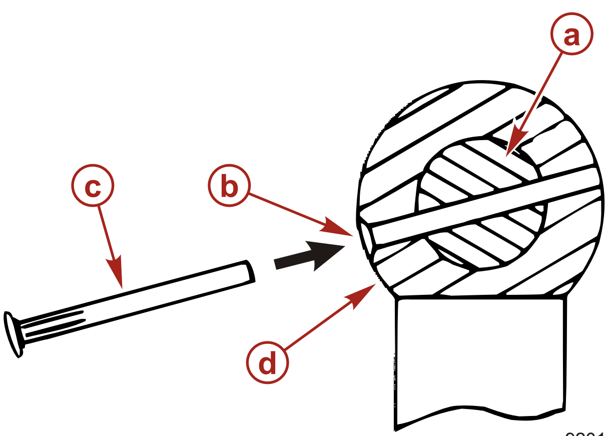
1. Assemble the swivel bracket/swivel pin assembly and wave washers between the transom brackets.
2. Insert the tilt tube through the transom brackets and the swivel brackets.
3. Install and tighten the tilt tube nuts in sequence:
    a. Thread the large nut onto the starboard end of the tilt tube until it bottoms on the shoulder.
    b. Tighten the large nut to the specified torque.
    c. Thread the small nut onto the port end of the tilt tube.
    d. Tighten the small nut to the specified torque, then back the nut off ¼ turn.



a - Starboard transom bracket
b - Swivel bracket
c - Swivel pin assembly
d - Port transom bracket
e - Tilt tube
f - 1-1/4 in. hex locknut
g - 1-3/8 in. hex locknut
h - Wave washer

Description		Nm	lb-in.	lb-ft
Tilt tube locknut (1-3/8 in. hex)		62		46
Tilt tube locknut (1-1/4 in. hex)	First torque	68		50
	Final torque	Back nut off ¼ turn		

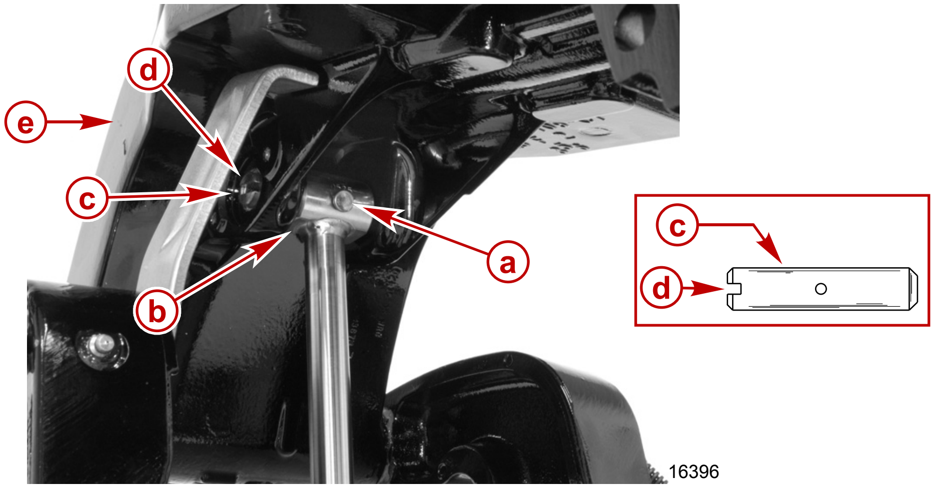
4. Align the power tilt cylinder rod eye and the swivel bracket cross holes.
    NOTE: The chamfered hole in the tilt rod eye faces aft.
5. Insert the upper pivot pin through the swivel bracket and power tilt cylinder rod eye.
    NOTE: The slotted end of the pivot pin faces the trim position sensor.



a - Upper swivel shaft (slot is in line with cross hole)
b - Chamfered end of hole (faces away from transom)
c - Trilobe pin
d - Tilt ram end

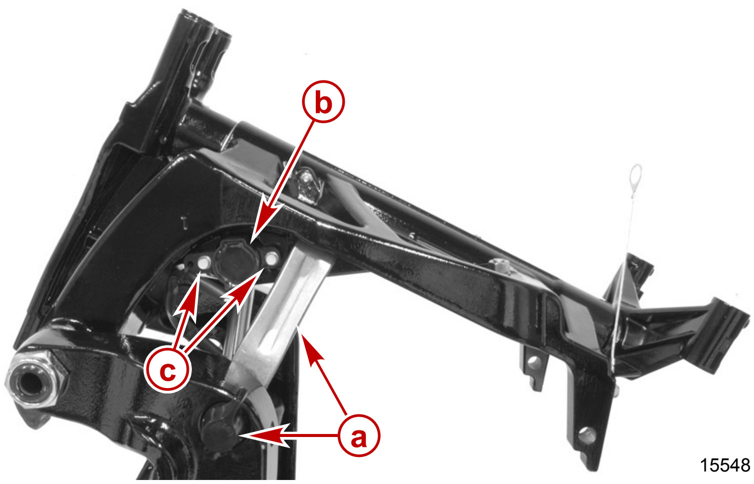
6. Insert a punch into the tilt ram hole to align the cross hole in the upper swivel shaft.

7. Install a new trilobe pin in the upper pivot pin and tilt cylinder rod eye. Tap the new trilobe pin in until flush.



- a - Trilobe pin
- b - Tilt cylinder rod eye
- c - Upper pivot pin
- d - Slotted end of pivot pin
- e - Swivel bracket assembly

8. Install the trim position sensor and secure with two screws. Tighten to the specified torque.



- a - Tilt lock
- b - Trim sensor
- c - Trim sensor mounting screw

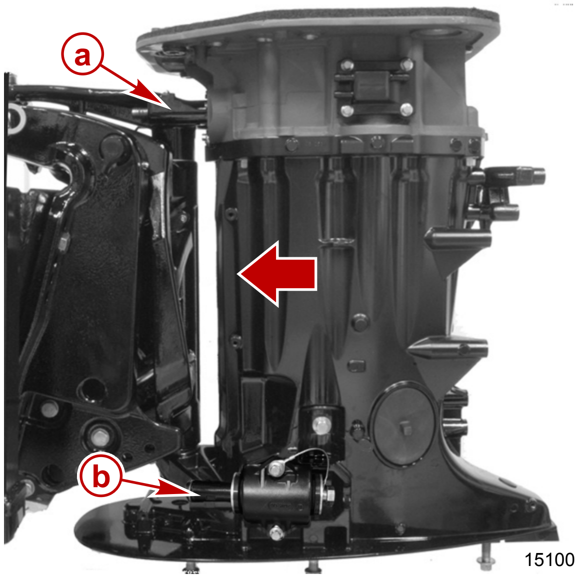
Description	Nm	lb-in.	lb-ft
Trim position sensor mounting screws	1.7	15	

9. Lubricate the swivel tube assembly through the grease fitting in the swivel bracket.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Swivel tube assembly	92-802859A 1

Driveshaft Housing and Swivel Bracket Assembly

1. Assemble the driveshaft housing/adapter plate to the swivel bracket assembly by installing the upper mount assembly bolt through the swivel pin assembly yoke and the lower mount bolts through the bottom yoke.



a - Swivel pin assembly yoke
b - Bottom yoke

2. Install a locknut on each upper mount assembly bolt. Tighten locknut to the specified torque.

Description	Nm	lb-in.	lb-ft
Upper mount locknut	150		110

3. Ensure the lower mount components are assembled correctly. Refer to **Lower Mount Installation**, preceding.
4. Install a locknut on each lower mount assembly bolt. Tighten locknut to the specified torque.

Description	Nm	lb-in.	lb-ft
Upper mount locknut	122		90

Mid-Section

Section 5B - Adapter Plate

Table of Contents

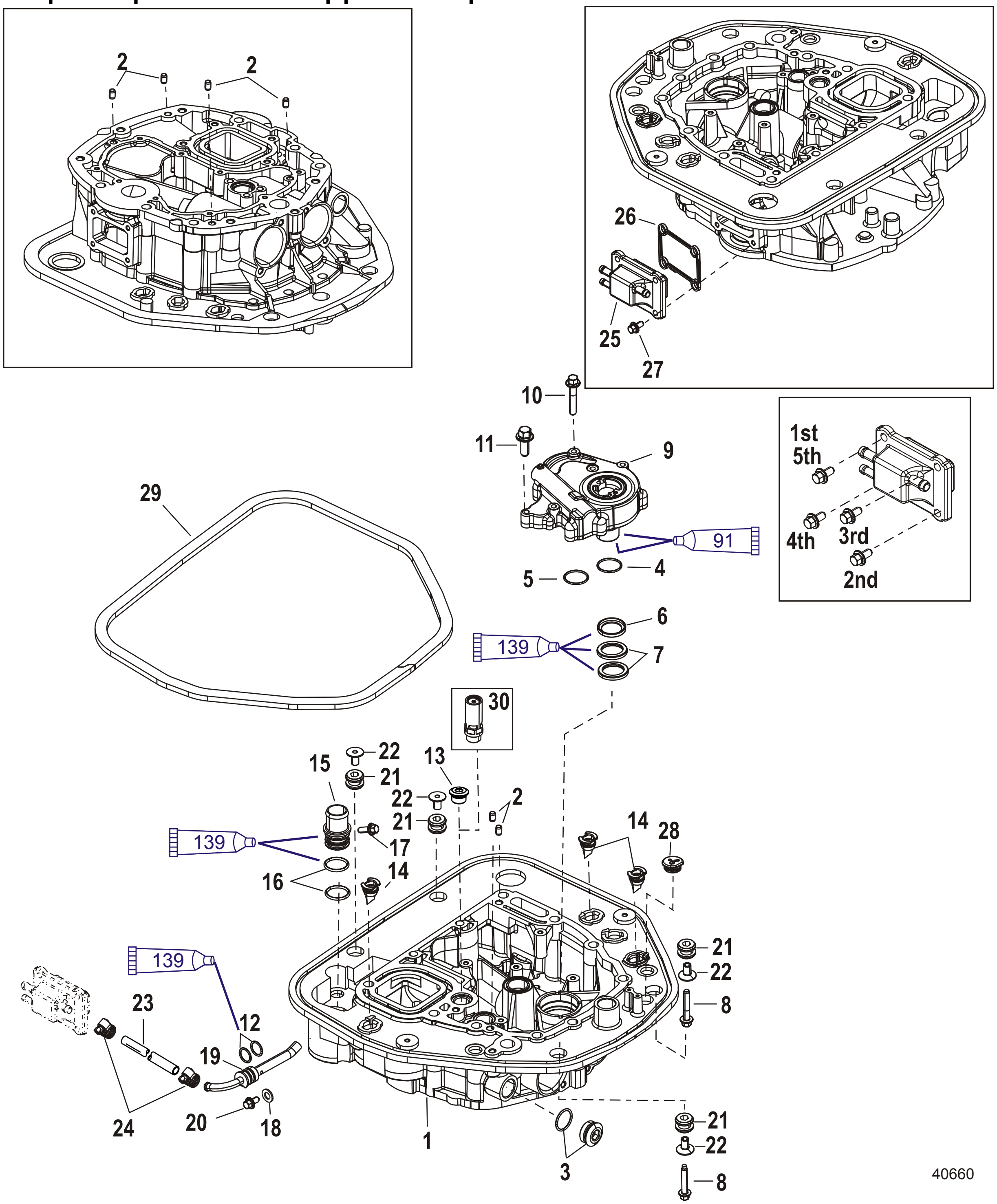
5
B

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Exhaust cooling fitting screw	92-809821
		Water manifold/strainer mounting screws	
		Oil pump mounting screws	
		Oil pickup tube mounting screws	
		Oil sump mounting screws	
		Exhaust tube mounting screws	
		Driveshaft housing mounting bolt threads	
91	Engine Coupler Spline Grease	Oil pump drive gear hub	92-802869A 1
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Dump fitting and O-rings, driveshaft seals, cooling jet O-rings	92-858052K01
		Exhaust cooling fitting O-rings	
		Driveshaft water seals	
		Driveshaft oil seal	
		Oil pump O-rings	
		Oil pump inlet port	

Notes:

Oil Pump/Adapter Plate - Upper Components

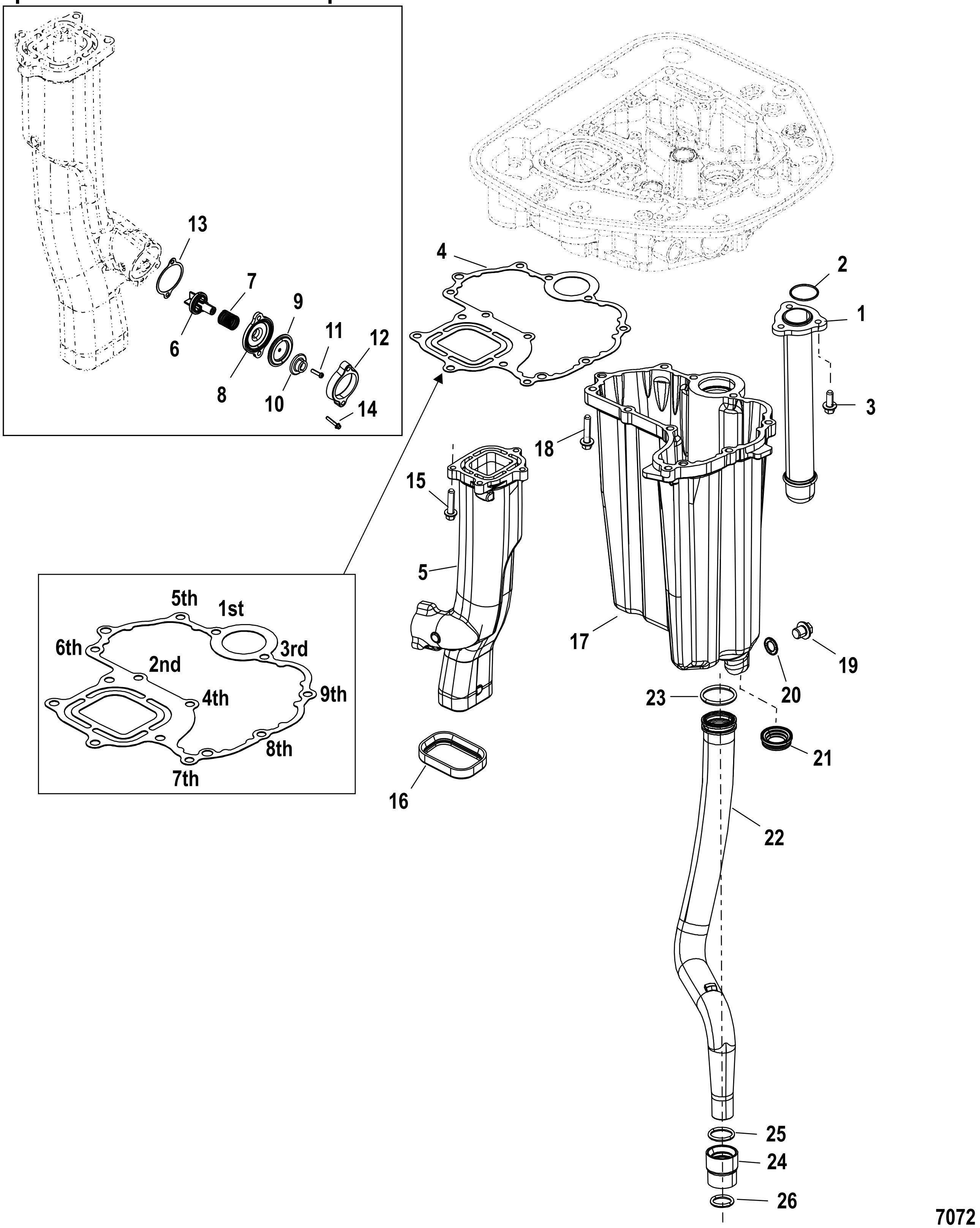


Oil Pump/Adapter Plate - Upper Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Adapter plate			
2	6	Dowel pin			
3	1	Plug	55		41
4	1	Inlet O-ring			
5	1	Outlet O-ring			
6	1	Oil seal			
7	2	Water seal			
8	4	Screw (M6)	10	89	
9	1	Oil pump assembly			
10	4	Bolt (M6 x 45)	10	89	
11	1	Bolt (M6 x 35)	10	89	
12	2	Cooling jet O-ring			
13	1	Plug (S/N 1B517159 and above)	40		30
14	3	Cowl drain			
15	1	Dump fitting assembly			
16	2	O-ring			
17	1	Screw (M6 x 12)	6	53	
18	1	Washer			
19	1	Cooling jet fitting			
20	1	Screw (M6 x 12)	6	53	
21	4	Grommet			
22	4	Bushing			
23	1	Tubing - 53 cm (21 in.)			
24	2	Worm gear clamp	3	27	
25	1	Manifold/strainer housing			
26	1	Seal			
27	4	Screw (M6 x 16)	Hand start and drive first screw snug. Drive remaining three screws in "X" pattern sequence to 6 Nm (53 lb-in.). Return to first screw and drive to torque.		
28	1	Grommet			
29	1	Adapter plate seal			
30	1	Pressure control valve (S/N 1B517158 and below)	40		30

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Oil pump drive gear hub	92-802869A 1
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Dump fitting and O-rings, driveshaft seals, cooling jet O-rings	92-858052K01

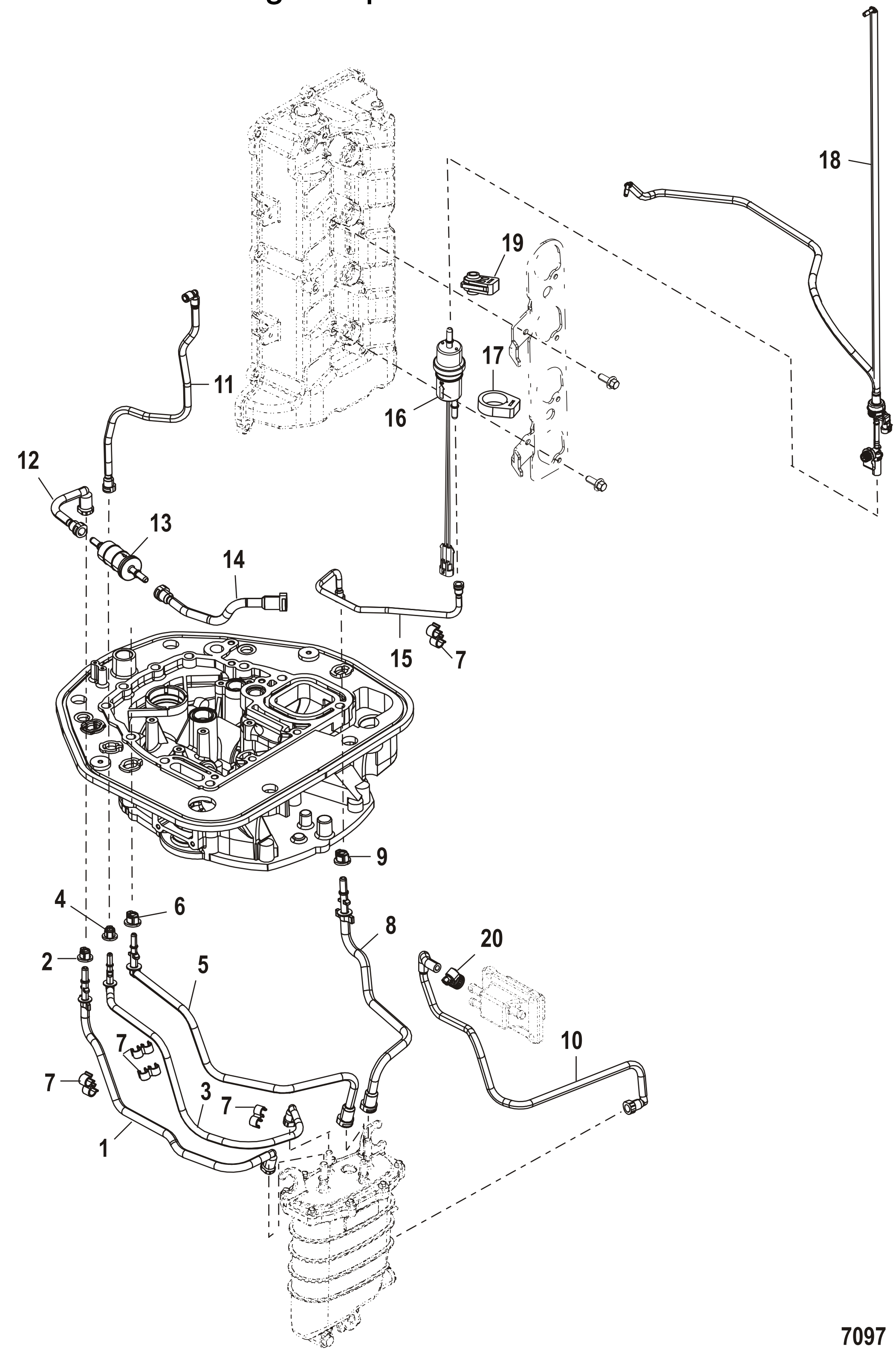
Adapter Plate - Lower Components



Adapter Plate - Lower Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Oil pickup tube			
2	1	O-ring			
3	3	Screw (M6 x 25)	10	89	
4	1	Oil sump gasket			
5	1	Exhaust tube			
6	1	Poppet assembly			
7	1	Spring			
8	1	Retainer			
9	1	Diaphragm			
10	1	Washer			
11	1	Screw (#10-16 x 0.750 in.)			
12	1	Poppet cover			
13	1	Poppet gasket			
14	2	Screw	5	44	
15	4	Screw (M8 x 35)	24		17.7
16	1	Exhaust tube seal			
17	1	Oil sump			
18	9	Screw (M6 x 20)	10	89	
19	1	Oil drain plug			
20	1	Drain plug seal			
21	1	Water tube seal			
22	1	Water tube assembly			
23	1	O-ring			
24	1	Coupling			
25	1	O-ring			
26	1	O-ring			

Adapter Plate Hose Routing Components



Adapter Plate Hose Routing Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Fuel supply module (FSM) outlet hose			
2	1	Grommet			
3	1	Manifold reference hose			
4	1	Grommet			
5	1	Vent hose			
6	1	Grommet			
7	5	Clip			
8	1	FSM inlet hose			
9	1	Grommet			
10	1	Water hose			
11	1	Charge air cooler (CAC) hose			
12	1	Fuel hose			
13	1	Filter			
14	1	Fuel rail hose			
15	1	Hose			
16	1	Vent canister assembly			
17	1	Grommet			
18	1	Purge vent assembly			
19	1	Grommet			
20	1	Worm gear clamp			

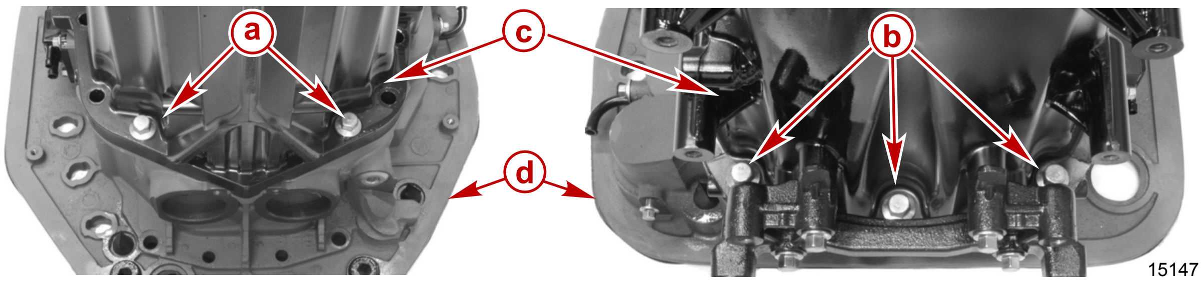
Preparing Outboard for Adapter Plate Disassembly

1. Remove the powerhead. Refer to **Section 4A - Dressed Powerhead Removal**.
2. Remove the driveshaft housing/adapter plate from the swivel bracket assembly. Refer to **Section 5A - Mid-Section Disassembly**.

Driveshaft Housing/Adapter Plate Disassembly

NOTE: The driveshaft housing may be removed from the adapter plate without removing the driveshaft housing/adapter plate from the swivel bracket assembly.

1. Place the driveshaft housing/adapter plate on a fixture or upside down on two blocks of wood.
2. Remove the two bolts at the front and the three bolts at the rear securing the driveshaft housing to the adapter plate.

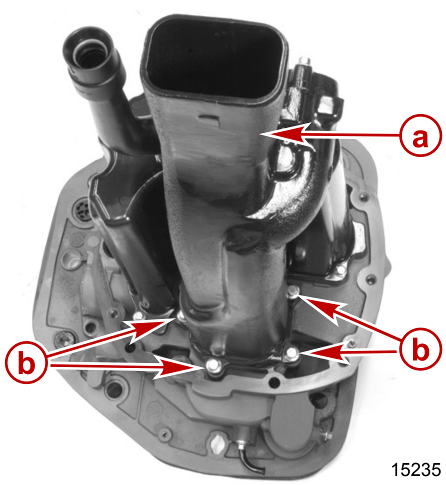


a - Front driveshaft housing mounting bolts (M10 x 40) (2)
b - Rear driveshaft housing mounting bolts (M10 x 40) (3)
c - Driveshaft housing
d - Adapter plate

3. Remove the driveshaft housing from the adapter plate.

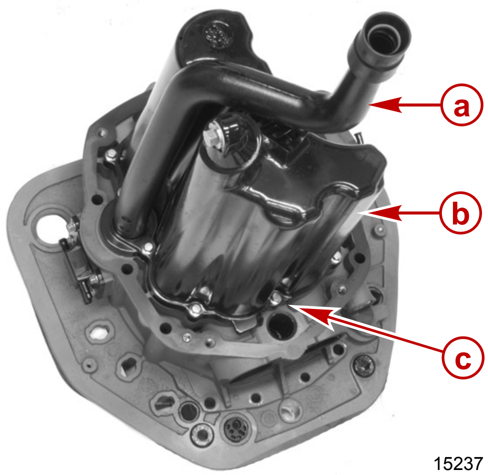
Adapter Plate Lower Component Removal

1. Remove the four screws securing the exhaust tube to the adapter plate. Remove the exhaust tube.



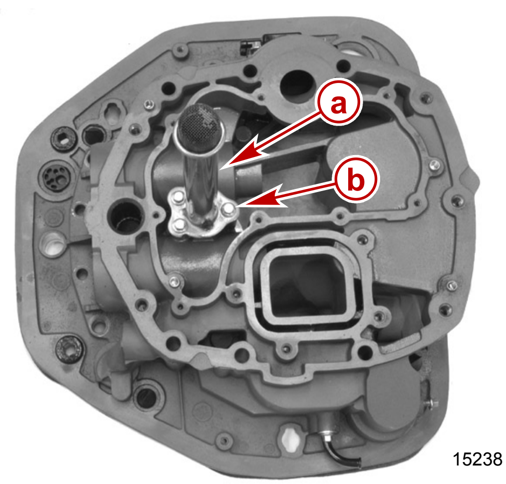
a - Exhaust tube
b - Exhaust tube mounting screw (M8 x 35) (4)

2. Remove the nine screws securing the oil sump to the adapter plate. Remove the oil sump and water pickup tube.



a - Water pickup tube
b - Oil sump
c - Oil sump mounting screws (M6 x 20) (9)

3. Remove the three screws securing the oil pickup tube to the adapter plate.



a - Oil pickup tube
b - Oil pickup tube mounting screws (M6 x 25) (3)

4. Remove the driveshaft housing gasket.
5. Remove the oil sump/exhaust tube gasket.
6. Clean gasket surfaces.

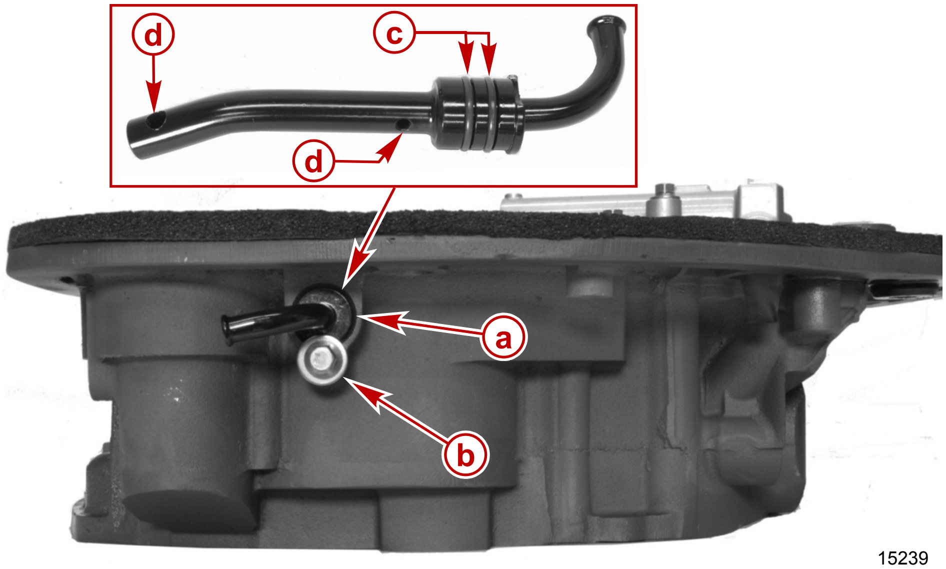
Adapter Plate Components

Exhaust Cooling Fitting

Removal/Inspection

1. Remove the screw securing the exhaust cooling fitting.
2. Remove the exhaust cooling fitting.

3. Inspect the exhaust cooling ports for debris and the O-rings for damage.



a - Exhaust cooling fitting
b - Screw (M6 x 12) and washer
c - O-ring (2)
d - Exhaust cooling ports

Installation

1. Lightly lubricate the O-rings on the exhaust cooling fitting. Install the exhaust cooling fitting in the adapter plate.

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Exhaust cooling fitting O-rings	92-858052K01

2. Apply Loctite 242 Threadlocker to the exhaust cooling fitting screw. Install the screw and washer in the adapter plate. Tighten screw to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Exhaust cooling fitting screw	92-809821

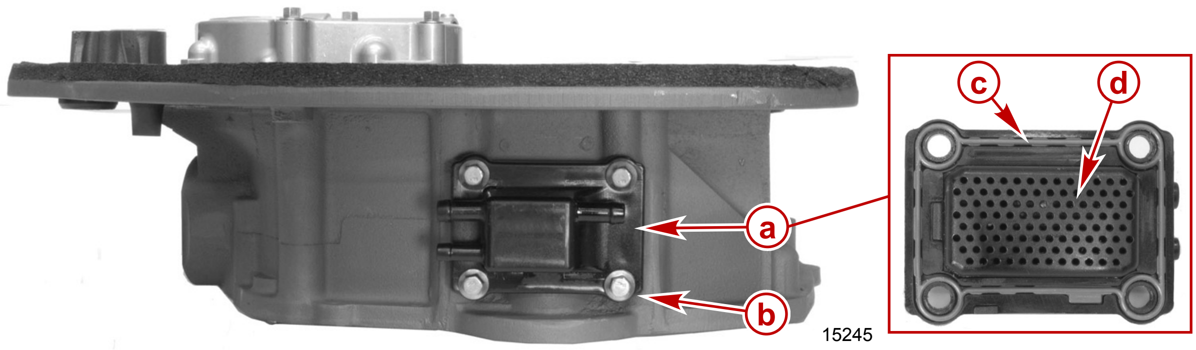
Description	Nm	lb-in.	lb-ft
Exhaust cooling fitting screw	6	53	

Water Manifold/Strainer

Removal/Inspection

1. Remove the four screws securing the manifold/strainer housing.
2. Remove the manifold/strainer housing.

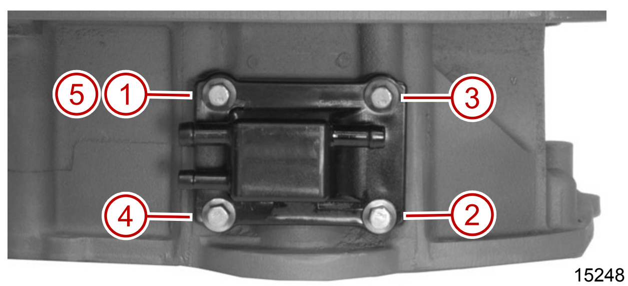
3. Inspect the manifold/strainer for debris and the seal for damage.



a - Water manifold/strainer
b - Screw (M6 x 16) (4)
c - Seal
d - Strainer

Installation

1. Install the seal on the manifold/strainer.
2. Install the water manifold/strainer into the adapter plate.
3. Apply Loctite 242 Threadlocker to manifold/strainer mounting screws. Install screws in adapter plate and tighten in sequence to the specified torque.



Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Water manifold/strainer mounting screws	92-809821

Description	Nm	lb-in.	lb-ft
Water manifold/strainer mounting screws - Drive first screw snug. Tighten remaining three screws in sequence to the specified torque. Return to the first screw and tighten to the specified torque.	6	53	

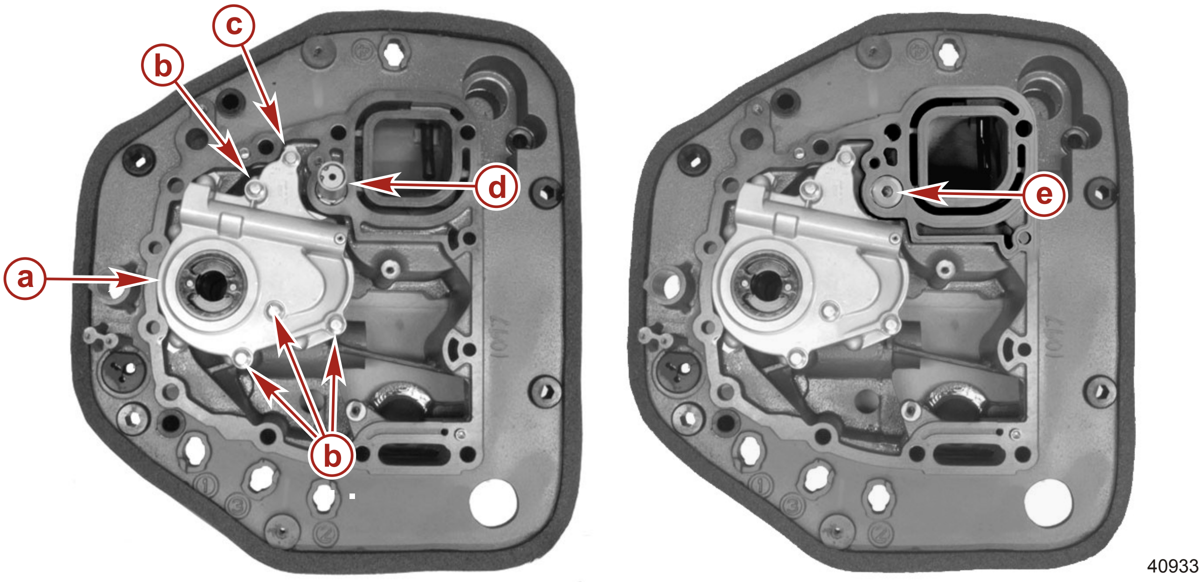
Oil Pump, Pressure Control Valve, and Driveshaft Seals

NOTE: The pressure control valve and the piston cooling jets were removed from the engine as part of a friction reduction package. The valve was replaced with a plug. Starting serial number for the installation of the plug is 1B517159.

Removal

1. Remove the five oil pump mounting screws.
2. Remove the oil pump.

3. Remove the pressure control valve or plug.

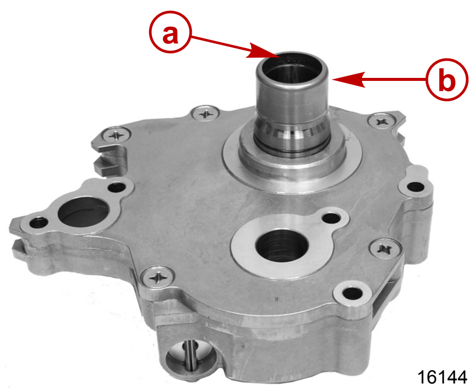


S/N 1B517158 and below

S/N 1B517159 and above

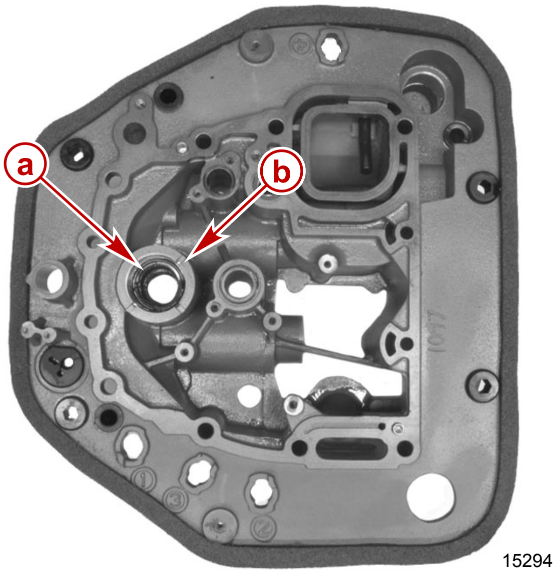
a - Oil pump
b - Oil pump mounting screw (M6 x 45) (4)
c - Oil pump mounting screw (M6 x 35) (1)
d - Pressure control valve (S/N 1B517158 and below)
e - Plug (S/N 1B517159 and above)

4. Remove the two O-rings inside of the oil pump drive gear hub.



a - O-ring (2)
b - Oil pump drive gear hub

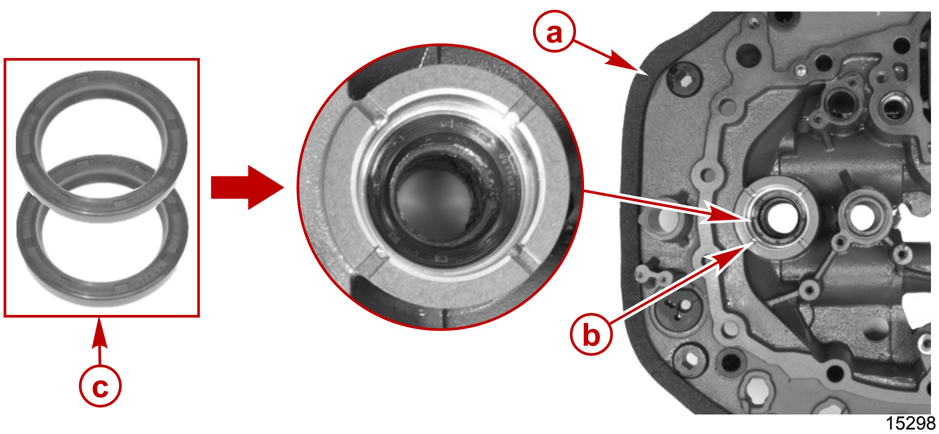
5. Remove the three driveshaft seals in the oil pump drive gear hub bore.



a - Driveshaft seal (3)
b - Oil pump drive gear bore

Driveshaft Seal Installation

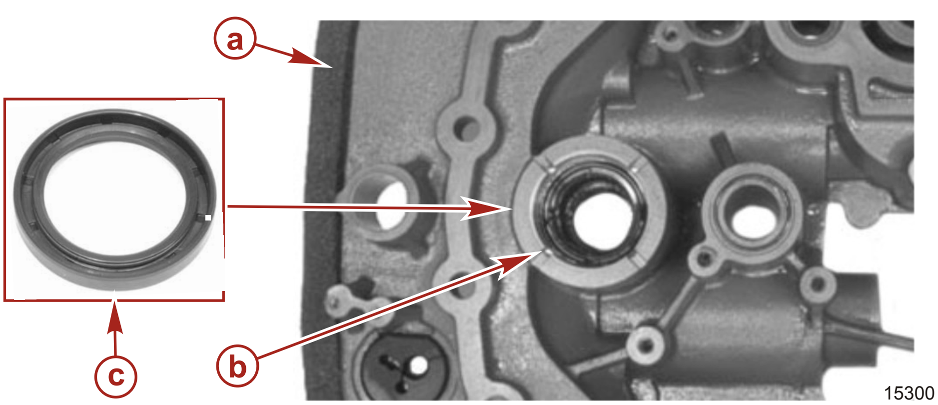
1. Lubricate the two driveshaft water seals with Synthetic Blend 4-Stroke Outboard Oil 25W-40. Install the two water seals, spring side down, into the oil pump drive gear hub bore. Press the seals into the bore until seated.



a - Adapter plate
b - Oil pump drive gear hub bore
c - Driveshaft water seals (spring side down)

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Driveshaft water seals	92-858052K01

2. Lubricate the driveshaft oil seal with Synthetic Blend 4-Stroke Outboard Oil 25W-40. Install the oil seal, spring side up, into the oil pump drive gear hub bore. Press the seal into the bore until it reaches the top ridge.

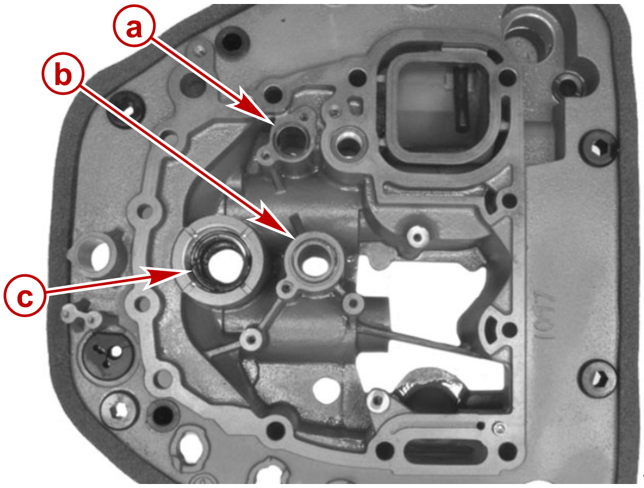


a - Adapter plate
b - Oil pump drive gear hub bore
c - Driveshaft oil seal (spring side up)

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Driveshaft oil seal	92-858052K01

Oil Pump and Pressure Control Valve Installation

1. Install new lubricated oil pump O-rings in the adapter plate O-ring grooves.

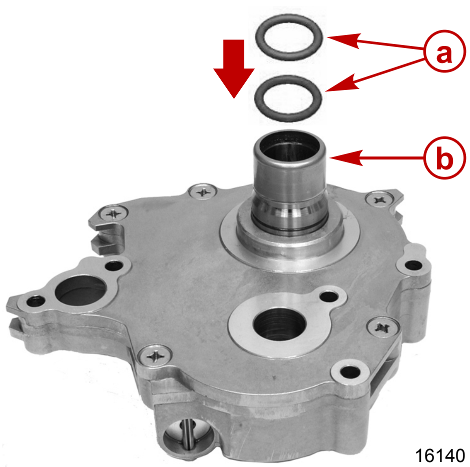


15267

a - Oil pump outlet O-ring (26.70 inside diameter x 1.78 mm width [1.051 x 1.070 in.])
b - Oil pump inlet O-ring (21.95 inside diameter x 1.78 mm width [0.864 x 0.070 in.])
c - Driveshaft seal (3)

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Oil pump O-rings	92-858052K01

2. Install new O-rings into the oil pump drive gear hub.



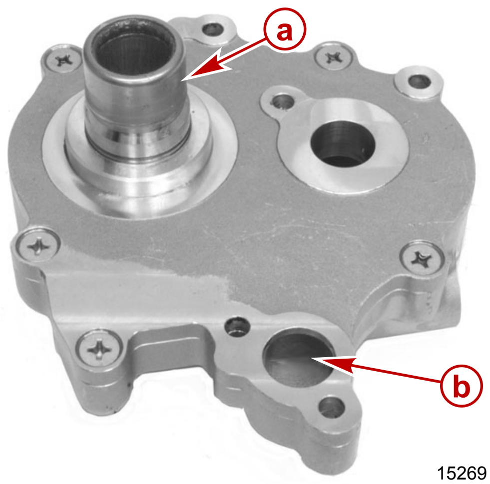
16140

a - O-ring (21.32 inside diameter x 3.78 mm width [0.839 x 0.149 in.])
b - Oil pump drive gear hub

3. Lubricate the inside and outside of the oil pump drive gear hub with Engine Coupler Spline Grease.

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Oil pump drive gear hub	92-802869A 1

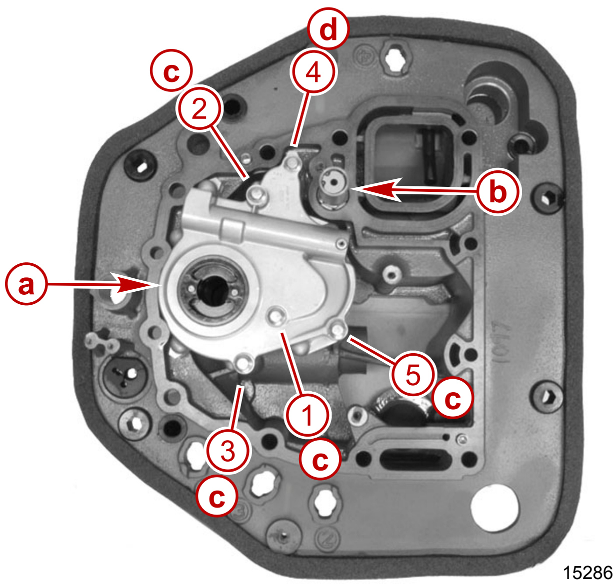
4. Lubricate the oil pump by pouring 5 ml (1 teaspoon) of Synthetic Blend 4-Stroke Outboard Oil 25W-40 into the inlet port. Rotate the pump driveshaft several revolutions to lubricate internal components.



a - Oil pump drive gear hub
b - Inlet port

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Oil pump inlet port	92-858052K01

5. Install the pressure control valve or plug onto the adapter plate. Tighten to the specified torque.
6. Install the oil pump onto the adapter plate. Apply a small amount of Loctite 242 Threadlocker onto the oil pump mounting screws. Install the five pump mounting screws and tighten in sequence to the specified torque.



Pressure control valve model
a - Oil pump
b - Pressure control valve (S/N 1B517158 and below)
c - Oil pump mounting screws (M6 x 45) (4)
d - Oil pump mounting screw (M6 x 35) (1)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Oil pump mounting screws	92-809821

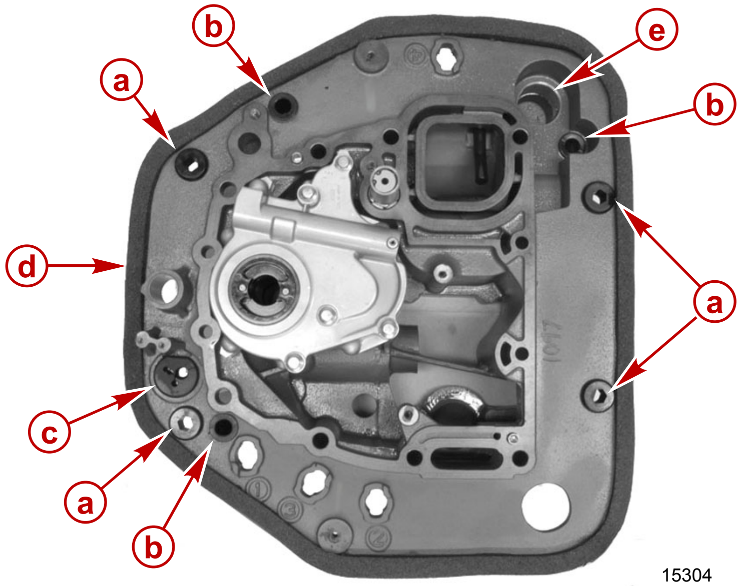
Description	Nm	lb-in.	lb-ft
Pressure control valve or plug	40		30
Oil pump mounting screws	10	89	

Adapter Plate Upper Components

Removal

1. Remove the four grommets and bushings.

2. Remove the three cowl drains.
3. Remove the power trim/water tube harness grommet.
4. Remove the adapter plate seal.



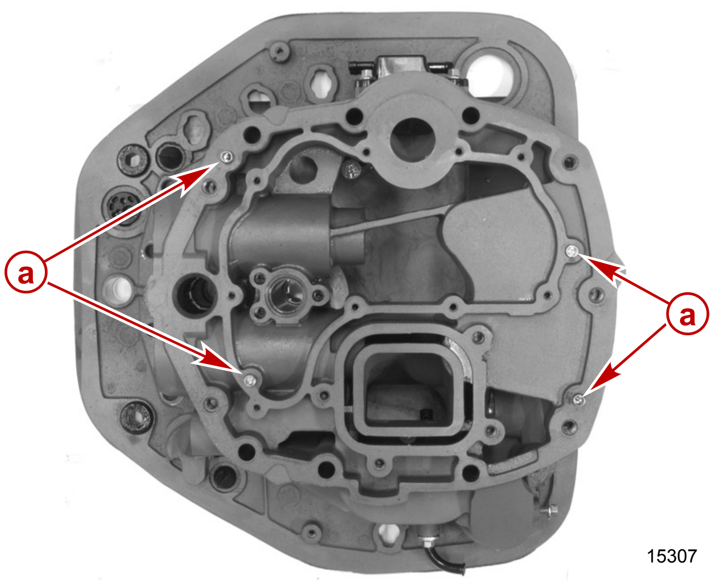
a - Grommet and bushing (4)
b - Cowl drain (3)
c - Power trim/water tube grommet
d - Adapter plate seal
e - Water dump fitting cavity

Installation

1. Clean the adapter plate seal surface with solvent. Ensure the surface is dry before installing the seal.
2. Remove the backing from the adapter plate seal.
3. Install the seal on the adapter plate.
4. Apply pressure to the seal with the palm of the hand to activate the adhesive.
5. Install the four grommets and bushings.
6. Install the three cowl drains.
7. Install the power trim/water tube harness grommet.

Adapter Plate Lower Component Installation

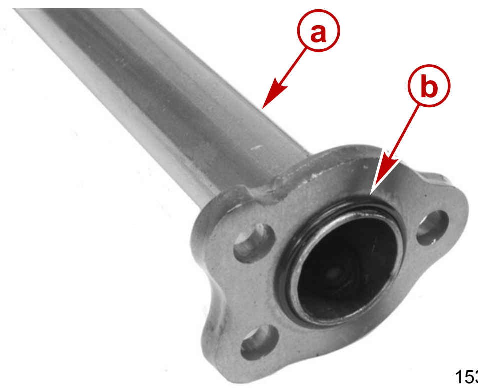
1. Inspect the dowel pins for damage. Replace if required.



a - Dowel pin (4)

2. Clean the gasket surfaces.

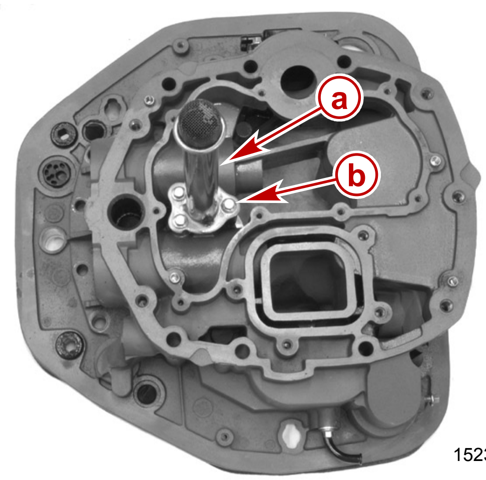
3. Install new O-ring on the oil pickup tube.



15308

a - Oil pickup tube
b - O-ring

4. Apply Loctite 242 Threadlocker to the three oil pickup tube mounting screws.
5. Assemble the oil pickup tube with O-ring to the adapter plate with three screws. Tighten to the specified torque.



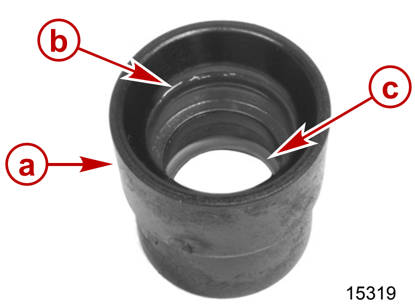
15238

a - Oil pickup tube
b - Oil pickup tube mounting screw (M6 x 25) (3)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Oil pickup tube mounting screws	92-809821

Description	Nm	lb-in.	lb-ft
Oil pickup tube mounting screws	10	89	

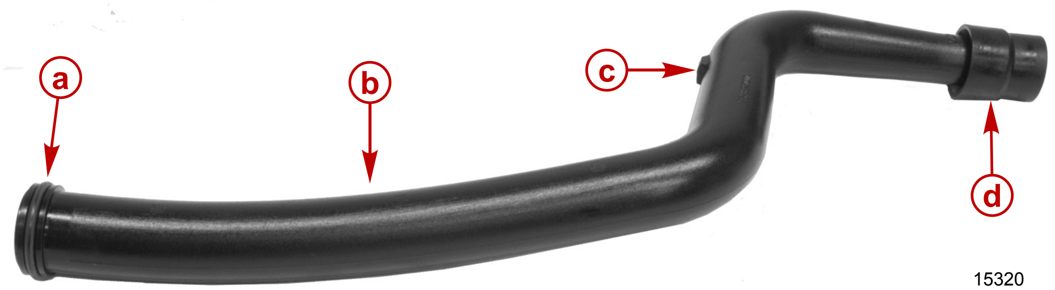
6. Install the drain plug and seal washer into the drain hole in the oil sump.
7. Install two new O-rings in the water tube coupler.



15319

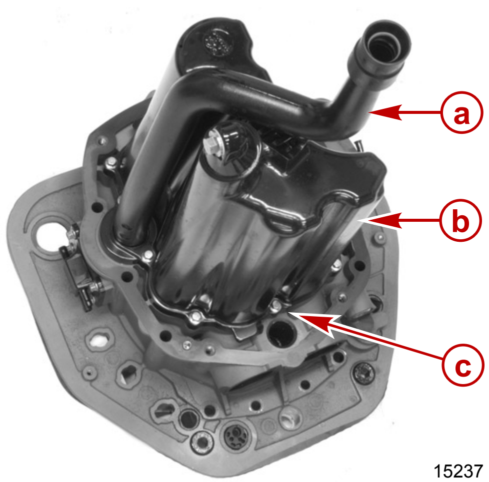
a - Water tube coupler
b - O-ring (23.39 inside diameter x 3.53 mm width [0.921 x 0.139 in.])
c - O-ring (20.22 inside diameter x 3.53 mm width [0.796 x 0.139 in.])

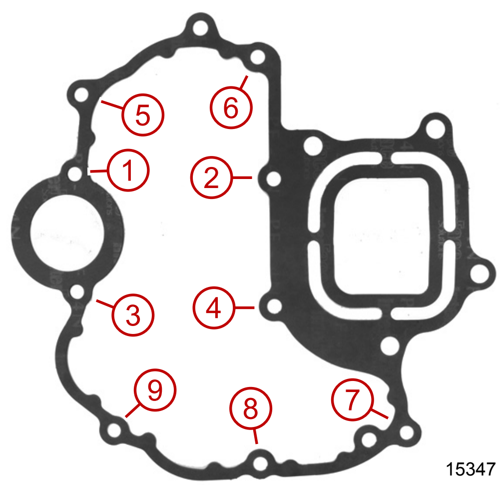
8. Install the coupler assembly (arrow towards water tube) and a new O-ring on the water tube.



a - O-ring
b - Water tube
c - Lock tab
d - Coupler assembly

9. Install the water tube through the opening in the oil sump. Ensure that it locks into the mounting pad on the bottom of the sump.
10. Install a new oil sump/exhaust tube gasket over the dowel pins in the adapter plate.
11. Apply Loctite 242 Threadlocker to the nine oil sump mounting screws.
12. Install the nine screws to the adapter plate. Tighten the screws in sequence to the specified torque.





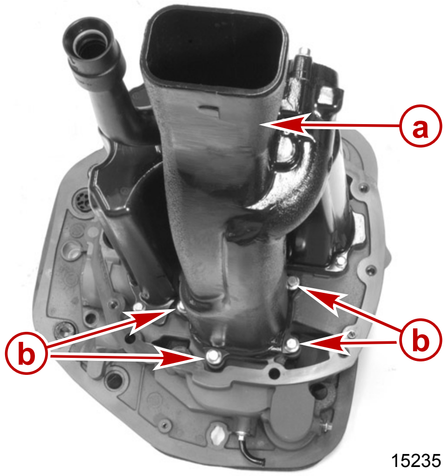
a - Water pickup tube
b - Oil sump
c - Oil sump mounting screw (M6 x 20) (9)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Oil sump mounting screws	92-809821

Description	Nm	lb-in.	lb-ft
Oil sump mounting screws	10	89	

13. Apply Loctite 242 Threadlocker to the four exhaust tube mounting screws.

14. Install the four screws to the adapter plate. Tighten the screws to the specified torque.



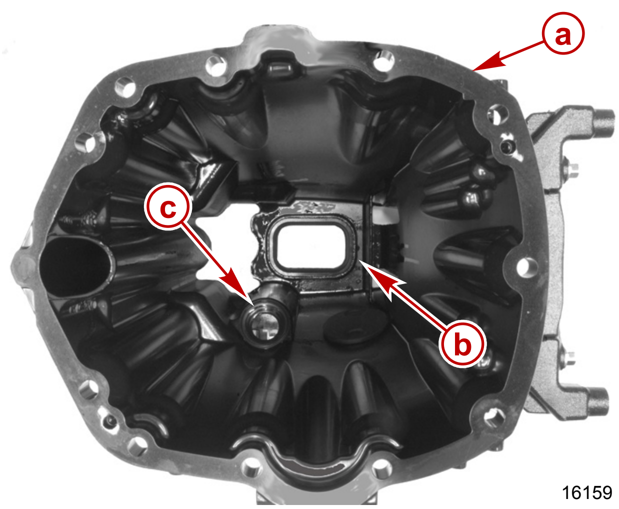
a - Exhaust tube
b - Exhaust tube mounting screw (M8 x 35) (4)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Exhaust tube mounting screws	92-809821

Description	Nm	lb-in.	lb-ft
Exhaust tube mounting screws	24		17.7

Driveshaft Housing/Adapter Plate Assembly

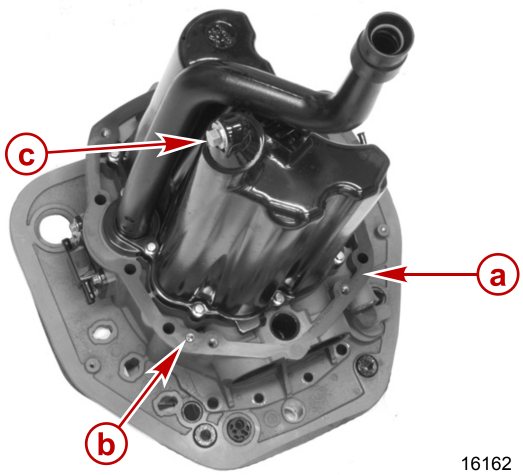
1. Install a new exhaust tube seal into the groove in the bottom of the driveshaft housing.
2. Install a new oil drain seal in the driveshaft housing.



a - Driveshaft housing
b - Exhaust tube seal
c - Oil drain seal

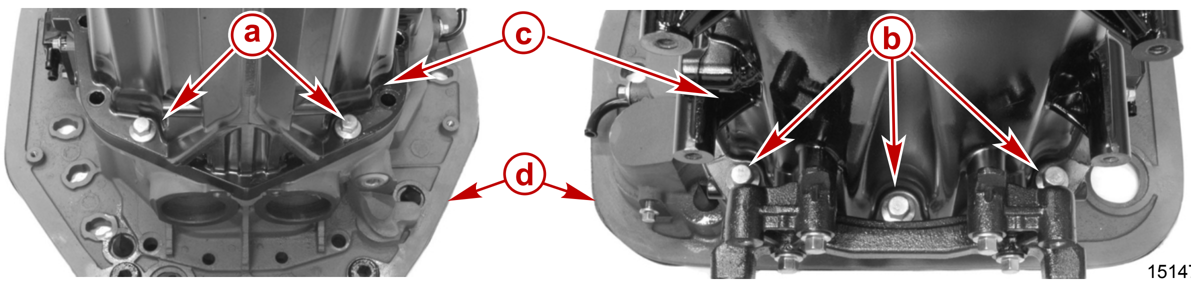
3. Remove the oil drain plug from the oil sump.
4. Clean the adapter plate and driveshaft housing gasket surfaces.

5. Install a new gasket over the dowel pins on the adapter plate.



a - Gasket surface
b - Dowel pin (1 of 2)
c - Oil drain plug

6. Apply Loctite 242 Threadlocker to the mounting bolt threads.
7. Assemble the driveshaft housing to the adapter plate with two bolts at the front and three at the rear of the housing.
8. Tighten the bolts to the specified torque.



a - Front driveshaft housing mounting bolts (M10 x 40)
b - Rear driveshaft housing mounting bolts (M10 x 40)
c - Driveshaft housing
d - Adapter plate

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Driveshaft housing mounting bolt threads	92-809821

Description	Nm	lb-in.	lb-ft
Driveshaft housing mounting bolts	47.5		35

9. Install the oil drain plug and seal washer into the drain hole in the oil sump.
10. Install the powerhead to the adapter plate/driveshaft housing. Refer to **Section 4A - Dressed Powerhead Installation.**

Mid-Section

Section 5C - Power Trim

Table of Contents

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C

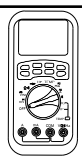
Power Trim Specifications

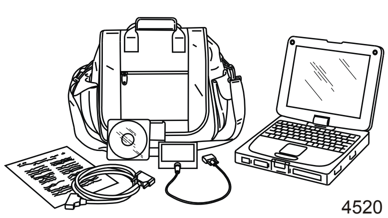
Power Trim Specifications	
Trim up relief valve - tilt extended relief pressure	6100–7750 kPa (885–1125 psi)
Trim down relief valve pressure	4400–7300 kPa (640–1060 psi)
System fluid	Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) Type F, FA, Dexron II, or Dexron III

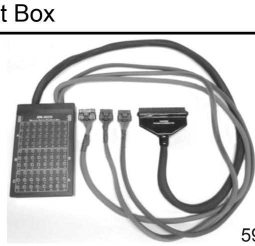
Lubricant, Sealant, Adhesives

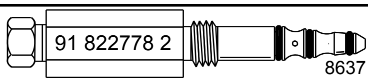
Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Brass fitting threads	92-809822
94	Anti-Corrosion Grease	Trim cylinder rod end rollers	92-802867Q 1
114	Power Trim and Steering Fluid	Power trim system	92-858074K01
		O-rings and seals	
		Tilt cylinder O-rings and seals	
		Power trim cylinder O-rings	
		Tilt ram alignment tool and shaft	
		Fill the trim system	
116	RTV 587 Ultra Blue Silicone Sealer	Shanks of the mount bolts	92-809825
128	Loctite 5900 Ultra Black RTV Silicone Sealant	Shanks of the mount bolts	92-809826

Special Tools

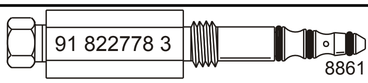
DMT 2004 Digital Multimeter	91-892647A01
 4516	Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments.

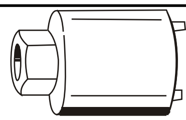
Computer Diagnostic System (CDS)	Order through SPX
 4520	Monitors all electrical systems for proper function, diagnostics, and calibration purposes. For additional information, pricing, or to order the Computer Diagnostic System contact: SPX Corporation 28635 Mound Rd. Warren, MI 48092 or call: USA - 1-800-345-2233 Canada - 800-345-2233 Europe - 49 6182 959 149 Australia - (03) 9544-6222

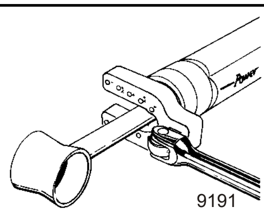
Breakout Box	SPX P/N MM-46225
 5974	Connects to Propulsion Control Module (PCM) to test engine circuits and components without probing wires. May be used with Computer Diagnostic System (CDS).

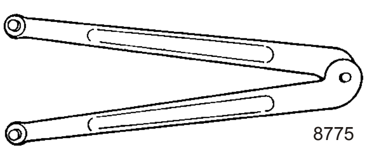
Adapter Fitting	91-822778A 2
	Install in place of the manual release valve to measure the internal pressure of the power trim pump in the up mode.

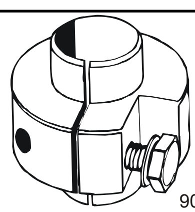
Power Trim Test Gauge Kit	91-52915A6
	Tests circuit pressures for various trim pumps.

Adapter Fitting	91-822778A 3
	Install in place of the manual release valve to measure the internal pressure of the power trim pump in the down mode.

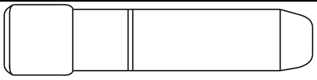
Trim Rod Guide Removal Tool	91-44487T 1
	Aids in the removal of the trim rod from the trim cylinders.

Trim Cylinder End Cap Tool	91-821709T
	Allows easy removal of the trim cylinder end caps. Required if tilt limit spacers are to be installed or if the trim in limit spacer is to be removed (to allow additional trim in range).

Spanner Wrench	91-74951
	Removes and installs trim cylinder end caps.

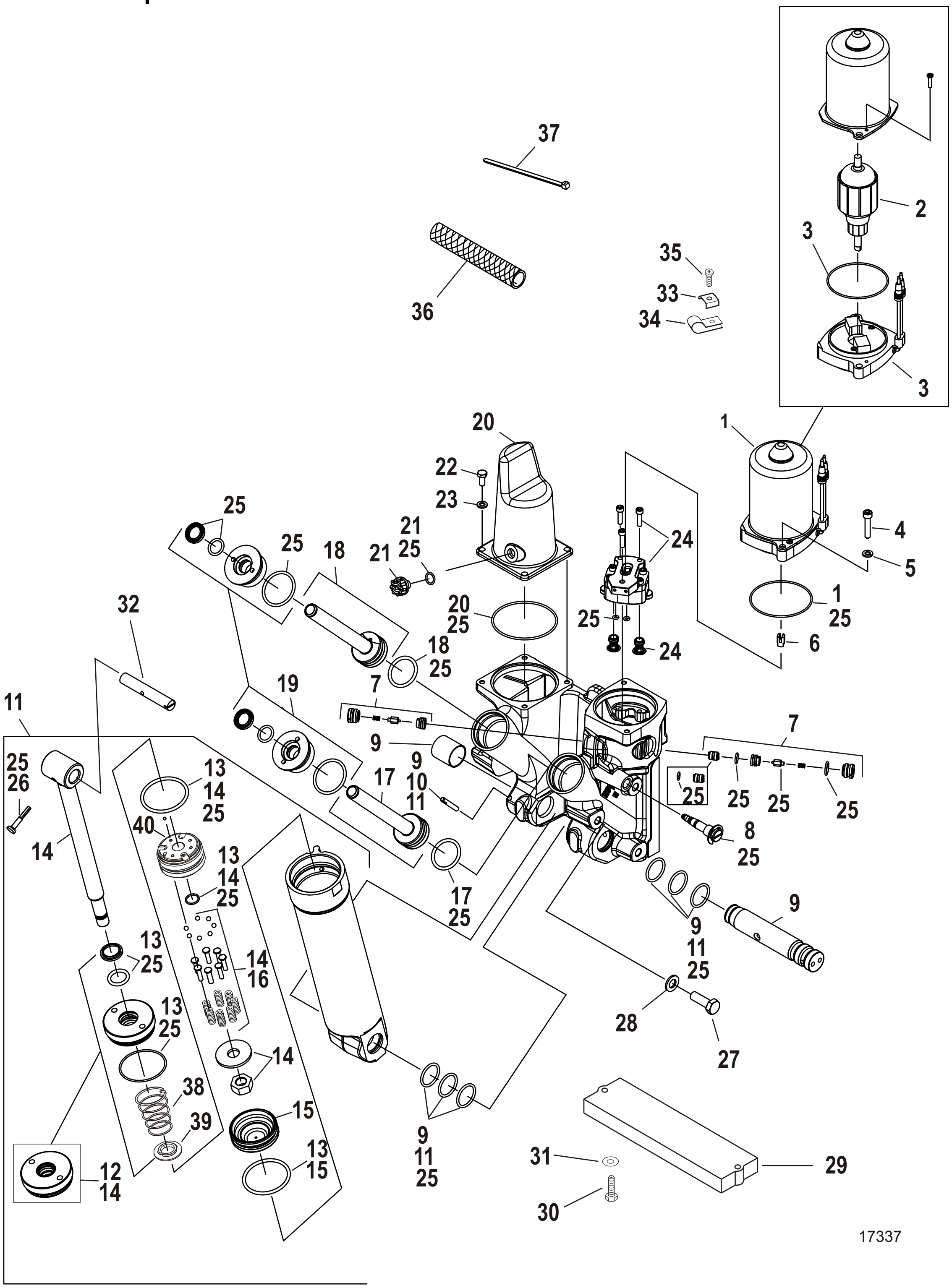
Trim Rod Removal Tool	91-44486A 1
	Aids in the removal of the trim rod from the trim cylinders.

Lockring Pliers	Snap-On SRP-4
	Aids in the removal of lockrings.

Alignment Tool	91-11230--1
 9078	Aligns the tilt ram with housing to aid installation of the pivot pin.

Notes:

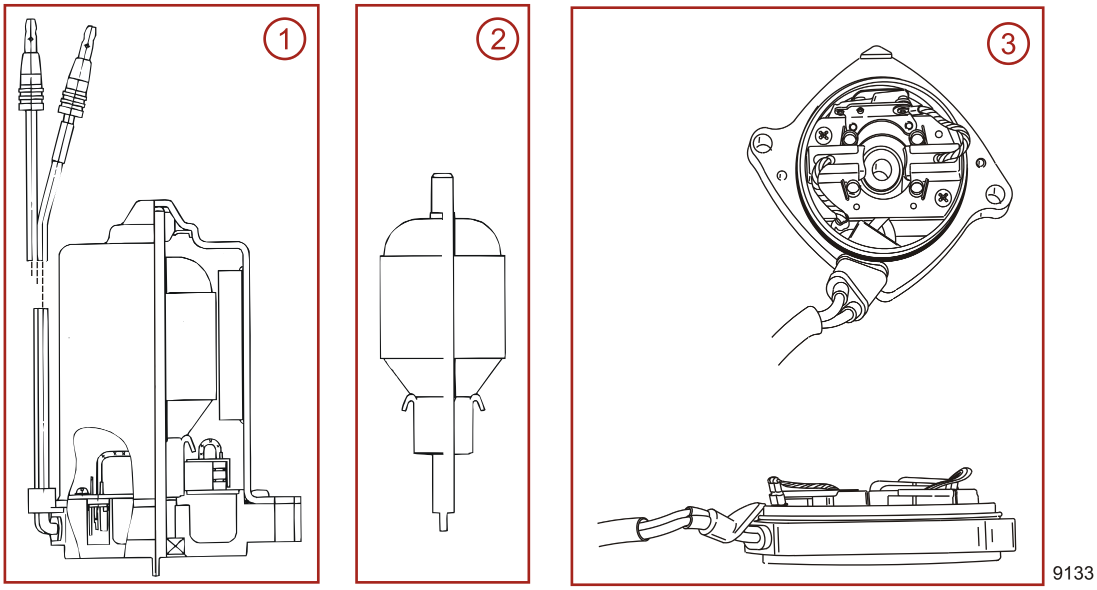
Power Trim Components



Power Trim Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Trim motor			
2	1	Armature			
3	1	End frame			
4	1	Screw (M6 x 30)	9	80	
5	2	Lockwasher			
6	2	Driveshaft			
7	1	Pressure operated (PO) check valve kit	13.5	120	
8	1	Manual release valve assembly	2.5	22	
9	1	Shaft kit			
10	1	Groove pin			
11	1	Tilt cylinder assembly			
12	1	Guide kit			
13	1	O-ring kit			
14	1	Shock rod kit	129		95
15	1	Memory piston			
16	1	Check valve repair kit			
17	1	Starboard trim rod			
18	1	Port trim rod			
19	2	Guide assembly			
20	1	Reservoir kit			
21	1	Plug kit	2.5	22	
22	4	Screw (M6 x 14)	7	60	
23	4	Washer			
24	1	Pump kit			
25	1	Power trim repair kit			
26	1	Groove pin			
27	6	Screw (M10 x 30)	61		45
28	6	Washer			
29	1	Anode assembly			
30	2	Screw (M6 x 25)	8	70	
31	2	Washer			
32	1	Shaft			
33	1	C-washer			
34	2	Clip			
35	1	Screw (10-16 x .50 in.)	Drive Tight		
36	1	Conduit (12 in.)			
37	1	Cable tie			
38	1	Damper spring			
39	1	Damper plate			
40	1	Shock piston			

Power Trim Motor



Ref.	Qty.	Description	Nm	lb-in.	lb-ft
-	1	Power trim motor			
1	1	Brush and seal kit			
2	1	Armature kit			
3	1	End frame			

Wire Color Code Abbreviations

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

Power Trim - General Information

Power Trim Characteristics

The power trim system consists of an electric motor, pressurized fluid reservoir, pump, tilt cylinder, and two trim cylinders.

The remote control or trim panel is equipped with a switch that is used for trimming the outboard up or down, and for tilting the outboard for shallow water operation at slow speeds or for trailering. The outboard can be trimmed up or down while engine is under power or when engine is not running.

NOTE: Because hull designs react differently in varying water conditions, changing the trim position will often improve the ride and boat handling. When trimming from a mid-range position with outboard trim tab in a straight fore and aft position, expect the following:

Trimming Outboard Up/Out

⚠ WARNING

Operating the boat at high speeds with the outboard trimmed too far out can reduce stability at high speeds. Rapidly reducing boat speed to correct this instability may cause a sudden change of steering torque and additional boat instability. If experiencing poor handling due to excessive trim out, reduce the power gradually and trim the outboard in slightly before resuming high-speed operation.

- Will lift the bow, increasing top speed
- Transfers and increases steering torque to port on installations with transom height less than 584 mm (23 in.)
- Increases gearcase clearance over submerged objects
- Excess trim can cause porpoising and propeller ventilation

NOTICE

Excessive outboard trim angle can result in insufficient water supply and overheat the water pump or engine. Ensure that the water level is above the drive's water intake ports when operating the engine.

Operating up circuit will actuate the up relay located under engine cowl and close the electric motor circuit. The electric motor will drive the pump, thus forcing fluid through internal passageways into the up side of the trim cylinder.

The trim cylinders position the outboard at the desired trim angle in the 20 degree maximum trim range. The system will not allow the outboard to be trimmed above the 20 degree trim range when the engine RPM is above approximately 2000 RPM.

The outboard can be trimmed above the 20 degree maximum trim angle for shallow water operation by keeping the engine RPM below 2000. If the RPM increases over 2000, if propeller is deep enough, propeller thrust will cause the trim system to return the outboard to the 20 degree maximum trim position.

Trimming Outboard Down/In

⚠ WARNING

Operating the boat at high speeds with the outboard trimmed too far under can create excessive bow steer, resulting in the operator losing control of the boat. Install the trim limit pin in a position that prevents excessive trim under and operate the boat in a safe manner.

- Aids planing, particularly with heavy loads
- Improves ride in choppy water conditions
- Excess trim in can cause bow steer (boat veers to left or right)
- Transfers steering torque to starboard (right)
- Improves acceleration to planing speed

Operating down circuit will actuate the down relay located under engine cowl and close the electric motor circuit. The motor will run in opposite direction of the up circuit. The electric motor will drive the pump, thus forcing fluid through internal passageways into the down side of the trim cylinder. The trim rod will move the engine downward to the desired angle.

Trailering Outboard

When the up circuit is actuated, the two trim cylinders and the tilt cylinder extend to move the outboard up through the trim range. When the trim cylinders are fully extended, the tilt cylinder continues to extend, moving the outboard to the trailer position.

Before the boat is transported, the operator should check for clearance between the outboard skeg and the pavement to prevent damage to the skeg.

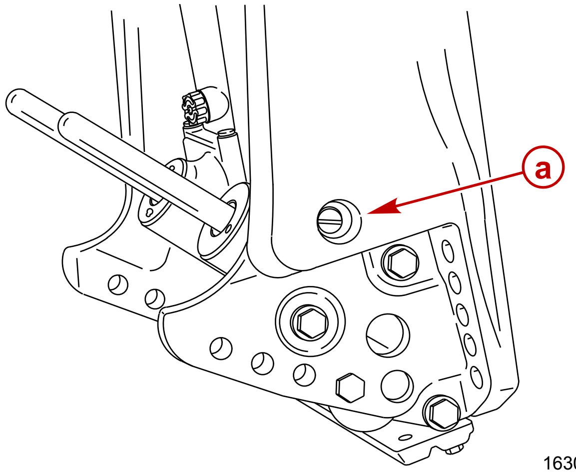
If the outboard must be tilted for clearance between skeg and pavement, a device such as a transom saver should be installed. This prevents stress to the boat transom from the weight of the outboard while the boat/engine are transported.

Tilting Outboard Manually

⚠ CAUTION

Opening the manual release valve relieves all pressure from the trim system, rapidly lowering the outboard to its full-down position. Stand clear of the outboard when opening the manual release valve.

The outboard can be raised or lowered manually by opening the manual release valve three to four turns counterclockwise. Close the manual release valve to hold outboard at the desired tilt position.



a - Manual release valve

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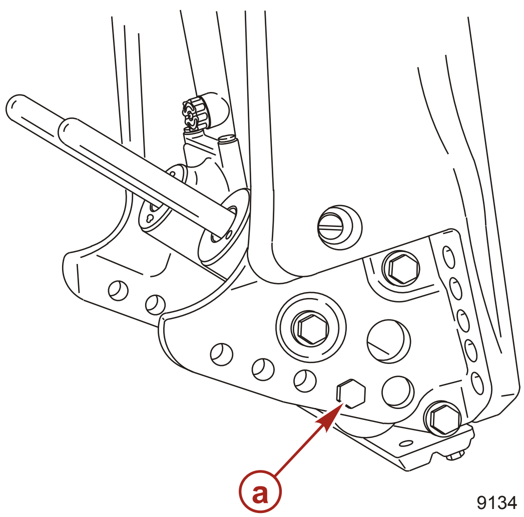
Trim In Angle Adjustment

> **⚠ WARNING**
>
> On some boats, increased trim-in range can cause handling problems at high speeds, resulting in personal injury or death. We recommend that only qualified personnel adjust the trim-in limit inserts and test the boat for handling problems.

IMPORTANT: Some boat/engine combinations not using the trim angle adjustment bolt and trimmed to the full in trim angle position, may not exhibit undesirable and/or unsafe handling and/or steering characteristics at planing speed. If so, not using the trim angle adjustment bolt may be advantageous to acceleration and planing. A water test is required to determine if these characteristics apply to a particular boat/engine combination.



a - Trim angle adjustment bolt

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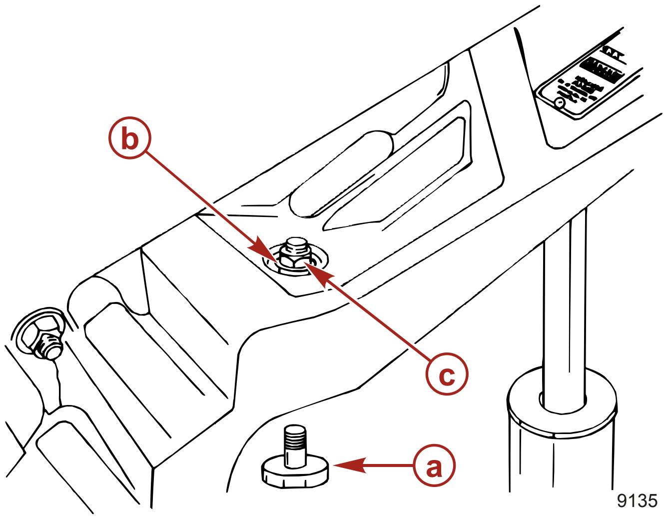
Striker Plate Replacement

Visually inspect striker plates and replace if worn excessively.



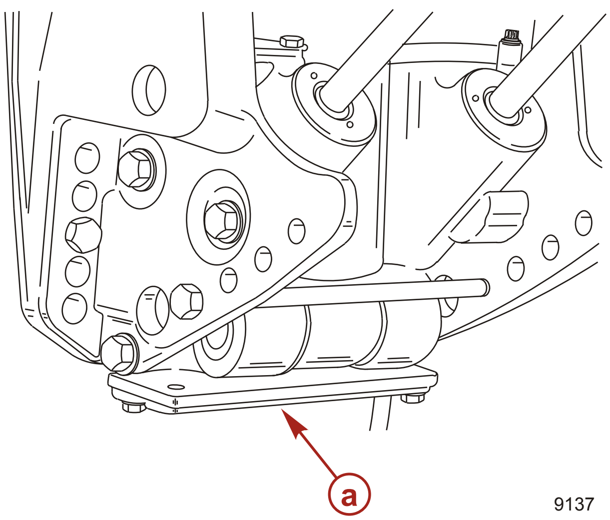
- a - Striker plate (2)
- b - Lockwasher
- c - Locknut

Description	Nm	lb-in.	lb-ft
Locknut	9	80	

Anode Plate

Anode plate is a self-sacrificing alloy plate that is consumed gradually by corrosion while providing protection to the midsection and power trim from galvanic corrosion. Replace anode plate when it is 50% consumed.

IMPORTANT: Do not paint or place protective coating on anode plate, or corrosion protection function will be lost.



- a - Anode plate

Trim Indicator Gauge

A Quicksilver trim indicator gauge accessory kit is available for the power trim sender (if not previously installed).

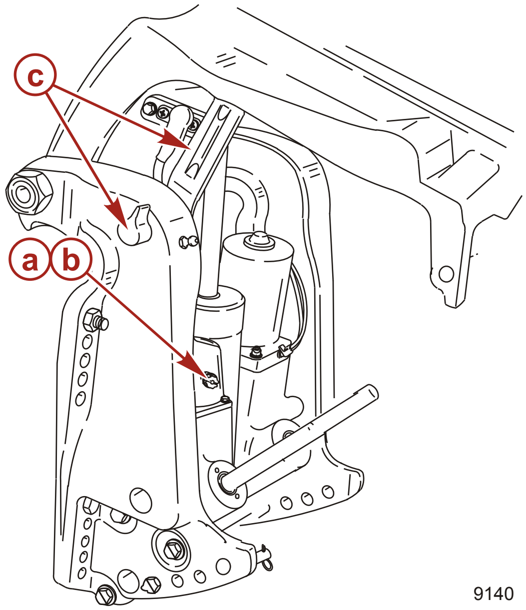
Check, Fill, and Purge - Power Trim System

To Check:

⚠ CAUTION
Avoid personal injury from a pressurized power trim system. To depressurize the system, tilt the outboard to the full up position and engage the tilt lock lever before checking the fluid level.

1. Extend the power tilt cylinder to the full up position.
2. Engage the tilt lock lever.
3. Remove the fill plug and O-ring.

4. The system is full when the fluid level is present at the filler hole.
5. Tighten the fill plug securely.



a - Fill plug and O-ring (remove to fill system, tighten securely)
b - Fill system with Power Trim and Steering Fluid
c - Tilt lock lever (engage to support engine in up position)

NOTE: *Power Trim and Steering Fluid, Automatic Transmission Fluid (ATF) Type F, FA, Dexron II, or Dexron III may be used.*

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Power trim system	92-858074K01

Description	Nm	lb-in.	lb-ft
Power trim fill plug	2.5	22	

To Fill:

CAUTION

Avoid personal injury from a pressurized power trim system. To depressurize the system, tilt the outboard to the full up position and engage the tilt lock lever before checking the fluid level.

1. Remove the fill plug only when the outboard is tilted to the full up position or the trim/tilt rams are fully extended.
2. Tighten the fill plug before tilting the outboard down or retracting the trim/tilt rams.
3. Remove the fill plug and O-ring.
4. The system is full when the oil level is present at the fill hole.
5. Tighten the fill plug securely.

Description	Nm	lb-in.	lb-ft
Power trim fill plug	2.5	22	

To Purge:

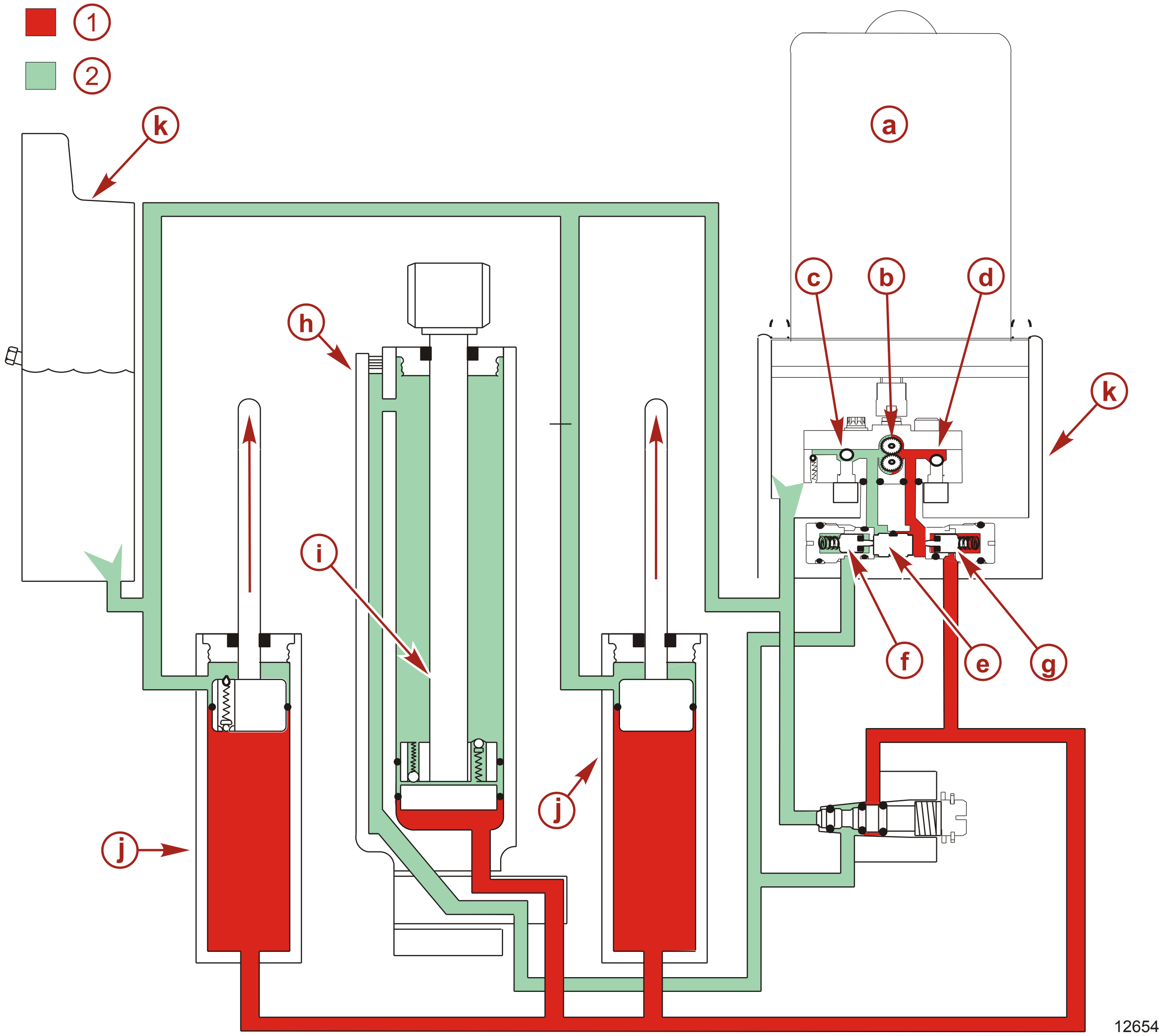
IMPORTANT: The fill plug and O-ring must be tightened securely before purging the system.

1. Run the trim system in short jogs until the pump is primed and the trim system moves. If the trim motor is run without priming the pump, driveshaft failure could result.
2. Cycle the outboard through the entire trim/tilt range four times. Check the fluid level after purging the system.
3. Push down on the outboard when the trim rams are slightly extended. If the rams retract more than 3.2 mm (1/8 in.), air is present in the system.
4. Cycle the system again and check the fluid level.

Notes:

Power Trim Flow Diagrams

Trim Up Circuit

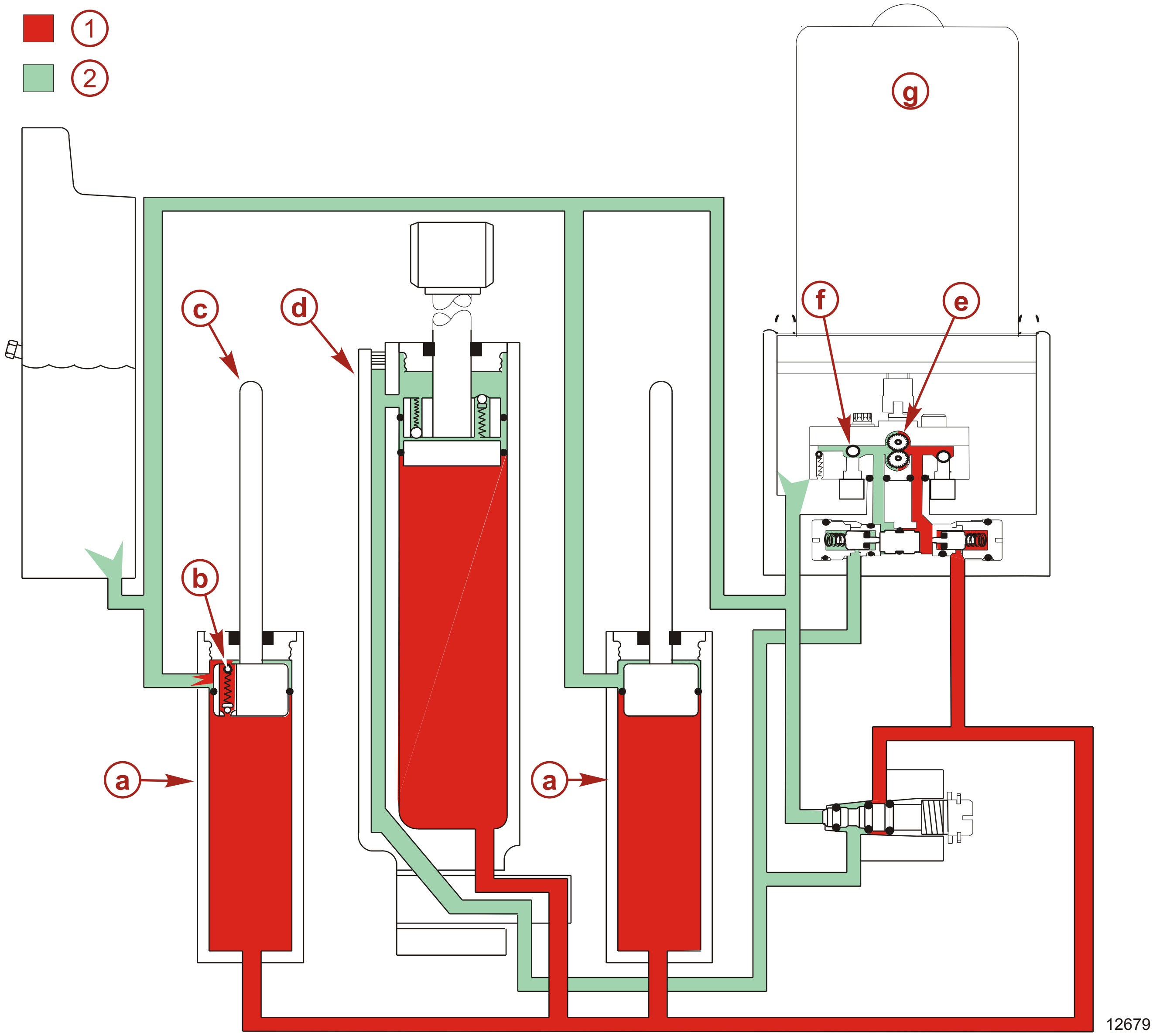


1 - High pressure
2 - Low pressure

a - Trim motor
b - Oil pump
c - Up circuit suction check valve
d - Down circuit suction check valve
e - Shuttle spool
f - Down circuit pressure operated valve
g - Up circuit pressure operated valve
h - Tilt cylinder
i - Tilt cylinder ram/piston
j - Trim cylinders
k - Reservoir

When the up button is activated, the electric motor will rotate the oil pump gears. As the oil pump gears begin to rotate, oil is drawn through the up circuit suction check valve and into the pump, supplying flow for the up circuit. Oil under pressure opens the up circuit pressure operated valve, allowing oil to enter the up pressure passages inside the manifold casting. The oil continues on through the up passages into the bottom of the cylinders below the pistons, pushing the trim and tilt rams up and out. Oil from the pump is blocked from returning into the reservoir by the closed down circuit suction check valve. Oil under pressure slides the shuttle spool to the left against the down circuit pressure operated valve. The shuttle spool will mechanically open the down circuit pressure operated valve, allowing oil to return into the pump from top of the tilt cylinder. Oil returning from the top side of the tilt cylinder piston flows through an interconnecting passage on the side of the tilt cylinder, through the lower pivot pin, past the open down circuit pressure operated valve, and into the pump, supplying some of the oil required for the up circuit. Oil returns into the reservoir, from the trim rams, through passages cast inside of the manifold.

Tilt Circuit



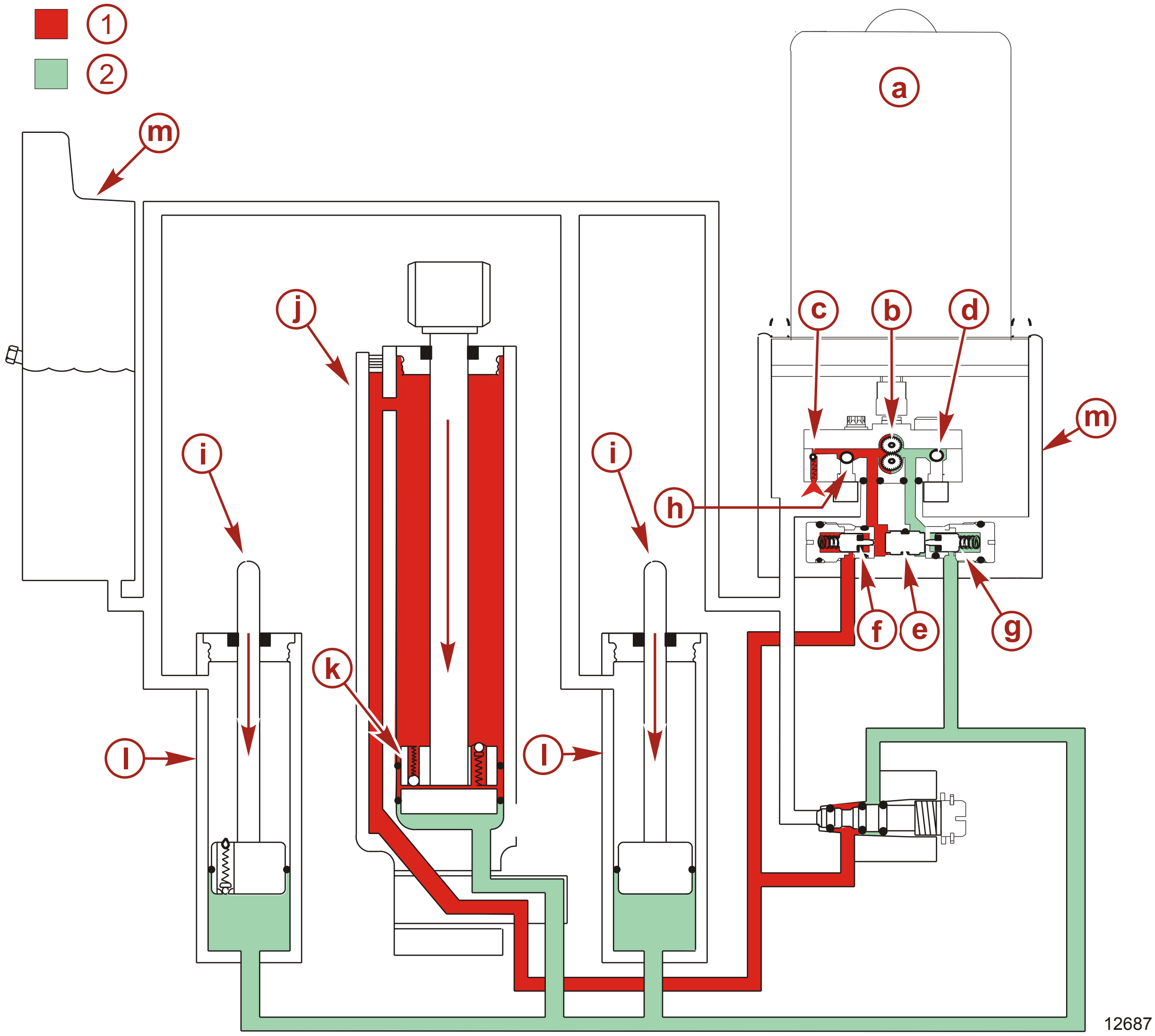
1 - High pressure
2 - Low pressure

a - Trim cylinders
b - Trim relief check valve
c - Port trim ram
d - Tilt cylinder
e - Oil pump
f - Up circuit suction check valve
g - Trim motor

In the up mode, as the trim rams reach the limit of their travel, the mechanical check valve of the trim relief valve, located in the port trim cylinder piston, contacts the cylinder cap. The pin contact with the cover mechanically opens the shut-off valve, allowing the trim relief valve to bypass oil and perform the following functions.

- Trim limit - While the engine is running under thrust (at high engine RPM), the high pressure develops below the pistons. The high pressure will open the check ball on the bottom of the trim relief valve, allowing oil to flow through the port trim cylinder piston. If the operator continues to depress the up button, the up pressure is not sufficient to overcome the propeller thrust, therefore the trim range is limited to the length of the trim cylinders. When the engine thrust falls (low engine RPM), the check ball in the trim relief valve closes, allowing oil flow to extend the tilt cylinder ram into the tilt range.
- Over trim at high thrust - As the operator increases the engine RPM when the engine is raised beyond the trim range, the pressure below the pistons begin to rise. When the pressure is sufficient, the high pressure will open the check ball on the bottom of the trim relief valve, allowing oil to flow through the port trim cylinder piston. Oil will continue to flow through the valve until either the engine contacts the trim rams and the mechanical shut-off valve closes or the engine RPM is reduced.
- Maximum up pressure reduction - As the tilt ram extends to its limit, the up pressure below the pistons will increase and open the trim relief check valve to relieve the up pressure. If the up button is not released, the up flow will continue to dump over relief causing the electric motor to heat up. The thermal overload switch inside the motor will open, stopping the motor.

Trim Down Circuit

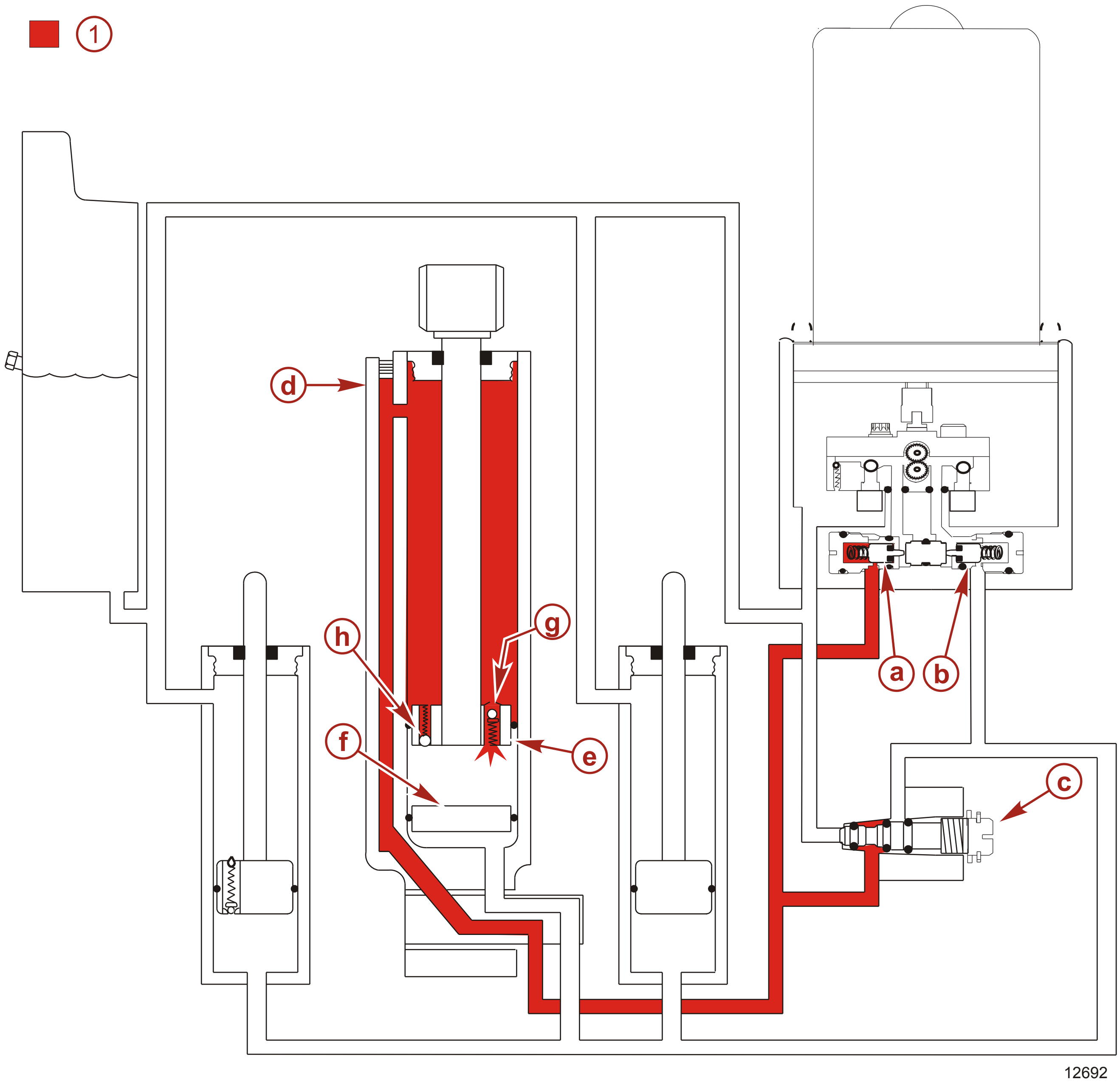


1 - High pressure
2 - Low pressure

- a - Trim motor
- b - Oil pump
- c - Down pressure relief valve
- d - Down circuit suction check valve
- e - Shuttle spool
- f - Down circuit pressure operated valve
- g - Up circuit pressure operated valve
- h - Up circuit suction check valve
- i - Trim ram
- j - Tilt cylinder
- k - Shock piston
- l - Trim cylinders
- m - Reservoir

When you depress the down button, the power trim pump is activated in the opposite direction. As the oil pump gears begin to rotate, oil is drawn through the down circuit suction check valve and into the pump, supplying flow for the down circuit. Oil is blocked from returning into the reservoir by the closed up circuit suction check valve. Oil under pressure then moves the shuttle spool to the right, mechanically opening the up circuit pressure operated valve, allowing oil from the bottom of the trim and tilt cylinders to supply oil to the trim pump for the down circuit. At this same time, oil under pressure opens the down circuit pressure operated valve allowing oil to exit through the down pressure port. The oil then continues through the down pressure passage, through the pivot pin, and into the interconnecting passage of the tilt cylinder leading to the cavity above the shock piston, and pushes the piston and ram assembly in (down). As the outboard contacts the extended trim rams, the weight of the motor and propeller thrust will force the trim rams to retract. When the outboard is fully trimmed in, the down circuit oil pressure is lowered by the down pressure relief valve. Excess oil flows over the relief valve and returns to the reservoir.

Trail Over and Shock Absorber



1 - High pressure

- a - Down circuit pressure operated valve
- b - Up circuit pressure operated valve
- c - Manual tilt valve
- d - Tilt cylinder
- e - Tilt cylinder piston
- f - Memory piston
- g - Impact relief and trail over valves
- h - Return valve

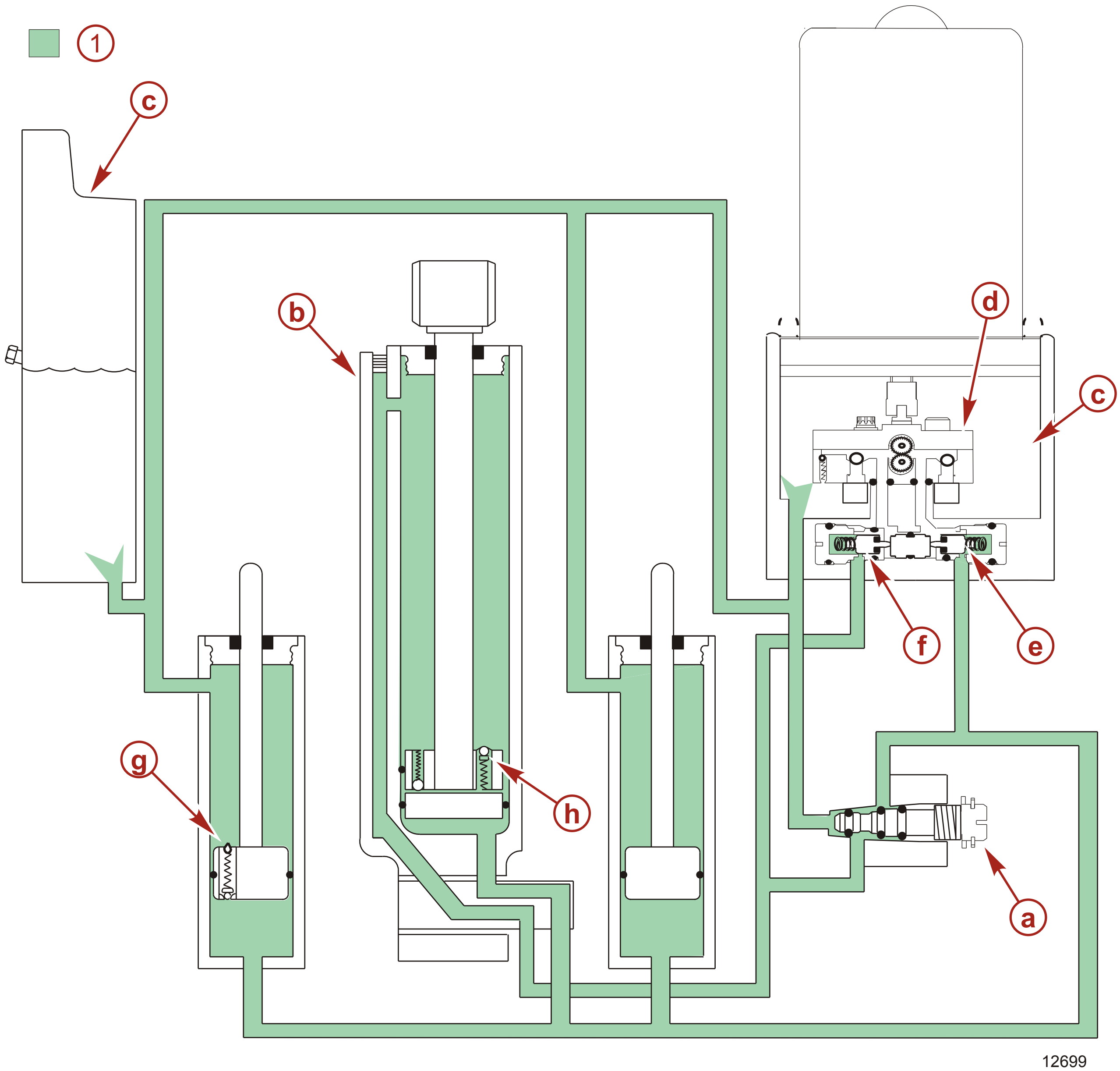
Trail Over System

Should the outboard strike a submerged object with light, steady pressure, while in forward motion, oil will build up sufficient pressure in the top of the tilt cylinder to open the piston trail over relief valve. Oil on the bottom side of the cylinder is locked in by the up circuit pressure operated valve and manual tilt valve. Therefore, the piston trail over relief valve allows the oil from the down side cavity of the trim cylinder to pass through the piston trail over relief valve, into the area between the tilt cylinder piston and the memory piston. The return valve allows the oil to return through the piston, back to the down side cavity as the outboard returns to its normal running position. Propeller thrust and the weight of the outboard provides the return motion for the engine.

Shock System

When a submerged object is hit with great force, oil will build up sufficient pressure in the top of the tilt cylinder to open both the trail over valve and the piston impact relief valves. Oil on the bottom side of the cylinder is locked in by the up circuit pressure operated valve and manual tilt valve. Therefore, the piston impact relief valve allows the oil from the down side cavity of the trim cylinder to pass through the piston impact relief valve, into the area between the tilt ram piston and the memory piston. The return valve allows the oil to return through the piston, back to the down side cavity as the outboard returns to its normal running position. Propeller thrust and the weight of the outboard provides the return motion for the engine.

Manual Tilt



1 - Low pressure

a - Manual tilt valve
b - Tilt cylinder
c - Reservoir
d - Pump
e - Up circuit pressure operated valve
f - Down circuit pressure operated valve
g - Trim relief check valve
h - Impact relief and trail over valves

Manual Tilt System

If the outboard is to be raised or lowered manually, turn the manual release (tilt) valve counterclockwise approximately three turns to the full out position. When in the full out position, oil in the tilt cylinder can flow freely from the up side to the down side or from the down side to the up side. The oil return line into the reservoir is also open, allowing free oil flow to either side of the tilt cylinder to accommodate the differential oil capacities between the tilt cylinder up side and down side cavities. When trimming the outboard in either the up or down position, with the manual tilt valve open or leaking, little or no movement will occur. Oil pressure from the pump will move to both, the up cavity and through the manual tilt valve into the down cavity, each cavity would have equal pressure resulting in little or no movement.

Reverse Operation

To prevent the outboard from coming up or trailing out, when shifted into reverse and/or throttling back rapidly, oil in the trim system must be locked in a static position. This is accomplished by closing the:

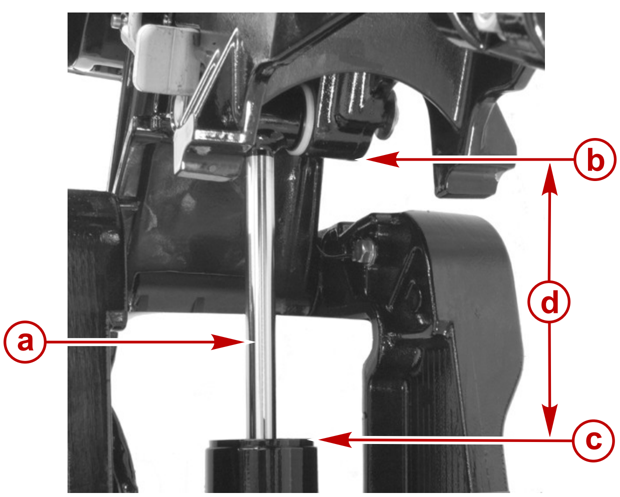
- Up circuit pressure operated valve
- Down circuit pressure operated valve
- Trim relief check valve
- Trail over valve
- Impact relief valves
- Manual release valve

When the above components are closed, oil is trapped, preventing oil in the system from flowing in either direction.

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

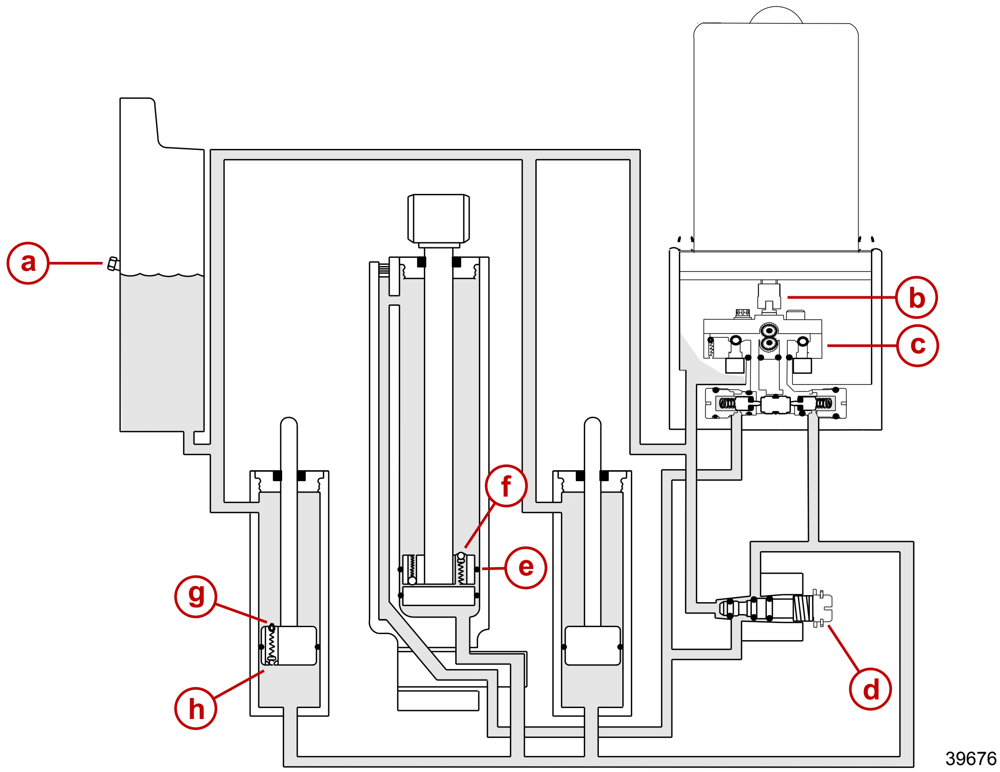
1. Extend the power tilt cylinder to the full up position.

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.)

Power Trim System Troubleshooting

Three Ram Trim System Troubleshooting Diagram



a - Reservoir oil level
b - Pump driveshaft
c - Pump
d - Manual release valve
e - Tilt ram O-ring
f - Tilt piston ball (impact relief and trail over ball)
g - Upper check ball (trim relief valve)
h - Lower check valve

Before troubleshooting the power trim on models with an integral trim system, perform the following checks:

- Visually inspect the system for disconnected wires.
- Visually inspect the system for loose, frayed, or corroded connections.
- Ensure the plug-in connectors are fully engaged.
- Ensure the battery is fully charged.

Trim Motor Does Not Run When the Trim Button is Pressed

Component or Problem	Possible Causes	Corrective Action	Refer To:
Battery	Weak voltage output	Test/charge/replace battery.	**Section 2B - Charging and Starting System**
	Battery voltage drops below 8 V while cranking (PCM cuts out below 8 V) (Fuel pump requires 9 V)	Check condition of battery terminals and cables for loose or corroded connections.	
	Battery cables are loose or corroded	Visually inspect. Service/replace as necessary.	
	Battery cable connections are reversed	Check the cables for correct polarity.	
		Inspect the fusible link between the alternator and the slave solenoid.	
		Service/replace components as necessary.	
Wiring	Wiring reversed in the remote control	Inspect and correct as necessary.	**Electrical System Troubleshooting**
	Wiring harness is corroded	Inspect and service/replace components as necessary.	
	Open circuit in the trim wiring	Visually inspect the wiring in the trim system for disconnected or damaged wires.	
Trim motor	Trim motor brushes need replacement	Inspect the motor brushes for correct length.	**Motor and Electrical Tests/Repair**
		Inspect the brushes for wear.	
		Replace components as necessary.	
	Armature is inoperable	Test the armature for fault. Replace components as necessary.	
	Motor commutator is dirty or worn	Inspect the commutator for wear or dirt. Clean/replace components as necessary.	
Trim switch	Trim switch failure	Determine which switch is faulty (engine or helm).	**Electrical System Troubleshooting**
		Troubleshoot the up or down circuit (whichever applies).	
		Compare results with **Troubleshooting the Up Circuit or Down Circuit,** following.	
Trim relays	Trim relay is inoperative	Perform a power trim relay test to determine failure.	**Power Trim Relay**

Outboard Trims Opposite the Button Direction

Component or Problem	Possible Cause	Corrective Action	Refer To:
Wiring	Wiring reversed in the remote control or on the cowl	Inspect and correct as necessary.	**Electrical System Troubleshooting**

Cowl-Mounted Trim Buttons Do Not Activate the Trim System

Component or Problem	Possible Causes	Corrective Action	Refer To:
Wiring	Open circuit in the trim wiring	Visually inspect the wiring in the trim system for disconnected or damaged wires.	
	Wiring harness is corroded	Inspect and service/replace components as necessary.	
Trim switch	Trim switch failure	Determine which switch is faulty (engine or helm).	**Electrical System Troubleshooting**
		Troubleshoot the up or down circuit (whichever applies).	
		Compare results with **Troubleshooting the Up Circuit or Down Circuit,** following.	

Trim Motor Runs, but Trim System Does Not Respond

Component or Problem	Possible Causes	Corrective Action	Refer To:
Oil level	Low oil level due to a leak	Check the trim fluid level and fill as necessary.	The appropriate procedure within **Check, Fill, and Purge** or **Testing Power Trim System with a Test Gauge** or **Power Trim Assembly Removal and Installation Procedures**
		Inspect for leaks and correct as necessary.	
Pump assembly	Pump assembly is faulty	Inspect the trim pump motor for fault. Service/replace components as necessary.	
Manual release valve	Leaking valve	Pressure check both circuits.	
		Inspect the O-ring condition.	
Pump driveshaft	Broken driveshaft	Inspect the driveshaft for damage/wear. Replace components as necessary.	

Outboard Does Not Trim Down

Component or Problem	Possible Causes	Corrective Action	Refer To:
Pump assembly	Pump assembly is faulty	Inspect the trim pump motor for fault.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures** or **Power Trim Relay**
		Service/replace components as necessary.	
	Pump dirty or clogged	Inspect and clean as necessary.	
Tilt ram piston	Piston ball not seated	Inspect the ball for wear, dirt, or displacement.	
		Service/replace components as necessary.	
		Perform a down pressure check. Replace components as necessary.	
	Worn O-ring	Inspect the O-ring for nicks, cuts, or abrasions.	
Up or down relay or solenoid	Faulty relay or solenoid	Check relay or solenoid for correct operation.	
		Replace as necessary.	

Outboard Does Not Trim Up

Component or Problem	Possible Causes	Corrective Action	Refer To:
Oil level	Low oil level	Check the trim fluid level and fill as necessary.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures** or **Power Trim Relay**
Check valve	Lower check valve is not seating in the port trim ram	Perform an up pressure check.	
		Replace components as necessary.	
Trim cylinder	Damaged cylinder due to impact	Inspect and replace damaged components as necessary.	
Up or down relay or solenoid	Faulty relay or solenoid	Check relay or solenoid for correct operation.	
		Replace as necessary.	

Partial or Jerky Trim Up or Down

Component or Problem	Possible Causes	Corrective Action	Refer To:
Oil level	Low oil level	Check the trim fluid level and fill as necessary.	The appropriate procedure within **Check, Fill, and Purge** or **Power Trim Assembly Removal and Installation Procedures**
Tilt ram piston	Piston ball not seated	Inspect the ball for wear, dirt, or displacement.	
		Service/replace components as necessary.	
Wiring	Loose connection	Check all wiring/harness connections. Correct as necessary.	

Thump Noise Heard When Shifting

Component or Problem	Possible Causes	Corrective Action	Refer To:
Pump assembly	Pump assembly is faulty	Service/replace components as necessary. Pressure operated check or shuttle spool sticking.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures**
		Inspect the trim pump for fault.	
System fluid	Air in oil. Air trapped under a piston or in a valve.	Check the trim fluid level and fill as necessary. Purge system.	
Tilt ram piston	Piston ball not seated	Inspect the ball for wear, dirt, or displacement.	
		Service/replace components as necessary.	
Check valve	Lower check valve is not seating in the port trim ram	Check components for fault. Service/replace components as necessary.	
	Upper check valve is not seating in the port trim ram	Check components for fault. Service/replace components as necessary.	

Outboard Does Not Trim Under Load

Component or Problem	Possible Causes	Corrective Action	Refer To:
Manual release valve	Leaking valve	Inspect the O-ring condition.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures** or **Check, Fill, and Purge**
Battery	Low battery voltage	Inspect/charge/replace as necessary.	
Motor assembly	Motor is inoperable	Replace motor assembly.	
Pump driveshaft	Broken driveshaft	Inspect the driveshaft for damage/wear.	
		Replace components as necessary.	

Outboard Does Not Maintain Trim Position Under Load

Component or Problem	Possible Causes	Corrective Action	Refer To:
Pump assembly	Pump assembly is faulty	Inspect the trim pump motor for fault.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures** or **Check, Fill, and Purge**
		Service/replace components as necessary.	
Manual release valve	Leaking valve	Inspect the O-ring condition.	
Check valve	Lower check valve is not seating in the port trim ram	Check components for fault.	
		Service/replace components as necessary.	
System fluid	Contamination	Drain fluid and refill with clean fluid.	

Trail Out When Backing Off from High Speed

Component or Problem	Possible Causes	Corrective Action	Refer To:
Tilt ram piston	Piston ball not seated	Inspect the ball for wear, dirt, or displacement.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures**
		Service/replace components as necessary.	
	Worn O-ring	Inspect the O-ring for nicks, cuts, or abrasions.	

System Leaks Down and Does Not Hold Trim

Component or Problem	Possible Causes	Corrective Action	Refer To:
Pump assembly	Pump assembly is faulty	Inspect the trim pump motor for fault.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures**
		Service/replace components as necessary.	
Manual release valve	Leaking valve	Inspect the O-ring condition.	
Check valve	Upper check valve is not seating in the port trim ram	Check components for fault.	
		Service/replace components as necessary.	

Trim is Slow Up or Down

Component or Problem	Possible Causes	Corrective Action	Refer To:
Battery	Low battery voltage	Inspect/charge/replace as necessary.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures** or **Check, Fill, and Purge**
Motor assembly	Worn brushes	Inspect and replace as necessary.	
	Loose connection	Inspect and replace as necessary.	
Oil level	Low oil level	Check the trim fluid level and fill as necessary.	
Pump assembly	Pump assembly is faulty	Inspect the trim pump motor for fault.	
		Service/replace components as necessary.	
Trim fluid	Incorrect type of trim fluid for application	Ensure the correct trim fluid is used.	

Starts to Trim Up from Full Down When the In Button is Pressed

Component or Problem	Possible Causes	Corrective Action	Refer To:
Tilt ram piston	Piston ball not seated	Inspect the ball for wear, dirt, or displacement.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures**
		Service/replace components as necessary.	
	Worn O-ring	Inspect the O-ring for nicks, cuts, or abrasions.	

Outboard Does Not Maintain Trim Position in Reverse

Component or Problem	Possible Causes	Corrective Action	Refer To:
Tilt ram piston	Piston ball not seated	Inspect the ball for wear, dirt, or displacement.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures**
		Service/replace components as necessary.	
	Worn O-ring	Inspect the O-ring for nicks, cuts, or abrasions.	

Electrical System Troubleshooting

General Checks

Before troubleshooting the power trim electrical system, check the following:

- Disconnected wires
- Connections are tight and corrosion-free
- Plug-in connections are fully engaged
- Battery is fully charged

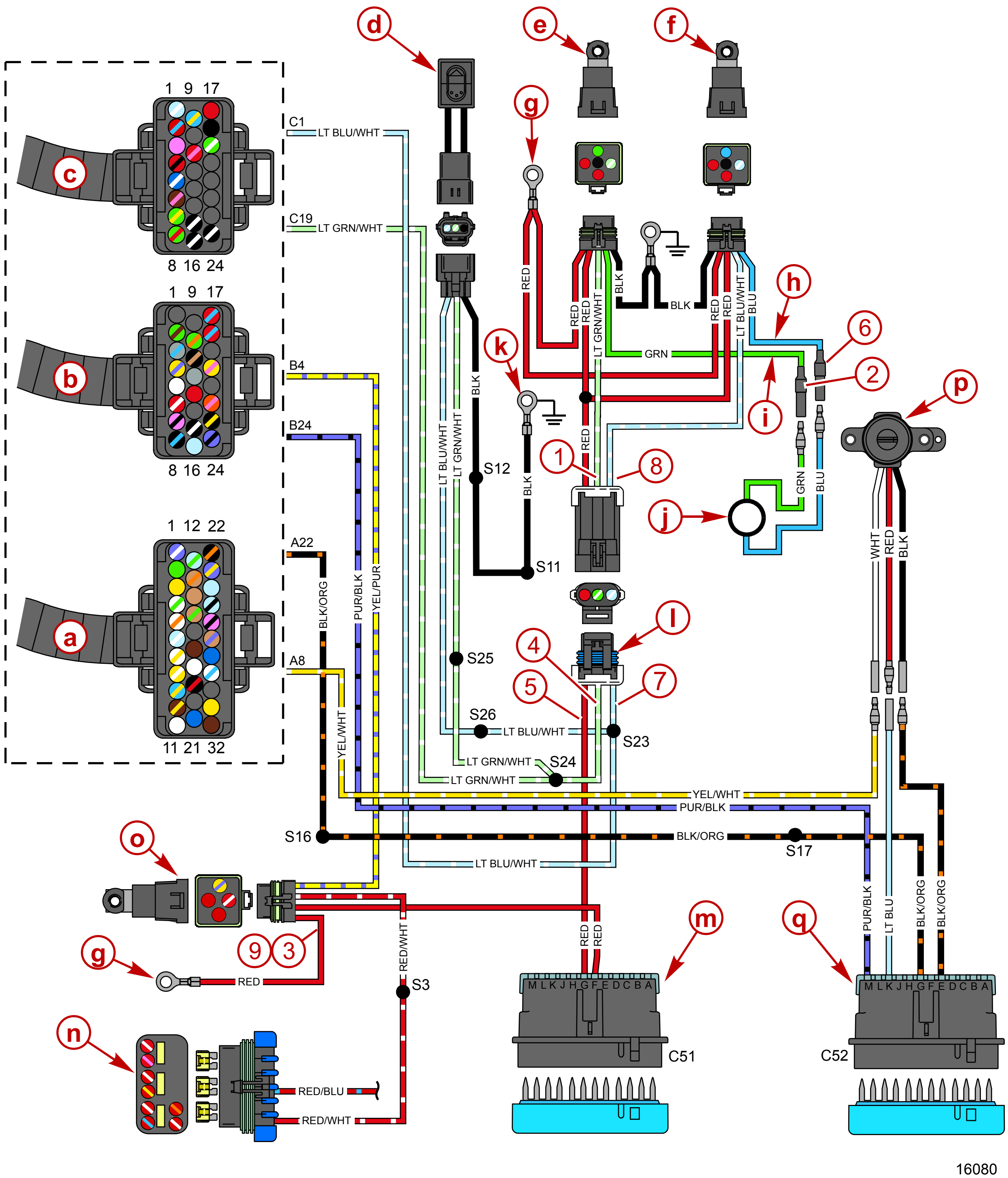
Condition/Problem

Condition of Trim System	Problem No.
Trim motor does not run when trim button is depressed	1, 2, 4, 5, 6, 8
Trim system trims opposite of buttons	3
Cowl-mounted trim buttons do not activate trim system	2, 4, 5, 6

Problem/Solution

No.	Problem	Solution
1.	Battery low or discharged	Check battery.
2.	Open circuit in trim wiring	Check for an open connection.
3.	Wiring reversed in remote control, cowl switch, or trim leads	Verify connections.
4.	Wire harness corroded through	Replace wire harness.
5.	Internal motor problem (brushes, shorted armature)	Check for open connection. Replace motor.
6.	Trim switch failure	Replace switch.
7.	Relay not operating	Verify relays are functioning correctly. Check voltage at trim bullets.

Power Trim Electrical Circuit



- a - PCM connector A
- b - PCM connector B
- c - PCM connector C
- d - Cowl tilt switch
- e - Down relay
- f - Up relay
- g - +12 V power
- h - Up lead at motor
- i - Down lead at motor
- j - Power trim motor
- k - –12 V ground
- l - Power trim harness connector
- m - Splice saver C51
- n - Fuse holder
- o - Main power relay
- p - Trim position sensor
- q - Splice saver C52

Troubleshooting the Down Circuit

NOTE: Refer to the preceding wiring diagrams for connection points when troubleshooting the electrical systems. Connection points are specified by number.

DMT 2004 Digital Multimeter	91-892647A01

Step	Test Procedure	Test Result
Step 1: Check for battery voltage at Point 1.	☐ Disconnect down relay. ☐ Connect voltmeter black lead to Point 1 and red lead to battery positive. ☐ Depress the down trim button.	Battery voltage measured: • Reconnect down trim relay. • 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.	☐ Disconnect 3 pin connector. ☐ Connect voltmeter black lead to Point 4 and red lead to battery positive. ☐ Depress the down trim button.	Battery voltage measured: • Wire is open between Points 4 and 1. No battery voltage measured: • Reconnect 3 pin connector. • 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: • Trim 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.	☐ Connect voltmeter red lead to Point 2 (female bullet connector) and black lead to ground. ☐ Depress the down trim 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 Trim Relay Test**.	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 connection points when troubleshooting the electrical systems. Connection points are specified by number.

DMT 2004 Digital Multimeter	91-892647A01

Step	Test Procedure	Test Result
Step 1: Check for battery voltage at Point 8.	☐ Disconnect up relay. ☐ Connect voltmeter black lead to Point 8 and red lead to battery positive. ☐ Depress the up trim button.	Battery voltage measured: • Reconnect up trim relay. • 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.	☐ Connect voltmeter black lead to Point 7 and red lead to battery positive. ☐ Depress the up trim button.	Battery voltage measured: • Wire is open between Points 7 and 8. No battery voltage measured: • Reconnect 3 pin connector. • 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: • Trim 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.	☐ Connect voltmeter red lead to Point 6 and black lead to ground. Depress the up trim 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 Trim Relay Test**.	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 connection points when troubleshooting the electrical systems. Connection points are specified by number.

DMT 2004 Digital Multimeter	91-892647A01

Step	Test Procedure	Test Result
Step 1: Check fuse.	☐ Visually inspect power trim motor fuse.	Fuse blown: • Correct problem that caused the fuse 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: Up trim switch.	☐ Connect voltmeter black lead to Point 1 and red lead to battery positive. ☐ Depress up trim 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:
		• Trim switch is faulty or
		• Open circuit in wires (grn/wht or blu/wht) between trim buttons and trim pump motor.
		• Check:
		  • Trim switch.
		  • All trim harness connections for loose or corroded connections.
		  • Pinched or severed wires.

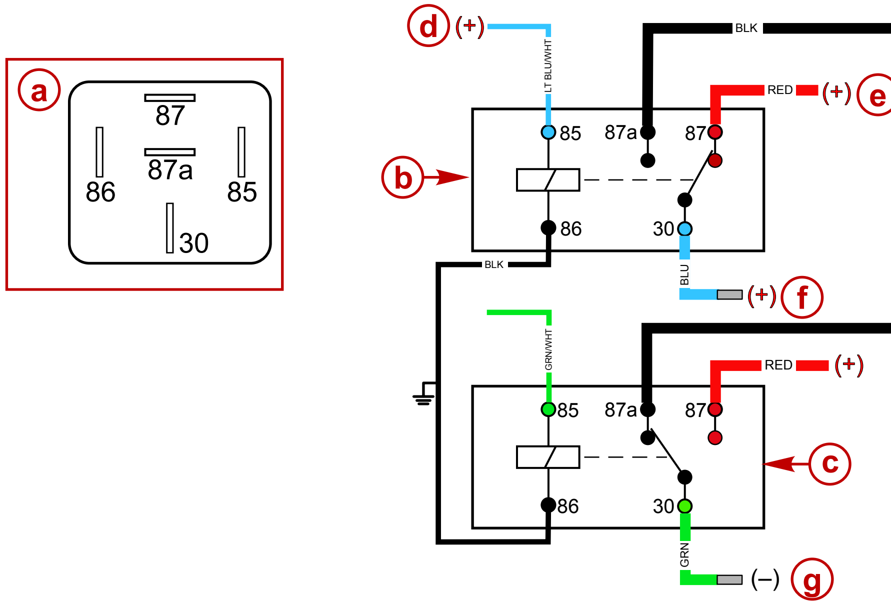
Step 5: Check voltage.	Check that voltage is being supplied to control by performing the following checks:
	☐ Do not start engine.
	☐ Turn ignition switch to "RUN" position.
	☐ Check for voltage at any instrument using a voltmeter.
		No voltage measured:
		• Red wire is open between Point 3 and red terminal on back of ignition switch.
		  • Check for loose or corroded connections.
		  • Check wires for open.
		Battery voltage measured:
		• There is an open circuit between Point 5 and red terminal on back of ignition switch.

Power Trim Relay

Trim Circuit

When the relays are de-energized, contacts 30 and 87a complete the circuit to the trim motor leads. Both motor leads are to ground.

When contact 85 is energized from the trim switch, the up relay is energized. Contacts 30 and 87 close, completing the circuit to 12 V (+) to the blue trim motor lead. The trim down relay remains de‑energized. The trim motor tilts the engine up.



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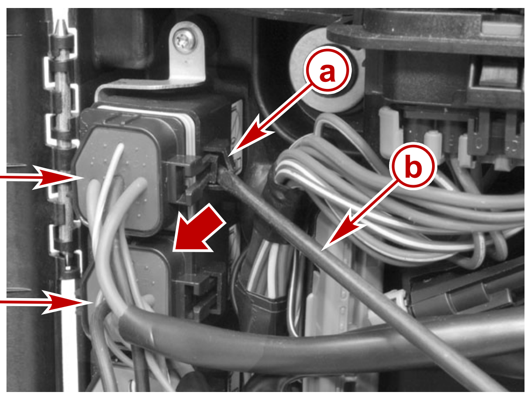
Trim up circuit

- a - Trim relay contacts
- b - Trim up relay
- c - Trim down relay
- d - To trim up switch
- e - 12 V (+)
- f - To trim motor (+)
- g - To trim motor (–)

Power Trim Relay Test

NOTE: To remove the power trim relays, insert a flat blade screwdriver in the relay lock tab. Gently twist the blade and pry the relay loose. Pull the relay out. Do not pull with the wires.



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- a - Lock tab
- b - Flat blade screwdriver
- c - Down trim relay
- d - Up trim relay

The trim motor relay system, used on permanent magnet trim systems, connects each of the two wires from the trim motor to either ground or positive 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 trim system does not operate in one direction:

1. Disconnect the heavy gauge pump wires from the trim control relay.
2. Check for continuity between the heavy leads from the trim relays to ground.

DMT 2004 Digital Multimeter	91‑892647A01

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Green	Ground	Full continuity (R x 1)	< 20 Ω
Blue	Ground	Full continuity (R x 1)	< 20 Ω

3. Replace the relay that does not have continuity.
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 and 12 volts on the green lead when the down switch is pushed. Replace the relay that does not switch the lead to positive.

Trim Position Sensor

Trim Position Sensor Troubleshooting

Trim Position Sensor

The trim position sensor (TPS) is located on the port side of the outboard. It supplies the propulsion control module (PCM) with trim position information. The TPS and PCM limit the trim angle when engine speed is greater than 2000 RPM and limits the tilt angle for trailering. The PCM will generate and store a failure code when the TPS fails, but it will not sound an alarm horn.

The trim sensor only affects trim functions controlled by the helm trim switch. The trim system will function with the cowl tilt switch and will operate regardless of the position reported by the trim position sensor. This means there are no trim or trailer limits when using the cowl tilt switch. The engine will trim as long as the tilt switch is depressed or until the mechanical stop is reached.

The following are some of the problems encountered with a faulty trim position sensor:

- Engine speed limited to 2000 RPM
- Engine will trim higher than the set trim limit at speeds above 2000 RPM
- Engine trims past the maximum trailer limits
- Engine trims normally, but there are no trailer limits

NOTE: If an operator tries to set trim limits with a faulty TPS without noticing the sender output is not changing, and sets the trim and trailer limits to the same point, the trim system will not function. The PCM needs to be reprogrammed or replaced.

Troubleshooting the Trim Position Circuit

Computer Diagnostic System (CDS)	Order through SPX
DMT 2004 Digital Multimeter	91-892647A01
Breakout Box	SPX P/N MM-46225

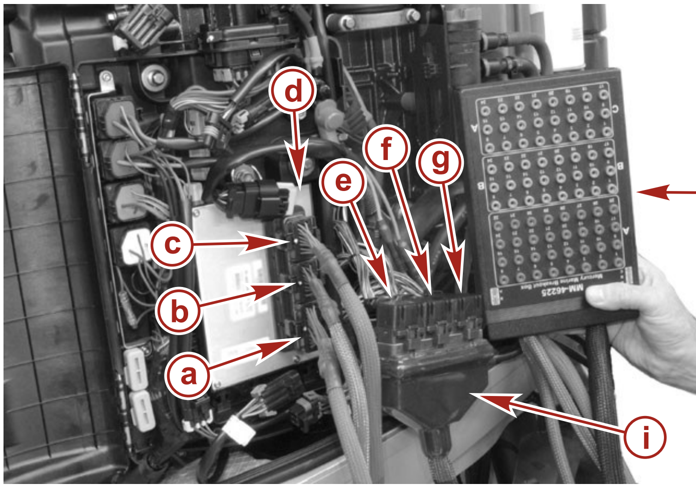
Step	Test Procedure	Test Result
Step 1: Check trim position sensor using trim gauge.	☐ Turn key to "ON" position. ☐ Trim engine up and down. ☐ Observe trim position gauge on instrument panel.	Trim position gauge varies with engine trim position: • Trim position sensor is good. • Go to Step 2. Trim position gauge does not vary with engine trim position: • Go to Step 2.
Step 2: Check trim position sensor using CDS.	☐ Turn key to "OFF" position. ☐ Connect digital CDS to engine. ☐ Turn key to "ON" position. ☐ Observe trim position sensor counts on CDS. ☐ Trim engine up and down.	Count increases as engine trims up and decreases as engine trims down: • Trim position sensor is good. Count does not vary with engine trim position: • Go to Step 3.
Step 3: Check PCM harness for open or short circuit.	☐ Turn key to "OFF" position. ☐ Disconnect CDS from engine. ☐ Connect breakout box black lead to PCM harness connectors. Do not connect red, green, or blue leads to PCM. Refer to **Breakout Box Connections,** following. ☐ Disconnect trim position sensor bullet connectors. Refer to **Trim Position Sensor Location,** following. ☐ Check resistance from breakout box pin to TPS harness connector (PCM harness side). ☐ Pin B24 to light blue. ☐ Pin A22 to black/orange. ☐ Pin A8 to yellow/white.	Resistance measured is less than 0.8 ohms: • Go to step 4. Resistance measured is greater than 0.8 ohms: • PCM harness may be faulty.

Step	Test Procedure	Test Result
Step 4: Check transducer voltage.	☐ Turn key to "OFF" position. ☐ Connect trim position sensor bullet connectors. ☐ Connect red, green, and blue breakout box leads to PCM. ☐ Turn key to "ON" position. ☐ Check transducer power between pin A22 and B24 of breakout box.	Voltage measured is 4.0–5.0 VDC: • Go to Step 5. Voltage measured is out of specified range: • Go to Step 6.
Step 5: Check trim position sensor output voltage.	☐ Turn key to "ON" position. ☐ Check trim position sensor voltage output between pin A22 and A8 of breakout box. ☐ Trim outboard from full in to full out.	Voltage measured varies between a minimum of 0.5 VDC and a maximum of 3.75 VDC: • Trim position sensor is good. Voltage measured is out of specified range: • Go to Step 6.
Step 6: Check trim position sensor resistance.	☐ Turn key to "OFF" position. ☐ Disconnect red, green, and blue breakout box leads from PCM. ☐ Check trim position sensor resistance. Refer to chart following for specifications.	Resistance measured is within specification in table: • Go to Step 7. Resistance measured is not within specification in table: • Trim position sensor is faulty. • Go to Step 7.
Step 7: Check resistance sensor signal pin and ground in PCM.	☐ Disconnect PCM harness leads from breakout box black lead. ☐ Connect red, green, and blue breakout box leads to PCM. ☐ Check resistance between pin A8 and B24 of breakout box.	Resistance measured is 215.6–224.4 kΩ. • Replace trim position sensor. Open or short measured: • Replace PCM.

Trim Position Sensor Resistance Table

Meter Test Leads		Meter Scale	Reading (Ω)
Red	Black		
Breakout box pin B24	Breakout box pin A22	Ω	4100–7600
Breakout box pin B24	Breakout box pin A8	Ω	120–220
Breakout box pin A22	Breakout box pin A8	Ω	4150–7700

Breakout Box Connections



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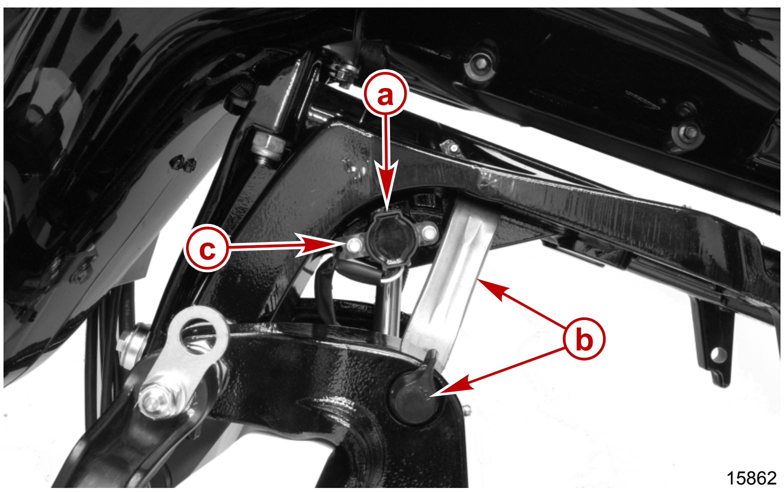
- a - Breakout box connector A - Red lead
- b - Breakout box connector B - Green lead
- c - Breakout box connector C - Blue lead
- d - PCM
- e - Engine harness connector C
- f - Engine harness connector B
- g - Engine harness connector A
- h - Breakout box
- i - Breakout box main connector - Black lead

DMT 2004 Digital Multimeter	91-892647A01
Breakout Box	SPX P/N MM-46225

Trim Position Sensor Location



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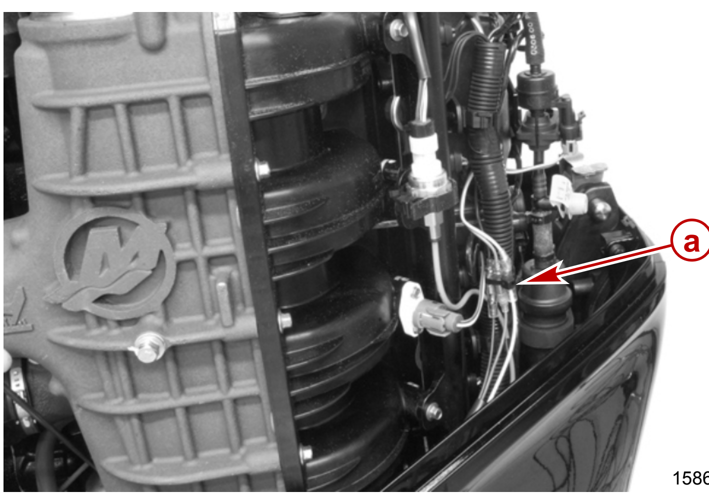
- a - Trim position sensor
- b - Tilt support lever
- c - Trim position sensor mounting screw (2)



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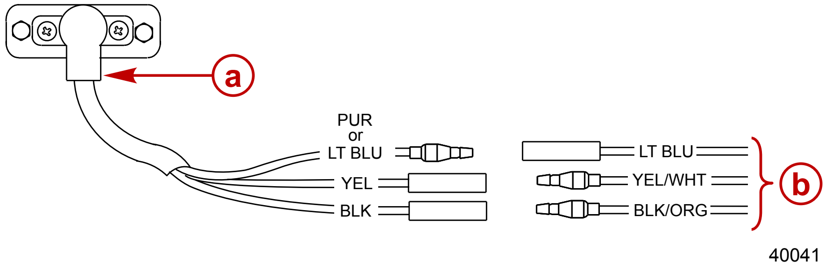
- a - Trim position sensor bullet connectors

Testing the Trim Position Sensor with DMT 2004A

The trim sender requires a 5 V reference signal from the PCM.



a - Trim position sensor
b - Engine harness

NOTE: The wire color on the trim position sender was changed from purple to light blue.

Check for voltage with the ignition switch in the "RUN" position and using an appropriate probe (paper clip, etc.) inserted in parallel at the trim sender bullet connectors.

DMT 2004 Digital Multimeter	91-892647A01

Meter Test Leads		Meter Scale	Reading
Red	Black		
Red (light blue)	Black (black/orange)	VDC	4.0–5.0

NOTE: The 5 V reference at the PCM can be monitored by the CDS. Voltage should be 5 VDC ± 0.1 VDC. Any other voltage indicates a defective PCM. If the PCM reference voltage is correct, but voltage at the trim sender is low or nonexistent, inspect the sender wiring and connections.

Voltage at the trim sender should rise and fall smoothly as the outboard is raised or lowered.

With the ignition switch in the "RUN" position and using an appropriate probe (paper clip, etc.) inserted in parallel at the trim sender bullet connectors, this voltage can be checked as follows:

Meter Test Leads		Trim Position	Reading (VDC)
Red	Black		
White (yellow/white)	Black (black/orange)	Full in	0.5–1.0
		Start of tilt	1.0–2.0
		Full up	3.0–3.75

If voltage is not as indicated or voltage rise and fall is erratic, the trim sender is defective.

Testing the Trim Position Sensor with Breakout Box

The trim sender requires a 5 V reference signal from the PCM.

Check for voltage with the ignition switch in the "RUN" position. Use the breakout box to measure voltage.

Breakout Box	SPX P/N MM-46225

Meter Test Leads		Meter Scale	Reading
Red	**Black**		
Breakout box pin B24	Breakout box pin A22	VDC	4.0–5.0

NOTE: The 5 V reference at the PCM can be monitored by the CDS. Voltage should be 5 VDC ± 0.1 VDC. Any other voltage indicates a defective PCM. If the PCM reference voltage is correct, but voltage at the trim sender is low or nonexistent, inspect the sender wiring and connections.

Voltage at the trim sender should rise and fall smoothly as the outboard is raised or lowered.

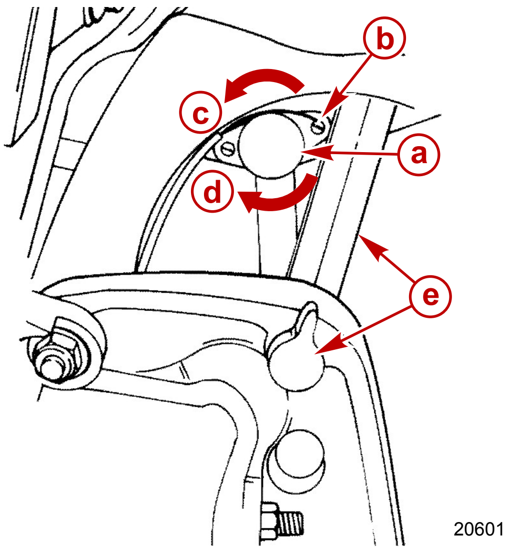
Check for voltage with the ignition switch in the "RUN" position. Use the breakout box to measure voltage.

Breakout Box	SPX P/N MM-46225

Meter Test Leads		Trim Position	Reading (VDC)
Red	**Black**		
Breakout box pin A8	Breakout box pin A22	Full in	0.5–1.0
		Start of tilt	1.0–2.0
		Full up	3.0–3.75

Trim Indicator Gauge Needle Adjustment

1. Turn the ignition key to the "RUN" position.
2. Tilt the outboard to the full in position. The needle of the trim indicator gauge should be in the full in position.
3. If not, tilt the outboard to the full out position to gain access to the trim sender.
4. Engage the tilt lock lever.
5. Loosen the trim sender screws and reposition the trim sender.
6. Tighten the trim sender screws.



a - Trim sender
b - Screw (2)
c - Rotate the sender counterclockwise to raise the needle reading
d - Rotate the sender clockwise to lower the needle reading
e - Tilt lock lever

Testing Power Trim System with a Test Gauge

Up Pressure Check

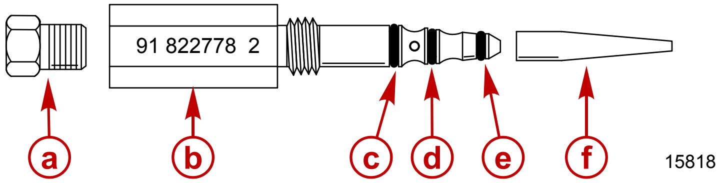
IMPORTANT: This test will not locate problems in the trim system. The test will show if the system is correct after a repair. If minimum pressures are not obtainable, the trim system requires additional repair.
Ensure battery is fully charged before performing tests.

⚠ 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.

1. Tilt outboard to full up position and engage tilt lock lever.
2. Slowly remove fill plug to bleed pressure from reservoir.
3. Remove circlip securing manual release valve and unscrew release valve from trim assembly.

   NOTE: A small amount of trim fluid may drip from manual release valve hole. Place a suitable container under trim assembly to collect any leakage.

NOTE: Assemble the test adapter by using the O-ring installation tool to position a small O-ring onto the adapter first. Then install the medium O-ring second. Lastly, install the large O-ring. Thread the brass fitting into the test adapter securely using 567 Pipe Sealant on the threads.



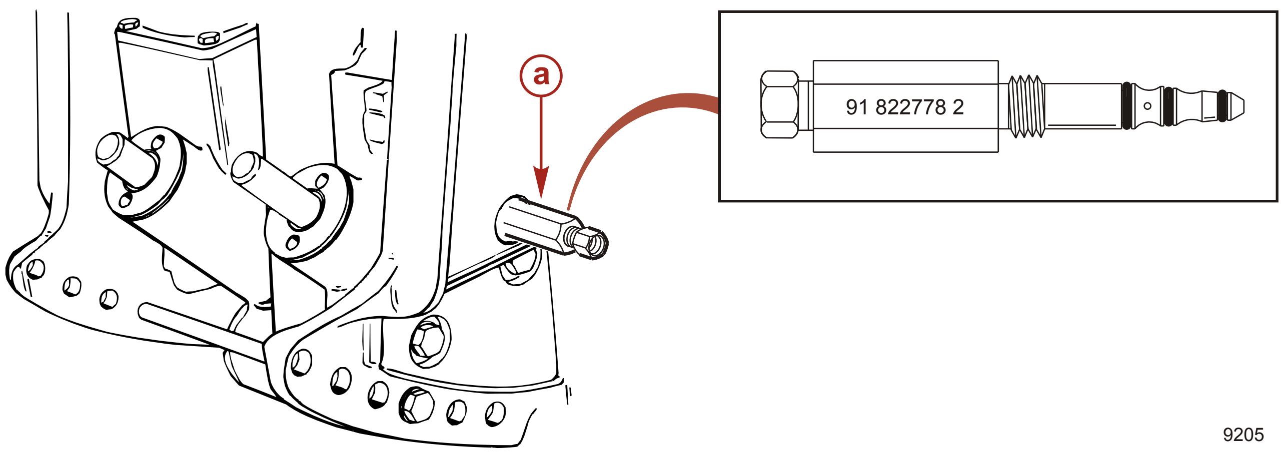
a - Brass fitting
b - Test adapter
c - Large O-ring (install last)
d - Medium O-ring (install second)
e - Small O-ring (install first)
f - O-ring installation tool

Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Brass fitting threads	92-809822

Adapter Fitting	91-822778A 2

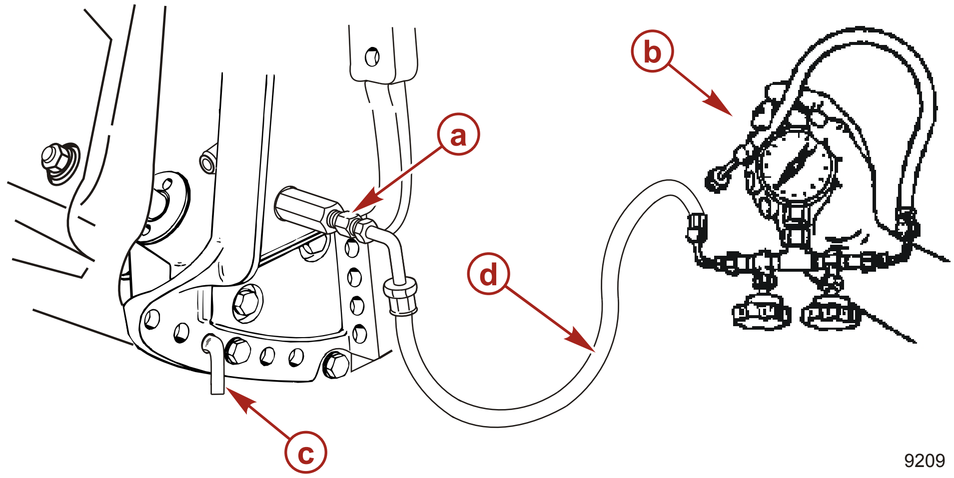
Trim Up Relief Valve Pressure (Tilt cylinder extended)	
Pressure	6100–7750 kPa (885–1125 psi)

4. Install test adapter into manual release valve hole.



a - Test adapter

5. Thread hose from test gauge kit into brass fitting on adapter.



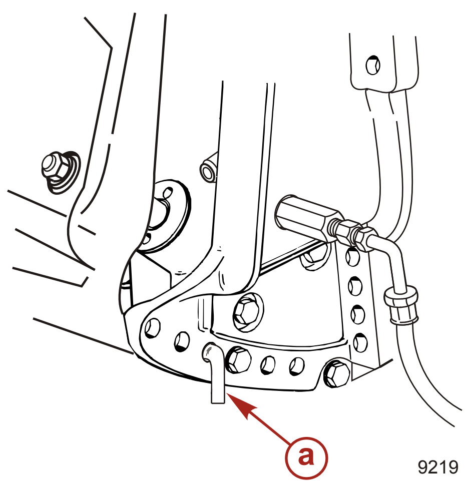
a - Brass fitting
b - Test gauge assembly
c - Tilt pin
d - Hose

Power Trim Test Gauge Kit	91-52915A6

6. Install fill plug.
7. Run trim up and disengage tilt lock lever.

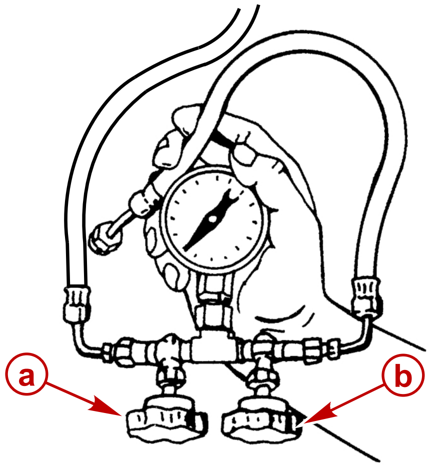
IMPORTANT: Install the tilt pin correctly to prevent transom failure and personal injury.

8. Move the outboard in until hole in swivel bracket ear aligns with the third tilt hole in transom bracket. Lock engine in trim range by installing a 10 mm (3/8 in.) diameter tilt pin or two 10 mm (3/8 in.) hardened bolts and nuts through the transom brackets and swivel bracket in the hole shown.



a - Tilt pin inserted into tilt pin hole

9. Open valve "a" and close valve "b."



a - Valve A
b - Valve B

10. Run trim up. The minimum pressure should be 6100 kPa (885 psi).
11. Run trim down to release pressure and remove spare tilt pin or bolts and nuts.
12. Tilt outboard full up and engage tilt lock lever.
13. Slowly remove fill plug to bleed pressure.
14. Remove test gauge hose and adapter.
15. Install manual release valve and secure valve with circlip.
16. Tighten fill plug.

NOTE: If pressure is less than 6100 kPa (885 psi), troubleshoot system per instructions preceding in this section.

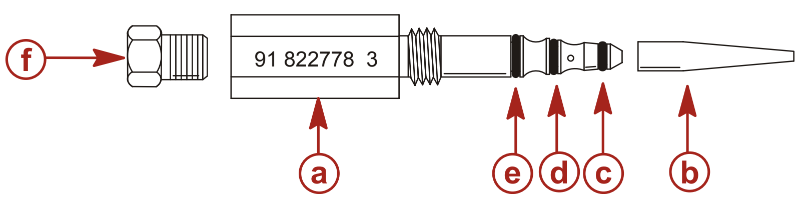
Down Pressure

IMPORTANT: Ensure battery is fully charged before performing tests.

1. Tilt outboard to full up position and engage tilt lock lever.
2. Slowly remove fill plug to bleed pressure from reservoir.
3. Remove circlip securing manual release valve and unscrew release valve from trim assembly.

NOTE: A small amount of trim fluid may drip from manual release valve hole. Place a suitable container under trim assembly to collect any leakage.

Assemble the test adapter by using the O-ring installation tool to position a small O-ring onto the adapter first. Then install the medium O-ring second. Lastly, install the large O-ring. Thread the brass fitting into the test adapter securely using 567 Pipe Sealant on the threads.



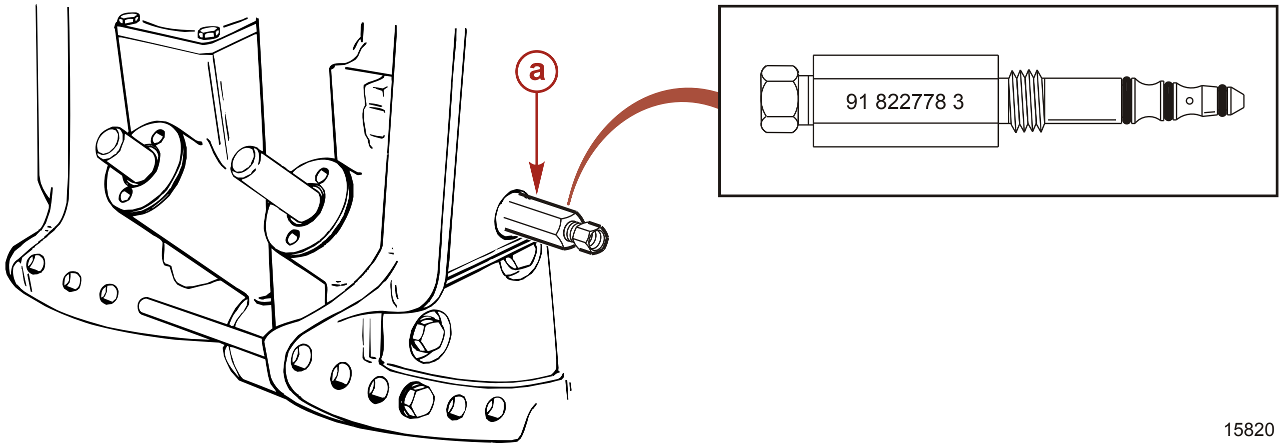
a - Test adapter
b - O-ring installation tool
c - Small O-ring (install first)
d - Medium O-ring (install second)
e - Large O-ring (install last)
f - Brass fitting

Tube Ref No.	Description	Where Used	Part No.
9	Loctite 567 PST Pipe Sealant	Brass fitting threads	92-809822

Adapter Fitting	91-822778A 3

Power Trim Down Relief Valve	
Pressure	4400–7300 kPa (640–1060 psi)

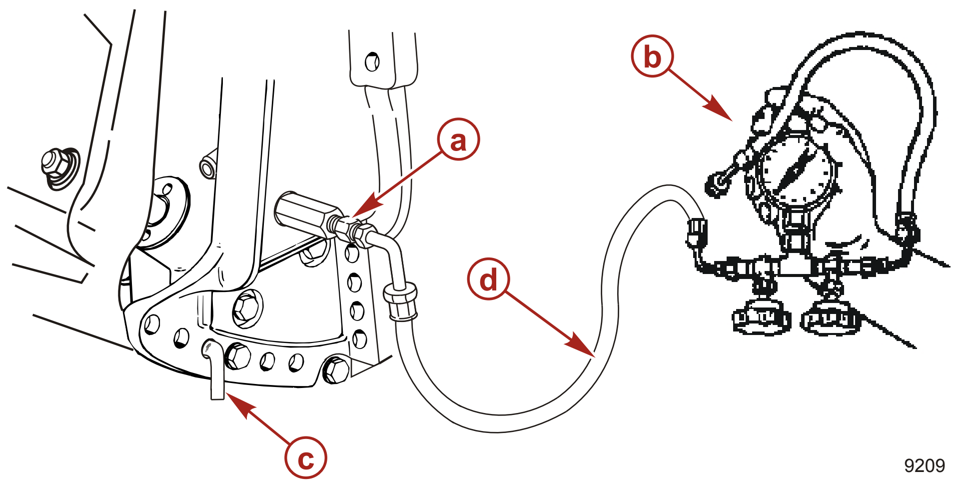
4. Install test adapter into manual release valve hole.



15820

a - Test adapter

5. Thread hose from test gauge kit into brass fitting on adapter.

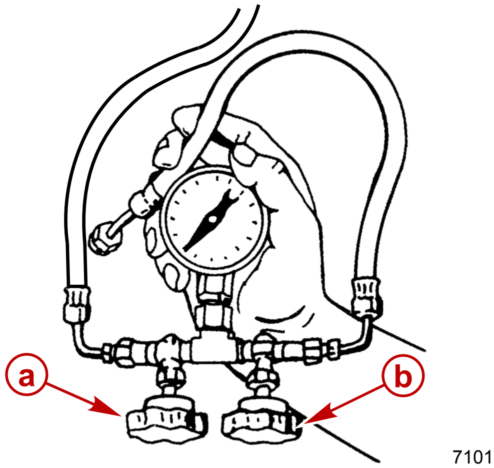


9209

a - Brass fitting
b - Test gauge assembly
c - Tilt pin
d - Hose

6. Install fill plug.
7. Run trim up.
8. Disengage tilt lock lever.

9. Open valve "a" and close valve "b."



a - Valve A
b - Valve B

Power Trim Test Gauge Kit	91-52915A6

10. Run trim down. Minimum pressure should be 4400 kPa (640 psi).
11. Tilt outboard full up and engage tilt lock lever.
12. Slowly remove fill plug to bleed pressure.
13. Remove test gauge hose and adapter.
14. Install manual release valve and secure valve with circlip.
15. Tighten fill plug.

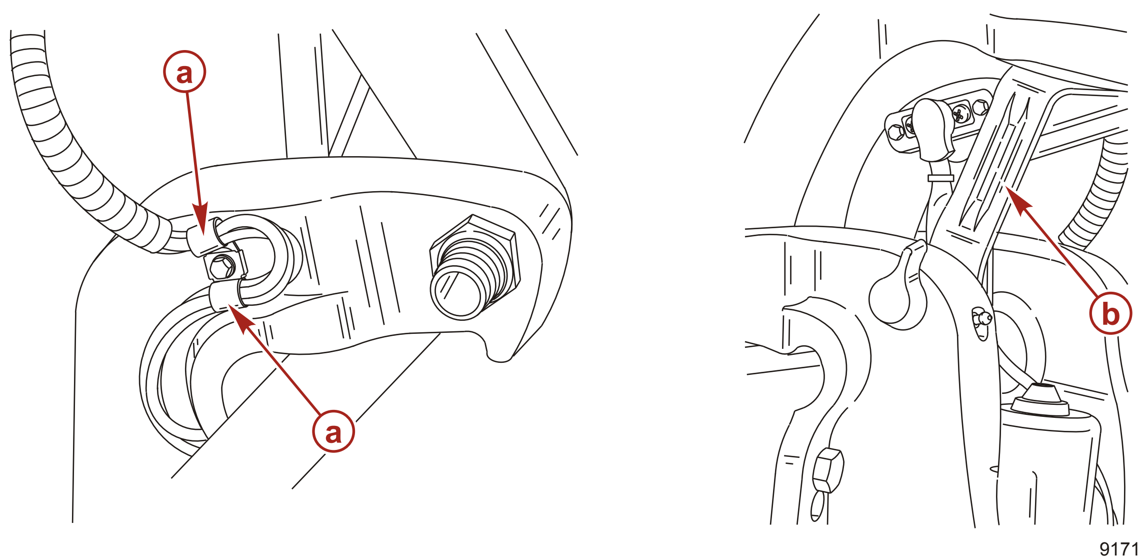
NOTE: If pressure is less than 4400 kPa (640 psi), troubleshoot system per instructions preceding in this section.

Power Trim Assembly Removal and Installation Procedures

Power Trim Assembly Removal

1. Remove the clamps on the transom bracket to free the power trim wiring.
2. Raise the outboard to full up position and engage the tilt lock lever.
3. Remove the trim indicator.

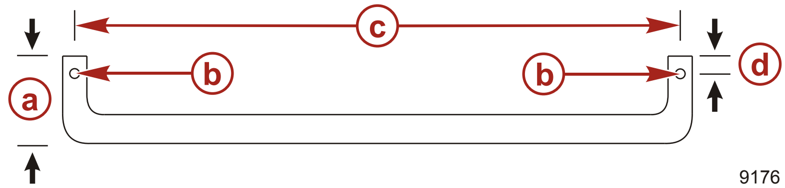
IMPORTANT: Support the outboard as shown below to prevent the engine from tipping when the power trim retaining pin is removed.



a - Clamps
b - Tilt lock lever

4. Create an appropriate support tool using a 9.5 mm (3/8 in.) diameter metal rod with the following dimensions:

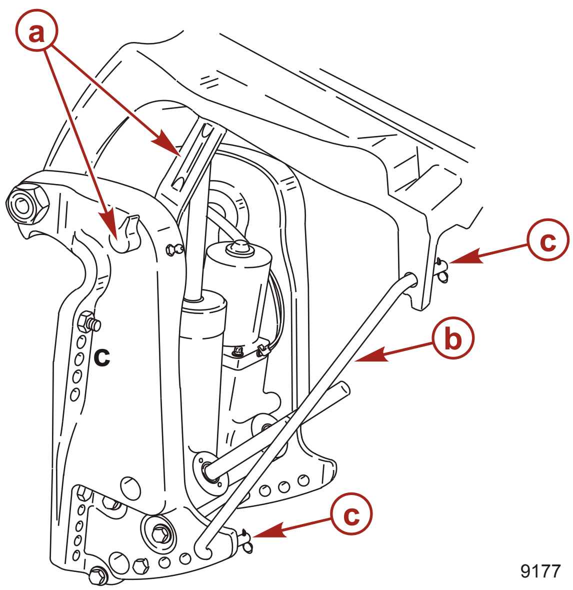
NOTE: A used shift shaft works well to create this support tool.



a - 50.8 mm (2 in.)
b - Drill holes for retaining clip
c - 35.56 cm (14 in.)
d - 6.35 mm (1/4 in.)

5. Support the outboard, as shown, using the support tool.

⚠ CAUTION
Failure to support the outboard can result in serious injury. Always support the outboard with the tilt-lock lever and support tool when servicing the outboard.

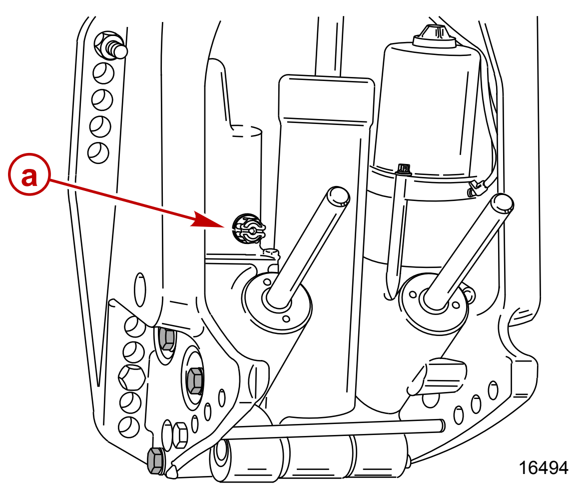


a - Tilt lock lever
b - Support tool
c - Retaining clips

6. Disconnect the blue and the green bullet connector harness.

⚠ 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.

7. Open the filler cap and release any remaining pressure in the system.

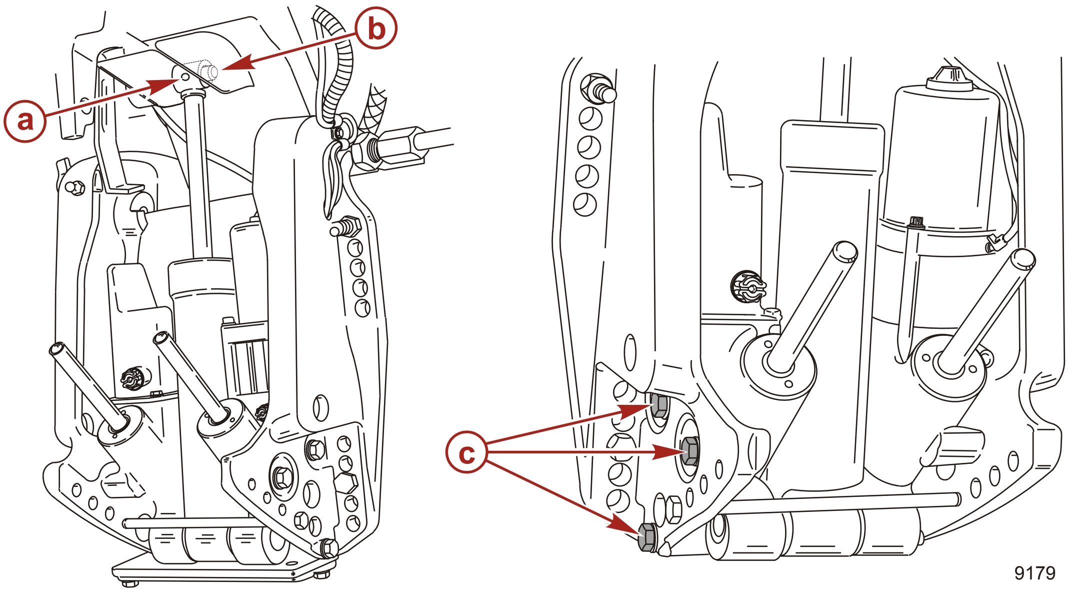


a - Filler cap

8. Pull out the trilobe pin, push out the upper swivel pin, and remove the three bolts and washers in the port clamp bracket.

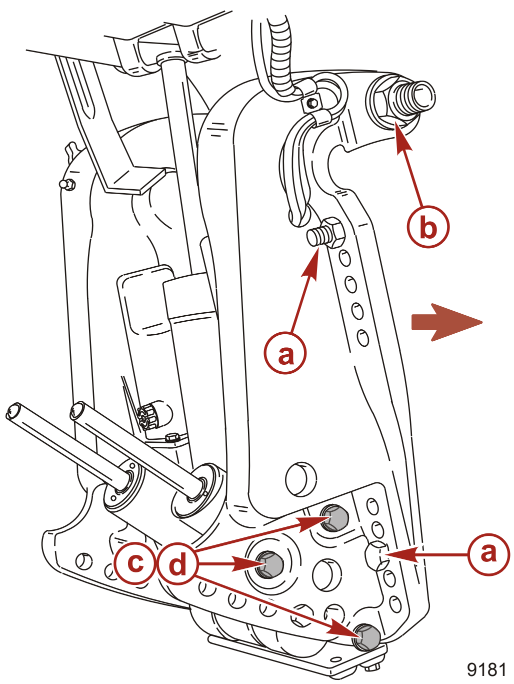
IMPORTANT: Do not reuse the trilobe pin.

NOTE: The six trim mounting bolts should not be reused. Replace with new patch lock bolts.



a - Trilobe pin
b - Upper swivel pin
c - Port transom bracket bolts and washers (3)

9. Remove the three bolts and washers in the starboard transom bracket.



a - Transom mount bolts
b - Tilt tube nut (flush with end of thread)
c - Bolts (3)
d - Washers (3)

10. Remove the outboard transom mounting bolts and loosen the tilt tube nut until it is flush with the end of the tilt tube thread.
11. Remove the system from the outboard.

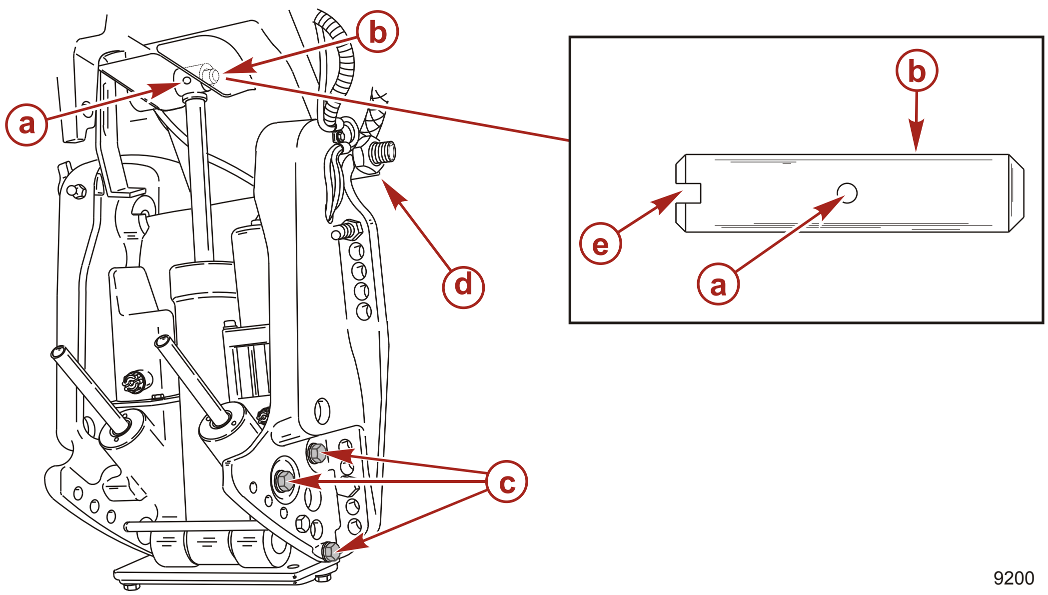
Power Trim Assembly Installation

NOTE: Inspect the upper pivot pin bushings in the swivel bracket for wear. Replace the swivel bracket bushings and trim rod shoes as necessary.

1. Paint any exposed metal surfaces to prevent corrosion.
2. Install the trim system, starboard transom bracket, and tilt tube nut.
3. Use a 12 volt power source to extend the tilt ram up to align the upper swivel shaft hole and the end of the ram.

4. Connect the trim motor wires; blue to positive (+) and green to negative (–). If the ram extends too far, retract the ram by connecting the green to positive (+) and the blue to negative (–).
5. Install the upper pivot pin with the slotted end to the trim position sensor side of the engine.

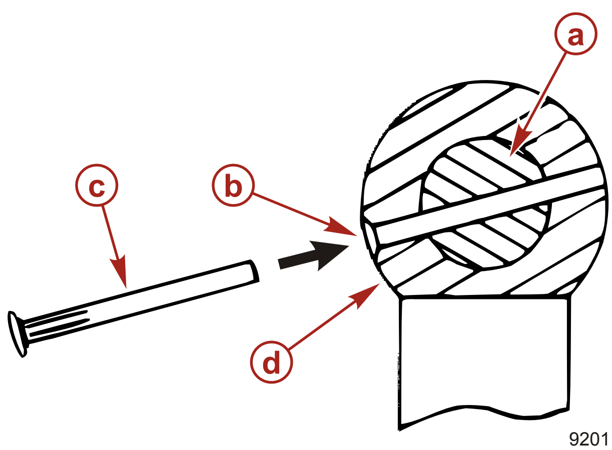
   IMPORTANT: Do not reuse the trilobe pin.



a - Trilobe hole (in line with slotted end)
b - Upper swivel pin
c - Screw (6) and flat washer (6) - install one washer per screw
d - Tilt tube nut
e - Slotted end

Description	Nm	lb-in.	lb-ft
Screw (6)	61		45

6. Position the slot on the end of the pivot pin in line with the hole in the tilt ram end.
7. Insert a punch into the tilt ram hole to align the cross hole in the upper pivot pin.
8. Install a new trilobe pin through the tilt cylinder end and upper pivot pin.
9. Tap the new trilobe pin in until flush.



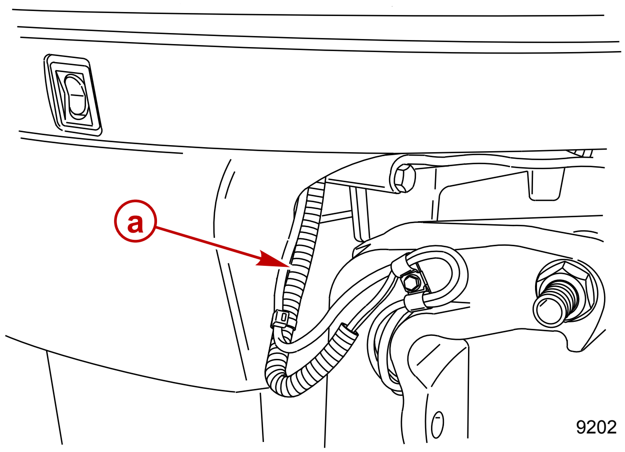
a - Upper pivot pin (slot is in line with cross hole)
b - Chamfered end of hole (faces away from transom)
c - Trilobe pin
d - Tilt ram end

10. Connect the trim motor wires to the relays. Refer to the appropriate wiring diagram for help.
11. Route the trim wires as specified in this manual.

⚠ WARNING

Damaged wires can cause electrical problems, resulting in system failure. In some cases, this can affect boat operation, leading to personal injury. Use conduit, hose clamps, grommets, or other appropriate measures to protect all electrical wires. Do not overtighten clamps and keep harnesses away from heat sources during installation.

NOTE: Encapsulate the two power leads going to the trim motor with conduit tubing.



a - Conduit tubing

12. Apply marine-grade silicone sealer to the shanks of the mount bolts and install the transom mount bolts. Secure with flat washers and locknuts. Ensure the installation is watertight.

Tube Ref No.	Description	Where Used	Part No.
116	RTV 587 Ultra Blue Silicone Sealer	Shanks of the mount bolts	92-809825
128	Loctite 5900 Ultra Black RTV Silicone Sealant	Shanks of the mount bolts	92-809826

IMPORTANT: Do not use an impact driver to tighten the transom mount bolts.

13. Tighten the tilt tube nut securely.

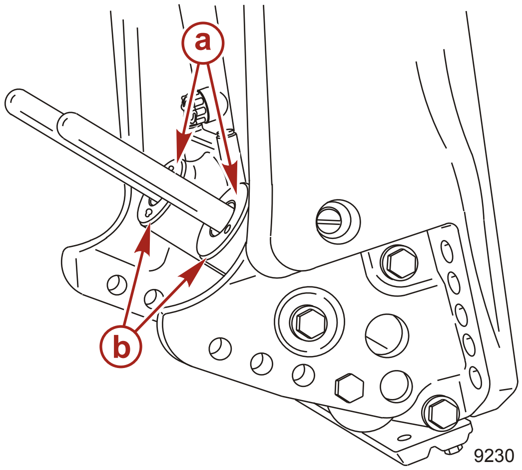
Trim Cylinder

Trim Rod Removal

NOTE: Power trim does not have to be removed from outboard to remove trim rods.

1. Tilt the outboard to full up position and engage the tilt lock lever.
2. Slowly remove the fill plug to bleed the reservoir pressure.
3. Turn the manual release valve three to four turns (counterclockwise) to bleed any remaining pressure.
4. Remove the trim rod cylinder end caps.

NOTE: Place a clean pan under the trim system to catch the fluid.



a - Trim rod cylinder end cap
b - Turn counterclockwise to remove

Trim Rod Guide Removal Tool	91-44487T 1
Trim Cylinder End Cap Tool	91-821709T
Spanner Wrench	91-74951

5. Install the trim rod removal tool and pull the trim rod from the cylinder.

Trim Rod Removal Tool	91-44486A 1

Cleaning and Inspection - Trim Rods and End Caps

⚠ CAUTION

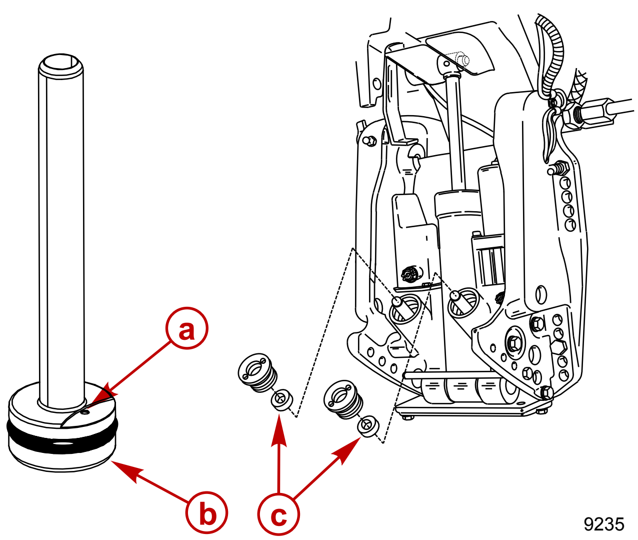
Contamination can damage the hydraulic system or cause the system to malfunction. Failure of power trim or steering components can result in injury or product damage. Ensure that the work area, shop tools and all components are clean and lint free during reassembly.

⚠ CAUTION

Removing the trim rod check valve can result in improper operating pressure and possible equipment damage. Do not remove the trim rod check valve, which is preset to operate at a specific pressure.

NOTE: The check valve is in the port side trim rod only.
Certain models may have trim limit reducers installed on the trim rod to limit trim out angle. Each reducer limits the amount of total trim by 2°. A maximum of five reducers may be installed on each trim rod.

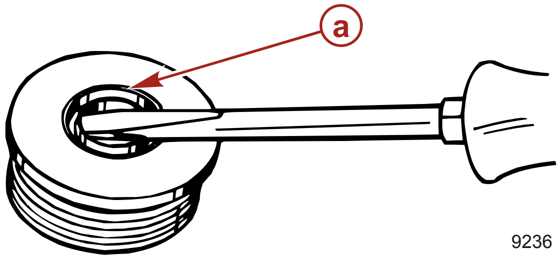
1. Inspect the check valve and check valve screen for debris. If debris cannot be removed, replace the trim rod assembly.
2. Clean the trim rod with a parts cleaner and dry with compressed air.



a - Check valve
b - Check valve screen
c - Trim limit reducers

Trim Rod End Cap Seal

1. Inspect the trim cap end seal and replace if damaged or if the seal does not keep the trim rod clean.
2. Inspect the trim cap internal O-ring and replace if damaged or worn.
3. Inspect the inner surface of the cap. Replace the trim cap if worn.



a - Seal

4. Install the new seal with the seal lip facing up.

Trim Rod Installation

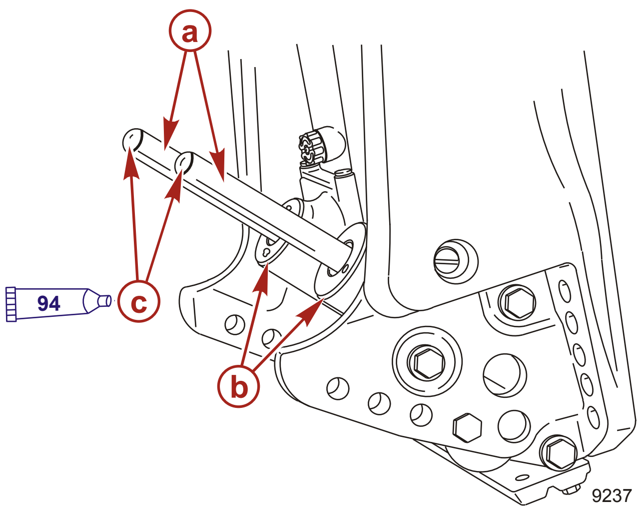
IMPORTANT: Components must be free of dirt and lint. Any debris in the system can cause a malfunction.

NOTE: Install the trim rod with the check valve in the port cylinder.

1. Apply ATF Dexron III or Power Trim and Steering Fluid on all O-rings and seals before installation.

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	O-rings and seals	92-858074K01

2. Install the trim rods and caps. Use trim rod guide removal/installation tool or a spanner wrench to tighten the caps to specifications.



a - Trim rods
b - Cylinder end caps
c - Rod end rollers

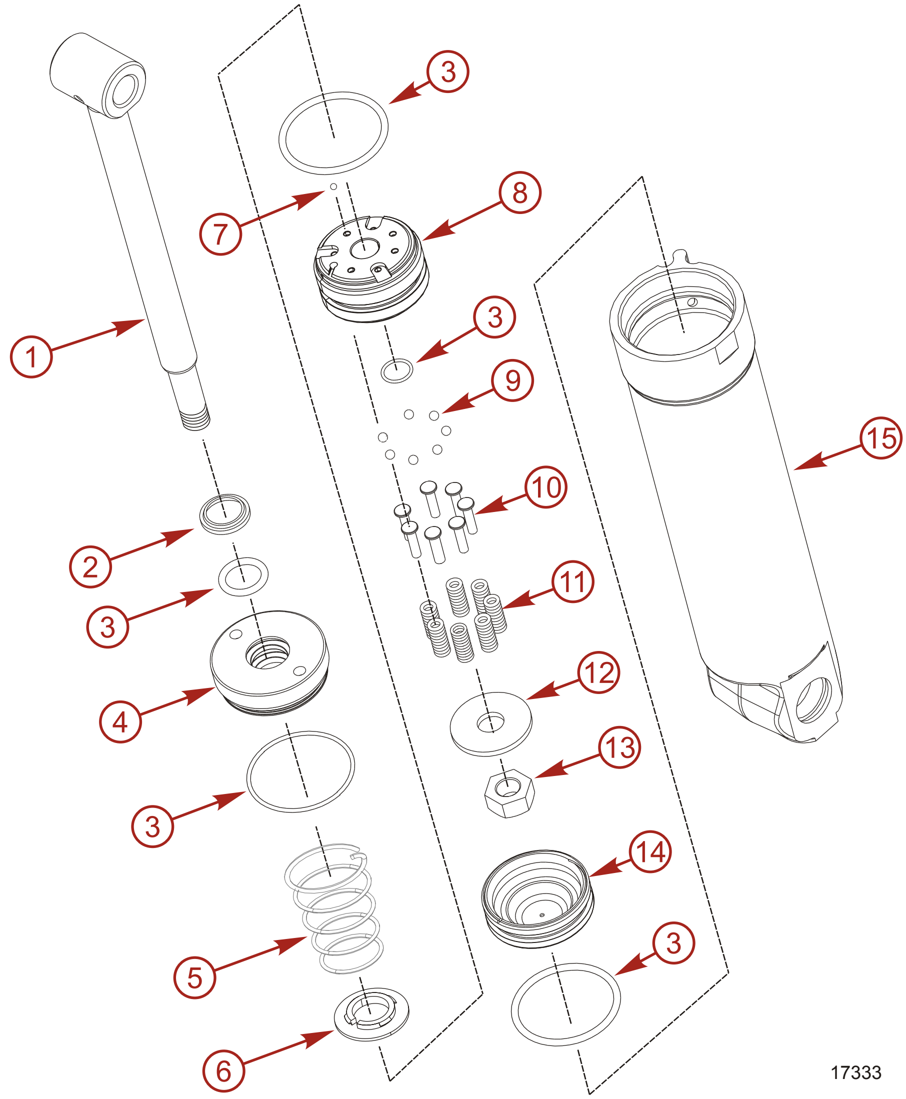
Trim Rod Guide Removal Tool	91-44487T 1
Trim Cylinder End Cap Tool	91-821709T

Tube Ref No.	Description	Where Used	Part No.
94	Anti-Corrosion Grease	Trim cylinder rod end rollers	92-802867Q 1

Description	Nm	lb-in.	lb-ft
Trim cylinder end caps	95		70

Tilt Cylinder

Tilt Cylinder Components



1 - Tilt cylinder rod
2 - Scraper seal
3 - O-ring[1.]
4 - Cylinder cap (blue anodized)
5 - Damper spring
6 - Damper plate
7 - Return ball
8 - Shock piston
9 - Shock balls
10 - Spring keepers (one is red)
11 - Shock springs (one is red for low speed trail over)
12 - Washer
13 - Nut
14 - Memory piston
15 - Housing

Tilt Ram Removal

Tilt Rod Assembly Only

The tilt rod assembly can be removed from the cylinder without removing the entire power trim system from the outboard.

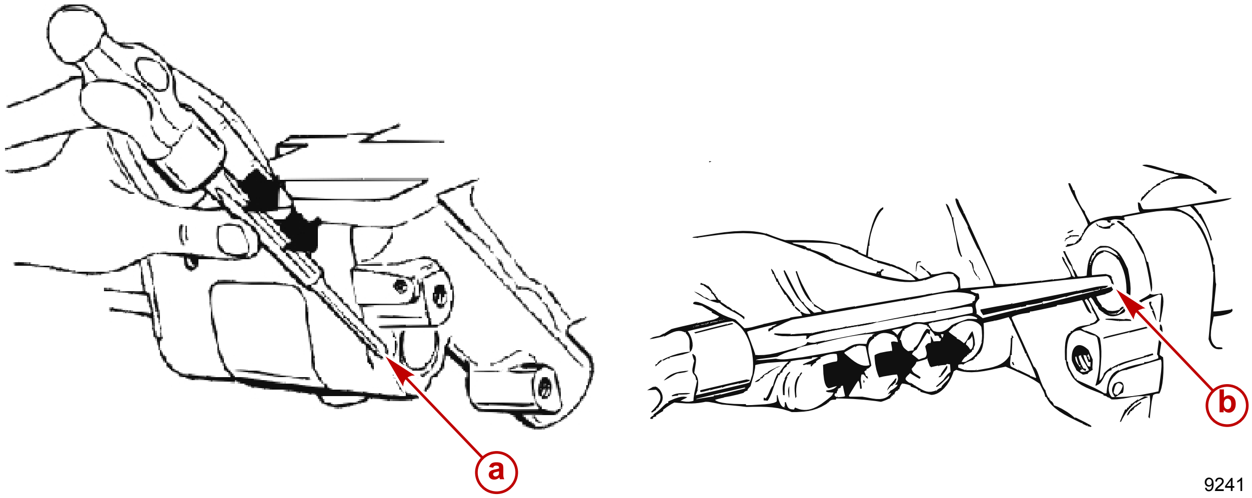
Power Trim System Removed from Outboard

⚠ CAUTION
Avoid personal injury from a pressurized power trim system. To depressurize the system, tilt the outboard to the full up position and engage the tilt lock lever before checking the fluid level.

1. Remove the cross pin.

1. O-ring repair kit available (P/N 811607A1)

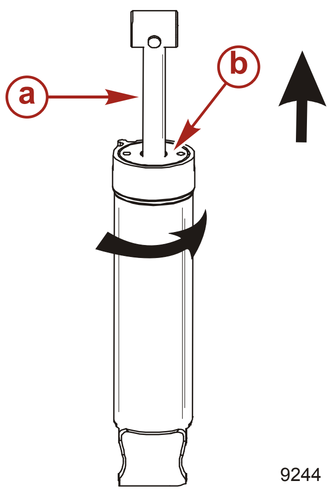
2. Remove the lower swivel pin.



a - Cross pin
b - Lower swivel pin

Disassembly

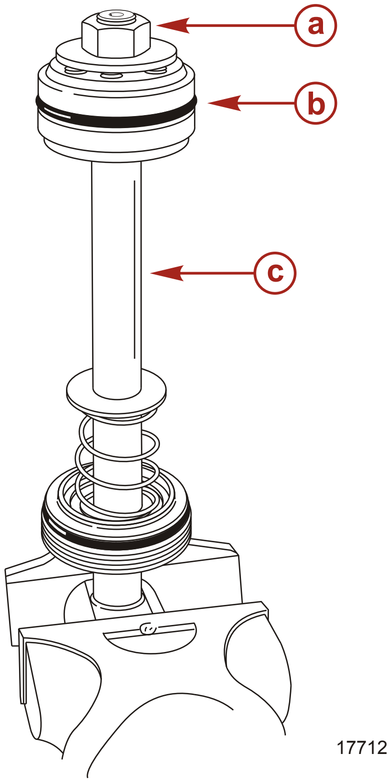
1. Secure the tilt ram in a soft jawed vise. Remove the end cap and tilt cylinder rod.



a - Tilt cylinder rod
b - End cap

Trim Cylinder End Cap Tool	91-821709T
Spanner Wrench	91-74951

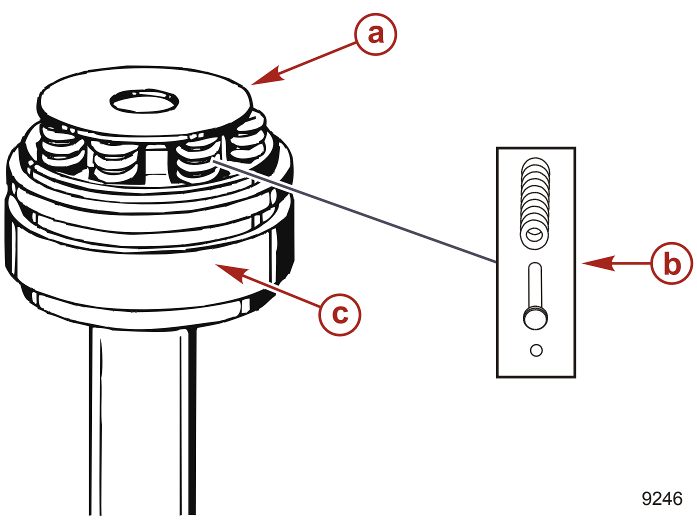
2. Clamp the tilt rod in a soft jawed vise. Remove the tilt cylinder piston O-ring. Remove the retaining nut to disassemble the rod assembly.



a - Retaining nut
b - Tilt cylinder piston O-ring
c - Tilt cylinder rod

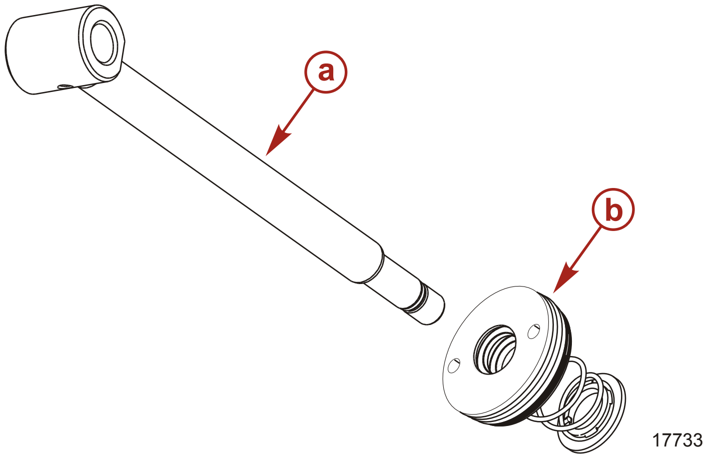
3. Remove the washer, check valve assemblies, and shock piston.

NOTE: The check valve held in by the roll pin can be cleaned, but not removed.



a - Washer
b - Check valve assembly (7)
c - Shock piston

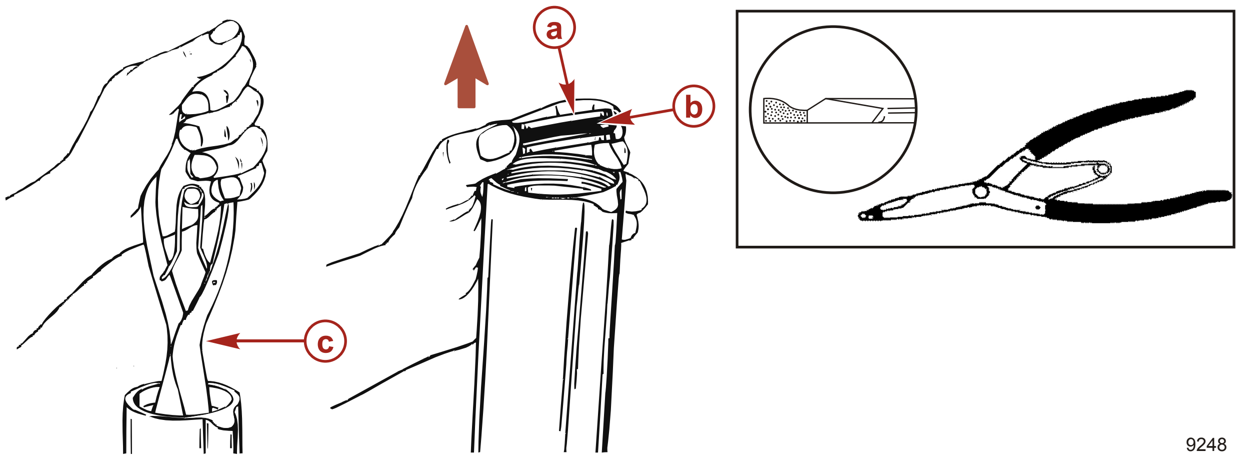
4. Remove the end cap from the tilt cylinder rod.



a - Tilt cylinder rod
b - End cap

Memory Piston Removal

1. Remove the memory piston from the cylinder using Snap-On™ lockring pliers or similar tool.
2. Remove the O-ring from the memory piston.



a - Memory piston
b - O-ring
c - Lockring pliers

Lockring Pliers	Snap-On SRP-4

Cleaning and Inspection

⚠ 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.

1. Inspect all internal parts for damage or wear. Clean and replace parts as necessary.
2. Inspect the tilt rod for scratches. Replace the scraper seal in the rod end cap if the tilt rod is scratched or worn.

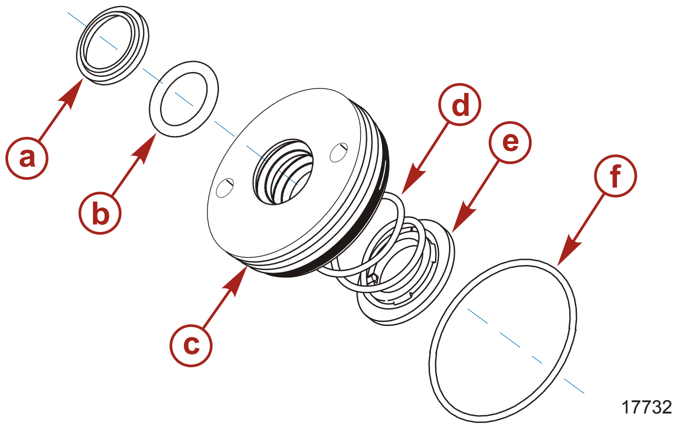
   NOTE: Slight scratches or tool marks less than 0.1 mm (0.005 in.) deep in the cylinder are acceptable.
3. Clean shock rod and components with parts cleaner and dry with compressed air.
4. Lubricate all O-rings with Power Trim and Steering Fluid. If not available, use automotive Automatic Transmission Fluid (ATF).

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Tilt cylinder O-rings and seals	92-858074K01

End Cap Components

Disassembly

1. Remove the scraper seal and rod seal O-ring from the end cap.
2. Remove the end cap O-ring.
3. Remove the damper spring from the end cap.
   a. The damper spring is held in place by an undercut groove in the end cap.
   b. Remove the spring from the end cap by rotating the spring clockwise.
   c. As the diameter of the spring decreases, lift the spring up to release it from the undercut groove in the end cap.
4. Remove the spring from the damper plate.



a - Scraper seal
b - Rod seal O-ring
c - End cap
d - Damper spring
e - Damper plate
f - End cap O-ring

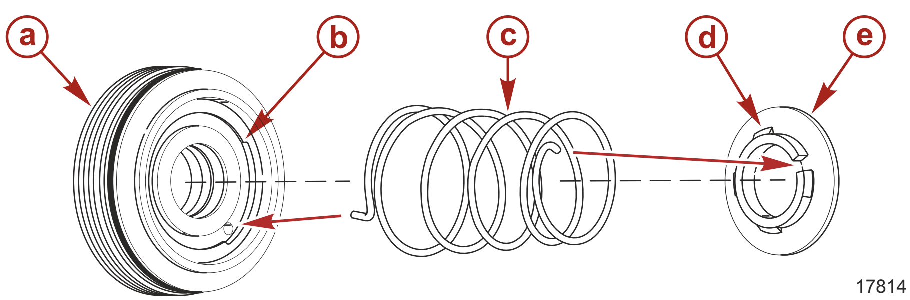
Reassembly

IMPORTANT: Components must be clean for reassembly. Any debris in the system can cause the system to malfunction.

1. Lubricate all O-rings and seals with Power Trim Fluid. If not available, use automotive (ATF) automatic transmission fluid.

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Power trim cylinder O-rings	92-858074K01

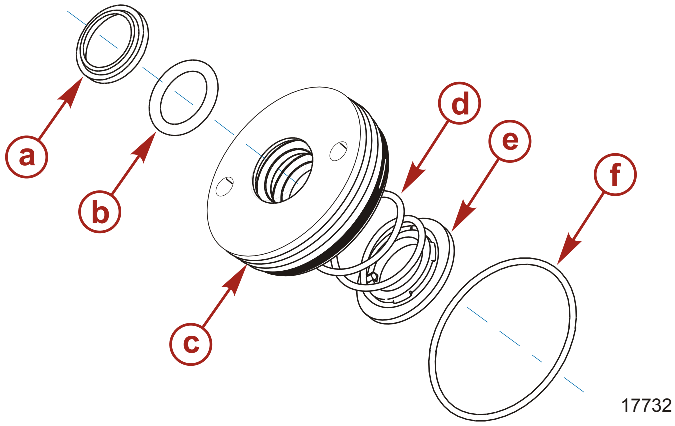
2. Install the damper plate on the damper spring.
   a. Insert the tang of the small end of the spring in the notch on the damper plate.
   b. Push the spring over the four tabs on the damper plate to lock the spring in place.
3. Install the damper spring on the end cap.
   a. Insert the tang of the spring in the small hole in the end cap.
   b. Rotate the spring clockwise.
   c. As the diameter of the spring decreases, push the spring in the undercut groove and release the spring tension.



a - End cap
b - Undercut groove
c - Damper spring
d - Tab
e - Damper plate

4. Install the rod seal O-ring and scraper seal in the end cap.

5. Install the end cap O-ring on the end cap.



a - Scraper seal
b - Rod seal O-ring
c - End cap
d - Damper spring
e - Damper plate
f - End cap O-ring

Tilt Cylinder Assembly

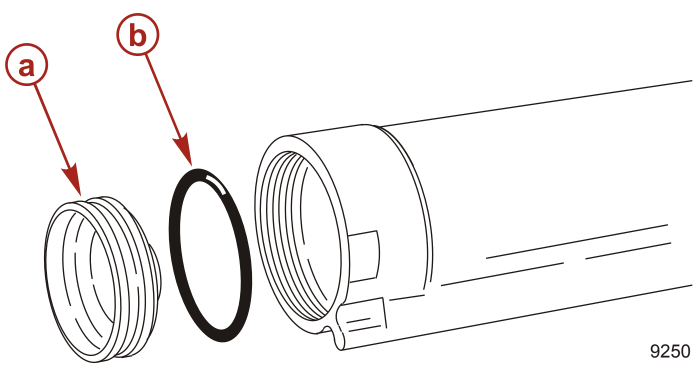
IMPORTANT: Components must be clean for reassembly. Any debris in the system can cause the system to malfunction.

*NOTE: Refer to **Tilt Ram Components** for proper O-ring sizes.*

1. Lubricate all O-rings and seals with Power Trim 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 trim cylinder O-rings	92-858074K01

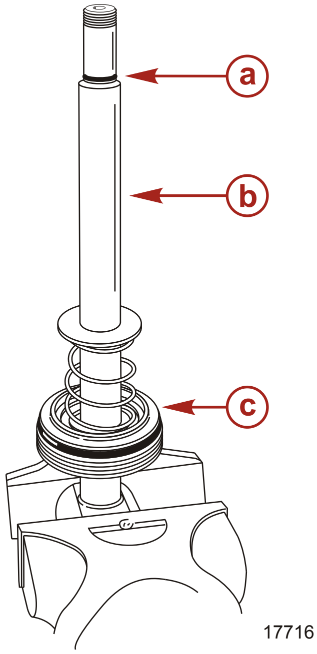
2. Install the O-ring on the memory piston and install in the cylinder.
3. Inspect the three O-rings in the bottom of the tilt cylinder. Replace as necessary.
4. Inspect the three pivot pin O-rings in the manifold. Replace as necessary.



a - Memory piston
b - O-ring

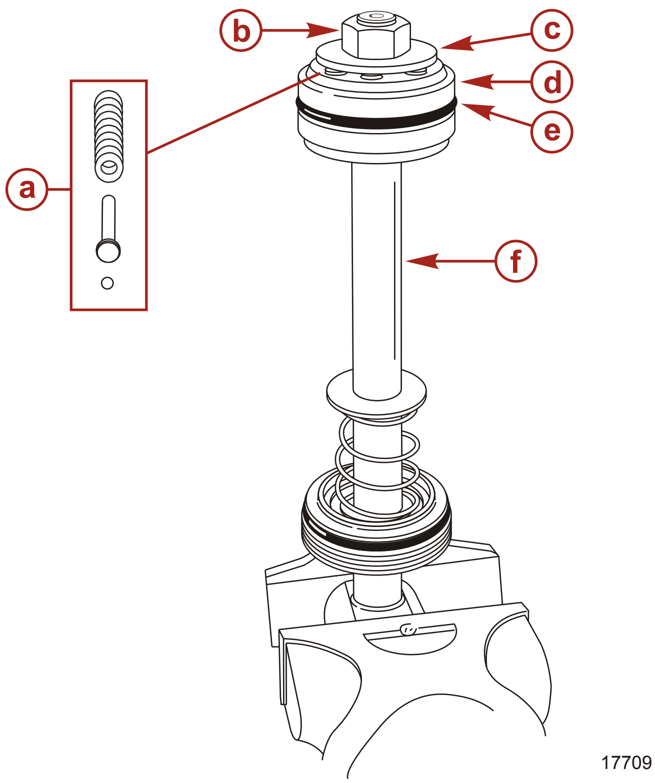
5. Install the assembled end cap on the tilt cylinder rod.

6. Install O-ring on the cylinder rod.



a - O-ring
b - Cylinder rod
c - Assembled end cap

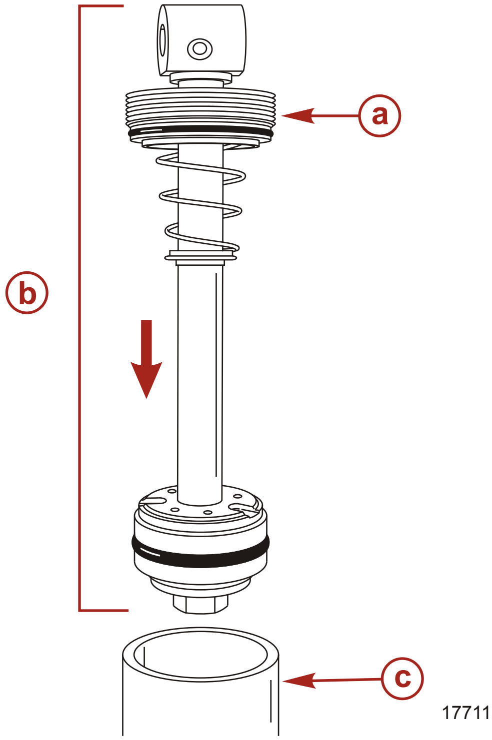
7. Install the shock piston on the tilt cylinder rod.
8. Install the impact relief valve components in the piston.
9. Place the washer over the impact relief springs and cylinder rod.
10. Install the retaining nut on the tilt cylinder rod. Tighten the retaining nut to specified torque.



a - Impact relief valve components (7)
b - Retaining nut
c - Washer
d - Shock piston
e - O-ring
f - Tilt cylinder rod

Description	Nm	lb-in.	lb-ft
Tilt cylinder rod/piston retaining nut	129		95

11. Clamp the tilt cylinder in a soft jawed vise and install the tilt rod assembly. Tighten the end cap to specified torque.



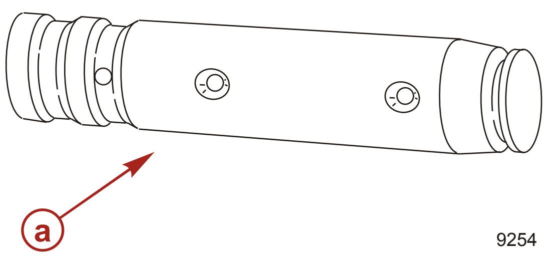
a - End cap
b - Tilt rod assembly
c - Tilt cylinder

Trim Cylinder End Cap Tool	91-821709T

Description	Nm	lb-in.	lb-ft
Tilt cylinder end cap	61		45

Tilt Ram Assembly Installation

1. Lubricate the alignment tool and shaft with Power Trim and Steering Fluid. If not available, use automotive Automatic Transmission Fluid (ATF).



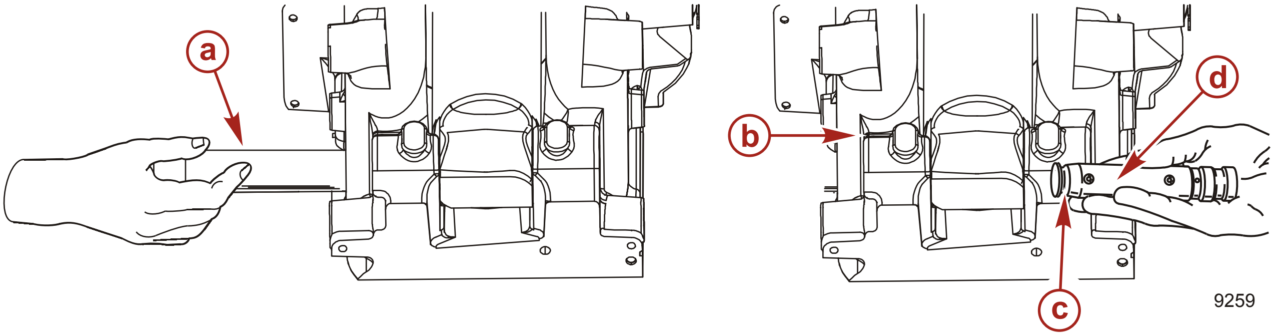
a - Shaft

Alignment Tool	91-11230--1

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Tilt ram alignment tool and shaft	92-858074K01

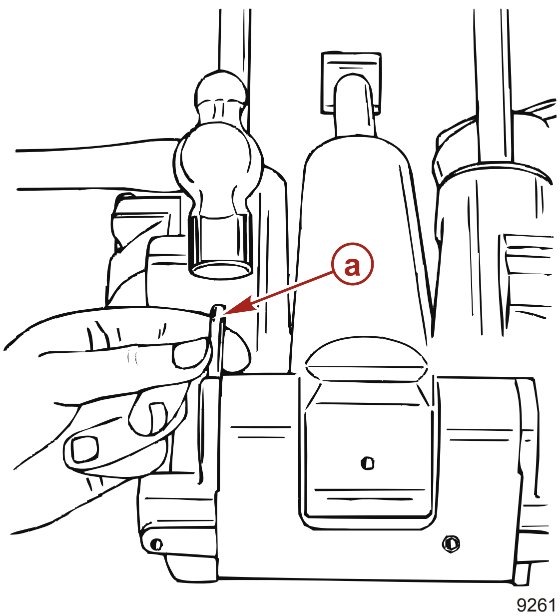
2. Align the tilt ram and housing using the alignment tool.

3. Install the shaft; aligning the groove with the hole.



a - Alignment tool
b - Hole
c - Groove
d - Shaft

4. Drive the pin in until flush.



a - Pin

Priming the Power Trim System

1. Fill the system with Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) Dexron III.

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Fill the trim system	92-858074K01

2. Refer to **Check, Fill, and Purge.**

   IMPORTANT: Run the trim system in short jogs until the pump motor primes and the trim system moves. If trim motor is run without priming pump, driveshaft failure could result.

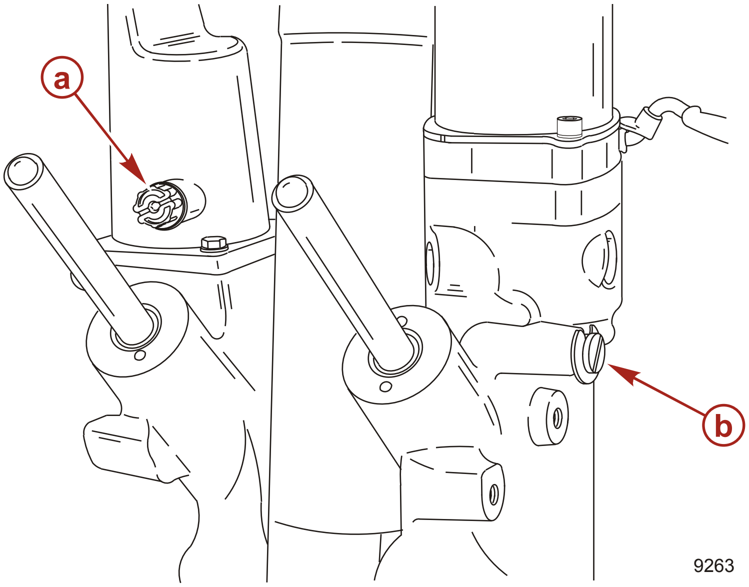
Power Trim Disassembly

Power Trim Removal

IMPORTANT: The power trim system is pressurized. The trim rams must be in the full up position (fully extended) prior to removal of the fill/drain plug or manual release valve.

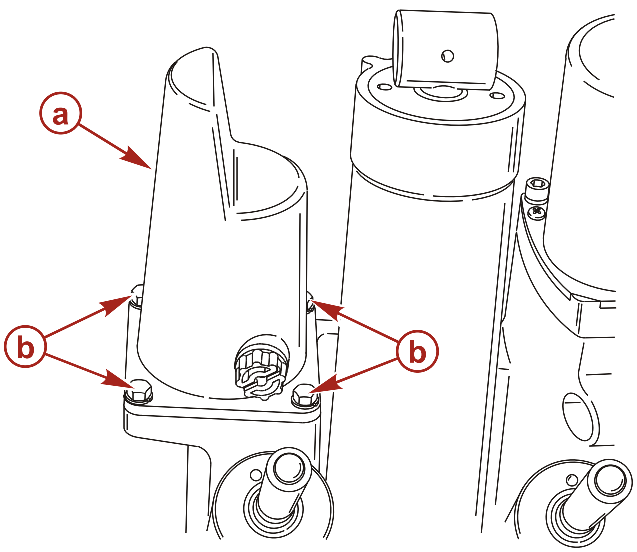
1. Remove the reservoir cap to drain the oil.

2. Remove the manual release valve to drain any remaining oil.



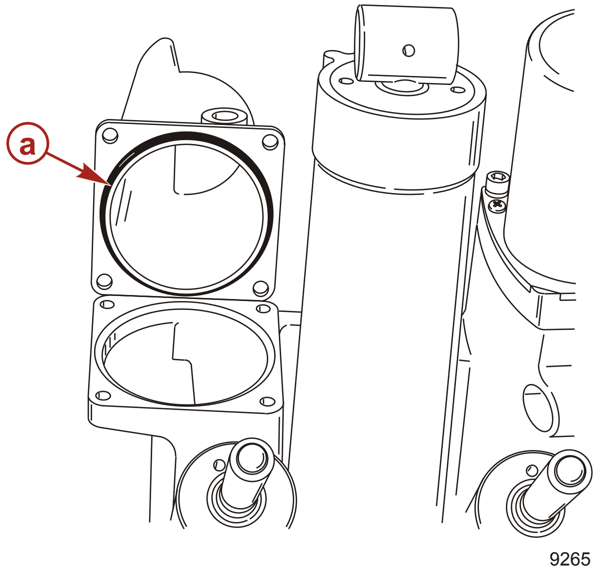
a - Reservoir cap
b - Manual release valve

3. Remove the four screws securing the reservoir cover and remove the cover.



a - Reservoir cover
b - Screw (4)

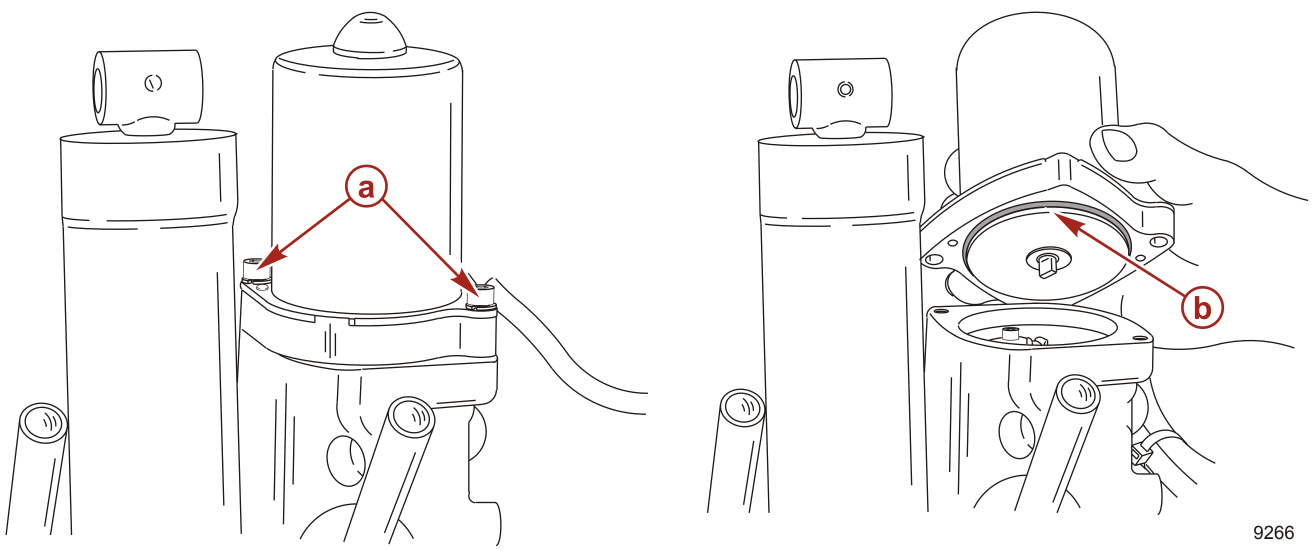
4. Inspect the reservoir cover O-ring for cuts or abrasions. Replace the O-ring as necessary.



a - O-ring

Trim Motor Removal

1. Secure the power trim assembly in a soft jaw vise.
2. Remove the two screws securing the motor and remove the motor.
3. Remove the motor O-ring (yellow) and coupler.
4. Inspect the O-ring for cuts and abrasions. Replace as necessary.



a - Screw and washer (2)
b - O-ring (yellow)

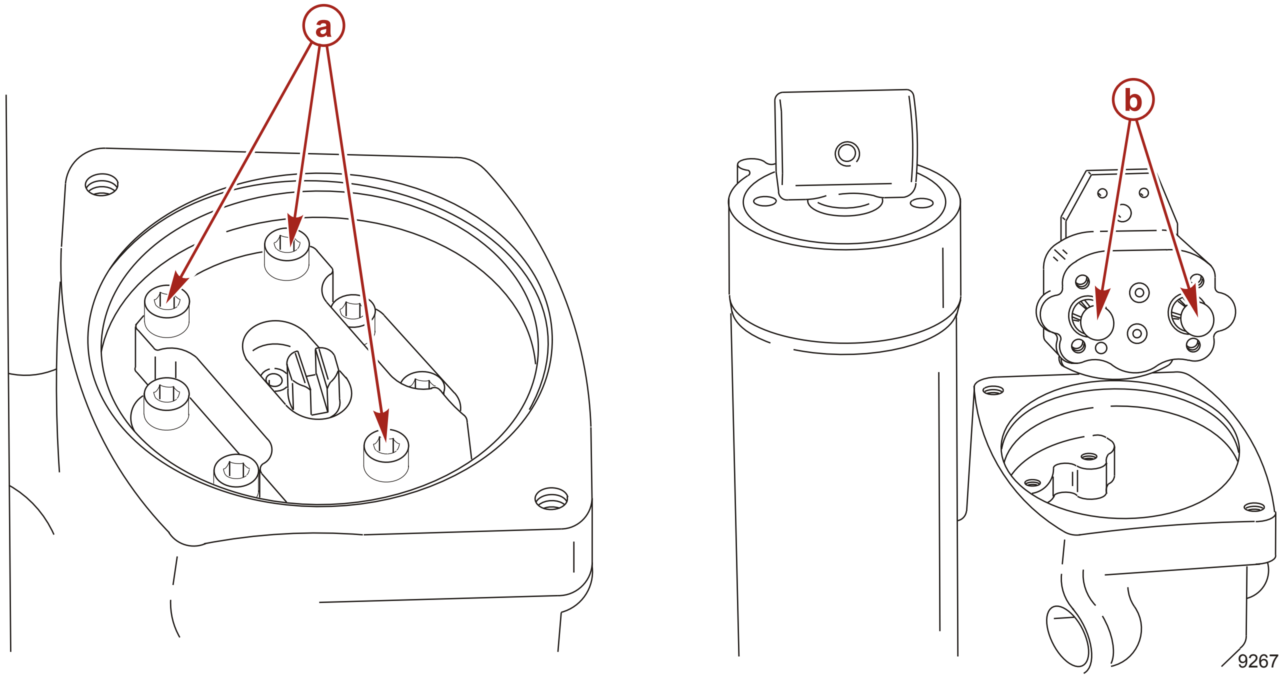
Pump and Component Removal

> **⚠ 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.

1. Remove the three screws securing the oil pump.

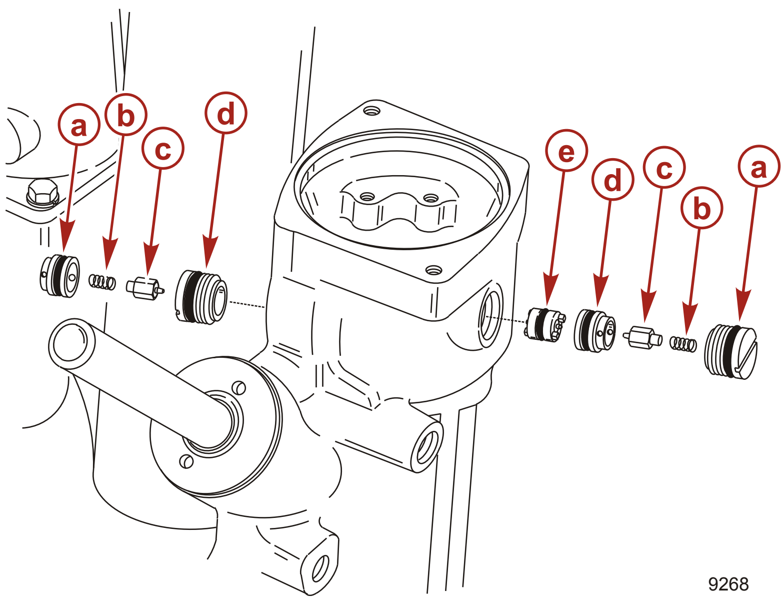
   NOTE: *There are no serviceable parts within the oil pump. Failure of, or damage to, internal components of the pump requires pump assembly replacement.*

2. Inspect the filter/O-ring assemblies on the bottom of the oil pump. Replace as necessary.



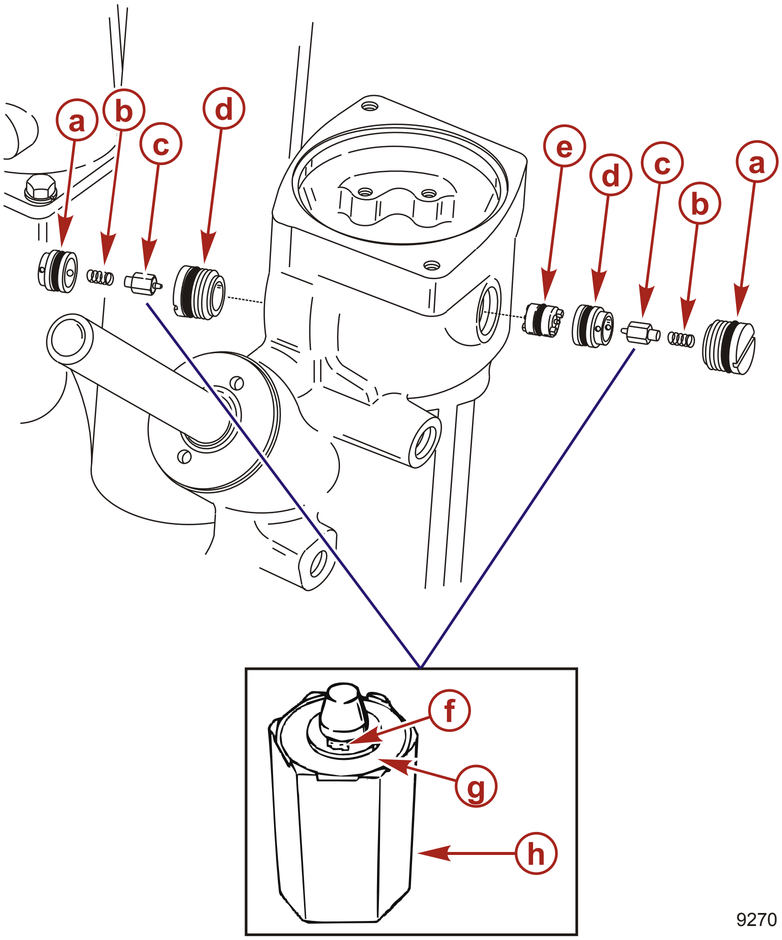
a - Screw (3)
b - Filter/O-ring assembly (2)

3. Remove both plugs in the manifold. Remove the springs, poppet/check valves, and seats from both sides. Remove the spool.



a - Plug (2)
b - Spring (2)
c - Poppet/check valve (2)
d - Seat (2)
e - Spool

IMPORTANT: Inspect the poppet assembly for debris in the area shown. If debris is found on the poppet, replace the poppet. Inspect the O-rings on both seats and spool for cuts or abrasions. Replace as necessary.



- a - Plug (2)
- b - Spring (2)
- c - Poppet/check valve (2)
- d - Seat (2)
- e - Spool
- f - Debris on rubber seat
- g - Neoprene seat
- h - Poppet assembly

Motor and Electrical Tests/Repair

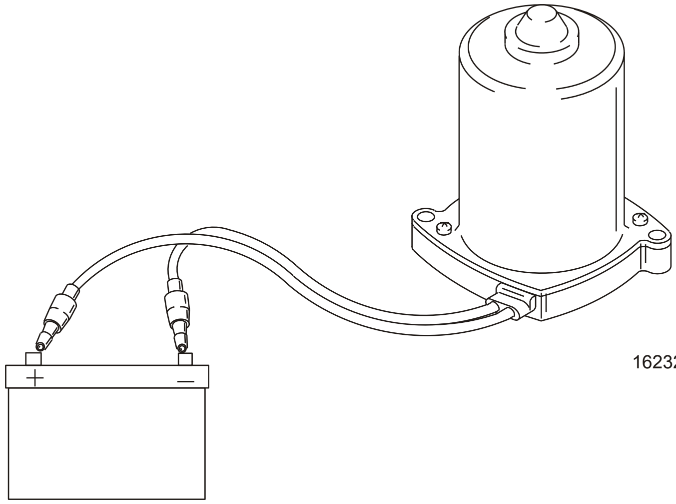
Trim Pump Motor Test

⚠ WARNING

A spark may occur when making connections that could result in fire or explosion. Do not perform this test near flammables or explosives.

1. Connect a 12 volt power supply to the motor wires. Connect one motor lead to the positive (+) battery terminal and the other motor lead to the negative (–) battery terminal. The motor should run.

2. Reverse the motor leads between battery terminals. The motor should run.

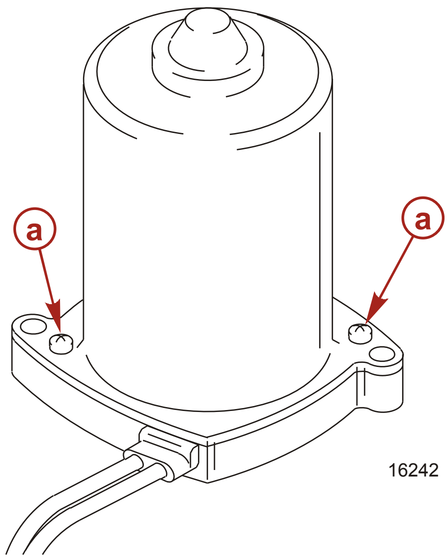


16232

3. If the motor does not run, disassemble and check components.

Motor Disassembly

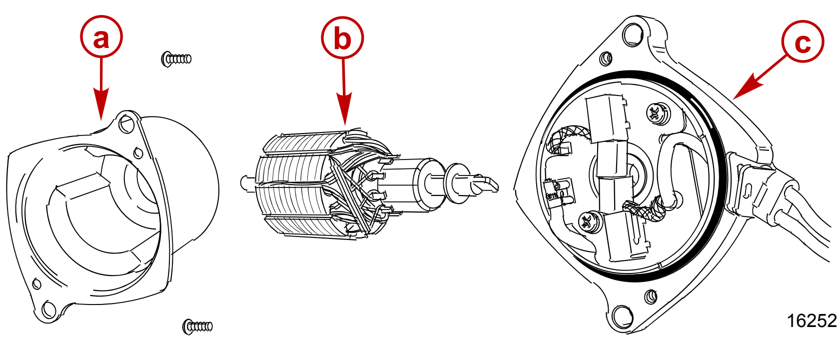
1. Remove the two screws.



16242

a - Screws

2. Remove the frame and armature from the end cap. Use care not to drop the armature.



16252

a - Frame
b - Armature
c - End Cap

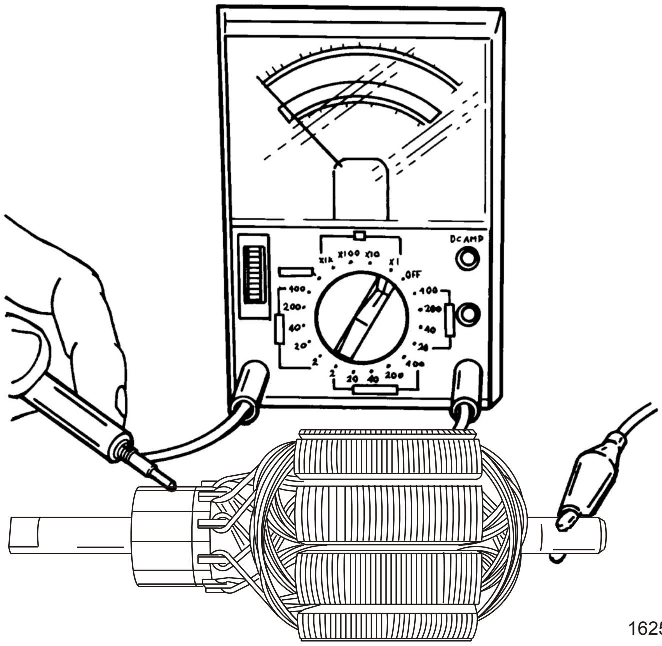
Armature Tests

Test for Shorts

Check the armature on a growler, per the growler manufacturer's instructions. Replace the armature if a short is indicated.

Test for Ground

Use an ohmmeter (R x 1 scale). Connect one lead on the armature shaft and the other lead on the commutator. If continuity is indicated, the armature is grounded. Replace the armature.

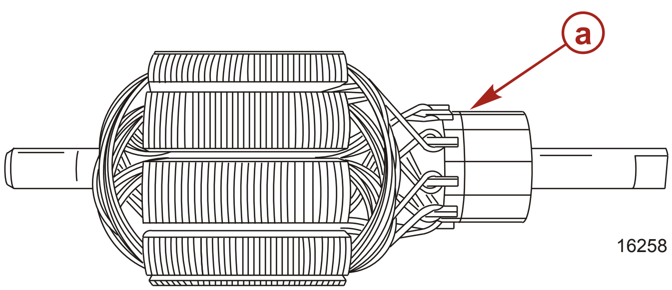


16257

Meter Test Leads		Meter Scale	Reading (Ω)
Red	**Black**		
Commutator	Armature shaft	R x 1	No continuity (OUCH)

Checking and Cleaning Commutator

If the commutator is worn, replace the armature.



16258

a - Commutator

Field Tests

IMPORTANT: The commutator end of the armature must be installed in brushes when performing the following tests.

Ohmmeter Leads Between	Resistance (Ohms)	Scale Reading* (x___________)
Blue and green motor wires	0	(R x 1)
Green motor wire and frame (motor housing)	No continuity	(R x 1)
Blue motor wire and frame	No continuity	(R x 1)

*If specified readings are not obtained, check for:

- A defective armature
- Dirty or worn brushes
- Dirty or worn commutator

If defective components are found, repair or replace components and retest.

Motor Repair

1. The power trim motor is not serviceable. It must be replaced as a unit.
2. Refer to **Trim Motor Removal** to remove the motor from the pump.

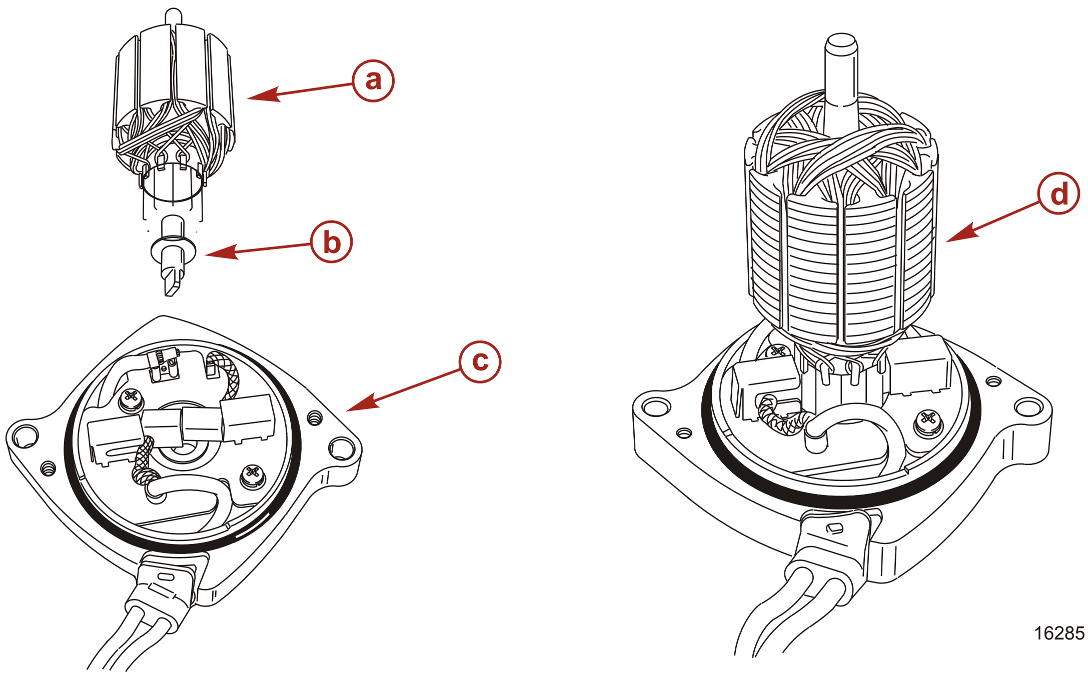
NOTE: The power trim system does not have to be removed from the outboard to replace the motor.

Power Trim Motor Assembly and Installation

Reassembly

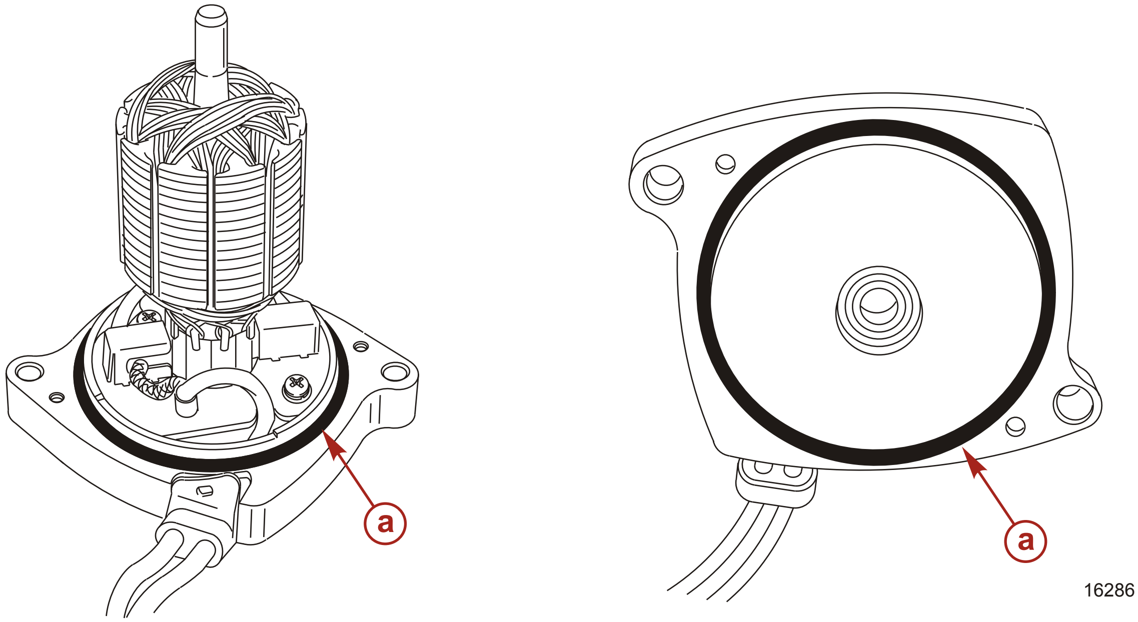
IMPORTANT: Components must be clean. Any debris in the power trim system can cause the system to malfunction.

1. Install the armature into the end cap/brush card assembly.



a - Armature
b - Shim
c - End cap assembly
d - Armature (spread brushes to install armature into end cap)

2. Install the O-rings in the end cap.

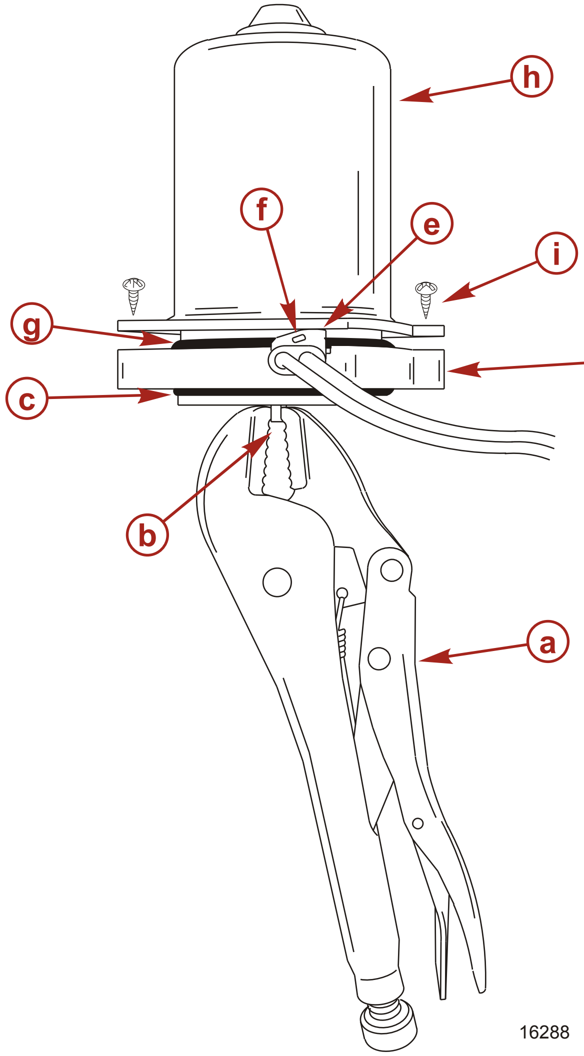


a - O-rings

IMPORTANT: Attach locking pliers to the armature shaft before installing the frame assembly. The locking pliers prevent the armature from being drawn out of the brush card assembly by the frame magnets while installing the frame assembly.

3. Install locking pliers on the armature shaft.
4. Carefully install the frame over the armature.
5. Position the harness retainer hole over the tab in the end cap.

6. Secure the frame assembly to the end cap with two screws. Drive screws tight.

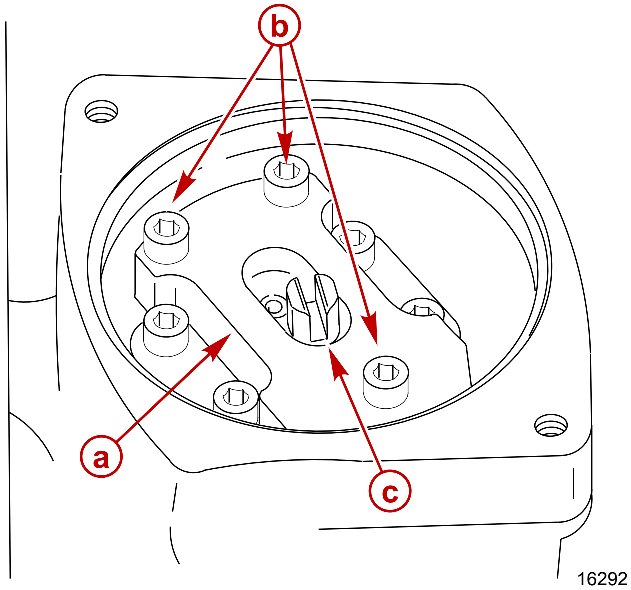


a - Locking pliers
b - Armature shaft
c - O-ring
d - End cap
e - Harness retainer
f - Retainer hole
g - O-ring
h - Frame
i - Screws

Reassembly - Motor and Pump

NOTE: The driveshaft is a loose part and may fall out of position.

1. Install the pump into the power trim manifold. Ensure the O-rings are in proper locations. Secure with three screws. Tighten screws to the specified torque.



a - Oil pump
b - Pump retaining screws (3)
c - Driveshaft

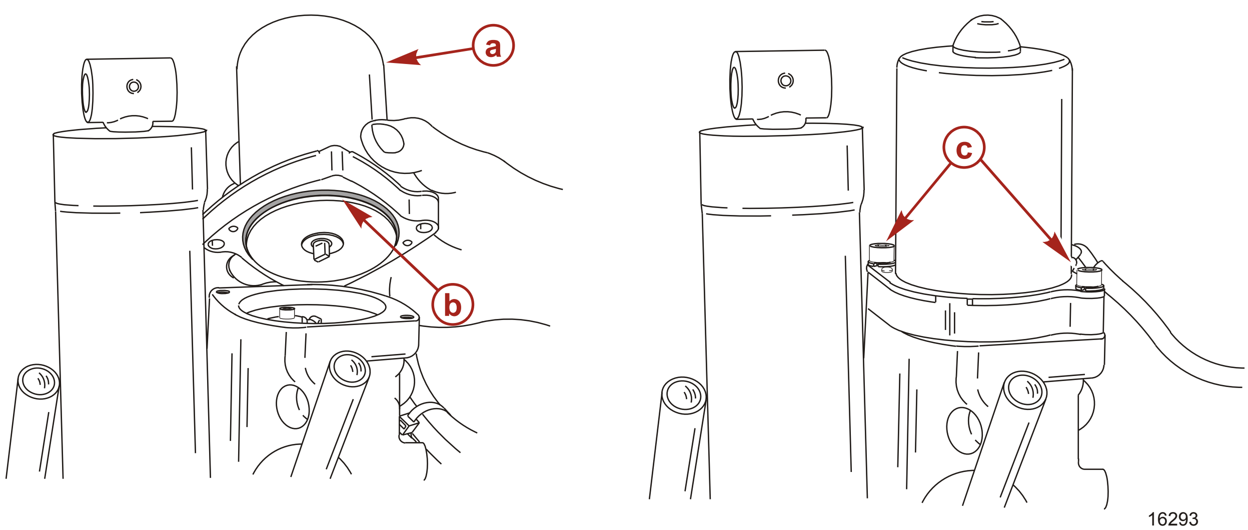
Description	Nm	lb-in.	lb-ft
Pump retaining screws (3)	7	60	

IMPORTANT: Install the pump with the location flat facing towards the starboard transom bracket.

2. Fill the pump with Power Trim and Steering Fluid prior to installing the motor.

Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Power trim system	92-858074K01

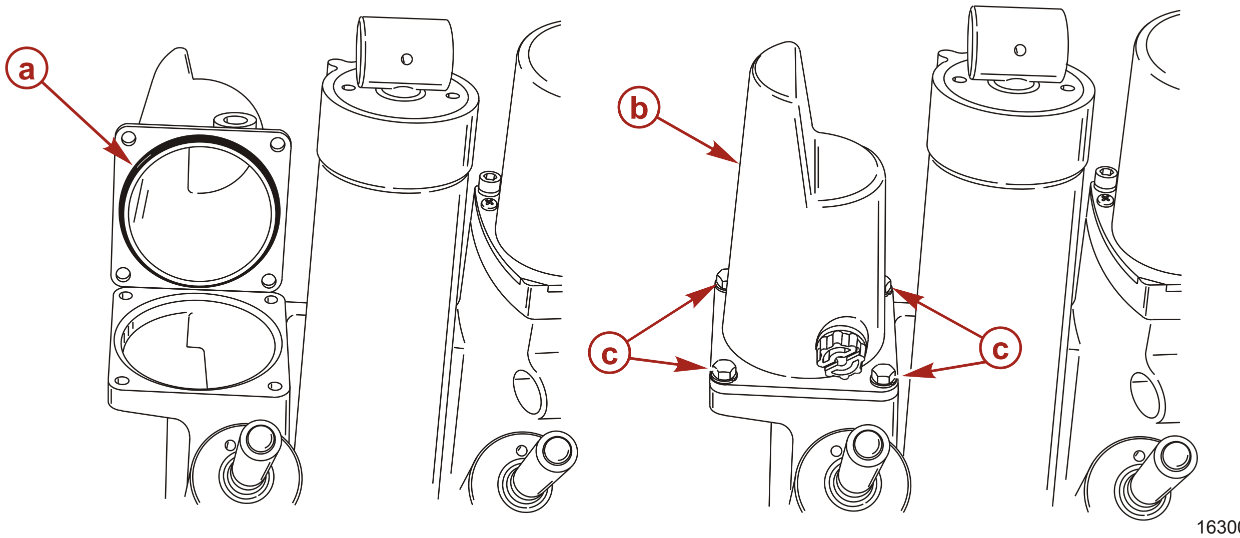
3. Align the motor shaft with the pump driveshaft.
4. Install the motor and secure with two screws. Tighten screws to the specified torque.



a - Motor
b - O-ring
c - Motor retaining screw (2)

Description	Nm	lb-in.	lb-ft
Motor retaining screw (2)	9	80	

5. Verify the cover O-ring is in place and in serviceable condition.
6. Reinstall the reservoir cover.
7. Secure the cover with four screws. Tighten screws to the specified torque.



a - O-ring
b - Reservoir cover
c - Reservoir cover screw (4)

Description	Nm	lb-in.	lb-ft
Reservoir cover screw (4)	7	60	

8. Complete the reassembly of the power trim system as outlined in **Installation**.

Gear Housing

Section 6A - Right-Hand Rotation

Table of Contents

6
A

Gear Housing Specifications

Gear Housing Specifications	
Gear ratio	2.08:1 (12/25 teeth)
Gearcase capacity	970 ml (32.8 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Pinion height	0.635 mm (0.025 in.)
Forward gear backlash	0.432–0.635 mm (0.017–0.025 in.)
Reverse gear backlash	1.24–1.45 mm (0.049–0.057 in.)
Water pressure at RPM	
At 650 RPM (idle)	15.2 kPa (2.2 psi)
At 6000 RPM (WOT)	
Warm water slow boat	88 kPa (12.8 psi)
Cold water fast boat	220 kPa (32 psi)
Gear housing pressure (without gear lubricant, five minutes without leakage)	103.4 kPa (15 psi)

Lubricants, Sealants, Adhesives

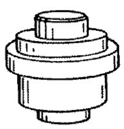
Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Cover assembly screw threads	92-809819
		Shift shaft cover screw threads	
		Pinion gear nut threads	
		Threads of pinion nut	
19	Perfect Seal	Speedometer connector threads	92-34227 1
87	High Performance Gear Lubricant	Tapered bearing race bore	92-858064K01
		Bearing bore in carrier	
		Inside diameter of driveshaft tapered bearing	
		Inside diameter of forward gear	
		Pinion bearing bore	
		Forward gear bearing cup bore	
		Outside diameter of pinion bearing	
		Gear housing	
91	Engine Coupler Spline Grease	Driveshaft splines	92-802869A 1
95	2-4-C with Teflon	Oil seal lips and between oil seals	92-802859A 1
		Bearing carrier O-ring	
		Seat of the shift shaft cover O-ring diameter and lip of the oil seal	
		O-ring	
		Pinion needle bearings	
		Retainer threads	
		Bearing carrier retainer nut threads and corresponding gear housing threads, bearing carrier O-ring, upper driveshaft bearing retainer threads	
		Carrier O-ring, forward and aft outer diameters of bearing carrier, gearcase area where carrier will seat, space between carrier seals	
		Bearing carrier retainer nut threads and corresponding gear housing threads	
		Oil seal carrier seal lips, space between oil seals, O-ring	
		Flat surface of the impeller key	
		Inside of water pump cover	
		Shift shaft splines	
134	Loctite 380	Outer diameter of oil seals	Obtain Locally
		Outer diameter of bearing carrier oil seal	
		Outside diameter of the oil seal	

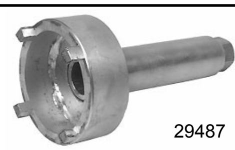
Special Tools

Dial Indicator	91- 58222A 1
 9479	Used to obtain a variety of measurements including gear backlash, pinion gear location, and TDC.

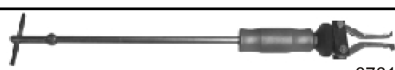
Dial Indicator Adapter	91-83155
 2999	Dial indicator holding fixture.

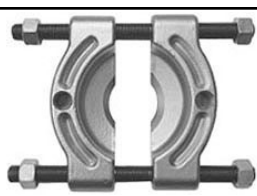
Dial Indicator Holding Tool	91- 89897
 29496	Secures the dial indicator to gear housing when checking backlash.

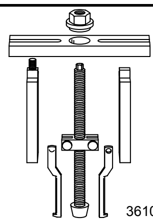
Oil Seal Driver	91-889844T
 29498	Installs seals in driveshaft seal carrier.

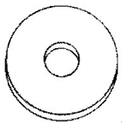
Bearing Carrier Retainer Nut Wrench	91-61069T
 29487	Installs and removes the bearing carrier retainer nuts.

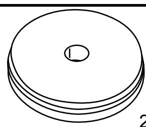
Puller Jaws Assembly	91-46086A1
 9514	Removes bearing carrier and bearing races; use with Puller Bolt (91-85716).

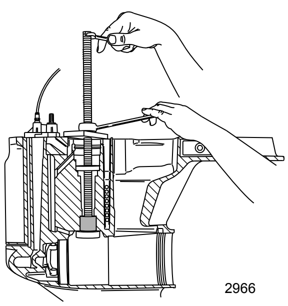
Slide Hammer	91-34569A 1
 6761	Aids in the removal of various engine components. Use with puller jaws.

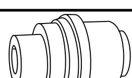
Universal Puller Plate	91-37241
 8505	Removes bearings from gears and the driveshaft.

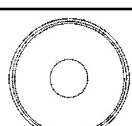
Bearing Puller Assembly	91-83165T
 3610	Removes bearings, races and bearing carriers

Pilot Washer	91-36571T
 29490	Used in pinion gear and pinion bearing installation.

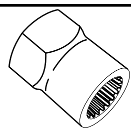
Seal Driver Guide	91-889845
 29590	Aids in the installation of bearing carrier seals.

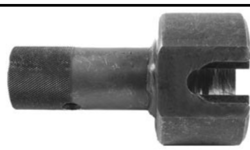
Bearing Removal and Installation Kit	91-31229A7
 2966	Installs and removes the bearings in all gearcases. 91-31229A7 tool assembly includes the following components: 11-24156 Hex Nut 12-34961 Washer 91-15755T Bearing Carrier 91-29310 Plate 91-29610 Pilot Plate 91-30366T1 Mandrel 91-31229 Puller Shaft 91-32325T Driver Head 91-32336 Driver Needle Bearing 91-36379 Puller/Head Gear 91-36569T Driver Head 91-36571T Pilot Washer 91-37292 Roller Bearing 91-37311 Driver Head 91-37312 -Driver Head 91-37323 Driver Head Rod 91-37324 Pilot Washer 91-38628T Puller/Driver Head 91-52393 Driver Needle Bearing 91-52394 Head Pull Rod

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T
 6229	Installs bearing carrier cup and seals.

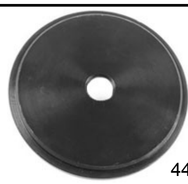
Bearing Cup Driver	91-885592T
 29492	Installs reverse gear bearing cup.

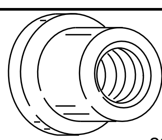
Driveshaft Bearing Retainer Wrench	91-43506T
 9520	Removes and installs the threaded bearing retainer.

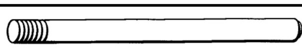
Driveshaft Holding Tool	91-889958T
 28677	Holds driveshaft during pinion nut removal on the Verado models.

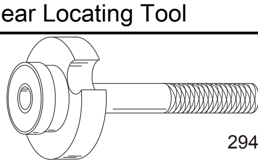
Pinion Nut Wrench	91- 61067T03
 29501	Holds the pinion nut when removing the pinion gear and driveshaft.

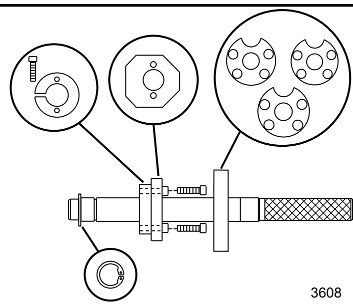
Propeller Shaft/Driveshaft Adapter	91-61077T
 10805	Provides a wrench surface to turn the propeller shaft or the driveshaft.

Guide Plate	91-816243
 4481	Centers the rod used to drive in the forward gear bearing on a standard rotation gearcase, and the reverse gear bearing on a counter rotation gearcase.

Driver Head	91- 36569T
 29499	Used in pinion gear and bearing installation.

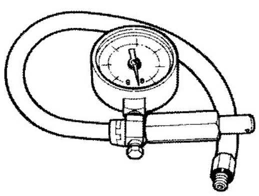
Driver Rod	91- 37323
 25431	Aids in the removal and installation of various bearings and bearing races

Pinion Gear Locating Tool	91-56048001
 29493	Measures pinion gear height.

Pinion Gear Locating Tool	91-12349A05
 3608	Measures pinion gear height.

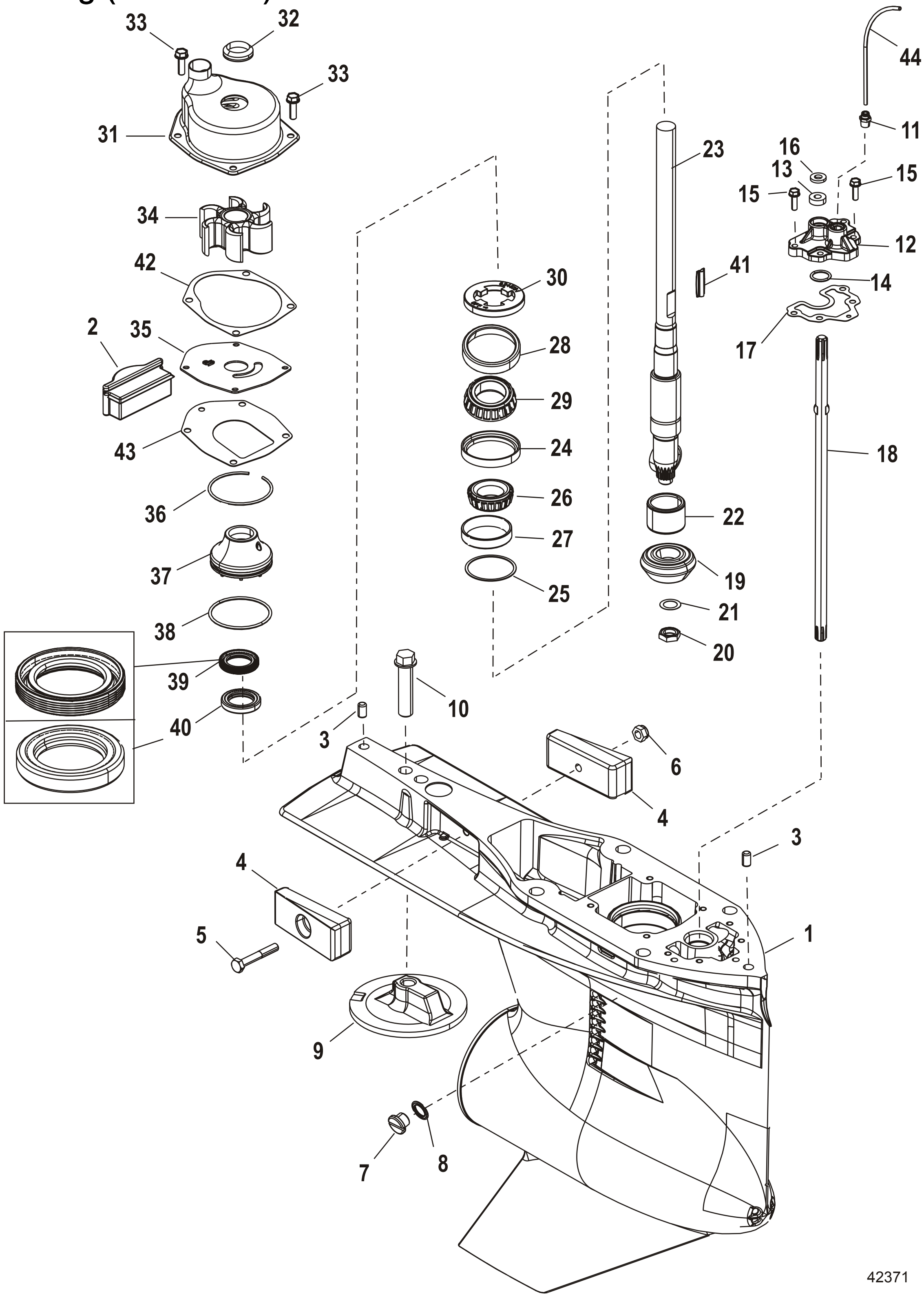
Puller Jaws Assembly Puller Bolt	91-46086A1/91-85716
 9514	Removes bearing carrier and bearing races.

Backlash Indicator Rod	91-78473
 9450	Aids in checking gear backlash.

Leakage Tester Kit	FT8950
 29497	Checks gear housing for leakage prior to filling with gear lubricant.

Notes:

Gear Housing (Driveshaft)

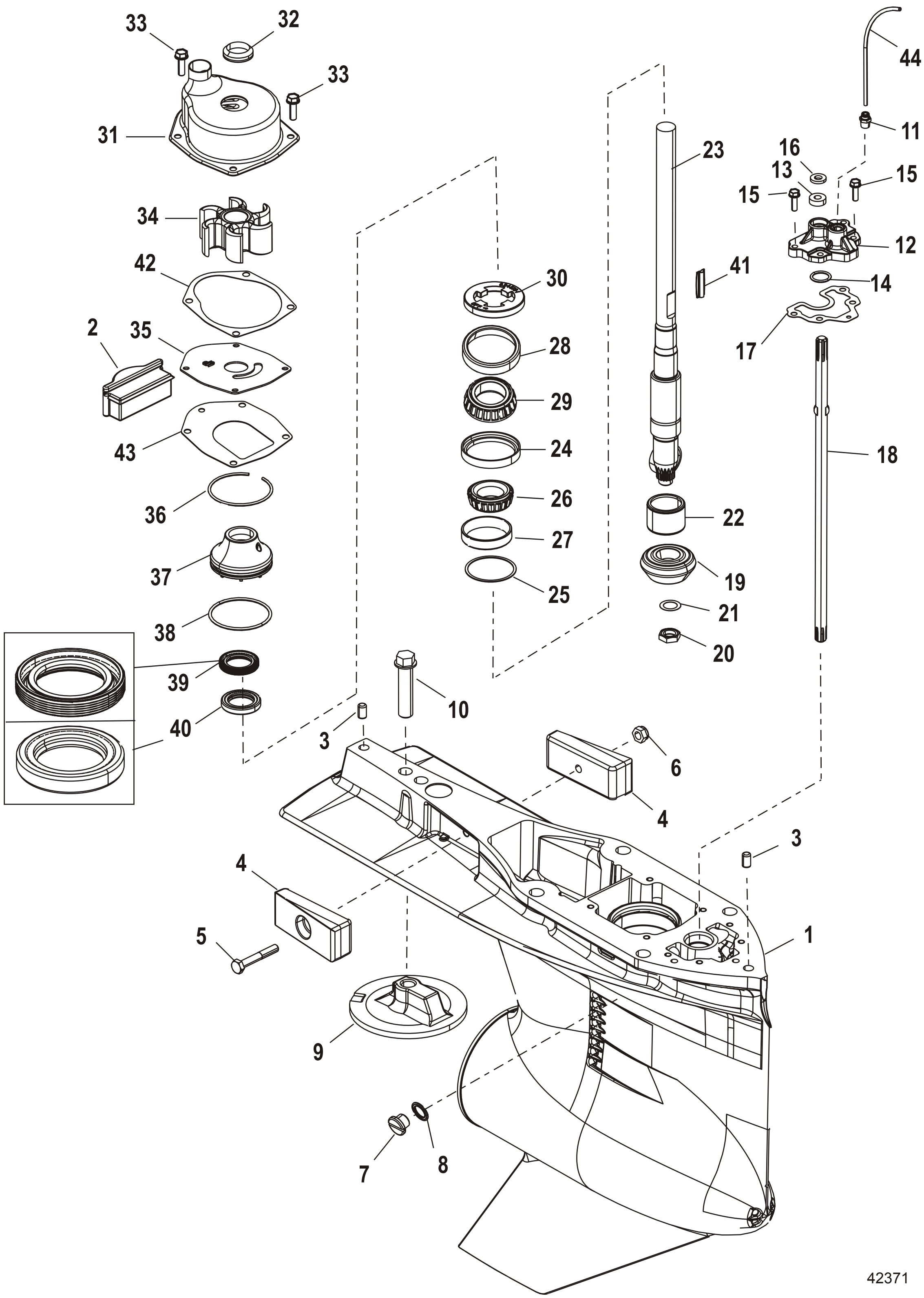


Gear Housing (Driveshaft)

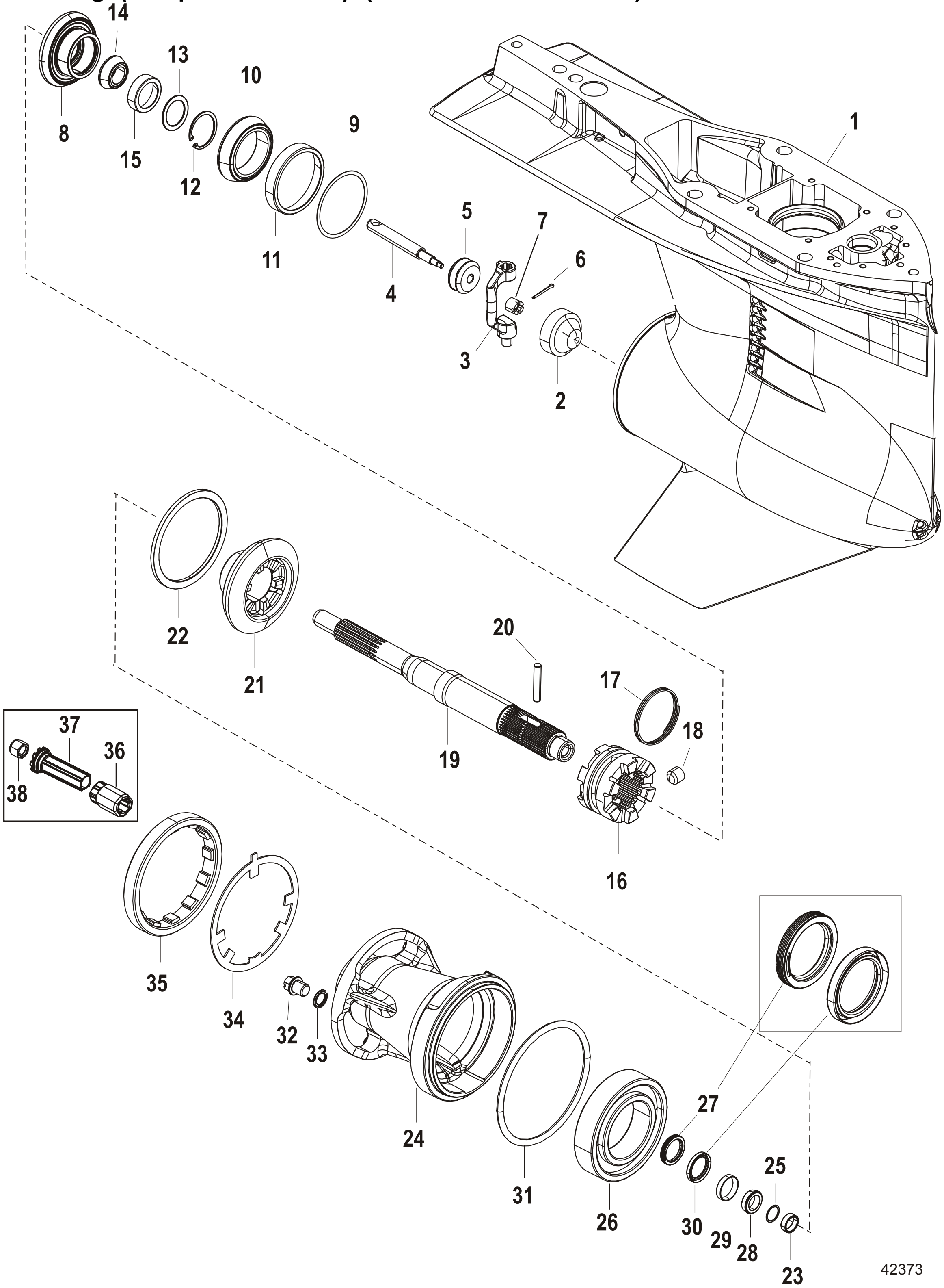
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing			
2	1	Filler block			
3	2	Dowel pin			
4	2	Anode			
5	1	Screw (M6 x 40)	6.8	60	
6	1	Nut			
7	1	Screw	6.8	60	
8	1	Seal			
9	1	Anodic plate			
10	1	Screw (0.437-14 x 1-3/4 in.)	54		40
11	1	Fitting	2.8	25	
12	1	Cover assembly			
13	1	Oil seal			
14	1	O-ring			
15	4	Screw (M6 x 20)	6.8	60	
16	1	Washer			
17	1	Gasket			
18	1	Lower shift shaft			
19	1	Pinion gear (12 teeth)			
20	1	Nut (5/8-18)	101		75
21	1	Washer			
22	1	Roller bearing			
23	1	Driveshaft (Long)			
		Driveshaft (X-Long)			
24	1	Shim/bearing assembly			
25	AR	Shim (0.002–0.050)			
26	1	Roller bearing assembly			
27	1	Cup			
28	1	Cup			
29	1	Roller bearing assembly			
30	1	Retainer	135.5		100
31	1	Water pump housing			
32	1	Face seal			
33	4	Screw (M6 x 20)	6.8	60	
34	1	Impeller			
35	1	Face plate			
36	1	Retaining ring			
37	1	Oil seal carrier			
38	1	O-ring (2.175 x 0.103)			
39	1	Oil seal			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
40	1	Oil seal			
41	1	Key			
42	1	Gasket			
43	1	Gasket			
44	1	Tube - 17.7 cm (7 in.) (Long)			
		Tube - 30.5 cm (12 in.) (X-long)			

Gear Housing (Driveshaft)



Gear Housing (Propeller Shaft) (Standard Rotation)



Gear Housing (Propeller Shaft) (Standard Rotation)

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing			
2	1	Plug	135.5		100
3	1	Shift crank			
4	1	Shift spool shaft			
5	1	Spool			
6	1	Cotter pin			
7	1	Adjusting sleeve			
8	1	Forward gear			
9	AR	Shim (0.002–0.050 in.)			
10	1	Roller bearing			
11	1	Cup			
12	1	Retaining ring			
13	1	Thrust washer			
14	1	Roller bearing assembly			
15	1	Cup			
16	1	Clutch			
17	1	Spring			
18	1	Detent pin			
19	1	Propeller shaft			
20	1	Cross pin			
21	1	Reverse gear			
22	1	Thrust ring			
23	1	Spacer			
24	1	Bearing carrier			
25	AR	Shim (0.002–0.070 in.)			
26	1	Ball bearing			
27	1	Oil seal			
28	1	Roller bearing			
29	1	Cup			
30	1	Oil seal			
31	1	O-ring			
32	1	Screw	6.8	60	
33	1	Seal			
34	1	Keyed washer			
35	1	Bearing retainer	285[1.]		210[1.]
36	1	Drive sleeve assembly			
37	1	Adapter			
38	1	Locknut	75		55

1. Torque retainer to 135.5 Nm (100 lb-ft) then check rolling torque on propeller shaft. If torque is within specification, torque retainer to 285 Nm (210 lb-ft)

General Service Recommendations

There may be more than one way to disassemble or reassemble a particular part, therefore, it is recommended the entire procedure be read prior to repair.

IMPORTANT: Read the following before attempting any repairs.

In many cases, disassembly of a subassembly 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 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** (on back of section divider) to find 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 the air line.

Bearings

Upon disassembly of the gear housing, all bearings must be cleaned and inspected. Clean 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 bearing with compressed air, as this may cause bearing to score from lack of lubrication. After cleaning, lubricate bearings with High Performance Gear Lubricant. Do not lubricate tapered bearing cups until after inspection.

Inspect all bearings for roughness, catches, and bearing race side wear. Work inner bearing race in and out, while holding outer race, to check for side wear.

When inspecting tapered bearings, determine condition of rollers and inner bearing race by inspecting bearing cup for pitting, scoring, grooves, uneven wear, imbedded particles and/or discoloration from overheating. Always replace tapered bearing and race as a set.

Inspect gear housing for bearing races that have spun in their respective bores. If race has spun, gear housing must be replaced.

Roller bearing condition is determined by inspecting the bearing surface of the shaft that the roller bearing supports. Check 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 location during disassembly to aid in reassembly. Be sure to follow shimming instructions during reassembly, as gears must be installed to correct depth and have the correct amount of backlash to avoid noisy operation and premature gear failure.

Seals

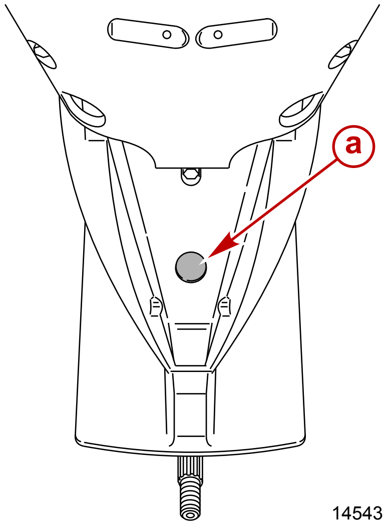
As a normal procedure, all O-rings and oil seals should be replaced without regard to appearance. To prevent leakage around oil seals, apply Loctite 271 to outer diameter of all metal case oil seals. When using Loctite on seals or threads, surfaces must be clean and dry. To ease installation, apply 2-4-C with Teflon on all O-rings. To prevent wear, apply 2-4-C with Teflon on inner diameter of oil seals.

Gearcase 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.

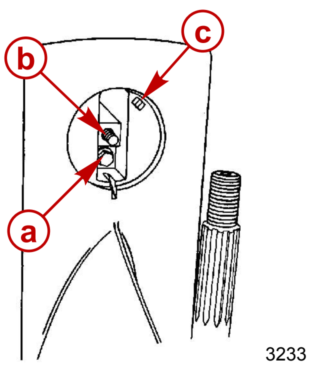
1. Ensure the gearcase is in neutral. The gearcase must be in neutral for installation.
2. Drain the engine oil. Failure to drain the oil prior to removing the gearcase will result in approximately 1 liter (1 US qt) of oil leakage when gearcase is removed. Refer to **Section 1B - Changing Engine Oil**.
3. Remove the propeller. Refer to **Section 1B - Propeller Replacement**.
4. Remove the top cowl.
5. Remove the port and starboard chaps. Refer to **Section 4A - Cowling Removal and Installation**.

6. Remove the rubber plug at the rear edge of the driveshaft housing. Remove the bolt (13 mm hex) that secures the anodic plate and remove the plate from the gear housing.



a - Rubber plug

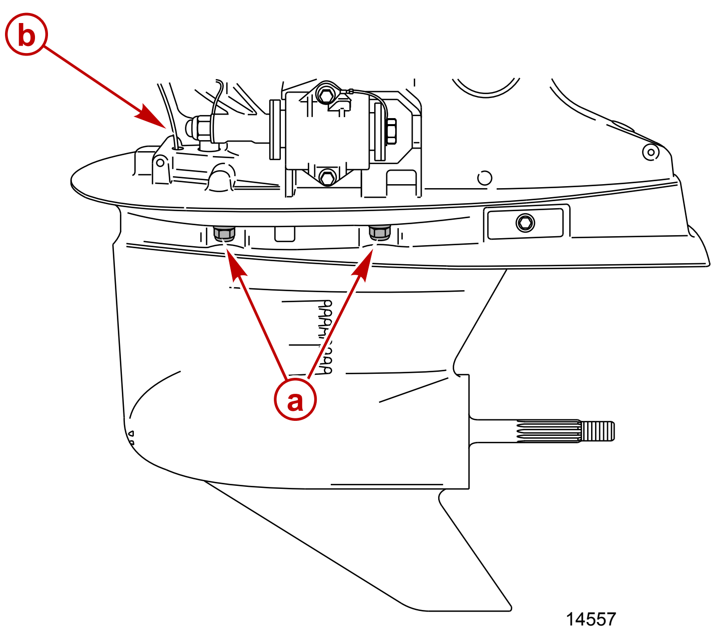
7. Once the plate is removed, remove the bolt (14 mm hex) from inside of the cavity.



a - Bolt (14 mm hex) (inside cavity)
b - Bolt (13 mm hex) (secures anodic plate)
c - Ribs

8. Loosen the side mounting locknuts. Do not attempt to remove one nut before the opposite side is loosened sufficiently, or the gear housing could be damaged. Support the gearcase as the last locknut is removed. The gearcase must be lowered slightly to gain access to the speedometer tube connection.

NOTE: After the retaining fasteners are removed from the gearcase, carefully lower gearcase assembly several inches to gain access to the speedometer tube connection. While pressing in on the speedometer tube junction, pull out on the tube to disconnect.



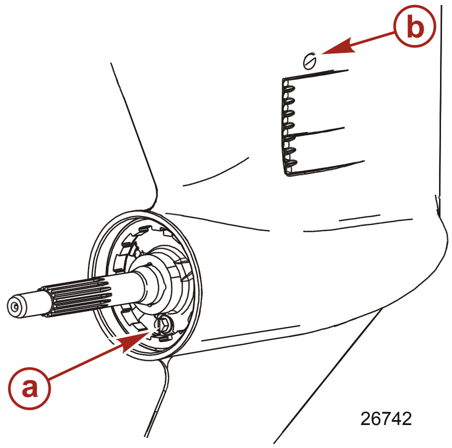
a - Nuts and washers (2 each side)
b - Speedometer tube

9. Pull the gear housing away from the driveshaft housing.

Gearcase Serviceability Inspection

Draining and Inspecting Gear Housing Lubricant

1. Place gear housing in a suitable holding fixture or vise with the driveshaft in a vertical position.
2. Position a clean drain pan under gear housing and remove fill and vent screws from gear housing with a 10 mm socket or slot screwdriver.



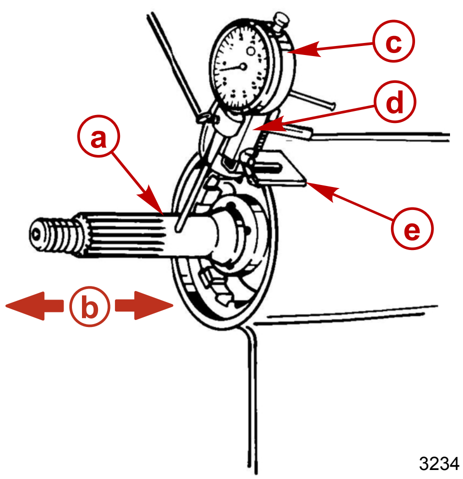
a - Fill screw
b - Vent screw

3. Inspect 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 need for gear housing disassembly, and component inspection.
4. Note the color of gear lubricant. White or cream color indicates presence of water in lubricant. Check drain pan for water separation from lubricant. Presence of water in gear lubricant indicates the need for disassembly, and inspection of oil seals, seal surfaces, O-rings, and gear housing components.

Propeller Shaft Inspection

Check for a bent propeller shaft as follows:

1. Rotate the propeller shaft while observing the dial indicator. If the deflection is more than 0.23 mm (0.009 in.), a bent propeller shaft is indicated.
2. Check for propeller shaft end play. There should be no end play. If end play exists, excessive wear has occurred and the gear housing must be disassembled for inspection.



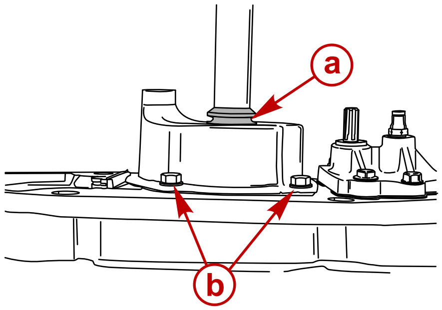
a - Propeller shaft runout
b - Propeller shaft end play
c - Dial indicator
d - Dial indicator holding tool
e - Dial indicator adapter

Dial Indicator	91- 58222A 1
Dial Indicator Adapter	91-83155
Dial Indicator Holding Tool	91- 89897

Water Pump

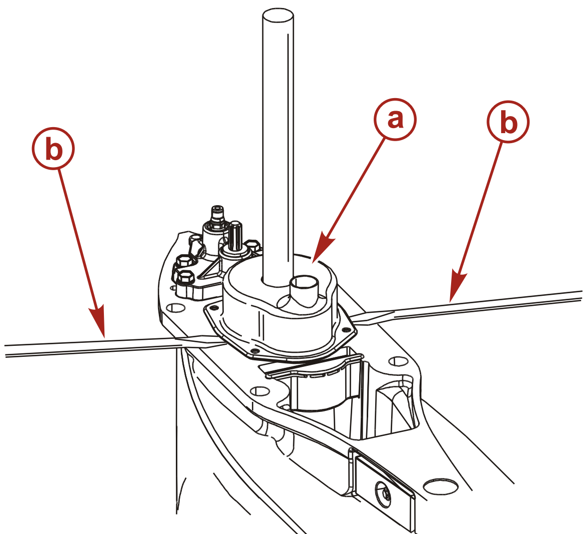
Removal and Disassembly

1. Remove the water seal and water pump screws.



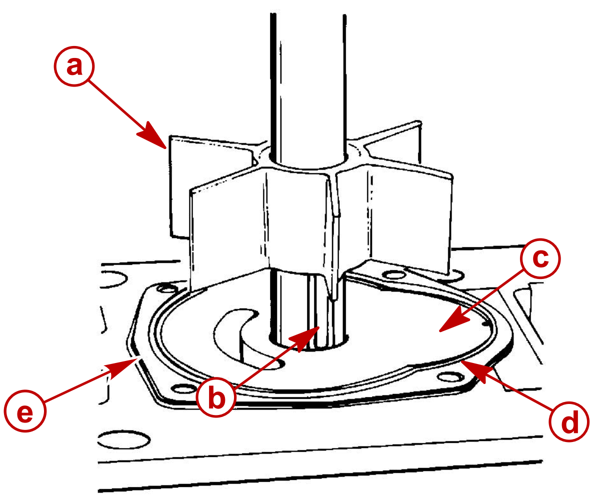
a - Water seal
b - Screws (2 each side)

2. Carefully slide the water pump straight up off of the driveshaft. It may be necessary to encourage the water pump up by gently prying up on its mounting flanges with screwdrivers.



a - Water pump body
b - Screwdrivers

3. Remove the impeller, impeller key, face plate, pump cover gasket, and pump base gasket.



a - Impeller
b - Key
c - Face plate
d - Pump cover gasket (gray bead faces up)
e - Pump cover base gasket

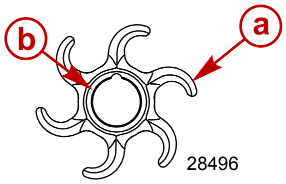
Cleaning and Inspection

NOTE: With the gearcase removed, inspect the water tube coupling assembly inside the driveshaft housing for wear or damage. If necessary, replace the worn or damaged components as required.

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

1. Inspect face plate and water pump liner for grooves and/or rough surfaces.

2. Inspect impeller side seal surfaces and ends of impeller blades for cracks, tears, and wear. Replace impeller if any of these conditions are found.
3. Inspect impeller bonding to impeller hub.



a - Impeller
b - Hub

4. Inspect impeller for glazed or melted appearance (caused by operation without sufficient water supply). Replace impeller if any of these conditions exist.

   IMPORTANT: When completing gear housing repairs that require removal of water pump impeller, it is recommended the impeller be replaced. If it is necessary, however, to reuse impeller, do not install in reverse to original rotation, or premature impeller failure will occur.

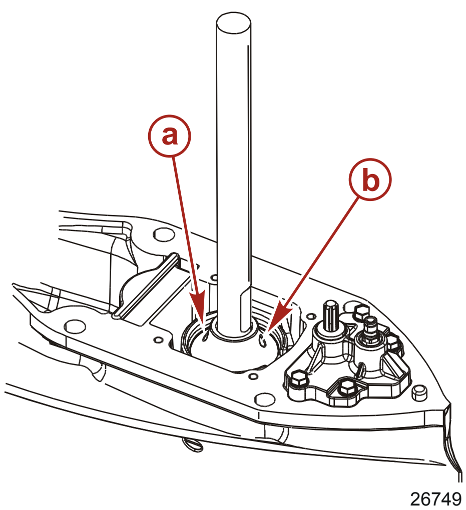
   IMPORTANT: It is recommended that all seals and gaskets be replaced (as a normal repair procedure) to assure effective repair.

Oil Seal Carrier Assembly

Removal

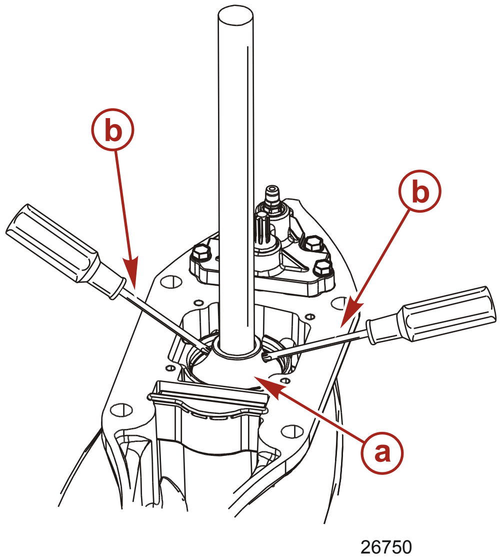
NOTE: Pushing down on the seal carrier may aid in the removal of the retaining ring above the seal carrier.

1. While pushing down on the seal carrier, use a flat tip screwdriver to aid in the removal of the retaining ring above the oil seal carrier.



a - Retaining ring
b - Seal carrier

2. Remove the oil seal carrier from the gear housing. It may be necessary to gently pry up on it with two screwdrivers.

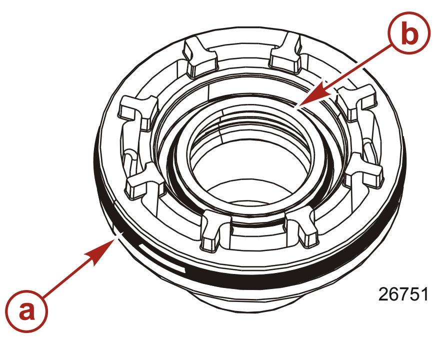


a - Oil seal carrier
b - Screwdrivers

Disassembly

NOTE: Complete the instructions in this section only if the assembly components have been found to be defective and are in need of repair or replacement.

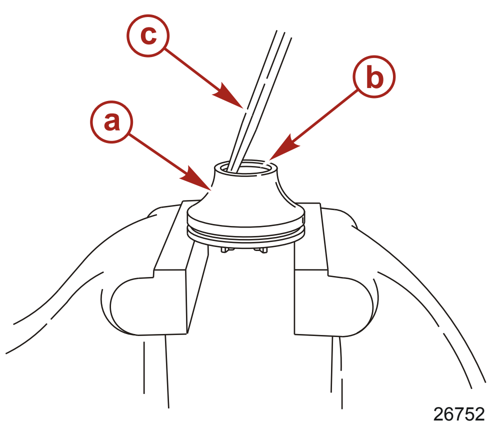
1. Remove the O-ring.



a - O-ring
b - Oil seals (2)

IMPORTANT: Use caution when removing carrier oil seals to avoid nicking or scratching the plastic surface the seals contact in the carrier, as water leakage into the gearcase could result.

2. Remove oil seals with a screwdriver or punch.

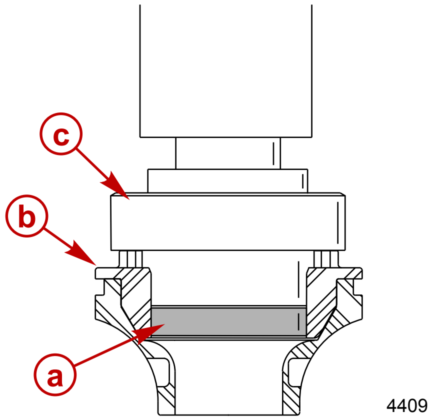


a - Oil seal carrier
b - Oil seals
c - Screwdriver

Reassembly

The oil seals in the carrier assembly are the same diameter. The bottom (first) seal lip faces down; the top (second) seal lip faces up. Apply 2-4-C with Teflon to seal lips and between seals. Apply Loctite 380 to outer diameter of both seals.

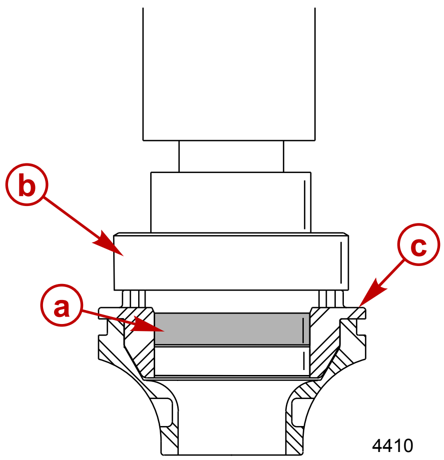
1. Press first seal into carrier with oil seal driver, using long side of seal driver.



a - First seal installed (lip faces away from driver)
b - Seal carrier
c - Oil seal driver

Oil Seal Driver	91-889844T

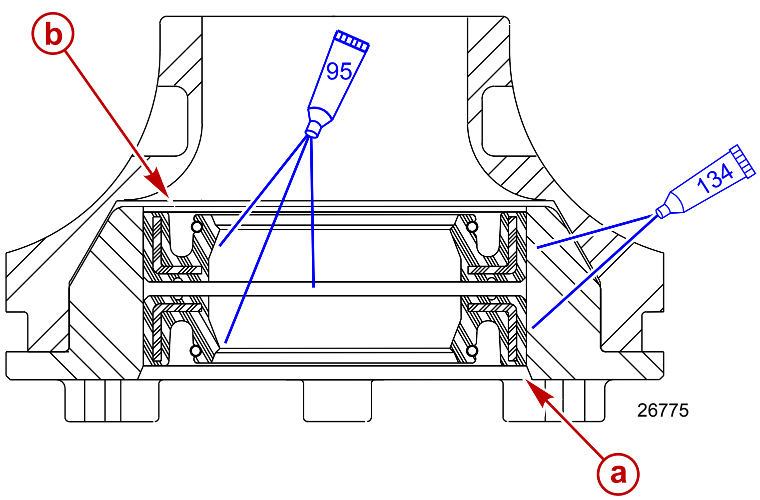
2. Reverse seal driver and using short side of driver, press second seal in until seal driver is flush with carrier surface.



a - Second seal installed (lip faces towards driver)
b - Oil seal driver
c - Seal carrier

Oil Seal Driver	91-889844T

3. Apply 2-4-C with Teflon to seal lips.



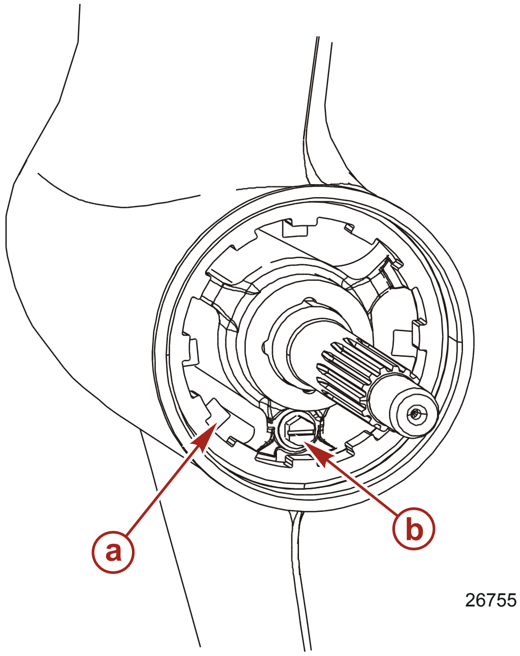
a - Second seal installed (lip faces down)
b - First seal installed (lip faces up)

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Oil seal lips and between oil seals	92-802859A 1
134	Loctite 380	Outer diameter of oil seals	Obtain Locally

Bearing Carrier and Propeller Shaft

1. Straighten any lock tabs on the tab washer.

   NOTE: Drain plug in bearing carrier must be removed before using bearing carrier retainer nut wrench to remove bearing carrier retainer.

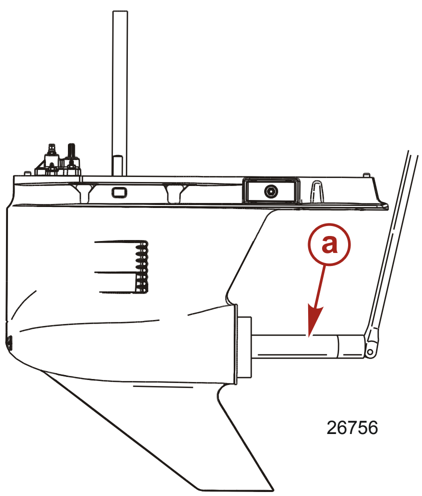


a - Tab
b - Drain plug

2. Remove the bearing carrier retainer following step "a" or "b" as follows:

   IMPORTANT: Drilling into the bearing carrier retainer can potentially damage the gearcase. Ensure you do not drill into the gearcase when removing a seized retainer.

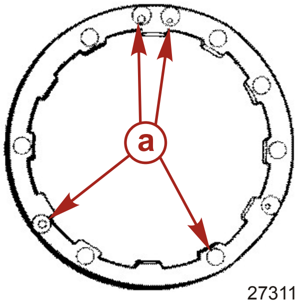
   a. Remove bearing carrier retainer turning retainer counterclockwise using bearing carrier retainer nut wrench.



a - Bearing carrier retainer nut wrench

Bearing Carrier Retainer Nut Wrench	91-61069T

b. If the retainer is corroded in place, drill four holes in the retainer and fracture the retainer with a chisel. Pry the remaining segments out.

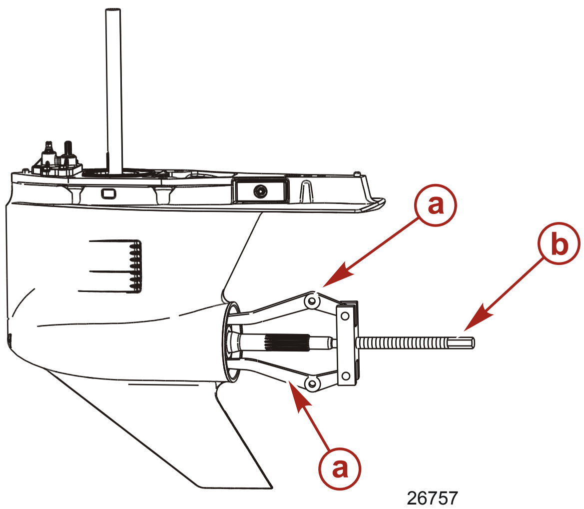


a - Drilled holes

c. Remove tab washer.

3. Pull the bearing carrier from the gear housing by pulling on the outer ring of the bearing carrier. Position puller jaws close to bosses in carrier.

NOTE: If the bearing carrier is seized in the gear housing, it may be necessary to use heat to loosen the carrier.



a - Puller jaws
b - Puller bolt

Puller Jaws Assembly	91-46086A1

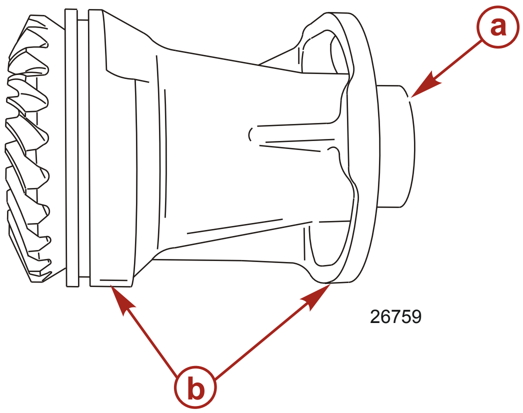
Cleaning/Inspection

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

1. Clean bearing carrier with solvent and dry with compressed air.

⚠ WARNING
Spin-drying bearings with compressed air can cause serious injury or death. The bearings can explode, even if spun at very slow speeds. Do not allow the bearings to spin when drying with compressed air.

2. Inspect the bearing carrier for signs of excessive corrosion especially in the area where the bearing carrier touches the gear housing. If excessive corrosion is evident replace the carrier.



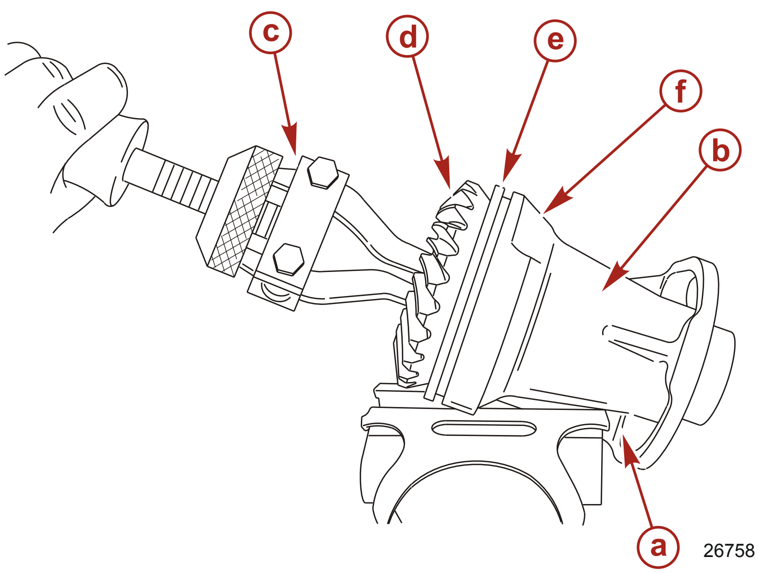
a - Bearing carrier
b - Inspect for corrosion

3. The propeller shaft utilizes a tapered roller bearing and cup for shaft support just forward of the bearing carrier seals. The reverse gear and bearing assembly must be removed from the bearing carrier to gain access to the propeller shaft tapered bearing for inspection.
4. Inspect reverse gear to pinion gear wear pattern (should be even and smooth). If not, replace reverse gear, pinion gear, and forward gear.
5. Check clutch jaws on reverse gear for damage. Replace reverse gear, if damage is found on clutch jaws.
6. Apply light oil to reverse gear bearing. Rotate reverse gear bearing while checking bearing for rough spots and/or catches. Push in and pull out on reverse gear to check for bearing side wear. Replace bearing if any of the listed conditions exist.

Disassembly

1. Remove and discard O-ring from between bearing carrier and thrust washer.

   IMPORTANT: Clamping the bearing carrier in a vise can damage the carrier. Clamp onto the reinforcing rib only.
2. Place the bearing carrier in a vise, clamping on the reinforcing rib.
3. Remove the reverse gear, thrust ring, and bearing as an assembly, using a slide hammer puller.

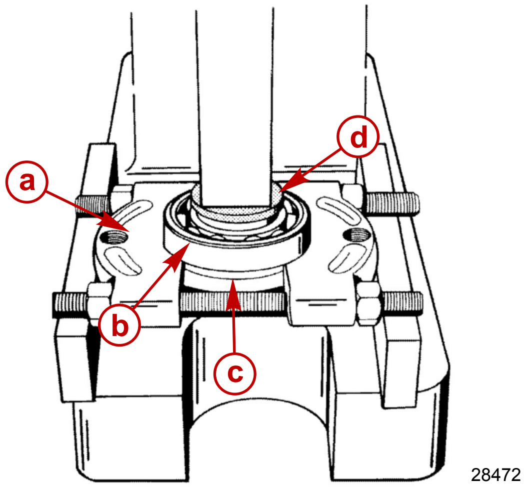


a - Bearing carrier reinforcing rib
b - Bearing carrier
c - Slide hammer puller
d - Reverse gear
e - Thrust ring
f - Bearing (not seen) - located inside carrier

Slide Hammer	91-34569A 1

4. Remove thrust washer from reverse gear assembly.

5. Using a suitable mandrel and the universal puller plate to support the bearing, press the bearing from the reverse gear as shown.



a - Universal puller plate
b - Bearing
c - Gear
d - Mandrel

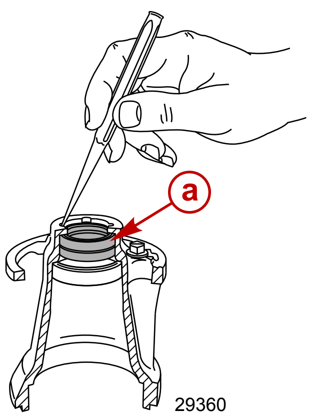
Universal Puller Plate	91-37241

a. Inspect the gear and thrust ring for excessive wear, cracks, or damage. Replace the appropriate components if any of these conditions are found.

NOTE: Inspect the aft propeller shaft tapered roller bearing for pits, scoring, discoloration or excessive looseness. Replace bearing and bearing race inside of carrier if these conditions exist.

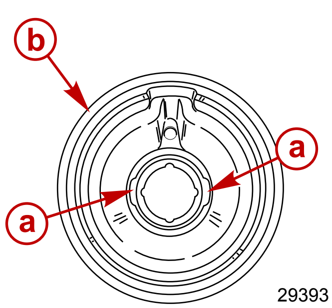
6. Perform the following step "a" or "b" as necessary.

a. **If replacing the seals only:** Remove the oil seals with a suitable punch, being careful not to damage the bore of the bearing carrier. Discard both of the seals.



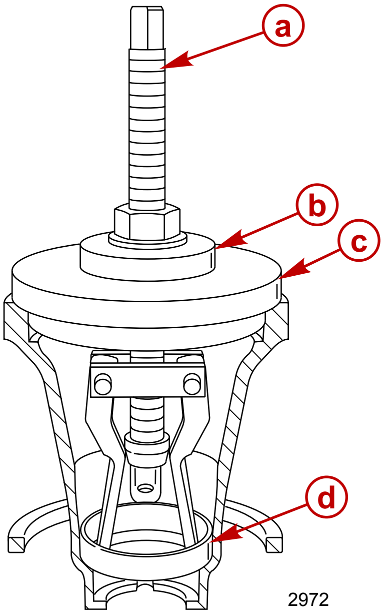
a - Seals

b. **If replacing the tapered roller bearing and seals:** Remove the seals with a punch as noted above. There are slots cast into the carrier to aid in the removal of the bearing race with puller jaws.



a - Slots
b - Bearing carrier

c. Remove the tapered bearing race from the carrier using bearing puller assembly, pilot washer, and seal driver guide. Discard the bearing, race, and both seals.

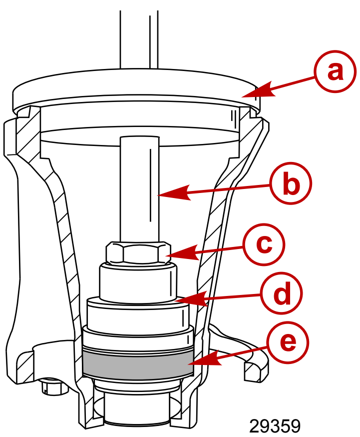


a - Bearing puller assembly
b - Pilot washer
c - Seal driver guide
d - Race

Bearing Puller Assembly	91-83165T
Pilot Washer	91-36571T
Seal Driver Guide	91-889845

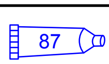
Reassembly

1. Clean all of the components with a suitable solvent and dry the parts thoroughly using compressed air.
2. Lubricate the bore that the tapered bearing race is pressed into with High Performance Gear Lubricant.
3. Assemble the bearing race onto the driver.
4. Press the bearing race into the bearing carrier until the race bottoms out in the bearing carrier.



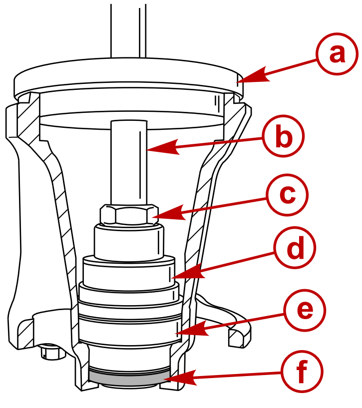
a - Seal driver guide
b - Driver rod
c - Nut
d - Bearing cup driver/oil seal installer
e - Tapered bearing race

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91-31229A7
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T

Tube Ref No.	Description	Where Used	Part No.
 87	High Performance Gear Lubricant	Tapered bearing race bore	92-858064K01

5. Thoroughly clean the bore in which the first seal is to be pressed.
6. Assemble the first seal (with the lip of the seal facing away from the driver shoulder) onto the long end of the oil seal driver.

7. Apply Loctite 380 to outer diameter of seal.
8. Press on the oil seal driver until the driver bottoms on the bearing race.

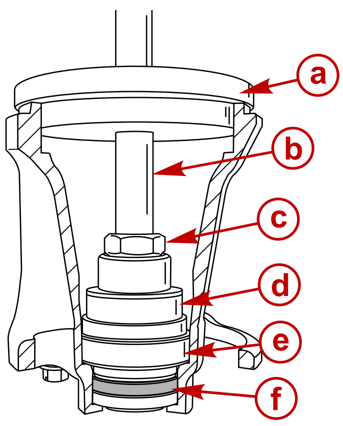


a - Seal driver guide
b - Driver rod
c - Nut
d - Bearing cup driver/oil seal installer
e - Bearing race
f - Oil seal (first)

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91-31229A7
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T

Tube Ref No.	Description	Where Used	Part No.
134	Loctite 380	Outer diameter of bearing carrier oil seal	Obtain Locally

9. Assemble the second seal (with the lips of the seal facing the driver shoulder) onto the short end of the driver seal.
10. Apply Loctite 380 to outer diameter of seal.
11. Press the oil seal with the driver until the driver bottoms out on the bearing race.



a - Seal driver guide
b - Driver rod
c - Nut
d - Bearing cup driver/oil seal installer
e - Bearing race
f - Oil seal (second)

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91-31229A7
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T

Tube Ref No.	Description	Where Used	Part No.
134	Loctite 380	Outer diameter of oil seals	Obtain Locally

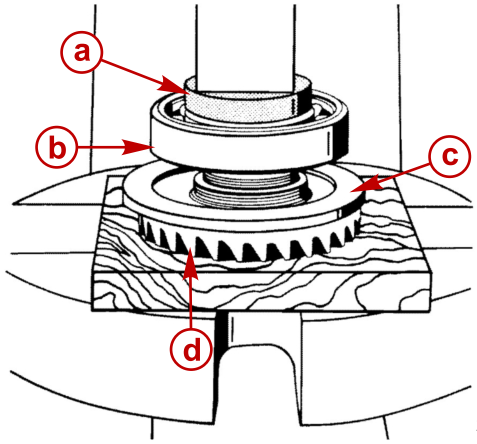
12. Lubricate the seal lips and fill the area between the seals with 2-4-C with Teflon.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Oil seal lips and between oil seals	92-802859A 1

13. Install propeller shaft tapered roller bearing into carrier bearing race.

NOTE: Reverse gear bearing is not fully seated until reverse gear/bearing assembly is pressed into the bearing carrier.

14. Install the thrust washer and a new ball bearing onto the reverse gear. Press on the inner race of the ball bearing using the pilot washer until the pilot washer bottoms out on the gear.



28473

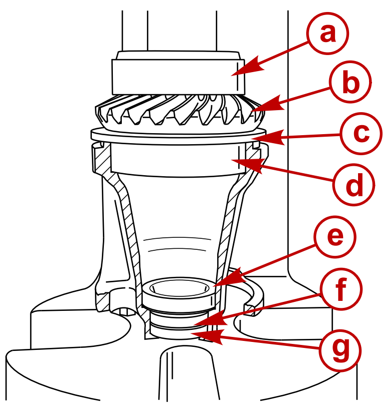
- a - Pilot washer
- b - Ball bearing
- c - Thrust washer
- d - Reverse gear

Pilot Washer	91-36571T

15. Lubricate the bore the bearing is pressed into with High Performance Gear Lubricant.

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Bearing bore in carrier	92-858064K01

16. Press the reverse gear assembly into the bearing carrier until the bearing bottoms out in the carrier.

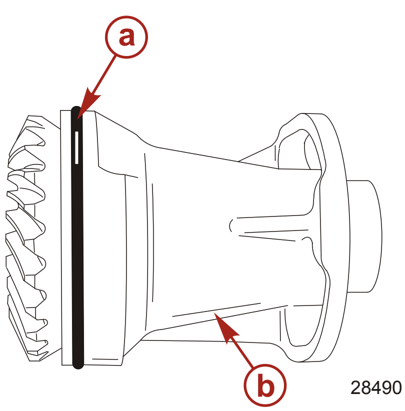


29354

- a - Bearing cup driver
- b - Reverse gear
- c - Thrust washer
- d - Ball bearing
- e - Tapered bearing
- f - Seal
- g - Seal

Bearing Cup Driver	91-885592T

17. Lubricate the O-ring with 2-4-C with Teflon and install the O-ring onto the bearing carrier.



28490

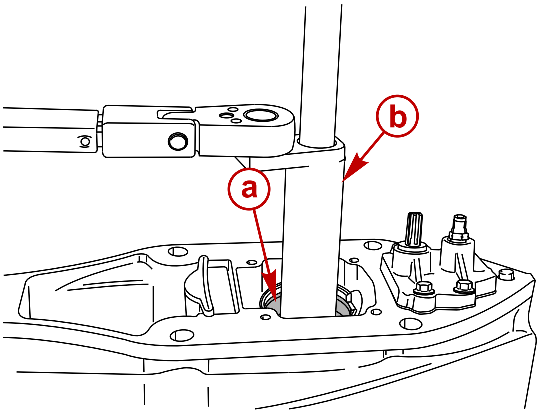
- a - O-ring
- b - Bearing carrier

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Bearing carrier O-ring	92-802859A 1

Driveshaft Assembly

Removal

1. Remove the driveshaft pinion nut as follows:
   a. Remove the upper driveshaft tapered bearing retainer.

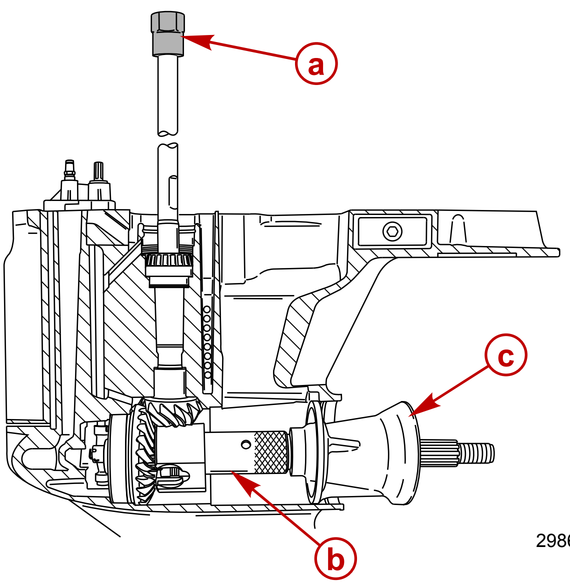


a - Retainer
b - Driveshaft bearing retainer wrench

29353

Driveshaft Bearing Retainer Wrench	91-43506T

   b. Place the driveshaft holding tool onto the driveshaft.
   c. Insert the pinion nut wrench with the MC1 slot facing the pinion gear into the gear housing. It may be necessary to slightly lift and rotate the driveshaft to align the pinion gear nut into the pinion nut wrench slot.
   d. Install the bearing carrier into the gear housing backwards to support the propeller shaft and to keep the pinion nut wrench aligned.
   e. Using the driveshaft holding tool, loosen the pinion nut by rotating the driveshaft counterclockwise.

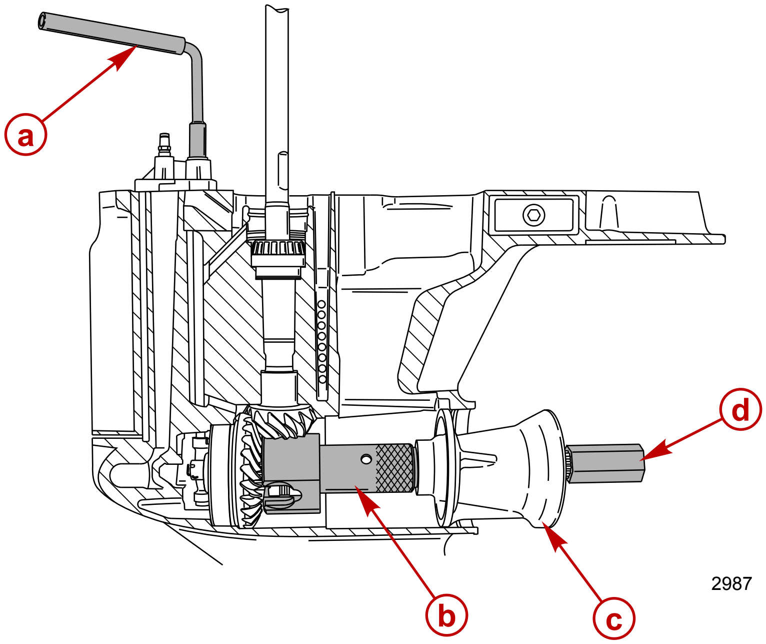


a - Driveshaft holding tool
b - Pinion nut wrench
c - Bearing carrier (installed backwards)

2986

Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03

f. If the driveshaft is broken, place propeller shaft adapter onto the propeller shaft splines, hold shift shaft in forward gear and loosen the pinion nut by rotating propeller shaft counterclockwise to turn gears, thus loosening the pinion nut.



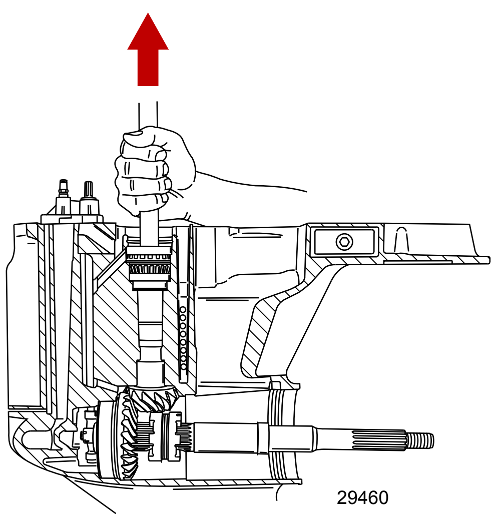
a - Shift shaft tool (fabricate from old shift shaft)
b - Pinion nut wrench
c - Bearing carrier (installed backwards)
d - Propeller shaft adapter

Pinion Nut Wrench	91- 61067T03
Propeller Shaft/Driveshaft Adapter	91-61077T

g. Completely unscrew the pinion nut by rotating the propeller shaft in a counterclockwise direction.

h. Remove all tools.

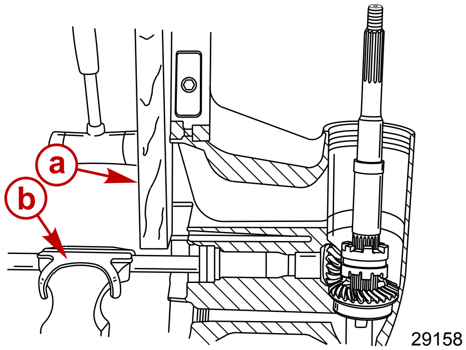
2. Remove the driveshaft and all components by pulling the driveshaft straight out of the gear housing as shown.



IMPORTANT: The pinion bearing rollers are free to fall out of the pinion bearing once the driveshaft is removed. Be careful not to lose the 18 rollers.

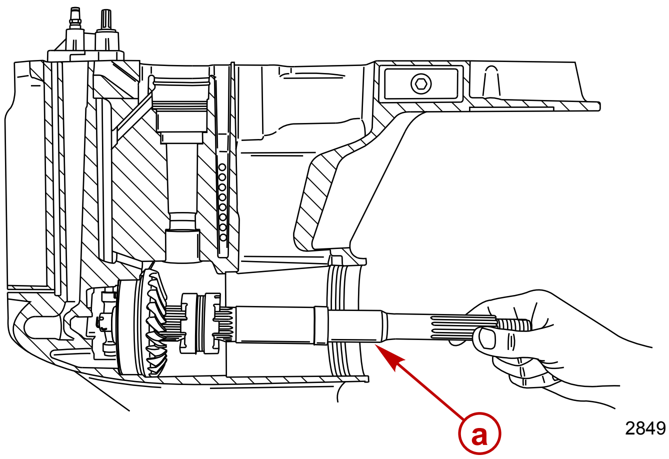
NOTE: If pinion gear is seized onto the driveshaft, place gearcase in a vise using soft jaw vise covers. Place a block of wood on gear housing mating surface. Use a mallet and carefully tap gear housing away from driveshaft.

IMPORTANT: Striking a gear housing directly with a mallet or dropping the gear housing could distort the gear housing. Distortion damage may result in gear housing failure.



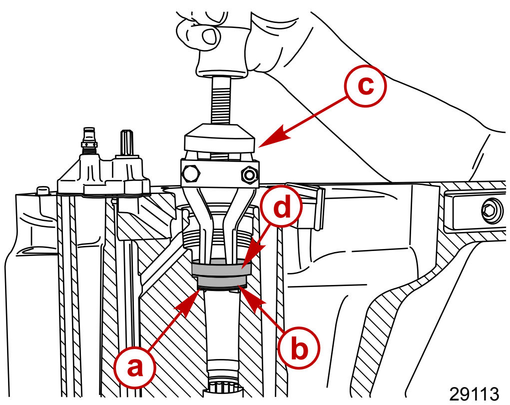
a - Wood block
b - Driveshaft in soft jaw vise

3. Retrieve the pinion gear, washer, and nut from inside the gear housing.
4. Move the propeller shaft to the starboard side of the gearcase to disengage the propeller shaft assembly from the shift crank. Remove the propeller shaft.



a - Propeller shaft

5. Remove spacer, bearing race, and shims using slide hammer puller (retain shims for reinstallation).



a - Shims
b - Bearing race
c - Slide hammer puller
d - Spacer

Slide Hammer	91-34569A 1

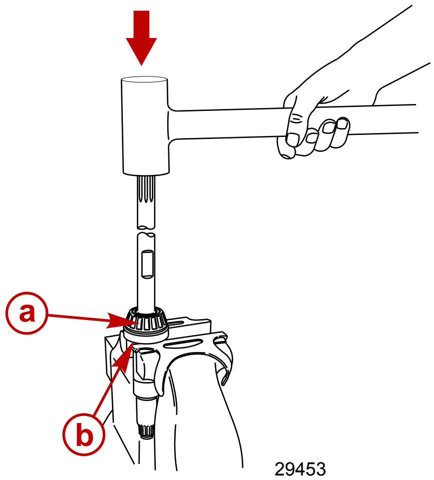
Disassembly

NOTE: Do not remove upper and lower tapered roller bearings from driveshaft unless replacement is indicated. Bearings cannot be reused after removal from driveshaft.

NOTE: If one driveshaft tapered roller bearing is damaged, both tapered bearings and spacer must be replaced as a set.

1. Both upper and lower tapered roller bearings can be removed from the driveshaft in one operation. Using the bottom bearing cup removed from the gearcase, place the cup on top of a vise leaving the vise jaws open enough to allow the driveshaft to slide through.

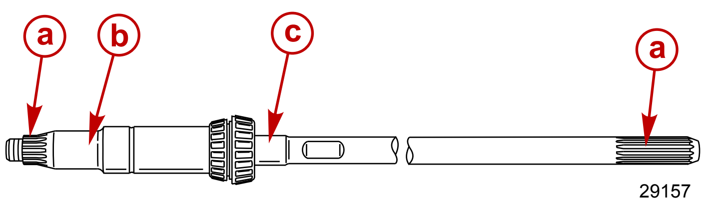
2. Place the driveshaft through the cup and vise until the bottom bearing is resting in the cup. While holding the driveshaft, tap on the top of the shaft with a dead blow hammer until the bearings are free. Do not drop the shaft when performing this operation.



a - Driveshaft with both upper and lower bearings
b - Lower bearing cup removed from gearcase

Inspection

1. Clean all parts with a suitable solvent and dry the parts thoroughly using compressed air, being careful not to spin the bearings.
2. The condition of the upper and lower driveshaft bearing cups is an indication of the condition of each of the tapered roller bearings on the driveshaft. Replace the bearing and bearing cup if the cup is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles.
3. Inspect the bearing surface on the driveshaft where the rollers of the lower pinion bearing roll. Replace the pinion bearing and the driveshaft if the shaft is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles.
4. Inspect the splines at both ends of the driveshaft for a worn or twisted condition. Replace the driveshaft if either condition exists.
5. Inspect driveshaft for grooves where the oil seal carrier oil seals contact the driveshaft. Replace the driveshaft if grooves are found.



a - Splines
b - Pinion bearing surface
c - Seal surface

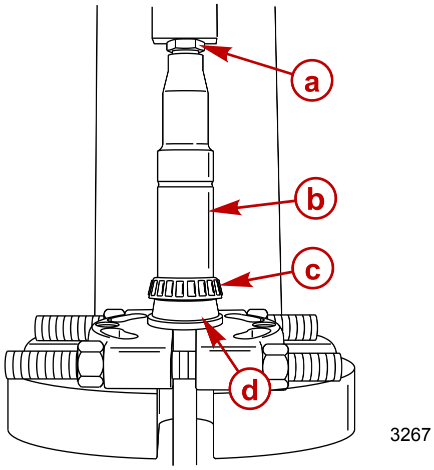
6. Inspect the pinion gear for pitting, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the pinion gear and the forward gear as a set if any defects are found.

Reassembly

NOTE: Complete the instructions in this section only if the components have been disassembled.

1. Apply a light coat of High Performance Gear Lubricant on inside diameter of the driveshaft tapered bearing.
2. Assemble a new lower tapered roller bearing to the driveshaft, with the small outside diameter of the bearing facing the pinion gear end of the driveshaft.
3. Thread a used pinion nut onto end of the driveshaft. Leave approximately 2 mm (1/16 in.) of nut threads exposed. Driveshaft threads must not extend beyond the nut or thread damage could result while pressing.

4. Press the tapered roller bearing onto the driveshaft using the universal puller plate and a suitable mandrel (an old tapered roller bearing inner race).

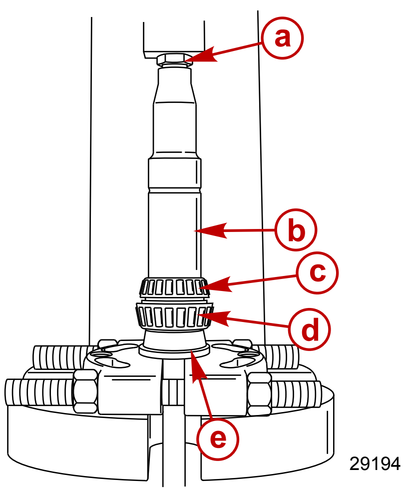


a - Pinion nut
b - Driveshaft
c - Lower driveshaft tapered bearing
d - Old tapered roller bearing inner race

Universal Puller Plate	91-37241

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of driveshaft tapered bearing	92-858064K01

5. Apply a light coat of High Performance Gear Lubricant on inside diameter of driveshaft tapered bearing.
6. Assemble a new upper tapered roller bearing to the driveshaft, with the large outside diameter of the bearing facing the pinion gear end of the driveshaft.
7. Thread a used pinion nut onto the end of the driveshaft. Leave approximately 2 mm (1/16 in.) of nut threads exposed. Driveshaft threads must not extend beyond the nut or thread damage could result while pressing.
8. Press the tapered roller bearing onto the driveshaft using the universal puller plate and a suitable mandrel (an old tapered roller bearing inner race).



a - Pinion nut
b - Driveshaft
c - Lower driveshaft tapered bearing
d - Upper driveshaft tapered bearing
e - Old tapered roller bearing inner race

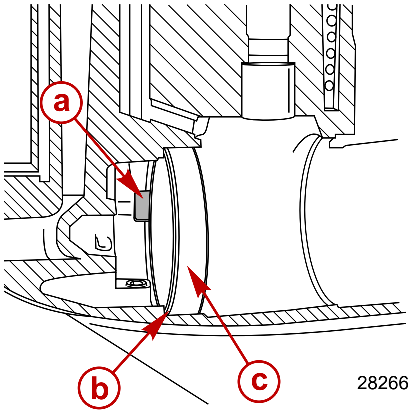
Universal Puller Plate	91-37241

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of driveshaft tapered bearing	92-858064K01

Propeller Shaft Assembly and Forward Gear Bearing Cup

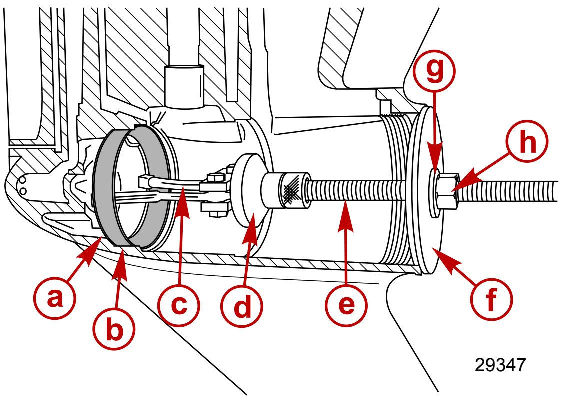
Removal

1. Two notches are provided in the gear housing just forward of the forward gear bearing cup, to position puller jaws for easier removal of the bearing cup and shims.



a - Notches
b - Shims
c - Forward gear bearing cup

2. Remove forward gear bearing cup and shims. Measure and make note of the shim thickness. If shims are not damaged, they may be reused.



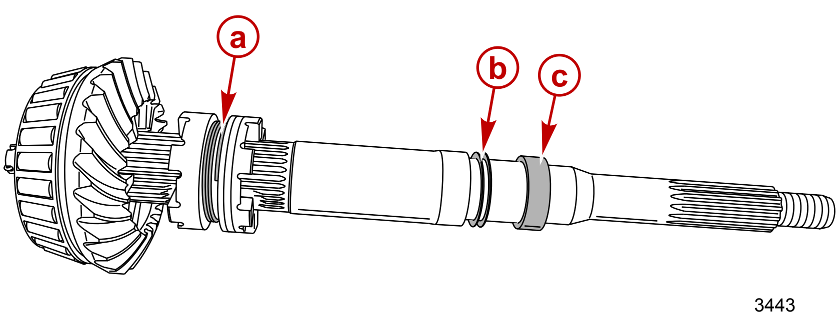
a - Shims
b - Bearing cup
c - Jaws (from slide hammer puller kit)
d - Puller Head (from slide hammer puller kit)
e - Puller shaft
f - Guide plate
g - Washer
h - Nut

Slide Hammer	91-34569A 1
Bearing Removal and Installation Kit	91-31229A7
Guide Plate	91-816243

Component Disassembly

NOTE: When accomplishing the next step, all of the parts are free to come apart. Work closely over a workbench to ensure the parts are not dropped or damaged and to avoid personal injury.

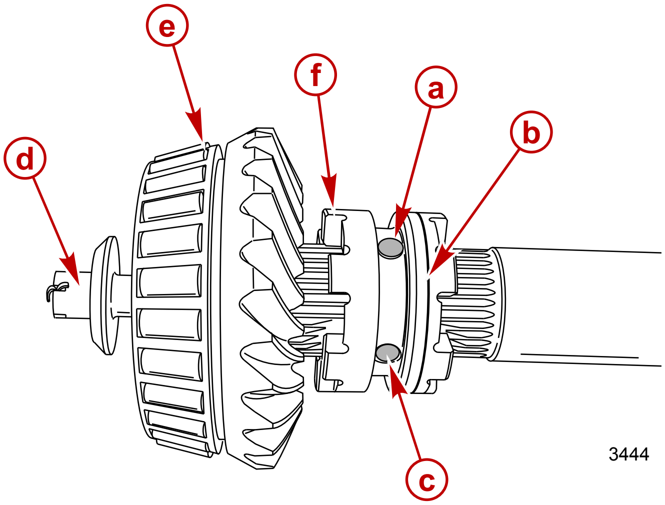
1. Remove propeller shaft preload spacer and shims.
2. Remove the spring around the clutch being careful not to overstretch it during removal. If the spring does not coil back to its normal position once it has been removed, it must be replaced.



a - Spring
b - Shims
c - Preload spacer

3. Remove detent pin.
4. Remove the cross pin that goes through the clutch.

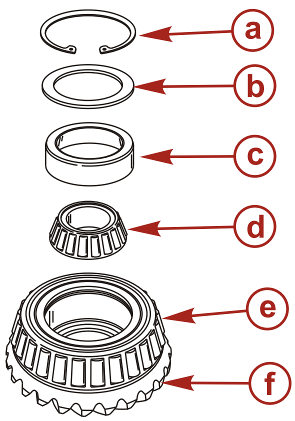
5. Remove the remainder of the components.



a - Detent pin
b - Clutch band (faces toward reverse gear)
c - Cross pin
d - Spool and actuating shaft assembly
e - Forward gear assembly
f - Clutch

Inspection

1. Clean all the parts with a suitable solvent and dry the parts thoroughly using compressed air, being careful not to spin bearings.
2. Inspect the sliding clutch jaws for damage. Jaws must not be chipped or rounded off. Replace the clutch if they are.
3. The propeller shaft utilizes two tapered roller bearing and cup assemblies for propeller shaft support. One tapered bearing is just forward of the bearing carrier seals. The reverse gear assembly must be removed from the bearing carrier to gain access to this bearing for inspection. The other tapered bearing is located inside the forward gear assembly. The forward gear assembly must be removed from the propeller shaft and a snap ring retainer and flat washer removed from the forward gear assembly to gain access to this tapered bearing for inspection.

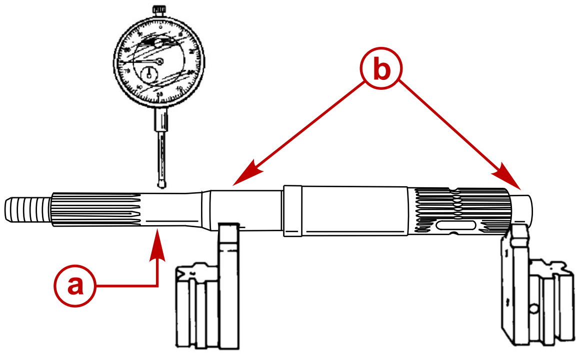


a - Snap ring
b - Flat washer
c - Tapered bearing race
d - Tapered bearing
e - Forward gear bearing
f - Forward gear

NOTE: Forward gear bearing should not be removed from forward gear unless replacement is necessary. Bearing is not reusable if bearing is removed.

4. Inspect the propeller shaft splines at both ends for a broken, worn, or twisted condition. Replace the propeller shaft if any of these conditions exist.
5. Inspect the propeller shaft for a bent condition using V-blocks and a dial indicator.
   a. Position the propeller shaft bearing surfaces on V-blocks.
   b. Adjust the height of V-blocks to level the propeller shaft.
   c. Position the dial indicator tip just forward of the propeller shaft splines.
6. Rotate the propeller shaft and observe the dial indicator movement, If the indicator in the dial moves more than 0.23 mm (0.009 in.), replace the propeller shaft.

7. Inspect bearing carrier seal surface area on propeller shaft for grooves. If grooves are present, propeller shaft must be replaced.



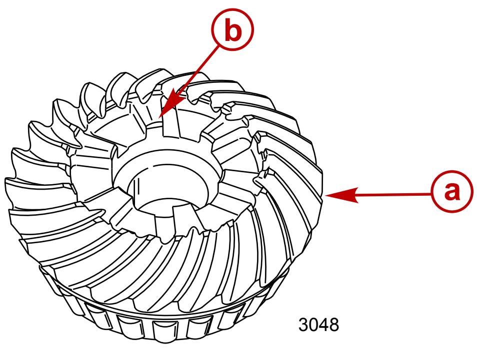
a - Check movement with dial indicator here
b - Seal surface area

Dial Indicator	91- 58222A 1

Forward Gear Assembly

Component Inspection

1. Clean the forward gear assembly and the forward gear bearing cup with a suitable solvent and dry with compressed air. Be careful not to spin the bearings.
2. Inspect the gear for pitting, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the forward gear and the pinion gear as a set if any defects are found.
3. Inspect the clutch jaws of the gear for damage. The surfaces must not be chipped or rounded off. Replace both the forward and pinion gear as a set if any of these conditions exist.



a - Forward gear teeth
b - Clutch jaws

4. Inspect the propeller shaft tapered roller bearing on the inside of the forward gear and its respective bearing cup. If either the bearing or the bearing cup surface is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles, remove and replace the tapered roller bearing assembly in the forward gear.
5. Inspect the tapered roller bearing pressed onto the forward gear and the bearing surface on the forward gear bearing cup. If either the roller bearing or the bearing surface of the forward gear bearing cup is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles, replace the forward gear bearing cup and remove and replace the tapered roller bearing as outlined in the next section.

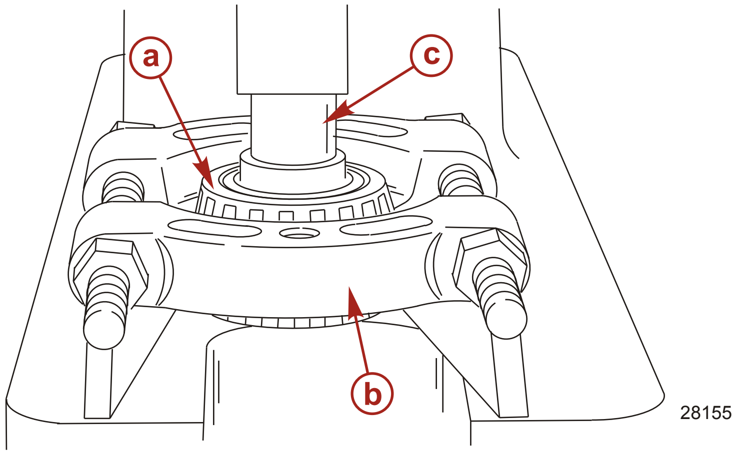
Disassembly

NOTE: Forward gear and propeller shaft assembly can only be removed from gear housing after driveshaft and pinion gear have been removed.

IMPORTANT: Do not remove pressed on tapered roller bearing from forward gear unless replacement of bearing is required. Bearing cannot be reused after it has been removed.

1. If inspection determines that replacement of forward gear tapered bearing is required, separate gear from bearing as follows:
    a. Press universal puller plate between forward gear and tapered bearing.
    b. Place assembly on press and press gear out of bearing with suitable mandrel.

NOTE: Tapered bearing and race must be replaced as a set.

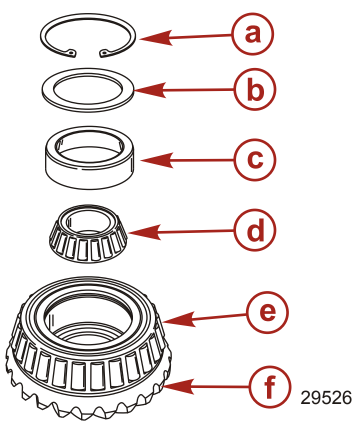


a - Forward gear bearing
b - Universal puller plate
c - Mandrel

Universal Puller Plate	91-37241

2. If inspection determines that replacement of propeller shaft tapered roller bearing is required, remove bearing as follows:
   a. Clamp forward gear in a soft jaw vise securely.

      IMPORTANT: Use suitable eye protection when removing or installing snap ring.
   b. Use snap ring pliers to remove snap ring. Push tapered roller bearing assembly out of inside of forward gear.



a - Snap ring
b - Flat washer
c - Tapered bearing race
d - Tapered bearing
e - Forward gear bearing
f - Forward gear

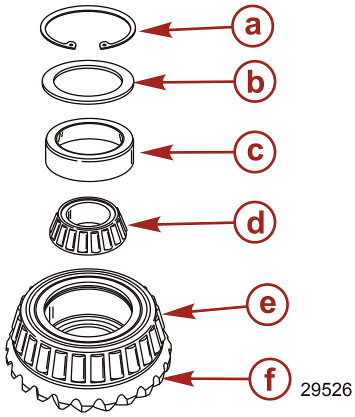
Reassembly

NOTE: Complete the instructions in this section only if the assembly components have been disassembled and repaired or replaced.

1. Apply High Performance Gear Lubricant to the inside diameter of the forward gear. Push tapered roller bearing assembly into forward gear until bearing seats.

   IMPORTANT: Use suitable eye protection when removing or installing snap ring.
2. Install flat washer onto bearing race.

3. Install snap ring into groove of forward gear to secure tapered roller bearing assembly.



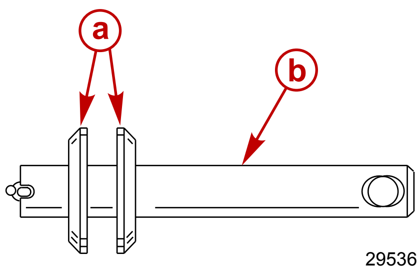
a - Snap ring
b - Flat washer
c - Tapered bearing race
d - Tapered bearing
e - Forward gear bearing
f - Forward gear

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of forward gear	92-858064K01

Shift Spool Assembly

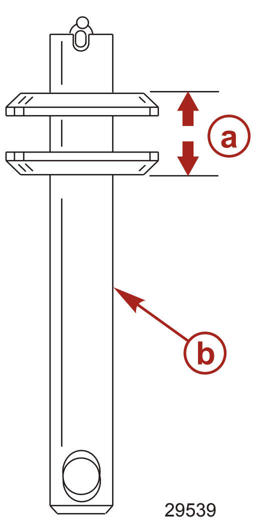
Inspection

1. Clean the assembly with a suitable solvent and dry the parts using compressed air.
2. Inspect the shift spool assembly for damage. Small nicks and burrs may be smoothed. If any parts are damaged or worn excessively, it will be necessary to replace the complete shift spool assembly. Individual parts are not available for the assembly.
3. Inspect the shift spool for wear in the area where the shift crank comes into contact.



a - Contact area
b - Nonratcheting shift spool

4. Inspect to ensure the spool spins freely (it may be helpful to lightly tap the castle nut end of the shift spool against a firm surface to align the internal parts).
5. Inspect to ensure the spool has end play. This end play may be achieved by turning the castle nut clockwise down until it is snug and then backing off the nut counterclockwise to the first cotter pin slot.



a - End play
b - Shift spool

Shift Spool	
End play	0.05–0.25 mm (0.002–0.010 in.)

Disassembly

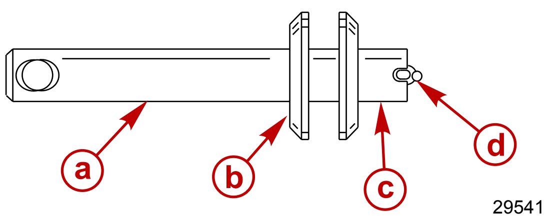
NOTE: If the spool spins freely and has the proper clearance, it will not be necessary to disassemble and reassemble the spool. If the spool does not function properly, proceed with the following disassembly procedures.

NOTE: Disassembly of the shift spool is for cleaning and inspection of the internal parts due to an improperly functioning shift spool assembly or debris in the gear housing and/or shift spool assembly. Individual components for the shift spool are not available as replacement parts. If the shift spool does not function properly and the following cleaning and adjustment procedures do not correct the problem, it will be necessary to order a new shift spool assembly.

1. Remove and discard the cotter pin.
2. Remove the castle nut and spool.

Reassembly

1. Place the shift spool onto the shift spool shaft.
2. Screw the castle nut down until it touches the spool and a slight resistance is felt.
3. Loosen the castle nut until the cotter pin slot of the nut is aligned with the hole in the shaft. If the castle nut is threaded down and the cotter pin slot is already aligned at the hole in the shift spool shaft, back the castle nut off until the next available slot in the nut is aligned with the hole in the shaft.
4. Insert a new cotter pin and bend the ends of the cotter pin in opposite directions.
5. Verify the spool has end play. If it does not, adjust the castle nut again.



a - Shift shaft
b - Spool
c - Castle nut
d - Cotter pin

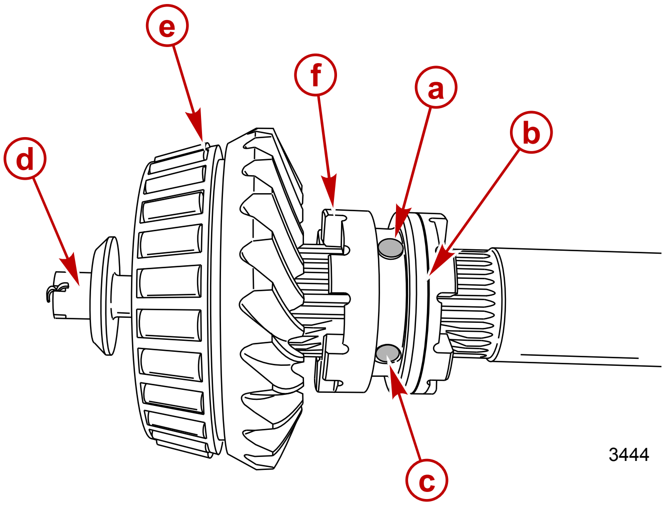
Shift Spool	
End play	0.05–0.25 mm (0.002–0.010 in.)

6. If this adjustment did not produce the desired results, it will be necessary to disassemble, clean, and reassemble the shift spool assembly. If the spool assembly has already been disassembled and cleaned, it will be necessary to replace the shift spool assembly.

Propeller Shaft Reassembly

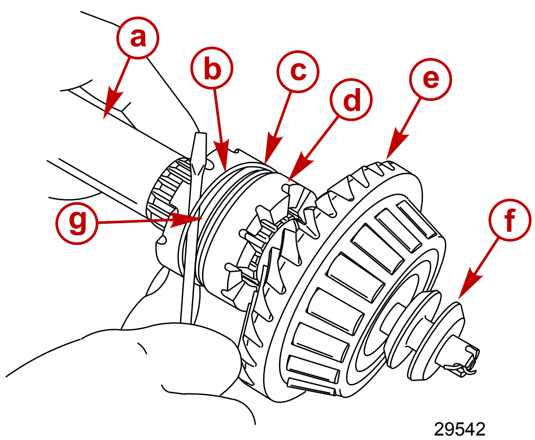
1. Install the sliding clutch (with band on clutch facing aft) onto the propeller shaft. Align the cross pin holes in the clutch with the slot in the propeller shaft.
2. Assemble the forward gear assembly to the propeller shaft.
3. Assemble the shift spool assembly to the propeller shaft, making sure the cross pin hole of the shift spool shaft is aligned with the clutch.
4. Assemble the cross pin through the sliding clutch, through the propeller shaft, and through the shift spool shaft hole.

5. Install detent pin in third hole in clutch.



a - Detent pin
b - Clutch band (faces aft)
c - Cross pin
d - Shift spool and actuating shaft assembly
e - Forward gear assembly
f - Clutch

6. Assemble the cross pin retaining spring over the propeller end of the propeller shaft and wind it around the clutch over the cross pin hole. Be careful not to distort the spring while assembling it. **Verify the spring is wound on so that it does not cross over on itself and that it lies flat against the clutch once it is assembled. If it does not lie flat against the clutch, a new spring must be installed.**



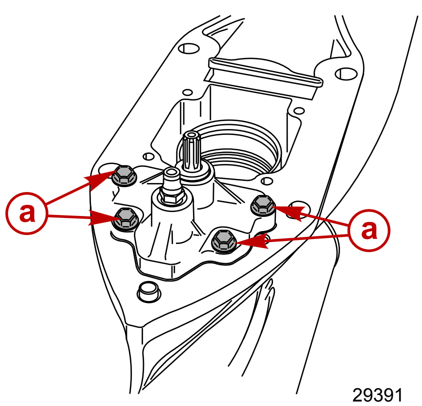
a - Propeller shaft
b - Cross pin retaining spring
c - Cross pin (hidden)
d - Sliding clutch
e - Forward gear assembly
f - Spool and actuating shaft assembly
g - Detent pin (hidden)

Shift Shaft Cover Assembly

Removal

NOTE: It is possible to remove and service the shift shaft assembly (but not the shift crank inside the gear housing) without removing any of the internal components of the gear housing.

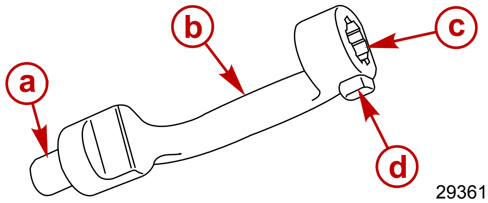
1. Remove the shift shaft cover screws. Remove the shift shaft and cover by pulling both straight out of the gear housing.



a - Shift shaft cover screws

2. Remove the shift crank from the inside of the gear housing. Clean it with a suitable solvent and dry it thoroughly with compressed air. Inspect it for wear in the areas that contact the shift spool and inspect the splines and the pivot pin for damage or wear.

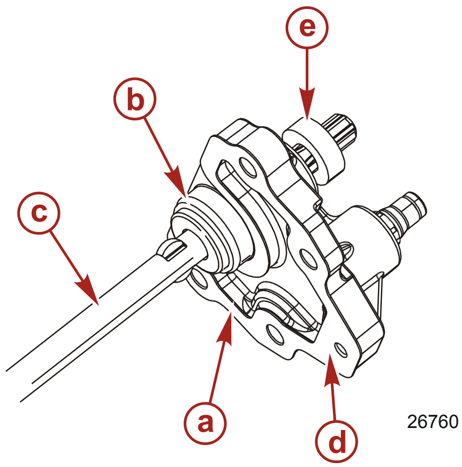
NOTE: The shift crank has a locating tab. On right-hand rotation gear housings, the tab faces toward the forward gear bearing assembly. On left-hand rotation gear housings, the tab faces away from the reverse gear bearing assembly.



- a - Pivot pin
- b - Contact area
- c - Splines
- d - Locating tab

Disassembly and Inspection

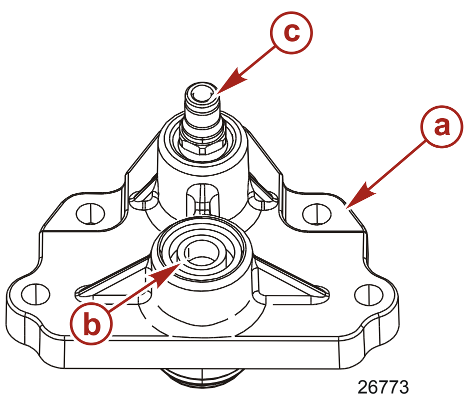
1. Remove the rubber washer from the shift shaft. Slide the cover assembly off the shift shaft.



- a - Shift shaft cover assembly
- b - O-ring
- c - Shift shaft
- d - Gasket
- e - Rubber washer

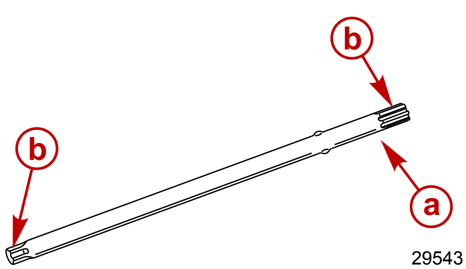
2. Clean all components with a suitable solvent and dry thoroughly with compressed air.
   a. Inspect the shift shaft cover for cracking, damage, or excessive wear.
   b. Inspect the oil seal inside the cover, the sleeve, and the O-ring on the outside of the cover for damage or excessive wear.
   c. Inspect the speedometer connector for damage or blockage.
   d. Inspect the speedometer passage through the shift shaft cover for debris.

   NOTE: If any of these conditions exist, replace the appropriate components.



- a - Shift shaft cover
- b - Oil seal (seal is replaceable)
- c - Speedometer tube connector

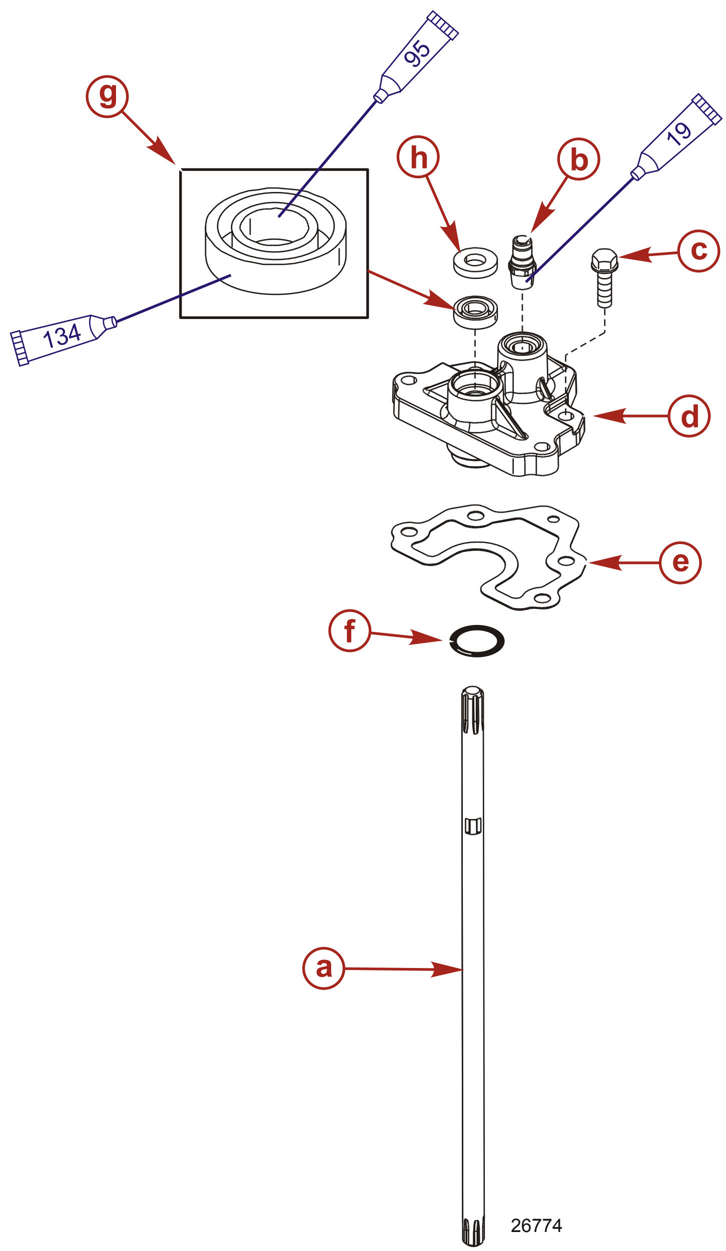
3. Inspect the shift shaft splines and oil seal surface for corrosion and/or excessive wear. Replace the shift shaft if either of these conditions are found.



- a - Oil seal surface
- b - Splines

Assembly

1. Lightly lubricate the seat of the O-ring diameter on the cover and the lip of the oil seal with 2-4-C with Teflon.
2. Apply Loctite 380 to the outside diameter of the oil seal. Wipe off any excess Loctite.
3. If the speedometer connector was removed and/or replaced, lightly coat the threads of the connector with Perfect Seal. Assemble the speedometer connector to the cover and tighten the connector to the specified torque.
4. Apply Loctite 271 Threadlocker to the cover assembly screw threads.
5. Assemble all components, as shown below. Be sure to position the O-ring onto the cover before installing the cover into the gear housing.



a - Shift shaft
b - Speedometer tube connector
c - Screws
d - Cover assembly
e - Gasket
f - O-ring
g - Seal (lip faces up)
h - Rubber washer

Tube Ref No.	Description	Where Used	Part No.
19	Perfect Seal	Speedometer connector threads	92-34227 1
95	2-4-C with Teflon	Seat of the shift shaft cover O-ring diameter and lip of the oil seal	92-802859A 1
134	Loctite 380	Outside diameter of the oil seal	Obtain Locally
7	Loctite 271 Threadlocker	Cover assembly screw threads	92-809819

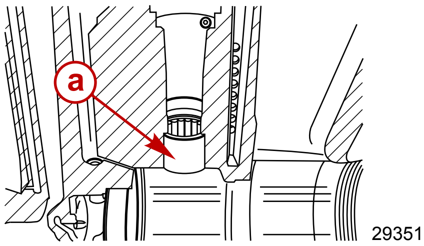
Description	Nm	lb-in.	lb-ft
Speedometer connector	2.8	25	
Cover assembly screws (M6 x 20) (4 each)	6.8	60	

Pinion Bearing Removal

NOTE: Inspect the bearing surface on the driveshaft where the rollers of the lower pinion bearing roll. The condition of the driveshaft at this location gives an indication of the condition of the roller bearing. Replace lower pinion bearing (rollers and race as a set) if the driveshaft is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles.

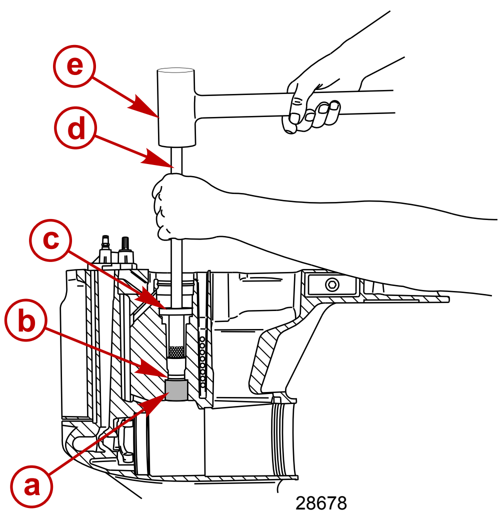
IMPORTANT: All the roller bearings (18) must be in place inside the bearing race while driving the pinion bearing from the gear housing. It is recommended that the cardboard tube provided with a new pinion bearing be used to keep the bearings in place while driving out the old pinion bearing.

IMPORTANT: Do not reuse the bearing (race or rollers) once it has been removed.



a - Pinion bearing

Remove and discard the pinion bearing (race and rollers) using the tools as shown.



a - Pinion bearing
b - Driver head
c - Pilot washer
d - Driver rod
e - Dead blow hammer

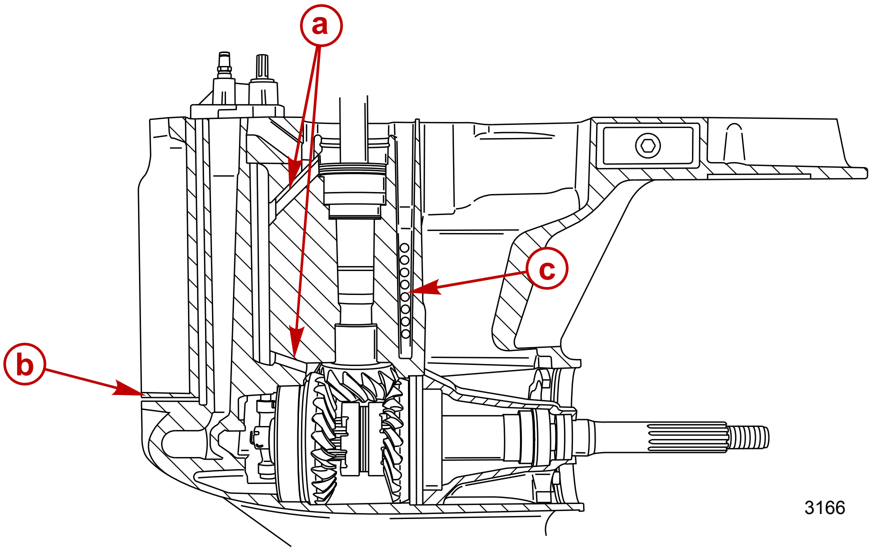
Driver Head	91- 36569T
Pilot Washer	91-36571T
Driver Rod	91- 37323

Gear Housing Inspection

1. Clean the gear housing thoroughly with a suitable solvent and a hard bristle brush. Dry the gear housing thoroughly using compressed air. Ensure all sealants, locking agents, and debris are removed.
2. Verify the two oil circulation holes in the driveshaft bore and the shift shaft hole are clear and free of debris.
3. Inspect the gear housing for excessive corrosion, impact, or any other damage. Excessive damage and/or corrosion requires replacement of the gear housing.
4. Inspect the bearing carrier retainer threads in the gear housing for corrosion and/or stripped threads. Damage or corrosion to the threads requires replacement of the gear housing.

   NOTE: The upper driveshaft bearing cup is a slip fit within the driveshaft bore and may show signs of movement. All other bearing cups are press fit and should not show any signs of movement.
5. Inspect bearing race/cup contact areas for evidence of bearing cup spinning. Check that bearing cups are not loose in bearing bores. A press fit type bearing bore in which the race/cup is loose will require replacement of the gear housing.

6. Inspect for blockage in water inlet holes and the speedometer hole, clean as necessary. Be careful not to enlarge the speedometer hole, as this could cause erroneous speedometer readings.



a - Oil circulation holes
b - Speedometer hole
c - Water inlet holes

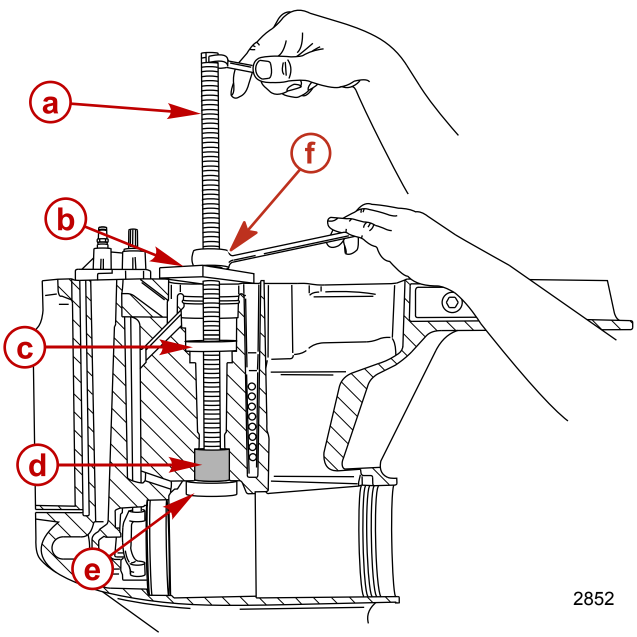
7. Verify the locating pins are in place in the gear housing and the corresponding holes in the driveshaft housing are not elongated. The driveshaft may break if the housings are not aligned properly due to missing locating pins or elongated holes.

Pinion Bearing Installation

IMPORTANT: Install only a new pinion bearing. Do not reinstall a pinion bearing that has been previously removed from a gear housing.

1. Lubricate the bore into which the pinion bearing is to be installed with High Performance Gear Lubricant.
2. Position the new pinion bearing (with the cardboard shipping sleeve in place) onto the driver head, with the lettered and numbered side of the bearing oriented upward.
3. Insert the driver with the bearing assembly, into position (by way of the propeller shaft bore) at the driveshaft bore as shown.

   NOTE: The puller/driver head used to install the pinion bearing is contained in the bearing removal and installation kit.
4. Install the bearing by screwing down the nut until the bearing is fully seated against the bore shoulder.



a - Puller rod
b - Puller plate
c - Pilot
d - Pinion bearing
e - Puller/driver head
f - Hex nut

Bearing Removal and Installation Kit	91-31229A7

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Pinion bearing bore	92-858064K01

Forward Bearing Cup

Installation

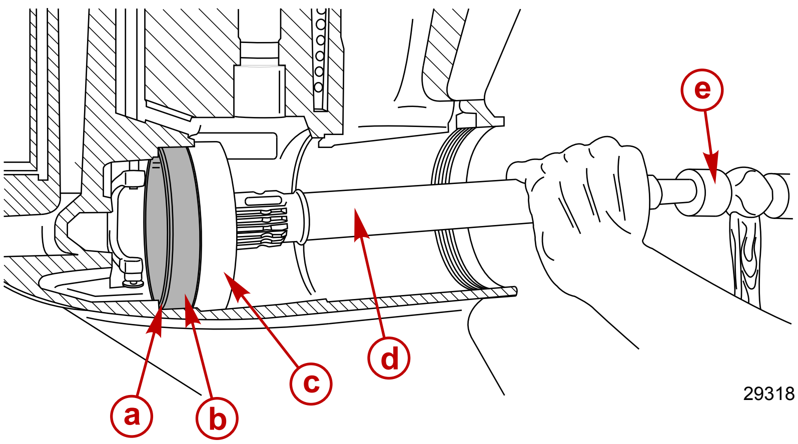
Forward Gear	
Backlash	0.432–0.635 mm (0.017–0.025 in.)

NOTE: If the forward gear, forward gear bearing and cup, or gear housing were not replaced, install the same quantity of shims that were taken out when cup was removed. If the forward gear, forward gear bearing/cup, or gear housing were replaced, install 0.76 mm (0.030 in.) of shims.

1. Lubricate the bore into which the forward gear bearing cup is to be installed with High Performance Gear Lubricant.
2. Place the shim into the forward bore of the gear housing.
3. Press the bearing cup into the gear housing using the installation tool as follows:

   NOTE: A guide plate may be used to center the rod used to drive in the forward gear bearing cup in a right-hand rotation gearcase or the reverse gear bearing cup on a counter rotation gearcase.

   IMPORTANT: Verify the bearing cup is positioned as straight as possible to avoid cocking it in the bore while pressing it in.



a - Shims
b - Race
c - Bearing cup driver
d - Propeller shaft (old nonserviceable)
e - Mallet

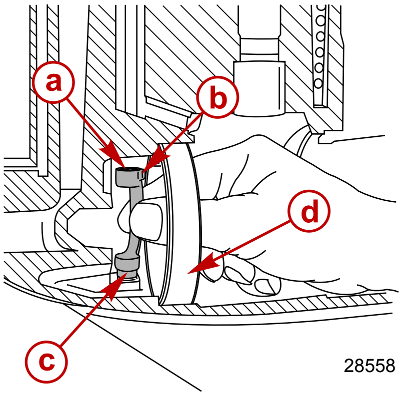
Bearing Cup Driver	91-885592T
Guide Plate	91-816243

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Forward gear bearing cup bore	92-858064K01

Shift Shaft Installation

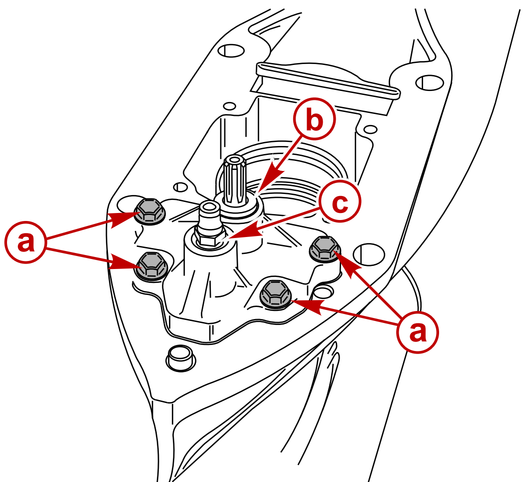
1. Place the shift crank into the pivot pin hole in the forward section of the gear housing. Ensure the shift crank faces towards the starboard side of the gear housing.

NOTE: The shift crank has a locating tab. On right-hand rotation gear housings, the locating tab faces toward the forward gear bearing assembly. On left-hand rotation gear housings, the locating tab faces away from the reverse gear bearing assembly.



a - Shift shaft splines
b - Locating tab
c - Pivot pin
d - Shift crank

2. Install the shift shaft assembly into the gear housing as shown. Engage the splined end of the shift shaft with the shift crank. Verify O-ring is positioned properly and lubricated with 2-4-C with Teflon.
3. Apply Loctite 271 Threadlocker to the shift shaft cover screw threads. Secure shift shaft cover with four screws. Tighten the screws and speedometer fitting to the specified torque.
4. Install rubber washer onto shift shaft.

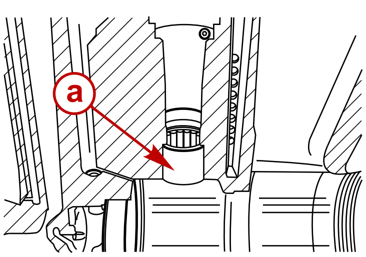


a - Screws (4)
b - Rubber washer
c - Speedometer fitting

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	O-ring	92-802859A 1
7	Loctite 271 Threadlocker	Shift shaft cover screw threads	92-809819

Description	Nm	lb-in.	lb-ft
Shift shaft cover screws (M6 x 20)	6.8	60	
Speedometer fitting	2.8	25	

NOTE: If the pinion bearing needle bearings have fallen out, install 18 needles into needle bearing outer race. Use 2-4-C with Teflon, to help hold needles in place.



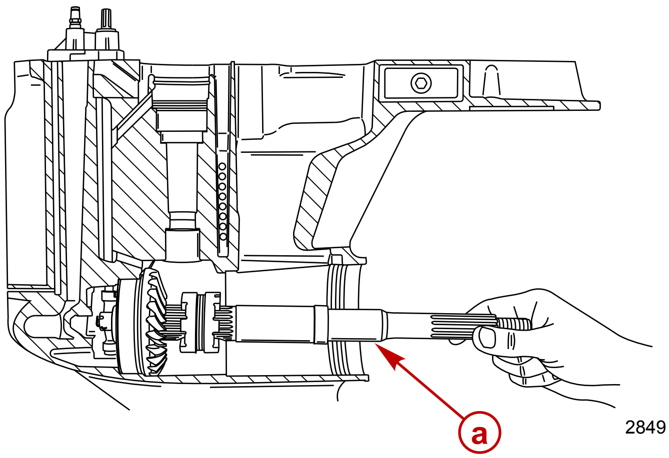
a - Pinion bearing

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Outside diameter of pinion bearing	92-858064K01
95	2-4-C with Teflon	Pinion needle bearings	92-802859A 1

Propeller Shaft Installation

NOTE: The shift/clutch assembly should be in the neutral detent position when installing the propeller shaft.

1. To allow for the engagement of the shift spool with the shift crank, tilt the propeller end of the propeller shaft assembly to the right (starboard) side of gear housing and hold the shift shaft in neutral while installing the shaft.



a - Propeller shaft

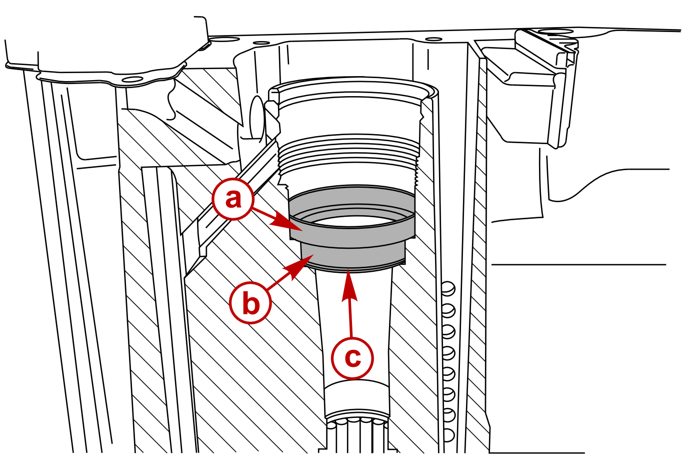
2. Operate the shift shaft to ensure it has been properly installed. The sliding clutch should move forward when the shift shaft is turned counterclockwise, and should move aft when the shift shaft is turned clockwise.

Driveshaft and Pinion Gear Installation

NOTE: If the original shims were not retained or if the pinion gear, driveshaft, driveshaft upper tapered roller bearing and cup, or gear housing were replaced, start off by installing a 0.508 mm (0.020 in.) shim, for the lower tapered roller bearing.

NOTE: If the original shims were retained (or measurement known) and none of the above listed parts were replaced, install the same shims or same amount of shims.

1. Place the lower tapered bearing shims into the driveshaft housing bore.
2. Install the lower tapered bearing race into the driveshaft housing bore.
3. Install the spacer (flanged end faces down).



a - Spacer
b - Tapered bearing race
c - Shims

4. Apply Loctite 271 to the threads of the pinion gear nut and place the pinion gear nut into the MR slot of the pinion nut adapter.

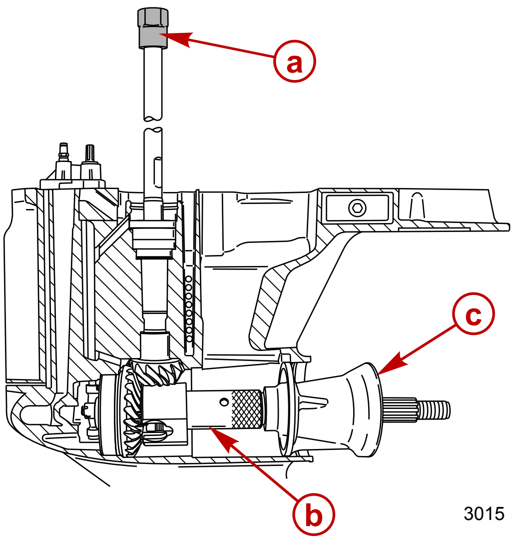
Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Pinion gear nut threads	92-809819

NOTE: Install the pinion gear nut with the flat side of the nut away from the pinion gear.

NOTE: For ease of installation, glue the washer to the pinion gear, using 3M Adhesive, or Bellows Adhesive, or equivalent.

NOTE: If the backlash has to be changed, it is recommended that Loctite 271 not be applied to the pinion nut until the backlash setting is finalized. Do not reuse the old pinion nut. Install a new pinion nut after backlash is finalized.

5. Place the pinion gear and washer into the gear housing.
6. With the propeller shaft horizontal, insert the pinion nut holding tool (with the nut) into the gear housing.
7. Insert the driveshaft into the gear housing driveshaft bore. It may be necessary to rotate the driveshaft to engage the driveshaft splines into the pinion gear splines.
8. Start the pinion nut onto the driveshaft threads by rotating the driveshaft until the nut is snug.
9. Install the bearing carrier into the gear housing backwards to hold the propeller shaft and the pinion nut holding tool in position.
10. Torque the pinion nut to specification by turning the driveshaft using the driveshaft holding tool and torque wrench.



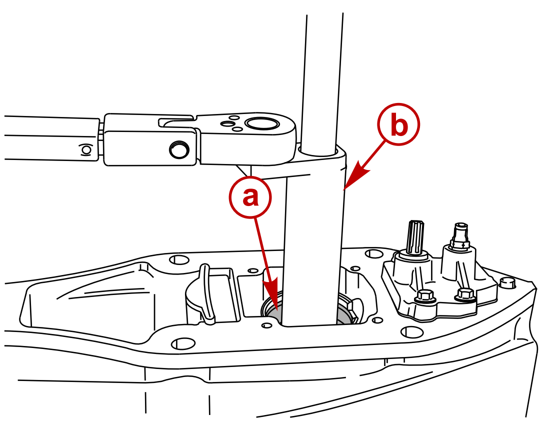
3015

a - Driveshaft holding tool
b - Pinion nut wrench
c - Bearing carrier (installed backwards)

Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03

Description	Nm	lb-in.	lb-ft
Pinion nut	101.7		75

11. Install the upper driveshaft tapered roller bearing cup. Apply 2-4-C with Teflon to the retainer threads and install the retainer. Torque retainer to specification.



29353

a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Retainer threads	92-802859A 1

Description	Nm	lb-in.	lb-ft
Retainer	135.5		100

12. Remove the bearing carrier, pinion nut wrench, and driveshaft bearing retainer wrench.

NOTE: Units correctly assembled to this point would show a driveshaft rolling torque of 0.2–0.9 Nm (2–8 lb-in.).

Pinion Gear Height

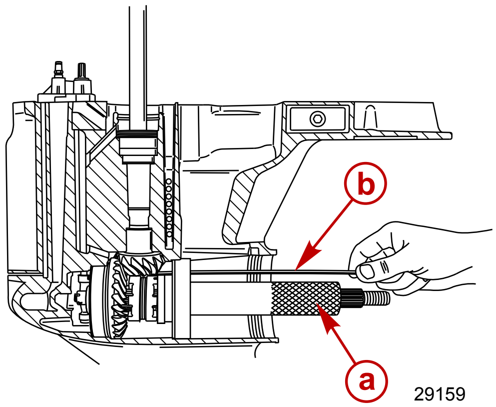
Checking and Adjusting Using Pinion Gear Locating Tool 91-56048001

NOTE: The propeller shaft and forward gear can be installed when checking pinion height if pinion gear locating tool (91-56048001) is used.

1. Place the pinion gear locating tool into the gear housing aligning window in tool with pinion gear.

   NOTE: Take the following measurements at three locations, rotating the driveshaft 120 degrees between each reading.

2. Insert the thickest feeler gauge that fits snugly between one tooth of the pinion gear and the high point of the locating tool.



a - Pinion gear locating tool
b - Feeler gauge

Pinion Gear Locating Tool	91-56048001

3. Rotate the driveshaft 120 degrees in a clockwise direction and take another reading.
4. Repeat this process until three readings have been taken.
5. Add the three readings together and divide the sum by three to get the average pinion gear height. Make note of this average measurement.

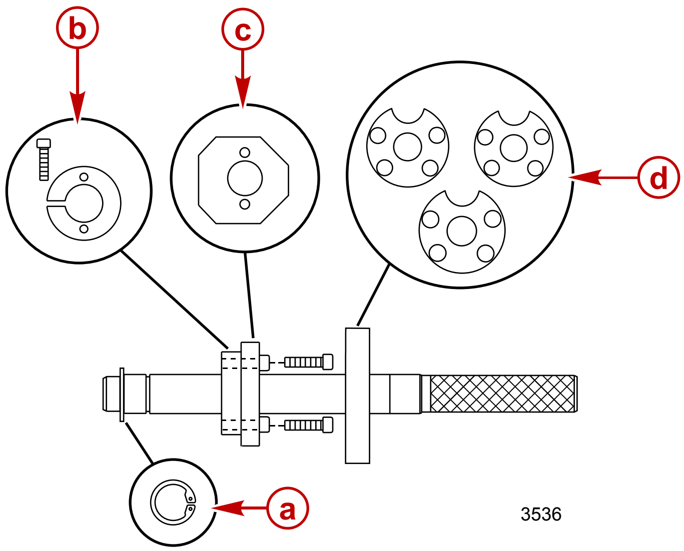
Pinion Gear	
Height	0.64 mm (0.025 in.)

6. If the average pinion gear height is not correct, add shims (to increase pinion height) or subtract shims (to lower pinion height) beneath the lower driveshaft tapered bearing race.
7. Install removed components and torque retainer to specifications.

Description	Nm	lb-in.	lb-ft
Retainer	135.5		100

8. Rotate the driveshaft at least three full turns in a clockwise direction. Check the pinion gear height. If pinion height is not within specification, adjust shim thickness and recheck. Repeat this process until the average pinion height is within specification.

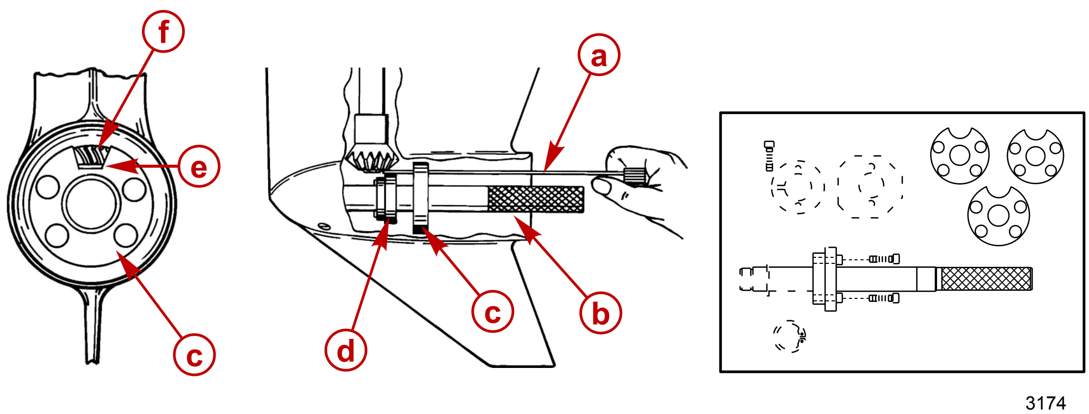
Checking and Adjusting using Pinion Gear Locating Tool 91-12349A05



a - Retaining ring - relocate to first groove
b - Split collar
c - Gauging block - use flat #4
d - Locating disc - use disc #2

NOTE: The forward gear assembly must be installed when using pinion gear locating tool 91-12349A05.

1. Install retaining ring on pinion height tool into first groove of arbor.
2. Using disc #2 and flat #4, install pinion gear locating tool into gearcase.



a - Feeler gauge
b - Pinion gear locating tool
c - Disc #2
d - Flat #4
e - 0.64 mm (0.025 in.)
f - Pinion gear

Pinion Gear Locating Tool	91-12349A05

NOTE: Take the following measurements at three locations, rotating the driveshaft 120 degrees between each reading (always rotate the driveshaft in a clockwise direction).

3. Insert the thickest feeler gauge that fits snugly between one tooth of the pinion gear and high point of the shimming tool.
4. Rotate the driveshaft 120 degrees in a clockwise direction and take another reading.
5. Repeat this process until three readings have been taken.
6. Add the three readings together and divide the sum by three to get the average pinion gear height. Make note of this average measurement.

Pinion Gear	
Height	0.64 mm (0.025 in.)

7. If the average pinion gear height is not correct, add or subtract shims beneath the lower driveshaft tapered bearing race.

8. Install removed components and torque retainer to specifications.

Description	Nm	lb-in.	lb-ft
Retainer	135.5		100

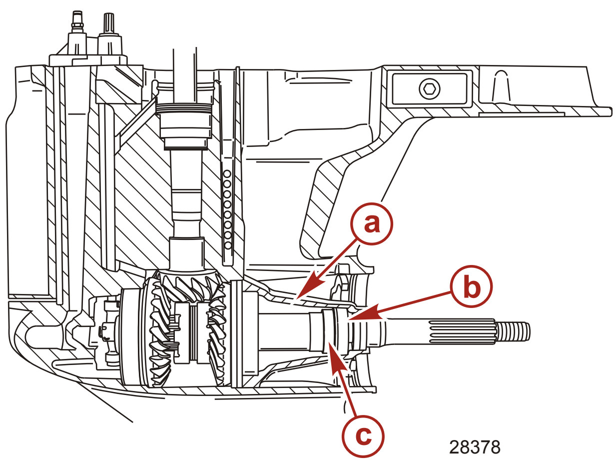
9. Rotate the driveshaft at least three full turns in a clockwise direction. Check the pinion gear height. If pinion height is not within specification, adjust shim thickness and recheck. Repeat this process until the average pinion height is within specification.

Forward Gear Backlash

1. Install propeller shaft preload spacer onto propeller shaft.

   NOTE: Propeller shaft preload shims will be installed when checking propeller shaft preload, following.

2. Place the bearing carrier assembly into the gear housing being careful to align the rear propeller shaft bearing with the propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion and reverse gears.
3. Fill the bearing carrier retainer nut threads and corresponding gear housing threads with 2-4-C with Teflon. Start the retainer into the gear housing threads and screw it down fully by hand.

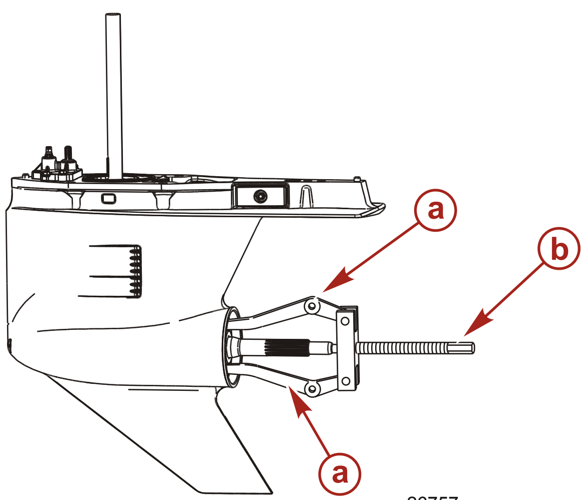


28378

a - Bearing carrier assembly
b - Propeller shaft bearing
c - Preload spacer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Bearing carrier retainer nut threads and corresponding gear housing threads, bearing carrier O-ring, upper driveshaft bearing retainer threads	92-802859A 1

4. Apply forward pressure to propeller shaft as follows:
   a. Attach puller jaws assembly onto bearing carrier bosses and propeller shaft.
   b. Torque the puller bolt to specification. Rotate driveshaft three full turns clockwise and torque the bolt to specification.



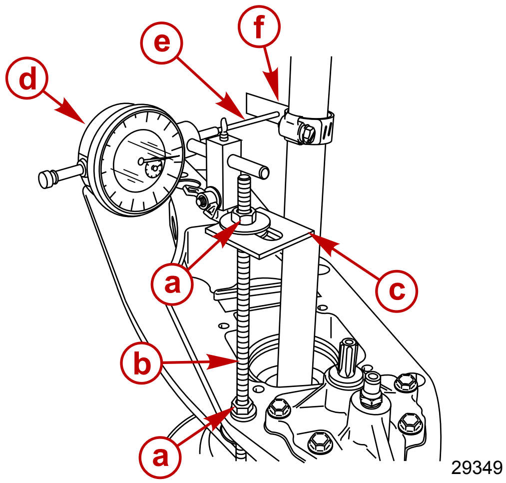
26757

a - Puller jaws assembly
b - Puller bolt

Puller Jaws Assembly Puller Bolt	91-46086A1/91-85716

Description	Nm	lb-in.	lb-ft
Propeller shaft torque	5.5	50	

5. Install a dial indicator and align the dial indicator pointer so it is perpendicular to and touching the "I" mark on the dial indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so the needle in the dial makes at least one full revolution and comes to "0" on the dial indicator scale.



a - Nuts (4) (obtain locally)
b - Threaded rod - 9.5 mm (3/8 in.) obtain locally
c - Dial indicator holding tool
d - Dial indicator
e - Indicator pointer
f - Backlash indicator rod

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Rod	91-78473

6. Take the backlash readings by lightly turning the driveshaft back and forth (no movement should be noticed at the propeller shaft).
   a. Observe the dial indicator and record the reading.
   b. Loosen the indicator tool and rotate the driveshaft 90 degrees in a clockwise direction.
   c. Repeat step 5 above and take and record another reading. Repeat step 6 until a total of four backlash readings have been taken.
7. Add the four readings together and divide the sum by four. This is your average backlash.

Forward Gear	
Backlash	0.432–0.635 mm (0.017–0.025 in.)

8. If backlash is less than the specified minimum, remove shims from in front of the forward gear bearing race to obtain correct backlash. When installing the pinion nut, apply Loctite 271 to the threads of the nut.
9. If backlash is more than the specified maximum, add shims in front of the forward gear bearing race to obtain the correct backlash. When installing the pinion nut, apply Loctite 271 to the threads of the nut.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Threads of pinion nut	92-809819

NOTE: *Adding or subtracting 0.025 mm (0.001 in.) shims will change the gear backlash by the same amount.*

Example 1 (if backlash is too high)	
If forward backlash checks:	1.02 mm (0.040 in.)
(Subtract):	0.56 mm (0.022 in.)
Add this quantity of shims:	0.46 mm (0.018 in.)
Provides backlash of:	0.56 mm (0.022 in.)

Example 2 (if backlash is too low)	
Backlash checks:	0.25 mm (0.010 in.)
Subtract this quantity of shims:	0.31 mm (0.012 in.)

Example 2 (if backlash is too low)	
Provides backlash of:	0.56 mm (0.022 in.)

10. Remove bearing carrier removal tool and puller bolt.

Reverse Gear Backlash

Reverse Gear	
Backlash	1.24–1.45 mm (0.049–0.057 in.)

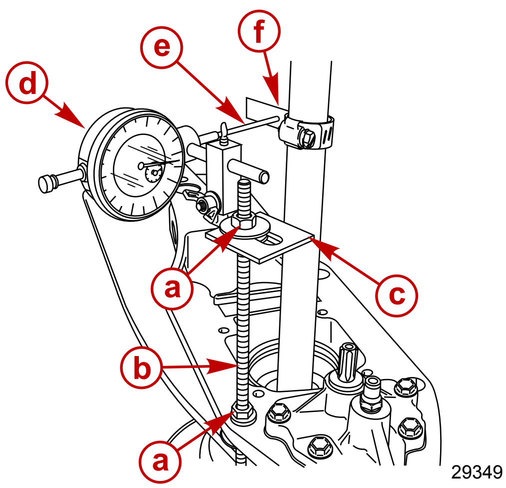
Although reverse gear backlash is not adjustable, it may be checked as follows:

NOTE: Pinion height must be set before checking reverse gear backlash.

NOTE: Torque bearing carrier retainer nut to specification.

Description	Nm	lb-in.	lb-ft
Bearing carrier retainer nut	285		210

1. Apply backward pressure on the propeller shaft by holding shift crank against reverse gear.
2. Install a dial indicator and align the dial indicator pointer so it is perpendicular to and touching the "I" mark on the backlash indicator rod. Tighten the backlash indicator rod onto the driveshaft and rotate the driveshaft so the needle in the dial makes at least one full revolution and comes to "0" on the dial indicator scale.



a - Nuts (4) (obtain locally)
b - Threaded rod - 9.5 mm (3/8 in.) obtain locally
c - Dial indicator holding tool
d - Dial indicator
e - Indicator pointer
f - Backlash indicator rod

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Rod	91-78473

3. Take the backlash readings by lightly turning the driveshaft back and forth, so as to feel the backlash between the gears (no movement should be noticed at the propeller shaft).
   a. Observe the dial indicator and record the reading.
   b. Loosen the backlash indicator rod and rotate the driveshaft 90 degrees in a clockwise direction.
   c. Repeat step 2 above and take and record another reading. Repeat step 3 until a total of four backlash readings have been taken.
4. Add the four readings together and divide the sum by four. This is your average backlash. If backlash is not as indicated, gearcase is not properly assembled or parts are excessively worn and must be replaced before returning gearcase to service.

Reverse Gear	
Backlash	1.24–1.45 mm (0.049–0.057 in.)

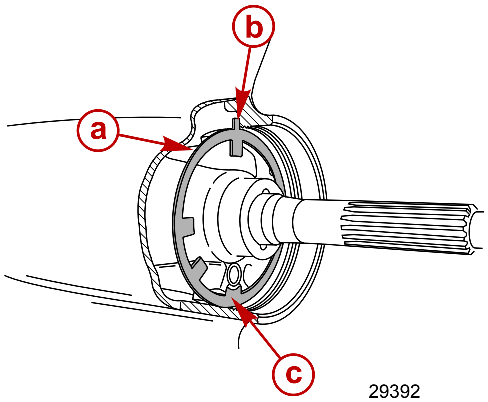
5. Remove the backlash indicator rod. Remove the dial indicator and all its mounting components.

Propeller Shaft Bearing Preload

NOTE: All gear housing components must be installed and correctly shimmed before checking propeller shaft bearing preload. Propeller shaft tapered roller bearing must be properly seated in the race during installation. Driveshaft retainer should be torqued to specification.

Description	Nm	lb-in.	lb-ft
Driveshaft retainer	135.5		100

1. Remove the bearing carrier.
2. Slide preload spacer off propeller shaft.
3. Install (retained) propeller shaft preload shims onto propeller shaft. If shims were lost, start with 0.9 mm (0.035 in.) shim thickness.
4. Install preload spacer onto propeller shaft.
5. Install bearing carrier, aligning rear propeller shaft bearing with propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion with the reverse gear.
6. Insert the small rectangular tab of the tab washer into its corresponding slot in the gearcase at the 12 o'clock position above the bearing carrier while aligning the U-shaped tab of the tab washer with its corresponding slot below the lubricant fill screw in the bearing carrier.



29392

a - Tab washer
b - Rectangular tab
c - U-shaped tab

7. With gear housing in neutral, torque bearing carrier retainer nut to initial specification.
8. Rotate propeller shaft several times to seat propeller shaft tapered roller bearings in their races.
9. Torque bearing carrier retainer nut to final specification.

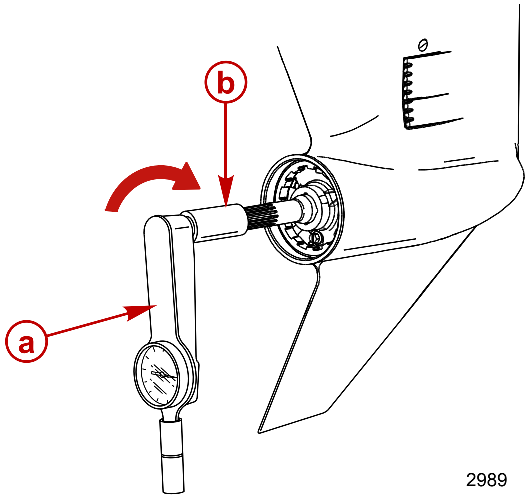
Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5		100
	Final	285		210

10. Install propeller shaft adapter and using a torque wrench, rotate propeller shaft in the direction of normal rotation with a slow steady motion.
11. Verify rolling torque is within specification for new or used bearings.

Description	Nm	lb-in.	lb-ft
Bearing rolling torque (new bearings)	1.1–1.8	10–16	
Bearing rolling torque (used bearings)	0.45–1.1	4–10	

NOTE: Preload will change approximately 0.056 Nm (1/2 lb-in.) of rolling torque per 0.025 mm (0.001 in.) of shim change.

12. If rolling torque is too high, remove shims from propeller shaft ahead of tapered bearing/spacer in bearing carrier. If torque is too low, add shims.



a - Torque wrench
b - Propeller shaft adapter

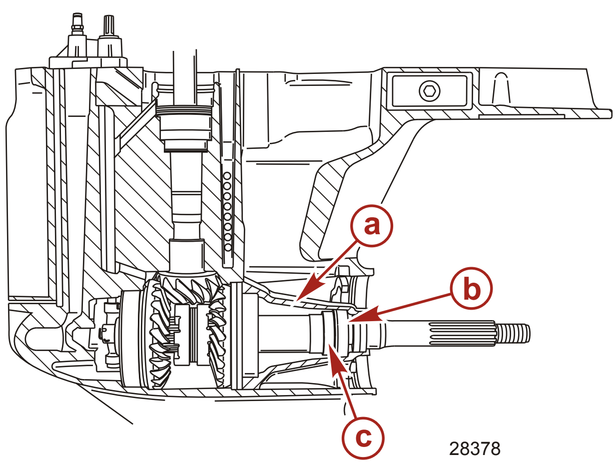
Propeller Shaft/Driveshaft Adapter	91-61077T

NOTE: *If shims are changed, torque bearing carrier to initial specification. Rotate propeller shaft several times to seat propeller shaft tapered bearing. Retorque retainer nut to final specification. Use torque wrench to check rolling torque. Repeat this procedure each time shims are changed.*

Description		Nm	lb-in.	lb-ft
Bearing carrier	**First**	135.5		100
	Final	285		210

Bearing Carrier Final Installation

1. Remove the bearing carrier and lubricate the following as specified:
   a. Lubricate the carrier O-ring with 2-4-C with Teflon.
   b. Lubricate both the forward and aft outer diameters of the bearing carrier and gearcase area where the carrier will seat with 2-4-C with Teflon.
   c. Fill the space between the carrier oil seals with 2-4-C with Teflon.

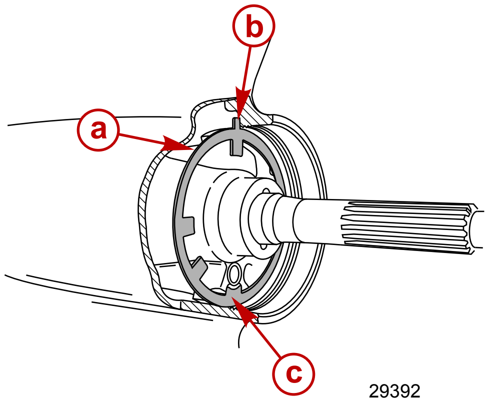


a - Bearing carrier
b - Propeller shaft bearing
c - Preload spacer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Carrier O-ring, forward and aft outer diameters of bearing carrier, gearcase area where carrier will seat, space between carrier seals	92-802859A 1

2. Place the bearing carrier assembly into the gear housing, being careful to align the rear propeller shaft bearing. It may be necessary to turn the driveshaft to align the teeth of the pinion and the reverse gears.
3. Lubricant fill screw in the bearing carrier should be located at the 6 o'clock position.

4. Insert the small rectangular tab of the tab washer into its corresponding slot in the gearcase at the 12 o'clock position above the bearing carrier while aligning the U-shaped tab of the tab washer with its corresponding slot below the lubricant fill screw in the bearing carrier.



a - Tab washer
b - Rectangular tab
c - U-shaped tab

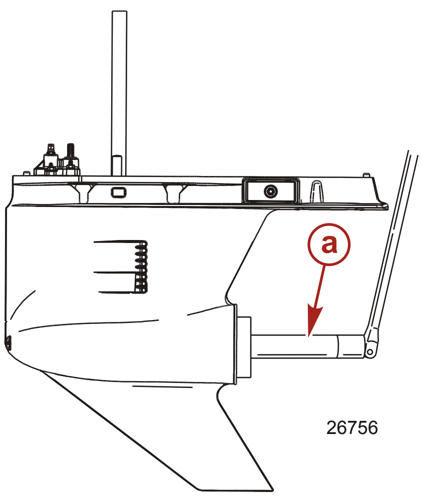
5. Fill the bearing carrier retainer nut threads and corresponding gear housing threads with 2-4-C with Teflon. Start the retainer into the gear housing threads and screw it down fully by hand.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Bearing carrier retainer nut threads and corresponding gear housing threads	92-802859A 1

IMPORTANT: Before torquing the bearing carrier retainer, the gearcase must be bolted to the driveshaft housing or securely fastened in a gearcase holding fixture to avoid possible damage to the gear housing.

NOTE: Torque retainer nut to initial specification first. Rotate propeller shaft several times to seat tapered roller bearings. Retainer nut can then be torqued to final specification.

6. Torque the bearing carrier retainer to specification. If one tab does not align up in space between two of the notches, continue to tighten retainer until alignment is achieved. Do not loosen retainer to achieve alignment.



a - Bearing carrier retainer nut wrench

Bearing Carrier Retainer Nut Wrench	91-61069T

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5		100
	Final	285		210

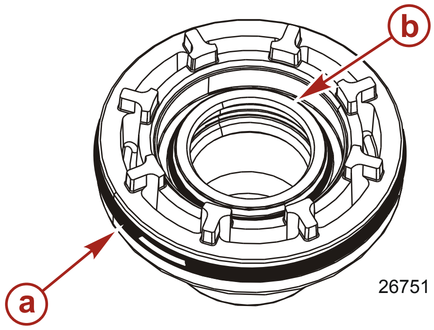
7. Bend one tab aft (outward) into a space between two of the notches of the retainer. Bend all the remaining tabs forward (inward).

Oil Seal Carrier Installation

NOTE: The oil seal carrier may be lightly tapped into position by sliding the driveshaft bearing retainer wrench over the driveshaft.

Driveshaft Bearing Retainer Wrench	91-43506T

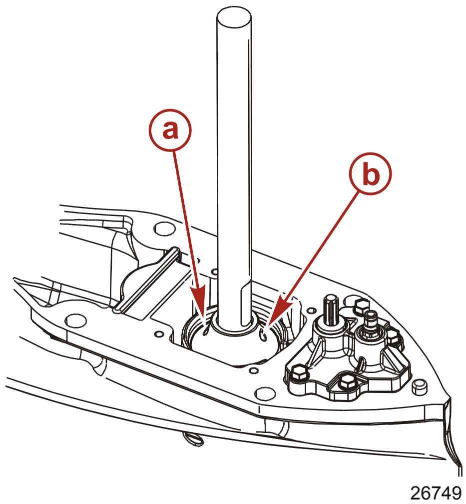
1. Lubricate the oil seal carrier oil seal lips, space between the seals, and the O-ring with 2-4-C with Teflon. Install the oil seal carrier over the driveshaft and into the gearcase.



a - O-ring
b - Oil seal lips

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Oil seal carrier seal lips, space between oil seals, O-ring	92-802859A 1

2. Install the retaining ring above the oil seal carrier.



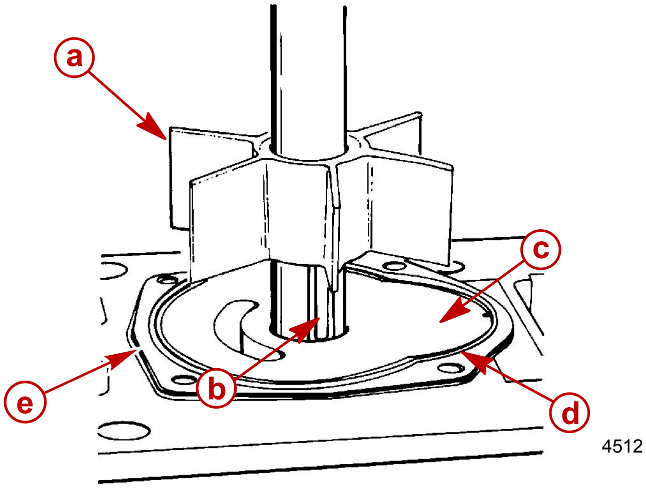
a - Retaining ring
b - Oil seal carrier

Water Pump Installation

1. Install water pump base gasket.
2. Install water pump face plate.
3. Install water pump cover gasket.
4. Place a small amount of 2-4-C with Teflon on the flat surface of the impeller key and install the key onto the driveshaft keyway.

   IMPORTANT: When using an impeller whose blades have taken a set, face the curl of the blades in a counterclockwise direction. Do not install the impeller with its blades oriented in a reversed direction from original rotation, or premature impeller failure will occur.

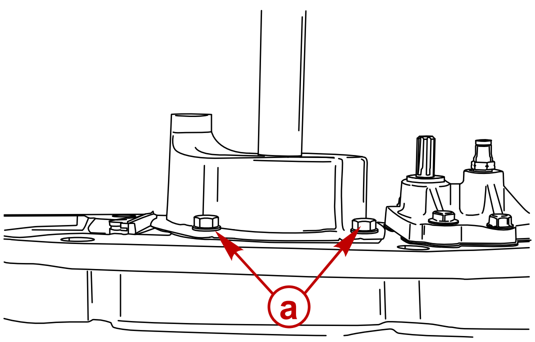
5. Assemble the water pump impeller onto the driveshaft and down over the key.

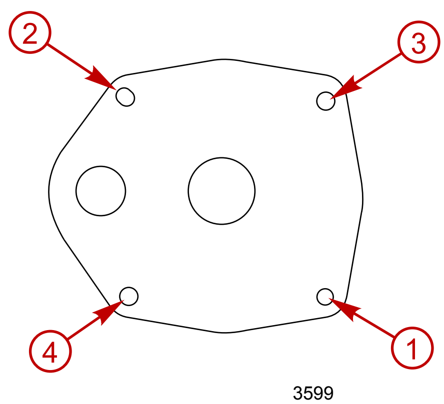


a - Impeller
b - Key
c - Face plate
d - Pump cover gasket (gray seal bead faces up)
e - Pump base gasket

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Flat surface of the impeller key	92-802859A 1

6. Apply a light coat of 2-4-C with Teflon to the inside of the pump cover. Rotate the driveshaft in a clockwise direction, while pushing down on the water pump cover to ease the water pump cover over the impeller blades.
7. Hand start starboard front fastener first into the water pump assembly. Install the remaining three fasteners. Run all fasteners down and torque in sequence to specification.





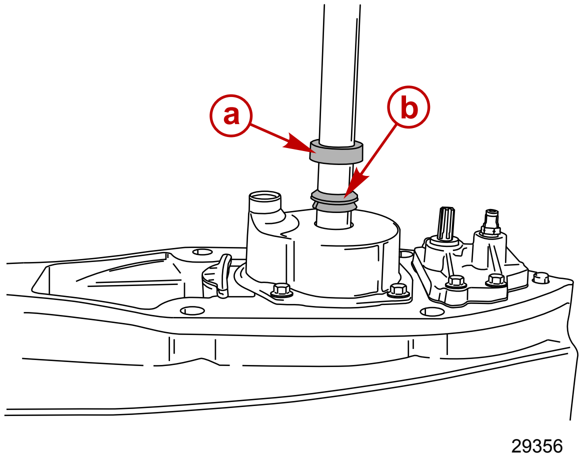
a - Water pump cover screws (4)

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Inside of water pump cover	92-802859A 1

Description	Nm	lb-in.	lb-ft
Water pump cover screws (4)	6.7	60	

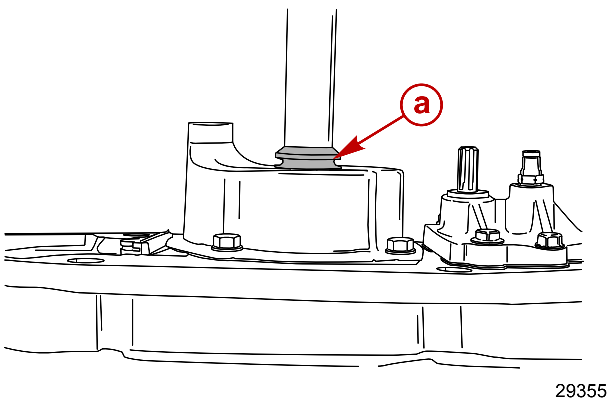
IMPORTANT: If seal installed above pump housing is not at the proper height, air will be drawn into the pump resulting in overheating of the engine.

8. Using tool provided in seal kit or water pump kit, press seal down over driveshaft (do not grease driveshaft) until tool seats against pump housing.



a - Tool
b - Seal

NOTE: If tool is not available, lightly press seal against housing until specified height is obtained.



a - Seal

Water Pump Cover	
Seal height	8.9 mm ± 0.76 mm (0.350 in. ± 0.030 in.)

Gear Lubricant Filling Instructions

NOTE: Gear housing should be pressure tested prior to filling gear housing with lubricant. Using leakage tester FT8950, gear housing should hold 103.4 kPa (15 psi) of pressure for 5 minutes without leakage. Failure to hold specified pressure indicates worn or damaged sealing surfaces or improperly assembled gear housing. Cause of leakage must be corrected before returning gear housing assembly to service.

Gear Housing Pressure	
Without gear lubricant for five minutes without leakage	103.4 kPa (15 psi)

Leakage Tester Kit	FT8950

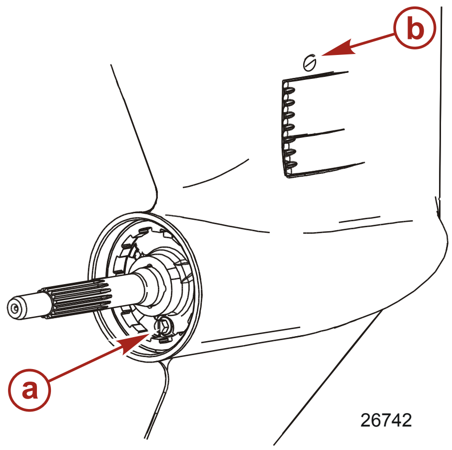
1. Inspect fill and vent sealing washers for cuts or abrasions. Replace washers if necessary.

   IMPORTANT: Never apply lubricant to gear housing without first removing vent screw, or gear housing cannot be filled because of trapped air. Fill gear housing only when housing is in a vertical position.

2. Slowly fill housing through fill hole with High Performance Gear Lubricant until lubricant flows out of vent hole and no air bubbles are visible.
3. Install vent screw into vent hole.

   IMPORTANT: Do not lose more than 30 cc (1 fl oz) of gear lubricant while installing the fill screw.

4. Remove grease tube (or hose) from fill hole and quickly install fill screw into fill hole. Torque fill and vent screws to specification.



a - Fill screw
b - Vent screw

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Gear housing	92-858064K01

Description	Nm	lb-in.	lb-ft
Fill and vent screws	6.8	60	

Installing Gear Housing to Driveshaft Housing

⚠ WARNING

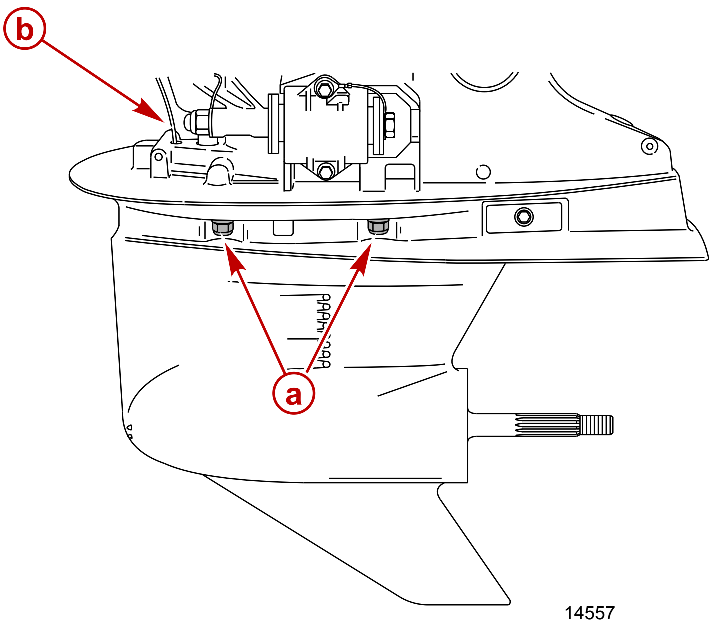
Accidental starting can cause serious injury. Before removing or installing the gear housing, disconnect and isolate the spark plug leads. Disable the ignition system by removing the keys from the ignition (if equipped) and engaging the lanyard stop switch to prevent the engine from starting.

1. Tilt the engine to full up position and engage the tilt lock lever.
2. Apply a light coat of Engine Coupler Spline Grease onto the driveshaft splines. Do not allow lubricant on top of the driveshaft.
3. Apply a light coat of 2-4-C with Teflon onto the shift shaft splines. Do not allow lubricant on top of the shift shaft.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Shift shaft splines	92-802859A 1
91	Engine Coupler Spline Grease	Driveshaft splines	92-802869A 1

4. Insert the anodic plate bolt into the hole in the rear of the gear housing.
5. Verify the neutral position switch is in the neutral position. Verify the gear housing is in the neutral position.
6. Position the gear housing so the driveshaft is protruding into the driveshaft housing. If the driveshaft splines will not align with the crankshaft splines, lower the gear housing and turn the driveshaft slightly in a clockwise direction. Repeat, as required, until the driveshaft splines match with the crankshaft splines.
7. Move the gear housing up toward the driveshaft housing while aligning the shift shaft splines with the shift shaft coupler, and the water tube outlet on the water pump cover with the water tube coupler (in driveshaft housing).
8. Insert the speedometer tube into the speedometer tube coupler.

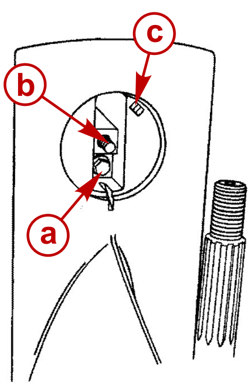
9. Place the flat washers onto the studs (located on either side of driveshaft housing). Start a nut on each stud and tighten finger-tight.



14557

a - Nuts and washers (2 each side)
b - Speedometer tube

10. Start the screw at the rear of the gear housing inside the trim tab recess. Do not tighten the screw at this time.



28855

a - Screw
b - Anodic plate attaching bolt
c - Ribs (align carefully with anodic plate)

IMPORTANT: Do not force the gear housing up into place with attaching nuts.

11. Evenly tighten the nuts which were started previously. Tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Nuts (2 each side)	75		55

12. After the nuts (located on either side of driveshaft housing) are tightened, check the shift operation as follows:
    a. Turn ignition switch to the "ON" position and move the remote control to the forward gear position; the propeller shaft should rotate clockwise and then lock (no ratcheting motion).
    b. Move the remote control into neutral position. The propeller shaft should rotate freely clockwise/counterclockwise.
    c. Move the remote control into reverse gear position; the propeller shaft should rotate counterclockwise and then lock (no ratcheting motion).

    IMPORTANT: If the shifting operation is not as described, the gear housing must be removed and the cause corrected.

13. Install the remaining washers and nuts onto the driveshaft studs and tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Gear housing attaching nut (2 each side)	75		55

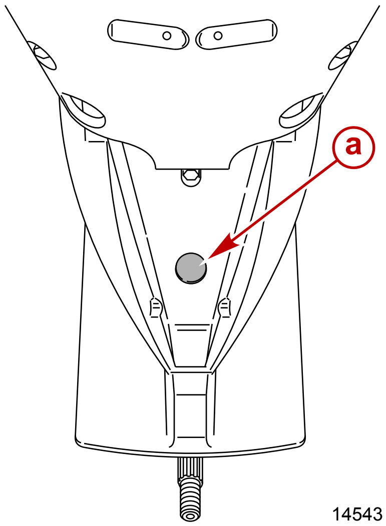
14. Tighten the screw (started in Step 10) to the specified torque.

Description	Nm	lb-in.	lb-ft
Screw (M12 x 35)	75		55

15. Position the trim tab or anodic plate into the gear housing. Align the grooves of trim tab with the ribs in the trim tab pocket. Adjust to position in which it had previously been installed, and while holding the trim tab, tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Trim tab screw (0.437-14 x 1-3/4 in.)	54		40

16. Install the rubber plug into the trim tab bolt opening at the rear edge of the driveshaft housing.



a - Rubber plug

17. Add engine oil. Refer to **Section 1B - Checking and Adding Engine Oil**.
18. Install the port and starboard chaps.
19. Install the top cowl. Refer to **Section 4A - Cowling Removal and Installation**.
20. Install the propeller. Refer to **Section 1B - Propeller Replacement**.

Notes:

Gear Housing

Section 6B - Left-Hand Rotation

Table of Contents

6
B

Gear Housing Specifications

Gear Housing Specifications	
Gear ratio	2.08:1 (12/25 teeth)
Gearcase capacity	970 ml (32.8 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Pinion height	0.635 mm (0.025 in.)
Forward gear backlash	0.432–0.635 mm (0.017–0.025 in.)
Reverse gear backlash	1.24–1.45 mm (0.049–0.057 in.)
Water pressure at RPM	
At 650 RPM (idle)	15.2 kPa (2.2 psi)
At 6000 RPM (WOT)	
Warm water slow boat	88 kPa (12.8 psi)
Cold water fast boat	220 kPa (32 psi)
Gear housing pressure (without gear lubricant, five minutes without leakage)	103.4 kPa (15 psi)

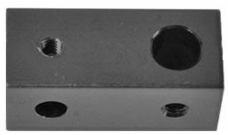
Lubricants, Sealants, Adhesives

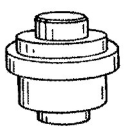
Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Cover assembly screw threads	92-809819
		Shift shaft cover screw threads	
		Pinion gear nut threads	
19	Perfect Seal	Speedometer connector threads	92-34227 1
87	High Performance Gear Lubricant	Bearing bore in carrier	92-858064K01
		Bearing carrier bore	
		Inside diameter of driveshaft tapered bearing	
		Outside diameter of reverse gear	
		Pinion bearing bore	
		Reverse gear bearing cup bore	
		Outside diameter of pinion bearing	
		Gear housing	
91	Engine Coupler Spline Grease	Driveshaft splines	92-802869A 1
95	2-4-C with Teflon	Oil seal lips and between oil seals	92-802859A 1
		Bore the roller bearing is pressed into	
		Bearing carrier O-ring	
		Seat of the shift shaft cover O-ring diameter and lip of the oil seal	
		O-ring	
		Pinion needle bearings	
		Retainer threads	
		Bearing carrier retainer threads, corresponding gear housing threads, and upper driveshaft bearing retainer threads	
		Carrier O-ring, forward and aft outer diameters of bearing carrier, gearcase area where carrier will seat, space between carrier seals	
		Bearing carrier retainer nut threads and corresponding gear housing threads	
		Oil seal carrier seal lips, space between oil seals, O-ring	
		Flat surface of the impeller key	
		Inside of water pump cover	
		Shift shaft splines	
134	Loctite 380	Outer diameter of oil seals	Obtain Locally
		Outer diameter of oil seal	
		Outside diameter of the oil seal	

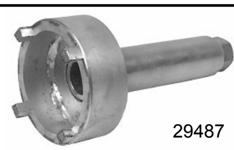
Special Tools

Dial Indicator	91- 58222A 1
 9479	Used to obtain a variety of measurements including gear backlash, pinion gear location, and TDC.

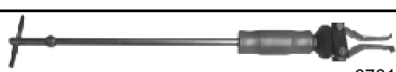
Dial Indicator Adapter	91-83155
 2999	Dial indicator holding fixture.

Dial Indicator Holding Tool	91- 89897
 29496	Secures the dial indicator to gear housing when checking backlash.

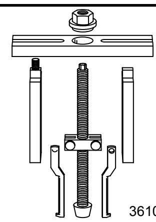
Oil Seal Driver	91-889844T
 29498	Installs seals in driveshaft seal carrier.

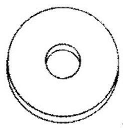
Bearing Carrier Retainer Nut Wrench	91-61069T
 29487	Installs and removes the bearing carrier retainer nuts.

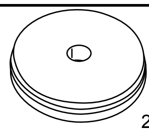
Puller Jaws Assembly	91-46086A1
 9514	Removes bearing carrier and bearing races; use with Puller Bolt (91-85716).

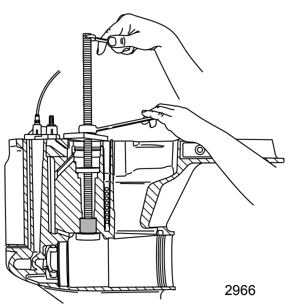
Slide Hammer	91-34569A 1
 6761	Aids in the removal of various engine components. Use with puller jaws.

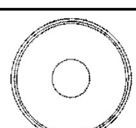
Needle Bearing Removal Tool	91-816245
 10793	Removes the needle bearings from the back adaptor of a counter rotating gearcase.

Bearing Puller Assembly	91-83165T
 3610	Removes bearings, races and bearing carriers

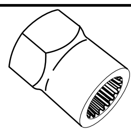
Pilot Washer	91-36571T
 29490	Used in pinion gear and pinion bearing installation.

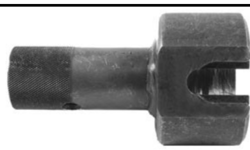
Seal Driver Guide	91-889845
 29590	Aids in the installation of bearing carrier seals.

Bearing Removal and Installation Kit	91-31229A7
 2966	Installs and removes the bearings in all gearcases. 91-31229A7 tool assembly includes the following components: 11-24156 Hex Nut 12-34961 Washer 91-15755T Bearing Carrier 91-29310 Plate 91-29610 Pilot Plate 91-30366T1 Mandrel 91-31229 Puller Shaft 91-32325T Driver Head 91-32336 Driver Needle Bearing 91-36379 Puller/Head Gear 91-36569T Driver Head 91-36571T Pilot Washer 91-37292 Roller Bearing 91-37311 Driver Head 91-37312 -Driver Head 91-37323 Driver Head Rod 91-37324 Pilot Washer 91-38628T Puller/Driver Head 91-52393 Driver Needle Bearing 91-52394 Head Pull Rod

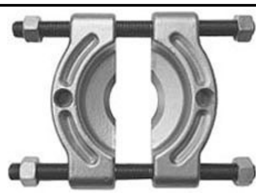
Bearing Cup Driver	91-885592T
 29492	Installs reverse gear bearing cup.

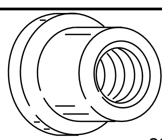
Driveshaft Bearing Retainer Wrench	91-43506T
 9520	Removes and installs the threaded bearing retainer.

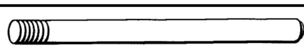
Driveshaft Holding Tool	91-889958T
 28677	Holds driveshaft during pinion nut removal on the Verado models.

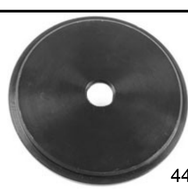
Pinion Nut Wrench	91- 61067T03
 29501	Holds the pinion nut when removing the pinion gear and driveshaft.

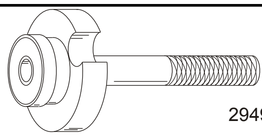
Propeller Shaft/Driveshaft Adapter	91-61077T
 10805	Provides a wrench surface to turn the propeller shaft or the driveshaft.

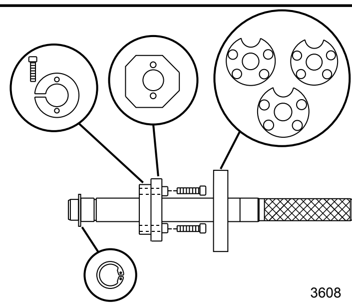
Universal Puller Plate	91-37241
 8505	Removes bearings from gears and the driveshaft.

Driver Head	91- 36569T
 29499	Used in pinion gear and bearing installation.

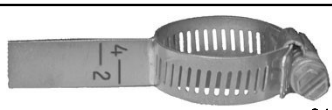
Driver Rod	91- 37323
 25431	Aids in the removal and installation of various bearings and bearing races

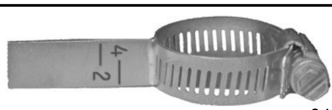
Guide Plate	91-816243
 4481	Centers the rod used to drive in the forward gear bearing on a standard rotation gearcase, and the reverse gear bearing on a counter rotation gearcase.

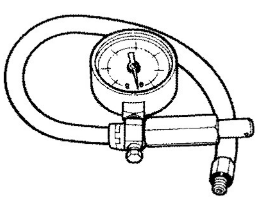
Pinion Gear Locating Tool	91- 56048001
 29493	Measures pinion gear height.

Pinion Gear Locating Tool	91- 12349A05
 3608	Measures pinion gear height.

Puller Jaws Assembly Puller Bolt	91-46086A1/91-85716
 9514	Removes bearing carrier and bearing races.

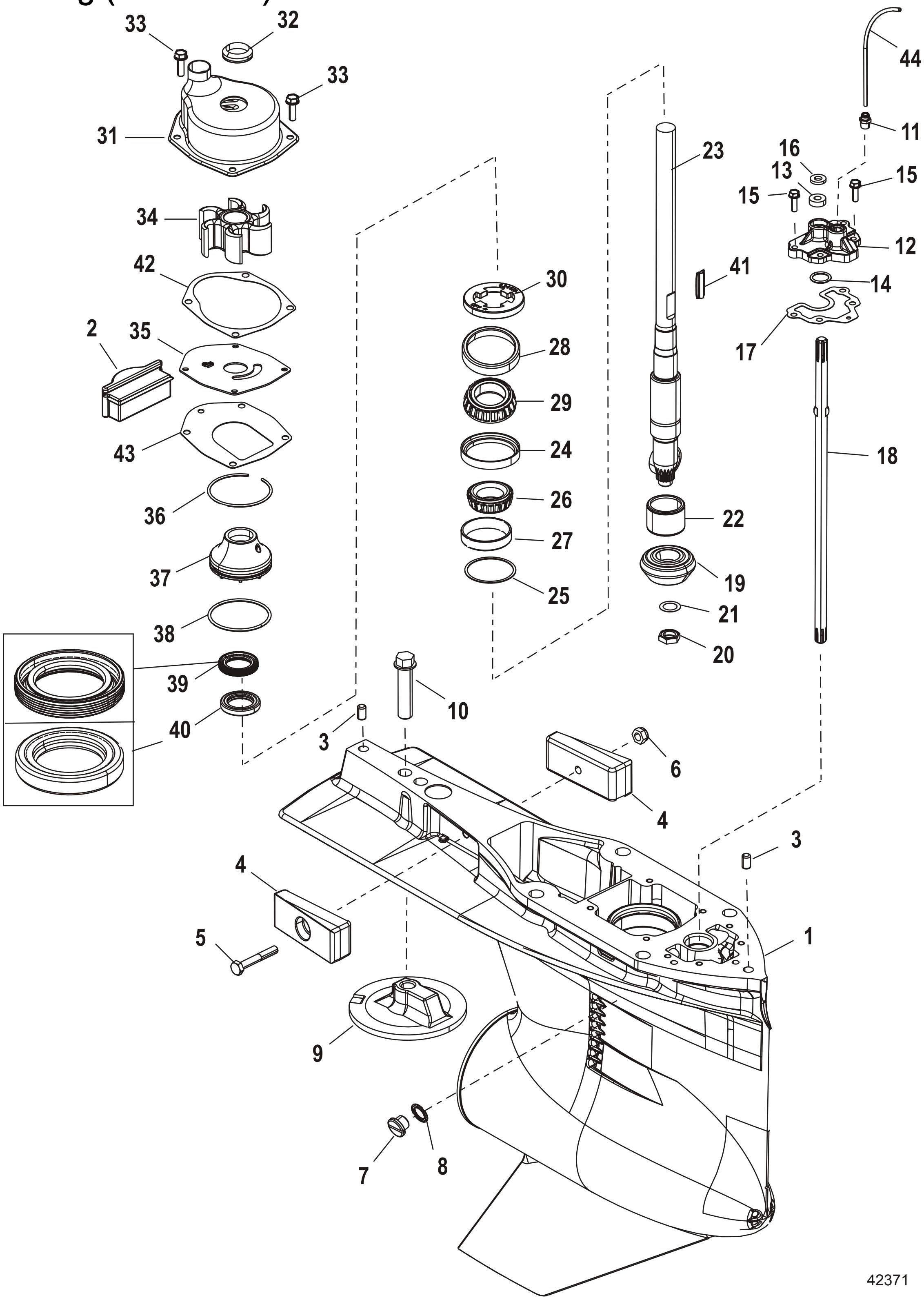
Backlash Indicator Rod	91- 78473
 9450	Aids in checking gear backlash.

Backlash Indicator Rod	91-78473
 9450	Aids in checking gear backlash.

Leakage Tester Kit	FT8950
 29497	Checks gear housing for leakage prior to filling with gear lubricant.

Notes:

Gear Housing (Driveshaft)

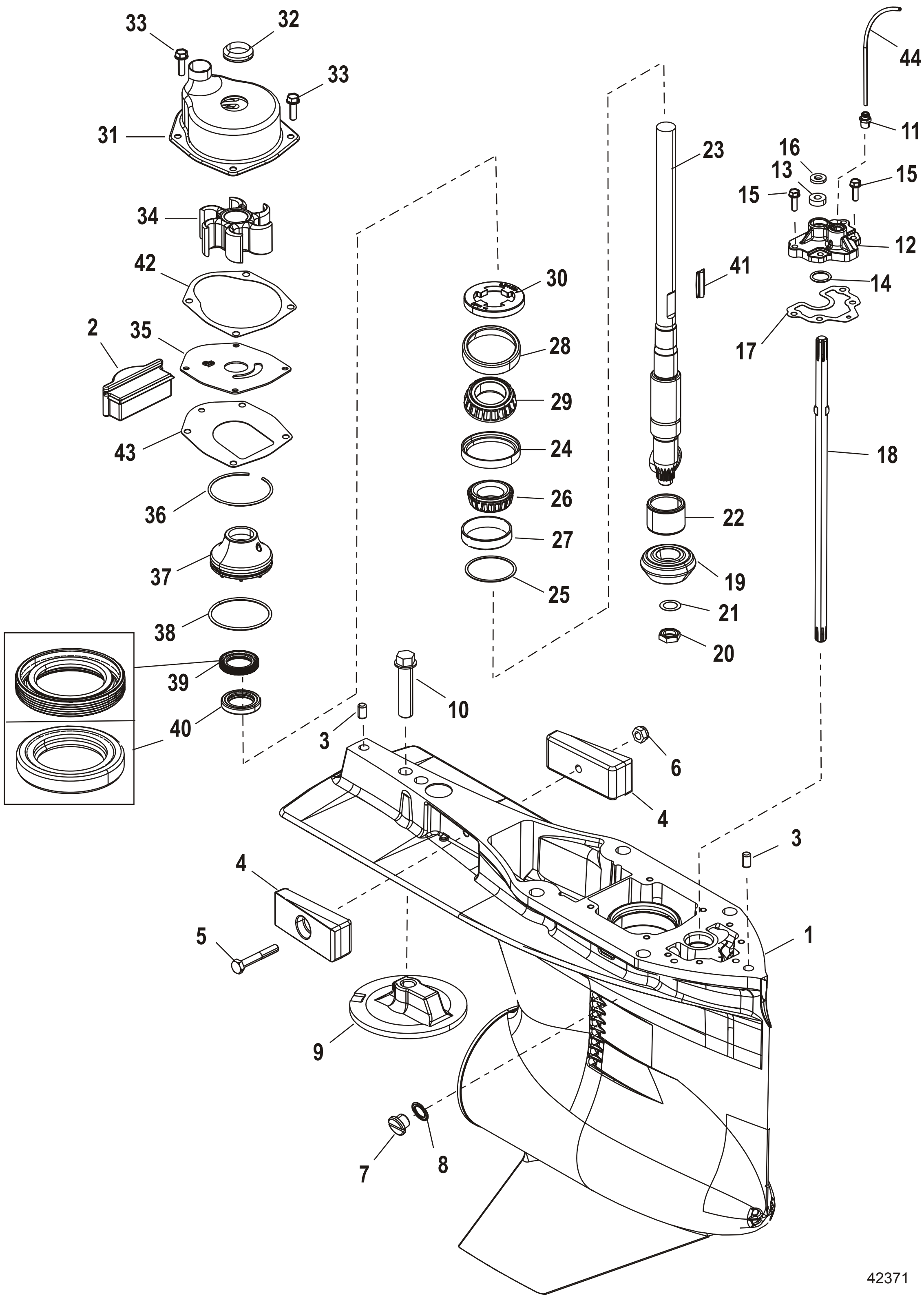


Gear Housing (Driveshaft)

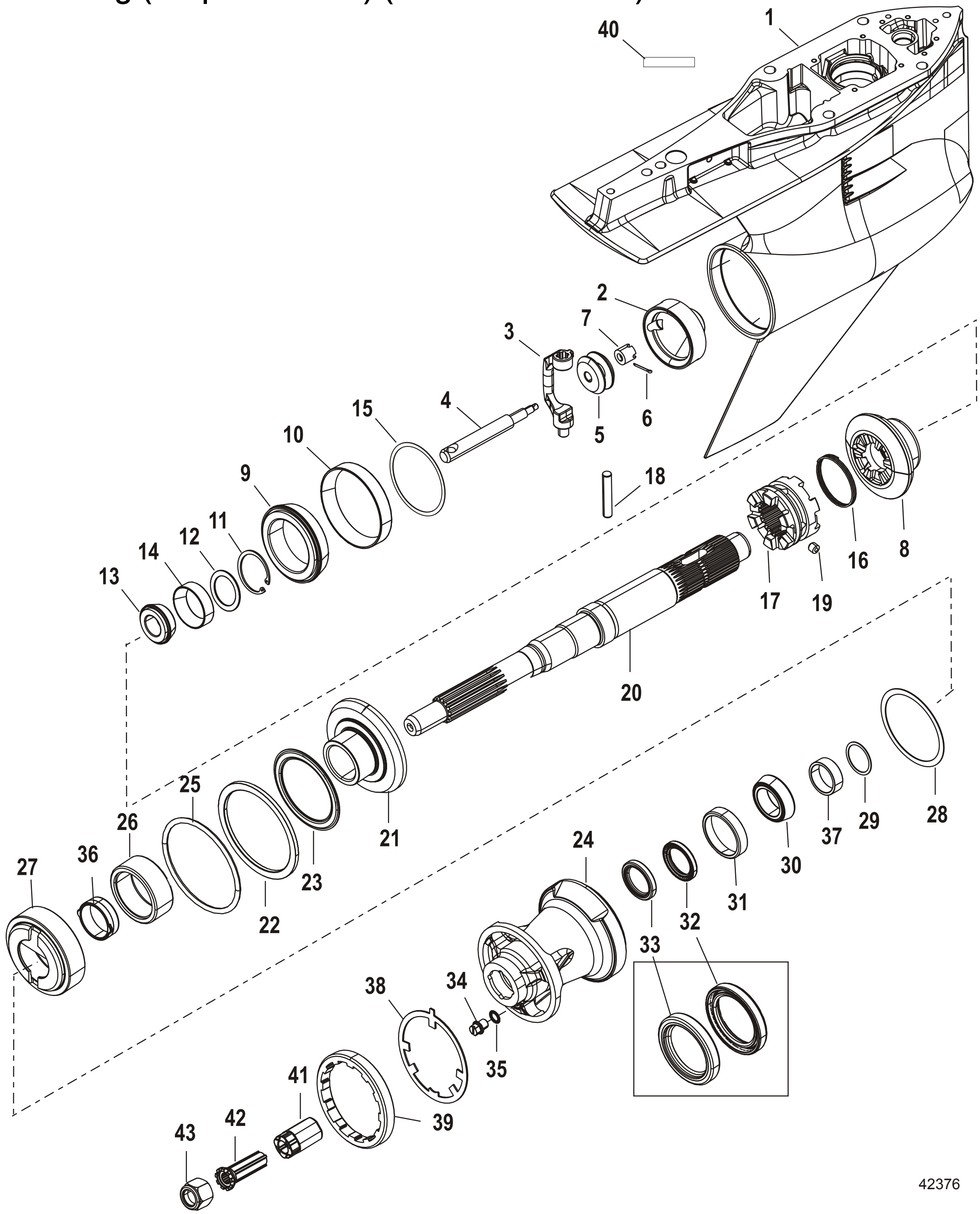
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing			
2	1	Filler block			
3	2	Dowel pin			
4	2	Anode			
5	1	Screw (M6 x 40)	6.8	60	
6	1	Nut			
7	1	Screw	6.8	60	
8	1	Seal			
9	1	Anodic plate			
10	1	Screw (0.437-14 x 1-3/4 in.)	54		40
11	1	Fitting	2.8	25	
12	1	Cover assembly			
13	1	Oil seal			
14	1	O-ring			
15	4	Screw (M6 x 20)	6.8	60	
16	1	Washer			
17	1	Gasket			
18	1	Lower shift shaft			
19	1	Pinion gear (12 teeth)			
20	1	Nut (5/8-18)	101		75
21	1	Washer			
22	1	Roller bearing			
23	1	Driveshaft (Long)			
		Driveshaft (X-Long)			
24	1	Shim/bearing assembly			
25	AR	Shim (0.002–0.050)			
26	1	Roller bearing assembly			
27	1	Cup			
28	1	Cup			
29	1	Roller bearing assembly			
30	1	Retainer	135.5		100
31	1	Water pump housing			
32	1	Face seal			
33	4	Screw (M6 x 20)	6.8	60	
34	1	Impeller			
35	1	Face plate			
36	1	Retaining ring			
37	1	Oil seal carrier			
38	1	O-ring (2.175 x 0.103)			
39	1	Oil seal			

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
40	1	Oil seal			
41	1	Key			
42	1	Gasket			
43	1	Gasket			
44	1	Tube - 17.7 cm (7 in.) (Long)			
		Tube - 30.5 cm (12 in.) (X-long)			

Gear Housing (Driveshaft)



Gear Housing (Propeller Shaft) (Counter Rotation)



Gear Housing (Propeller Shaft) (Counter Rotation)

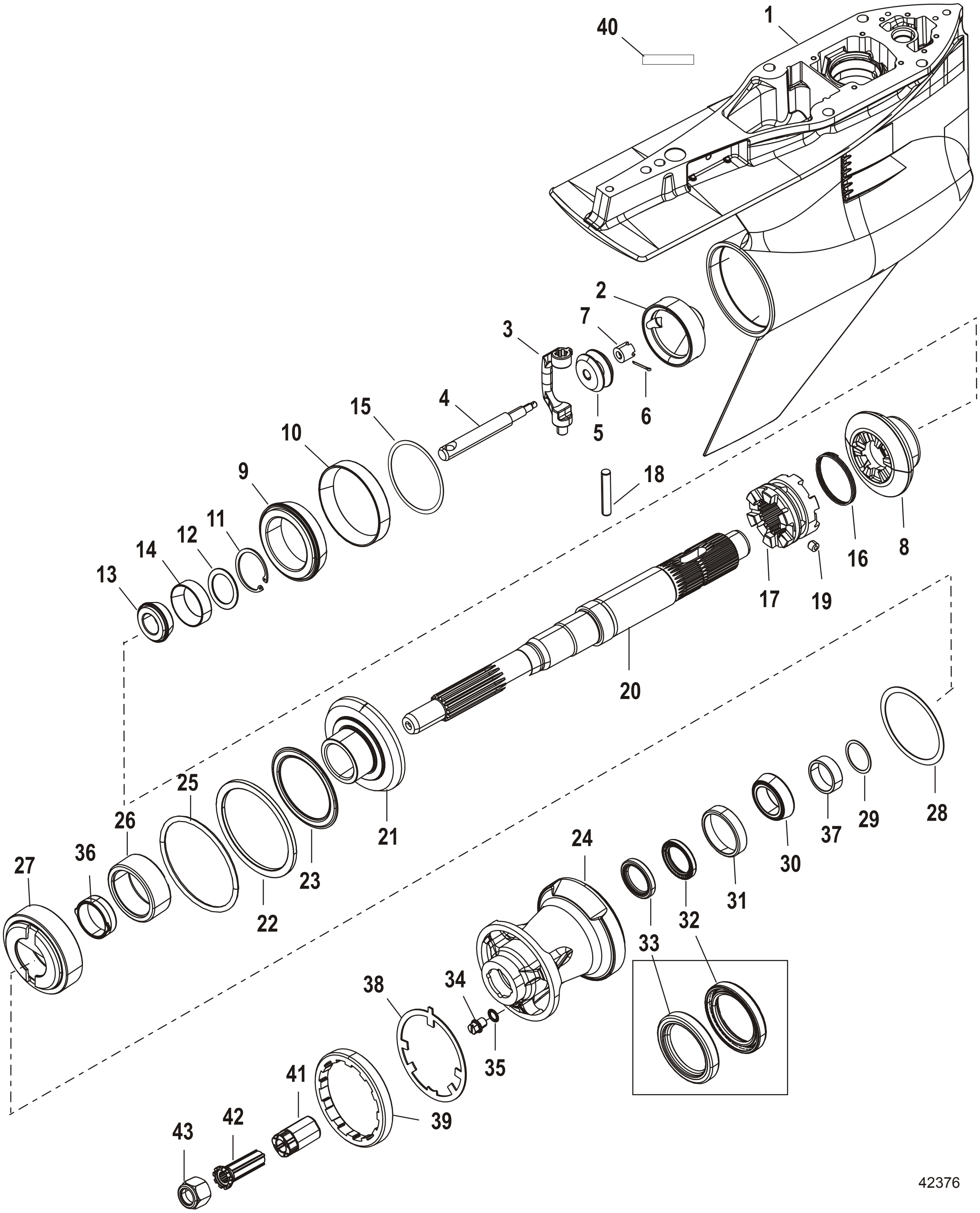
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing			
2	1	Plug	135.5		100
3	1	Shift crank			
4	1	Shift spool shaft			
5	1	Spool			
6	1	Cotter pin			
7	1	Adjusting sleeve			
8	1	Reverse gear			
9	1	Roller bearing			
10	1	Cup			
11	1	Retaining ring			
12	1	Thrust washer			
13	1	Roller bearing assembly			
14	1	Cup			
15	AR	Shim (0.002–0.050 in.)			
16	1	Spring			
17	1	Clutch			
18	1	Cross pin			
19	1	Detent pin			
20	1	Propeller shaft			
21	1	Forward gear			
22	1	Thrust ring			
23	1	Thrust bearing			
24	1	Bearing carrier			
25	1	O-ring			
26	1	Needle roller bearing			
27	1	Bearing adapter			
28	AR	Shim (0.002–0.045 in.)			
29	AR	Shim (0.030–0.070 in.)			
30	1	Roller bearing assembly			
31	1	Cup			
32	1	Oil seal			
33	1	Oil seal			
34	1	Screw	6.8	60	
35	1	Seal			
36	1	Adapter			
37	1	Spacer			
38	1	Keyed washer			
39	1	Retainer	285[1.]		210[1.]

1. Torque retainer to 135.5 Nm (100 lb-ft) then check rolling torque on propeller shaft. If torque is within specification, torque retainer to 285 Nm (210 lb-ft)

Left-Hand Rotation

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
40	1	Counter rotation decal			
41	1	Drive sleeve assembly			
42	1	Adapter			
43	1	Locknut	75		55

Gear Housing (Propeller Shaft) (Counter Rotation)



General Service Recommendations

There may be more than one way to disassemble or reassemble a particular part, therefore, it is recommended the entire procedure be read prior to repair.

IMPORTANT: Read the following before attempting any repairs.

In many cases, disassembly of a subassembly 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 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** (on back of section divider) to find 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 the air line.

Bearings

Upon disassembly of the gear housing, all bearings must be cleaned and inspected. Clean 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 bearing with compressed air, as this may cause bearing to score from lack of lubrication. After cleaning, lubricate bearings with High Performance Gear Lubricant. Do not lubricate tapered bearing cups until after inspection.

Inspect all bearings for roughness, catches, and bearing race side wear. Work inner bearing race in and out, while holding outer race, to check for side wear.

When inspecting tapered bearings, determine condition of rollers and inner bearing race by inspecting bearing cup for pitting, scoring, grooves, uneven wear, imbedded particles and/or discoloration from overheating. Always replace tapered bearing and race as a set.

Inspect gear housing for bearing races that have spun in their respective bores. If race has spun, gear housing must be replaced.

Roller bearing condition is determined by inspecting the bearing surface of the shaft that the roller bearing supports. Check 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 location during disassembly to aid in reassembly. Be sure to follow shimming instructions during reassembly, as gears must be installed to correct depth and have the correct amount of backlash to avoid noisy operation and premature gear failure.

Seals

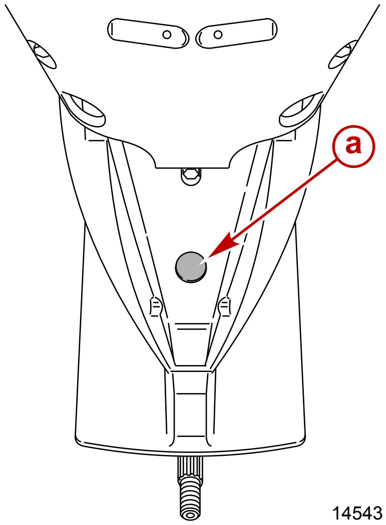
As a normal procedure, all O-rings and oil seals should be replaced without regard to appearance. To prevent leakage around oil seals, apply Loctite 271 to outer diameter of all metal case oil seals. When using Loctite on seals or threads, surfaces must be clean and dry. To ease installation, apply 2-4-C with Teflon on all O-rings. To prevent wear, apply 2-4-C with Teflon on inner diameter of oil seals.

Gearcase 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.

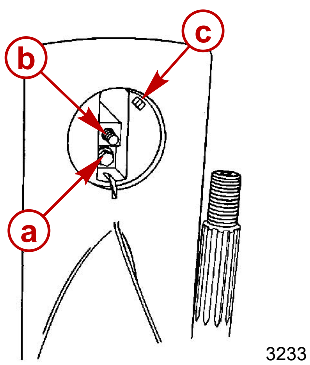
1. Ensure the gearcase is in neutral. The gearcase must be in neutral for installation.
2. Drain the engine oil. Failure to drain the oil prior to removing the gearcase will result in approximately 1 liter (1 US qt) of oil leakage when gearcase is removed. Refer to **Section 1B - Changing Engine Oil**.
3. Remove the propeller. Refer to **Section 1B - Propeller Replacement**.
4. Remove the top cowl.
5. Remove the port and starboard chaps. Refer to **Section 4A - Cowling Removal and Installation**.

6. Remove the rubber plug at the rear edge of the driveshaft housing. Remove the bolt (13 mm hex) that secures the anodic plate and remove the plate from the gear housing.



a - Rubber plug

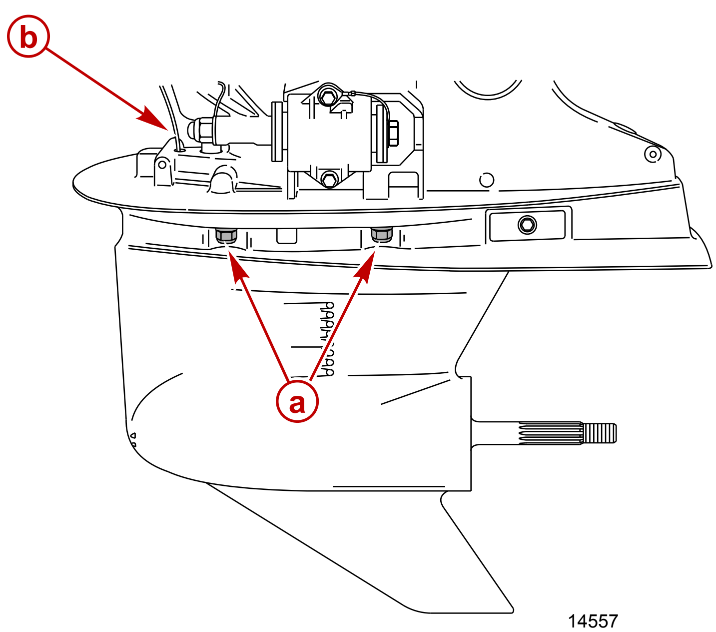
7. Once the plate is removed, remove the bolt (14 mm hex) from inside of the cavity.



a - Bolt (14 mm hex) (inside cavity)
b - Bolt (13 mm hex) (secures anodic plate)
c - Ribs

8. Loosen the side mounting locknuts. Do not attempt to remove one nut before the opposite side is loosened sufficiently, or the gear housing could be damaged. Support the gearcase as the last locknut is removed. The gearcase must be lowered slightly to gain access to the speedometer tube connection.

NOTE: After the retaining fasteners are removed from the gearcase, carefully lower gearcase assembly several inches to gain access to the speedometer tube connection. While pressing in on the speedometer tube junction, pull out on the tube to disconnect.



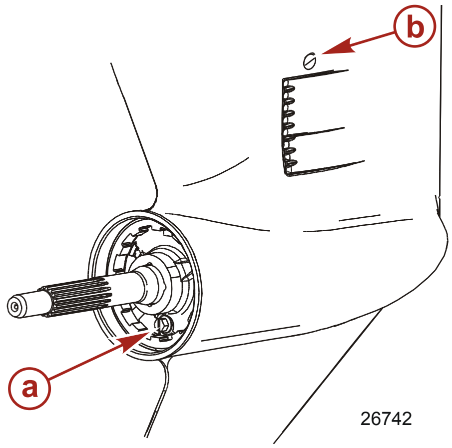
a - Nuts and washers (2 each side)
b - Speedometer tube

9. Pull the gear housing away from the driveshaft housing.

Gearcase Serviceability Inspection

Draining and Inspecting Gear Housing Lubricant

1. Place gear housing in a suitable holding fixture or vise with the driveshaft in a vertical position.
2. Position a clean drain pan under gear housing and remove fill and vent screws from gear housing with a 10 mm socket or slot screwdriver.



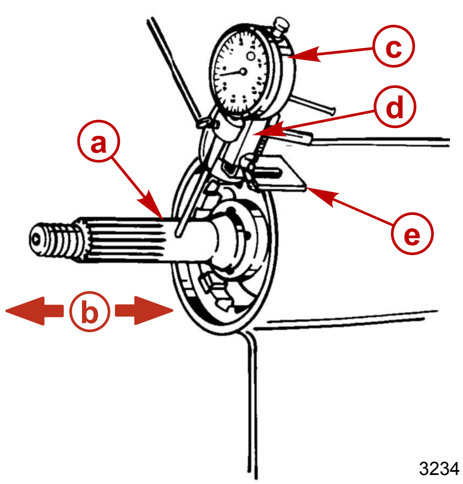
a - Fill screw
b - Vent screw

3. Inspect 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 need for gear housing disassembly, and component inspection.
4. Note the color of gear lubricant. White or cream color indicates presence of water in lubricant. Check drain pan for water separation from lubricant. Presence of water in gear lubricant indicates the need for disassembly, and inspection of oil seals, seal surfaces, O-rings, and gear housing components.

Propeller Shaft Inspection

Check for a bent propeller shaft as follows:

1. Rotate the propeller shaft while observing the dial indicator. If the deflection is more than 0.23 mm (0.009 in.), a bent propeller shaft is indicated.
2. Check for propeller shaft end play. There should be no end play. If end play exists, excessive wear has occurred and the gear housing must be disassembled for inspection.



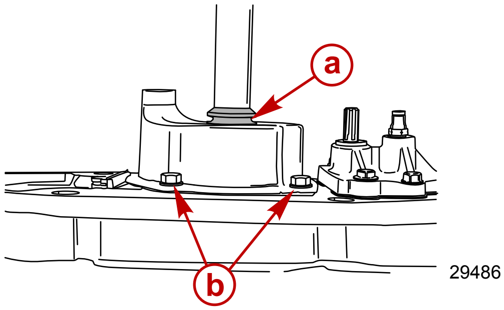
a - Propeller shaft runout
b - Propeller shaft end play
c - Dial indicator
d - Dial indicator holding tool
e - Dial indicator adapter

Dial Indicator	91- 58222A 1
Dial Indicator Adapter	91-83155
Dial Indicator Holding Tool	91- 89897

Water Pump

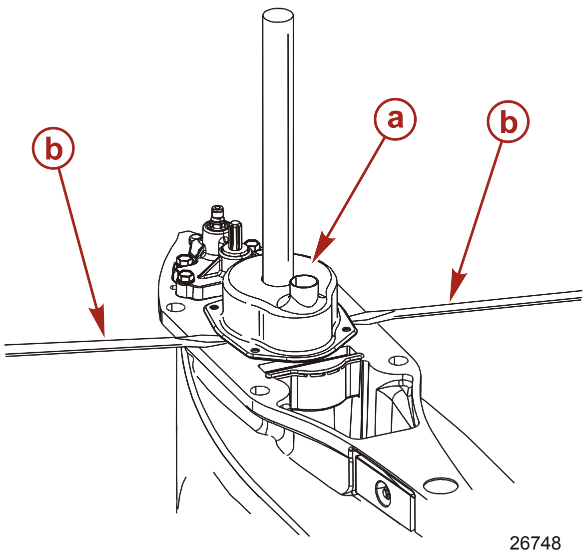
Removal and Disassembly

1. Remove the water seal and water pump screws.



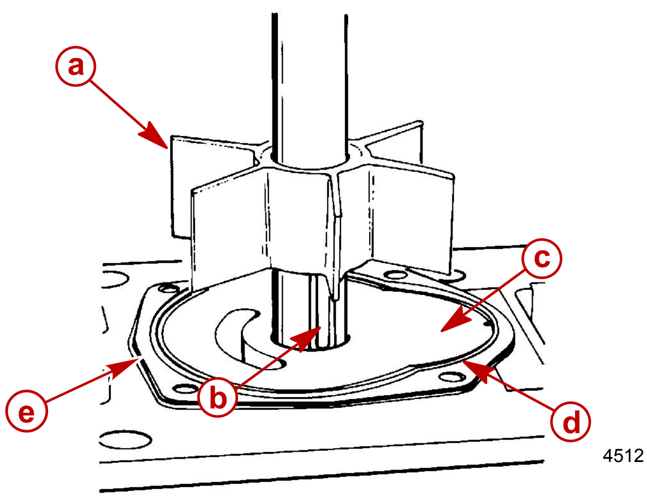
a - Water seal
b - Screws (2 each side)

2. Carefully slide the water pump straight up off of the driveshaft. It may be necessary to encourage the water pump up by gently prying up on its mounting flanges with screwdrivers.



a - Water pump body
b - Screwdrivers

3. Remove the impeller, impeller key, face plate, pump cover gasket, and pump base gasket.



a - Impeller
b - Key
c - Face plate
d - Pump cover gasket (gray bead faces up)
e - Pump cover base gasket

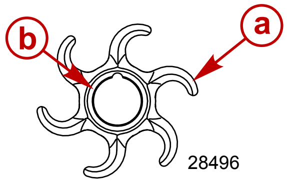
Cleaning and Inspection

NOTE: With the gearcase removed, inspect the water tube coupling assembly inside the driveshaft housing for wear or damage. If necessary, replace the worn or damaged components as required.

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

1. Inspect face plate and water pump liner for grooves and/or rough surfaces.

2. Inspect impeller side seal surfaces and ends of impeller blades for cracks, tears, and wear. Replace impeller if any of these conditions are found.
3. Inspect impeller bonding to impeller hub.



a - Impeller
b - Hub

4. Inspect impeller for glazed or melted appearance (caused by operation without sufficient water supply). Replace impeller if any of these conditions exist.

   IMPORTANT: When completing gear housing repairs that require removal of water pump impeller, it is recommended the impeller be replaced. If it is necessary, however, to reuse impeller, do not install in reverse to original rotation, or premature impeller failure will occur.

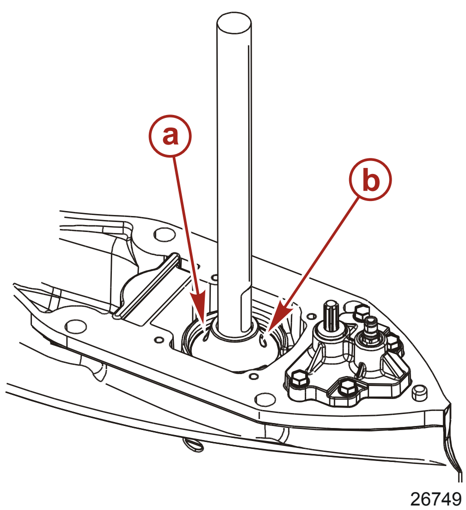
   IMPORTANT: It is recommended that all seals and gaskets be replaced (as a normal repair procedure) to assure effective repair.

Oil Seal Carrier Assembly

Removal

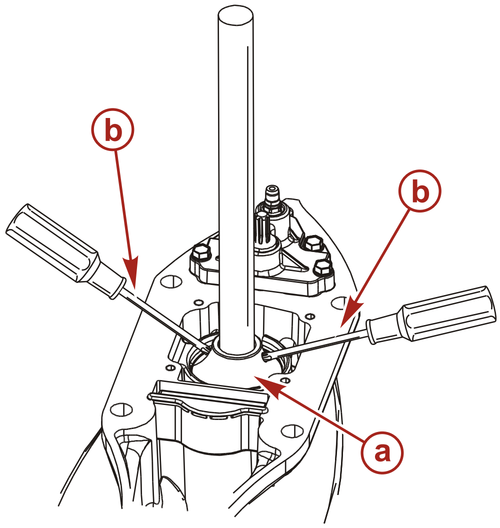
NOTE: Pushing down on the seal carrier may aid in the removal of the retaining ring above the seal carrier.

1. While pushing down on the seal carrier, use a flat tip screwdriver to aid in the removal of the retaining ring above the oil seal carrier.



a - Retaining ring
b - Seal carrier

2. Remove the oil seal carrier from the gear housing. It may be necessary to gently pry up on it with two screwdrivers.



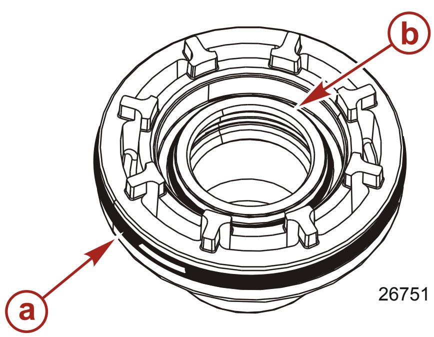
26750

a - Oil seal carrier
b - Screwdrivers

Disassembly

NOTE: Complete the instructions in this section only if the assembly components have been found to be defective and are in need of repair or replacement.

1. Remove the O-ring.

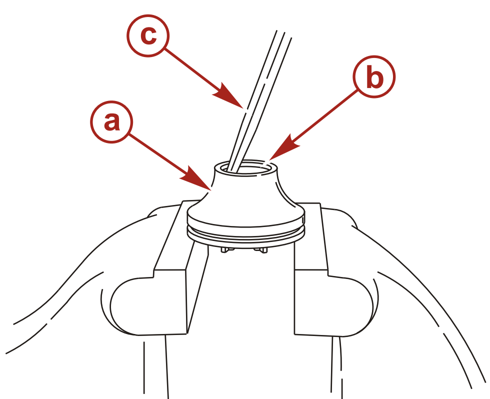


26751

a - O-ring
b - Oil seals (2)

IMPORTANT: Use caution when removing carrier oil seals to avoid nicking or scratching the plastic surface the seals contact in the carrier, as water leakage into the gearcase could result.

2. Remove oil seals with a screwdriver or punch.



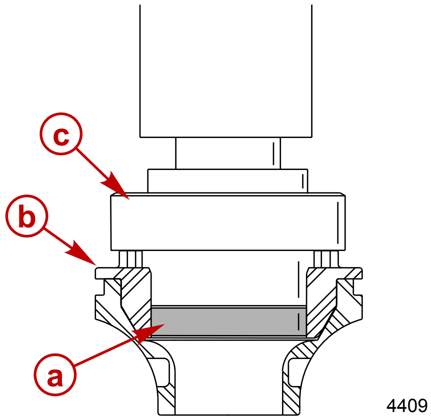
26752

a - Oil seal carrier
b - Oil seals
c - Screwdriver

Reassembly

The oil seals in the carrier assembly are the same diameter. The bottom (first) seal lip faces down; the top (second) seal lip faces up. Apply 2-4-C with Teflon to seal lips and between seals. Apply Loctite 380 to outer diameter of both seals.

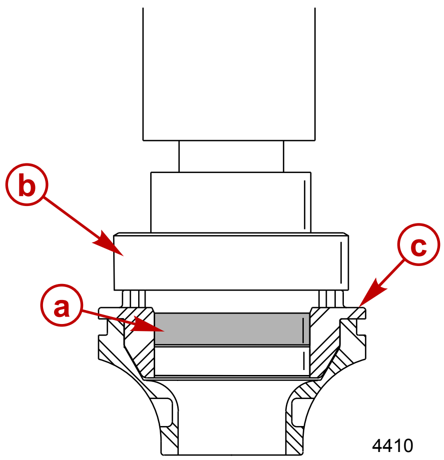
1. Press first seal into carrier with oil seal driver, using long side of seal driver.



a - First seal installed (lip faces away from driver)
b - Seal carrier
c - Oil seal driver

Oil Seal Driver	91-889844T

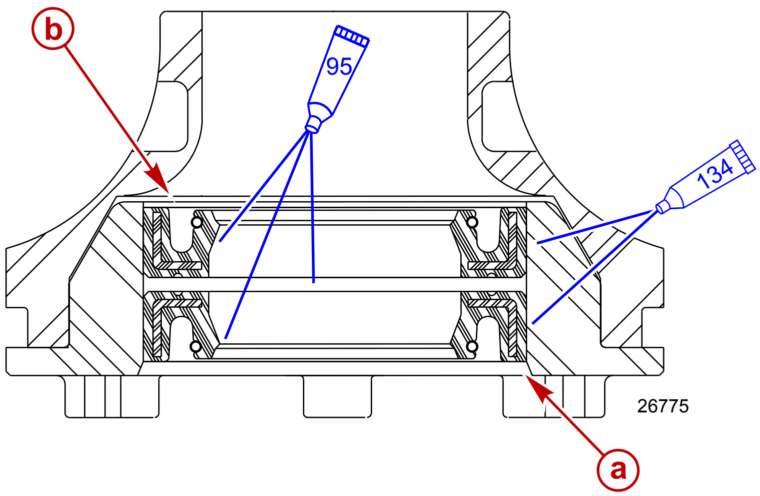
2. Reverse seal driver and using short side of driver, press second seal in until seal driver is flush with carrier surface.



a - Second seal installed (lip faces towards driver)
b - Oil seal driver
c - Seal carrier

Oil Seal Driver	91-889844T

3. Apply 2-4-C with Teflon to seal lips.



a - Second seal installed (lip faces down)
b - First seal installed (lip faces up)

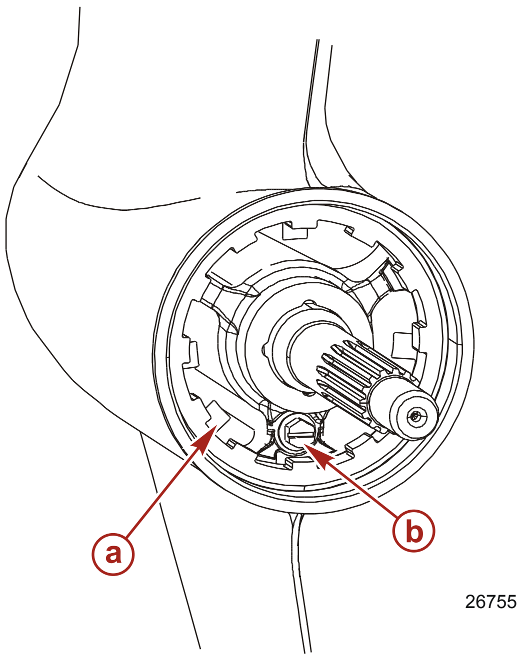
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Oil seal lips and between oil seals	92-802859A 1
134	Loctite 380	Outer diameter of oil seals	Obtain Locally

Bearing Carrier and Propeller Shaft

Removal

1. Straighten the tab on the tab washer.

   NOTE: *Drain plug in bearing carrier must be removed before using bearing carrier retainer nut wrench to remove bearing carrier retainer.*



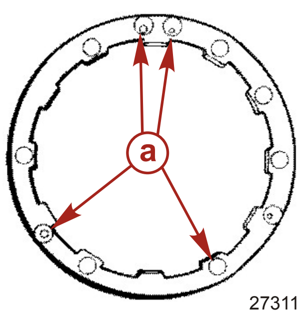
a - Tab
b - Drain plug

Bearing Carrier Retainer Nut Wrench	91-61069T

2. Remove the bearing carrier retainer following step "a" or "b" as follows:

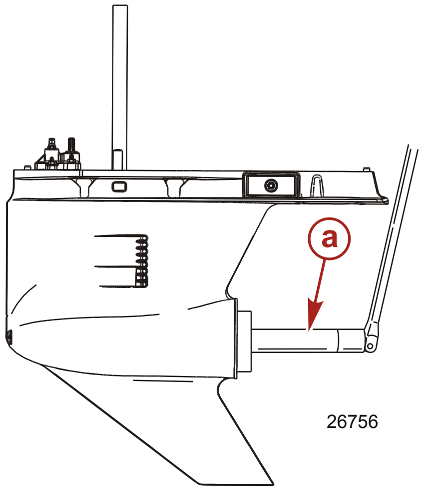
   IMPORTANT: Drilling into the bearing carrier retainer can potentially damage the gearcase. Ensure you do not drill into the gearcase when removing a seized retainer.

   a. If the retainer is corroded in place, drill four holes in the retainer and fracture the retainer with a chisel. Pry the remaining segments out.



a - Drilled holes

b. Remove bearing carrier retainer using bearing carrier retainer nut wrench.

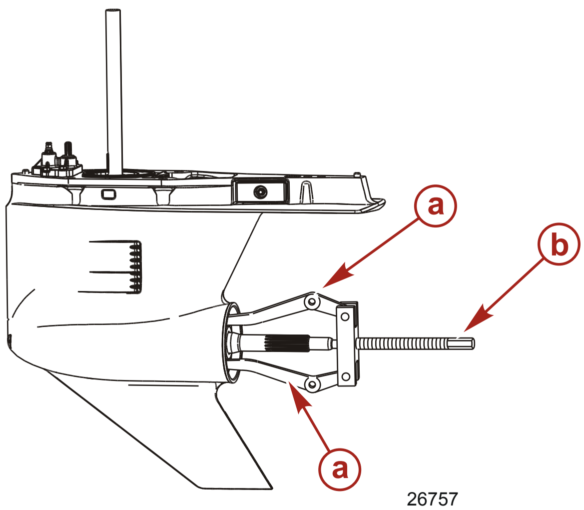


a - Bearing carrier retainer nut wrench

Bearing Carrier Retainer Nut Wrench	91-61069T

3. Pull the bearing carrier from the gear housing by pulling on the outer ring of the bearing carrier. Position puller jaws close to bosses in carrier.

NOTE: If the bearing carrier is seized in the gear housing, it may be necessary to use heat to loosen the carrier.



a - Puller jaws assembly
b - Puller bolt

Puller Jaws Assembly	91-46086A1

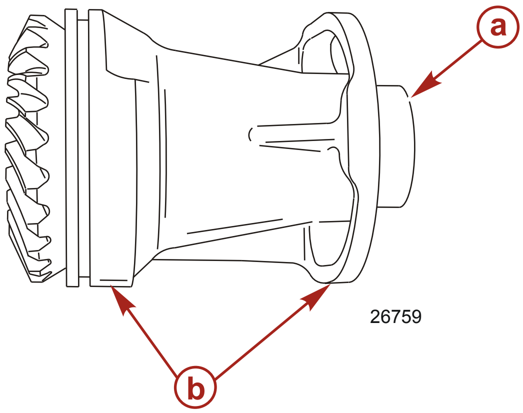
Cleaning/Inspection

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

1. Clean bearing carrier with solvent and dry with compressed air.

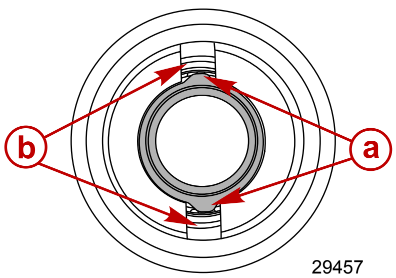
⚠ WARNING
Spin-drying bearings with compressed air can cause serious injury or death. The bearings can explode, even if spun at very slow speeds. Do not allow the bearings to spin when drying with compressed air.

2. Inspect the bearing carrier for signs of excessive corrosion especially in the area where the bearing carrier touches the gear housing. If excessive corrosion is evident replace the carrier.



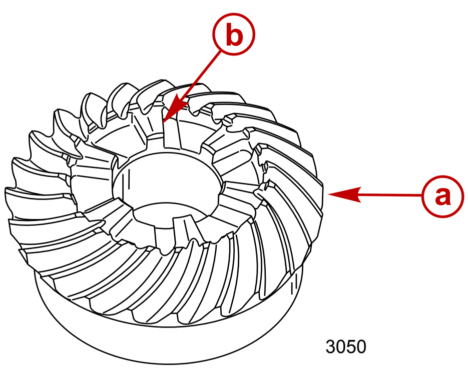
a - Bearing carrier
b - Inspect for corrosion

3. The propeller shaft utilizes a tapered roller bearing and cup for shaft support just forward of the bearing carrier seals. The forward gear and bearing adapter assembly must be removed from the bearing carrier to gain access to the propeller shaft tapered bearing for inspection.
4. Forward gear can be removed from the adapter/bearing carrier assembly by rotating gear until forward gear sleeve tabs align with slots in adapter. Forward gear can then be removed from adapter/bearing carrier assembly.



a - Forward gear sleeve tabs
b - Adapter slots

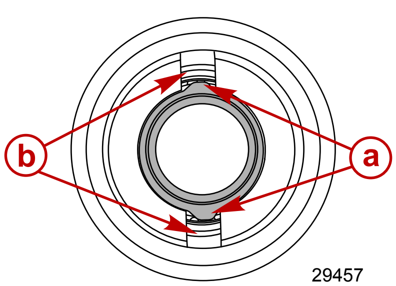
5. Inspect forward gear for pitted, chipped, broken teeth, hairline fractures, and excessive or uneven wear. Replace forward gear and the pinion gear if any defects are found.
6. Check clutch jaws on forward gear for damage. Replace forward gear, if damage is found on clutch jaws.



a - Forward gear
b - Clutch jaws

Disassembly

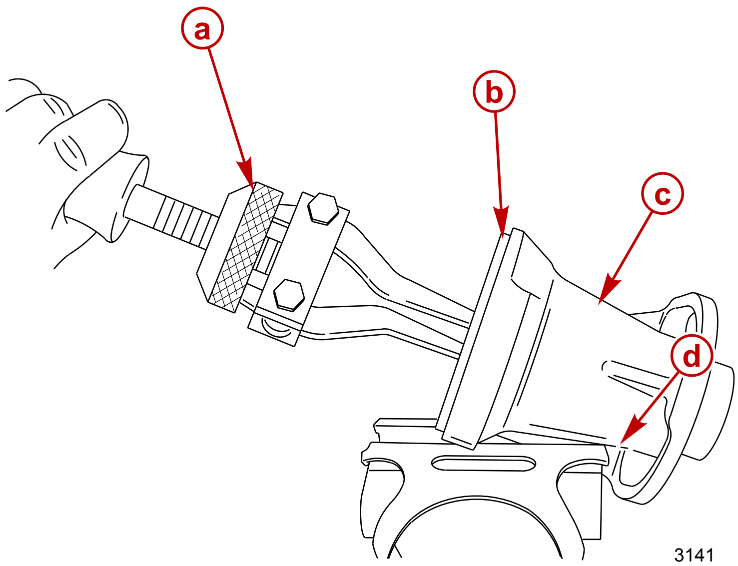
1. Remove and discard O-ring from between bearing carrier and thrust washer.
2. Remove forward gear assembly by rotating forward gear sleeve tabs to align with bearing adapter slots and remove gear.



a - Forward gear sleeve tabs
b - Adapter slots

IMPORTANT: Clamping the bearing carrier in a vise can damage the carrier. Clamp onto the reinforcing rib only.

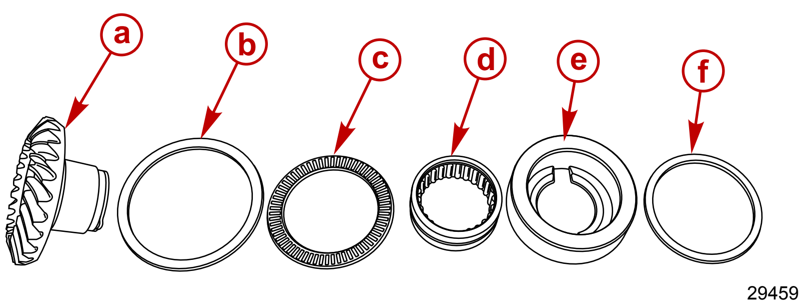
3. Remove forward gear bearing adapter by placing the bearing carrier in a vise, clamping on the reinforcing rib.
4. Remove the bearing adapter as an assembly, using a slide hammer puller.



a - Slide hammer puller
b - Bearing adapter
c - Bearing carrier
d - Bearing carrier reinforcing rib

Slide Hammer	91-34569A 1

5. Clean the forward gear bearing adapter assembly with a suitable solvent and dry it using compressed air.

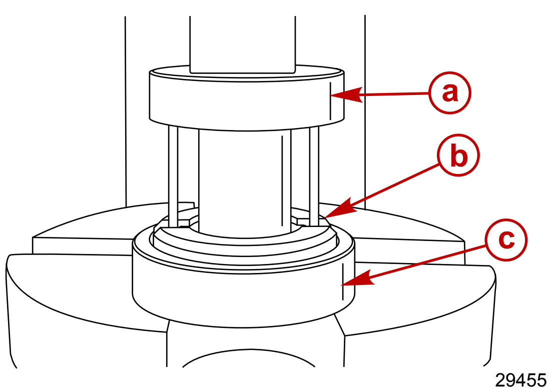


a - Forward gear
b - Thrust washer
c - Thrust bearing
d - Roller bearing
e - Bearing adapter
f - Shim

NOTE: *The condition of the bearing surfaces on the forward gear in the areas the bearings of the bearing adapter and the thrust bearing rides, is an indication of the condition of respective bearings. Replace the bearings if the surface of the gear and/or thrust washer is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded metal particles.*

IMPORTANT: Do not remove the roller bearing from the bearing adapter unless replacement is necessary. Bearing should not be reused after it has been removed from the bearing adapter.

6. If roller bearing in bearing adapter must be replaced, remove bearing from adapter using the bearing removal tool. Align the pins of the tool with slots of the adapter and apply force to the center of the tool so the pressure is equal on both of the pins. Discard the bearing after removal.

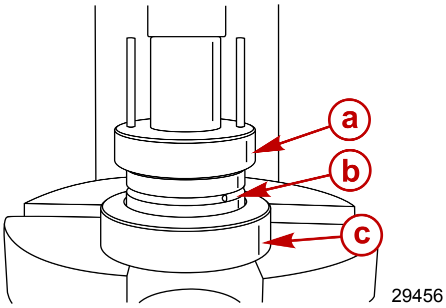


a - Bearing removal tool
b - Roller bearing
c - Bearing adapter

Needle Bearing Removal Tool	91-816245

7. Assemble the adapter as follows:

a. Lubricate the bore the roller bearing is pressed into with 2-4-C with Teflon.
b. Install the roller bearing into the adapter with the numbered end of the bearing facing the driver shoulder.
c. Press the roller bearing into the adapter using bearing removal tool until the bearing removal tool contacts the adapter.

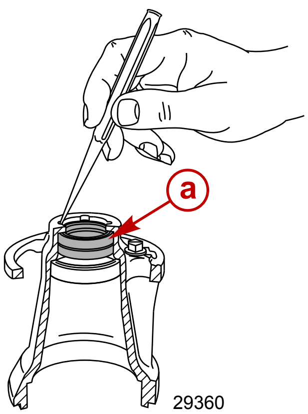


a - Bearing removal tool
b - Roller bearing (numbers/letters face driver)
c - Bearing adapter

Needle Bearing Removal Tool	91-816245

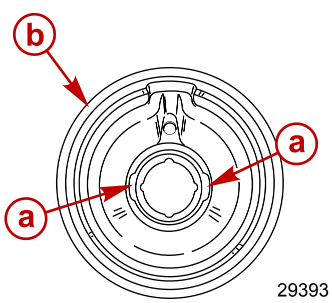
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Bore the roller bearing is pressed into	92-802859A 1

8. Perform the following step "a" or "b" as necessary.
   a. **If replacing the seals only:** Remove the oil seals with a suitable punch, being careful not to damage the bore of the bearing carrier. Discard both of the seals.



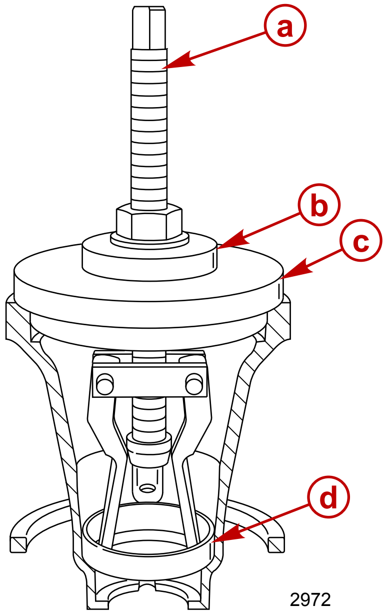
a - Seals

   b. **If replacing the tapered roller bearing and seals:** Remove the seals with a punch as noted above. There are slots cast into the carrier to aid in the removal of the bearing race with puller jaws.



a - Slots
b - Bearing carrier

c. Remove the tapered bearing race from the carrier using bearing puller assembly, pilot washer, and seal driver guide. Discard the bearing, race, and both seals.



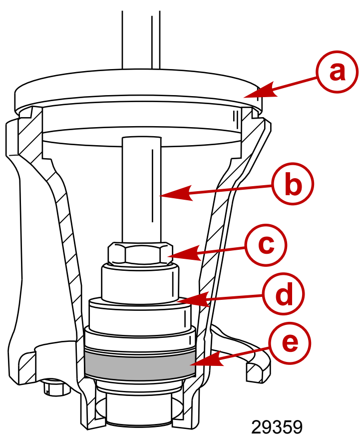
a - Bearing puller assembly
b - Pilot washer
c - Seal driver guide
d - Race

Bearing Puller Assembly	91-83165T
Pilot Washer	91-36571T
Seal Driver Guide	91-889845

Reassembly

NOTE: Complete the instructions in this section only if the assembly components have been disassembled and repaired or replaced.

1. Clean all of the components with a suitable solvent and dry the parts thoroughly using compressed air.
2. Lubricate the bore the roller bearing race is pressed into with High Performance Gear Lubricant.
3. Assemble the bearing race onto the driver.
4. Press the bearing race into the bearing carrier until the race bottoms out in the bearing carrier.

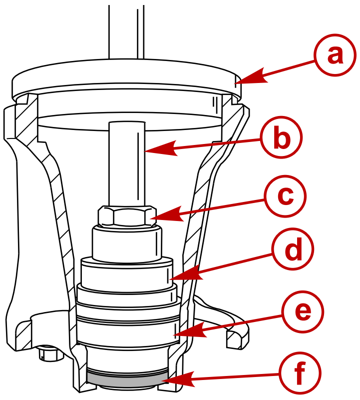


a - Seal driver guide
b - Driver rod
c - Hex nut
d - Oil seal driver
e - Tapered bearing race

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91-31229A7
Oil Seal Driver	91-889844T

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Bearing bore in carrier	92-858064K01

5. Thoroughly clean the bore in which the first seal is to be pressed.
6. Assemble the first seal (with the lips of the seal facing away from the driver shoulder) onto the long end of the oil seal driver.
7. Apply Loctite 380 to the outside diameter of the oil seal.
8. Press on the oil seal driver until the driver bottoms on the bearing race.



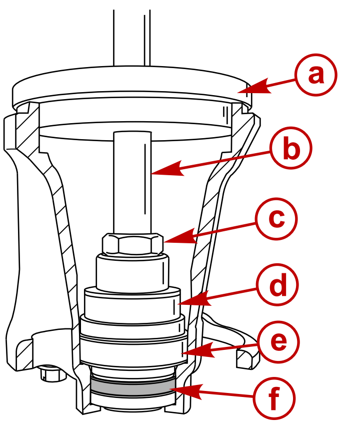
29357

a - Seal driver guide
b - Driver rod
c - Hex nut
d - Oil seal driver
e - Bearing race
f - Oil seal

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91-31229A7
Oil Seal Driver	91-889844T

Tube Ref No.	Description	Where Used	Part No.
134	Loctite 380	Outer diameter of oil seal	Obtain Locally

9. Assemble the second seal (with the lips of the seal facing the driver shoulder) onto the short end of the driver.
10. Apply Loctite 380 to the outside diameter of the oil seal.
11. Press the oil seal with the driver until the driver bottoms out on the bearing race.



29358

a - Seal driver guide
b - Driver rod
c - Hex nut
d - Oil seal driver
e - Bearing race
f - Oil seal

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91-31229A7
Oil Seal Driver	91-889844T

Tube Ref No.	Description	Where Used	Part No.
134	Loctite 380	Outer diameter of oil seal	Obtain Locally

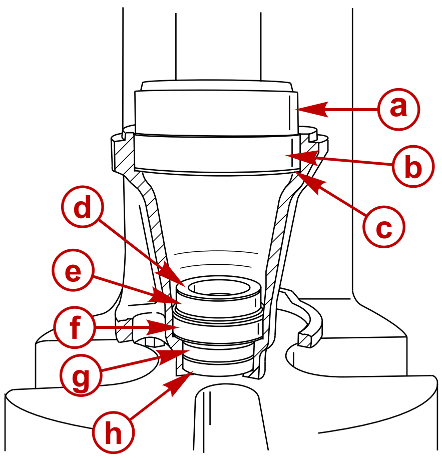
12. Lubricate the seal lips and fill the area between the seals with 2-4-C with Teflon.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Oil seal lips and between oil seals	92-802859A 1

13. Install propeller shaft tapered roller bearing into carrier bearing race.
14. Lubricate the bore the bearing is pressed into with High Performance Gear Lubricant.

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Bearing carrier bore	92-858064K01

15. Install bearing adapter shim into bearing carrier.
16. Press the bearing adapter into the carrier and until the adapter bottoms out in the bearing carrier.



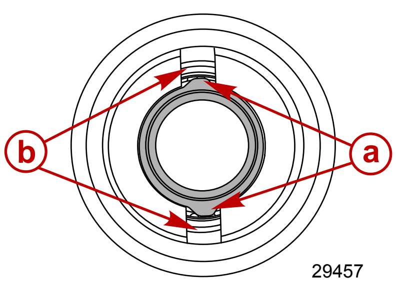
3157

- a - Bearing cup driver
- b - Bearing adapter
- c - Bearing adapter shim
- d - Shim
- e - Spacer
- f - Tapered bearing
- g - Seal
- h - Seal

Bearing Cup Driver	91-885592T

NOTE: The shim and spacer above the tapered bearing may be installed before the propeller shaft or both placed on the propeller shaft and installed into the carrier with the propeller shaft. However, without the propeller shaft installed in the bearing carrier, the shim, spacer, and tapered bearing may fall out of alignment.

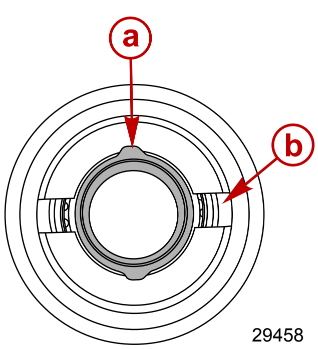
17. Install thrust bearing onto bearing adapter.
18. Install thrust washer onto bearing adapter.
19. Install forward gear into bearing adapter by aligning forward gear adapter sleeve tabs with slots in bearing adapter.



29457

- a - Forward gear sleeve tabs
- b - Bearing adapter slots

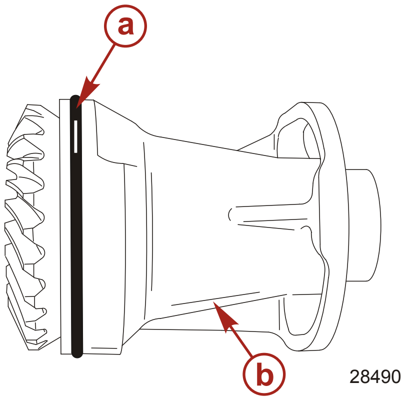
20. Rotate forward gear 90 degrees after installing gear into bearing adapter.



29458

- a - Forward gear sleeve tabs
- b - Bearing adapter slots

21. Lubricate the O-ring with 2-4-C with Teflon and install the O-ring onto the bearing carrier.



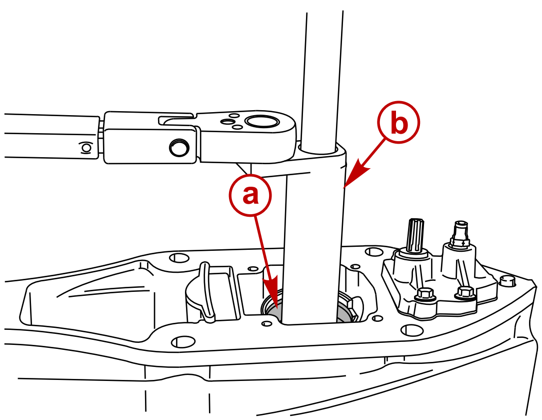
a - O-ring
b - Bearing carrier

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Bearing carrier O-ring	92-802859A 1

Driveshaft Assembly

Removal

1. Remove the driveshaft pinion nut as follows:
   a. Remove the upper driveshaft tapered bearing retainer.

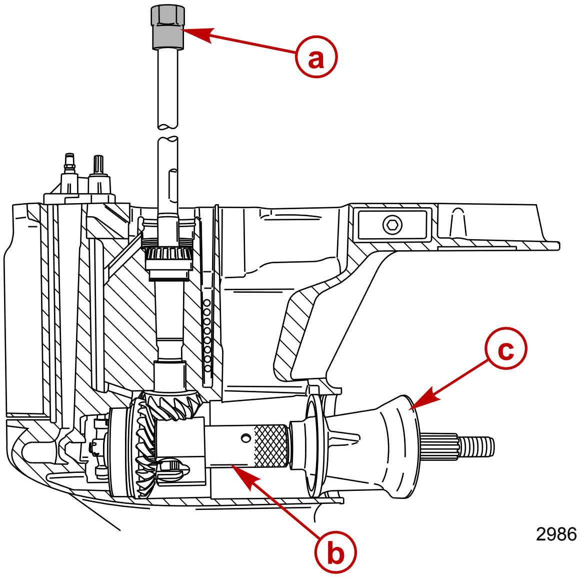


a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

   b. Place the driveshaft holding tool onto the driveshaft.
   c. Insert the pinion nut wrench with the MC1 slot facing the pinion gear into the gear housing. It may be necessary to slightly lift and rotate the driveshaft to align the pinion gear nut into the pinion nut wrench slot.
   d. Install the bearing carrier into the gear housing backwards to support the propeller shaft and to keep the pinion nut wrench aligned.

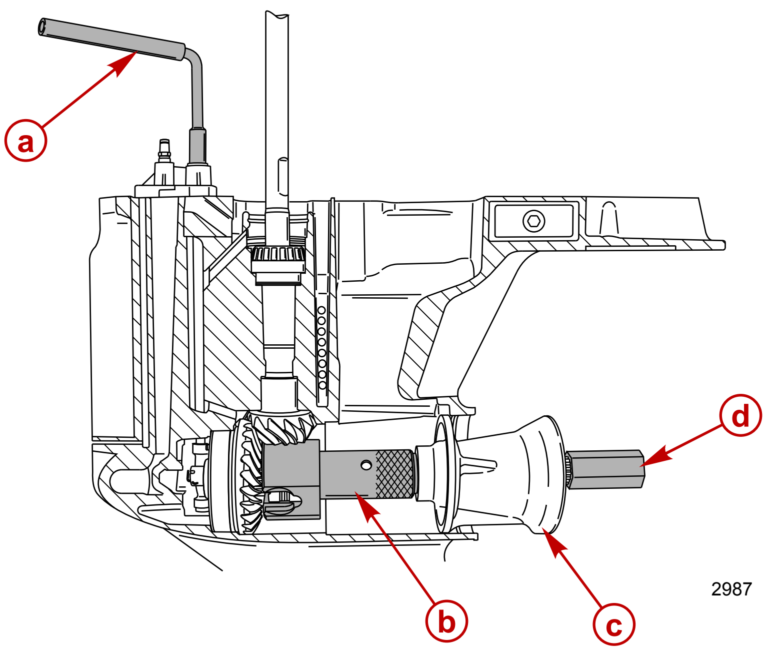
e. Using the driveshaft holding tool, loosen the pinion nut by rotating the driveshaft counterclockwise.



a - Driveshaft holding tool
b - Pinion nut wrench
c - Bearing carrier (installed backwards)

Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03

f. If the driveshaft is broken, place propeller shaft adapter onto the propeller shaft splines, hold shift shaft in forward gear and loosen the pinion nut by rotating propeller shaft counterclockwise to turn gears, thus loosening the pinion nut.



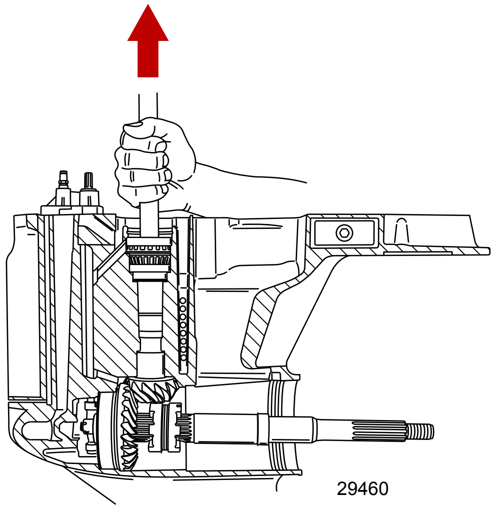
a - Shift shaft tool (fabricate from old shift shaft)
b - Pinion nut wrench
c - Bearing carrier (installed backwards)
d - Propeller shaft adapter

Pinion Nut Wrench	91- 61067T03
Propeller Shaft/Driveshaft Adapter	91-61077T

g. Completely unscrew the pinion nut by rotating the propeller shaft in a counterclockwise direction.

h. Remove all tools.

2. Remove the driveshaft and all components by pulling the driveshaft straight out of the gear housing as shown.

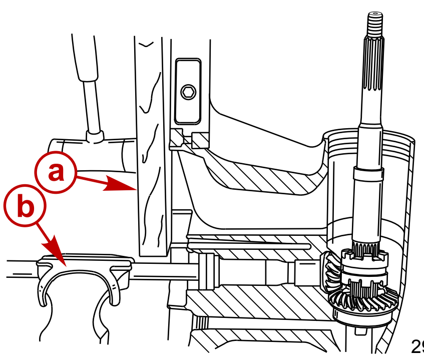


29460

IMPORTANT: The pinion bearing rollers are free to fall out of the pinion bearing once the driveshaft is removed. Be careful not to lose the 18 rollers.

NOTE: If pinion gear is seized onto the driveshaft, place gearcase in a vise using soft jaw vise covers. Place a block of wood on gear housing mating surface. Use a mallet and carefully tap gear housing away from driveshaft.

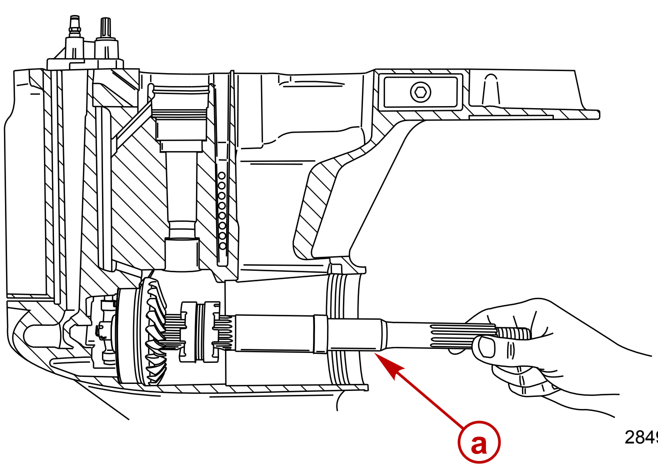
IMPORTANT: Striking a gear housing directly with a mallet or dropping the gear housing could distort the gear housing resulting in gear housing failure.



29158

a - Wood block
b - Driveshaft in soft jaw vise

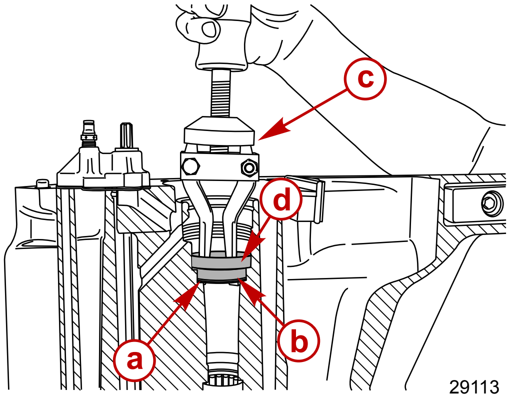
3. Retrieve the pinion gear, washer, and nut from inside the gear housing.
4. Move the propeller shaft to the port side of the gearcase to disengage the propeller shaft assembly from the shift crank. Remove the propeller shaft.



2849

a - Propeller shaft

5. Remove spacer, bearing race, and shims using slide hammer puller (retain shims for reinstallation).



a - Shims
b - Bearing race
c - Slide hammer puller
d - Spacer

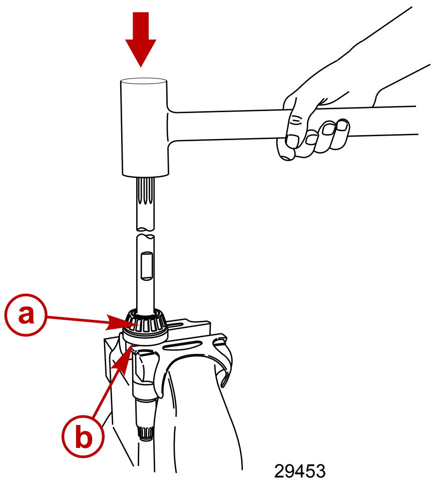
Slide Hammer	91-34569A 1

Disassembly

NOTE: Do not remove upper and lower tapered roller bearings from driveshaft unless replacement is indicated. Bearings cannot be reused after removal from driveshaft.

NOTE: If one driveshaft tapered roller bearing is damaged, both tapered bearings and spacer must be replaced as a set.

1. Both upper and lower tapered roller bearings can be removed from the driveshaft in one operation. Using the bottom bearing cup removed from the gearcase, place the cup on top of a vise leaving the vise jaws open enough to allow the driveshaft to slide through.
2. Place the driveshaft through the cup and vise until the bottom bearing is resting in the cup. While holding the driveshaft, tap on the top of the shaft with a dead blow hammer until the bearings are free. Do not drop the shaft when performing this operation.

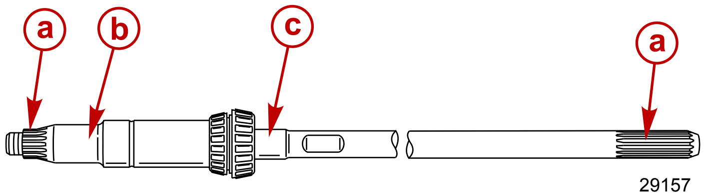


a - Driveshaft with both upper and lower bearings
b - Lower bearing cup removed from gearcase

Inspection

1. Clean all parts with a suitable solvent and dry the parts thoroughly using compressed air, being careful not to spin the bearings.
2. The condition of the upper and lower driveshaft bearing cups is an indication of the condition of each of the tapered roller bearings on the driveshaft. Replace the bearing and bearing cup if the cup is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles.
3. Inspect the bearing surface on the driveshaft where the rollers of the lower pinion bearing roll. Replace the pinion bearing and the driveshaft if the shaft is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles.
4. Inspect the splines at both ends of the driveshaft for a worn or twisted condition. Replace the driveshaft if either condition exists.

5. Inspect driveshaft for grooves where the oil seal carrier oil seals contact the driveshaft. Replace the driveshaft if grooves are found.



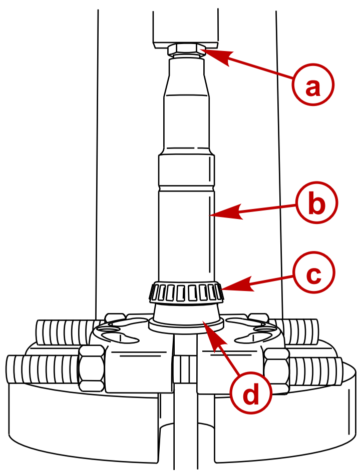
a - Splines
b - Pinion bearing surface
c - Seal surface

6. Inspect the pinion gear for pitting, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the pinion gear and the forward gear as a set if any defects are found.

Reassembly

NOTE: Complete the instructions in this section only if the components have been disassembled.

1. Apply a light coat of High Performance Gear Lubricant on inside diameter of the driveshaft tapered bearing.
2. Assemble a new lower tapered roller bearing to the driveshaft, with the small outside diameter of the bearing facing the pinion gear end of the driveshaft.
3. Thread a used pinion nut onto end of the driveshaft. Leave approximately 2 mm (1/16 in.) of nut threads exposed. Driveshaft threads must not extend beyond the nut or thread damage could result while pressing.
4. Press the tapered roller bearing onto the driveshaft using the universal puller plate and a suitable mandrel (an old tapered roller bearing inner race).



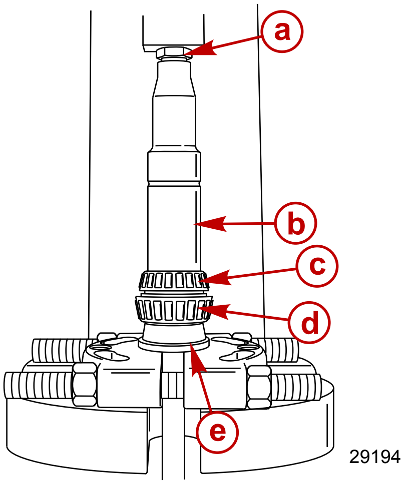
a - Pinion nut
b - Driveshaft
c - Lower driveshaft tapered bearing
d - Old tapered roller bearing inner race

Universal Puller Plate	91-37241

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of driveshaft tapered bearing	92-858064K01

5. Apply a light coat of High Performance Gear Lubricant on inside diameter of driveshaft tapered bearing.
6. Assemble a new upper tapered roller bearing to the driveshaft with the large outside diameter of the bearing facing the pinion gear end of the driveshaft.
7. Thread a used pinion nut onto the end of the driveshaft. Leave approximately 2 mm (1/16 in.) of nut threads exposed. Driveshaft threads must not extend beyond the nut or thread damage could result while pressing.

8. Press the tapered roller bearing onto the driveshaft using the universal puller plate and a suitable mandrel (an old tapered roller bearing inner race).



- a - Pinion nut
- b - Driveshaft
- c - Lower driveshaft tapered bearing
- d - Upper driveshaft tapered bearing
- e - Old tapered roller bearing inner race

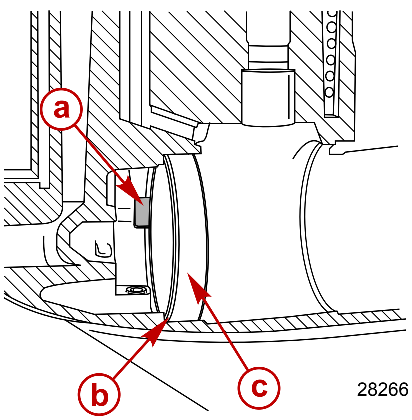
Universal Puller Plate	91-37241

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of driveshaft tapered bearing	92-858064K01

Propeller Shaft Assembly and Reverse Gear Bearing Cup

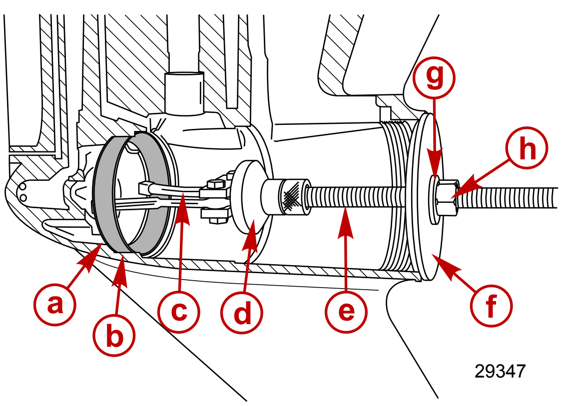
Removal

1. Two notches are provided in the gear housing just forward of the reverse gear bearing cup to position puller jaws for easier removal of the bearing cup and shims.



- a - Notches
- b - Shims
- c - Reverse gear bearing cup

2. Remove reverse gear bearing cup and shims. Measure and make note of the shim thickness. If the shims are not damaged, they may be reused.



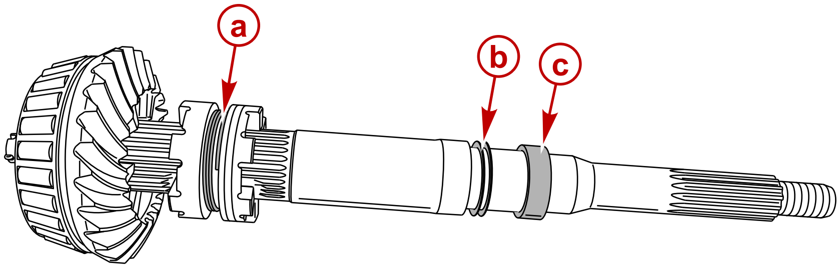
- a - Shims
- b - Bearing cup
- c - Jaws (from slide hammer puller kit)
- d - Puller head (from slide hammer puller kit)
- e - Puller shaft
- f - Guide plate
- g - Washer
- h - Hex nut

Slide Hammer	91-34569A 1
Bearing Removal and Installation Kit	91-31229A7

Disassembly

***NOTE:** When accomplishing the next step, all of the parts are free to come apart. Work closely over a workbench to ensure the parts are not dropped or damaged and to avoid personal injury.*

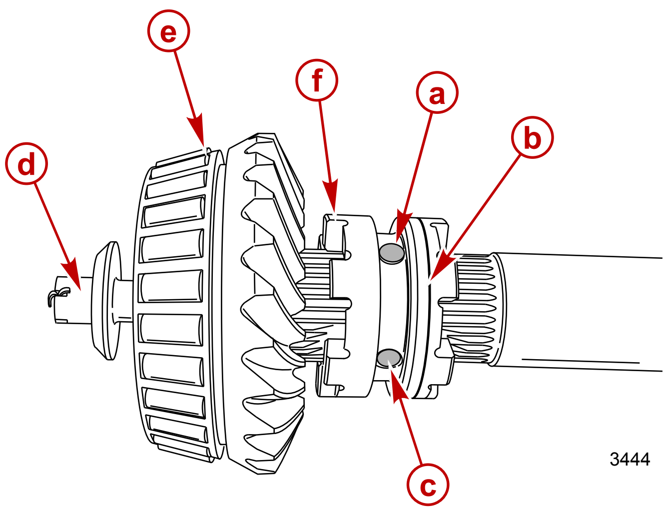
1. Remove the spring around the clutch being careful not to overstretch it during removal. If the spring does not coil back to its normal position once it has been removed, it must be replaced.



3443

a - Spring
b - Shims
c - Preload spacer

2. Remove detent pin.
3. Remove the cross pin that goes through the clutch.
4. Remove the remainder of the components.



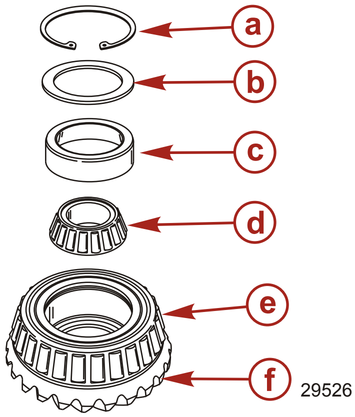
3444

a - Detent pin
b - Ring - faces forward gear
c - Cross pin
d - Spool and actuating shaft assembly
e - Reverse gear assembly
f - Clutch

Inspection

1. Clean all the parts with a suitable solvent and dry the parts thoroughly using compressed air, being careful not to spin bearings.
2. Inspect the sliding clutch jaws for damage. Jaws must not be chipped or rounded off. Replace the clutch if they are.

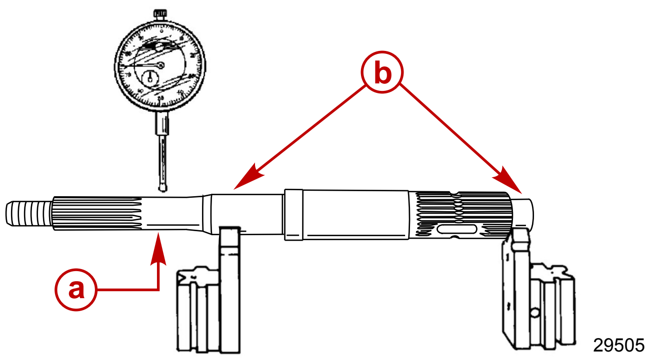
3. The propeller shaft utilizes two tapered roller bearing and cup assemblies for propeller shaft support. One tapered bearing is just forward of the bearing carrier seals. The forward gear assembly and bearing adapter must be removed from the bearing carrier to gain access to this bearing for inspection. The other tapered bearing is located inside the reverse gear assembly. The reverse gear assembly must be removed from the propeller shaft and a snap ring retainer and flat washer removed from the reverse gear assembly to gain access to this tapered bearing for inspection.



a - Snap ring
b - Flat washer
c - Tapered bearing race
d - Tapered bearing
e - Reverse gear bearing
f - Reverse gear

NOTE: Reverse gear bearing should not be removed from reverse gear unless replacement is necessary. Bearing is not reusable if bearing is removed.

4. Inspect the propeller shaft splines at both ends for a broken, worn, or twisted condition. Replace the propeller shaft if any of these conditions exist.
5. Inspect the surface of the propeller shaft where the bearing carrier seal lips contact the shaft. If the oil seals have made grooves, replace the propeller shaft and oil seals.
6. Inspect the propeller shaft for a bent condition using V-blocks and a dial indicator.
   a. Position the propeller shaft bearing surfaces on V-blocks.
   b. Adjust the height of V-blocks to level the propeller shaft.
   c. Position the dial indicator tip just forward of the propeller shaft splines.
7. Rotate the propeller shaft and observe the dial indicator movement, If the indicator in the dial moves more than 0.23 mm (0.009 in.), replace the propeller shaft.



a - Check movement with dial indicator here
b - Seal surface area

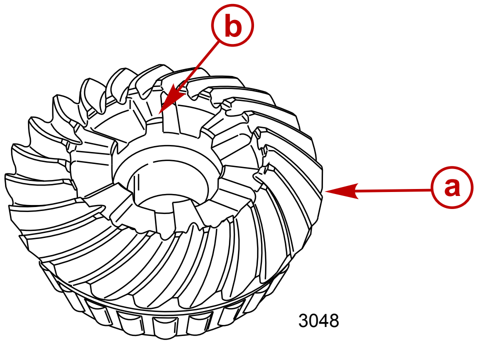
Dial Indicator	91- 58222A 1

Reverse Gear Assembly

Inspection

1. Clean the reverse gear assembly with a suitable solvent and dry with compressed air. Be careful not to spin the bearings.
2. Inspect the gear for pitting, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the reverse gear and the pinion gear as a set if any defects are found.

3. Inspect the clutch jaws of the gear for damage. The surfaces must not be chipped or rounded off. Replace both the reverse and pinion gear as a set if any of these conditions exist.



a - Reverse gear teeth
b - Clutch jaws

4. Inspect the propeller shaft tapered roller bearing on the inside of the reverse gear and its respective bearing cup. If either the bearing or the bearing cup surface is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles, remove and replace the tapered roller bearing assembly in the reverse gear as outlined in the next section.
5. Inspect the tapered roller bearing pressed onto the reverse gear and the bearing surface on the reverse gear bearing cup. If either the roller bearing or the bearing surface of the reverse gear bearing cup is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles, replace the reverse gear bearing cup and remove and replace the tapered roller bearings as outlined in the next section.

Disassembly

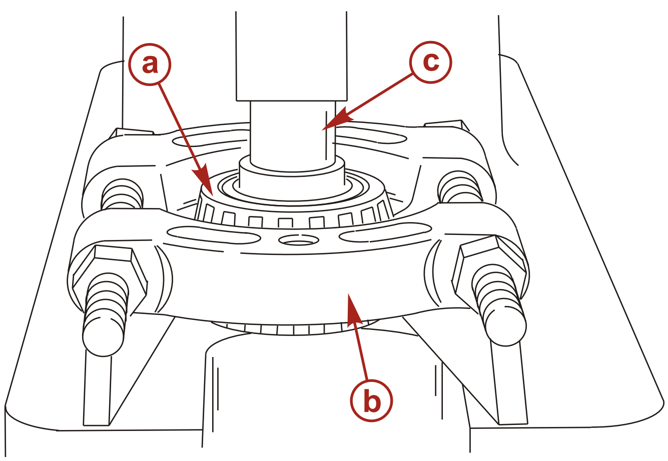
NOTE: Reverse gear and propeller shaft can only be removed from gear housing after driveshaft and pinion gear have been removed.

1. Tilt the propeller shaft to the port side of gear housing and remove the propeller shaft and gear assembly.

   IMPORTANT: Do not remove pressed on tapered bearing from reverse gear unless replacement of bearing is required. Bearing cannot be reused after it has been removed.

2. If inspection determines that replacement of reverse gear tapered bearing is required, separate gear from bearing as follows:
   a. Press universal puller plate between reverse gear and tapered bearing.
   b. Place assembly on press and press gear out of bearing with suitable mandrel.

      NOTE: Tapered bearing and race must be replaced as a set.



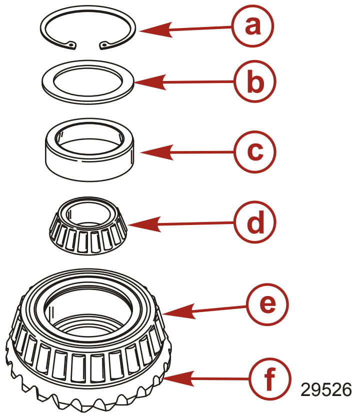
a - Reverse gear bearing
b - Universal puller plate
c - Mandrel

Universal Puller Plate	91-37241

3. If inspection determines that replacement of propeller shaft tapered roller bearing is required, remove bearing as follows:
   a. Clamp reverse gear in a soft jaw vise securely.

      IMPORTANT: Use suitable eye protection when removing or installing snap ring.

b. Use snap ring pliers to remove snap ring. Push tapered roller bearing assembly out of inside of reverse gear.



a - Snap ring
b - Flat washer
c - Tapered bearing race
d - Tapered bearing
e - Reverse gear bearing
f - Reverse gear

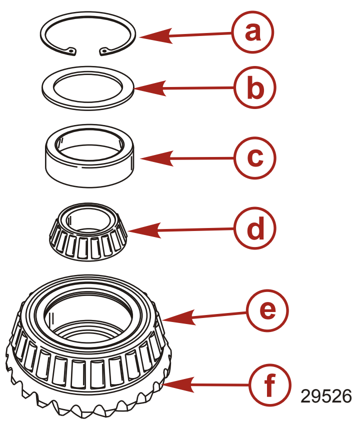
Reverse Gear Reassembly

NOTE: Complete the instructions in this section only if the assembly components have been disassembled and repaired or replaced.

1. Apply High Performance Gear Lubricant to the outer diameter of the reverse gear. Using a suitable mandrel that contacts only the inner portion of the race, press the tapered roller bearing assembly onto the reverse gear until the bearing seats.

   IMPORTANT: Use suitable eye protection when removing or installing the snap ring.

2. Install the washer and snap ring into the groove of the reverse gear to secure the tapered roller bearing assembly.



a - Snap ring
b - Flat washer
c - Tapered bearing race
d - Tapered bearing
e - Reverse gear bearing
f - Reverse gear

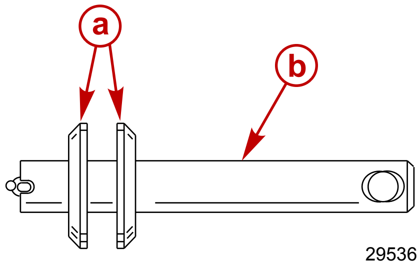
Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Outside diameter of reverse gear	92-858064K01

Shift Spool Assembly

Inspection

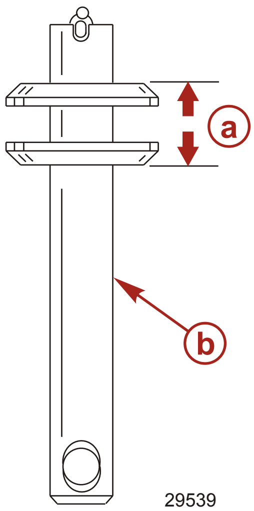
1. Clean the assembly with a suitable solvent and dry the parts using compressed air.
2. Inspect the shift spool assembly for damage. Small nicks and burrs may be smoothed. If any parts are damaged or worn excessively, it will be necessary to replace the complete shift spool assembly. Individual parts are not available for the assembly.

3. Inspect the shift spool for wear in the area where the shift crank comes into contact.



a - Contact area
b - Nonratcheting shift spool

4. Inspect to ensure the spool spins freely (it may be helpful to lightly tap the castle nut end of the shift spool against a firm surface to align the internal parts).
5. Inspect to ensure the spool has end play. This end play may be achieved by turning the castle nut clockwise down until it is snug and then backing off the nut counterclockwise to the first cotter pin slot.



a - End play
b - Shift spool

Shift Spool	
End play	0.05–0.25 mm (0.002–0.010 in.)

Disassembly

NOTE: If the spool spins freely and has the proper clearance, it will not be necessary to disassemble and reassemble the spool. If the spool does not function properly, proceed with the following disassembly procedures.

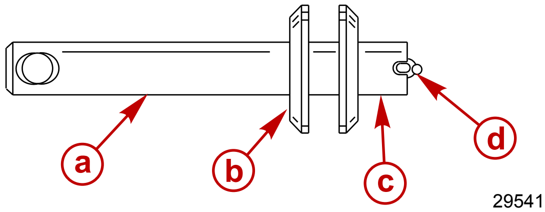
NOTE: Disassembly of the shift spool is for cleaning and inspection of the internal parts due to an improperly functioning shift spool assembly or debris in the gear housing and/or shift spool assembly. Individual components for the shift spool are not available as replacement parts. If the shift spool does not function properly and the following cleaning and adjustment procedures do not correct the problem, it will be necessary to order a new shift spool assembly.

1. Remove and discard the cotter pin.
2. Remove the castle nut and spool.

Reassembly

1. Place the shift spool onto the shift spool shaft.
2. Screw the castle nut down until it touches the spool and a slight resistance is felt.
3. Loosen the castle nut until the cotter pin slot of the nut is aligned with the hole in the shaft. If the castle nut is threaded down and the cotter pin slot is already aligned at the hole in the shift spool shaft, back the castle nut off until the next available slot in the nut is aligned with the hole in the shaft.
4. Insert a new cotter pin and bend the ends of the cotter pin in opposite directions.

5. Verify the spool has end play. If it does not, adjust the castle nut again.



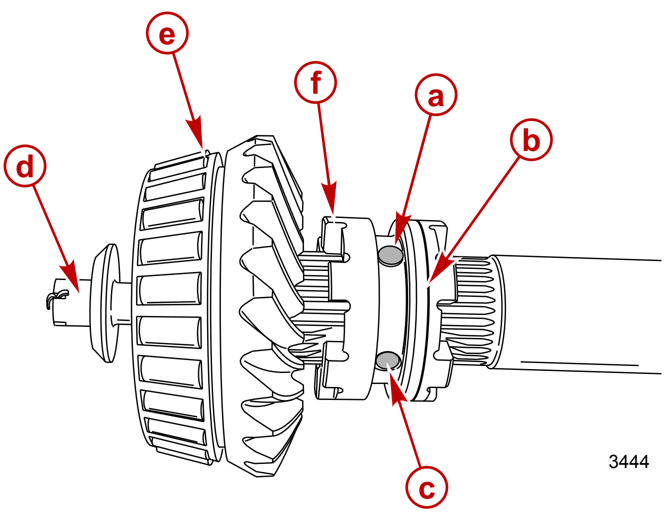
a - Shift shaft
b - Spool
c - Castle nut
d - Cotter pin

Shift Spool	
End play	0.05–0.25 mm (0.002–0.010 in.)

6. If this adjustment did not produce the desired results, it will be necessary to disassemble, clean, and reassemble the shift spool assembly. If the spool assembly has already been disassembled and cleaned, it will be necessary to replace the shift spool assembly.

Propeller Shaft Reassembly

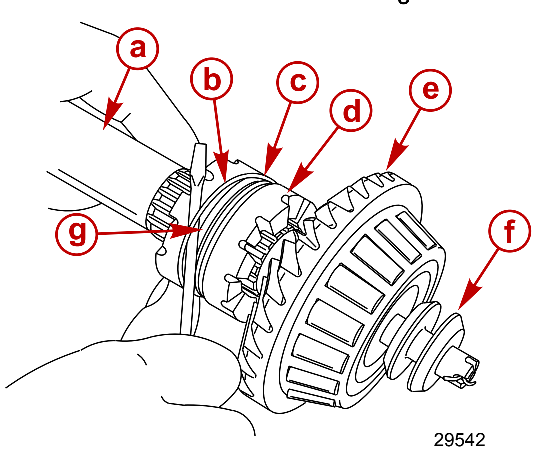
1. Install the sliding clutch onto the propeller shaft. Align the cross pin holes in the clutch with the slot in the propeller shaft.
2. Assemble the reverse gear assembly to the propeller shaft.
3. Assemble the shift spool assembly to the propeller shaft, making sure to align the cross pin hole of the shift spool shaft with the clutch.
4. Assemble the cross pin through the sliding clutch, through the propeller shaft, and through the shift spool shaft hole.
5. Install detent pin in third hole in clutch.



a - Detent pin
b - Clutch band (faces aft)
c - Cross pin
d - Shift spool and actuating shaft
e - Reverse gear assembly
f - Clutch

6. Assemble the cross pin retaining spring over the propeller end of the propeller shaft and wind it around the clutch over the cross pin hole. Be careful not to distort the spring while assembling it.

IMPORTANT: Verify the spring is wound on so that it does not cross over on itself and that it lies flat against the clutch once it is assembled. If it does not lie flat against the clutch, a new spring must be installed.



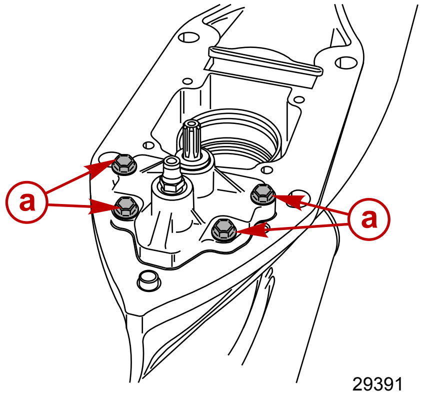
a - Propeller shaft
b - Cross pin retaining spring
c - Cross pin (hidden)
d - Sliding clutch
e - Reverse gear assembly
f - Spool and actuating shaft assembly
g - Detent pin (hidden)

Shift Shaft Cover Assembly

Removal

NOTE: It is possible to remove and service the shift shaft assembly (but not the shift crank inside the gear housing) without removing any of the internal components of the gear housing.

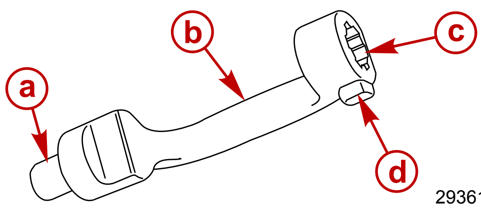
1. Remove the shift shaft cover screws. Remove the shift shaft and cover by pulling both straight out of the gear housing.



a - Shift shaft cover screws

2. Remove the shift crank from the inside of the gear housing. Clean it with a suitable solvent and dry it thoroughly with compressed air. Inspect it for wear in the areas that contact the shift spool and inspect the splines and the pivot pin for damage or wear.

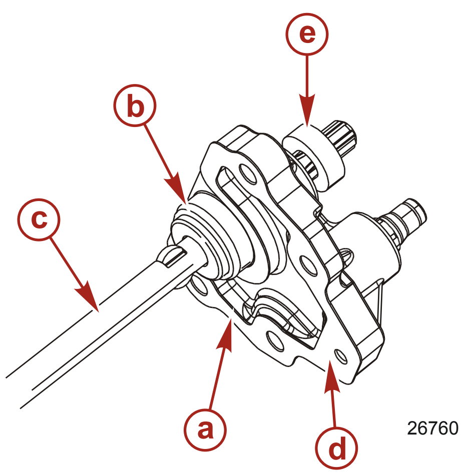
   NOTE: The shift crank has a locating tab. On right-hand rotation gear housings, the tab faces toward the forward gear bearing assembly. On left-hand rotation gear housings, the tab faces away from the reverse gear bearing assembly.



a - Pivot pin
b - Contact area
c - Splines
d - Locating tab

Disassembly and Inspection

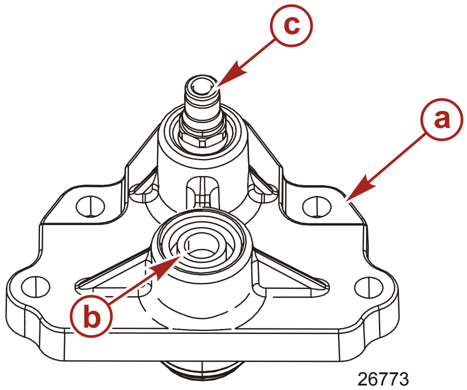
1. Remove the rubber washer from the shift shaft. Slide the cover assembly off the shift shaft.



a - Shift shaft cover assembly
b - O-ring
c - Shift shaft
d - Gasket
e - Rubber washer

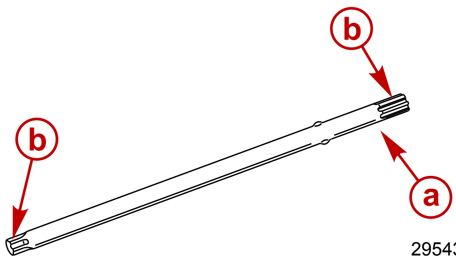
2. Clean all components with a suitable solvent and dry thoroughly with compressed air.
   a. Inspect the shift shaft cover for cracking, damage, or excessive wear.
   b. Inspect the oil seal inside the cover, the sleeve, and the O-ring on the outside of the cover for damage or excessive wear.
   c. Inspect the speedometer connector for damage or blockage.
   d. Inspect the speedometer passage through the shift shaft cover for debris.

NOTE: If any of these conditions exist, replace the appropriate components.



a - Shift shaft cover
b - Oil seal (seal is replaceable)
c - Speedometer tube connector

3. Inspect the shift shaft splines and oil seal surface for corrosion and/or excessive wear. Replace the shift shaft if either of these conditions are found.

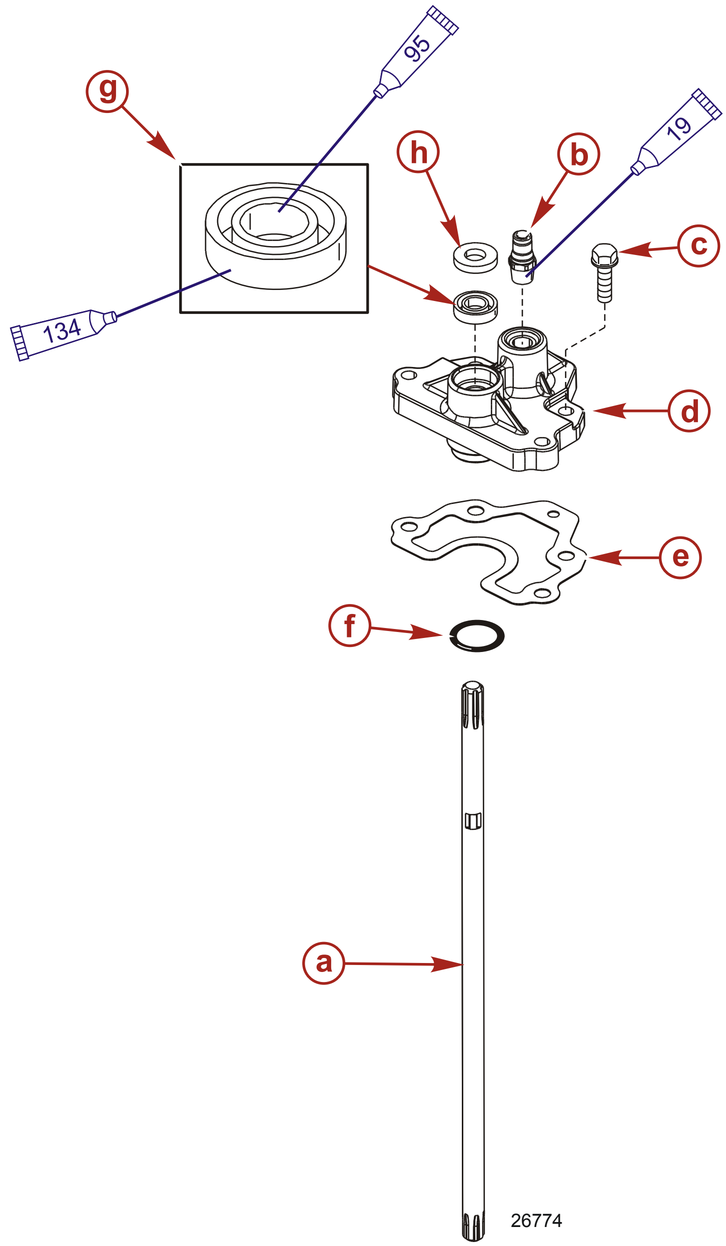


a - Oil seal surface
b - Splines

Assembly

1. Lightly lubricate the seat of the O-ring diameter on the cover and the lip of the oil seal with 2-4-C with Teflon.
2. Apply Loctite 380 to the outside diameter of the oil seal. Wipe off any excess Loctite.
3. If the speedometer connector was removed and/or replaced, lightly coat the threads of the connector with Perfect Seal. Assemble the speedometer connector to the cover and tighten the connector to the specified torque.
4. Apply Loctite 271 Threadlocker to the cover assembly screw threads.

5. Assemble all components, as shown below. Be sure to position the O-ring onto the cover before installing the cover into the gear housing.



a - Shift shaft
b - Speedometer tube connector
c - Screws
d - Cover assembly
e - Gasket
f - O-ring
g - Seal (lip faces up)
h - Rubber washer

Tube Ref No.	Description	Where Used	Part No.
19	Perfect Seal	Speedometer connector threads	92-34227 1
95	2-4-C with Teflon	Seat of the shift shaft cover O-ring diameter and lip of the oil seal	92-802859A 1
134	Loctite 380	Outside diameter of the oil seal	Obtain Locally
7	Loctite 271 Threadlocker	Cover assembly screw threads	92-809819

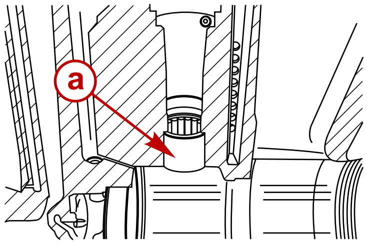
Description	Nm	lb-in.	lb-ft
Speedometer connector	2.8	25	
Cover assembly screws (M6 x 20) (4 each)	6.8	60	

Pinion Bearing Removal

NOTE: Inspect the bearing surface on the driveshaft where the rollers of the lower pinion bearing roll. The condition of the driveshaft at this location gives an indication of the condition of the roller bearing. Replace lower pinion bearing (rollers and race as a set) if the driveshaft is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles.

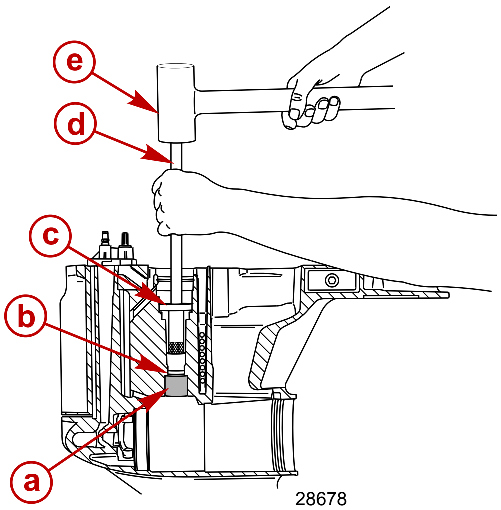
IMPORTANT: All the roller bearings (18) must be in place inside the bearing race while driving the pinion bearing from the gear housing. It is recommended that the cardboard tube provided with a new pinion bearing be used to keep the bearings in place while driving out the old pinion bearing.

IMPORTANT: Do not reuse the bearing (race or rollers) once it has been removed.



a - Pinion bearing

Remove and discard the pinion bearing (race and rollers) using the tools as shown.



a - Pinion bearing
b - Driver head
c - Pilot washer
d - Driver rod
e - Dead blow hammer

Driver Head	91- 36569T
Pilot Washer	91-36571T
Driver Rod	91- 37323

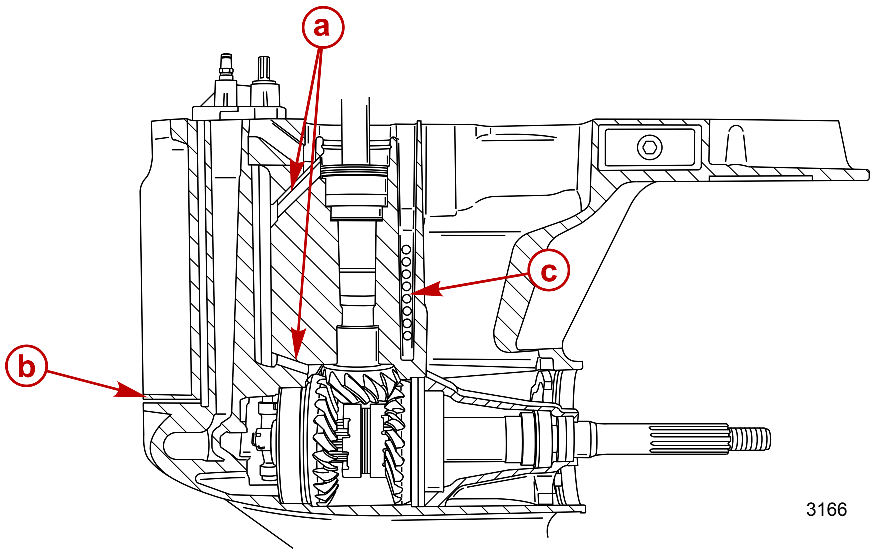
Gear Housing Inspection

1. Clean the gear housing thoroughly with a suitable solvent and a hard bristle brush. Dry the gear housing thoroughly using compressed air. Ensure all sealants, locking agents, and debris are removed.
2. Verify the two oil circulation holes in the driveshaft bore and the shift shaft hole are clear and free of debris.
3. Inspect the gear housing for excessive corrosion, impact, or any other damage. Excessive damage and/or corrosion requires replacement of the gear housing.
4. Inspect the bearing carrier retainer threads in the gear housing for corrosion and/or stripped threads. Damage or corrosion to the threads requires replacement of the gear housing.

   NOTE: The upper driveshaft bearing cup is a slip fit within the driveshaft bore and may show signs of movement. All other bearing cups are press fit and should not show any signs of movement.

5. Inspect bearing race/cup contact areas for evidence of bearing cup spinning. Check that bearing cups are not loose in bearing bores. A press fit type bearing bore in which the race/cup is loose will require replacement of the gear housing.

6. Inspect for blockage in water inlet holes and the speedometer hole, clean as necessary. Be careful not to enlarge the speedometer hole, as this could cause erroneous speedometer readings.



a - Oil circulation holes
b - Speedometer hole
c - Water inlet holes

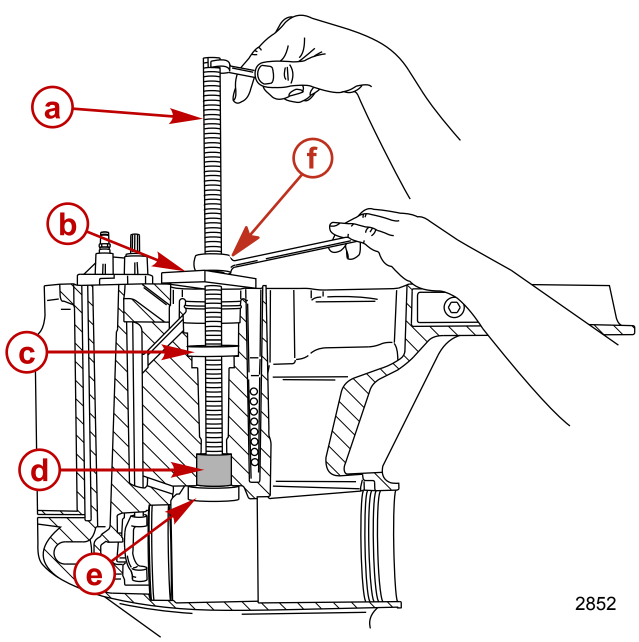
7. Verify the locating pins are in place in the gear housing and the corresponding holes in the driveshaft housing are not elongated. The driveshaft may break if the housings are not aligned properly due to missing locating pins or elongated holes.

Pinion Bearing Installation

IMPORTANT: Install only a new pinion bearing. Do not reinstall a pinion bearing that has been previously removed from a gear housing.

1. Lubricate the bore into which the pinion bearing is to be installed with High Performance Gear Lubricant.
2. Position the new pinion bearing (with the cardboard shipping sleeve in place) onto the driver head, with the lettered and numbered side of the bearing oriented upward.
3. Insert the driver with the bearing assembly, into position (by way of the propeller shaft bore) at the driveshaft bore as shown.

   NOTE: The puller/driver head used to install the pinion bearing is contained in the bearing removal and installation kit.
4. Install the bearing by screwing down the nut until the bearing is fully seated against the bore shoulder.



a - Puller rod
b - Puller plate
c - Pilot
d - Pinion bearing
e - Puller/driver head
f - Hex nut

Bearing Removal and Installation Kit	91-31229A7

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Pinion bearing bore	92-858064K01

Reverse Gear Bearing Cup

Installation

Reverse Gear	
Backlash	1.24–1.45 mm (0.049–0.057 in.)

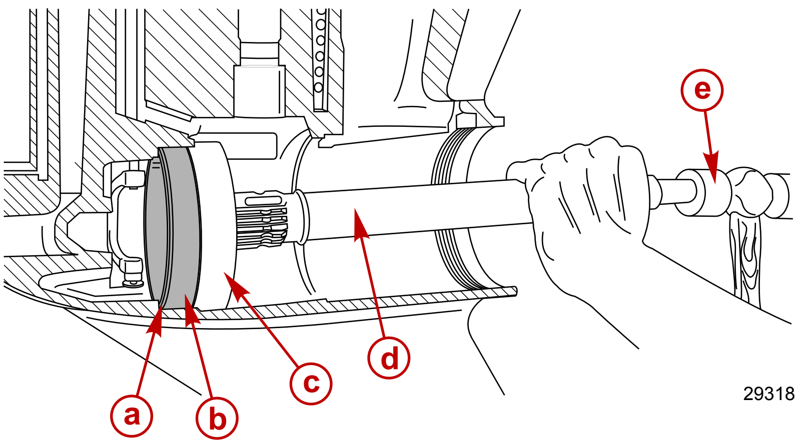
NOTE: If the reverse gear, reverse gear bearing and cup, or gear housing were not replaced, install the same quantity of shims that were taken out when cup was removed. If the reverse gear, reverse gear bearing/cup, or gear housing were replaced, install 0.51 mm (0.020 in.) of shims.

NOTE: If backlash has already been checked and it was determined that it needs to be adjusted (see checking reverse gear backlash), adding or subtracting 0.03 mm (0.001 in.) shims will change the gear backlash by the same amount.

1. Lubricate the bore into which the reverse gear bearing cup is to be installed with High Performance Gear Lubricant.
2. Place the shim into the reverse bore of the gear housing.
3. Press the bearing cup into the gear housing using the installation tool.

   NOTE: A guide plate may be used to center the rod used to drive in the forward gear bearing cup in a right-hand rotation gearcase or the reverse gear bearing cup on a counter rotation gearcase.

   IMPORTANT: Verify the bearing cup is positioned as straight as possible to avoid cocking it in the bore while pressing it in.



a - Shims
b - Race
c - Bearing cup driver
d - Propeller shaft
e - Mallet

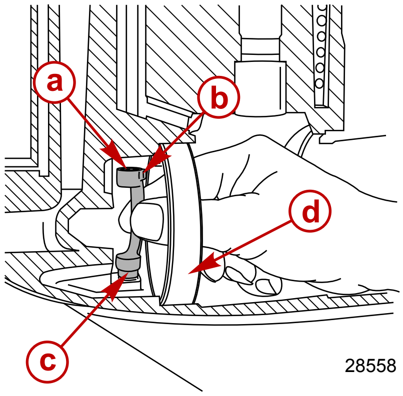
Guide Plate	91-816243
Bearing Cup Driver	91-885592T

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Reverse gear bearing cup bore	92-858064K01

Shift Shaft Installation

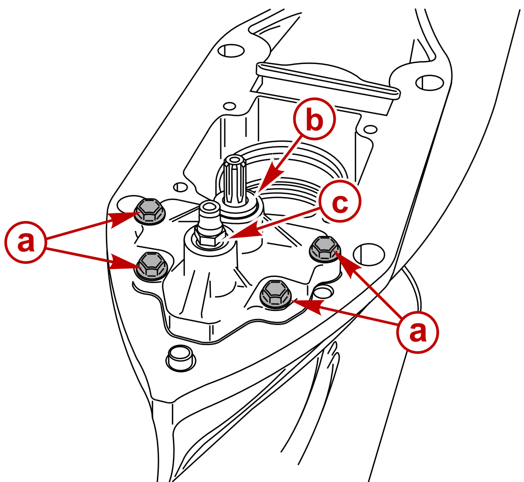
1. Place the shift crank into the pivot pin hole in the forward section of the gear housing. Ensure the shift crank faces towards the port side of the gear housing.

NOTE: The shift crank has a locating tab. On right-hand rotation gear housings, the locating tab faces toward the forward gear bearing assembly. On left-hand rotation gear housings, the locating tab faces away from the reverse gear bearing assembly.



a - Shift shaft splines
b - Locating tab
c - Pivot pin
d - Shift crank

2. Install the shift shaft assembly into the gear housing as shown. Engage the splined end of the shift shaft with the shift crank. Verify O-ring is positioned properly and lubricated with 2-4-C with Teflon.
3. Apply Loctite 271 Threadlocker to the shift shaft cover screw threads. Secure shift shaft cover with four screws. Tighten the screws and speedometer fitting to the specified torque.
4. Install rubber washer onto shift shaft.

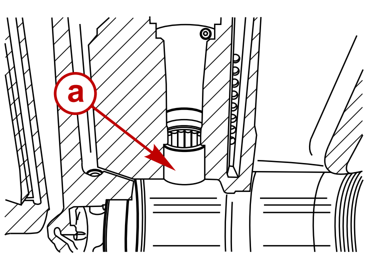


a - Screws (4)
b - Rubber washer
c - Speedometer fitting

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	O-ring	92-802859A 1
7	Loctite 271 Threadlocker	Shift shaft cover screw threads	92-809819

Description	Nm	lb-in.	lb-ft
Shift shaft cover screws (M6 x 20)	6.8	60	
Speedometer fitting	2.8	25	

NOTE: If the pinion bearing needle bearings have fallen out, install 18 needles into needle bearing outer race. Use 2-4-C with Teflon, to help hold needles in place.



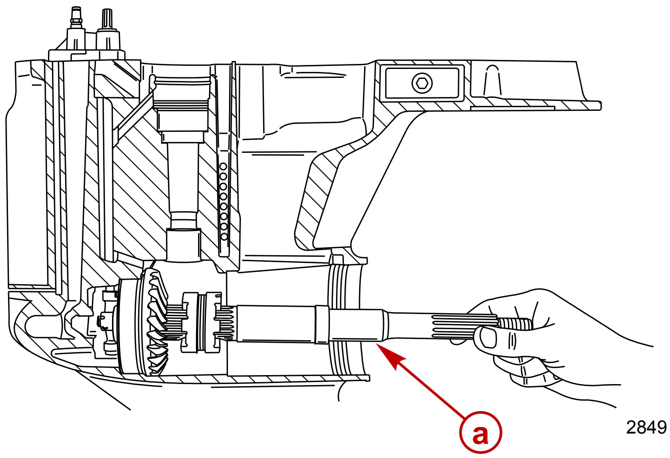
a - Pinion bearing

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Outside diameter of pinion bearing	92-858064K01
95	2-4-C with Teflon	Pinion needle bearings	92-802859A 1

Propeller Shaft Installation

NOTE: The shift/clutch assembly should be in the neutral detent position when installing the propeller shaft.

1. To allow for the engagement of the shift spool with the shift crank, tilt the propeller end of the propeller shaft assembly to the left (port) side of the gear housing and rotate the shift shaft from reverse to neutral while installing the shaft.



a - Propeller shaft

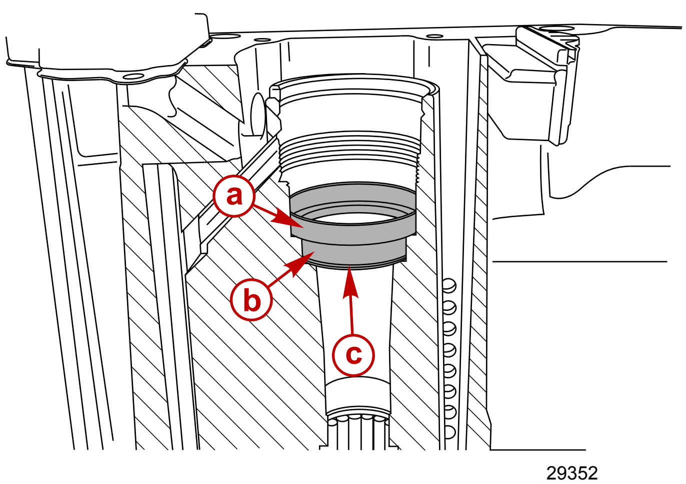
2. Operate the shift shaft to ensure it has been properly installed. The sliding clutch should move forward when the shift shaft is turned clockwise, and should move aft when the shift shaft is turned counterclockwise.

Driveshaft and Pinion Gear Installation

NOTE: If the original shims were not retained or if the pinion gear, driveshaft, driveshaft upper tapered roller bearing and cup, or gear housing were replaced, start off by installing a 0.508 mm (0.020 in.) shim, for the lower tapered roller bearing.

NOTE: If the original shims were retained (or measurement known) and none of the above listed parts were replaced, install the same shims or same amount of shims.

1. Place the lower tapered bearing shims into the driveshaft housing bore.
2. Install the lower tapered bearing race into the driveshaft housing bore.
3. Install the spacer (flanged end faces down).



a - Spacer
b - Tapered bearing race
c - Shims

4. Apply Loctite 271 to the threads of the pinion gear nut and place the pinion gear nut into the MR slot of the pinion nut adapter.

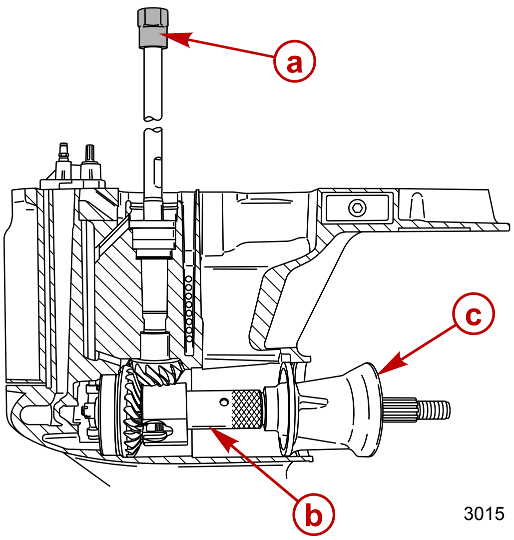
Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Pinion gear nut threads	92-809819

NOTE: Install the pinion gear nut with the flat side of the nut away from the pinion gear.

NOTE: For ease of installation, glue the washer to the pinion gear, using 3M Adhesive, or Bellows Adhesive, or equivalent.

NOTE: If the backlash has to be changed, it is recommended that Loctite 271 not be applied to the pinion nut until the backlash setting is finalized. Do not reuse the old pinion nut. Install a new pinion nut after backlash is finalized.

5. Place the pinion gear and washer into the gear housing.
6. With the propeller shaft horizontal, insert the pinion nut holding tool (with the nut) into the gear housing.
7. Insert the driveshaft into the gear housing driveshaft bore. It may be necessary to rotate the driveshaft to engage the driveshaft splines into the pinion gear splines.
8. Start the pinion nut onto the driveshaft threads by rotating the driveshaft until the nut is snug.
9. Install the bearing carrier into the gear housing backwards to hold the propeller shaft and the pinion nut holding tool in position.
10. Torque the pinion nut to specification by turning the driveshaft using the driveshaft holding tool and torque wrench.



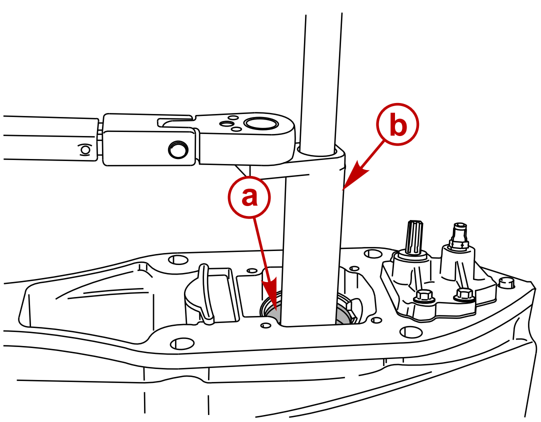
3015

a - Driveshaft holding tool
b - Pinion nut wrench
c - Bearing carrier (installed backwards)

Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03

Description	Nm	lb-in.	lb-ft
Pinion nut	101.7		75

11. Install the upper driveshaft tapered roller bearing cup. Apply 2-4-C with Teflon to the retainer threads and install the retainer. Torque retainer to specification.



29353

a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Retainer threads	92-802859A 1

Description	Nm	lb-in.	lb-ft
Retainer	135.5		100

12. Remove the bearing carrier, pinion nut wrench, and driveshaft bearing retainer wrench.

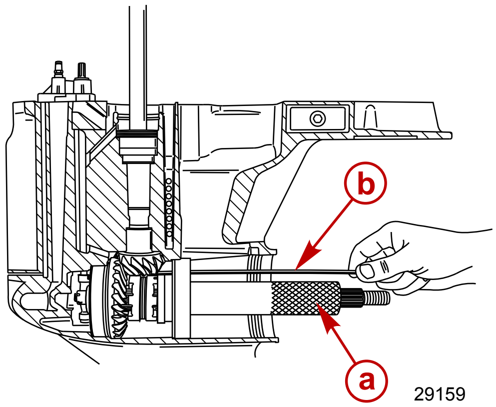
NOTE: Units correctly assembled to this point would show a driveshaft rolling torque of 0.2–0.9 Nm (2–8 lb-in.).

Pinion Gear Height

Checking and Adjusting using Pinion Gear Locating Tool 91-56048001

NOTE: The propeller shaft and reverse gear can be installed if the pinion gear locating tool (91-56048001) is used.

1. Place the pinion gear locating tool into the gear housing, aligning the window in the tool with the pinion gear.
2. Insert the thickest feeler gauge that fits snugly between one tooth of the pinion gear and the high point of the shimming tool.



a - Pinion gear locating tool
b - Feeler gauge

Pinion Gear Locating Tool	91- 56048001

3. Rotate the driveshaft 120° in a clockwise direction and measure the clearance.
4. Repeat this process until three measurements have been taken.
5. Add the three measurements together and divide the sum by three to get the average pinion gear clearance. Make note of this average measurement.

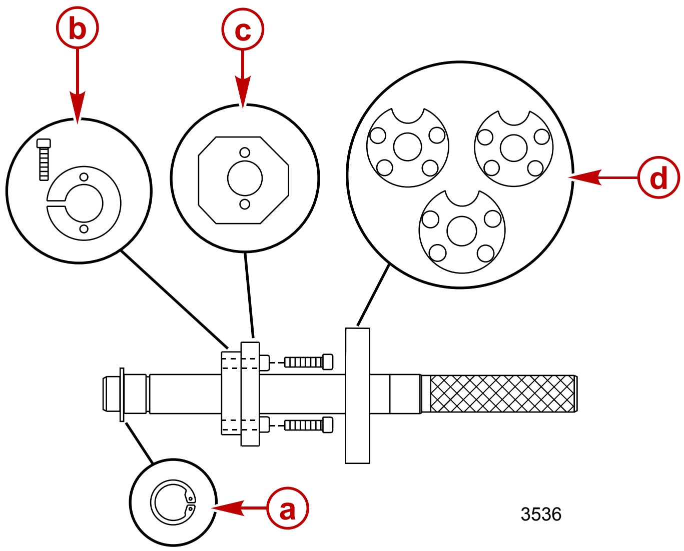
Pinion Gear Specification	
Clearance	0.635 mm (0.025 in.)

6. If the average pinion gear clearance is not within specification, add or subtract shims below the lower driveshaft tapered bearing race.
7. Install the removed components and tighten the retainer to the specified torque.

Description	Nm	lb-in.	lb-ft
Retainer	135.5		100

8. Rotate the driveshaft three turns in a clockwise direction and check the pinion gear clearance. If the pinion gear clearance is not within specification, adjust the shim thickness and repeat this process until the average pinion gear clearance is within specification.

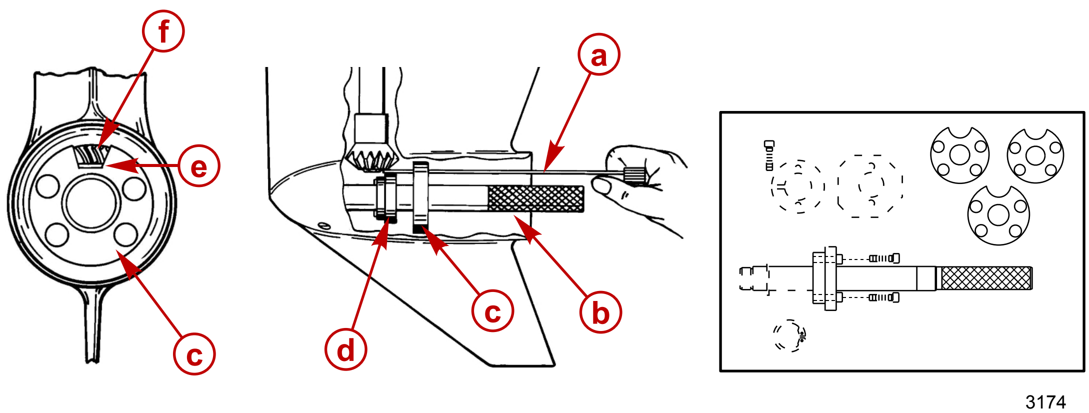
Checking and Adjusting using Pinion Gear Locating Tool 91-12349A05



a - Retaining ring
b - Split collar
c - Gauging block
d - Locating disc

***NOTE:** The reverse gear assembly must be installed when using pinion gear locating tool 91-12349A05.*

1. Use disc #2 and flat #4. Install the pinion gear locating tool into the gear housing.



a - Feeler gauge
b - Pinion gear locating tool
c - Disc #2
d - Flat #4
e - 0.635 mm (0.025 in.)
f - Pinion gear

Pinion Gear Locating Tool	91- 12349A05

2. Insert the thickest feeler gauge that fits snugly between one tooth of the pinion gear and shimming tool.
3. Rotate the driveshaft 120° in a clockwise direction and measure the clearance.
4. Repeat this process until three measurements have been taken.
5. Add the three measurements together and divide the sum by three to get the average pinion gear clearance. Make note of this average measurement.

Pinion Gear Specification	
Clearance	0.635 mm (0.025 in.)

6. If the average pinion gear clearance is not correct, add or subtract shims below the lower driveshaft tapered bearing race.
7. Install the removed components and tighten the retainer to the specified torque.

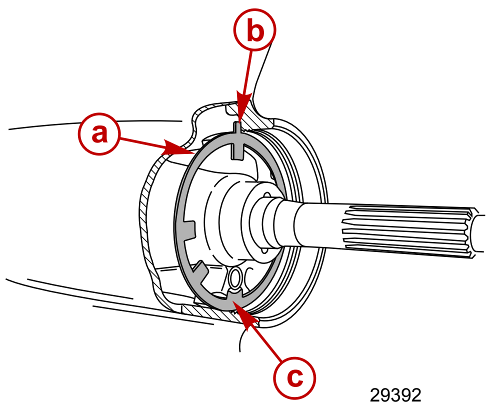
Description	Nm	lb-in.	lb-ft
Retainer	135.5		100

8. Rotate the driveshaft three turns in a clockwise direction and check the pinion gear clearance. If the pinion gear clearance is not within specification, adjust the shim thickness and repeat this process until the average pinion gear clearance is within specification.

Bearing Carrier Installation

NOTE: If backlashes have already been checked and they are to specification, proceed to ***Bearing Carrier Final Installation*** *section.*

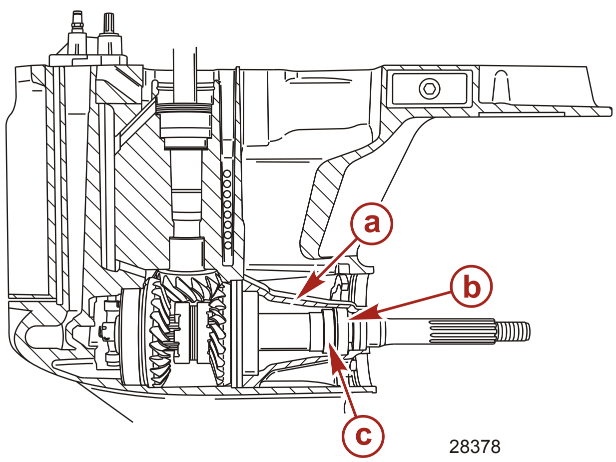
1. Place the bearing carrier assembly into the gear housing. It may be necessary to turn the driveshaft to align the teeth of the pinion and the forward gears.
2. Insert the small rectangular tab of the tab washer into its corresponding slot in the gearcase at the 12 o'clock position above the bearing carrier while aligning the U-shaped tab of the tab washer with its corresponding slot below the lubricant fill screw in the bearing carrier.



29392

a - Tab washer
b - Rectangular tab
c - U-shaped tab

3. Lubricate the bearing carrier retainer threads and corresponding gear housing threads with 2-4-C with Teflon. Start the retainer into the gear housing threads and screw it down fully by hand.



28378

a - Bearing carrier assembly
b - Propeller shaft bearing
c - Preload spacer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Bearing carrier retainer threads, corresponding gear housing threads, and upper driveshaft bearing retainer threads	92-802859A 1

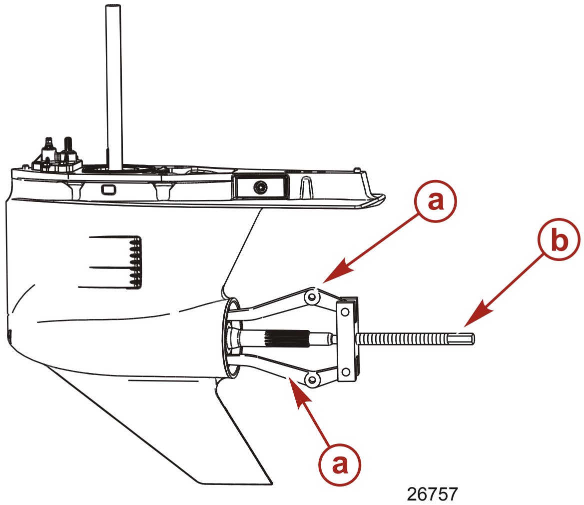
Reverse Gear Backlash

Reverse Gear	
Backlash	1.24–1.45 mm (0.049–0.057 in.)

NOTE: Pinion height must be set before checking reverse gear backlash.

1. Apply forward pressure on the propeller shaft as follows:
   a. Attach puller jaws assembly onto bearing carrier bosses and propeller shaft.

b. Torque propeller nut to specification. Rotate the driveshaft three full turns in a clockwise direction and retorque the propeller nut.

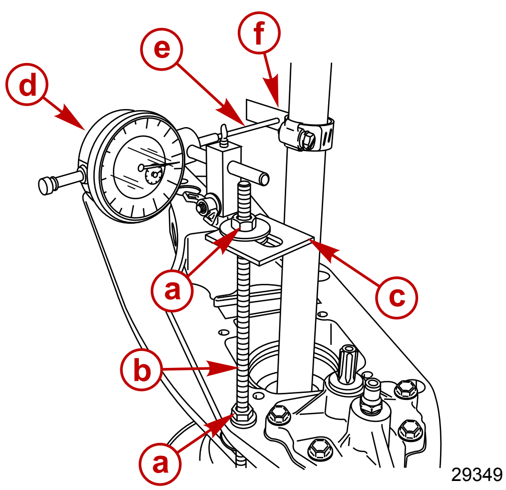


a - Puller jaws assembly
b - Puller bolt

Puller Jaws Assembly Puller Bolt	91-46086A1/91-85716

Description	Nm	lb-in.	lb-ft
Propeller nut	5	45	

2. Install a dial indicator and align the dial indicator pointer so it is perpendicular to and touching the "I" mark on the backlash indicator rod. Tighten the indicator rod onto the driveshaft and rotate the driveshaft so the needle in the dial makes at least one full revolution and comes to "0" on the dial indicator scale.



a - Nuts (4) (obtain locally)
b - Threaded rod - 9.5 mm (3/8 in.) obtain locally
c - Dial indicator adapter
d - Dial indicator
e - Indicator pointer
f - Backlash indicator rod

Dial Indicator	91- 58222A 1
Dial Indicator Adapter	91-83155
Backlash Indicator Rod	91- 78473

3. Take the backlash readings by lightly turning the driveshaft back and forth, so as to feel the backlash between the gears (no movement should be noticed at the propeller shaft).
   a. Observe the dial indicator and record the reading.
   b. Loosen the indicator tool and rotate the driveshaft 90 degrees in a clockwise direction.
   c. Repeat step 2 above and take and record another reading. Repeat step 3 until a total of four backlash readings have been taken.
4. Add the four readings together and divide the sum by four. The result is the average backlash.

Reverse Gear	
Backlash	1.24–1.45 mm (0.049–0.057 in.)

5. If the backlash is less than the specified minimum, remove shims from in front of the reverse bearing race to obtain the correct backlash. When installing the pinion nut, apply Loctite 271 to the threads of the nut.
6. If backlash is more than the specified maximum, add shims in front of the reverse gear bearing race to obtain the correct backlash. When installing the pinion nut, apply Loctite 271 to the threads of the nut.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Pinion gear nut threads	92-809819

NOTE: By adding or subtracting 0,025 mm (0.001 in.) shim, the backlash will change approximately 0.025 mm (0.001 in.).

Forward Gear Backlash

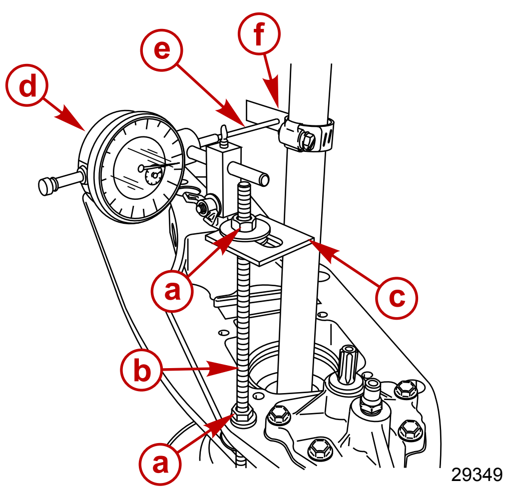
Forward Gear	
Backlash	0.432–0.635 mm (0.017–0.025 in.)

NOTE: Pinion height must be set before checking forward gear backlash.

NOTE: Propeller shaft shims must be removed from propeller shaft to check forward gear backlash.

Description	Nm	lb-in.	lb-ft
Cover nut	285		210

1. Install a dial indicator and align the dial indicator pointer so it is perpendicular to and touching the "I" mark on the backlash indicator rod. Tighten the indicator rod onto the driveshaft and rotate the driveshaft so the needle in the dial makes at least one full revolution and comes to "0" on the dial indicator scale.



a - Nuts (4) (obtain locally)
b - Threaded rod - 9.5 mm (3/8 in.) obtain locally
c - Dial indicator adapter
d - Dial indicator
e - Indicator pointer
f - Backlash indicator rod

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Rod	91-78473

2. Apply backward pressure on the propeller shaft by holding shift crank against forward gear.
3. Take the backlash readings by lightly turning the driveshaft back and forth (no movement should be noticed at the propeller shaft).
   a. Observe the dial indicator and record the reading.
   b. Loosen the indicator tool and rotate the driveshaft 90 degrees in a clockwise direction.
   c. Repeat step 1 above and take and record another reading. Repeat step 3 until a total of four backlash readings have been taken.
4. Add the four readings together and divide the sum by four. The result is the average backlash.

Forward Gear	
Backlash	0.432–0.635 mm (0.017–0.025 in.)

5. If backlash is less than the specified minimum, remove shims from behind the forward gear bearing adapter to obtain correct backlash.
6. If backlash is more than the specified maximum, add shims behind the forward gear bearing adapter to obtain correct backlash.

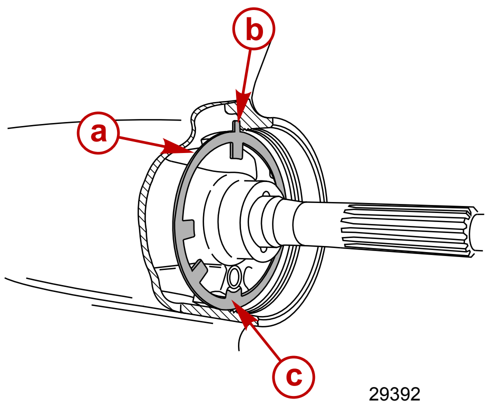
NOTE: By adding or subtracting 0.025 mm (0.001 in.) shim, the backlash will change approximately 0.025 mm (0.001 in.). Recheck backlash after making shim adjustments.

Propeller Shaft Bearing Preload

NOTE: All gear housing components must be installed and correctly shimmed before checking propeller shaft bearing preload. Propeller shaft tapered roller bearing must be properly seated in the race during installation. Driveshaft retainer should be torqued to specification.

Description	Nm	lb-in.	lb-ft
Driveshaft retainer	135.5		100

1. Remove the bearing carrier.
2. Slide preload spacer off propeller shaft.
3. Install (retained) propeller shaft preload shims onto propeller shaft. If shims were lost, start with 0.9 mm (0.035 in.) shim thickness.
4. Install preload spacer onto propeller shaft.
5. Install bearing carrier, aligning rear propeller shaft bearing with propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion with the reverse gear.
6. Insert the small rectangular tab of the tab washer into its corresponding slot in the gearcase at the 12 o'clock position above the bearing carrier while aligning the U-shaped tab of the tab washer with its corresponding slot below the lubricant fill screw in the bearing carrier.



29392

a - Tab washer
b - Rectangular tab
c - U-shaped tab

7. With gear housing in neutral, torque bearing carrier retainer nut to initial specification.
8. Rotate propeller shaft several times to seat propeller shaft tapered roller bearings in their races.
9. Torque bearing carrier retainer nut to final specification.

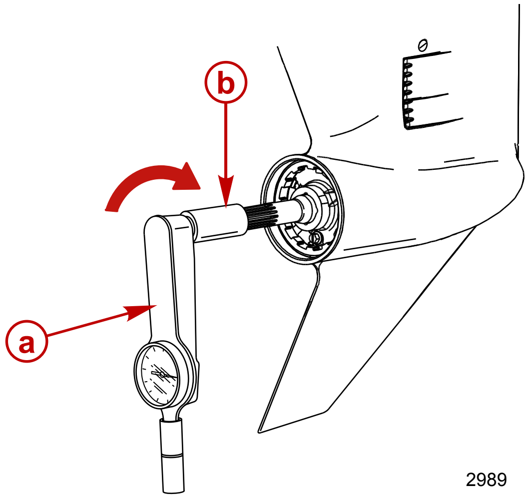
Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5		100
	Final	285		210

10. Install propeller shaft adapter and using a torque wrench, rotate propeller shaft in the direction of normal rotation with a slow steady motion.
11. Verify rolling torque is within specification for new or used bearings.

Description	Nm	lb-in.	lb-ft
Bearing rolling torque (new bearings)	1.1–1.8	10–16	
Bearing rolling torque (used bearings)	0.45–1.1	4–10	

NOTE: Preload will change approximately 0.056 Nm (1/2 lb-in.) of rolling torque per 0.025 mm (0.001 in.) of shim change.

12. If rolling torque is too high, remove shims from propeller shaft ahead of tapered bearing/spacer in bearing carrier. If torque is too low, add shims.



a - Torque wrench
b - Propeller shaft adapter

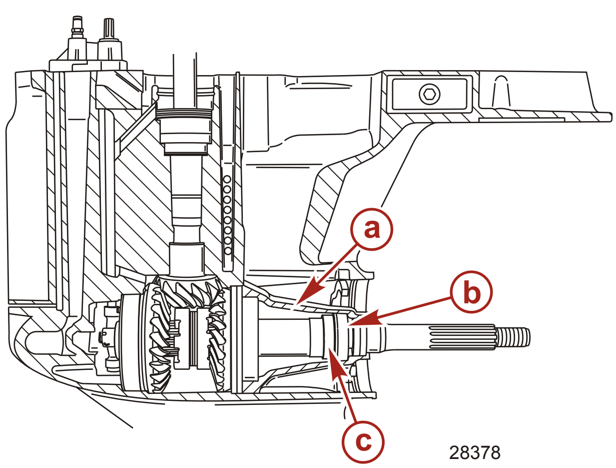
Propeller Shaft/Driveshaft Adapter	91-61077T

NOTE: *If shims are changed, torque bearing carrier to initial specification. Rotate propeller shaft several times to seat propeller shaft tapered bearing. Retorque retainer nut to final specification. Use torque wrench to check rolling torque. Repeat this procedure each time shims are changed.*

Description		Nm	lb-in.	lb-ft
Bearing carrier	**First**	135.5		100
	Final	285		210

Bearing Carrier Final Installation

1. Remove the bearing carrier and lubricate the following as specified:
   a. Lubricate the carrier O-ring with 2-4-C with Teflon.
   b. Lubricate both the forward and aft outer diameters of the bearing carrier and gearcase area where the carrier will seat with 2-4-C with Teflon.
   c. Fill the space between the carrier oil seals with 2-4-C with Teflon.

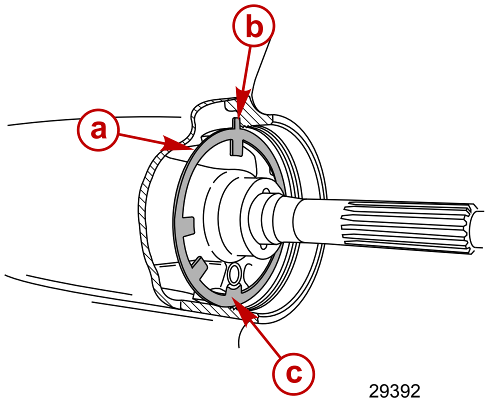


a - Bearing carrier
b - Propeller shaft bearing
c - Preload spacer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Carrier O-ring, forward and aft outer diameters of bearing carrier, gearcase area where carrier will seat, space between carrier seals	92-802859A 1

2. Place the bearing carrier assembly into the gear housing, being careful to align the rear propeller shaft bearing. It may be necessary to turn the driveshaft to align the teeth of the pinion and the reverse gears.
3. Lubricant fill screw in the bearing carrier should be located at the 6 o'clock position.

4. Insert the small rectangular tab of the tab washer into its corresponding slot in the gearcase at the 12 o'clock position above the bearing carrier while aligning the U-shaped tab of the tab washer with its corresponding slot below the lubricant fill screw in the bearing carrier.



29392

a - Tab washer
b - Rectangular tab
c - U-shaped tab

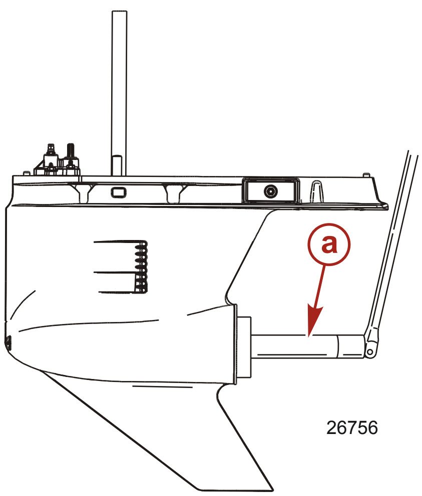
5. Fill the bearing carrier retainer nut threads and corresponding gear housing threads with 2-4-C with Teflon. Start the retainer into the gear housing threads and screw it down fully by hand.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Bearing carrier retainer nut threads and corresponding gear housing threads	92-802859A 1

IMPORTANT: Before torquing the bearing carrier retainer, the gearcase must be bolted to the driveshaft housing or securely fastened in a gearcase holding fixture to avoid possible damage to the gear housing.

NOTE: *Torque retainer nut to initial specification first. Rotate propeller shaft several times to seat tapered roller bearings. Retainer nut can then be torqued to final specification.*

6. Torque the bearing carrier retainer to specification. If one tab does not align up in space between two of the notches, continue to tighten retainer until alignment is achieved. Do not loosen retainer to achieve alignment.



26756

a - Bearing carrier retainer nut wrench

Bearing Carrier Retainer Nut Wrench	91-61069T

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5		100
	Final	285		210

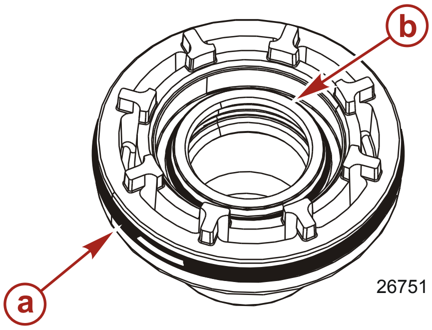
7. Bend one tab aft (outward) into a space between two of the notches of the retainer. Bend all the remaining tabs forward (inward).

Oil Seal Carrier Installation

NOTE: *The oil seal carrier may be lightly tapped into position by sliding the driveshaft bearing retainer wrench over the driveshaft.*

Driveshaft Bearing Retainer Wrench	91-43506T

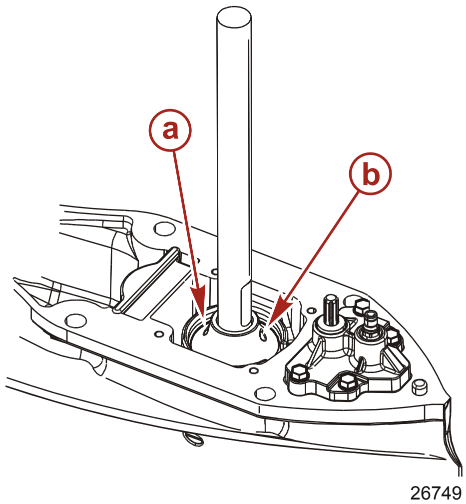
1. Lubricate the oil seal carrier oil seal lips, space between the seals, and the O-ring with 2-4-C with Teflon. Install the oil seal carrier over the driveshaft and into the gearcase.



a - O-ring
b - Oil seal lips

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Oil seal carrier seal lips, space between oil seals, O-ring	92-802859A 1

2. Install the retaining ring above the oil seal carrier.



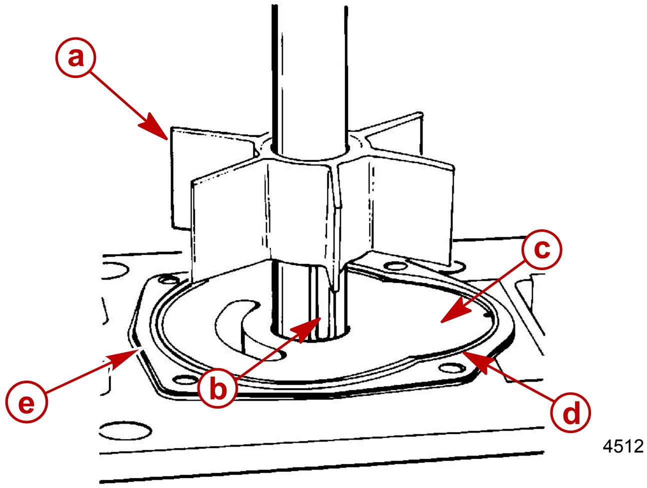
a - Retaining ring
b - Oil seal carrier

Water Pump Installation

1. Install water pump base gasket.
2. Install water pump face plate.
3. Install water pump cover gasket.
4. Place a small amount of 2-4-C with Teflon on the flat surface of the impeller key and install the key onto the driveshaft keyway.

IMPORTANT: When using an impeller whose blades have taken a set, face the curl of the blades in a counterclockwise direction. Do not install the impeller with its blades oriented in a reversed direction from original rotation, or premature impeller failure will occur.

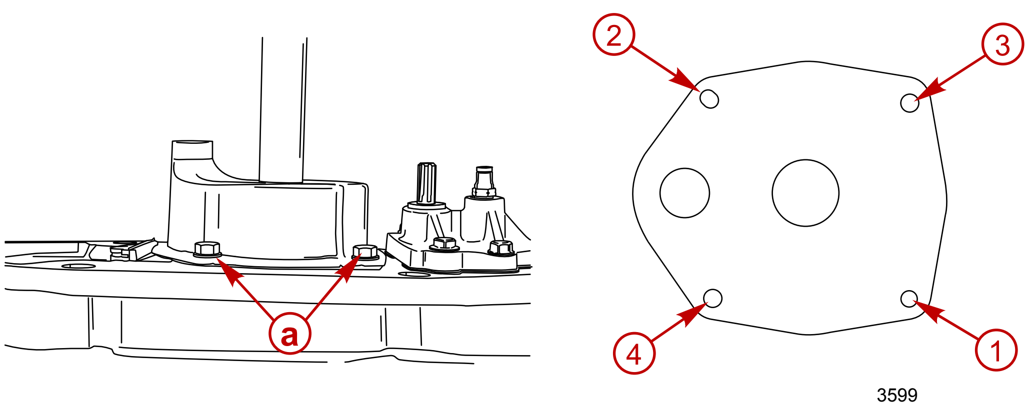
5. Assemble the water pump impeller onto the driveshaft and down over the key.



a - Impeller
b - Key
c - Face plate
d - Pump cover gasket (gray seal bead faces up)
e - Pump base gasket

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Flat surface of the impeller key	92-802859A 1

6. Apply a light coat of 2-4-C with Teflon to the inside of the pump cover. Rotate the driveshaft in a clockwise direction, while pushing down on the water pump cover to ease the water pump cover over the impeller blades.
7. Hand start starboard front fastener first into the water pump assembly. Install the remaining three fasteners. Run all fasteners down and torque in sequence to specification.



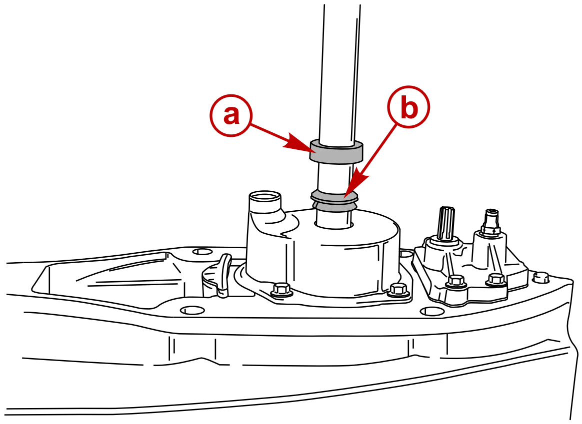
a - Water pump cover screws (4)

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Inside of water pump cover	92-802859A 1

Description	Nm	lb-in.	lb-ft
Water pump cover screws (4)	6.7	60	

IMPORTANT: If seal installed above pump housing is not at the proper height, air will be drawn into the pump resulting in overheating of the engine.

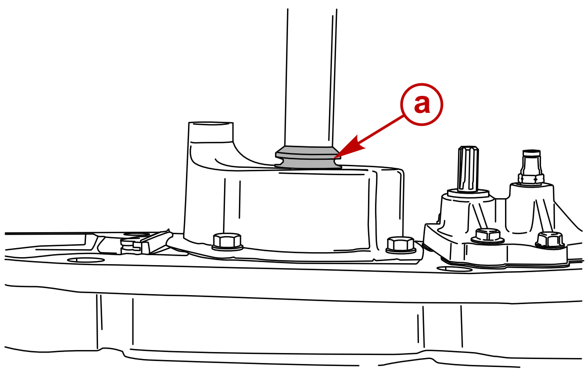
8. Using tool provided in seal kit or water pump kit, press seal down over driveshaft (do not grease driveshaft) until tool seats against pump housing.



a - Tool
b - Seal

29356

NOTE: If tool is not available, lightly press seal against housing until specified height is obtained.



a - Seal

29355

Water Pump Cover	
Seal height	8.9 mm ± 0.76 mm (0.350 in. ± 0.030 in.)

Gear Lubricant Filling Instructions

NOTE: Gear housing should be pressure tested prior to filling gear housing with lubricant. Using leakage tester FT8950, gear housing should hold 103.4 kPa (15 psi) of pressure for 5 minutes without leakage. Failure to hold specified pressure indicates worn or damaged sealing surfaces or improperly assembled gear housing. Cause of leakage must be corrected before returning gear housing assembly to service.

Gear Housing Pressure	
Without gear lubricant for five minutes without leakage	103.4 kPa (15 psi)

Leakage Tester Kit	FT8950

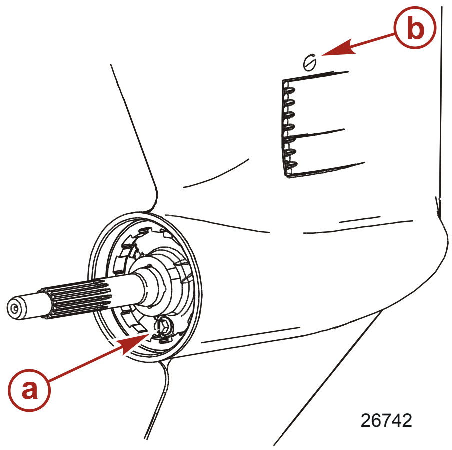
1. Inspect fill and vent sealing washers for cuts or abrasions. Replace washers if necessary.

   IMPORTANT: Never apply lubricant to gear housing without first removing vent screw, or gear housing cannot be filled because of trapped air. Fill gear housing only when housing is in a vertical position.

2. Slowly fill housing through fill hole with High Performance Gear Lubricant until lubricant flows out of vent hole and no air bubbles are visible.
3. Install vent screw into vent hole.

   IMPORTANT: Do not lose more than 30 cc (1 fl oz) of gear lubricant while installing the fill screw.

4. Remove grease tube (or hose) from fill hole and quickly install fill screw into fill hole. Torque fill and vent screws to specification.



a - Fill screw
b - Vent screw

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Gear housing	92-858064K01

Description	Nm	lb-in.	lb-ft
Fill and vent screws	6.8	60	

Installing Gear Housing to Driveshaft Housing

⚠ WARNING

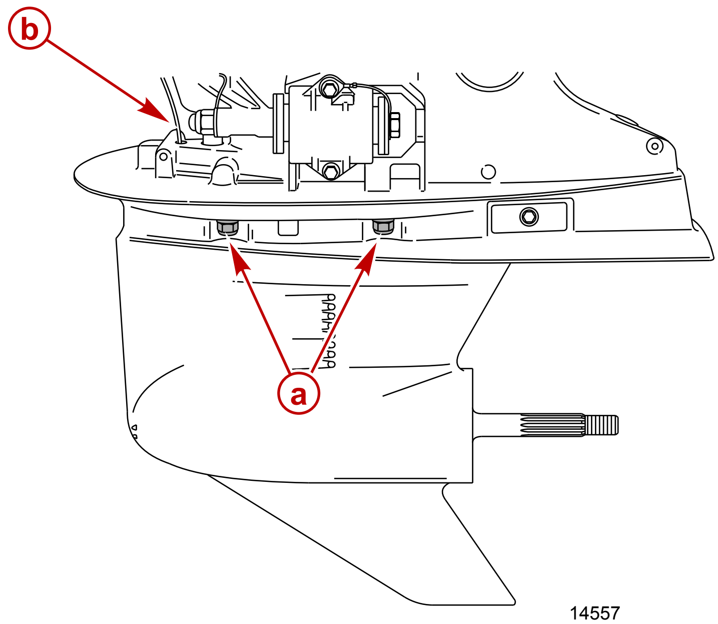
Accidental starting can cause serious injury. Before removing or installing the gear housing, disconnect and isolate the spark plug leads. Disable the ignition system by removing the keys from the ignition (if equipped) and engaging the lanyard stop switch to prevent the engine from starting.

1. Tilt the engine to full up position and engage the tilt lock lever.
2. Apply a light coat of Engine Coupler Spline Grease onto the driveshaft splines. Do not allow lubricant on top of the driveshaft.
3. Apply a light coat of 2-4-C with Teflon onto the shift shaft splines. Do not allow lubricant on top of the shift shaft.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Shift shaft splines	92-802859A 1
91	Engine Coupler Spline Grease	Driveshaft splines	92-802869A 1

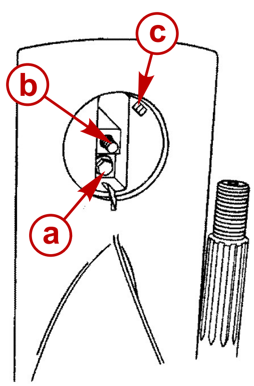
4. Insert the anodic plate bolt into the hole in the rear of the gear housing.
5. Verify the neutral position switch is in the neutral position. Verify the gear housing is in the neutral position.
6. Position the gear housing so the driveshaft is protruding into the driveshaft housing. If the driveshaft splines will not align with the crankshaft splines, lower the gear housing and turn the driveshaft slightly in a clockwise direction. Repeat, as required, until the driveshaft splines match with the crankshaft splines.
7. Move the gear housing up toward the driveshaft housing while aligning the shift shaft splines with the shift shaft coupler, and the water tube outlet on the water pump cover with the water tube coupler (in driveshaft housing).
8. Insert the speedometer tube into the speedometer tube coupler.

9. Place the flat washers onto the studs (located on either side of driveshaft housing). Start a nut on each stud and tighten finger-tight.



a - Nuts and washers (2 each side)
b - Speedometer tube

10. Start the screw at the rear of the gear housing inside the trim tab recess. Do not tighten the screw at this time.



a - Screw
b - Anodic plate attaching bolt
c - Ribs (align carefully with anodic plate)

IMPORTANT: Do not force the gear housing up into place with attaching nuts.

11. Evenly tighten the nuts which were started previously. Tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Nuts (2 each side)	75		55

12. After the nuts (located on either side of driveshaft housing) are tightened, check the shift operation as follows:
    a. Turn ignition switch to the "ON" position and move the remote control to the forward gear position; the propeller shaft should rotate clockwise and then lock (no ratcheting motion).
    b. Move the remote control into neutral position. The propeller shaft should rotate freely clockwise/counterclockwise.
    c. Move the remote control into reverse gear position; the propeller shaft should rotate counterclockwise and then lock (no ratcheting motion).

    IMPORTANT: If the shifting operation is not as described, the gear housing must be removed and the cause corrected.

13. Install the remaining washers and nuts onto the driveshaft studs and tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Gear housing attaching nut (2 each side)	75		55

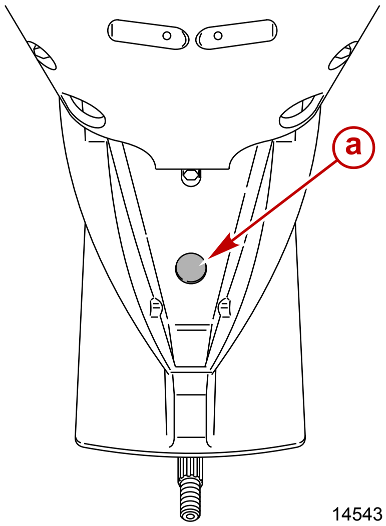
14. Tighten the screw (started in Step 10) to the specified torque.

Description	Nm	lb-in.	lb-ft
Screw (M12 x 35)	75		55

15. Position the trim tab or anodic plate into the gear housing. Align the grooves of trim tab with the ribs in the trim tab pocket. Adjust to position in which it had previously been installed, and while holding the trim tab, tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Trim tab screw (0.437-14 x 1-3/4 in.)	54		40

16. Install the rubber plug into the trim tab bolt opening at the rear edge of the driveshaft housing.



a - Rubber plug

17. Add engine oil. Refer to **Section 1B - Checking and Adding Engine Oil**.
18. Install the port and starboard chaps.
19. Install the top cowl. Refer to **Section 4A - Cowling Removal and Installation**.
20. Install the propeller. Refer to **Section 1B - Propeller Replacement**.

Notes:

Attachments

Section 7A - Attachments

Table of Contents

7
A

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Battery and APS connections	92- 25711 3
51	Loctite 222 Threadlocker	Retaining screw threads	92-809818
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Tie bar attaching bolt threads	Obtain Locally
138	Synthetic Power Steering Fluid SAE 0W-30	Steering system	92-858076K01

Special Tools

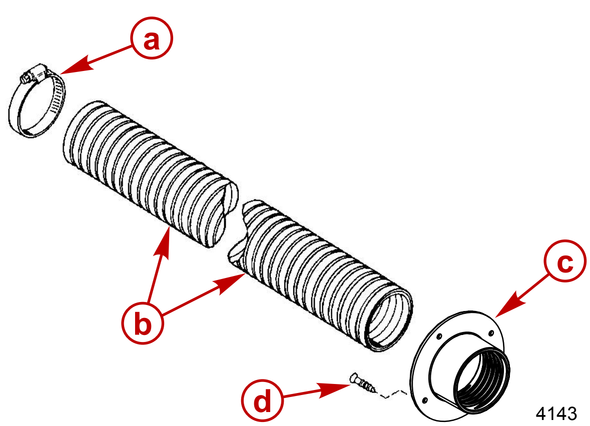
Power Steering Module Primer Kit	91-895040K01
 5547	Bleeds power steering system without running engine.

Wire Color Code Abbreviations

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

Rigging Hose Kit (825191A03)

Components Contained in Kit (825191A03)

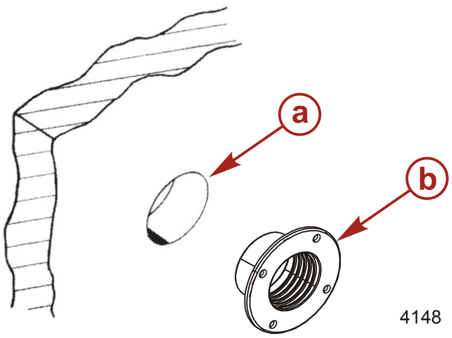


4143

a - Clamp
b - Rigging hose
c - Transom housing
d - Screw (4)

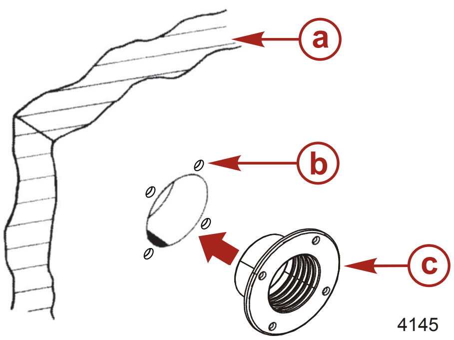
Selecting Location on Transom

1. Position the transom housing ahead of the engine so it allows for sufficient play in the harnesses, cables, and fuel lines being routed through the rigging hose. The rigging hose should have large sweeping bends during steering.
2. Choose a path for the harnesses, cables, and fuel lines that will allow them to be routed as straight as possible to avoid any sharp bends.
3. Make a 73 mm (2-7/8 in.) diameter hole in the location for the transom housing.



a - Hole cut in transom
b - Transom housing

4. Insert transom housing into the hole in transom. Mark and drill 3 mm (1/8 in.) pilot holes for the four mounting screws, using the transom housing as a template. Do not attach transom housing to transom at this time.



a - Transom
b - Pilot hole (4)
c - Transom housing

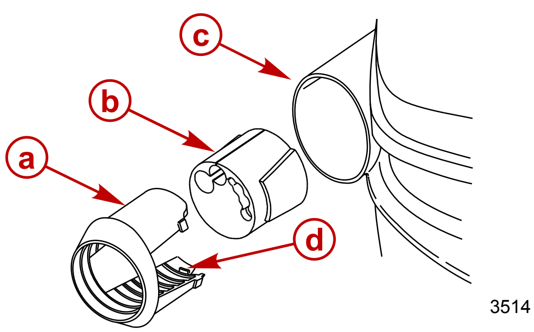
Determining Rigging Hose Length

Establish length of rigging hose needed by turning engine from full port to full starboard and all tilt angles. Rigging hose should have large sweeping bends so wiring harness, hoses, and cables inside rigging hose do not bend. Make allowance for the length of hose threaded into the transom housing and cowl adapter.

Installing Rigging Hose Kit (825191A03)

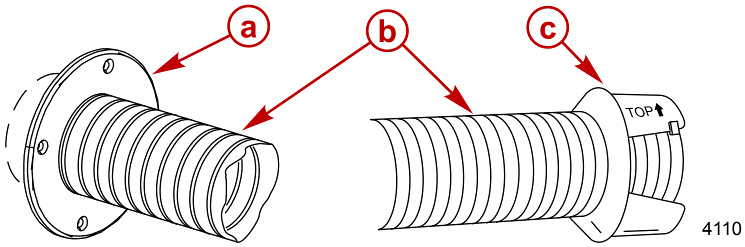
Verado Models

1. Remove cowl adapter and grommet from cowl.
2. Retain cowl adapter for rigging hose installation. Discard grommet.



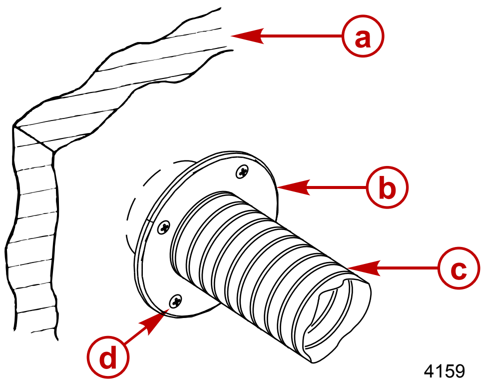
a - Cowl adapter
b - Grommet
c - Cowl
d - Rigging hose stop

3. Thread transom housing (from kit) and retained cowl adapter on rigging hose in a counterclockwise direction (left-hand thread). Thread cowl adapter until hose contacts rigging hose stop. Maintain a minimum of 32 mm (1.25 in.) hose engagement in transom housing.



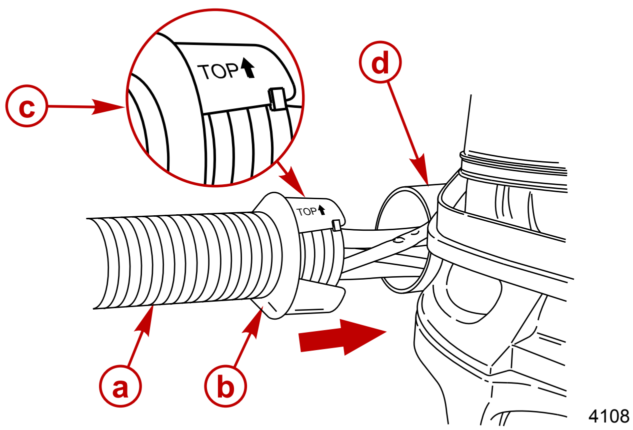
a - Transom housing
b - Rigging hose
c - Cowl adapter

4. Pull harnesses, cables, and fuel line through the rigging hose in the following order:
   a. Helm harness (14 pin connector) from boat to engine
   b. Wire harnesses
   c. Fuel line
   d. Battery cables
5. Fasten transom housing to transom with four screws.



a - Transom
b - Transom housing
c - Rigging hose
d - Screw (4)

6. Adjust rigging hose length by threading hose in or out of transom housing. Maintain a minimum of 32 mm (1.25 in.) hose engagement in transom housing.
7. Position adapter on rigging hose so the end marked "TOP" is facing up.
8. Push cowl adapter with rigging hose into cowl.



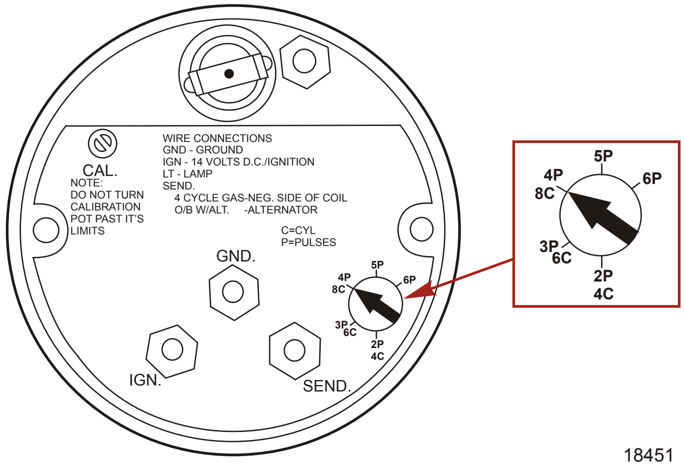
a - Rigging hose
b - Cowl adapter
c - Top of cowl adapter
d - Cowl

9. Check operation of outboard to ensure steering is not obstructed.

Analog Gauge Interface (AGI)

Analog Gauge Interface Installation

NOTE: The analog gauge interface (AGI) module can be used on MerCruiser or outboard models with the 14 pin non-DTS digital or the 14 pin digital throttle and shift (DTS) systems. Use the ring terminals on the AGI adapter harness to connect to analog gauges. Tape back any unused terminals. Tachometers with pulse adjusting capability must be set to 4 pulse.

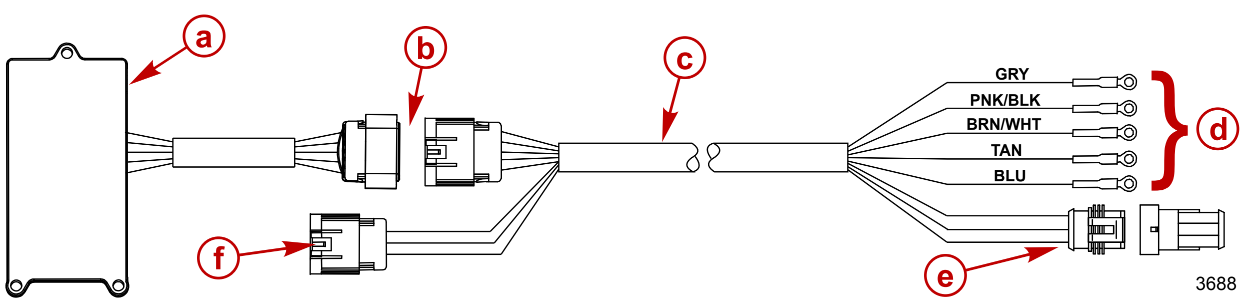


NOTE: For SmartCraft System Link gauges, use the 3 pin System Link connection on the AGI adapter harness. The AGI system can support 10 System Link gauges per helm, two helms maximum.

IMPORTANT: Mount the AGI module with potted wires facing down to prevent moisture collecting at base of wires and wicking into the AGI module. Route and secure all wires and harnesses away from hot or moving parts.

1. Mount the AGI module securely under dash or helm with the wires facing down, in close proximity to gauges.
2. Refer to the following table for the AGI adapter harness wire connections. Tape back any unused terminals. Secure connections per gauge manufacturer's specifications.

Analog Gauge Type	AGI Adapter Harness Wire Color
Tachometer	Gray
Oil pressure/oil level	Blue
Water temperature	Tan
Trim positions	Brown/white
Fuel level	Pink/black

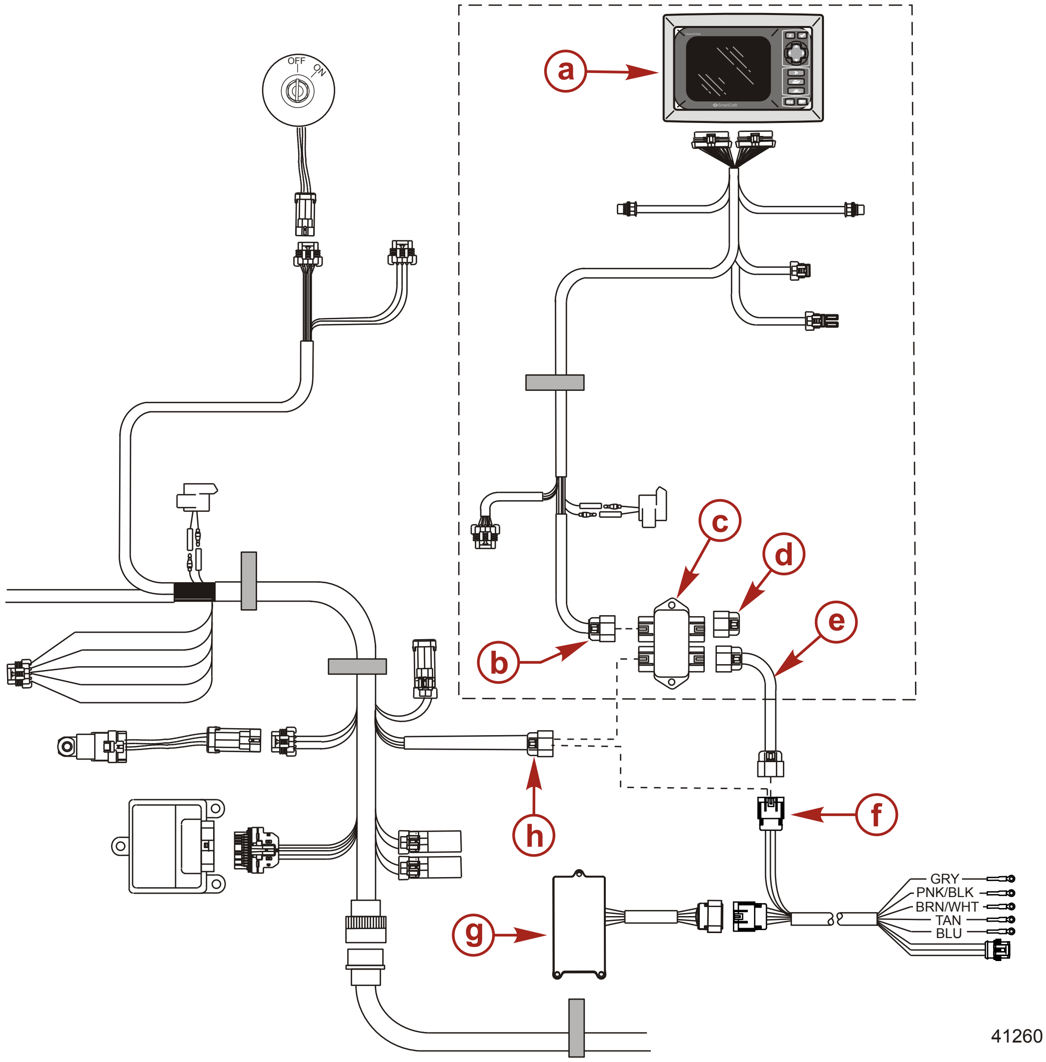


a - AGI module
b - 14 pin connection
c - AGI adapter harness
d - Analog gauge terminal connections
e - 3 pin System Link connection
f - AGI 10 pin connection

3. Ensure a 12 volt positive (+) power source from the key switch is connected to the analog gauges.
4. Ensure analog gauges are connected to a common engine ground.
5. Connect any SmartCraft System Link gauges to the 3 pin System Link connection.

6. Connect the AGI adapter harness to the AGI module.
7. Ensure the command module harness 10 pin junction box connector is connected to the AGI adapter harness 10 pin connector.
   - If SmartCraft Vessel View is not used, plug the AGI 10 pin adapter directly into the command module harness 10 pin junction box connector.
   - If SmartCraft Vessel View is used, a junction box and a harness adapter is required. Plug the command module harness 10 pin junction box connector, the Vessel View harness 10 pin junction box connector, and one end of the harness adapter into the junction box. Plug the AGI 10 pin harness adapter into the harness adapter. Install weather caps on all unused junction box ports.

Typical AGI Module



a - Vessel View display
b - Vessel View harness 10 pin junction box connector
c - Junction box
d - Weather cap
e - Harness adapter
f - AGI 10 pin harness adapter
g - AGI module
h - Command module harness 10 pin junction box connector

Configuring Tachometer Signal Through the PCM

IMPORTANT: The PCM tachometer configuration is factory default set to analog.

The following options are configurations of analog and digital gauges, along with the PCM tachometer configuration setting to run them.

Gauge Configuration	Analog	Digital
Analog tachometer only	X	
System Link gauges used with Vessel View, System Monitor, or System Tachometer	–	–
System Link gauges used in conjunction with System Link adapter harness and Command Module harness without the use of Vessel View, System Monitor, or System Tachometer		X
AGI used with or without Vessel View, System Monitor, or System Tachometer, to run analog and System Link gauges		X

The computer diagnostic system (CDS) can be used to select a PCM tachometer configuration for analog or digital.

PCM Configuration with CDS

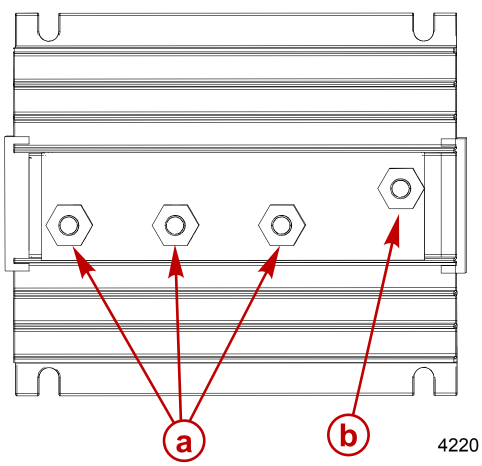
1. Attach CDS to engine. Refer to on-line help if needed.
2. From the "Logon" screen, navigate to the "Engine Select" screen.
3. From the "Engine Select" screen, fill in the engine type information and select "Tool Box."
4. From the "Tool Box" screen, select "Active Diagnostics."
5. From the "Active Diagnostics" screen, scroll down and select "Tach Link Config."
6. To change the PCM configuration from analog to digital, select "Enable" and then select "Run."
7. To change the PCM configuration from digital to analog, select "Disable" and then select "Run."

Automatic Power Switch (87-895091K03)

Automatic Power Switch (APS) Installation

IMPORTANT: An automatic power switch must be used anytime there are multiple engine/battery installations. Refer to the Cable Length vs. Required Cable Size (AWG) table and Typical Multiple Engine Installation schematics following.

1. Mount APS securely in close proximity to cranking batteries and power steering pump.
2. Connect up to three cranking batteries, 12 volt positive cables, to APS input terminals.
3. Connect power steering pump 12 volt positive harness to output terminal on APS.
4. Connect power steering pump ground harness to 12 volt negative cranking battery connection.
5. Apply Liquid Neoprene to all battery and APS connections.



a - APS input terminals
b - APS output terminal

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Battery and APS connections	92- 25711 3

Cable Length vs. Required Cable Size (AWG)

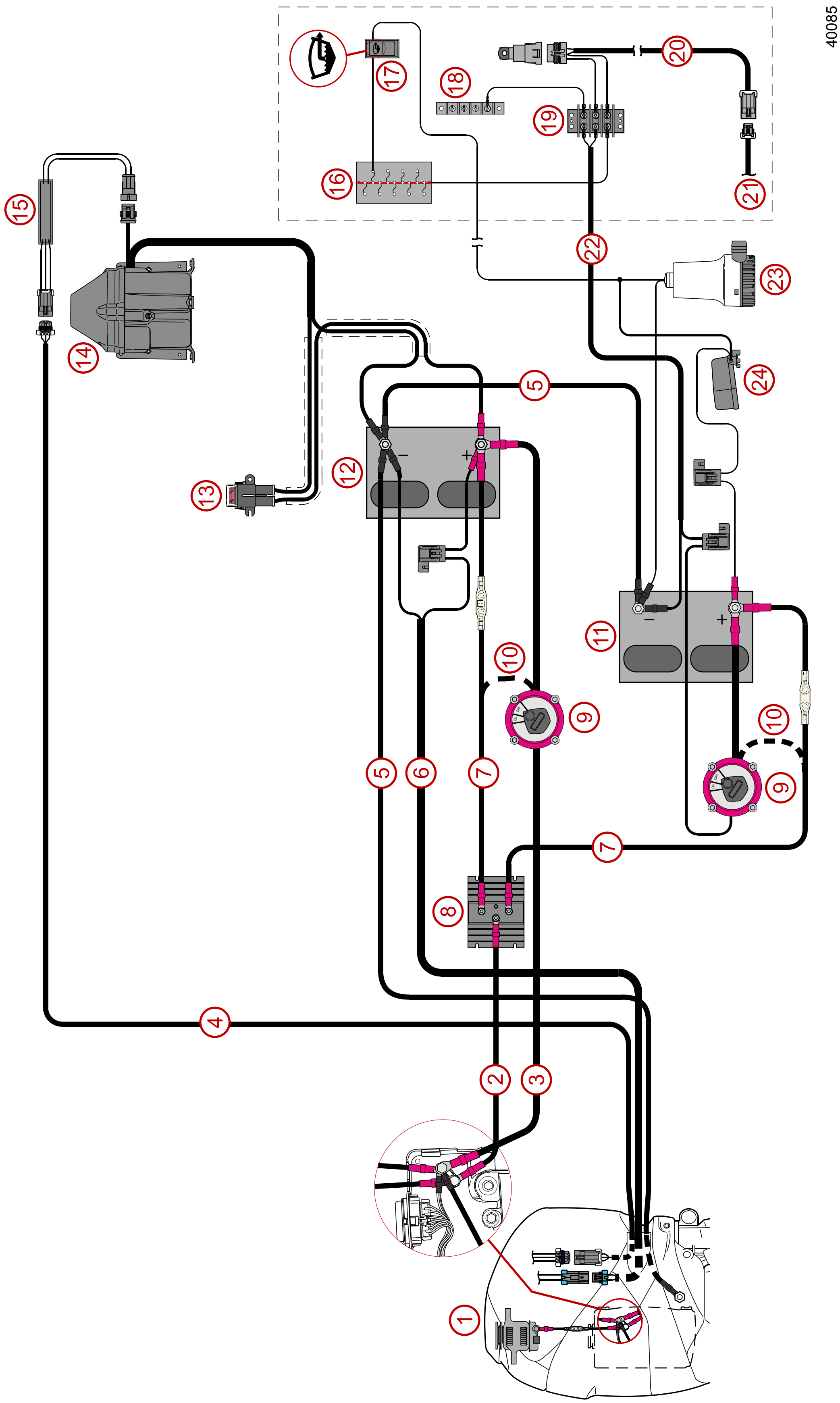
IMPORTANT: Wiring to be in compliance with ANSI/IEEE standard 45-1983.

Cable Length vs. Required Cable Size (AWG)										
Description	Cable Length									
	1.8 m (6 ft.)	2.4 m (8 ft.)	3 m (10 ft.)	3.6 m (12 ft.)	4.3 m (14 ft.)	4.9 m (16 ft.)	5.5 m (18 ft.)	6.1 m (20 ft.)	6.7 m (22 ft.)	7.3 m (24 ft.)
	Required Cable Size (AWG)									
Engine to cranking battery positive	3.6 m (12 ft.) 4 AWG cables are standard equipment on "L" models only.			4	2	2	2	2	1	1
Engine to cranking battery negative	3.6 m (12 ft.) 4 AWG cables are standard equipment on "L" models only.			4	2	2	2	2	1	1
Cranking battery positive to automatic power switch input terminal	Must be 1.8 m (6 ft.) maximum and 4 AWG minimum									
Cranking battery negative to cranking battery negative	4	4	4	4	2	2	2	2	1	1
Power steering pump to automatic power switch output terminal	3.6 m (12 ft.) 8 AWG or 7.3 m (24 ft.) 6 AWG is standard equipment									
Power steering pump to cranking battery negative	3.6 m (12 ft.) 8 AWG or 7.3 m (24 ft.) 6 AWG is standard equipment									
Automatic power switch output terminal to automatic power switch output terminal	3.6 m (12 ft.) 8 AWG or 7.3 m (24 ft.) 6 AWG is standard equipment									

Notes:

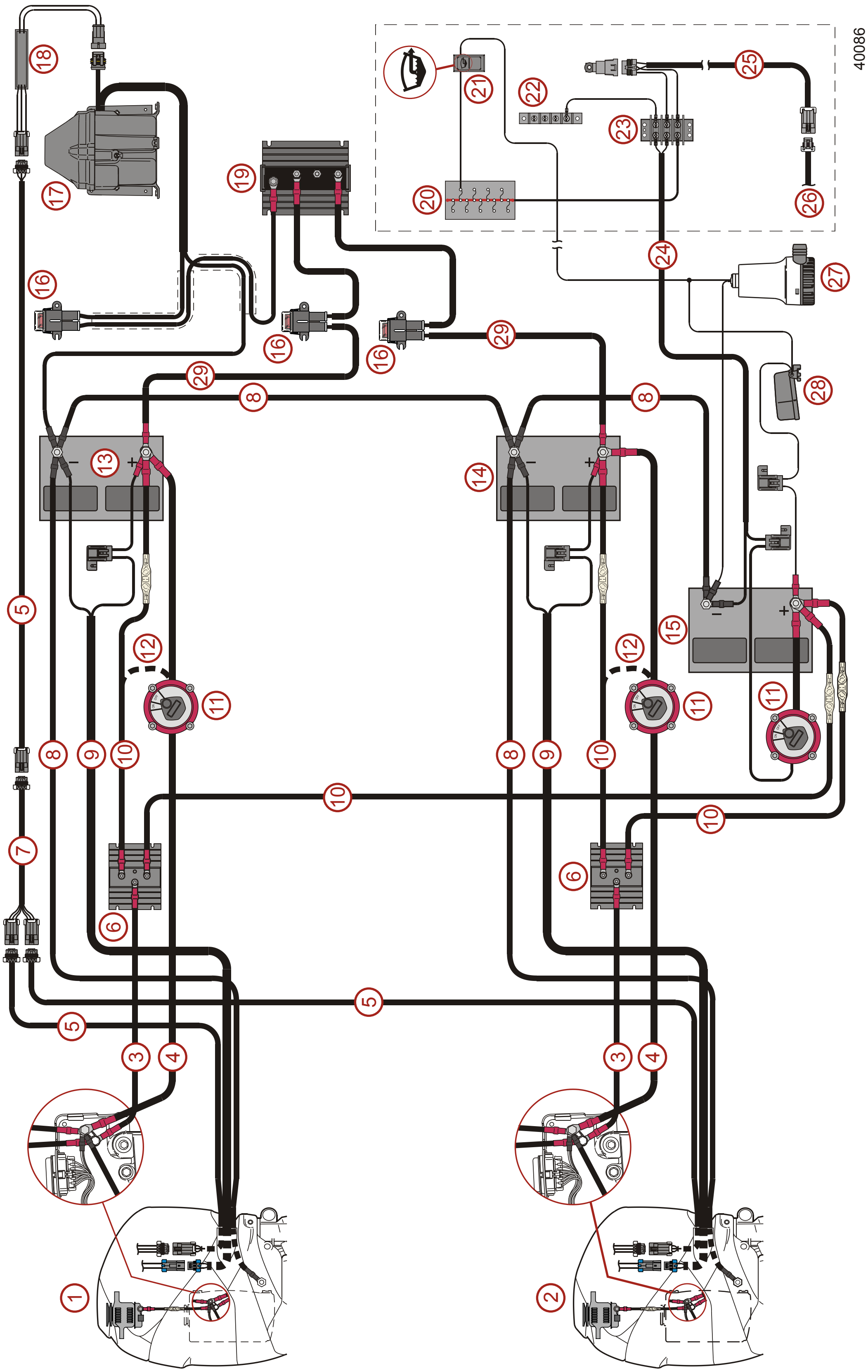
Typical Engine Installation

Single Engine Electrical Connections (50 Amp Maxi Fuse)



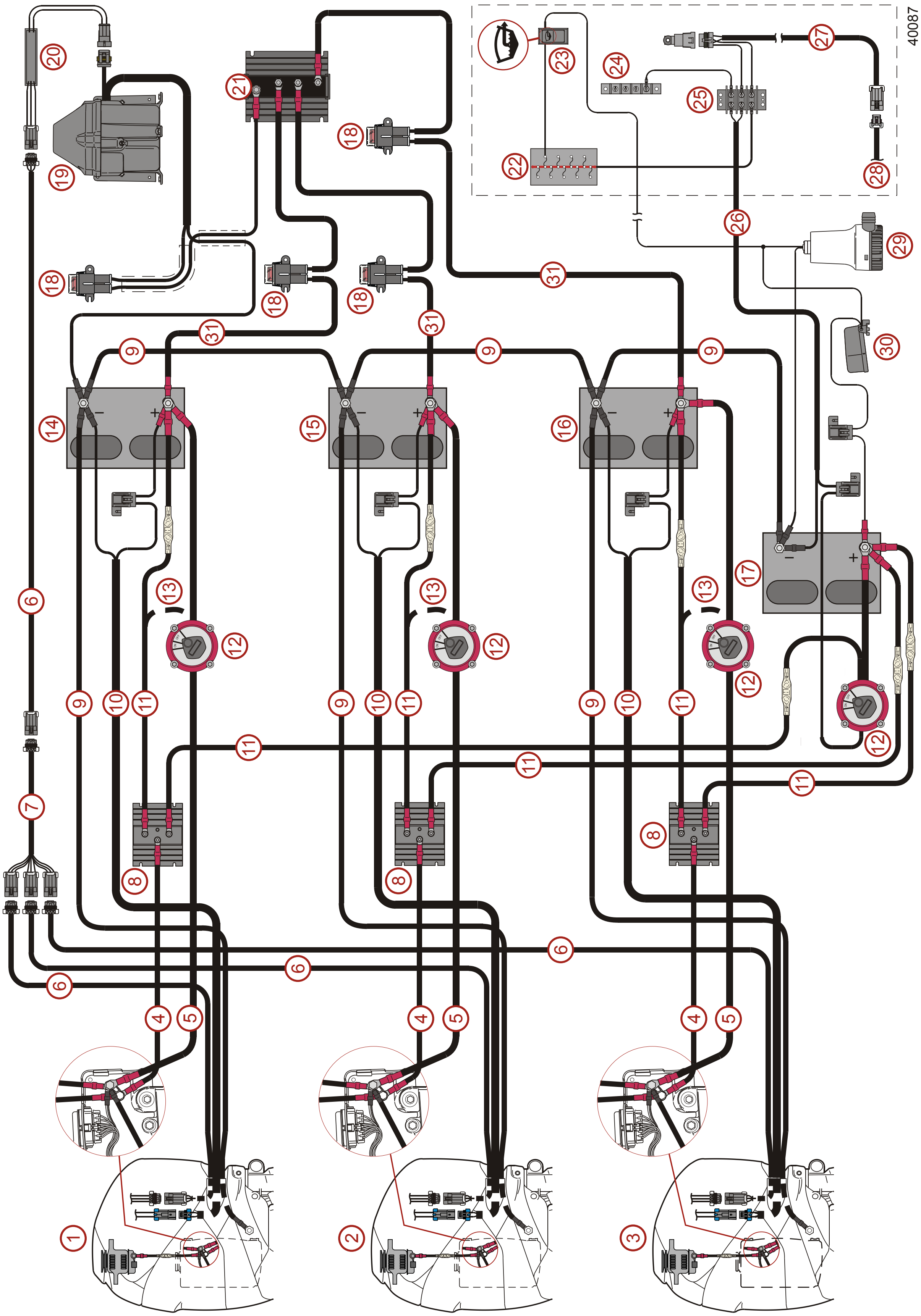
1 - Engine
2 - Alternator wire
3 - Positive battery cable
4 - Power steering signal harness
5 - Negative battery cable
6 - DTS power harness
7 - Fused harness
8 - Battery isolator
9 - Battery switch
10 - Alternate connection option
11 - Auxiliary battery
12 - Starting battery
13 - 50 amp maxi fuse
14 - Power steering pump
15 - Power steering driver module harness
16 - Fuse panel
17 - Bilge pump switch
18 - Ground terminal block
19 - Terminal block
20 - Relay harness
21 - DTS command module harness
22 - Accessory power harness
23 - Bilge pump
24 - Bilge pump float switch

Dual Engine Electrical Connections (50 Amp Maxi Fuse)



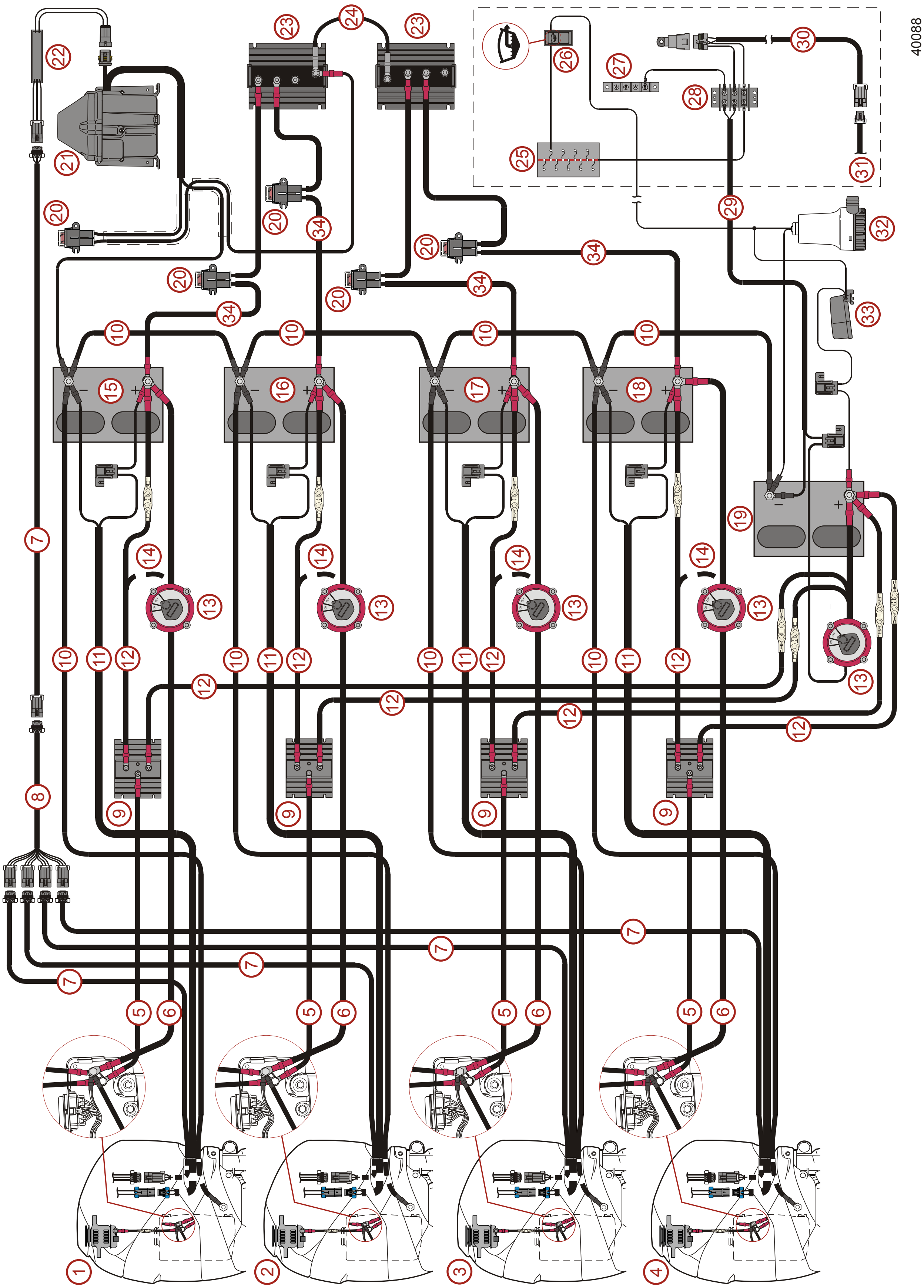
1 - Port engine
2 - Starboard engine
3 - Alternator wire
4 - Positive battery cable
5 - Power steering signal harness
6 - Battery isolator
7 - Dual engine power steering signal harness adapter
8 - Negative battery cable
9 - DTS power harness
10 - Fused harness
11 - Battery switch
12 - Alternate connection option
13 - Port engine starting battery
14 - Starboard engine starting battery
15 - Auxiliary battery
16 - 50 amp maxi fuse
17 - Power steering pump
18 - Power steering driver module harness
19 - Automatic power switch (APS)
20 - Fuse panel
21 - Bilge pump switch
22 - Ground terminal block
23 - Terminal block
24 - Accessory power harness
25 - Relay harness
26 - DTS command module harness
27 - Bilge pump
28 - Bilge pump float switch
29 - Positive battery cable with 50 amp maxi fuse

Triple Engine Electrical Connections (50 Amp Maxi Fuse)



1 - Port engine
2 - Center engine
3 - Starboard engine
4 - Alternator wire
5 - Positive battery cable
6 - Power steering signal harness
7 - Triple engine power steering signal harness adapter
8 - Battery isolator
9 - Negative battery cable
10 - DTS power harness
11 - Fused harness
12 - Battery switch
13 - Alternate connection option
14 - Port engine starting battery
15 - Center engine starting battery
16 - Starboard engine starting battery
17 - Auxiliary battery
18 - 50 amp maxi fuse
19 - Power steering pump
20 - Power steering driver module harness
21 - Automatic power switch (APS)
22 - Fuse panel
23 - Bilge pump switch
24 - Ground terminal block
25 - Terminal block
26 - Accessory power harness
27 - Relay harness
28 - DTS command module harness
29 - Bilge pump
30 - Bilge pump float switch
31 - Positive battery cable with 50 amp maxi fuse

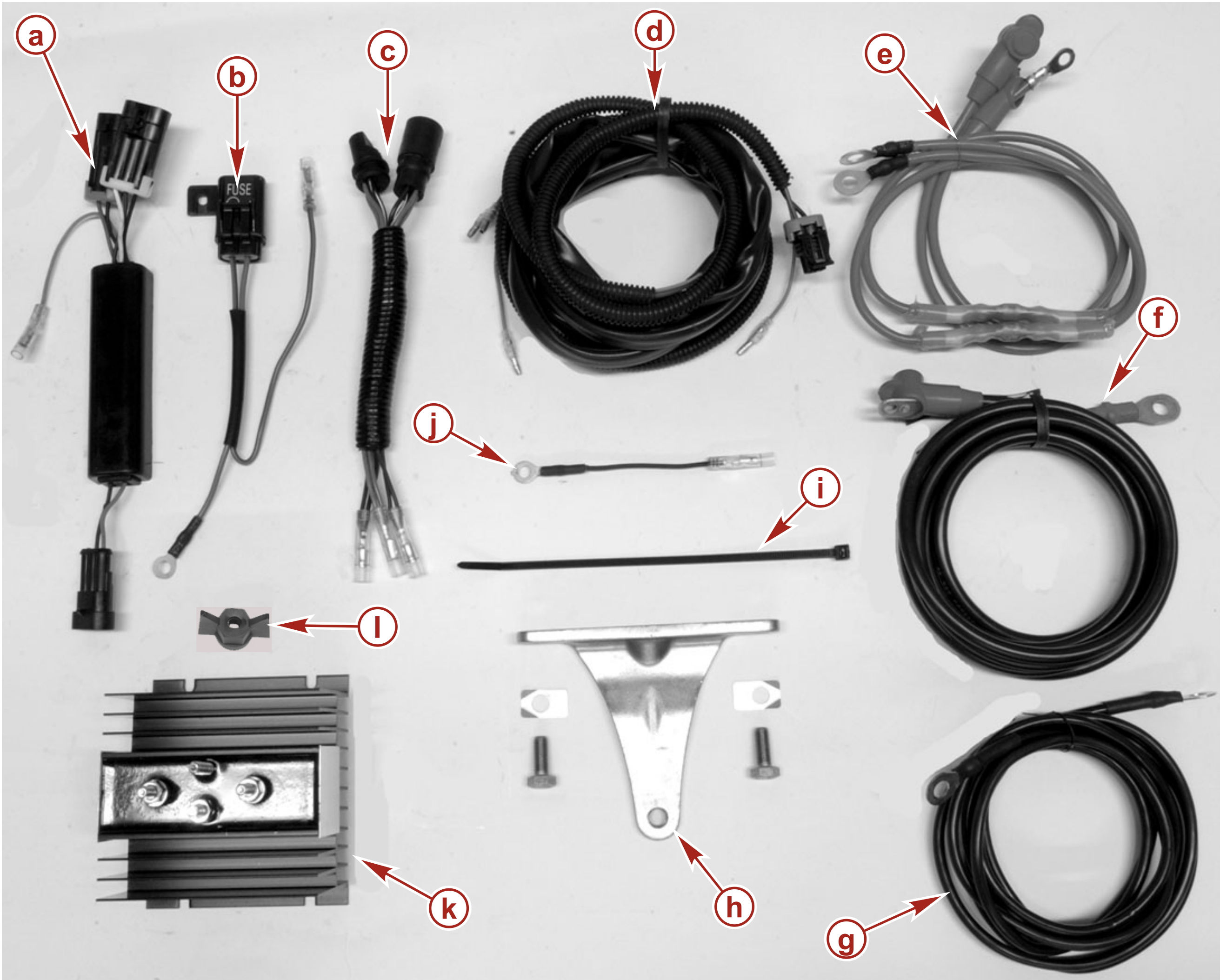
Quad Engine Electrical Connections (50 Amp Maxi Fuse)



1 - Port outside engine
2 - Port inside engine
3 - Starboard inside engine
4 - Starboard outside engine
5 - Alternator wire
6 - Positive battery cable
7 - Power steering signal harness
8 - Quad engine power steering signal harness adapter
9 - Battery isolator
10 - Negative battery cable
11 - DTS power harness
12 - Fused harness
13 - Battery switch
14 - Alternate connection option
15 - Port outside engine starting battery
16 - Port inside engine starting battery
17 - Starboard inside engine starting battery
18 - Starboard outside engine starting battery
19 - Auxiliary battery
20 - 50 amp maxi fuse
21 - Power steering pump
22 - Power steering driver module harness
23 - Automatic power switch (APS)
24 - APS jumper cable 15.24 cm (6 in.) or less; 8 gauge PVC at 105 °C (221 °F) (84-88807A33)
25 - Fuse panel
26 - Bilge pump switch
27 - Ground terminal block
28 - Terminal block
29 - Accessory power harness
30 - Relay harness
31 - DTS command module harness
32 - Bilge pump
33 - Bilge pump float switch
34 - Positive battery cable with 50 amp maxi fuse

Auxiliary Power Steering Kit (89748K02)

Components Contained in Kit (897478K02)



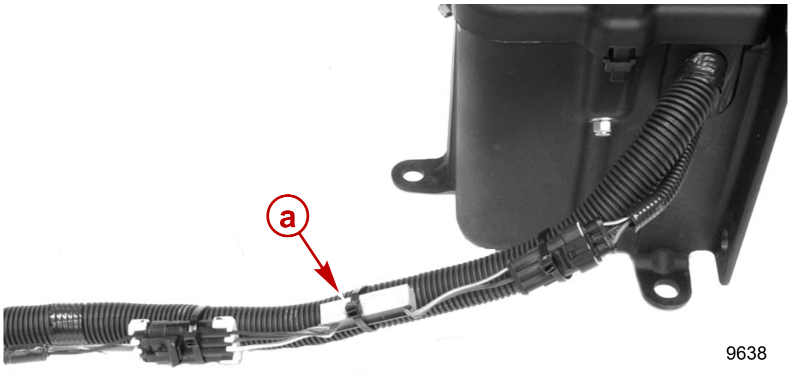
9636

- a - Auxiliary outboard power steering module
- b - 20 amp fuse harness assembly
- c - Tachometer harness
- d - Auxiliary outboard power steering harness
- e - 100 amp fusible link (2)
- f - Battery cable #6 AWG
- g - Battery cable #8 AWG
- h - Steering bracket kit
- i - Cable tie (6)
- j - Cable assembly
- k - Battery isolator
- l - Nylon wing nut

Installation Instructions (not using a remote control for auxiliary engine)

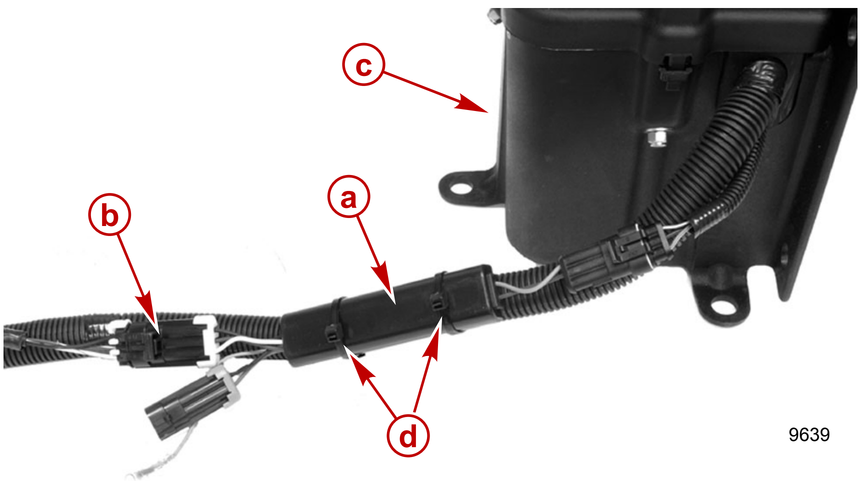
IMPORTANT: The Verado power steering module should be retained by the boat operator as a replacement in the event of a failure of the auxiliary outboard power steering module.

1. Remove the Verado power steering module from the power steering pump/signal harness.



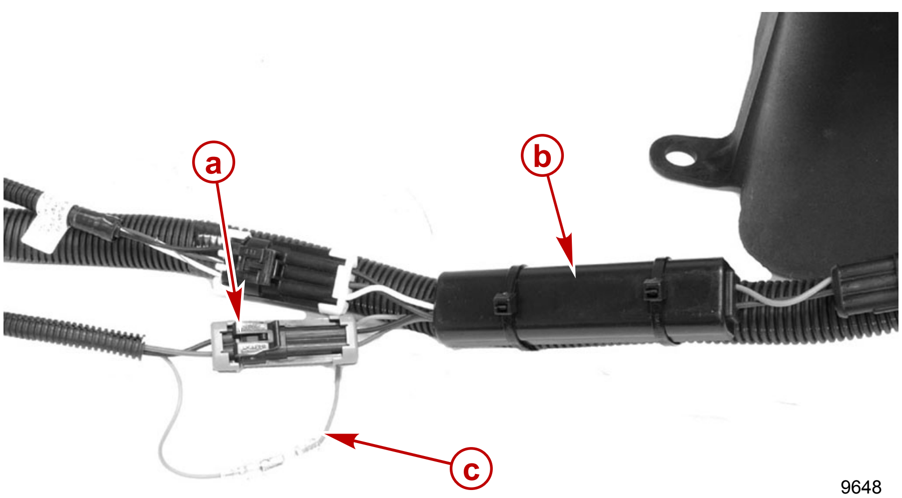
a - Power steering module (retain)

2. Install the auxiliary outboard power steering module into the Verado power steering pump/signal harness. Secure the module with cable ties. After the harness connections are made, secure the module harness connectors with cable ties.



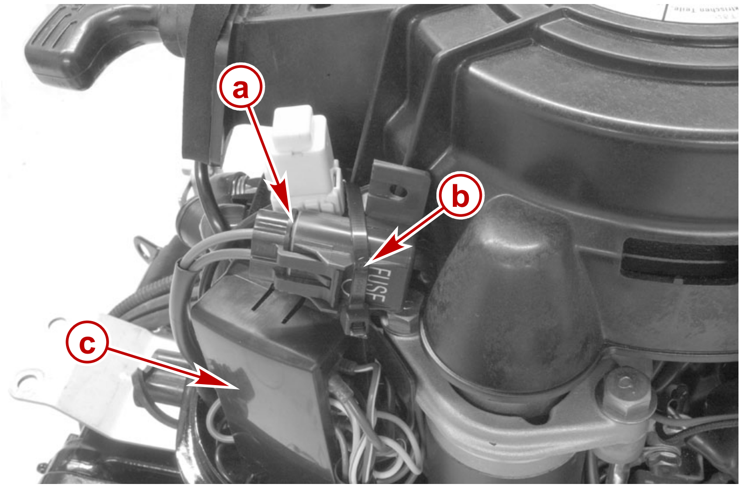
a - Auxiliary outboard power steering module
b - Verado power steering/signal harness
c - Power steering pump
d - Cable ties

3. Connect the auxiliary power steering/signal harness to the auxiliary power steering module.
4. Connect the gray lead of the auxiliary power steering/signal harness to the corresponding gray lead of the power steering module.



a - Auxiliary outboard power steering/signal harness
b - Auxiliary outboard power steering module
c - Gray tachometer lead

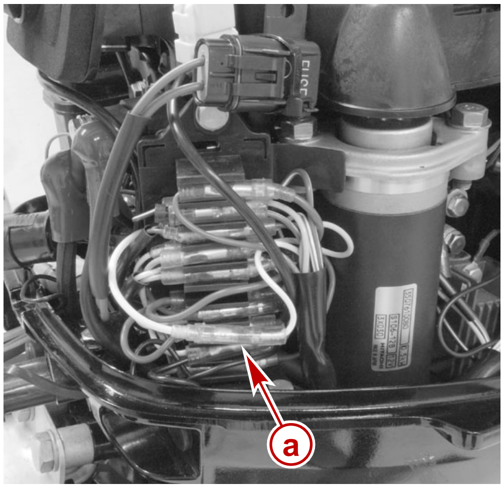
5. Remove the top cowl of the auxiliary outboard and secure the 20 amp fuse harness assembly to the engine wiring terminal bracket with a cable tie.



a - 20 amp fuse harness assembly
b - Cable tie
c - Terminal cover

9649

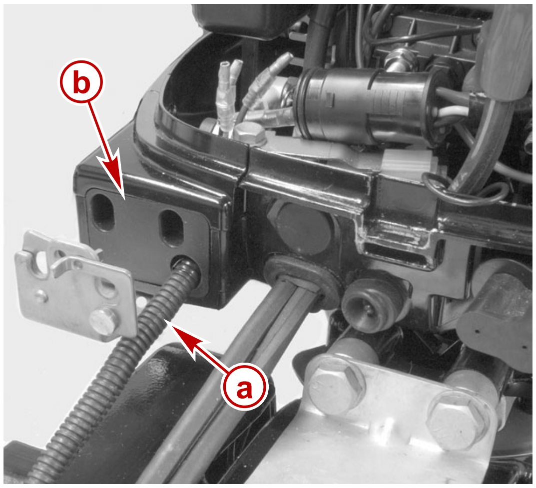
6. Remove the wiring terminal cover and disconnect the white accessory bullet connector (white lead goes to ECM).



a - White accessory bullet connector

9651

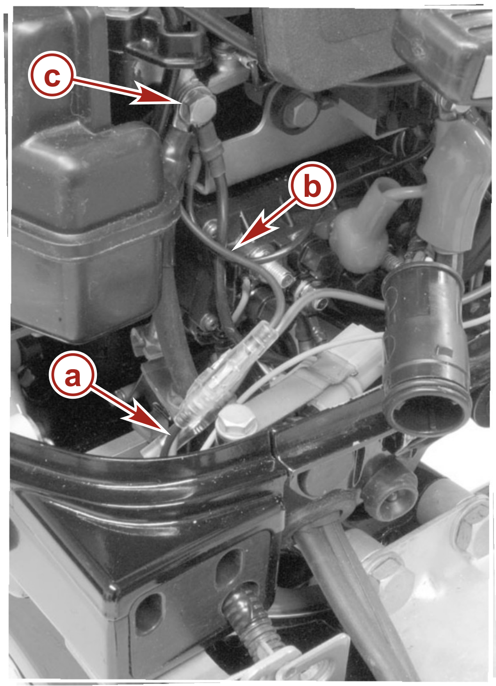
7. Route the auxiliary power steering/signal harness through the cable grommet on the auxiliary outboard.



a - Auxiliary power steering/signal harness
b - Grommet

9652

8. Secure the black lead of the power steering harness to the ground terminal using the cable assembly provided. Tighten the ground terminal screw to the specified torque.

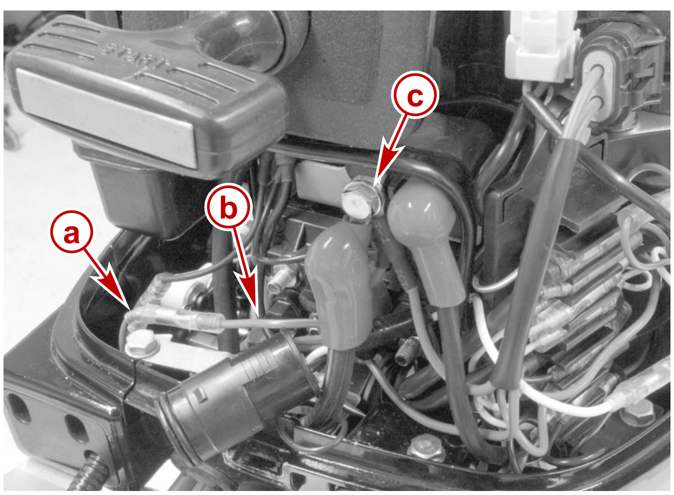


9653

a - Black lead
b - Cable assembly
c - Terminal screw

Description	Nm	lb-in.	lb-ft
Terminal screw	6	53	

9. Connect the purple/white lead of the auxiliary power steering/signal harness to the female bullet red lead of the 20 amp fuse harness.
10. Connect the red eyelet terminal end of the 20 amp fuse harness to the starter solenoid terminal. Tighten the screw to the specified torque.



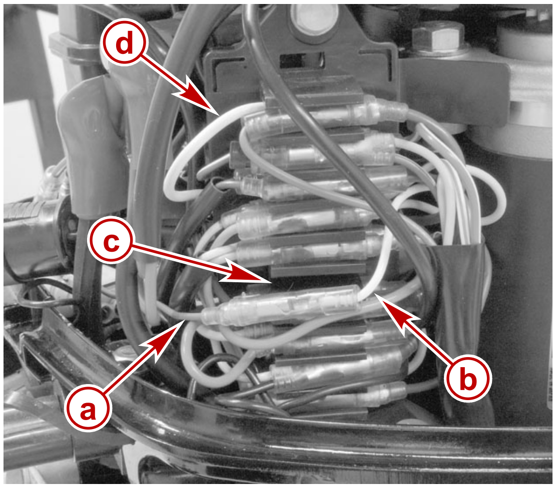
9656

a - Purple/white lead of power steering harness
b - Red lead of 20 amp fuse harness
c - Red eyelet terminal end of fuse harness

Description	Nm	lb-in.	lb-ft
Screw	2.8	25	

11. Connect the gray lead of the auxiliary power steering/signal harness to the white accessory lead bullet connector. Install the gray/white bullet connector into the wiring terminal holder.

12. Install the unused male end of the white accessory lead into the wiring terminal holder.



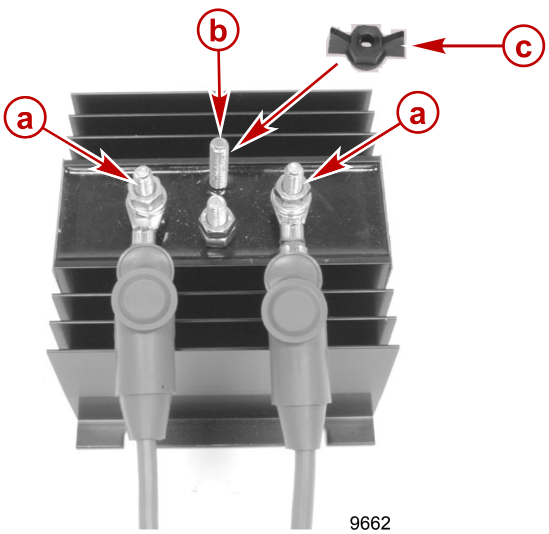
9661

a - Gray lead
b - White lead
c - Terminal holder
d - Unused white lead

13. Install the wiring terminal cover.
14. Following instructions provided with the isolator, mount the isolator in an appropriate location in the boat.

IMPORTANT: Do not connect any cable to the blue tipped stud on the isolator.

15. Connect one 100 amp fusible link cable to each outside stud on the isolator. Route each cable to the positive terminal of the cranking and auxiliary batteries, respectively. Tighten the nuts to the specified torque. Install the nylon wing nut onto the blue tipped stud to help prevent an accidental short.

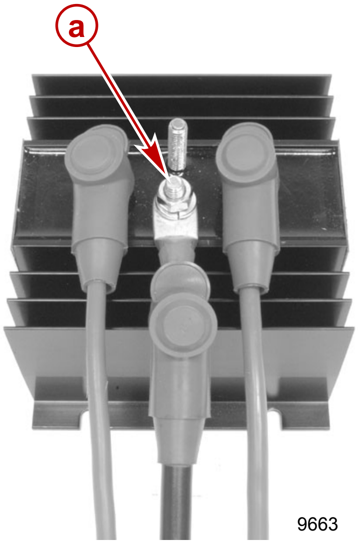


9662

a - 100 amp fusible link cable
b - Blue tipped stud
c - Nylon wing nut

Description	Nm	lb-in.	lb-ft
Attaching nut	5.6	50	

16. Connect the battery cable #6 AWG to the center isolator terminal. Tighten the nut to the specified torque.

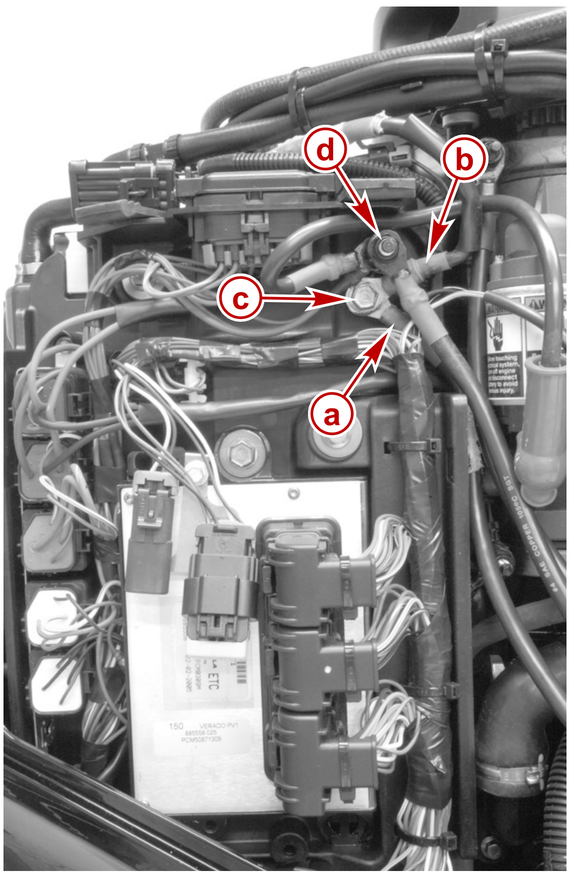


9663

a - Battery cable #6 AWG

Description	Nm	lb-in.	lb-ft
Attaching nut	5.6	50	

17. Route the battery cable from the isolator through the Verado cable tubing and harness grommet to the 8 mm bolt on the Verado electrical plate.
18. Remove the alternator fusible output lead from the positive terminal and attach the lead to the 8 mm bolt on the electrical plate. Tighten the engine positive terminal nut and the 8 mm bolt to the specified torque.



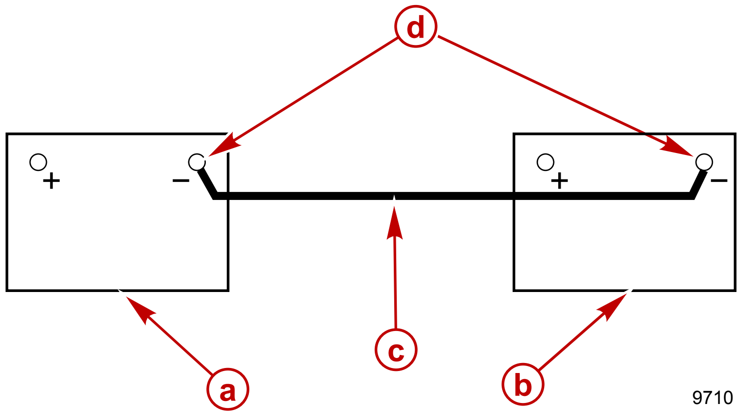
15668

a - Battery cable from isolator
b - Alternator fusible output lead
c - 8 mm bolt
d - Positive terminal nut

Description	Nm	lb-in.	lb-ft
8 mm bolt	9	80	

Description	Nm	lb-in.	lb-ft
Positive terminal nut	17	150	

19. Route battery cable #8 AWG from the auxiliary battery to the starting battery and attach the battery cable to the negative post of each battery.



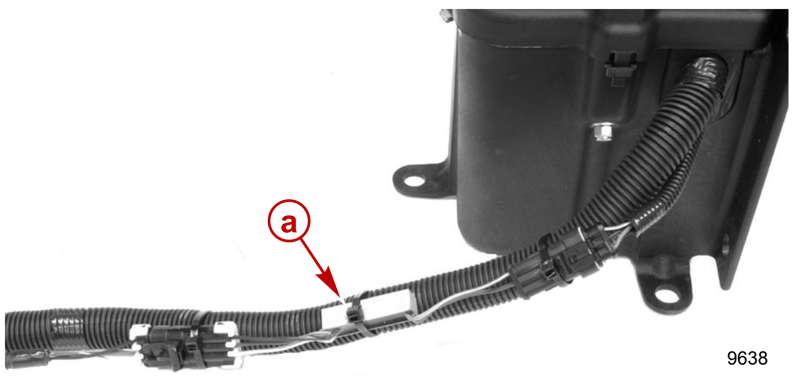
a - Auxiliary battery
b - Starting battery
c - Battery cable #8 AWG
d - Negative posts

20. Following instructions provided with the adapter steering arm, install the steering arm onto the Verado engine.

Installation Instructions (using a remote control for auxiliary engine)

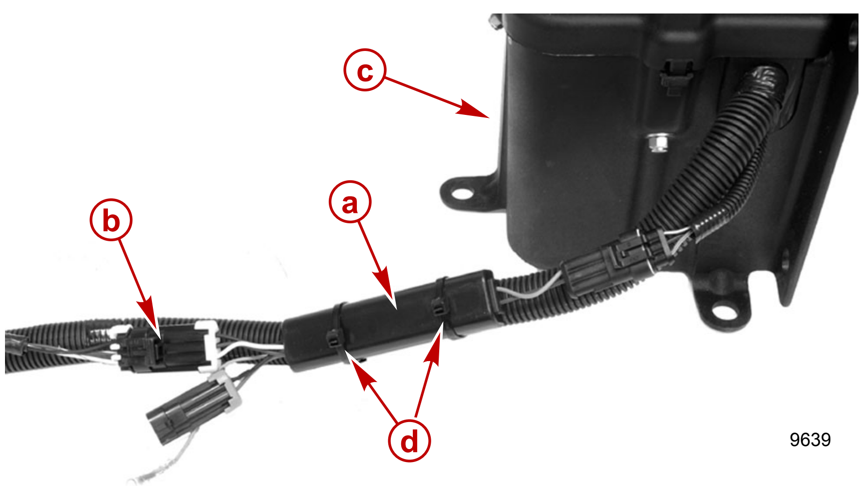
IMPORTANT: The Verado power steering module should be retained by the boat operator as a replacement in the event of a failure of the auxiliary outboard power steering module.

1. Remove the Verado power steering module from the power steering pump/signal harness.



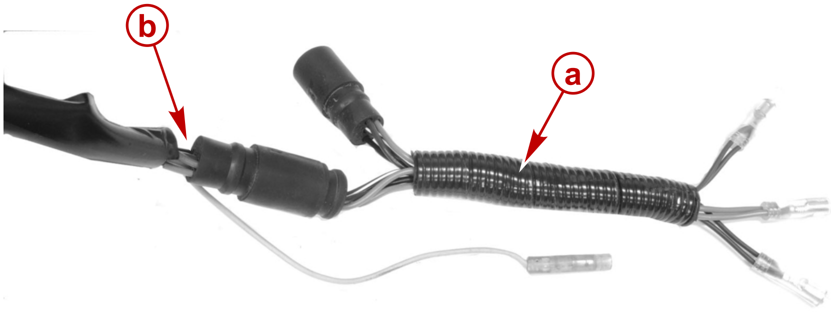
a - Power steering module (retain)

2. Install the auxiliary outboard power steering module into the Verado power steering pump/signal harness. Secure the module with cable ties. After the harness connections are made, secure the module harness connectors with cable ties.



a - Auxiliary outboard power steering module
b - Verado power steering/signal harness
c - Power steering pump
d - Cable ties

3. Connect the tachometer harness adapter to the remote control tachometer connector.

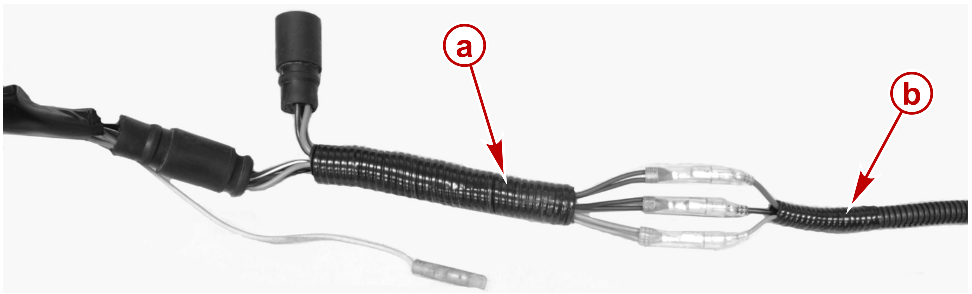


9665

a - Tachometer harness adapter
b - Remote control tachometer connector

4. Connect the bullet connector end of the auxiliary outboard power steering/signal harness to the tachometer adapter harness.

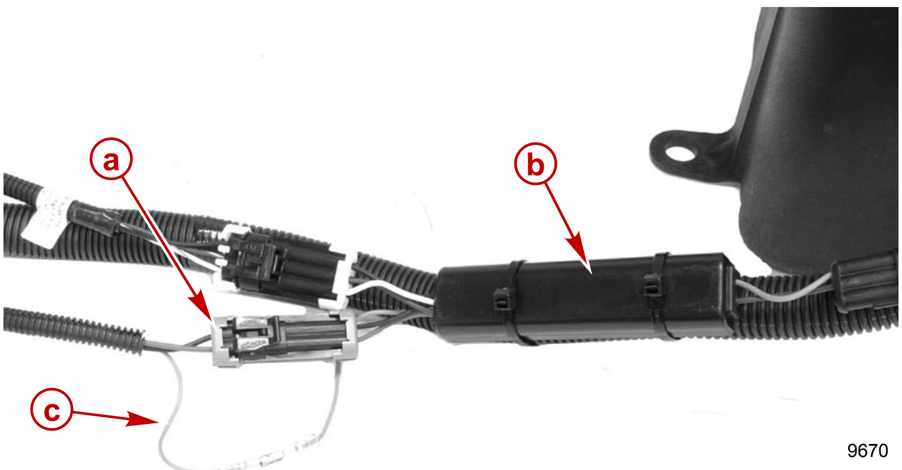
Power Steering/Signal Harness	Tachometer Adapter Harness
Purple/white lead	Purple lead
Gray lead	Gray lead
Black lead	Black lead



9667

a - Tachometer adapter harness
b - Power steering harness

5. Connect the purple/white and black wire connector end of the auxiliary outboard power steering/signal harness to the corresponding connector on the power steering module.
6. Connect the gray lead of the auxiliary power steering/signal harness to the corresponding gray lead of the power steering module.



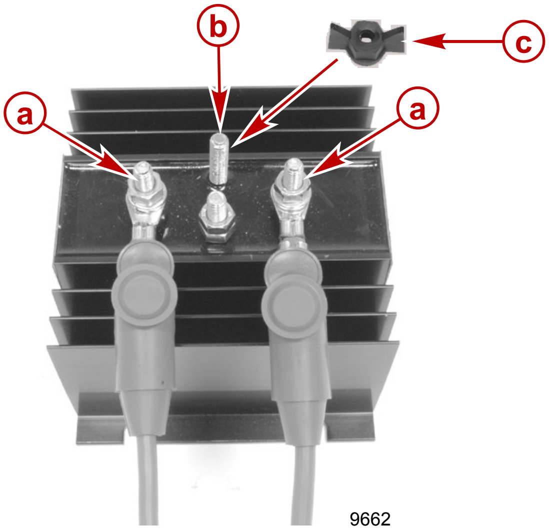
9670

a - Auxiliary power steering/signal harness
b - Power steering module
c - Gray lead

7. Following instructions provided with the isolator, mount the isolator in an appropriate location in the boat.

IMPORTANT: Do not secure any cable to blue tipped stud on the isolator.

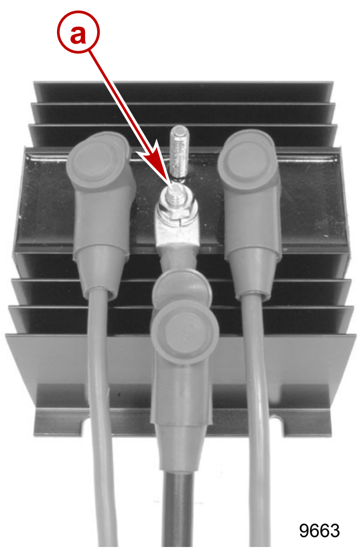
8. Attach one 100 amp fusible link cable to each outside stud on the isolator. Torque attaching nut to specification. Route each cable to the positive terminal of the cranking and auxiliary batteries, respectively. Install the nylon wing nut onto the blue tipped stud to help prevent an accidental short.



a - 100 amp fusible link cable
b - Blue tipped stud
c - Nylon wing nut

Description	Nm	lb-in.	lb-ft
Attaching nut	5.6	50	

9. Attach the battery cable #6 AWG to the center terminal on the isolator. Torque nut to specification.

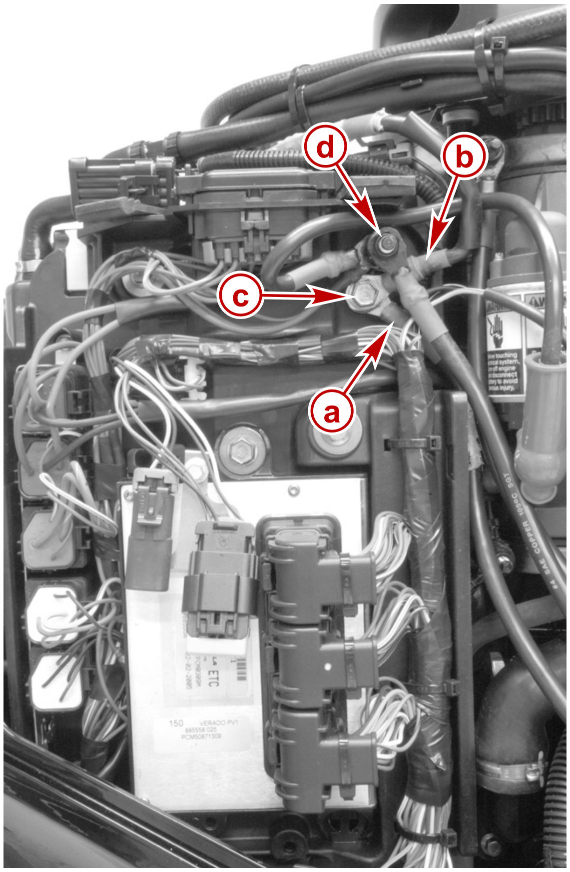


a - Battery cable #6 AWG

Description	Nm	lb-in.	lb-ft
Attaching nut	5.6	50	

10. Route the battery cable from the isolator through the cable tubing and harness grommet to the 8 mm bolt on the Verado electrical plate.

11. Remove the Verado alternator fusible output lead from the positive terminal and attach to the 8 mm bolt on the electrical plate. Torque 8 mm bolt to specification. Torque positive terminal nut to specification.



15668

a - Battery cable from isolator
b - Alternator fusible output lead
c - 8 mm bolt
d - Positive terminal nut

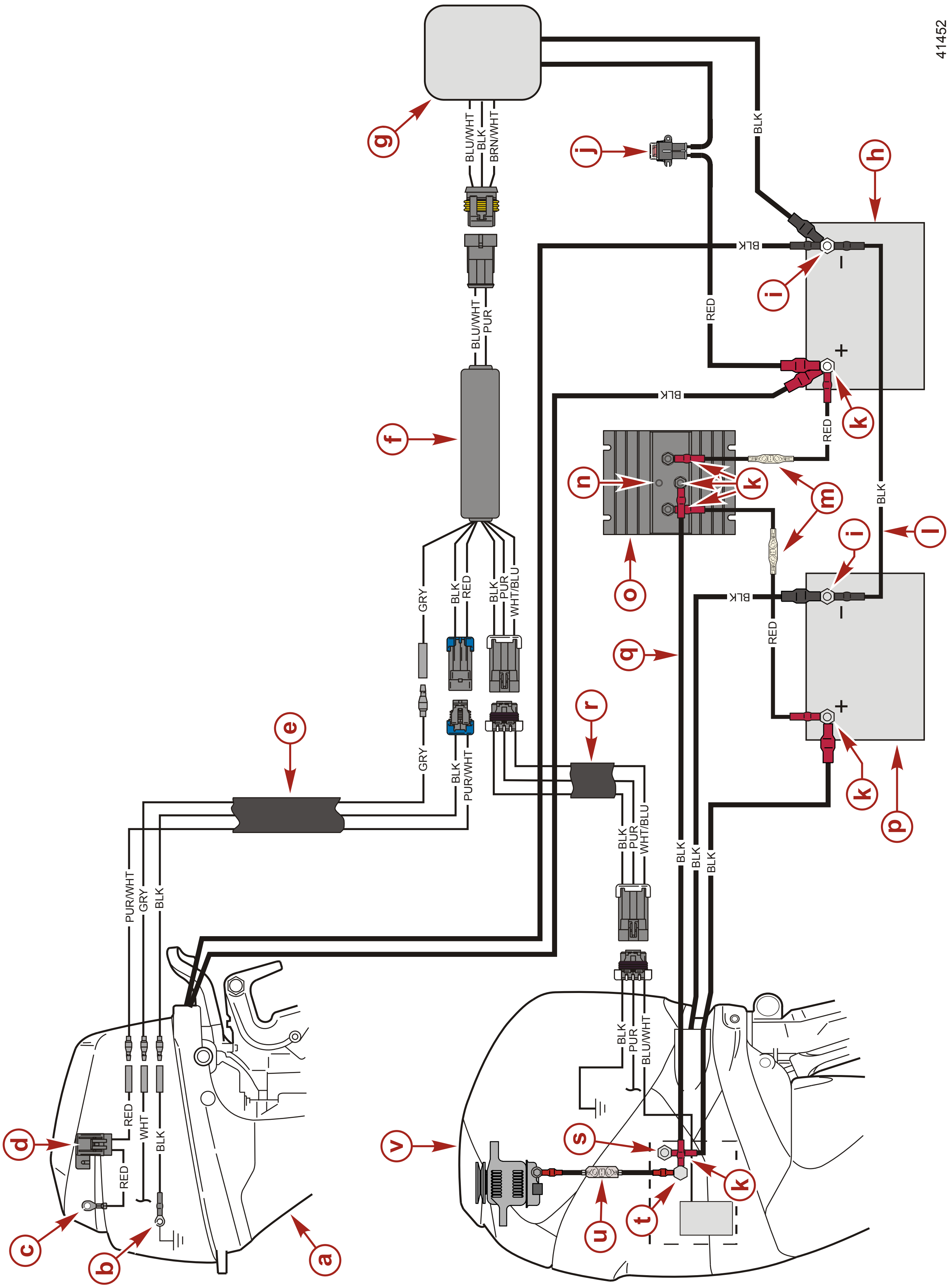
Description	Nm	lb-in.	lb-ft
8 mm bolt	9	80	
Positive terminal nut	17	150	

12. Route battery cable #8 AWG from the auxiliary battery to the cranking battery and attach the battery cable to the negative post of each battery.
13. Following instructions provided with the adapter steering arm, install the steering arm onto the Verado engine.

Wire Color Code Abbreviations

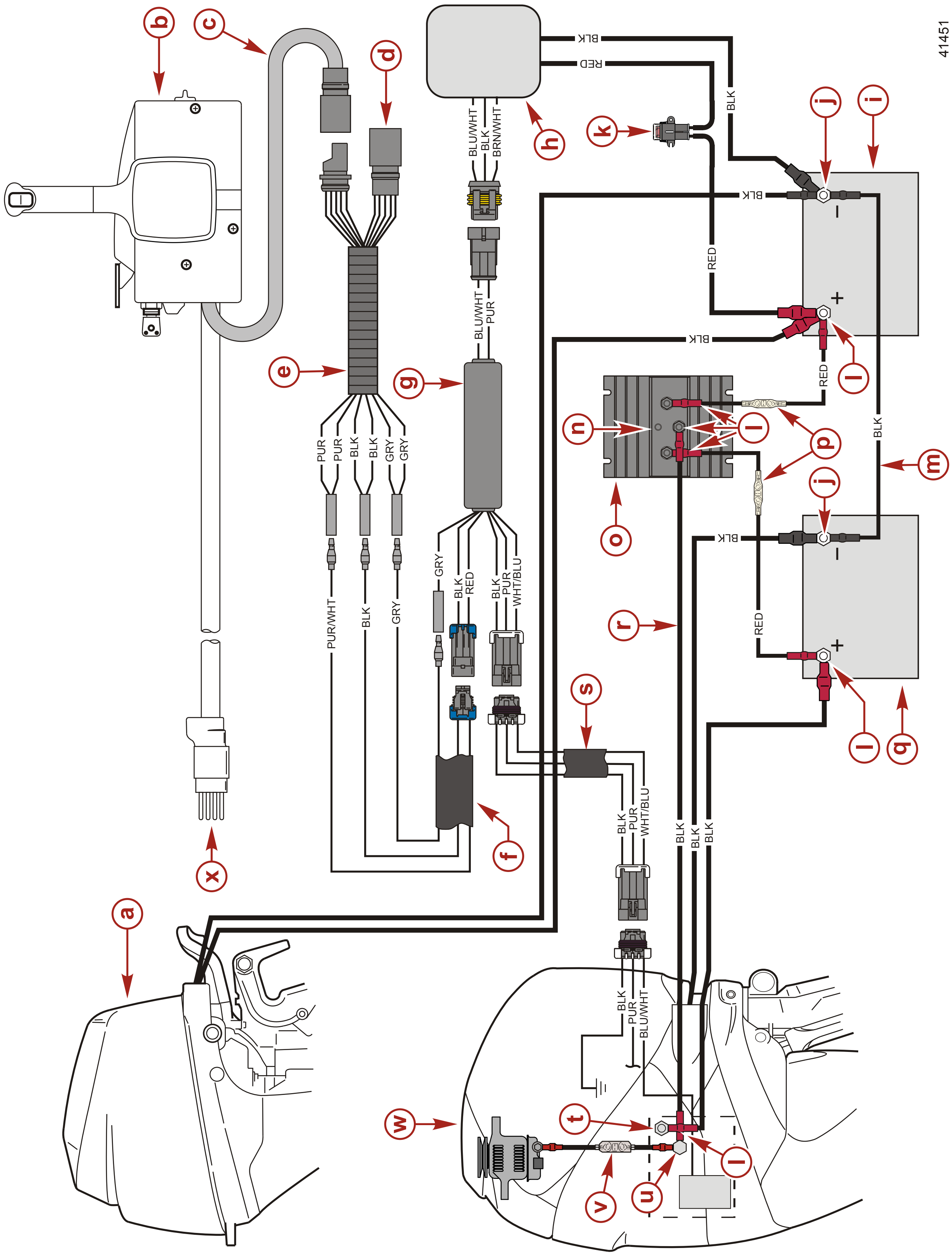
Wire Color Abbreviations					
BLK	Black		BLU	Blue
BRN	Brown		GRY	Gray
GRN	Green		ORN or ORG	Orange
PNK	Pink		PPL or PUR	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT or LIT	Light		DK or DRK	Dark

Auxiliary Outboard Power Steering without Remote Control



- a - Auxiliary outboard
- b - Cable assembly (connect to engine ground)
- c - Fuse assembly lead (connect to starter solenoid)
- d - 20 amp fuse harness assembly
- e - Auxiliary outboard power steering/signal harness
- f - Auxiliary outboard power steering module
- g - Power steering pump
- h - Auxiliary battery
- i - Black sleeved lead (negative battery terminal)
- j - 50 amp power steering pump fuse
- k - Red sleeved lead (positive battery terminal)
- l - Battery cable #8 AWG
- m - 100 amp fusible link
- n - Blue tipped terminal stud (do not attach lead to this terminal)
- o - Battery isolator
- p - Starting battery
- q - Battery cable #6 AWG
- r - Verado power steering/signal harness
- s - Positive terminal stud
- t - 8 mm bolt (junction for alternator output lead and battery isolator lead)
- u - 150 amp fusible link
- v - Verado outboard

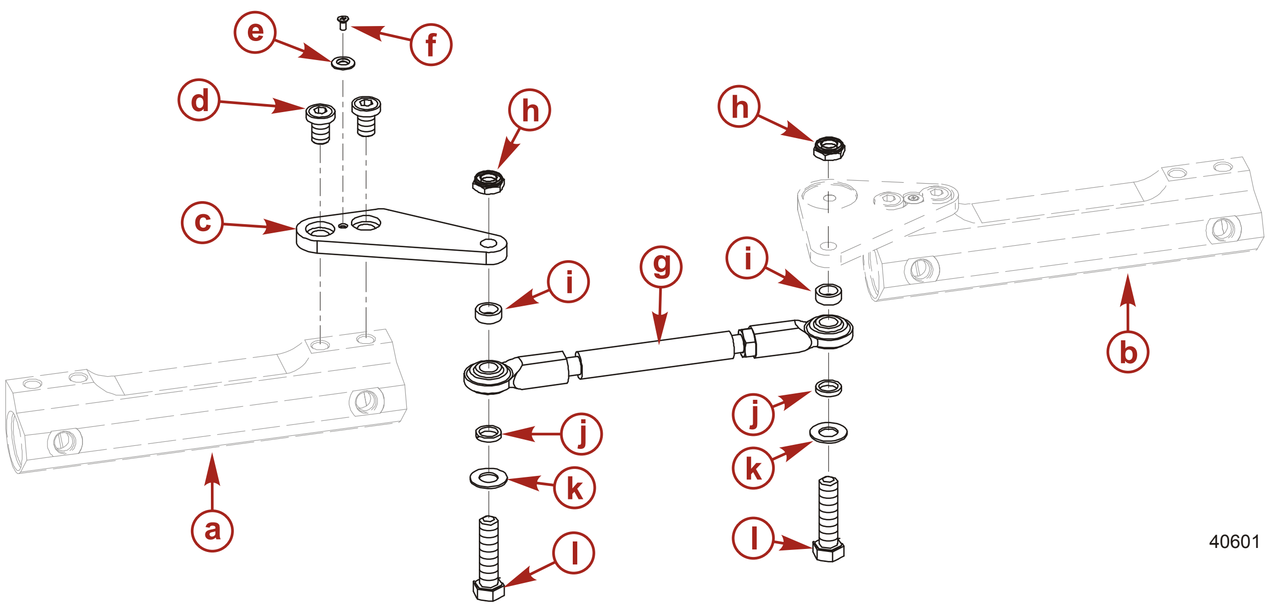
Auxiliary Outboard Power Steering with Remote Control



- a - Auxiliary outboard
- b - Remote control
- c - Remote control tachometer harness
- d - Connector for optional gauges for auxiliary outboard
- e - Tachometer harness
- f - Auxiliary outboard power steering/signal harness
- g - Auxiliary outboard power steering module
- h - Power steering pump
- i - Auxiliary battery
- j - Black sleeved leads (negative battery terminal)
- k - 50 amp power steering pump fuse
- l - Red sleeved leads (positive battery terminal)
- m - Battery cable #8 AWG
- n - Blue tipped terminal stud (do not attach lead to this terminal)
- o - Battery isolator
- p - 100 amp fusible link
- q - Starting battery
- r - Battery cable #6 AWG
- s - Verado power steering/signal harness
- t - Positive terminal stud
- u - 8 mm bolt (junction for alternator output lead and battery isolator lead)
- v - 150 amp fusible link
- w - Verado outboard
- x - To auxiliary outboard engine harness

Dual Outboard Tie Bar Kit

Components Contained in Dual Engine Tie Bar Kit



- a - Starboard steering cylinder (not contained in kit)
- b - Port steering cylinder (not contained in kit)
- c - Starboard tie bar plate
- d - Screw (2)
- e - Retaining washer
- f - Retaining screw
- g - Tie bar
- h - Locknut (1/2-20) (2)
- i - Thick spacer (2)
- j - Thin spacer (2)
- k - Washer (2)
- l - Bolt (1/2-20) (2)

Torque Specifications

Description	Nm	lb-in.	lb-ft
Mounting screws for starboard tie bar plate	76		56
Retaining screw	2.7	24	
Tie bar attaching bolts (0.50 in.-20)	54		40
Locknut (0.50 in.-20)	27		20

Description	Nm	lb-in.	lb-ft
Jam nut	54		40

Tie Bar Kit Application

Measure the spacing between the centerlines of the outboards. Use the correct tie bar that matches the outboard centerline spacing. The length of the tie bar can be adjusted to allow for a ± 9.5 mm (3/8 in.) tolerance between outboard centerline spacing.

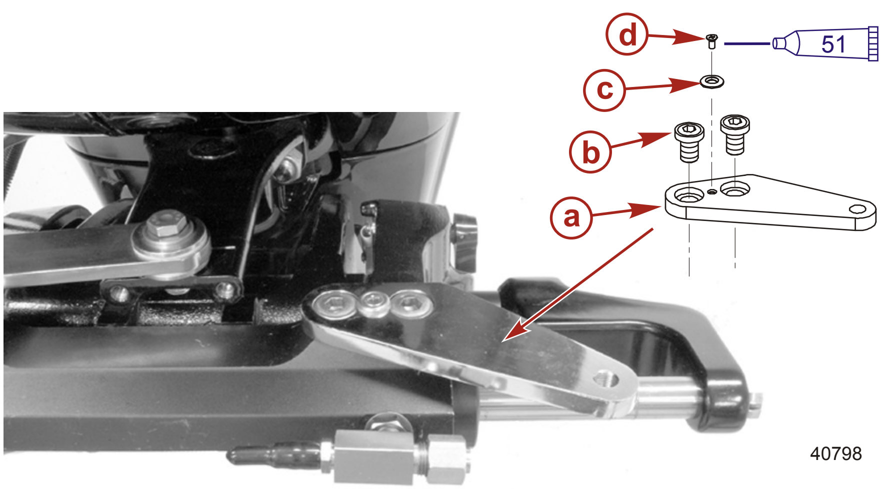
Kit Part Number	Kit Application
64-892789Q22	For outboard centerline spacing of 66.0 cm (26 in.)
64-892789Q23	For outboard centerline spacing of 71.1 cm (28 in.)
64-892789Q25	For outboard centerline spacing of 76.2 cm (30 in.)
64-892789Q26	For outboard centerline spacing of 81.3 cm (32 in.)
64-892789Q27	For outboard centerline spacing of 86.4 cm (34 in.)
64-892789Q24	For outboard centerline spacing of 91.5 cm (36 in.)

Installation

⚠ WARNING

Improper fasteners or improper installation procedures can result in loosening or disengagement of the tie bar. 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 all tie bar installation instructions and torque procedures.

1. Install the starboard tie bar plate to the starboard steering cylinder, as follows:
   a. Remove the two rubber plugs from the starboard steering cylinder.
   b. Attach the starboard tie bar plate to the starboard steering cylinder with two screws, as shown. Tighten the screws to the specified torque.
   c. Install the retaining screw and washer, as shown. Apply Loctite 222 Threadlocker to the retaining screw threads. Tighten the retaining screw to the specified torque.

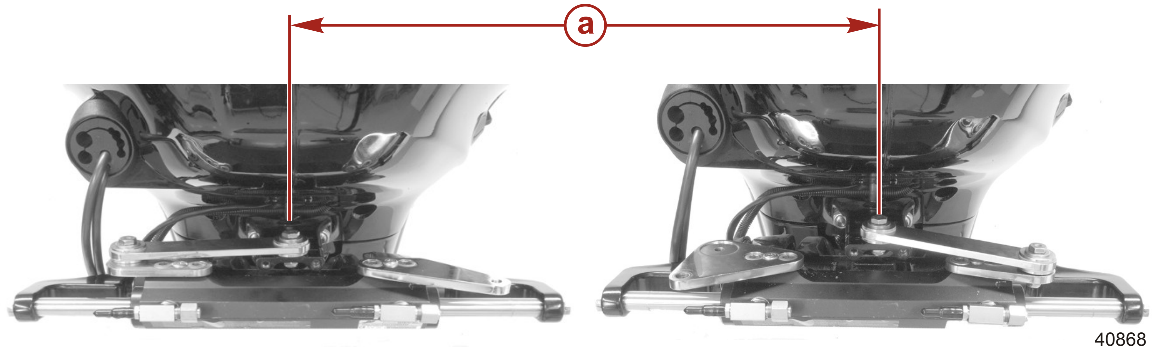


a - Starboard tie bar plate
b - Screw (5/16 in. internal hex)
c - Retaining washer
d - Retaining screw

Tube Ref No.	Description	Where Used	Part No.
51	Loctite 222 Threadlocker	Retaining screw threads	92-809818

Description	Nm	lb-in.	lb-ft
Screws for attaching the starboard tie bar plate	76		56
Retaining screw	2.7	24	

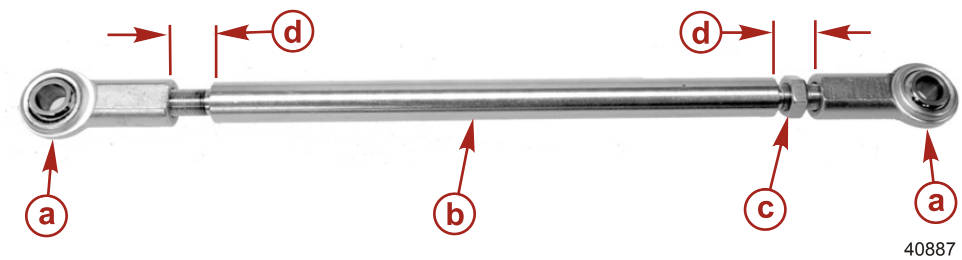
2. Position the outboards so they are facing straight forward. The distance between the centers of the hex bolts in the steering arms must be equal to the distance between the propeller shaft centerlines.



a - Distance between the centers of the hex bolts in the steering arms

3. Thread the steering eyes equally onto the threaded ends of the tie bar so the distance between the holes in the steering eyes is equal to the distance between the mounting holes in the tie bar plates.

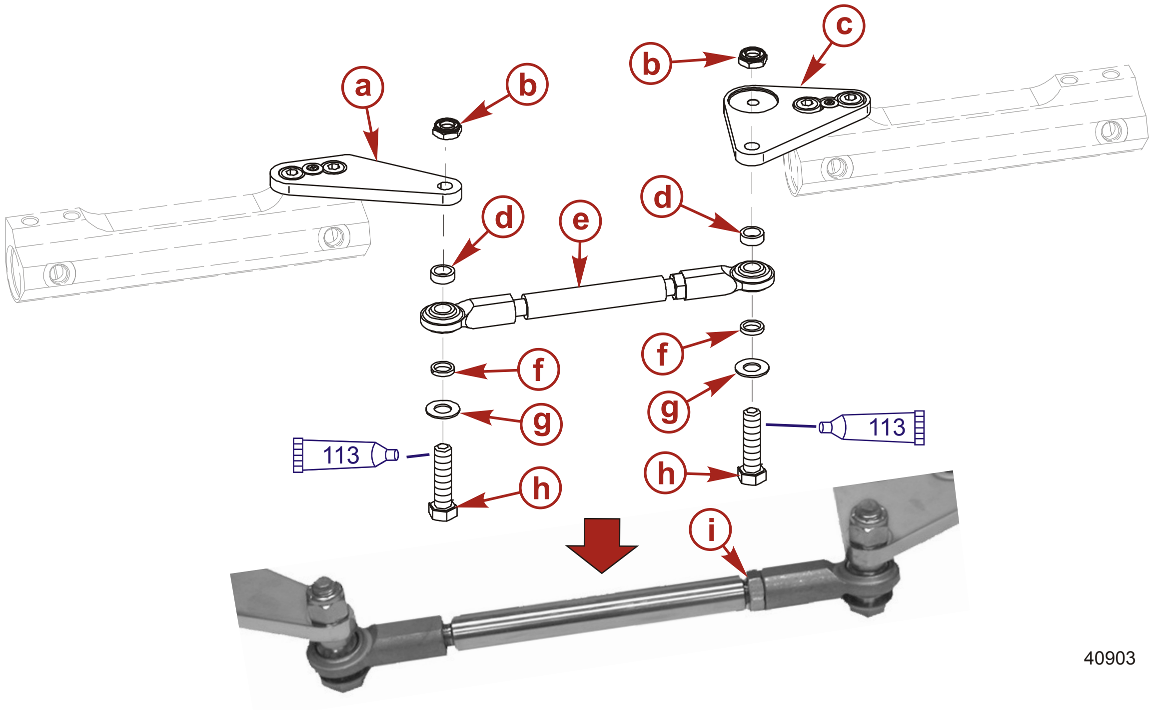
   IMPORTANT: Both steering eyes must be threaded onto the threaded ends of the tie bar 14.3 mm (9/16 in.) minimum. The maximum allowable amount of exposed thread extending out the steering eyes is 19 mm (3/4 in.). The jam nut must be tightened to specification against the steering eye to prevent the tie bar from turning. Insufficient engagement of the steering eye threads could result in the steering eyes pulling off of the tie bar and disengaging the steering.



a - Steering eye
b - Tie bar
c - Jam nut
d - Maximum amount of exposed thread - 19 mm (3/4 in.)

4. Assemble the tie bar between the tie bar plates, as shown. Lubricate the threads of the attaching bolts with Loctite Moly Paste. Tighten the bolts to the specified torque. Tighten the locknuts to the specified torque.

5. Tighten the jam nut against the steering eye to the specified torque.



a - Starboard tie bar plate
b - Locknut (0.50 in.-20)
c - Port tie bar plate
d - Thick spacer
e - Tie bar
f - Thin spacer
g - Flat washer
h - Bolt (0.50 in.-20)
i - Jam nut

Tube Ref No.	Description	Where Used	Part No.
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Tie bar attaching bolt threads	Obtain Locally

Description	Nm	lb-in.	lb-ft
Bolts (0.50 in.-20)	54		40
Locknuts (0.50 in.-20)	27		20
Jam nut	54		40

IMPORTANT: After the installation is complete (and before operating outboards), check that the boat will turn right when the steering wheel is turned right and that the boat will turn left when the steering wheel is turned left. Check steering through full range (left and right) at all trim and tilt angles to ensure interference-free movement.

Maintenance Instructions

Maintenance inspection is the owner's responsibility and must be performed at the specific intervals.

Normal service - Every 50 hours of operation or 60 days (whichever comes first).

Severe service - Every 25 hours of operation or 30 days (whichever comes first).

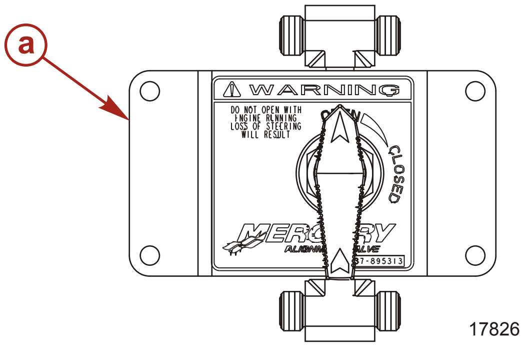
NOTE: Operation in saltwater is considered severe service.

1. Check the steering system components for wear. Replace any worn parts.
2. Check the steering system fasteners to ensure they are tightened to the correct torque specification.

Description	Nm	lb-in.	lb-ft
Tie bar attaching bolts	54		40
Locknuts located on the tie bar attaching bolts	27		20
Jam nut against the steering eye	54		40

Liquid Tie Bar Kit

Component Contained In Liquid Tie Bar Kit (893396A02)

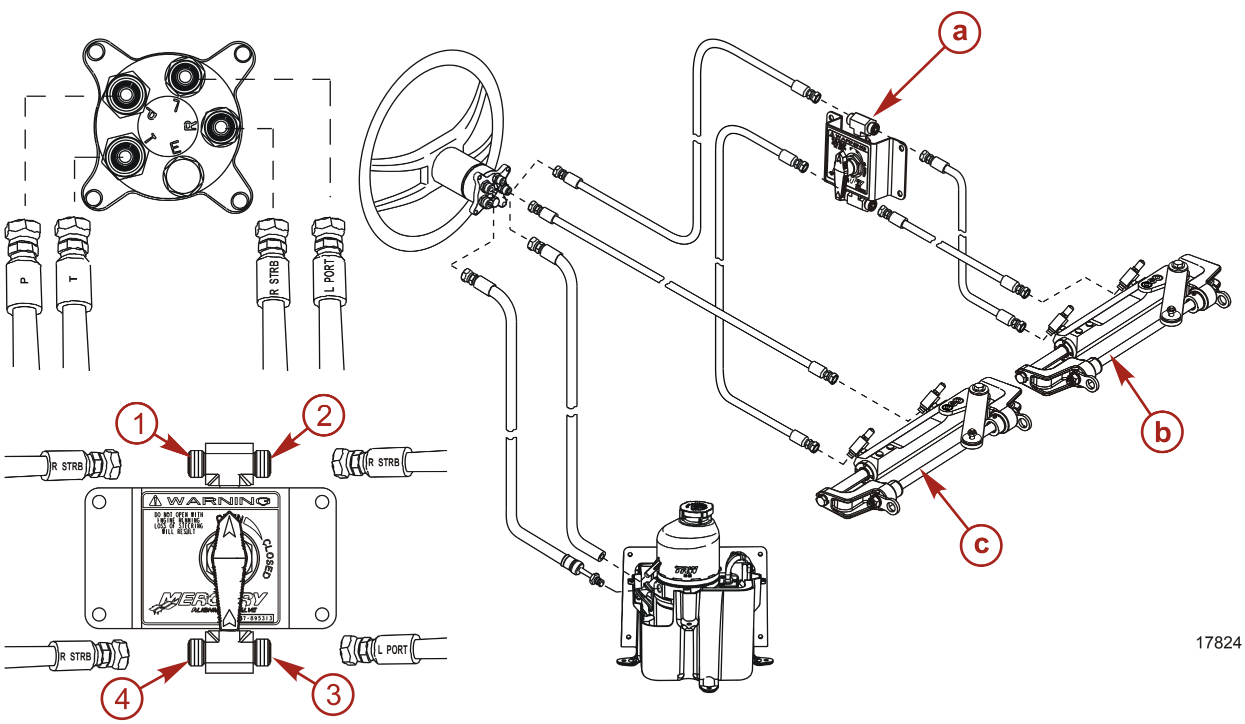


a - Tie bar valve

Liquid Tie Bar Installation

135/150/175/200 Verado with Power Steering

1. Mount the tie bar valve in an area where the valve will be accessible for making periodic realignments.
2. Refer to the **Mercury Precision Parts Accessories Guide** and order the hydraulic hoses in the required length.
3. Connect hydraulic hoses to the steering helm and power steering pump following the instructions which accompany the steering helm and pump.
4. Connect hydraulic hoses between the tie bar valve and steering cylinders.



a - Tie bar valve
b - Steering cylinder, starboard outboard
c - Steering cylinder, port outboard

Steering Helm Fitting ID Mark	Hose ID Mark	Description
P	P	Pressure from pump to helm
T	T	Tank low pressure return to pump
R	R STRB	Hose connects to tie bar valve
L	L PORT	Hose connects to starboard side fitting on port steering cylinder

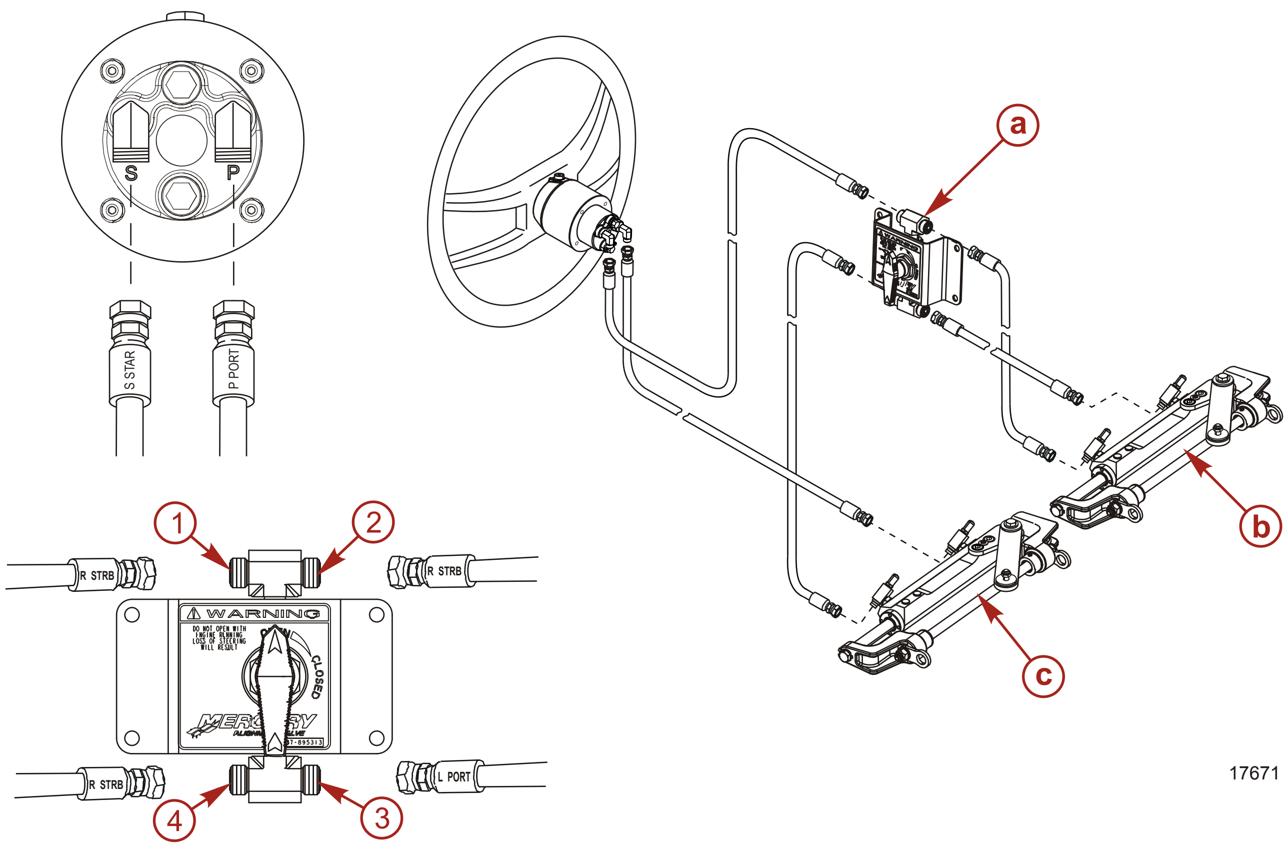
Tie Bar Valve Fitting ID	Hose ID Mark	Description
1	R STRB	Hose connects to R fitting on steering helm
2	R STRB	Hose connects to port side fitting on starboard steering cylinder
3	L PORT	Hose connects to starboard side fitting on starboard steering cylinder
4	R STRB	Hose connects to port side fitting on port steering cylinder

5. Open the tie bar valve.
6. Fill steering system with Synthetic Power Steering Fluid SAE 0W-30. Follow the filling instructions provided with the power steering pump. Complete the bleeding instructions following.

Tube Ref No.	Description	Where Used	Part No.
138	Synthetic Power Steering Fluid SAE 0W-30	Steering system	92-858076K01

135/150/175/200 Verado with Hydraulic Steering

1. Mount the tie bar valve in an area where the valve will be accessible for making periodic realignments.
2. Refer to the **Mercury Precision Parts Accessories Guide** and order the hydraulic hoses in the required length.
3. Connect hydraulic hoses to the steering helm following the instructions which accompany the steering helm.
4. Connect hydraulic hoses between the tie bar valve and steering cylinders.



a - Tie bar valve
b - Steering cylinder, starboard outboard
c - Steering cylinder, port outboard

Steering Helm Fitting ID Mark	Hose ID Mark	Description
S (starboard side)	R STRB	Hose connects to tie bar valve
P (port side)	L PORT	Hose connects to starboard side fitting on port steering cylinder

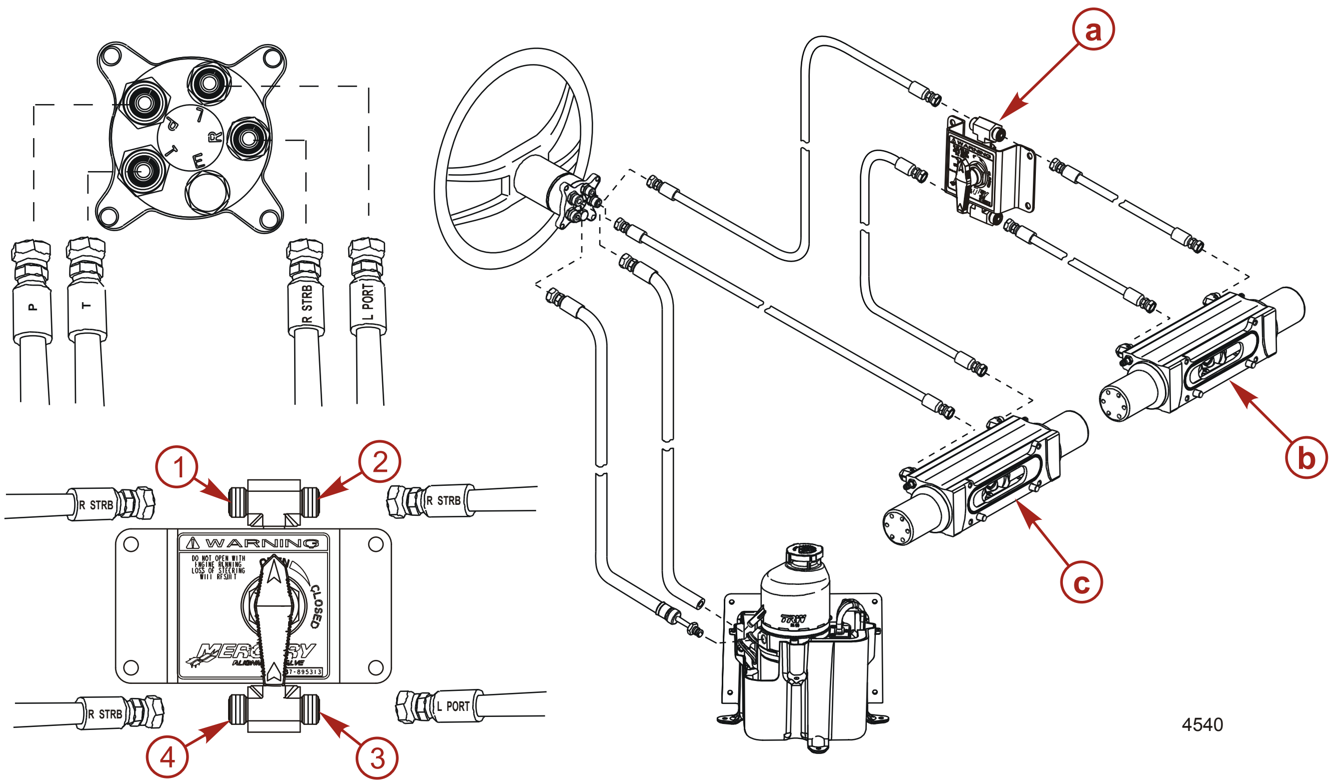
Tie Bar Valve Fitting ID	Hose ID Mark	Description
1	R STRB	Hose connects to S fitting (starboard side) on steering helm
2	R STRB	Hose connects to port side fitting on starboard steering cylinder
3	L PORT	Hose connects to starboard side fitting on starboard steering cylinder
4	R STRB	Hose connects to port side fitting on port steering cylinder

5. Open the tie bar valve.
6. Fill steering system with Hydraulic Helm Steering Fluid. Follow the filling instructions provided with the steering helm. Complete the bleeding instructions following.

Fluid Type	Capacity	Mercury Part Number
Hydraulic Helm Steering Fluid	1–2 liter (1–2 US qt) depending on length of steering hoses	92-858078Q01

200/225/250/275 Verado with Power Steering

1. Mount the tie bar valve in an area where the valve will be accessible for making periodic realignments.
2. Install steering cylinder (896500A01) to left-hand rotation outboard (XL, XXL). Follow the installation instructions which are provided with the steering cylinder.
3. Refer to the **Mercury Precision Parts Accessories Guide** and order the hydraulic hoses in the required length.
4. Connect hydraulic hoses to the steering helm and power steering pump following the instructions which accompany the steering helm and pump.
5. Connect hydraulic hoses between the tie bar valve and steering cylinders.



a - Tie bar valve
b - Steering cylinder, starboard outboard
c - Steering cylinder, port outboard

Steering Helm Fitting ID Mark	Hose ID Mark	Description
P	P	Pressure from pump to helm
T	T	Tank low pressure return to pump
R	R STRB	Hose connects to tie bar valve
L	L PORT	Hose connects to port side fitting on port steering cylinder

Tie Bar Valve Fitting ID	Hose ID Mark	Description
1	R STRB	Hose connects to R fitting on steering helm
2	R STRB	Hose connects to starboard side fitting on starboard steering cylinder
3	L PORT	Hose connects to port side fitting on starboard steering cylinder
4	R STRB	Hose connects to starboard side fitting on port steering cylinder

6. Open the tie bar valve.
7. Fill steering system with Synthetic Power Steering Fluid SAE 0W-30. Follow the filling instructions provided with the power steering pump. Complete the bleeding instructions following.

Tube Ref No.	Description	Where Used	Part No.
138	Synthetic Power Steering Fluid SAE 0W-30	Steering system	92-858076K01

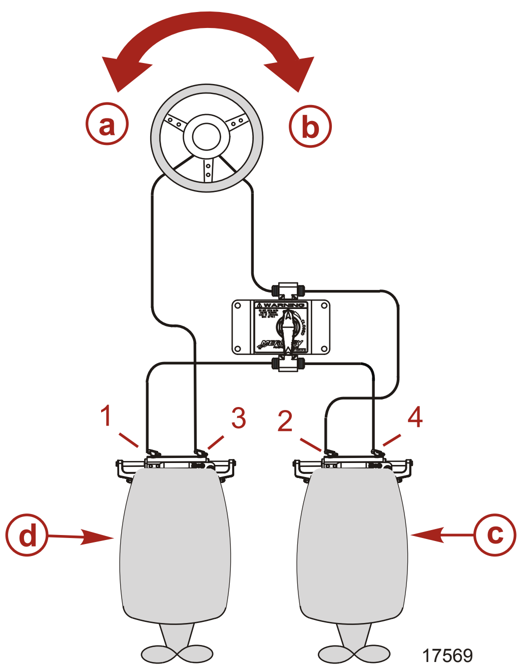
Bleeding Instructions

135/150/175/200 Verado

1. Power steering models - Have the engines running, or electrically operate the power steering pump using the power steering module primer kit.

Power Steering Module Primer Kit	91-895040K01

2. Open the tie bar valve.



a - Port steering wheel direction
b - Starboard steering wheel direction
c - Starboard outboard
d - Port outboard

NOTE: *Attach an 8 mm (5/16 in.) I.D. transparent bleed hose to the bleed fitting being opened. Route the other end of the bleed hose to a suitable container for hydraulic models or back into the steering pump tank for power steering models. On power steering models, do not bleed power steering fluid into a different container, this will only be pumping fluid out of the system that was just filled up.*

3. Turn steering wheel to starboard until the end of the steering cylinder (bleed fitting 1 end) arrives at the end of travel. Open bleed fitting 1. Turn steering wheel to starboard until an air free stream of fluid comes from fitting. Close bleed fitting 1.

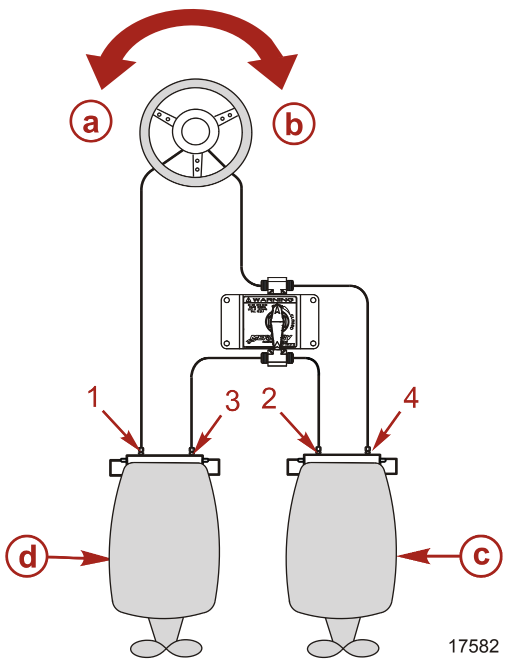
4. Take hold of the starboard outboard and turn it manually until the steering cylinder (bleed fitting 2 end) arrives at the end of travel. Open bleed fitting 2. Turn steering wheel to starboard until an air free stream of fluid comes from fitting. Close bleed fitting 2.
5. Open bleed fitting 3. Turn steering wheel to port until an air free stream of fluid comes from fitting. Close bleed fitting 3.
6. Turn steering wheel to port until the end of the steering cylinder (bleed fitting 3 end) arrives at the end of travel.
7. Open bleed fitting 4. Turn steering wheel to starboard until an air free stream of fluid comes from fitting. Close bleed fitting 4.
8. Close the tie bar valve.
9. Refer to **Realignment Instructions** (following) to align the outboards.

200/225/250/275 Verado

1. Have the engines running, or electrically operate the power steering pump using the power steering module primer kit.

Power Steering Module Primer Kit	91-895040K01

2. Open the tie bar valve.



a - Port steering wheel direction
b - Starboard steering wheel direction
c - Starboard outboard
d - Port outboard

***NOTE:** Attach an 8 mm (5/16 in.) I.D. transparent bleed hose to the bleed fitting being opened. Route the other end of the bleed hose back into the steering pump tank. Do not bleed power steering fluid into a different container, this will only be pumping fluid out of the system that was just filled up.*

3. Turn steering wheel to starboard until the port outboard is facing bleed fitting 1 and contacting the full steering stop. Open bleed fitting 1 until an air free stream of fluid comes from fitting. Close bleed fitting 1.
4. Take hold of the starboard outboard and turn it manually so it is facing bleed fitting 2 and contacting the full steering stop. Open bleed fitting 2 until an air free stream of fluid comes from fitting. Close bleed fitting 2.
5. Open bleed fitting 3. Take hold of the port outboard and manually turn it so it is facing bleed fitting 3 and contacting the full steering stop. Leave bleed fitting open until an air free stream of fluid comes from fitting. Close bleed fitting 3.
6. Open bleed fitting 4. Take hold of the starboard outboard and manually turn it so it is facing bleed fitting 4 and contacting the full steering stop. Leave bleed fitting open until an air free stream of fluid comes from fitting. Close bleed fitting 4.
7. Close the tie bar valve.
8. Refer to **Realignment Instructions** (following) to align the outboards.

Realignment Instructions

During normal usage, it is possible for the outboards to become misaligned. Outboard alignment should be checked before each use.

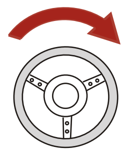
If misalignment occurs, complete the following steps to realign.

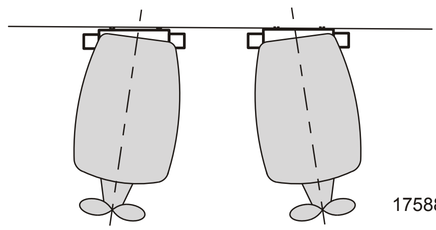
Propellers too Far Apart

1. Power steering models - Have the engines running, or electrically operate the power steering pump using the power steering module primer kit.

Power Steering Module Primer Kit	91-895040K01

2. Turn the steering wheel to full starboard. Both outboards will move. Starboard outboard will contact its full steering stop first.
3. After the starboard outboard contacts its full steering stop, open the tie bar valve.
4. Continue to turn the steering wheel to full starboard until the port outboard contacts its full steering stop.
5. Close the tie bar valve.





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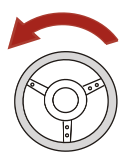
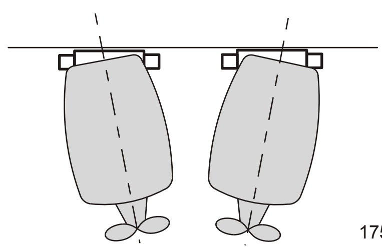
Propellers too Close Together

1. Power steering models - Have the engines running, or electrically operate the power steering pump using the power steering module primer kit.

Power Steering Module Primer Kit	91-895040K01

2. Turn the steering wheel to full port. Both outboards will move. Starboard outboard will contact its full steering stop first.
3. After the starboard outboard contacts its full steering stop, open the tie bar valve.
4. Continue to turn the steering wheel to full port until the port outboard contacts its full steering stop.
5. Close the tie bar valve.





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Steering

Section 8A - Power Steering

Table of Contents

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A

Power Steering Specifications

Power Steering Specifications	
Fluid type	Synthetic Power Steering Fluid SAE 0W-30
Capacity	Typical 1–2 liters (1–2 US quarts)
Current draw	Not to exceed 75 A
Steering ratio (32 cc helm and single steering cylinder, lock to lock) - preferred configuration	3.8 turns
Steering ratio (40 cc helm and single steering cylinder, lock to lock)	3.0 turns
Steering ratio (50 cc helm and single steering cylinder, lock to lock)	2.4 turns
Steering ratio (32 cc helm with dual steering cylinders, lock to lock)	7.6 turns
Steering ratio (40 cc helm with dual steering cylinders, lock to lock) - preferred configuration	6.0 turns
Steering ratio (50 cc helm with dual steering cylinders, lock to lock)	4.8 turns

Lubricants, Sealants, Adhesives

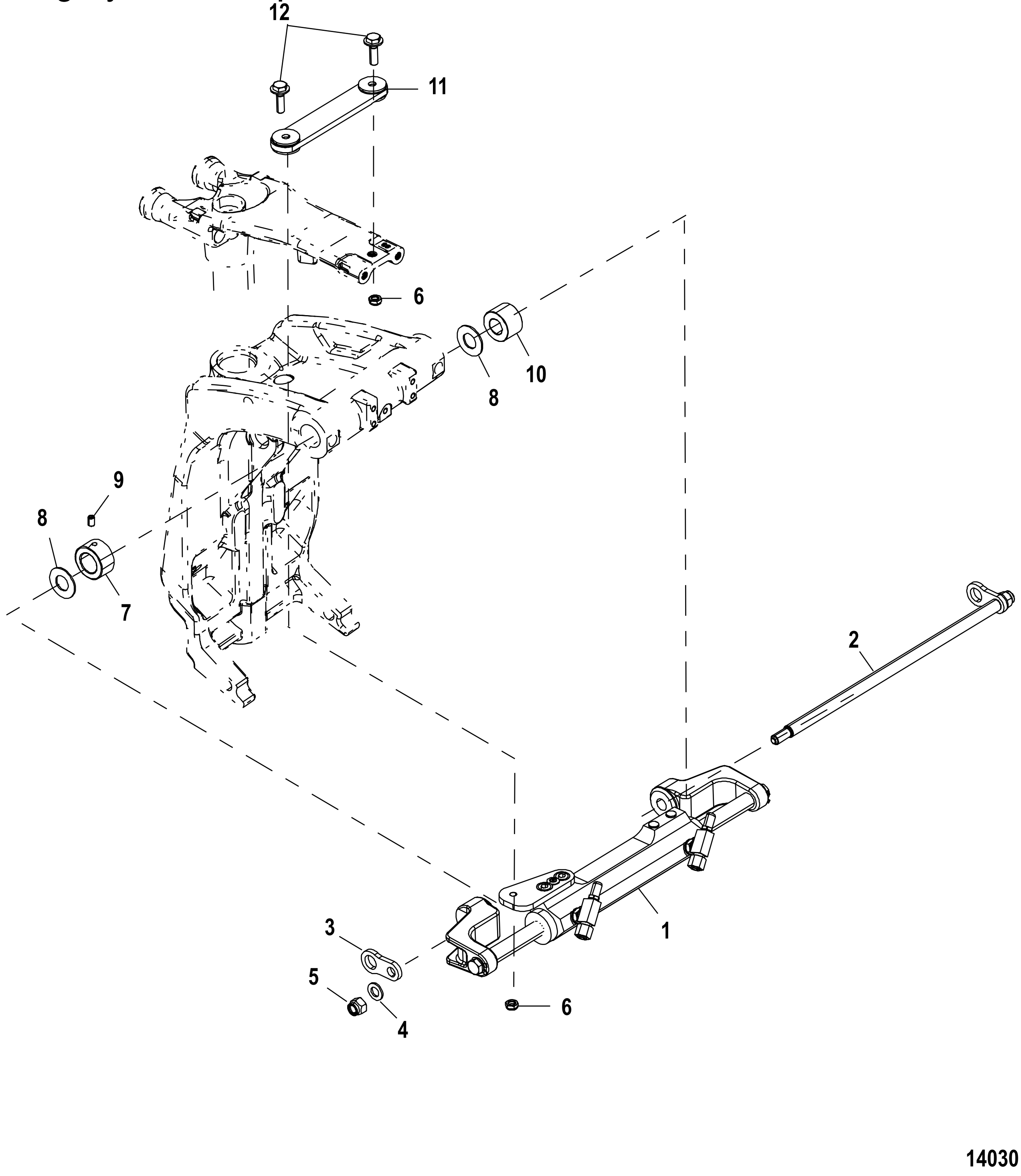
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Steering cylinder tie rod surface	92-802859A 1
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Steering cylinder tie rod threads	Obtain Locally
138	Synthetic Power Steering Fluid SAE 0W-30	Power steering pump	92-858076K01

Special Tools

Power Steering Module Primer Kit	91-895040K01
	Bleeds power steering system without running engine.

Notes:

Steering Cylinder Components

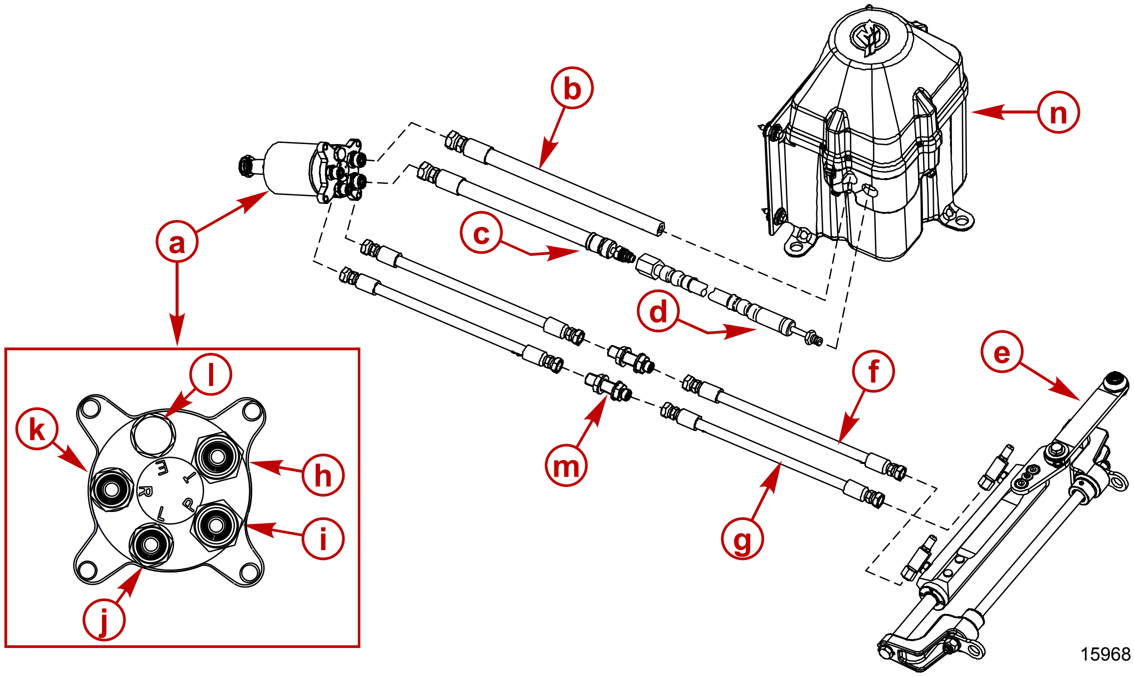


Steering Cylinder Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Steering actuator assembly			
2	1	Tie rod assembly			
3	1	Lifting eye plate			
4	1	Washer			
5	1	Nut	88		65
6	2	Nut (0.375-24)	27		20
7	1	Collar			
8	2	Washer			
9	1	Set screw	9	80	
10	1	Spacer			
11	1	Steering link assembly			
12	2	Screw (0.375-24 x 1.375)	54.2		40

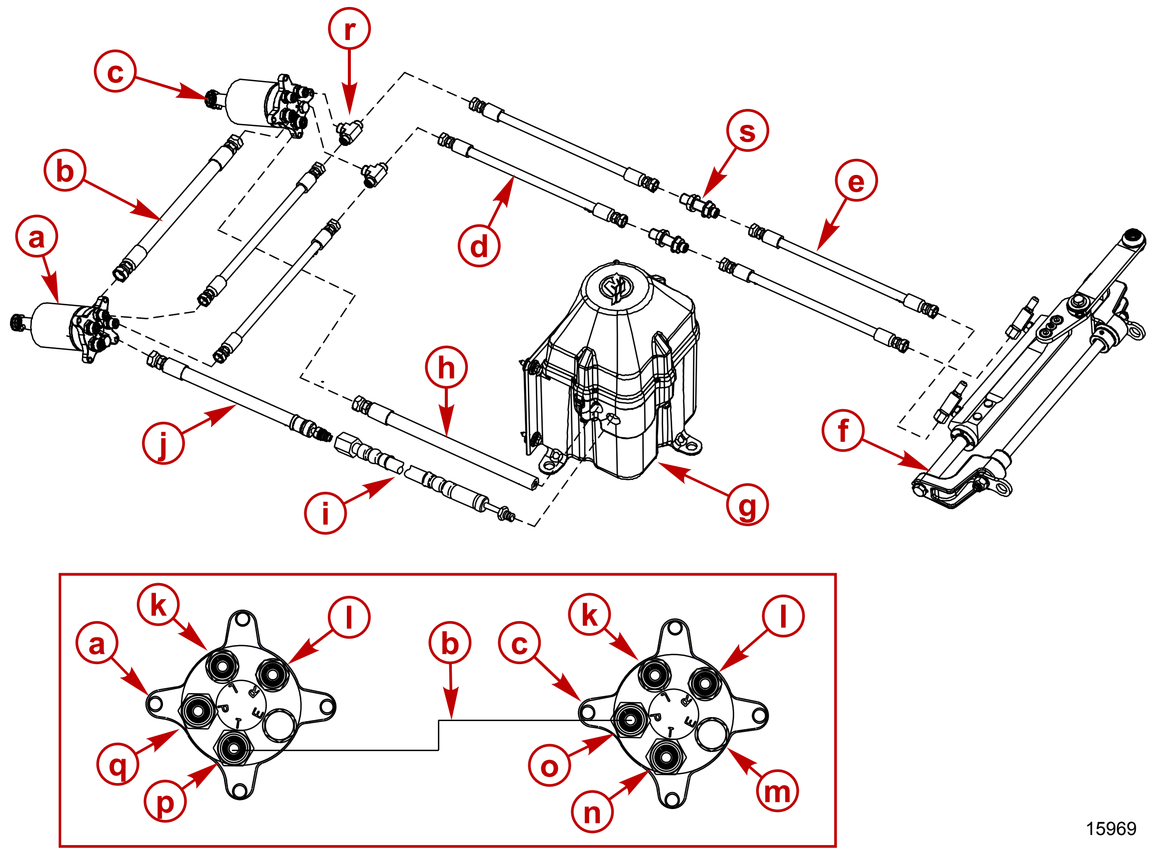
Power Steering Systems

Single Helm - Single Cylinder



- a - Helm
- b - Tank hose (T)
- c - Pressure hose (P)
- d - Sound dampening hose
- e - Power steering cylinder
- f - Hose to port side of steering cylinder
- g - Hose to starboard side of steering cylinder
- h - "T" - Tank connection
- i - "P" - Pressure connection
- j - "L" - Starboard connection
- k - "R" - Port connection
- l - Plug
- m - Bulkhead fitting (2) (optional)
- n - Power steering pump module

Dual Helm - Single Cylinder



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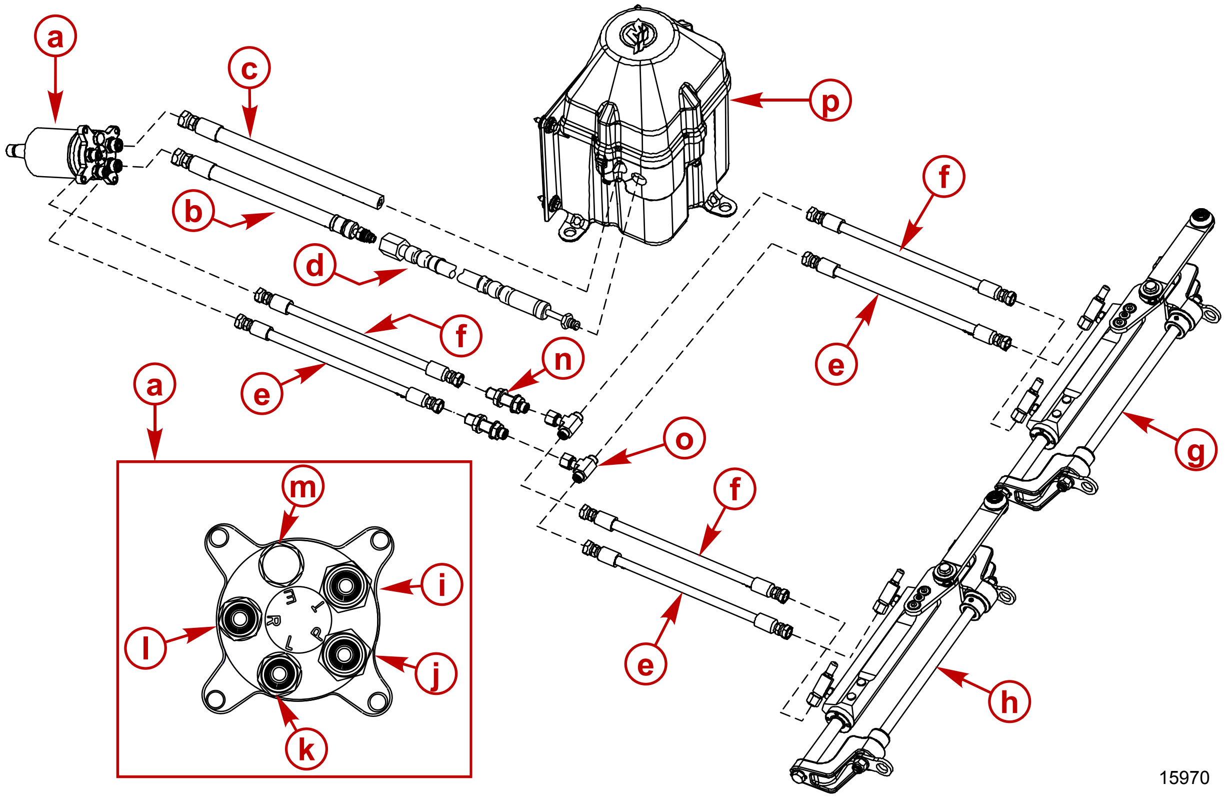
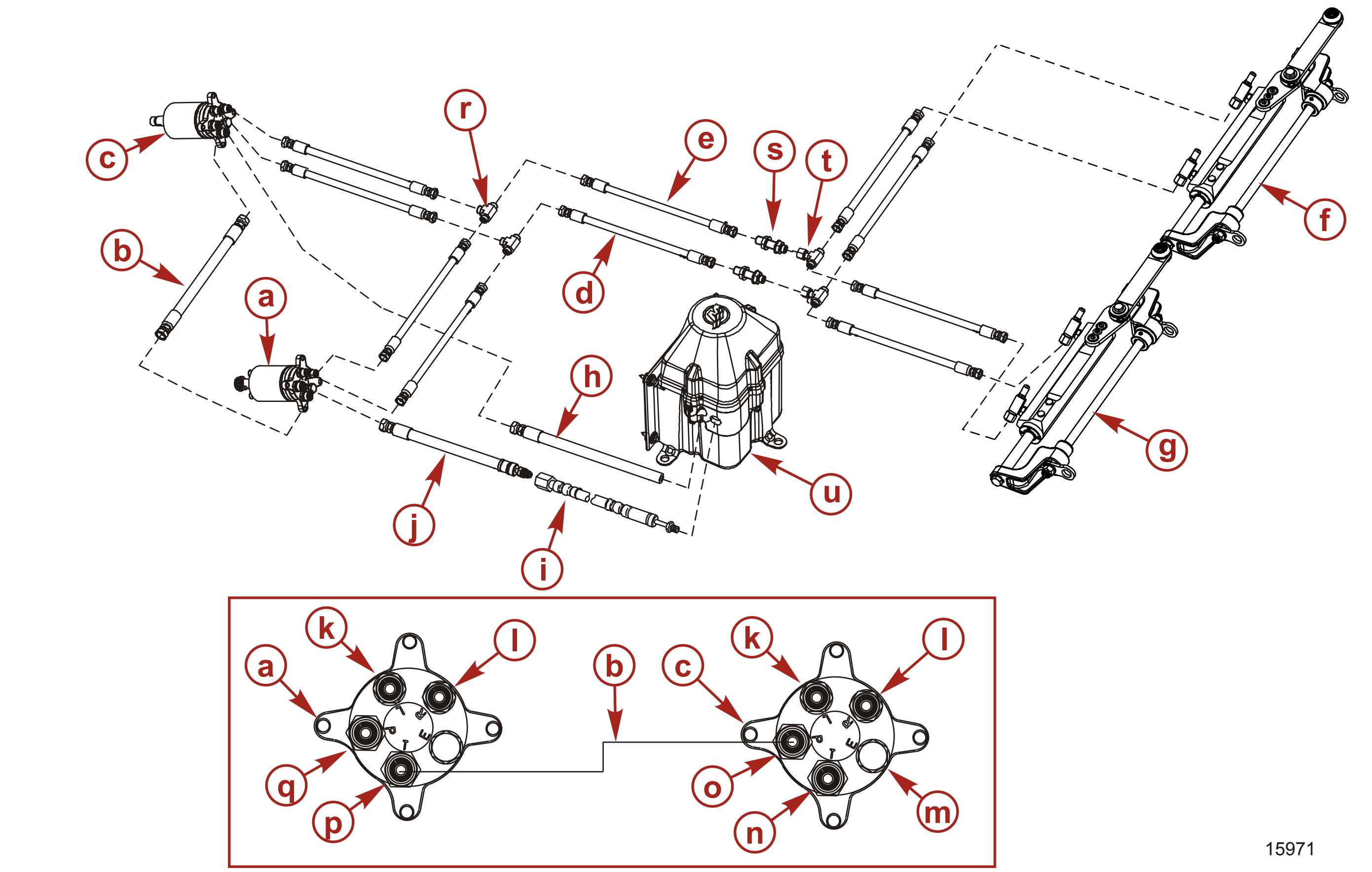
- a - Main helm
- b - Tank 1 to pressure 2 hose
- c - Second helm
- d - Hose to starboard side of steering cylinder
- e - Hose to port side of steering cylinder
- f - Power steering cylinder
- g - Power steering pump module
- h - Tank hose (T)
- i - Sound dampening hose
- j - Pressure hose (P)
- k - "L" - Starboard connection
- l - "R" - Port connection
- m - Plug
- n - "T" - Tank 2 (return to tank connection)
- o - "P" - Pressure 2 connection
- p - "T" - Tank 1 connection (to "P" 2)
- q - "P" - Pressure 1 (supply from pump connection)
- r - T-fitting (2)
- s - Bulkhead fitting (2) (optional)

Single Helm - Dual Cylinder



- a - Helm
- b - Pressure hose (P)
- c - Tank hose (T)
- d - Sound dampening hose
- e - Hose to starboard side of steering cylinder
- f - Hose to port side of steering cylinder
- g - Starboard power steering cylinder
- h - Port power steering cylinder
- i - "T" - Tank connection
- j - "P" - Pressure connection
- k - "L" - Starboard connection
- l - "R" - Port connection
- m - Plug
- n - Bulkhead fitting (2) (optional)
- o - Swivel T-fitting (2)
- p - Power steering pump module

Dual Helm - Dual Cylinder



- **a -** Main helm
- **b -** Tank 1 to pressure 2 hose
- **c -** Second helm
- **d -** Hose to starboard side of steering cylinder
- **e -** Hose to port side of steering cylinder
- **f -** Starboard power steering cylinder
- **g -** Port power steering cylinder
- **h -** Tank hose (T)
- **i -** Sound dampening hose
- **j -** Pressure hose (P)
- **k -** "L" - Starboard connection
- **l -** "R" - Port connection
- **m -** Plug
- **n -** "T" - Tank 2 (return to tank connection)
- **o -** "P" - Pressure 2 connection
- **p -** "T" - Tank 1 connection (to "P" 2)
- **q -** "P" - Pressure 1 (supply from pump connection)
- **r -** T-fitting (2)
- **s -** Bulkhead fitting (2) (optional)
- **t -** Swivel T-fitting (2)
- **u -** Power steering pump module

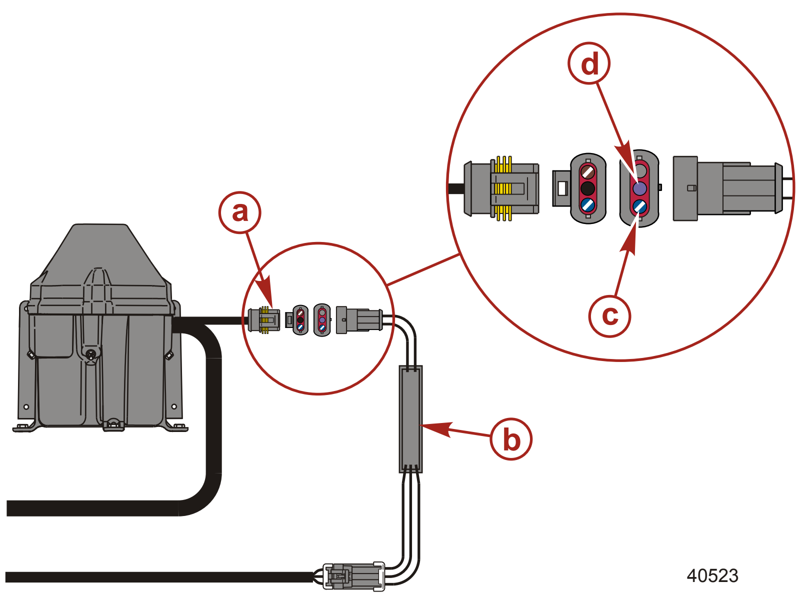
Troubleshooting the Power Steering System

Power Steering Module Primer Kit	91-895040K01

Problem	Possible Cause	Remedy
Power steering system operates (pump runs), but the outboard does not steer.	Hoses connections.	Check the pressure and tank hoses for correct connections at helm.
Power steering system operates (pump runs), but the outboard does not steer, steers slowly, or erratic. Hose connections are correct.	Air in system.	Bleed the power steering system. Refer to **Filling Power Steering System with Engine Running.**
Power steering pump does not operate (pump does not run).	Blown fuse, battery connections, or low voltage.	1. Check fuse at power steering pump. Replace if blown. 2. Check battery connection. 3. Check battery voltage. It must be greater than 10.5 volts.
Power steering pump does not operate (pump does not run). Fuse is good. Battery is good.	Driver module.	1. Check pin connections. Refer to **Troubleshooting an Inoperable Power Steering Pump.** Replace if defective. 2. Refer to **Filling Power Steering System with Engine Not Running.**
Power steering pump does not operate (pump does not run). Fuse is good. Driver module is good.	Driver module harness.	1. Check the driver module harness connections. Replace if defective. 2. Start the pump with primer module. Refer to **Filling Power Steering System with Engine Not Running.** If pump starts, replace the driver module harness.
Power steering pump does not operate (pump does not run). Fuse is good. Driver module is good. Signal harness is good.	Outboard PCM.	1. Start the pump with primer module. Refer to **Filling Power Steering System with Engine Not Running.** If pump starts, test the PCM. 2. Test the PCM. Refer to **Section 2A - Troubleshooting with the Computer Diagnostic System (CDS).**

Troubleshooting an Inoperable Power Steering Pump

1. Verify the battery cables, power steering pump signal harnessing, and driver module, are installed according to the engine's installation/service manual architecture.
2. Verify that battery voltage is present on the battery cables leading to the power steering pump. Be sure to check the voltage on the power steering pump side of the fuse located on the positive cable.
   a. When battery voltage is present on these leads, the power steering pump will actuate when the expected voltage is completed from the power steering signal harness/driver module. This voltage is sent in a two-step process: Step 1 - key on, Step 2 - engine starts and runs.
      - The power steering pump may ramp-up slowly if this two-step process is not completed.
      - The power steering pump will not actuate unless the engine is running.
3. Check for proper voltage across the power steering driver module. To test, open the connection between the driver module and the power steering pump.



a - Power steering pump harness connector
b - Power steering driver module
c - Pin 1 (blue/white)
d - Pin 2 (purple)

a. With the key in the off position, no voltage should be present across the blue/white to purple wire or across either of these wires to ground.

b. With the key on and the engine not running, battery voltage must be present across the purple lead and the engine/battery ground.

- There should be less than 1 volt (<1 volt) across the blue/white wire and engine/battery ground.

DMT Meter Leads			
	Red	Black	Circuit voltage =
Power steering driver module - key on and engine off	Purple	Engine/battery ground	Battery voltage
	Blue/white	Engine/battery ground	<1 volt

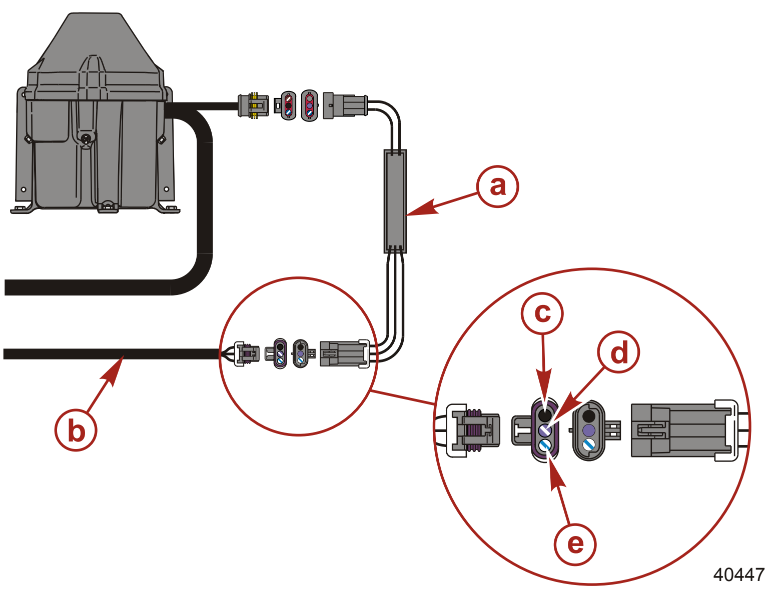
c. With the engine running, battery voltage should be present across the blue/white lead and engine/battery ground, and across the purple lead and engine/battery ground.

DMT Meter Leads			
	Red	Black	Circuit voltage =
Power steering driver module - engine starts and runs	Purple	Engine/battery ground	Battery voltage
	Blue/white	Engine/battery ground	Battery voltage

- If these voltages are not observed with a good battery and key switch harness, continue with testing the power steering signal harness circuit.
- If the voltages are correct across the driver module, the power steering pump may be the problem. Use the power steering module primer kit to confirm a power steering pump failure.

Power Steering Module Primer Kit	91-895040K01

4. Check for proper voltage across the power steering signal harness. To test, open the connection between the power steering signal harness and the driver module.



a - Power steering driver module
b - Power steering signal harness - to engine
c - Pin A (black)
d - Pin B (purple/white)
e - Pin C (white/blue)

NOTE: These procedures cover a single engine application. A multi-engine signal harness adapter will be installed on boats powered by multiple outboards. Be sure to check for the proper voltages before and after the multi-engine adapter harness.

a. With the key in the off position, no voltage should be present across any wire pair of the three signal harness wires or across any of these wires to ground.

b. With the key on and the engine not running, battery voltage should be present across the purple/white and black wires.

- There should be less than 1 volt (<1 volt) between the purple/white and white/blue wires.

DMT Meter Leads			
	Red	Black	Circuit voltage =
Power steering signal harness - key on and engine off	Purple/white	Black	Battery voltage
	Purple/white	White/blue	<1 volt

c. With the engine running, battery voltage should be present across the purple/white and white/blue wires, and across the purple/white and black wires.

DMT Meter Leads			
	Red	Black	Circuit voltage =
Power steering signal harness - engine starts and runs	Purple/white	Black	Battery voltage
	Purple/white	White/blue	Battery voltage

- If these voltages are not observed with a good battery and key switch harness, check for the same voltages at the engine wire harness which connects to the signal harness. If the listed voltages are not present, a problem may exist within the 3 wire circuit on the engine wire harness or the PCM. With the PCM disconnected, complete an ohms/continuity check on these wires. If the circuits have no shorts to ground and less than one ohm of resistance, a PCM may be the problem.

If the power steering pump is inoperable, test the power steering pump directly with the power steering primer module, bypassing the engine and all boat harnessing. With battery power hooked to the power steering pump and the primer module installed, a working power steering pump will operate when the two-stage module is activated in the proper sequence. Refer to the instruction sheet supplied with the power steering primer module kit.

Power Steering Module Primer Kit	91-895040K01

Vessels with Multi-Engine Electro-Hydraulic Power Steering Troubleshooting Tips

NOTE: On installations exhibiting these symptoms, all engines will still start and run normally.

Problem: All engines power-up with the activation of a single key switch.

Symptoms:

- The key-on systems check horn chirp will sound for all engines when the first key is turned on (sounds like one horn). If only one key is turned on, an e-stop alarm will be activated (six intermittent beeps). This is because all engines and/or command modules are powered up with a single key on and the remaining engine key switches are still in the off position.
- When the other keys are turned on, the key-on horn chirp will not sound and the e-stop alarms will clear.

Possible problem: Multi-engine power steering adapter harness.

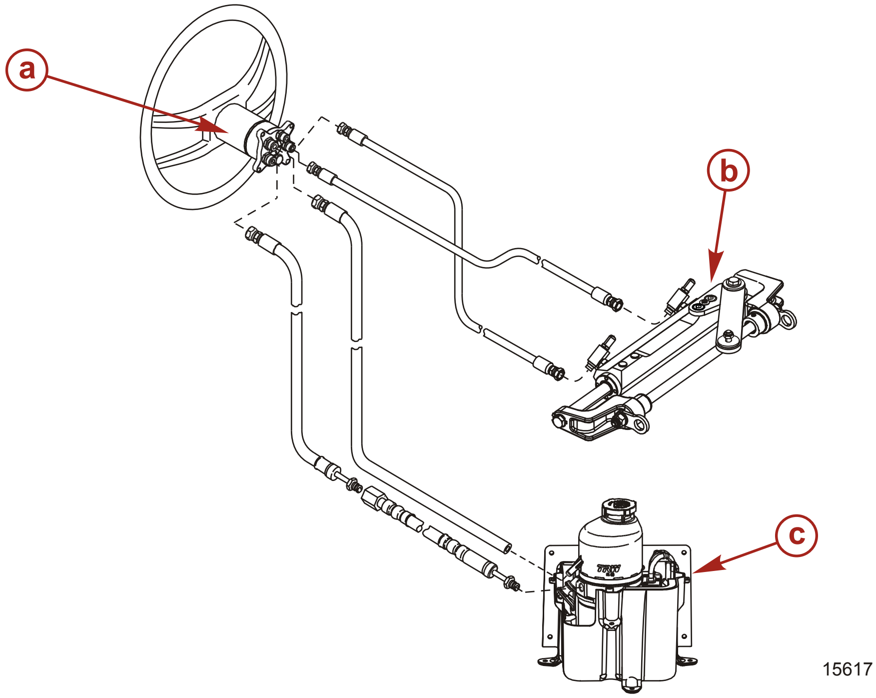
Diagnostic procedure: Remove the multi-engine adapter harness. Connect the power steering signal harness from the starboard/outside engine directly to the power steering pump. Turn the starboard/outside key switch to the run position. If the sister engines no longer power-up with a single key switch, the multi-engine power steering adapter harness is the problem. Replace as necessary.

Part number for replacement multi-engine power steering adapter harness:

- Dual - 892868T01
- Triple - 892868T02
- Quad - 892868T03

Power Steering Installation

Power Steering System



a - Steering helm
b - Steering cylinder on outboard
c - Power steering pump

Installation Procedure

Selecting Location for the Power Steering Pump

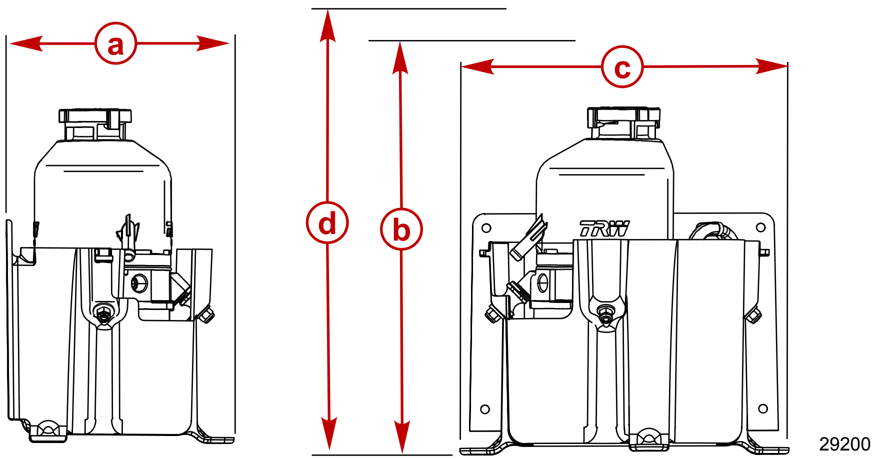
⚠ WARNING

Dirt or contaminants in the hydraulic steering system can damage the steering system's internal components. Damaged components can lead to serious injury or death due to loss of boat control. Do not allow dirt or contamination to enter the helm, lines, or cylinder of this steering system and perform all hydraulic inspections, service, or assembly procedures in a clean work area.

Select a mounting location (floor or side of internal bulkhead) for the installation of the power steering pump that meets the following requirements:

- To reduce noise on aluminum or metal hulls, isolate steering hoses from hull with suitable nonabrasive hangers.
- Steering hoses from steering wheel helm must be free of twists or stress. Gently secure hose bundle together with a cable tie, located approximately 25.4 cm (10 in.) from the steering wheel helm.
- Do not mount pump on an angle greater than 15° from vertical position.
- The pump electrical wiring must be within reach of the auxiliary battery.
- Pump should be mounted in an area that allows sound enclosure, cover removal, and easy access to the fill cap.
- Install the pump in an area where bilge water will not contaminate the pump.
- To reduce transmitted noise, mount the pump on a wood or fiberglass surface. Avoid mounting the pump on aluminum or steel surfaces.

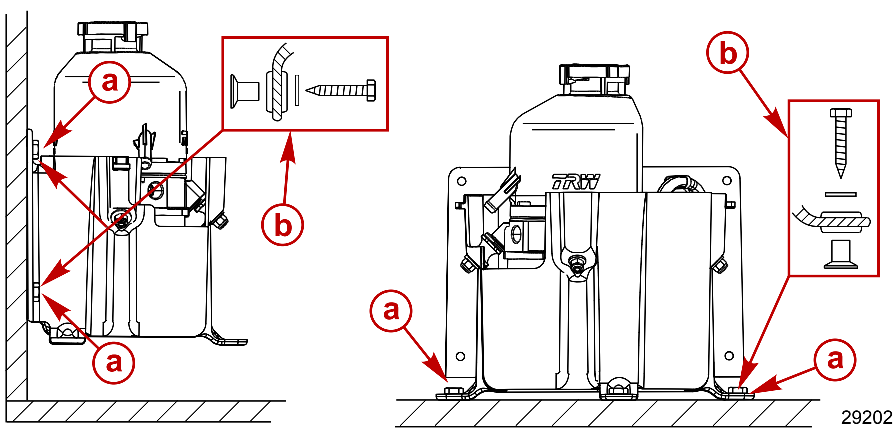
Required Mounting Clearances for the Power Steering Pump



- a - 215 mm (8-1/2 in.)
- b - 310 mm (12-7/32 in.) to top cover (not shown)
- c - 285 mm (11-1/4 in.)
- d - 432 mm (17 in.) clearance required for cover removal

Installing Power Steering Pump

1. The power steering pump can be mounted two ways:
   - On a side of the internal bulkhead
   - Mounted on the floor
2. Mount the power steering pump at the selected location, using appropriate fastening hardware suitable for the type of material and thickness of the mounting surface.



Mounted on internal bulkhead   Mounted on the floor

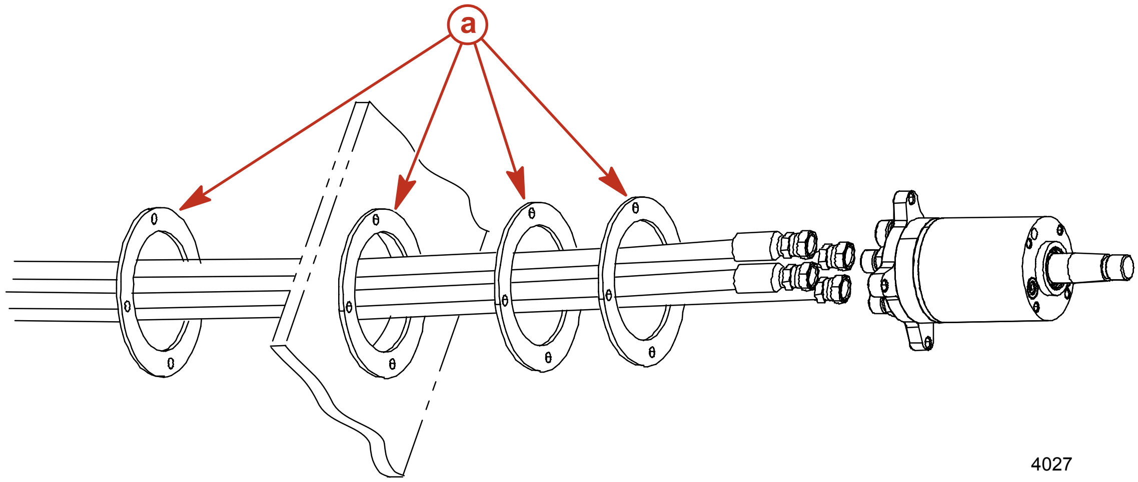
- a - Lag screws or through bolts (3 or 4)
- b - Mounting hardware

Connection of the Hydraulic Hoses to the Power Steering Helm

NOTE: Hoses must be routed up through steering helm opening in dash and secured to helm fittings prior to mounting the steering helm.

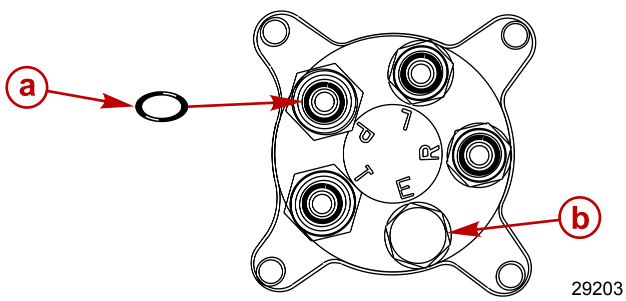
1. Place the steering hoses through one backing plate on the internal side of the dashboard. Route the steering hoses through the drilled opening, and place the required amount of backing plates on the hoses on the external side of the dashboard.

NOTE: The number of backing plates varies depending on helm displacement.



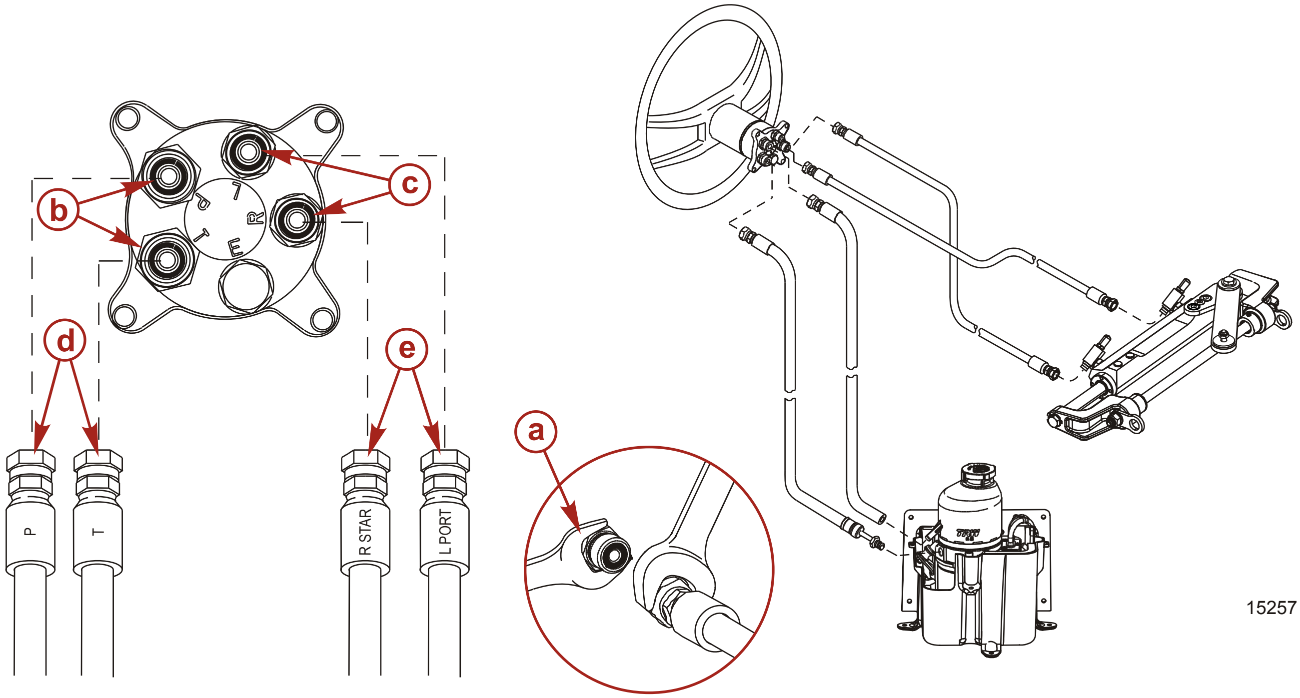
a - Backing plates

2. Remove and discard the shipping caps from the ends of the four fittings on the steering helm. Ensure the O-ring seals did not lift off with the shipping caps.
3. Ensure O-ring seals are in place on end of steering helm fittings.



a - O-ring seals (4)
b - Plug - not used

4. Make the hose connections to the steering helm as shown. Use a thin wrench and hold the helm fittings from turning while tightening hoses. Do not overtighten the hose connections.



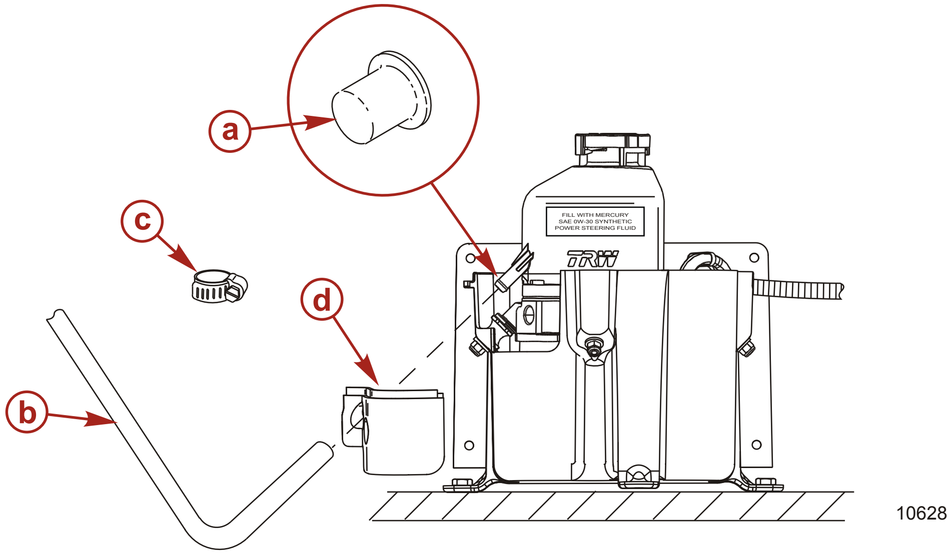
- **a -** Thin wrench
- **b -** Helm hex fitting wrench size (P and T) - 19 mm (3/4 in.)
- **c -** Helm hex fitting wrench size (R and L) - 16 mm (5/8 in.)
- **d -** Hydraulic hose hex fitting wrench size (P and T) - 21 mm (13/16 in.)
- **e -** Hydraulic hose hex fitting wrench size (R STAR and L PORT) - 18 mm (11/16 in.)

Helm Fitting ID Mark	Hose ID Mark	Description
P	P	Pressure from pump to helm
T	T	Tank low pressure return to pump
R	R STAR	Hose connects to port side of steering cylinder
L	L PORT	Hose connects to starboard side of steering cylinder

Connection of the Hydraulic Hoses to the Power Steering Pump

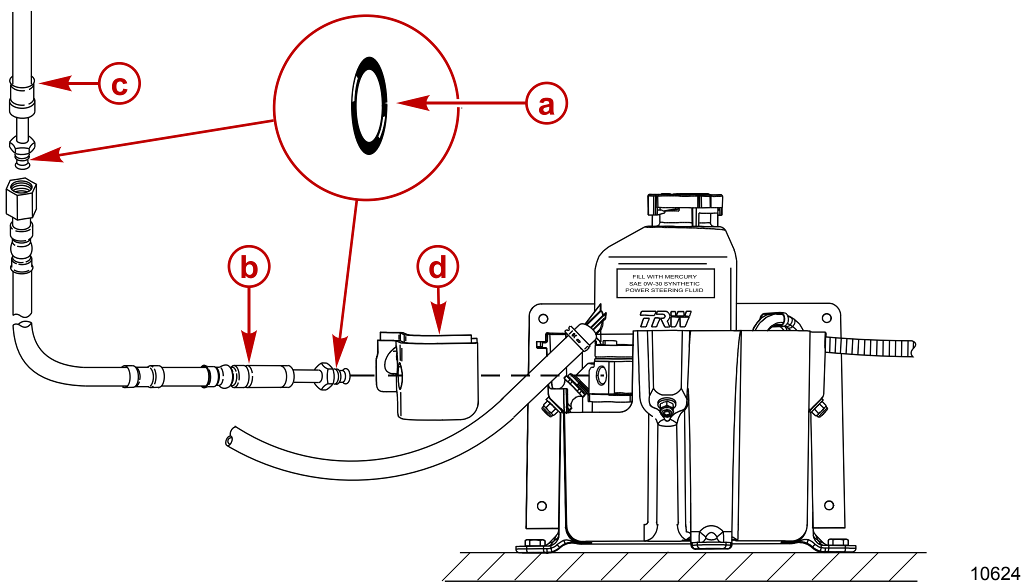
1. Remove and discard the yellow protector cap from the reservoir.

2. Connect the low-pressure hydraulic hose from the steering helm to the low-pressure fitting on the pump reservoir as shown. Fasten hose to fitting with a hose clamp.



a - Yellow protector cap (remove and discard)
b - Low-pressure hydraulic hose from steering helm
c - Hose clamp
d - Grommet

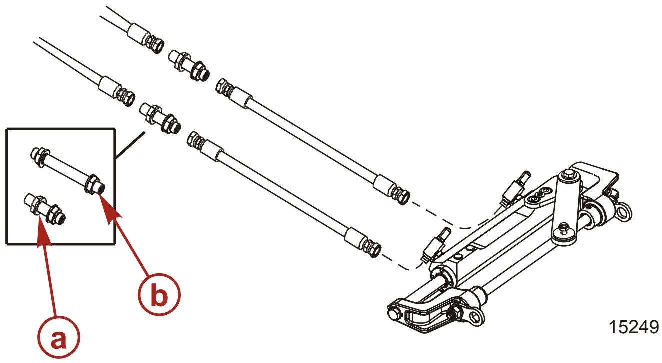
3. Remove and discard cap and plug from the ends of the dampening hose.
4. Ensure the O-ring seal is on the end of the dampening hose fitting.
5. Connect the high-pressure dampening hose to the power steering pump.
6. Ensure the O-ring seal is on the end of a high-pressure hydraulic steering hose fitting.
7. Connect the high-pressure hydraulic hose from the steering helm to the dampening hose.
8. Install grommet on power steering pump enclosure.



a - O-ring
b - Dampening hose
c - High-pressure hydraulic steering hose
d - Grommet

Connection of the Hydraulic Hoses to the Steering Cylinder

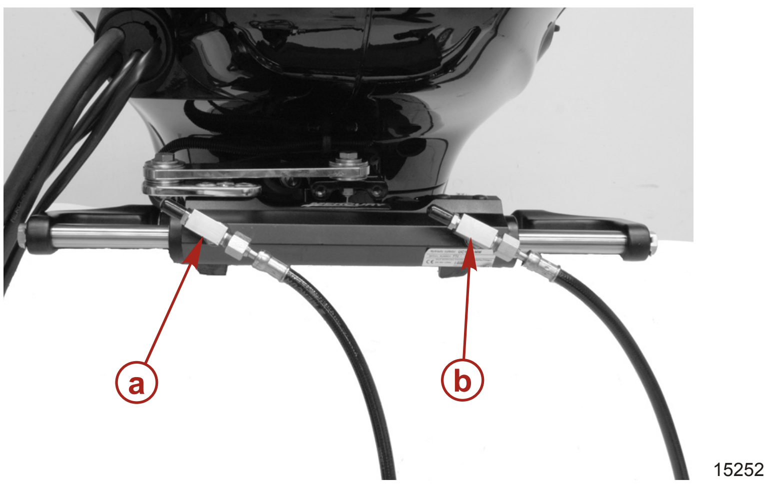
1. Route the hydraulic hoses to the outboard steering cylinder. Bulkhead fittings are available if an opening does not exist in the engine well.



a - Bulkhead fitting - bulkhead thickness up to 1.9 cm (0.75 in.) (22-892517)
b - Bulkhead fitting - bulkhead thickness up to 7.62 cm (3 in.) (22-892518)

NOTE: The 90° hose fittings are available and can be threaded onto the hose fittings if straight hose routing is desired.

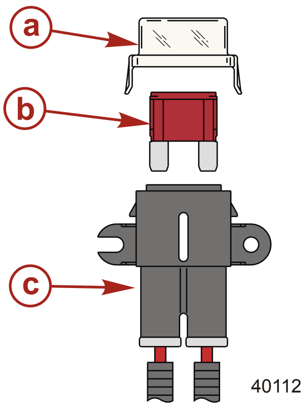
2. Position hose fittings to the desired direction. Loosen fastening nuts in order to rotate. Position fittings and tighten fastening nuts.
3. Ensure O-ring seals are in place on end of each fitting.
4. Make the hose connections to the steering cylinder as shown.



a - Starboard fitting - Hose marked L PORT
b - Port fitting - Hose marked R STAR

Power Steering Pump Harness Installation

1. Mount the power steering pump harness fuse so the cover is up, and in a location that is accessible. Ensure the power steering pump harness battery ring terminals can reach the battery. Secure the fuse housing with appropriate hardware.



a - Fuse cover
b - 50 amp maxi fuse
c - Fuse housing

2. Connect the red cable from the power steering pump harness to the positive post on the battery and secure with a nut. Tighten the nut to the specified torque.
3. Connect the black cable from the power steering pump harness to the negative post on the battery and secure with a nut. Tighten the nut to the specified torque.

Description	Nm	lb-in.	lb-ft
Battery nuts	13.5	120	

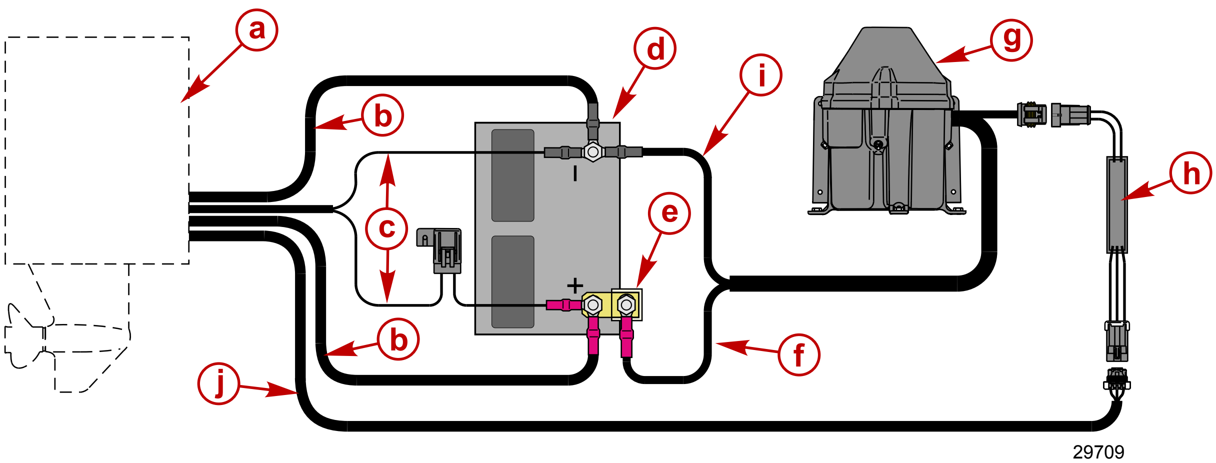
4. Connect the driver module harness connector to the power steering pump harness connector.
5. Connect the power steering signal harness to the driver module harness connector.

   NOTE: On multiple engine applications, connect the driver module harness to the dual, triple, or quad engine power steering signal harness adapter.
6. Route the power steering signal harness to the engines.
7. Secure the power steering signal harness with cable ties to prevent damage.

   IMPORTANT: On multiple engine installations, an automatic power switch (APS) must be used to connect all starting batteries to the power steering pump. The APS directs the voltage from the battery with the highest capacity charge to the output terminal of the APS.

Electrical Connections to the Steering Pump

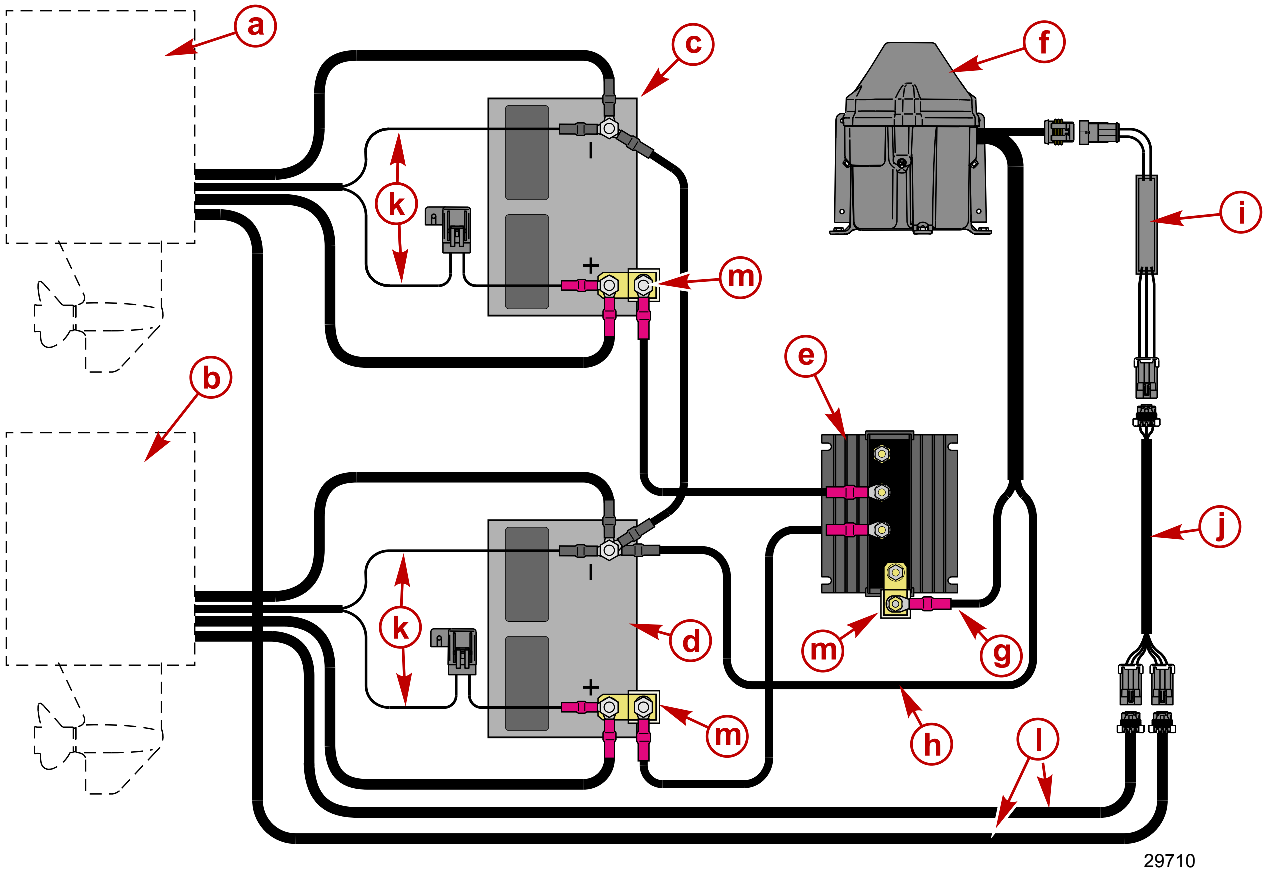
NOTE: For single engine installation, the power steering pump battery cables should be connected directly to the outboard starting battery.



Single engine application

- a - Engine
- b - Battery cable
- c - DTS power harness
- d - Battery
- e - Power steering fuse - 90 amp
- f - Power steering pump 12 V positive harness
- g - Power steering pump
- h - Power steering pump driver module harness
- i - Power steering pump ground harness
- j - Power steering signal harness

NOTE: On multiple installations, the automatic power switch (APS) (87-895091K01) must be used to connect all outboard starting batteries to the power steering pump. The APS allows battery voltage to be drawn from the starting battery with the highest state of charge.



Dual engine application

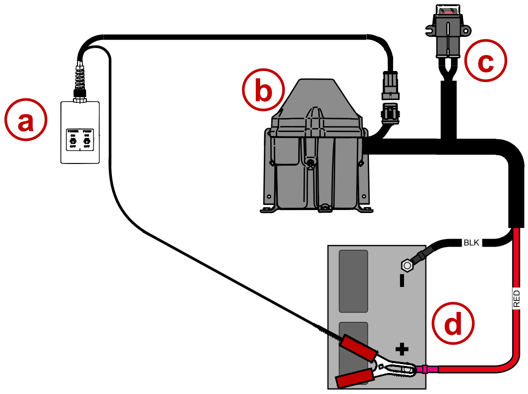
- a - Port engine
- b - Starboard engine
- c - Port engine cranking battery
- d - Starboard engine cranking battery
- e - Automatic power switch (APS)
- f - Power steering pump
- g - Power steering pump to APS output terminal
- h - Power steering pump to cranking battery negative
- i - Power steering pump driver module harness
- j - Dual engine power steering adapter
- k - DTS power harness
- l - Power steering signal harness
- m - Fuse - 90 amp

Filling Power Steering System (Engine Not Running)

Use Synthetic Power Steering Fluid SAE 0W-30 in the power steering system. In an emergency, if recommended power steering fluid is not available, the use of any full synthetic engine oil can be temporarily used. The power steering fluid should then be drained and replaced with Synthetic Power Steering Fluid SAE 0W-30 as soon as possible to avoid loss of performance in the power steering system.

Tube Ref No.	Description	Where Used	Part No.
138	Synthetic Power Steering Fluid SAE 0W-30	Power steering pump	92-858076K01

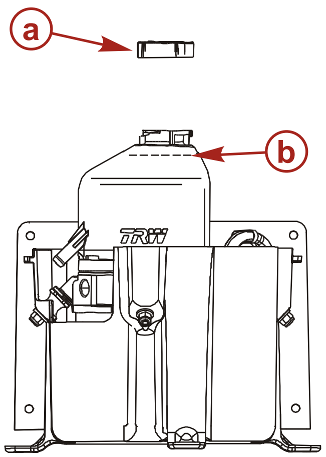
1. Connect the power steering module primer kit to the power steering pump and a 12 volt positive power source.



a - Power steering module primer kit
b - Power steering pump
c - 50 amp maxi fuse
d - 12 volt battery

Power Steering Module Primer Kit	91-895040K01

2. Remove the fill cap from the power steering pump.
3. Fill the pump tank with the recommended power steering fluid.



a - Fill cap
b - Full level

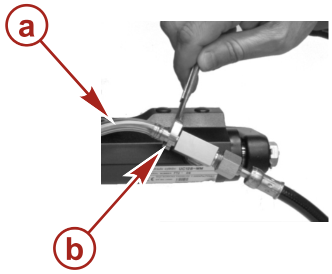
IMPORTANT: The power steering module primer has two switches, "POWER" - "ON" and "OFF," and "PUMP" - "ON" and "OFF." To power up and activate the power steering pump, there are two steps: 1) turn the "POWER" switch to the "ON" position to power up the pump, wait for two seconds, 2) turn the "PUMP" switch to the "ON" position to activate the pump.

IMPORTANT: Do not run the pump out of fluid. If the pump draws air during bleeding, the bleeding procedure will take two to three times longer.

4. Power up and activate the pump until the fluid level stops dropping. Turn off both switches on the power steering primer module and refill the pump tank. Repeat this operation until the tank stays full.
5. Power up and activate the pump while slowly turning the steering wheel towards the full lock position in one direction. Carefully monitor the fluid level until fluid drops halfway. Stop turning the wheel, turn off the switches, and refill the pump tank. Repeat this operation turning the steering wheel to full lock to full lock 10 times until the pump tank stays full.
6. For bleeding air out of the steering system, turn the switches on and turn the steering wheel in one direction to the full lock position.
7. Attach an 8 mm I.D. (5/16 in. I.D.) transparent bleed hose to the bleed valve on the end of the steering cylinder that the engine is pointing away from. Route the bleed hose into the pump tank.

NOTE: Do not bleed the power steering fluid into a different container, this will pump the fluid out of the system.

8. Open the bleed valve to release any remaining air in the power steering system. Allow adequate time, depending on length of power steering hose, for air to escape from the system. Tighten the bleed valve securely and remove bleed hose.



15266

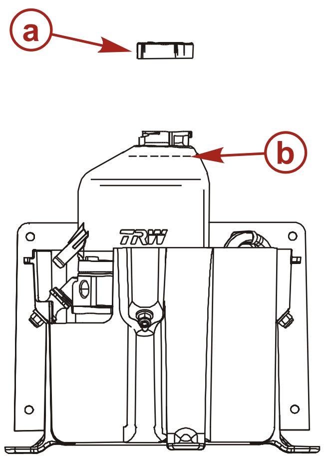
a - Bleed hose
b - Bleed valve in steering cylinder

9. Turn the steering wheel opposite of the full lock position, and repeat procedure for bleeding steering system.
10. Replace the fill cap on the power steering pump.
11. Turn off both switches, remove the power steering primer module kit, and connect the power steering module extension harness to the pump.

NOTE: The power steering system should be bled after sitting overnight to remove any air that may be in the system. Repeat the steps for bleeding the steering system.

Filling Power Steering System with Engine Running

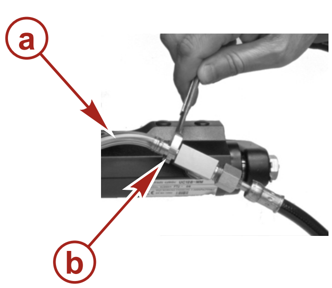
1. Remove the fill cap from the power steering pump.
2. Fill the pump tank with recommended power steering fluid.



15296

a - Fill cap
b - Full level

3. Start and run the engine until the steering pump fluid drops halfway. Turn off the engine and refill the pump. Repeat this operation until pump stays full.
4. Start and run the engine while slowly turning the steering wheel towards the full lock position in one direction. Carefully monitor the fluid level until fluid drops halfway. Stop turning wheel, turn off engine, and refill the pump tank. Repeat this operation turning the steering wheel to full lock to full lock 10 times until pump tank stays full.
5. For bleeding any air left in the steering system, start and run the engine, and turn the steering wheel in one direction until the full lock position is met.
6. Attach an 8 mm (5/16 in.) I.D. transparent bleed hose to the bleed valve on the end of the steering cylinder the engine is pointing away from. Route bleed hose into pump tank (do not bleed power steering fluid into a different container, as this will only be pumping fluid out of the system that was just filled).
7. Open bleed valve to release any remaining air in the power steering system. Allow adequate time, depending on length of power steering hose, for air to escape from system. Tighten bleed valve securely and remove bleed hose.



15266

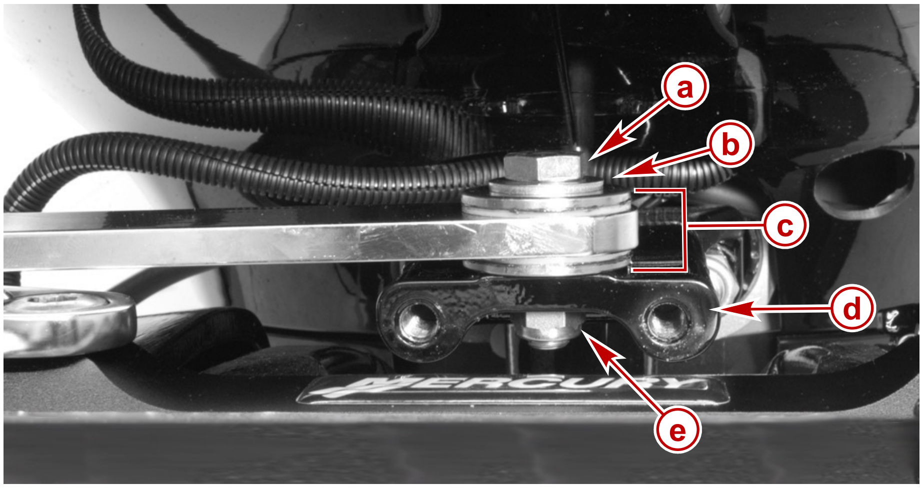
a - Bleed hose
b - Bleed valve in steering cylinder

8. Turn the steering wheel to opposite full lock position, and repeat procedure for bleeding steering system.

9. Replace the filter on the power steering pump.
10. If desired, the power steering system can be checked after sitting overnight to remove any air that may possibly be left in the system. Repeat steps for bleeding steering system, preceding.

Steering Cylinder Removal

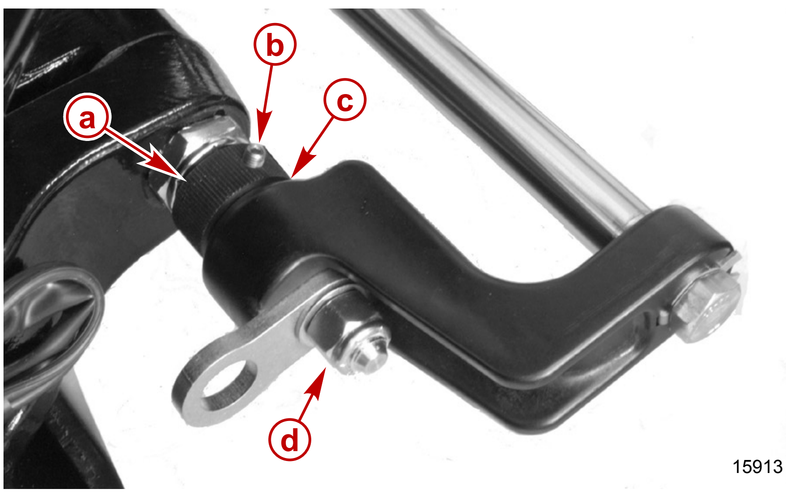
1. Remove the steering link from the steering arm by removing the locknut and bolt.



15897

a - Bolt
b - Washer
c - Link components
d - Steering arm
e - Locknut

2. Remove locknut from the starboard side of the tie rod assembly.
3. Remove the washer and lifting eye plate.



15913

a - Collar
b - Set screw
c - Washer (not visible)
d - Locknut

4. Remove the tie rod assembly, washer, and spacer from the steering cylinder/swivel bracket.
5. Remove the steering cylinder and two washers from the swivel bracket.

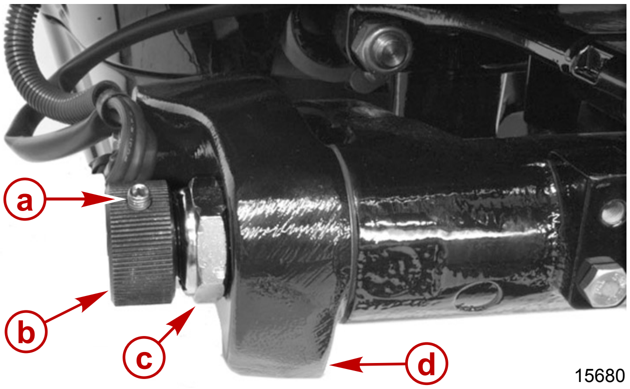
6. Remove the collar from the tilt tube by loosening the set screw and unthreading the collar.

12758

- a - Washer
- b - Collar
- c - Washer
- d - Spacer
- e - Tie rod
- f - Lifting eye
- g - Locknut and washer
- h - Steering cylinder assembly

Steering Cylinder Installation

1. Thread the collar on the starboard side of the tilt tube. Do not tighten the set screw at this time.



15680

- a - Set screw
- b - Collar
- c - Starboard side tilt tube locknut
- d - Starboard transom bracket

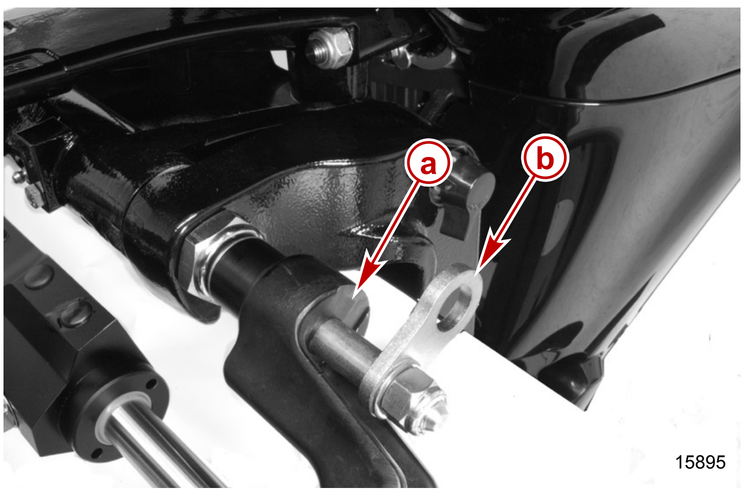
2. Apply 2-4-C with Teflon to the entire tie rod surface.
3. Partially insert the tie rod assembly (tie rod, lifting eye, washer, and locknut) into the steering cylinder bracket.
4. Assemble the spacer and a washer on the tie rod assembly.

5. Insert tie rod completely through the steering cylinder and tilt tube.

a - Washer
b - Collar
c - Washer
d - Spacer
e - Tie rod
f - Lifting eye
g - Locknut and washer
h - Steering cylinder assembly

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Steering cylinder tie rod surface	92-802859A 1

6. Ensure the lifting eye is positioned in the undercut on the steering cylinder bracket.



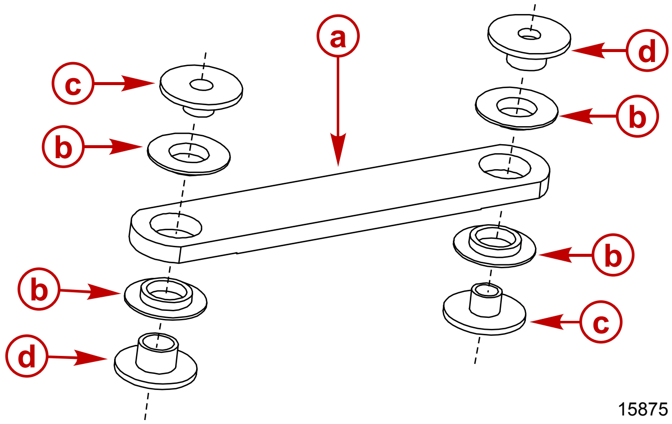
a - Undercut in steering cylinder bracket
b - Lifting eye

7. Apply Loctite Moly Paste to the tie rod threads.

Tube Ref No.	Description	Where Used	Part No.
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Steering cylinder tie rod threads	Obtain Locally

8. Install a washer, lifting eye, and locknut to the tie rod end. Do not tighten the locknut at this time.
9. Inspect link assembly components for wear. Replace if necessary.

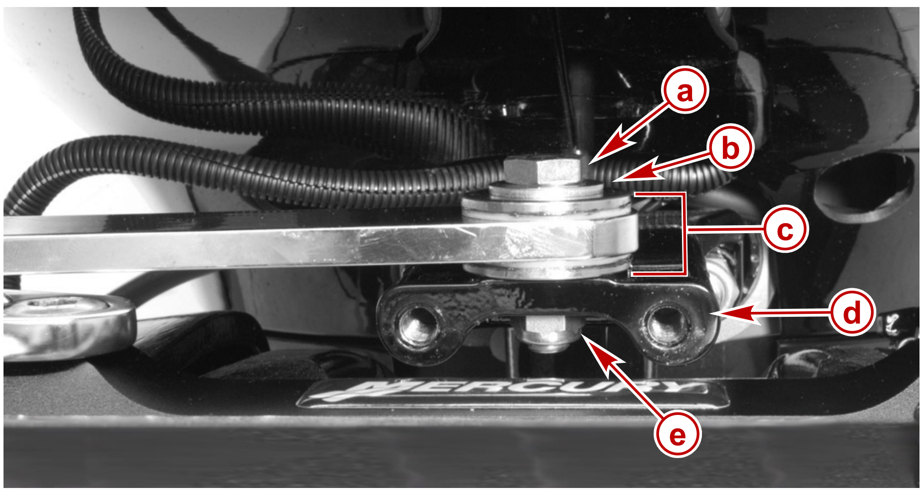
10. Assemble the link assembly components.



Link assembly

a - Link
b - Bushing
c - Bushing
d - Bushing

11. Install the link on the steering cylinder plate to the steering arm on the outboard.
    a. Install a washer and bolt in the link.
    b. Thread the bolt into the steering arm.
    c. Tighten the bolt to the specified torque.
    d. Install a locknut on the bolt.
    e. Tighten the locknut to the specified torque.

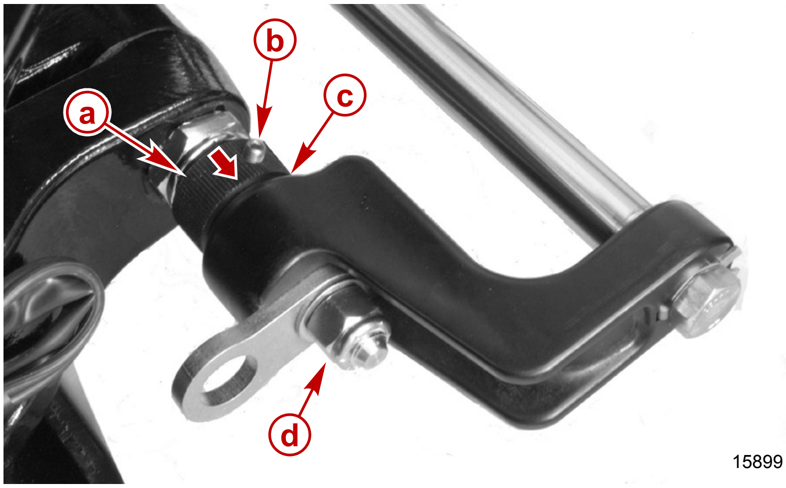


a - Bolt
b - Washer
c - Link components
d - Steering arm
e - Locknut

Description	Nm	lb-in.	lb-ft
Steering link to steering arm bolt	54.2		40
Steering link locknut	27		20

12. Tighten the locknut on the starboard side of the tie bar to the specified torque.
13. Thread the collar against the washer (outward) and steering cylinder bracket. Tighten finger-tight.

14. Tighten the set screw to the specified torque.



a - Collar
b - Set screw
c - Washer (not visible)
d - Locknut and washer

Description	Nm	lb-in.	lb-ft
Steering cylinder tie bar locknuts	88		65
Steering cylinder collar set screw	9	80	

IMPORTANT: If the steering hoses were disconnected from the steering cylinder, the hydraulic steering system must be bled. Refer to Filling Power Steering System.

Notes:

Steering

Section 8B - Hydraulic Steering

Table of Contents

8
B

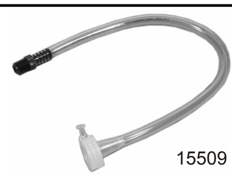
Hydraulic Steering Specifications

Hydraulic Steering Specifications	
Fluid type	Hydraulic Helm Steering Fluid
Steering ratio (28 cc helm and single steering cylinder, lock to lock) - preferred configuration	4.3 turns
Steering ratio (33 cc helm and single steering cylinder, lock to lock)	3.7 turns
Steering ratio (39 cc helm and single steering cylinder, lock to lock)	3.1 turns
Steering ratio (28 cc helm with dual steering cylinders, lock to lock)	8.6 turns
Steering ratio (33 cc helm with dual steering cylinders, lock to lock)	7.3 turns
Steering ratio (39 cc helm with dual steering cylinders, lock to lock) - preferred configuration	6.2 turns

Lubricant, Sealant, Adhesives

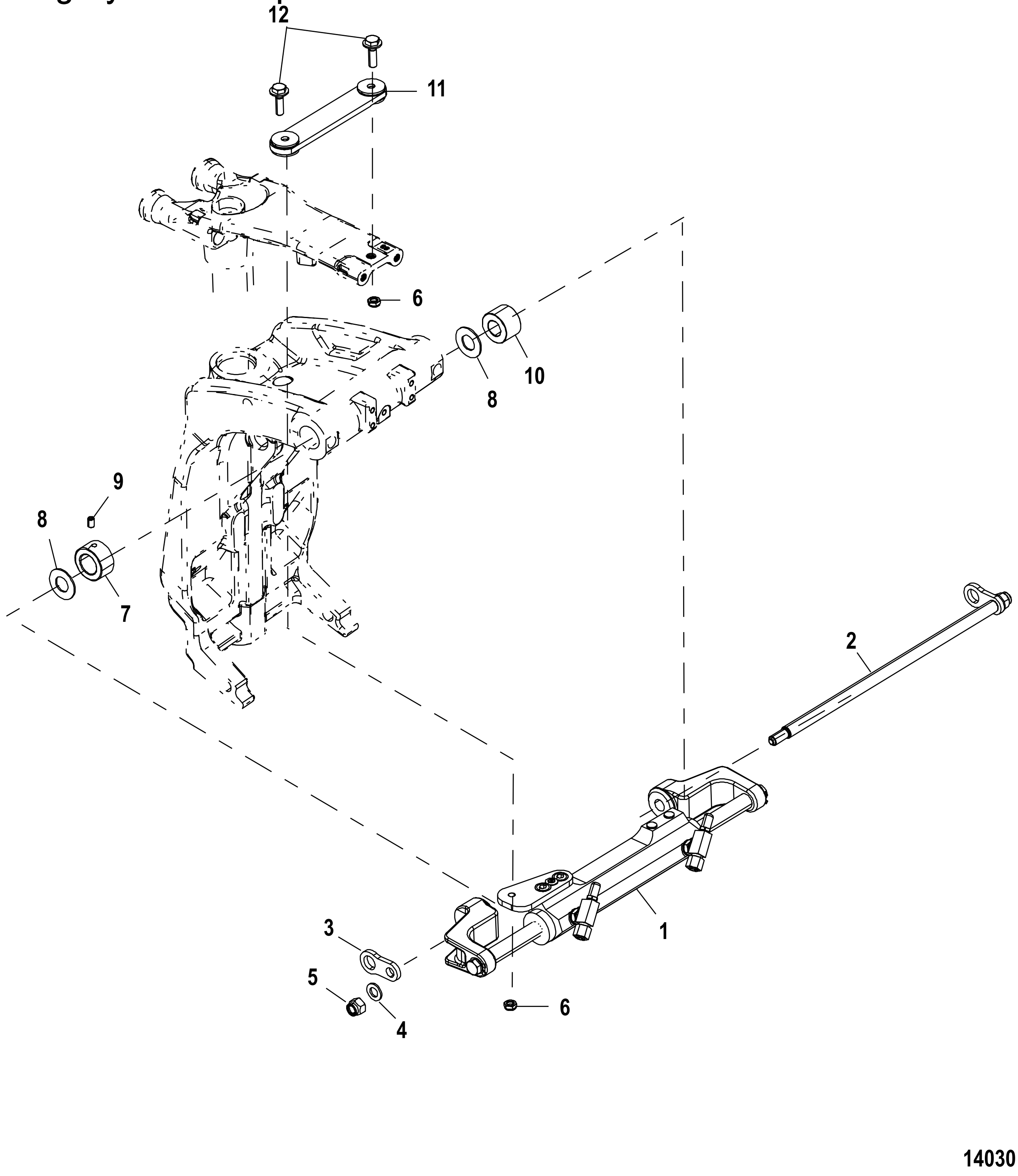
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Steering cylinder tie rod surface	92-802859A 1
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Steering cylinder tie rod threads	Obtain Locally

Special Tools

Steering Helm Fill Adapter	64-826525A 1
 15509	Connects between the fluid bottle and helm to aid in filling the hydraulic steering helm.

Notes:

Steering Cylinder Components

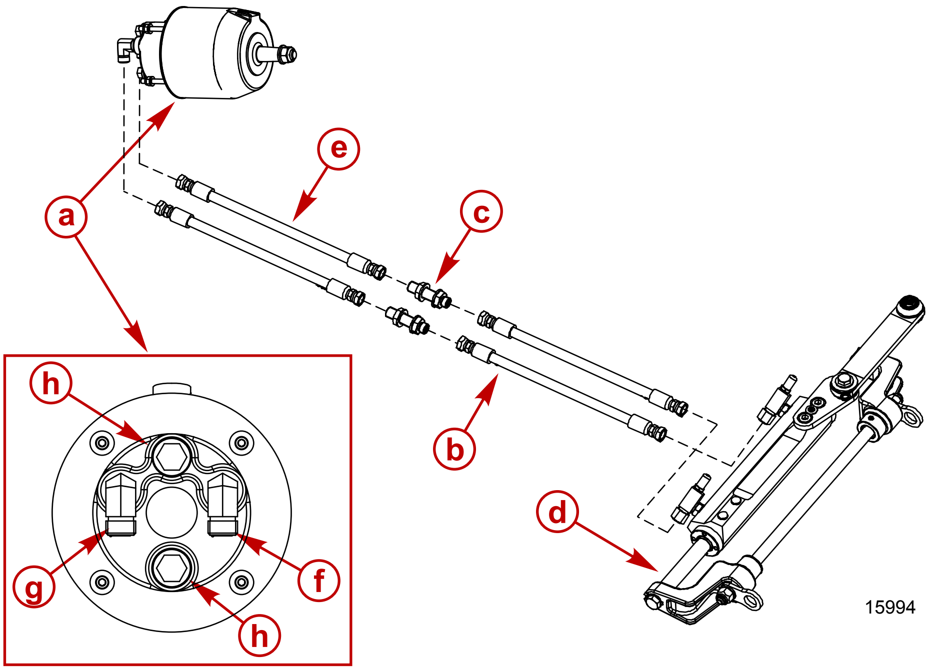


Steering Cylinder Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Steering actuator assembly			
2	1	Tie rod assembly			
3	1	Lifting eye plate			
4	1	Washer			
5	1	Nut	88		65
6	2	Nut (0.375-24)	27		20
7	1	Collar			
8	2	Washer			
9	1	Set screw	9	80	
10	1	Spacer			
11	1	Steering link assembly			
12	2	Screw (0.375-24 x 1.375)	54.2		40

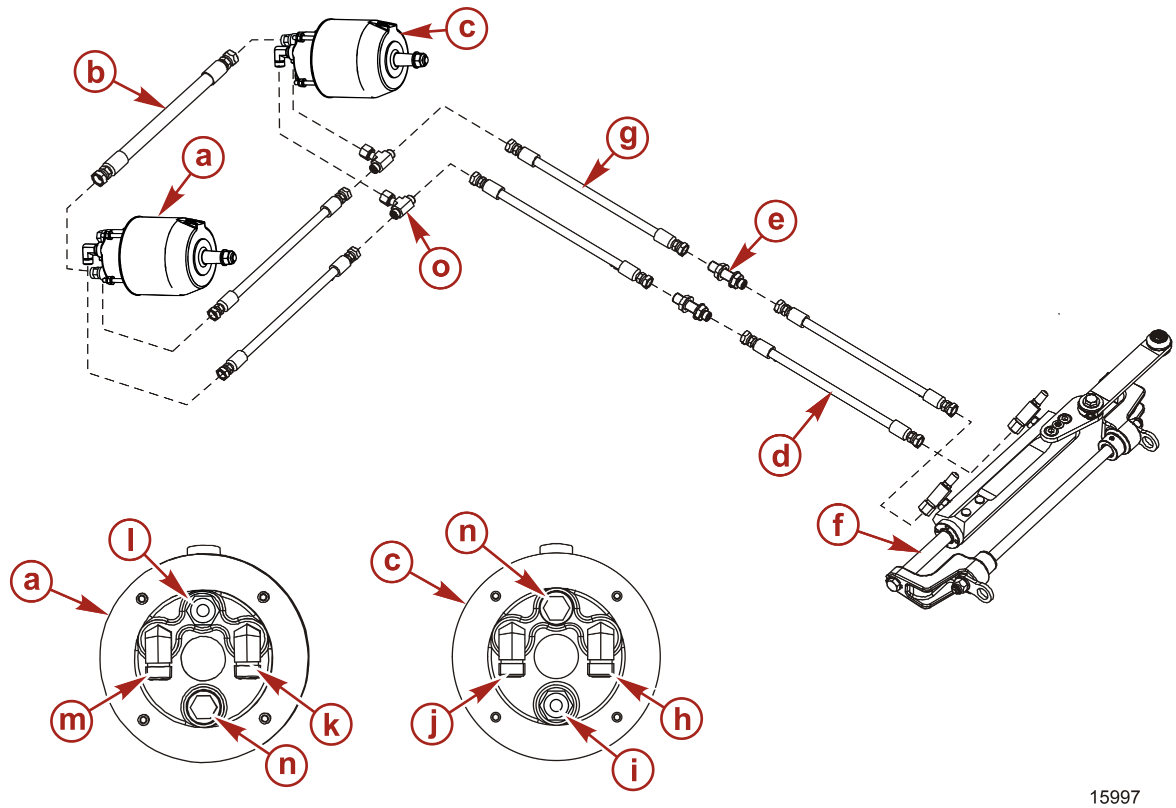
Hydraulic Steering Systems

Single Helm - Single Cylinder



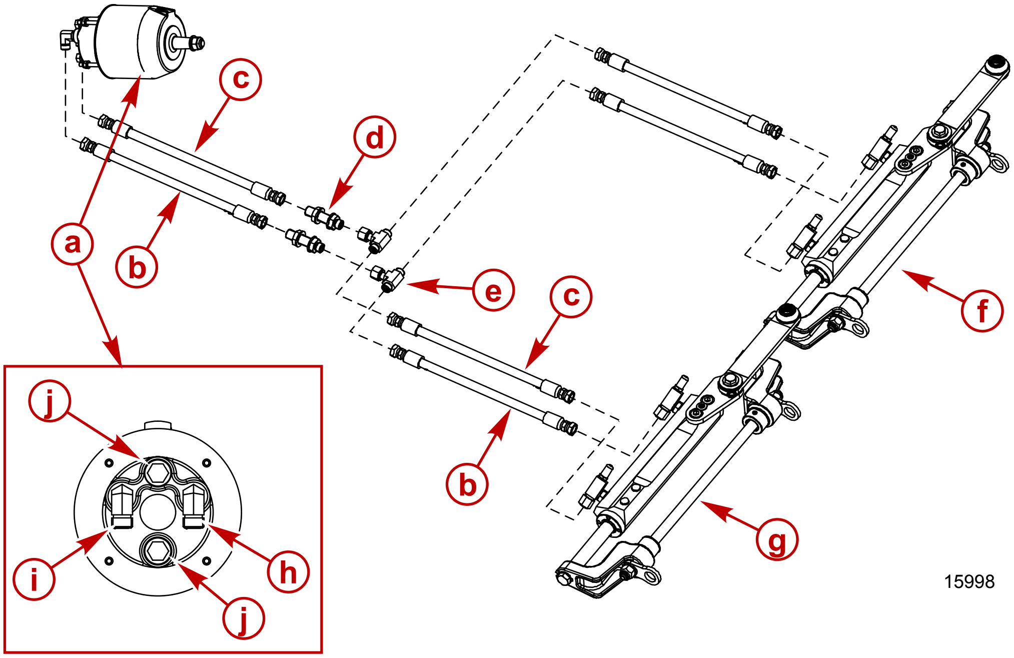
a - Helm
b - Hose to starboard side of steering cylinder
c - Bulkhead fitting (2)
d - Steering cylinder
e - Hose to port side of steering cylinder
f - Helm to starboard side of steering cylinder
g - Helm to port side of steering cylinder
h - Plug

Dual Helm - Single Cylinder



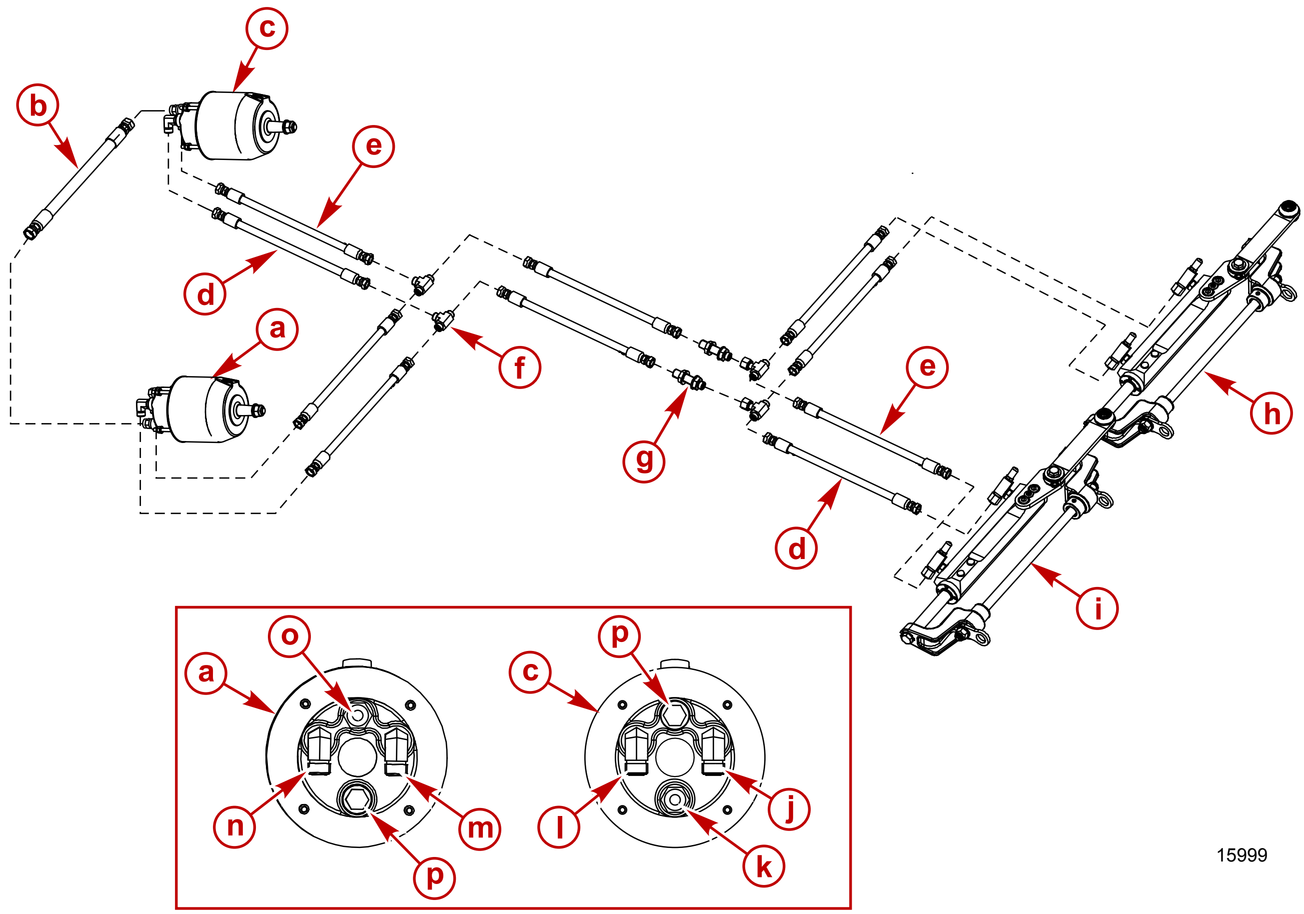
- a - Main helm
- b - Main helm to second helm hose
- c - Second helm
- d - Hose to starboard side of steering cylinder
- e - Bulkhead fitting (2)
- f - Steering cylinder
- g - Hose to port side of steering cylinder
- h - Helm to starboard side of steering cylinder
- i - Second helm to main helm station
- j - Helm to port side of steering cylinder
- k - Helm to starboard side of steering cylinder
- l - Main helm to second helm
- m - Helm to port side of steering cylinder
- n - Plug
- o - Swivel T-fitting (2)

Single Help - Dual Cylinder



- a - Helm
- b - Hose to starboard side of steering cylinder
- c - Hose to port side of steering cylinder
- d - Bulkhead fitting (2)
- e - Swivel T-fitting
- f - Starboard steering cylinder
- g - Port steering cylinder
- h - Helm to starboard side of steering cylinder
- i - Helm to port side of steering cylinder
- j - Plug

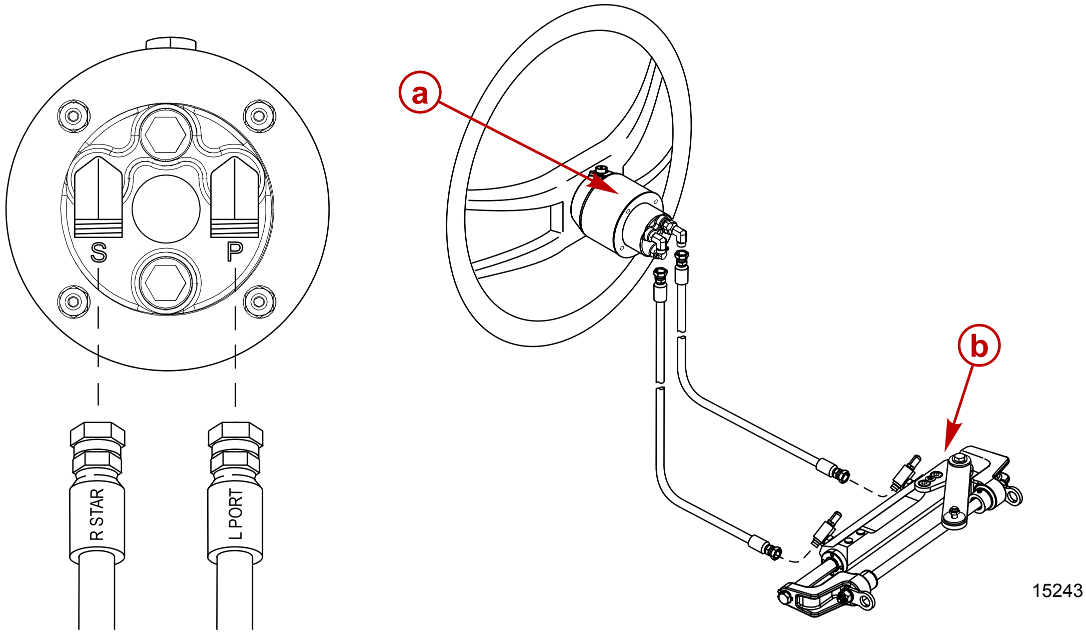
Dual Helm - Dual Cylinder



- **a -** Main helm
- **b -** Main helm to second helm hose
- **c -** Second helm
- **d -** Hose to starboard side of steering cylinder
- **e -** Hose to port side of steering cylinder
- **f -** T-fitting
- **g -** Bulkhead fitting (2)
- **h -** Starboard steering cylinder
- **i -** Port steering cylinder
- **j -** Second helm to starboard side of steering cylinder
- **k -** Second helm to main helm
- **l -** Second helm to port side of steering cylinder
- **m -** Main helm to starboard side of steering cylinder
- **n -** Main helm to port side of steering cylinder
- **o -** Main helm to second helm
- **p -** Plug

Steering Cylinder

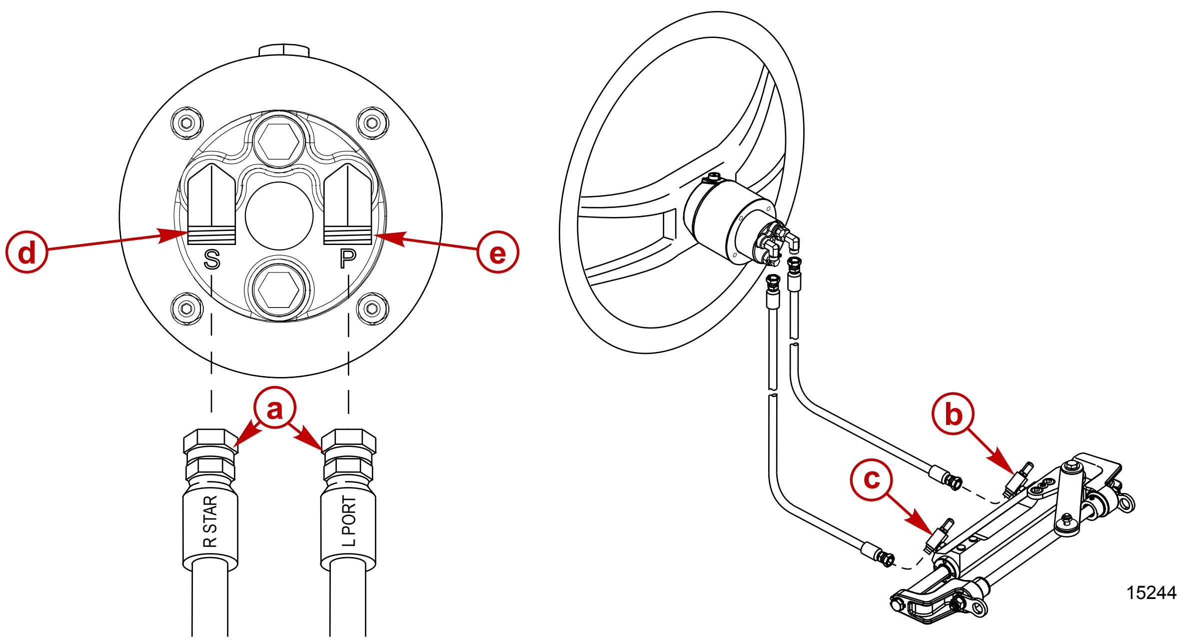
Hydraulic Steering System



- a - Steering helm
- b - Steering cylinder on outboard

Connection of the Hydraulic Hoses to the Steering Helm

Make the hose connections to the steering helm as shown.

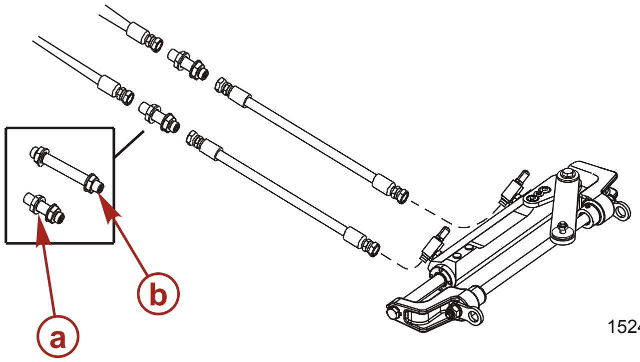


- a - Hydraulic hose hex fitting wrench size (R STAR and L PORT) - 18 mm (11/16 in.)
- b - Starboard fitting
- c - Port fitting
- d - S helm fitting
- e - P helm fitting

Helm Fitting ID Mark	Hose ID Mark	Steering Cylinder Connection
S	R STAR	Connects to port fitting
P	L PORT	Connects to starboard fitting

Connection of the Hydraulic Hoses to the Steering Cylinder

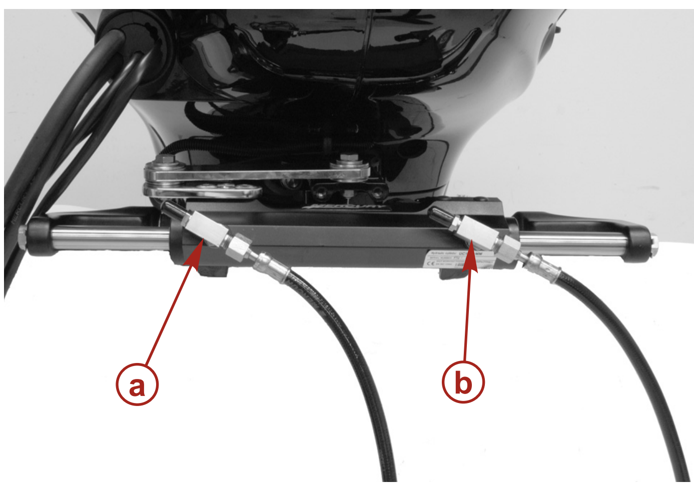
1. Route the hydraulic hoses to the outboard steering cylinder. Bulkhead fittings are available if an opening does not exist in the engine well.



a - Bulkhead fitting - bulkhead thickness up to 1.9 cm (0.75 in.) (22-892517)
b - Bulkhead fitting - bulkhead thickness up to 7.62 cm (3 in.) (22-892518)

NOTE: The 90° hose fittings are available and can be threaded onto the hose fittings if straight hose routing is desired.

2. Position hose fittings to the desired direction. Loosen fastening nuts in order to rotate. Position fittings and tighten fastening nuts.
3. Ensure O-ring seals are in place on end of each fitting.
4. Make the hose connections to the steering cylinder as shown.



a - Starboard fitting - Hose marked L PORT
b - Port fitting - Hose marked R STAR

Power Filling and Purging the Hydraulic Steering System

When using the SeaStar Power Purge® tool to fill and purge the hydraulic steering system, refer to the filling and purging instructions provided with the Power Purge tool.

Manually Filling and Purging the Hydraulic Type Steering System

Dual outboard installations - perform the following steps at the same time for both outboard steering cylinders.

NOTE: Due to the system design, one technician may not be able to completely fill and purge all the air from the system. This will result in spongy and unresponsive steering. Two technicians are required for successful filling and purging of the system.

Use Hydraulic Helm Steering Fluid in the hydraulic steering system.

Fluid Type	Capacity	Mercury Part Number
Hydraulic Helm Steering Fluid	1–2 liter (1–2 US qt) depending on length of steering hoses	92-858078Q01

Step 1

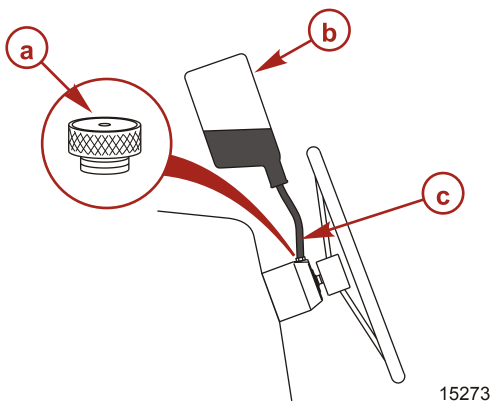
NOTE: Start the filling of the system at the steering helm. On dual steering systems, always start at the lower steering helm.

1. Remove the fill plug from the steering helm. Thread the fill tube (from bottle filler kit) into the fill hole.

Steering Helm Fill Adapter	64-826525A 1

2. Attach the fill tube (from steering helm) to a new bottle of steering fluid.
3. Turn the bottle upside-down and vent the bottle by poking a hole into the bottom. Fill the steering helm until no air/bubbles are visible in the fill tube.

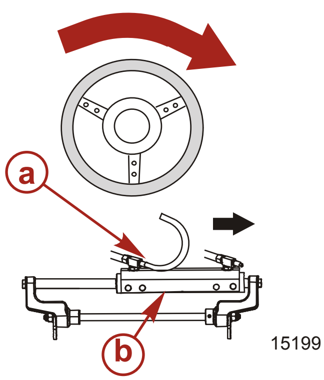
   NOTE: Keep the fill tube full of fluid between the bottle of fluid and steering helm during the entire filling procedure. Replace the empty bottle while the fill tube is still full. If the system sucks in air, it will have to be bled again.



a - Fill plug
b - Bottle of fluid
c - Fill tube

Step 2

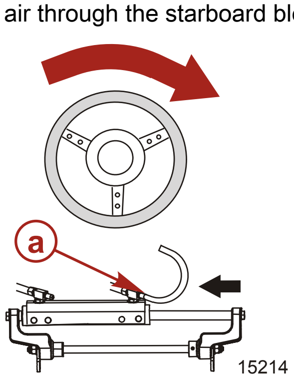
1. Attach a transparent bleed hose to the port bleed fitting. Route the other end of the bleed hose into a container to avoid spillage.
2. Open the port bleed fitting.
3. Manually push the steering cylinder to the right/starboard side until it stops.
4. Slowly turn the steering wheel to the starboard side pushing air through the port bleed fitting.
5. Once a steady stream of fluid is visible without air/bubbles, close the bleed fitting.



a - Port bleed fitting
b - Steering cylinder

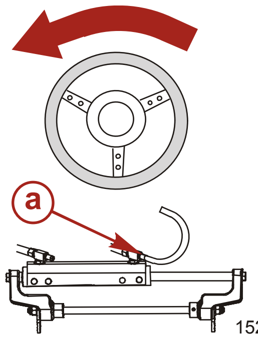
Step 3

1. Attach a transparent bleed hose to the starboard bleed fitting. Route the other end of the bleed hose into a container to avoid spillage.
2. Open the starboard bleed fitting.
3. Slowly turn the steering wheel to the starboard side until it stops. The steering cylinder will travel to the port side while pushing air through the starboard bleed fitting.



a - Starboard bleed fitting

4. Change direction of the steering wheel. Slowly turn the steering wheel to the port side pushing air through the starboard bleed fitting.
5. Once a steady stream of fluid is visible without air/bubbles, close the bleed fitting.



15216

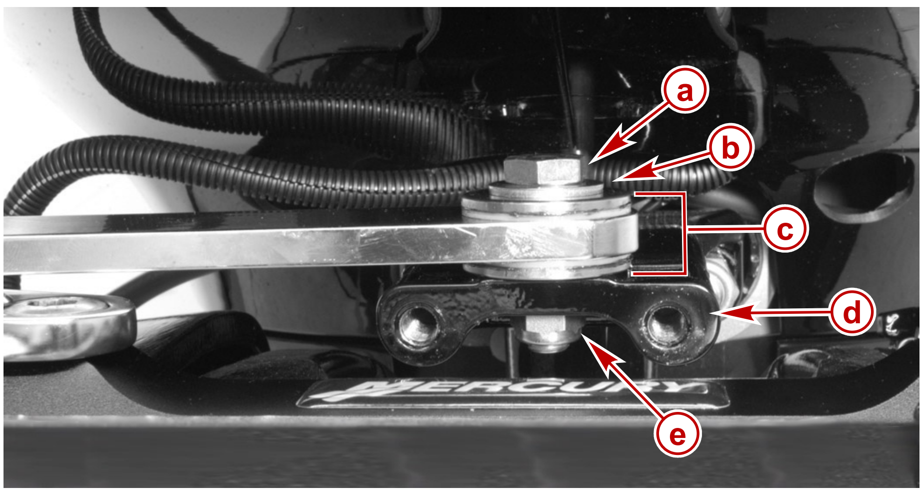
a - Starboard bleed fitting

6. The filling and purging is complete. Remove the fill tube from the steering helm and install the fill plug.

Any small amount of air that could be trapped in the system may migrate through the vented fill plug in the steering helm as the system is operated.

Steering Cylinder Removal

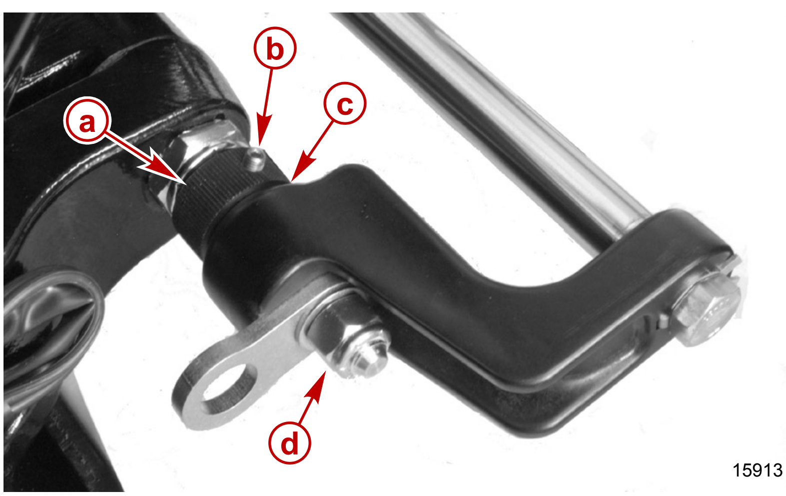
1. Remove the steering link from the steering arm by removing the locknut and bolt.



15897

a - Bolt
b - Washer
c - Link components
d - Steering arm
e - Locknut

2. Remove locknut from the starboard side of the tie rod assembly.
3. Remove the washer and lifting eye plate.



15913

a - Collar
b - Set screw
c - Washer (not visible)
d - Locknut

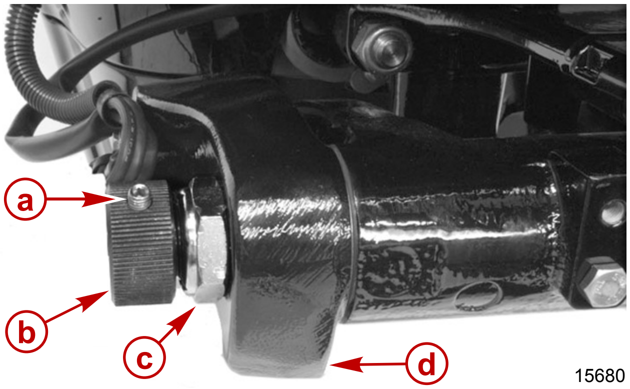
4. Remove the tie rod assembly, washer, and spacer from the steering cylinder/swivel bracket.
5. Remove the steering cylinder and two washers from the swivel bracket.

6. Remove the collar from the tilt tube by loosening the set screw and unthreading the collar.

a - Washer
b - Collar
c - Washer
d - Spacer
e - Tie rod
f - Lifting eye
g - Locknut and washer
h - Steering cylinder assembly

Steering Cylinder Installation

1. Thread the collar on the starboard side of the tilt tube. Do not tighten the set screw at this time.



a - Set screw
b - Collar
c - Starboard side tilt tube locknut
d - Starboard transom bracket

2. Apply 2-4-C with Teflon to the entire tie rod surface.
3. Partially insert the tie rod assembly (tie rod, lifting eye, washer, and locknut) into the steering cylinder bracket.
4. Assemble the spacer and a washer on the tie rod assembly.

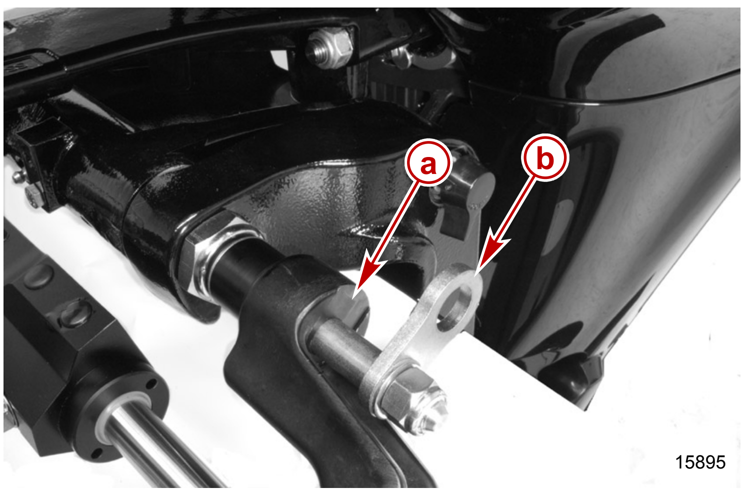
5. Insert tie rod completely through the steering cylinder and tilt tube.

12758

a - Washer
b - Collar
c - Washer
d - Spacer
e - Tie rod
f - Lifting eye
g - Locknut and washer
h - Steering cylinder assembly

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with Teflon	Steering cylinder tie rod surface	92-802859A 1

6. Ensure the lifting eye is positioned in the undercut on the steering cylinder bracket.



15895

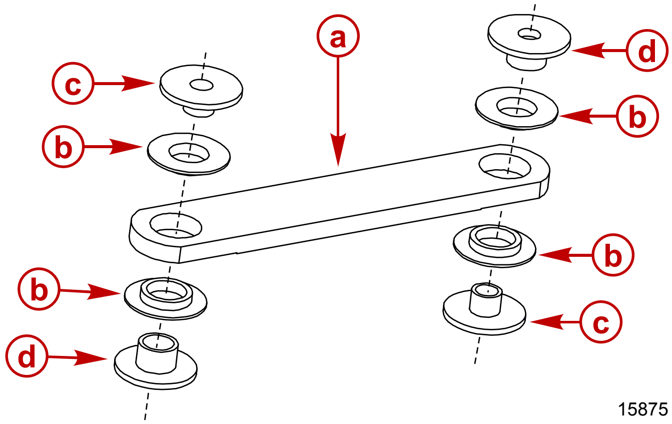
a - Undercut in steering cylinder bracket
b - Lifting eye

7. Apply Loctite Moly Paste to the tie rod threads.

Tube Ref No.	Description	Where Used	Part No.
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Steering cylinder tie rod threads	Obtain Locally

8. Install a washer, lifting eye, and locknut to the tie rod end. Do not tighten the locknut at this time.
9. Inspect link assembly components for wear. Replace if necessary.

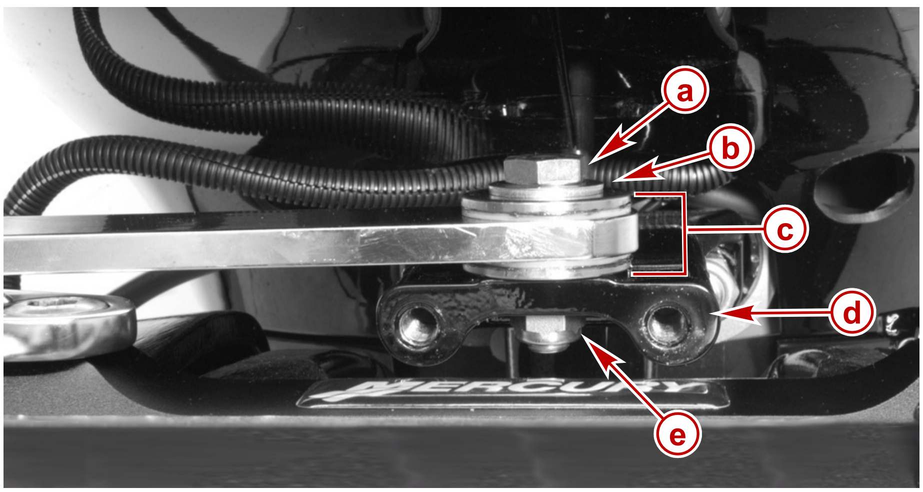
10. Assemble the link assembly components.



Link assembly

- a - Link
- b - Bushing
- c - Bushing
- d - Bushing

11. Install the link on the steering cylinder plate to the steering arm on the outboard.
    a. Install a washer and bolt in the link.
    b. Thread the bolt into the steering arm.
    c. Tighten the bolt to the specified torque.
    d. Install a locknut on the bolt.
    e. Tighten the locknut to the specified torque.



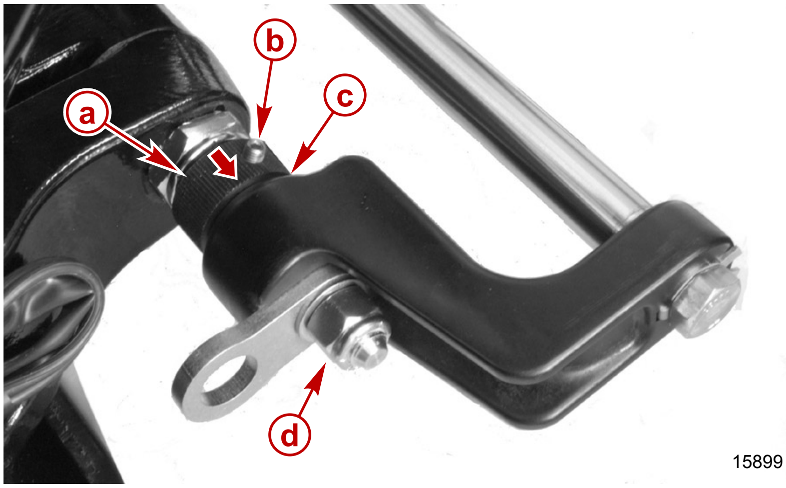
15897

- a - Bolt
- b - Washer
- c - Link components
- d - Steering arm
- e - Locknut

Description	Nm	lb-in.	lb-ft
Steering link to steering arm bolt	54.2		40
Steering link locknut	27		20

12. Tighten the locknut on the starboard side of the tie bar to the specified torque.
13. Thread the collar against the washer (outward) and steering cylinder bracket. Tighten finger-tight.

14. Tighten the set screw to the specified torque.



a - Collar
b - Set screw
c - Washer (not visible)
d - Locknut and washer

Description	Nm	lb-in.	lb-ft
Steering cylinder tie bar locknuts	88		65
Steering cylinder collar set screw	9	80	

IMPORTANT: If the steering hoses were disconnected from the steering cylinder, the hydraulic steering system must be bled. Refer to Filling Power Steering System.

Notes: