MERCURY

V6 175/200/225
V8 200/225/250/300
FourStroke CMS
Outboard

SERVICE

MANUAL

FOURSTROKE

PROXS

SEAPRO

Starting serial number 2B529482

MERCURY

V6 175/200/225 V8 200/225/250/300
FourStroke CMS Outboard

SERVICE MANUAL

90-8M0124302
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Notice to Users of This Manual

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

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

⚠ WARNING

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

⚠ CAUTION

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

Additional alerts provide information that requires special attention:

NOTICE

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

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

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

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

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

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

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

Precautions

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

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

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

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

Replacement Parts

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

⚠ WARNING

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

Cleanliness and Care of Product

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

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

Copyright and Trademark Information

Manual Outline

Important Information

Section 1A - Master Specifications

Table of Contents

V8 CMS General Specifications

Model Specifications		
Kilowatts (horsepower)		147 kW (200 hp) 165 kW (225 hp) 184 kW (250 hp) 221 kW (300 hp)
Cylinder configuration		V8—64°, with dual overhead cam (DOHC), and 32 valves
Weight		
Dry weight—L*		229 kg (505 lb)
Dry weight—XL*		240 kg (530 lb)
Dry weight—XXL*		249 kg (548 lb)
Displacement—all HP		4576 cc/4.6 L (279.2 in.³)
Standard bore		92 mm (3.62 in.)
Standard stroke		86 mm (3.38 in.)
RPM		
Idle RPM in neutral **		600 RPM
Idle charge compensation ***		600–725 RPM
Troll control RPM (if equipped)		550–1000 RPM
WOT		250/300 FourStroke—5200–6000 RPM 200/225/250/300 Pro XS—5600–6200 RPM 225/250/300 SeaPro—4800–5600 RPM
Induction system		SmartCraft DTS® electronic throttle, naturally aspirated
Fuel system		Electronic fuel injection—EFI Computer Controlled with Advanced Range Optimization
Recommended fuel		Unleaded Regular 87 Octane minimum (R+M/2) or 91 RON fuel, 10% Ethanol maximum
Ignition system		SmartCraft propulsion control module (PCM) 112 digital inductive
Charging system		Regulated belt driven 85 A, 1150 watt maximum output Regulated belt driven 115 A, 1550 watt maximum output
Starting system		Electric start with SmartStart protection
Recommended spark plug		NGK LKAR7C-9
Spark plug gap		0.9 mm (0.035 in.)
Spark plug hex size		14 mm
Spark plug torque		20 Nm (15 lb-ft)
Spark plug hole size		12 mm
Firing order		1-2-7-3-4-5-6-8
Required battery type		12-volt AGM (absorbed glass mat) battery
Battery rating ****	USA (SAE)	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 RC25 rating
	International (EN)	975 minimum cold cranking amps (CCA) with a minimum 65 amp hour (Ah)
Exhaust system		Through the propeller
Cooling system		Water-cooled - thermostat with pressure control
Thermostat		
Valve stroke—minimum, at full open temperature		10.0 mm (0.39 in.)
Start to open temperature		57–61 °C (134.6–141.8 °F)
Full open temperature		77 °C (170.6 °F)
Lubrication system		Integrated dry sump
Oil capacity		6.6 liters (7.0 US qt)
Recommended oil		NMMA Certified FCW SAE10W-30 NMMA Certified FCW SAE 25W-40 or FCW SAE 10W-30—SeaPro models

Model Specifications	
Engine control system	SmartCraft PCM 112 digital throttle and shift (DTS)
Trim system	Power trim
Maximum trim range	20° (–5° to 15°)
Power trim fluid	Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) Type F, FA, Dexron II, or Dexron III
Steering system	Hydraulic—required Power—optional Big Tiller—power steering only *****
CARB star rating	3

* Dry weight includes gear lube and steering cylinder.

** Engine at normal operation temperature.

*** The idle charge compensation may automatically increase the engine speed up to 725 RPM to compensate for a low battery charge condition. The increased idle RPM will charge the battery at a higher rate. Activating troll control (optional accessory) will override the idle charge compensation feature.

**** Battery manufacturers may rate and test their batteries to different standards. MCA, CCA, Ah, and reserve capacity (RC) are the ratings recognized by Mercury Marine. Manufacturers that use standards different than these, such as equivalent MCA, do not meet Mercury Marine battery requirements.

***** Big Tiller optional for 250 horsepower and below.

V6 CMS General Specifications

Model Specifications		
Kilowatts (horsepower)		129 kW (175 hp) 147 kW (200 hp) 165 kW (225 hp)
Cylinder configuration		V6—64°, with dual overhead cam (DOHC), and 24 valves
Weight		
Dry weight—L*		215 kg (475 lb)
Dry weight—XL*		220 kg (485 lb)
Dry weight—XXL*		225 kg (495 lb)
Displacement—all HP		3432 cc/3.4 L (209.4 in.³)
Bore		92mm (3.62 in.)
Stroke		86 mm (3.38 in.)
RPM		
Idle RPM in neutral **		600 RPM
Idle charge compensation ***		600–725 RPM
Troll control RPM limit—if equipped		550–1000 RPM
WOT		175—5000–5800 RPM 175 Pro XS—5400–6000 RPM 200—5000–5800 RPM 200 SeaPro—4600–5400 RPM 225—5200-6000 RPM
Induction system		SmartCraft DTS® electronic throttle, naturally aspirated
Fuel system		Computer controlled sequential multiport electronic fuel injection
Recommended fuel		Unleaded Regular 87 Octane minimum (R+M/2) or 91 RON fuel, 10% Ethanol maximum
Ignition system		SmartCraft propulsion control module (PCM) 112 digital inductive
Charging system		Regulated belt driven 85 A, 1071 watt maximum output
Required battery type		12-volt AGM (absorbed glass mat) battery
Battery rating ****	USA (SAE)	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 RC25 rating
	International (EN)	975 minimum cold cranking amps (CCA) with a minimum 65 amp hour (Ah)

Model Specifications	
Recommended spark plug	NGK LKAR7C-9
Spark plug gap	0.9 mm (0.035 in.)
Spark plug hex size	14 mm
Spark plug torque	20 Nm (15 lb-ft)
Spark plug hole size	12 mm
Firing order	1-2-3-4-5-6
Exhaust system	Through the propeller
Cooling system	Water-cooled - thermostat with pressure control
Thermostat	
Valve stroke—minimum, at full open temperature	10.0 mm (0.39 in.)
Start to open temperature	57–61 °C (134.6–141.8 °F)
Full open temperature	77 °C (170.6 °F)
Lubrication system	Integrated dry sump
Oil capacity	6.6 liters (7.0 US qt)
Recommended oil	NMMA Certified FCW SAE10W-30 NMMA Certified FCW SAE 25W-40 or FCW SAE 10W-30—SeaPro models
Engine control system	SmartCraft PCM 112 digital throttle and shift (DTS)
Trim system	Power trim
Maximum trim range	20° (–5° to 15°)
Power trim fluid	Power Trim and Steering Fluid or Automatic Transmission Fluid (ATF) Type F, FA, Dexron II, or Dexron III
Steering system	Hydraulic—required Power—optional Big Tiller—power steering only *****

* Dry weight includes gear lube and steering cylinder.

** Engine at normal operation temperature.

*** The idle charge compensation may automatically increase the engine speed up to 725 RPM to compensate for a low battery charge condition. The increased idle RPM will charge the battery at a higher rate. Activating troll control (optional accessory) will override the idle charge compensation feature.

**** Battery manufacturers may rate and test their batteries to different standards. MCA, CCA, Ah, and reserve capacity (RC) are the ratings recognized by Mercury Marine. Manufacturers that use standards different than these, such as equivalent MCA, do not meet Mercury Marine battery requirements.

***** Big Tiller optional for 250 horsepower and below.

Ignition Specifications - V8 Models

Description		Specification
Full throttle RPM range	SeaPro	4800–5600
	250 and 300	5200–6000
	Pro XS	5600–6200
Idle RPM (see NOTE)		600
Ignition type		Digital inductive
Spark plug type		NGK LKAR7C-9
Spark plug gap		0.9 mm (0.035 in.)
Spark plug hex size		14 mm
Spark plug torque		20 Nm (177 lb-in.)
Firing order		1-2-7-3-4-5-6-8
Ignition timing at idle		Not adjustable; PCM controlled (approximately 2° ATDC)

Description	Specification
Ignition timing at WOT	Not adjustable; PCM controlled

Ignition Specifications - V6 Models

Description		Specification
Full throttle RPM range	200 SeaPro	4600–5400
	175 and 200	5000–5800
	175 Pro XS	5400–6000
	225	5200–6000
Idle RPM (see NOTE)		600
Ignition type		Digital inductive
Spark plug type		NGK LKAR7C-9
Spark plug gap		0.9 mm (0.035 in.)
Spark plug hex size		14 mm
Spark plug torque		20 Nm (177 lb-in.)
Firing order		1-2-3-4-5-6
Ignition timing at idle		Not adjustable; PCM controlled (approximately 2° ATDC)
Ignition timing at WOT		Not adjustable; PCM controlled
PCM overspeed limiter		See chart

NOTE: *The idle RPM set point may increase due to the low battery voltage ramp-up strategy.*

PCM Overspeed Limiter Specifications

NOTE: *The idle RPM set point may increase due to the low battery voltage ramp-up strategy.*

Model	Partial	Full
300 Verado (AMS)	6150	6300
300 FourStroke (CMS)	6150	6300
300 ProXS (CMS)	6350	6500
300 ProXS (CMS)	6350	6500
300 SeaPro (CMS)	5750	5900
300 SeaPro (AMS)	5750	5900
250 Verado (AMS)	6150	6300
250 FourStroke (CMS)	6150	6300
250 ProXS (CMS)	6350	6500
250 ProXS (CMS)	6350	6500
250 SeaPro (CMS)	5750	5900
225 SeaPro (CMS)	5750	5900
225 ProXS (CMS)	6350	6500
225 ProXS (CMS)	6350	6500
200 ProXS (CMS)	6350	6500
225 FourStroke (CMS)	6350	6500
200 FourStroke (CMS)	5950	6100
200 SeaPro (CMS)	5550	5700
175 FourStroke (CMS)	5950	6100
175 ProXS (CMS)	6150	6300
300R (CMS)	6550	6700
250R (CMS)	6350	6500

Charging and Starting Specifications

Description		Specification	
Alternator model series		8Si	9Si
Alternator output (regulated)	1800 RPM	37 A	42 A
	6000 RPM	85 A	115 A
Regulator voltage set point		14.5 ± 0.25 V	
Starter current draw	Under load	170–190 A	
	No load	60–80 A	

Battery Specifications

Required Starting Battery

Description		Specification
Battery type		12-volt absorbed glass mat (AGM) battery
Rating	USA and Canada (SAE)	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 RC25 rating
	International (EN)	975 minimum cold cranking amps (CCA) with a minimum of 65 ampere hour (Ah)

For additional details, refer to **Section 1D - Battery Requirements**.

Fuel System Specifications

Fuel System Specifications	
Recommended fuel octane rating	87 (R+M)/2, 91 RON
Approximate fuel pressure at idle	290–340 kPa (42.1–43.9 psi)
Approximate fuel pressure engine not running	340–370 kPa (49.3–53.7 psi)
Fuel filtration	
Inlet filter, engine mounted	10 microns
Inlet filter, remote boat mounted	10 microns
High-pressure, at fuel rail inlet	46 microns
Fuel pump current draw	12 A ± 2 A (at 14.4 V)
Maximum fuel system inlet vacuum	10.16 kPa (3.0 in. Hg), (1.47 psi)

V8 Cylinder Block/Crankcase Specifications

V8 Cylinder Block/Crankcase Specifications	
Number of cylinders	8
V-angle	64°
Displacement	4576 cc/4.6 L (279.2 cid)
Compression ratio	10:1
Standard bore	92.00 mm (3.6220 in.)
Standard bore service limit	92.015 mm (3.6226 in.)
Stroke	86.00 mm (3.386 in.)
Cylinder bore maximum taper	0.02 mm (0.0007 in.)
Cylinder bore maximum out of round	0.015 mm (0.0006 in.)
Cylinder block main bearing bore	64.988–65.012 mm (2.5586–2.5595 in.)
Crankshaft main bearing journal	59.984–60.000 mm (2.3616–2.3622 in.)
Connecting rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)
Crankshaft end play	0.00–0.432 mm (0.000–0.017 in.)
Crankshaft runout	0.05 mm (0.002 in.)
Crankshaft main bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.036–0.070 mm (0.0015–0.0027 in.)
Connecting rod bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.046–0.074 mm (0.0019–0.0029 in.)
Crankshaft thrust bearing surface width	25.95–26.05 mm (1.0217–1.0255 in.)
Connecting rod wrist pin bore diameter	20.014–20.022 mm (0.7880–0.7882 in.)
Connecting rod bore diameter (without bearing inserts)	57.000–57.016 mm (2.2441–2.2447 in.)
Piston skirt standard diameter	91.927–91.937 mm (3.6192–3.6195 in.)
Piston wrist pin bore diameter	20.005–20.010 mm (0.7876–0.7878 in.)
Wrist pin diameter	19.996–20.001 mm (0.7873–0.7874 in.)
Top ring groove width	1.22–1.25 mm (0.0480–0.0492 in.)
Second ring groove width	1.01–1.03 mm (0.0398–0.0405 in.)
Third ring groove width	2.01–2.03 mm (0.0791–0.799 in.)
Top ring thickness—maximum	1.20 mm (0.0472 in.)
Second ring thickness—maximum	1.00 mm (0.0393 in.)
Top ring side clearance	0.02–0.05 mm (0.0008–0.0019 in.)
Second ring side clearance	0.01–0.03 mm (0.0004–0.0011 in.)
Top ring end gap	0.20–0.215 mm (0.008–0.0084 in.)
Second ring end gap	0.40–0.425 mm (0.016–0.0167 in.)
Oil ring end gap (top and bottom) (expander not applicable)	0.40–0.425 mm (0.016–0.0167 in.)

V6 Cylinder Block/Crankcase Specifications

V6 Cylinder Block/Crankcase Specifications	
Number of cylinders	6
V-angle	64°
Displacement	3432 cc/3.4 L (209.4 cid)
Compression ratio	10:1
Standard bore	92.00 mm (3.6220 in.)
Standard bore service limit	92.015 mm (3.6226 in.)
Stroke	86.00 mm (3.386 in.)
Cylinder bore maximum taper	0.02 mm (0.0007 in.)
Cylinder bore maximum out of round	0.015 mm (0.0006 in.)
Cylinder block main bearing bore	74.988–75.012 mm (2.9523–2.953 in.)
Crankshaft main bearing journal	69.984–70.000 mm (2.7552–2.7559 in.)
Connecting rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)
Crankshaft end play	0.00–0.432 mm (0.000–0.017 in.)
Crankshaft runout	0.05 mm (0.002 in.)
Crankshaft main bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.054–0.088 mm (0.0022–0.0034 in.)
Connecting rod bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.046–0.074 mm (0.0019–0.0029 in.)
Crankshaft thrust bearing surface width	23.95–24.05 mm (0.9429–0.9468 in.)
Connecting rod wrist pin bore diameter	20.014–20.022 mm (0.7880–0.7882 in.)
Connecting rod crankshaft pin diameter	57.000–57.016 mm (2.2441–2.2447 in.)
Piston skirt standard diameter	91.927–91.937 mm (3.6192–3.6195 in.)
Piston wrist pin bore diameter	20.005–20.010 mm (0.7876–0.7878 in.)
Wrist pin diameter	19.996–20.001 mm (0.7873–0.7874 in.)
Top ring groove width	1.22–1.25 mm (0.0480–0.0492 in.)
Second ring groove width	1.01–1.03 mm (0.0398–0.0405 in.)
Third ring groove width	2.01–2.03 mm (0.0791–0.799 in.)
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Second ring thickness—maximum	1.00 mm (0.0393 in.)
Top ring side clearance	0.02–0.05 mm (0.0008–0.0019 in.)
Second ring side clearance	0.01–0.03 mm (0.0004–0.0011 in.)
Top ring end gap	0.20–0.215 mm (0.008–0.0084 in.)
Second ring end gap	0.40–0.425 mm (0.016–0.0167 in.)
Oil ring end gap (top and bottom) (expander not applicable)	0.40–0.425 mm (0.016–0.0167 in.)

V8 Cylinder Head Specifications

Description	Specification
Head deck maximum warp	0.1 mm (0.0039 in.)
Number of valves	32
Number of valves per cylinder	4
Camshaft bearing inside diameter (cylinder head)	26.000–26.021 mm (1.0236–1.0244 in.)
Camshaft bearing journal	25.96–25.98 mm (1.022–1.023 in.)
Camshaft lobe height	

Description	Specification
Intake	43.02 mm (1.694 in.)
Exhaust	44.24 mm (1.742 in.)
Valve lash clearance	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 in.)
Valve seat angles (referenced relative to the valve guide axis)	
Intake	30°, 44° ± 0.25°, 60°
Exhaust	35°, 44° ± 0.25°, 55°
Valve seat width (44°)	
Intake	1.0 ± 0.1 mm (0.039 ± 0.0039 in.)
Exhaust	1.2 ± 0.1 mm (0.047 ± 0.0039 in.)
Valve spring height	
Uncompressed	Reference 46.1 mm (1.815 in.)
Compressed to 33.66 mm (1.3252 in.)	157–173 Nm (35.295–38.892 lb-ft) spring load
Compressed to 24.31 mm (0.9149 in.)	356–390 Nm (80.03–87.67 lb-ft) spring load
Valve outside diameter	
Intake	36.9–37.1 mm (1.4528–1.4606 in.)
Exhaust	30.9–31.1 mm (1.2165–1.2244 in.)
Valve face angle (referenced relative to the end face of the valve)	
Intake	44.75°–45.25°
Exhaust	43.75°–44.25°
Valve margin width	
Intake	0.875 mm (0.034 in.)
Exhaust	1.331 mm (0.052 in.)
Valve stem diameter	
Intake	5.4645–5.4805 mm (0.2151–0.2158 in.)
Exhaust	5.456–5.472 mm (0.2148–0.2154 in.)
Valve stem runout (service limit measured at valve face)	
Intake and exhaust	0.030 mm (0.0012 in.)
Valve height	
Intake	88.49 ± 0.25 mm (3.484 ± 0.0098 in.)
Exhaust	87.667 ± 0.25 mm (3.451 ± 0.0098 in.)
Valve guide bore inside diameter	
Intake and exhaust	5.500–5.512 mm (0.2165–0.217 in.)
Valve stem to valve guide clearance	
Intake	0.0195–0.0475 mm (0.0008–0.0019 in.)
Exhaust	0.028–0.056 mm (0.0011–0.0022 in.)
Valve guide height (dimension from spring seat to end of guide)	
Intake	14.5 mm (0.570 in.)
Exhaust	14.5 mm (0.570 in.)
Valve bucket	
Intake bucket bore inside diameter	32.000–32.025 mm (1.2589–1.2608 in.)
Exhaust bucket bore inside diameter	32.005–32.025 mm (1.2600–1.2608 in.)
Valve bucket outside diameter	31.964–31.980 mm (1.2584–1.2591 in.)
Bucket to bore clearance	0.020–0.061 mm (0.0008–0.0024 in.)

V6 Cylinder Head Specifications

Description	Specification
Head deck maximum warp	0.1 mm (0.0039 in.)

Description	Specification
Number of valves	24
Number of valves per cylinder	4
Camshaft bearing inside diameter (cylinder head)	26.000–26.021 mm (1.0236–1.0244 in.)
Camshaft bearing journal	25.96–25.98 mm (1.022–1.023 in.)
Camshaft lobe height	
Intake	43.02 mm (1.694 in.)
Exhaust	44.24 mm (1.742 in.)
Valve lash clearance	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 in.)
Valve seat angles (referenced relative to the valve guide axis)	
Intake	30°, 44° ± 0.25°, 60°
Exhaust	35°, 44° ± 0.25°, 55°
Valve seat width (44°)	
Intake	1.0 ± 0.1 mm (0.039 ± 0.0039 in.)
Exhaust	1.2 ± 0.1 mm (0.047 ± 0.0039 in.)
Valve spring height	
Uncompressed	Reference 46.1 mm (1.815 in.)
Compressed to 33.66 mm (1.3252 in.)	157–173 Nm (35.295–38.892 lb-ft) spring load
Compressed to 24.31 mm (0.9149 in.)	356–390 Nm (80.03–87.67 lb-ft) spring load
Valve outside diameter	
Intake	36.9–37.1 mm (1.4528–1.4606 in.)
Exhaust	30.9–31.1 mm (1.2165–1.2244 in.)
Valve face angle (referenced relative to the end face of the valve)	
Intake	44.75°–45.25°
Exhaust	43.75°–44.25°
Valve margin width	
Intake	0.875 mm (0.034 in.)
Exhaust	1.331 mm (0.052 in.)
Valve stem diameter	
Intake	5.4645–5.4805 mm (0.2151–0.2158 in.)
Exhaust	5.456–5.472 mm (0.2148–0.2154 in.)
Valve stem runout (service limit measured at valve face)	
Intake and exhaust	0.030 mm (0.0012 in.)
Valve height	
Intake	88.49 ± 0.25 mm (3.484 ± 0.0098 in.)
Exhaust	87.667 ± 0.25 mm (3.451 ± 0.0098 in.)
Valve guide bore inside diameter	
Intake and exhaust	5.500–5.512 mm (0.2165–0.217 in.)
Valve stem to valve guide clearance	
Intake	0.0195–0.0475 mm (0.0008–0.0019 in.)
Exhaust	0.028–0.056 mm (0.0011–0.0022 in.)
Valve guide height (dimension from spring seat to end of guide)	
Intake	14.5 mm (0.570 in.)
Exhaust	14.5 mm (0.570 in.)
Valve bucket	
Intake bucket bore inside diameter	32.000–32.025 mm (1.2589–1.2608 in.)
Exhaust bucket bore inside diameter	32.005–32.025 mm (1.2600–1.2608 in.)
Valve bucket outside diameter	31.964–31.980 mm (1.2584–1.2591 in.)

Description	Specification
Bucket to bore clearance	0.020–0.061 mm (0.0008–0.0024 in.)

Lubrication System Specifications

Description		Specification
Engine capacity with filter replacement		6.6 L (7.0 US qt)
Oil pressure	Idle RPM (oil cold or warm)*	150–650 kPa (21–95 psi)
	WOT RPM (oil cold or warm)*	400–900 kPa (58–130 psi)
	Idle RPM (oil hot)	60–150 kPa (8–22 psi)
	WOT RPM (oil hot)	350–550 kPa (50–80 psi)
**When the oil is cold, the pressure will be toward the upper end of the range. As the oil warms, the pressure will be toward the lower end of the range.*		

Cooling System Specifications

Description		Specification
Cooling system		Water cooled, thermostat control
Water pressure	At 600 RPM (idle)	10–20 kPa (1.5–2.9 psi)
	At 6000 RPM (WOT)	60–260 kPa (8.7–37.7 psi)
Thermostat	Valve stroke (minimum) at full open temperature	10.0 mm (0.39 in.)
	Start to open temperature	57–61 °C (134.6–141.8 °F)
	Full open temperature	77 °C (170.6 °F)

Conventional Midsection (CMS) Power Trim Specifications

Power Trim Specifications	
Trim up relief valve—tilt extended relief pressure	17237 kPa (2500 psi) minimum
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

Swivel Bracket and Driveshaft Housing Specifications—CMS

Description		Specification
Recommended transom height	Long shaft	508 mm (20 in.)
	XL shaft	635 mm (25 in.)
	XXL shaft	762 mm (30 in.)
Steering pivot range		60°
Full tilt up angle		71°
Trim angle (on 14° boat transom)		– 6° to + 14°
Allowable transom thickness	Minimum	44.5 mm (1.75 in.)
	Maximum	70 mm (2.75 in.)

Gear Housing Specifications

Gear Housing Specifications (4.8 in. Diameter)

Description	Specification
Gear ratio	1.85:1 (13/24 teeth)
Gearcase capacity—right-hand rotation	710 ml (24 fl oz)
Gearcase capacity—left-hand rotation	810 ml (27.4 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Pinion height	0.635 mm (0.025 in.)
Front gear backlash—right-hand rotation (forward gear)	0.482–0.660 mm (0.019–0.026 in.)
Front gear backlash—left-hand rotation (reverse gear)	1.27–1.47 mm (0.050–0.058 in.)
Rear gear backlash—right-hand rotation (reverse gear)	1.27–1.47 mm (0.050–0.058 in.)
Rear gear backlash—left-hand rotation (forward gear)	0.482–0.660 mm (0.019–0.026 in.)
Gear housing pressure (without gear lubricant, 5 minutes without leakage)	103.4 kPa (15 psi)
Propeller shaft runout	0.23 mm (0.009 in.)

Gear Housing Specifications (5.44 in. Diameter)

Description	Specification
Propeller shaft	31.75 mm (1.25 in.) diameter, 19-spline
Propeller hub	
Option 1	Flo-Torq II HD solid hub kit
Option 2	Flo-Torq SSR HD hub kit
Gear ratio	
Standard	1.75:1
Optional	1.85:1
Gear teeth count pinion/forward	
1.75:1	12/21
1.85:1	13/24
Gear housing lubricant capacity	
Right-hand	720 ml (24.4 fl oz)
Left-hand	680 ml (23.0 fl oz)
Right-hand—SeaPro	980 ml (33.1 fl oz)
Left-hand—SeaPro	980 ml (33.1 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Propeller shaft lubricant	2-4-C with PTFE
Propeller shaft runout limit (bent)	0.23 mm (0.009 in.)
Propeller shaft end play	No end play
Pinion height tool (optional)	91-8M0046443
Pinion height	0.635 mm (0.025 in.)
Backlash indicator tool	8M0053505
Align dial indicator pin with mark	5
Front gear backlash—right-hand rotation (forward gear)	0.508–0.609 mm (0.020–0.024 in.)
Front gear backlash—left-hand rotation (reverse gear)	0.787–0.965 mm (0.031–0.038 in.)
Rear gear backlash—right-hand rotation 1.75:1 (reverse gear)	0.787–0.940 mm (0.031–0.037 in.)
Rear gear backlash—right-hand rotation 1.85:1 (reverse gear)	1.067–1.219 mm (0.042–0.048 in.)
Rear gear backlash—left-hand rotation (forward gear)	0.457–0.584 mm (0.018–0.023 in.)
Water pressure	
At 600 RPM (idle)	10–20 kPa (1.5–2.9 psi)
At 6000 RPM (WOT)	60–260 kPa (8.7–37.7 psi)

Description	Specification
Gear housing leak test pressure (without gear lubricant, 5 minutes without leakage)	103.4 kPa (15 psi)

IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "5" mark and are only valid if the pinion height is within specification.

Gear Housing Specifications (Torque Master)

Gear Housing Specifications	
Gear ratio	1.75:1 (12/21 teeth)
Gearcase capacity—Torque Master	520 ml (17.6 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Pinion height	0.635 mm (0.025 in.)
Front (forward) gear backlash	0.482–0.660 mm (0.019–0.026 in.)
Rear (reverse) gear backlash	1.27–1.47 mm (0.050–0.058 in.)
Gear housing pressure (without gear lubricant, 15 minutes without leakage)	103.4 kPa (15 psi)
Propeller shaft runout	0.23 mm (0.009 in.)

Steering System Specifications

Power Steering Specifications

Power Steering Specifications	
Fluid type	Synthetic Power Steering Fluid SAE 0W-30
Capacity	Typical 1–2 liters (1–2 US qt)
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

Notes:

Important Information

Section 1B - Maintenance

1 B

Table of Contents

Lubricant, Sealant, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Quickleen Engine & Fuel System Cleaner	Fuel tank	8M0047931
	Extreme Grease	Propeller shaft	8M0071842
		Propeller shaft splines	
		Swivel bracket, tilt lock, propeller shaft	
81	Anti-Seize Compound	Spark plug threads	92-898101389
95	2-4-C with PTFE	Fuel filter grommet	92-802859A 1
		Propeller shaft	
		Propeller shaft splines	
		Swivel bracket, tilt lock, tilt tube, propeller shaft	
114	Power Trim and Steering Fluid	Power trim system	92-858074K01
120	Corrosion Guard	External metal surfaces of the powerhead and powerhead components.	92-802878 55
138	Synthetic Power Steering Fluid SAE 0W-30	Power steering system	92-858077K01

Special Tools

Crankcase Oil Pump	802889A1
 11591	Aids in the removal of engine oil without draining the crankcase.

Oil Drain Hose	8M0137866
 64627	Aids in the removal of engine oil without draining the crankcase. Connect to the crankcase oil pump.

Cleaning Care Recommendations

Do Not Use Caustic Cleaning Chemicals

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

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

Cleaning Gauges

IMPORTANT: Never use high-pressure water to clean gauges.

Routine cleaning of the gauges is recommended to prevent a buildup of salt and other environmental debris. Crystalized salt can scratch the gauge display lens when using a dry or damp cloth. Ensure that the cloth has a sufficient amount of fresh water to dissolve and remove salt or mineral deposits. Do not apply aggressive pressure on the display lens while cleaning.

When water marks cannot be removed with a damp cloth, mix a 50/50 solution of warm water and isopropyl alcohol to clean the display lens. **Do not use** acetone, mineral spirits, turpentine type solvents, or ammonia based cleaning products. The use of strong solvents or detergents may damage the coating, the plastics, or the rubber keys on the gauges. If the gauge has a sun cover available, it is recommended that the cover be installed when the unit is not in use to prevent UV damage to the plastic bezels and rubber keys.

Cleaning Remote Controls

IMPORTANT: Never use high-pressure water to clean remote controls.

Routine cleaning of the remote control external surfaces is recommended to prevent a buildup of salt and other environmental debris. Use a cloth towel which has a sufficient amount of fresh water to dissolve and remove salt or mineral deposits.

When water marks cannot be removed with a damp cloth, mix a 50/50 solution of warm water and isopropyl alcohol to clean the remote control. **Do not use** acetone, mineral spirits, turpentine type solvents, or ammonia based cleaning products. The use of strong solvents or detergents may damage the coating, the plastics, or the rubber components on the remote control.

Cleaning Care for Top and Bottom Cowls

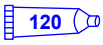
IMPORTANT: Dry wiping (wiping the plastic surface when it is dry) will result in minor surface scratches. Always wet the surface before cleaning. Do not use detergents containing hydrochloric acid. Follow the cleaning and waxing procedure.

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).

Cleaning Care for the Powerhead (Saltwater Use)

IMPORTANT: If the outboard is operated in saltwater, remove the top cowl. Inspect the powerhead and powerhead components for salt build-up. Wash off any salt build-up from the powerhead and powerhead components with fresh water. Keep water spray out of the air filter/intake and alternator. After washing, allow the powerhead and components to dry. Apply Quicksilver or Mercury Precision Lubricants Corrosion Guard spray on the external metal surfaces of the powerhead and powerhead components. Do not allow the Corrosion Guard spray to come in contact with the alternator drive belt, belt pulleys, or the outboard motor mounts. The alternator drive belt could slip and be damaged if it becomes coated with any lubricant or Corrosion Guard spray.

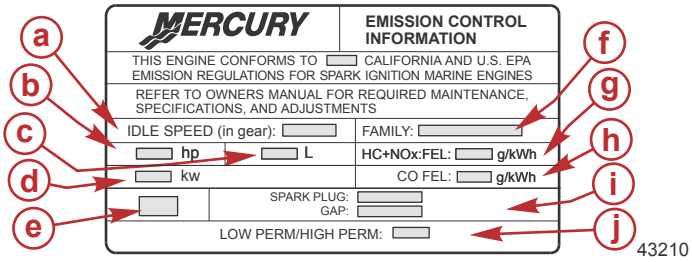
Tube Ref No.	Description	Where Used	Part No.
	Corrosion Guard	External metal surfaces of the powerhead and powerhead components.	92-802878 55

EPA Emissions 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 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.**

Emission Certification Label

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



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

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 emission levels to exceed their predetermined factory specifications.

Inspection and Maintenance Schedule

Before Each Use

- Check engine oil level. Refer to **Checking Engine Oil Level**.
- Check that the 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, tighten the outboard mounting fasteners to the specified torque. When looking for signs of looseness, look for loss of outboard transom bracket material or paint caused by movement between the outboard mounting fasteners and the outboard transom brackets. Also look for signs of movement between the outboard transom brackets and the boat transom (lift plate/setback bracket).

Description	Nm	lb-in.	lb-ft
Outboard mounting locknuts and bolts - standard boat transom	75	–	55.3
Outboard mounting locknuts and bolts - metal lift plates and setback brackets	122	–	90

- Visually inspect the fuel system for deterioration or leaks.
- Check the steering system for binding or loose components.
- Check the propeller blades for damage.
- Inspect the hydraulic steering fittings and hoses for leaks or damage, if equipped.
- Inspect the hydraulic steering fluid level, if equipped.

After Each Use

- Flush out the outboard cooling system if operating in salt, polluted, or muddy 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.
- If operating in saltwater, inspect the powerhead and powerhead components for salt buildup. Refer to **Cleaning Care for the Powerhead (Saltwater Use)**.

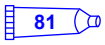
Every 100 Hours of Use or Once Yearly, Whichever Occurs First

- Inspect the exhaust water strainer. Refer to **Exhaust Water Strainer Inspection**.
- Change 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 and Filter**.
- Check the engine mounted water-separating low-pressure fuel filter for water or contaminants. Replace the filter if required. Refer to **Fuel System**.

- Check the boat mounted water-separating fuel filter for the presence of water or contaminants. Drain the water or replace the filter if required.
- Remove the propeller and lubricate the propeller shaft. Refer to **Propeller Replacement**.
- Inspect the thermostat visually for corrosion or a broken spring. Ensure the thermostat closes completely at room temperature—dealer service.
- Check the outboard mounting fasteners that fasten the outboard to the boat transom. Tighten the fasteners to the specified torque—dealer service.

Description	Nm	lb-in.	lb-ft
Outboard mounting locknuts and bolts - standard boat transom	75	–	55.3
Outboard mounting locknuts and bolts - metal lift plates and setback brackets	122	–	90

- Check corrosion control anodes. Check more frequently when used in saltwater. Refer to **Corrosion Control Anodes**.
- Drain and replace gearcase lubricant. Refer to **Gearcase Lubrication**.
- Inspect battery. Refer to **Battery Inspection**.
- Saltwater usage: Remove and inspect spark plugs for corrosion and replace as necessary. Apply Anti-Seize Compound only on threads of spark plug prior to installation. Refer to **Spark Plug Inspection and Replacement**.

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

- Check tightness of bolts, nuts, and other fasteners—dealer service.
- Add Quickleen to the fuel tank.

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

- Check cowl seals to ensure seals are intact and not damaged.
- Check that the intake silencer is in place, if equipped.
- Check that the idle relief muffler is in place, if equipped.
- Check for loose hose clamps and rubber boots on the air intake assembly, if equipped.

Every 300 Hours of Use or Three Years

- Check power trim fluid. Refer to **Checking Power Trim Fluid**.
- Lubricate all lubrication points. Lubricate more frequently when used in saltwater. Refer to **Lubrication Points**.
- Replace water pump impeller—dealer service.[1]
- Lubricate the splines on the upper driveshaft—dealer service.
- Check wiring and connectors—dealer service.
- Replace alternator drive belt. Refer to **Alternator Drive Belt**—dealer service.
- Replace the spark plugs.

Before Periods of Storage

- Refer to **Storage** section.

Maintenance Schedule Decals

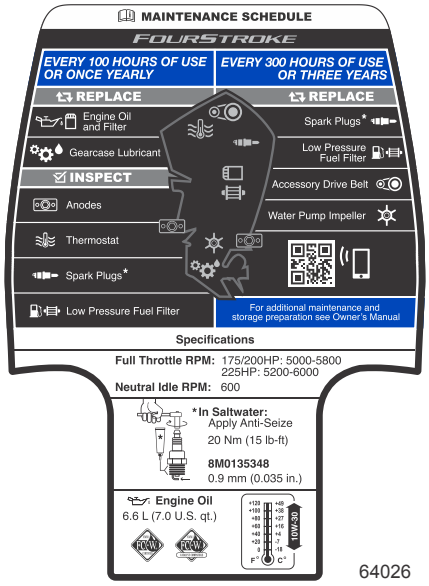
Maintenance Schedule Decal Icons

A maintenance schedule decal is located on the engine to remind the owner or operator when the power package important maintenance items require attention. The following table shows the icons and a general description of the scheduled maintenance items.

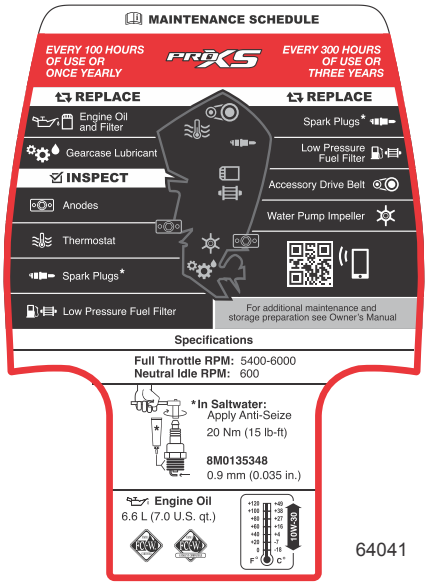
1. Replace the water pump impeller more often if overheating occurs or reduced water pressure is noted.

Icon	Definition	Icon	Definition
58249	Replace	58250	Inspect
58251	Engine oil and filter	58252	Gearcase lubricant
58253	Spark plugs	58254	Thermostat
58255	Low-pressure fuel filter	58256	Anodes
58257	Accessory drive belt	58258	Water pump impeller

V6 FourStroke Models Maintenance Schedule Decal



V6 Pro XS Models Maintenance Schedule Decal



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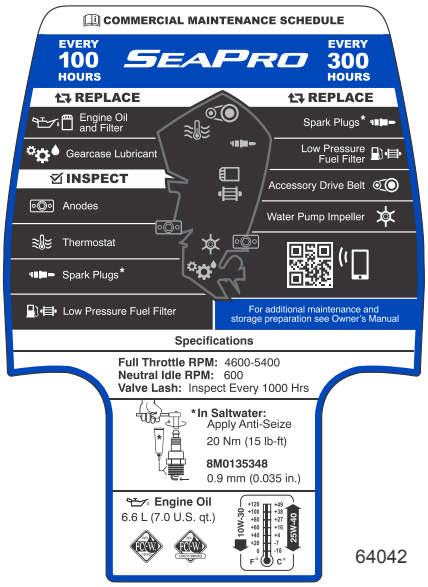
SeaPro V6 Models Maintenance Schedule Decal



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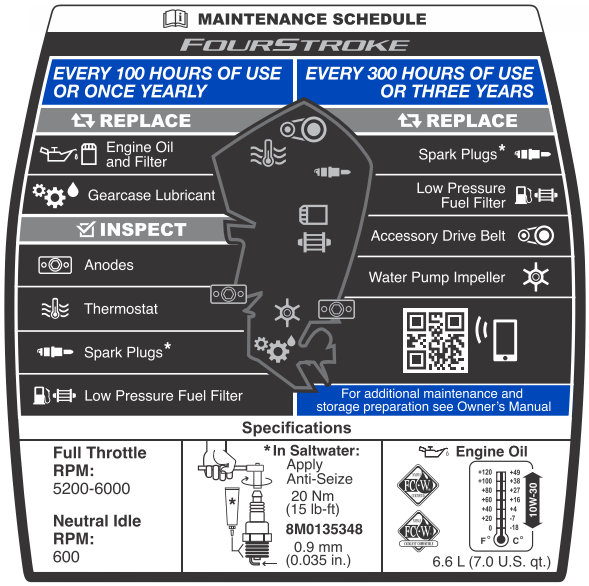
V8 FourStroke Models Maintenance Schedule Decal



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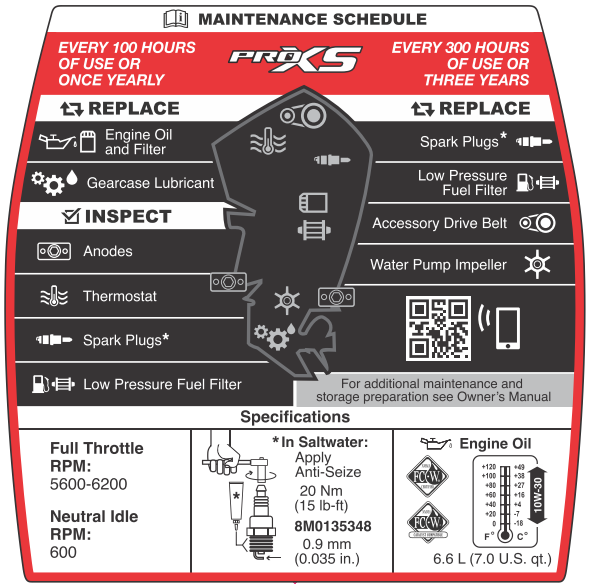
V8 Pro XS Models Maintenance Schedule Decal



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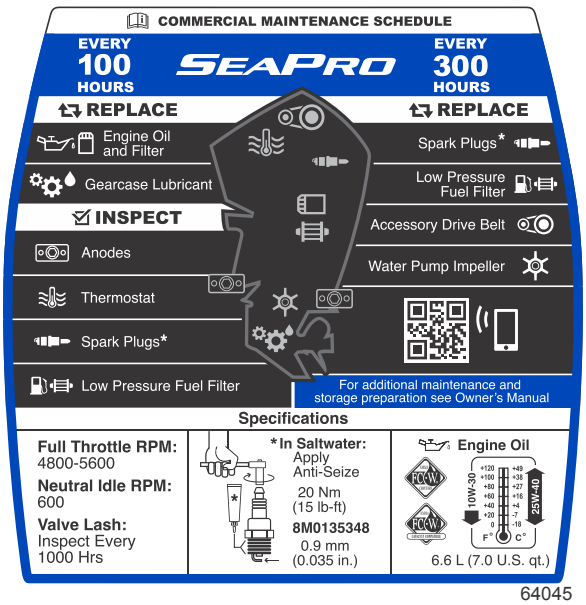
SeaPro V8 Models Maintenance Schedule Decal



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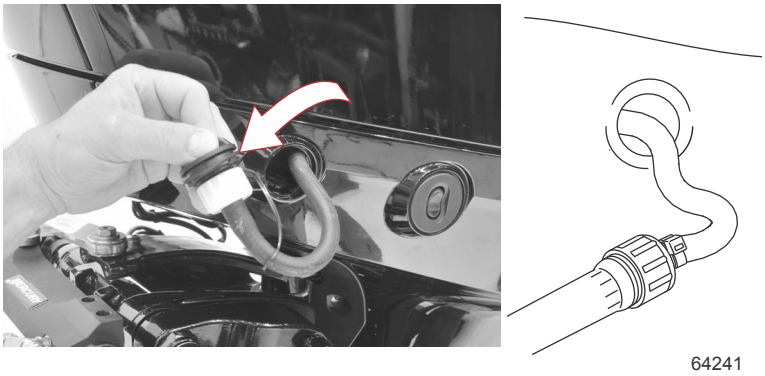
Flushing the Cooling System

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.



64241

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 the water and disconnect the water hose.
6. Install the cover on the flush connector. Place the flush connector back into the bottom cowl.

Top Cowl Removal and Installation

NOTE: *It is recommended to remove and install the cowl while standing inside the boat.*

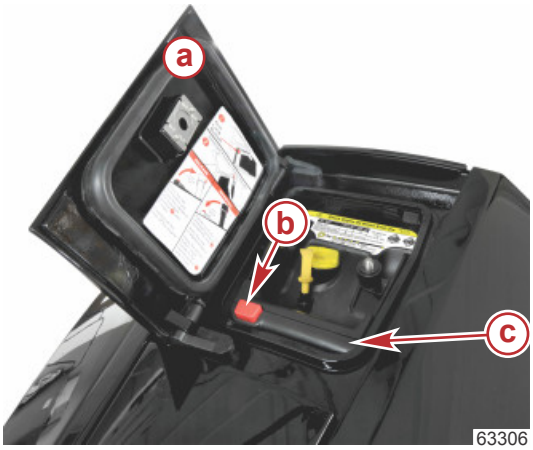
Removal

1. Tilt the outboard up so the top of the cowl is facing you.

2. Push down on the port side of the service access door to unlock and open the door.

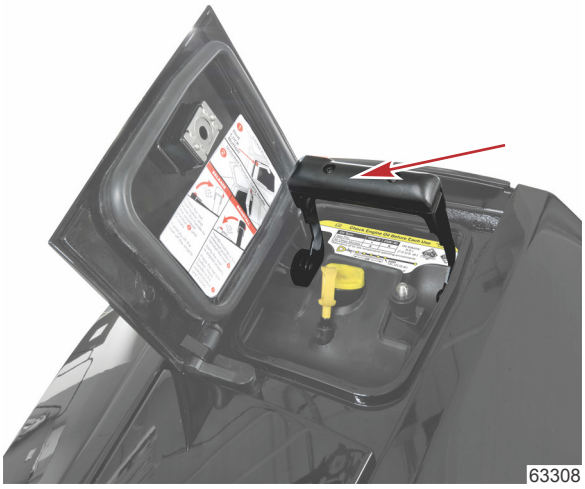
Push here to unlock

3. Press on the red lock button and lift the handle.



a - Service access door
b - Red lock button
c - Handle

4. Push the handle towards the aft to lock the handle into the cowl lift position.



Handle locked in the lift position

5. With a firm grip on the handle, carefully lift the cowl off the engine.

Installation

1. With a firm grip on the handle, carefully lower the top cowl over the engine.

2. Verify the cowl is correctly aligned by checking the cowl alignment guides on the port and starboard side of the cowl. If there is misalignment, one side of the cowl will have a gap that is larger than the other side.

   NOTE: *It may be necessary to slightly lift the larger gap side of the cowl to correctly position the alignment guides.*
3. Gently push down on the cowl.
4. Push the red lock button and pull the handle. Continue to push the handle down into the locked position.
5. Close the service access door.

Battery Inspection

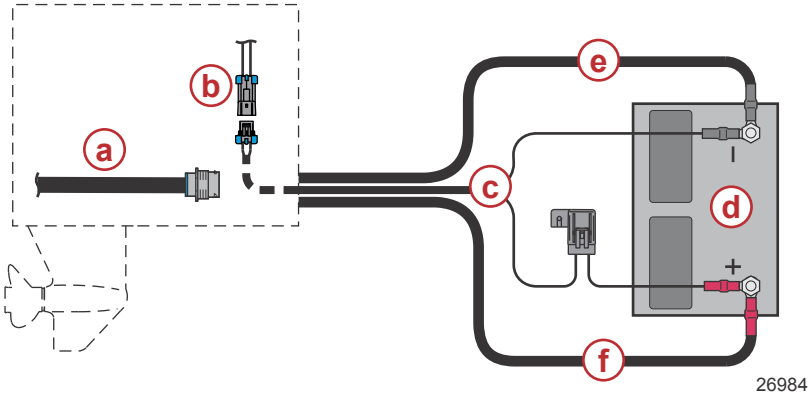
The battery should be inspected at periodic intervals to ensure proper engine starting capability.

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

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

Battery Cables and Clean Power Harness

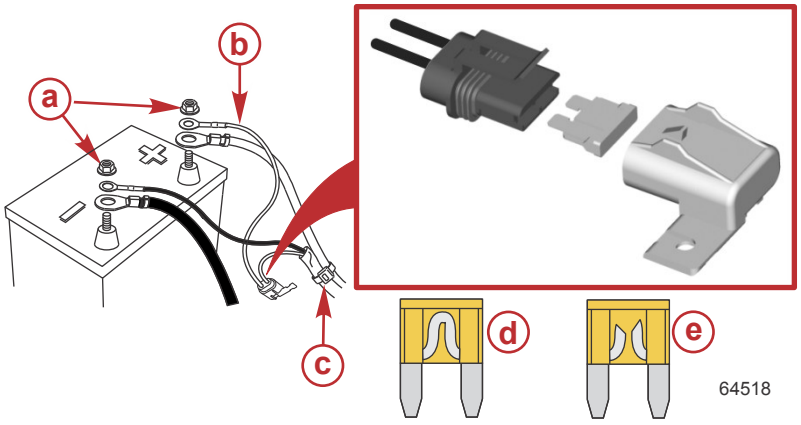
The battery cable connections should be checked often for corrosion or loose retaining hardware. Maintaining this electrical connection helps ensure the engine operation and accessories functionality remains trouble-free. The engine starting battery cables and the clean power harness wires must be secured to the engine starting battery with nuts. Wing nuts are not acceptable. The clean power harness must be secured to one of the battery cables with a cable tie or other type of secure fastener.



- **a -** 14-pin data harness
- **b -** Clean power harness connector at engine
- **c -** Clean power harness
- **d -** Battery
- **e -** Negative engine battery cable
- **f -** Positive engine battery cable

If the clean power harness fuse is open, try to locate and correct the cause of the overload. If the cause is not found, the fuse may open again. Remove the clean power fuse and look at the silver band inside the fuse. If the band is broken (open), replace the fuse with the same rating (5 amp) and type fuse.

IMPORTANT: An ATC fuse has the fuse element enclosed or sealed inside the plastic housing. This type of fuse must be used for marine applications. Marine applications are exposed to environments that may have the potential to accumulate explosive vapors. ATO fuses have exposed elements and should never be used in marine applications.



- **a -** Nuts
- **b -** Clean power harness
- **c -** Cable tie
- **d -** Good fuse
- **e -** Open fuse

Battery Connections

IMPORTANT: The engine electrical system is negative (–) ground.

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.

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

Order of Connection

Connect the battery cables in the following order:

1. All jumpers between parallel, multiple battery packs
2. From the batteries to the positive (+) engine lead
3. From the batteries to the positive (+) clean power
4. From the batteries to the negative (–) engine lead
5. From the batteries to the negative (–) clean power
6. From the batteries or main ground (–) bus to the negative (–) starboard helm main power relay

Fuel System

⚠ WARNING

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

IMPORTANT: 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.

Low-Pressure Fuel Filter

The low-pressure fuel filter can be serviced as a general maintenance item when the water-in-fuel alarm is activated.

⚠ WARNING

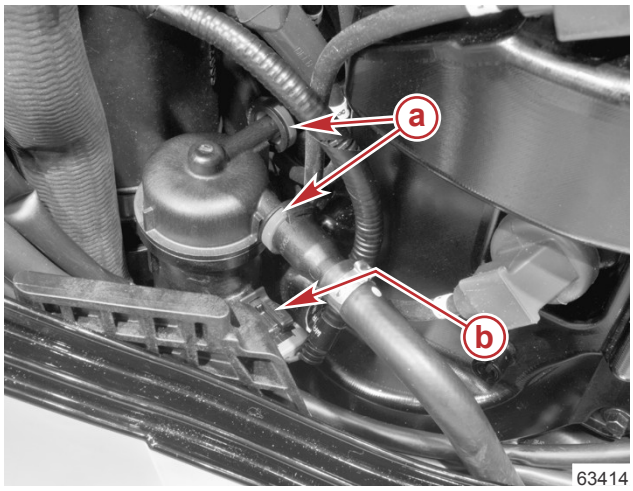
Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for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

Removal

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 container.

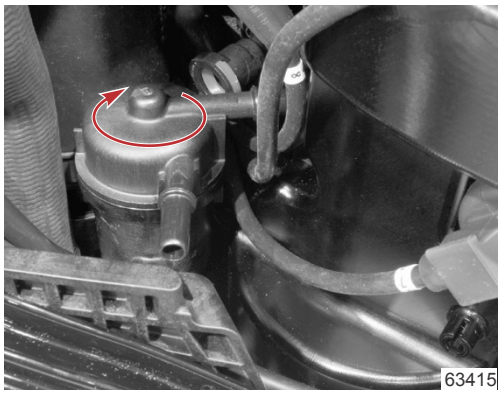
1. Verify the ignition key switch is in the OFF position and that the lanyard switch is positioned so the engine cannot start.
2. Remove the top cowl.
3. Locate the fuel filter on the starboard aft side of the engine near the bottom spark plug.
4. Push in on the fuel hose release tabs and disconnect the fuel hoses from the fuel filter.
5. Disconnect the water-in-fuel sensor harness.

NOTE: *If there is a boat mounted water-separating fuel filter with a water-in-fuel sensor installed, the sensor harness would be connected to the boat mounted filter.*



a - Fuel hose release tabs
b - Water-in-fuel sensor harness

6. Rotate the filter clockwise approximately 1/4 of a turn and lift the filter out.

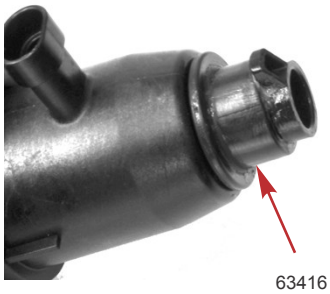


Filter rotated 1/4 turn

7. Empty the fuel filter contents into an approved container and dispose according to local regulations.
8. Wipe up any spilled fuel.

Installation

1. Apply a small amount of 2-4-C with PTFE to the fuel filter grommet.



Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Fuel filter grommet	92-802859A 1

2. Install the fuel filter and rotate counterclockwise 1/4 turn to retain the filter.
3. Connect the water-in-fuel sensor harness.

NOTE: *If there is a boat mounted water-separating fuel filter with a water-in-fuel sensor installed, the sensor harness would be connected to the boat mounted filter.*

4. Connect the fuel hoses to the fuel filter securely with the locking hose connections.
5. Turn the key to the RUN position and inspect for fuel leaks. Repair any fuel leaks if necessary.

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 50% eroded. Never paint or apply a protective coating on the anode as this will reduce effectiveness of the anode.

Two anodes are located on the engine; one anode is on the gear housing and the other is on the bottom of the transom bracket assembly.

Propeller Replacement

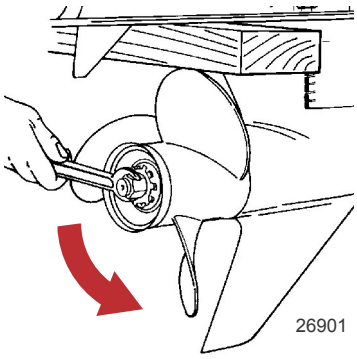
⚠ WARNING

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

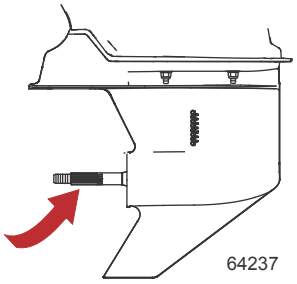
1. Shift outboard to the neutral (N) position.

2. Remove the key from the ignition.
3. Straighten the bent tabs on the propeller nut retainer.

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



5. Pull the propeller straight off the shaft. If the propeller is seized to the shaft and cannot be removed, have the propeller removed by an authorized dealer.
6. Apply a liberal amount of Extreme Grease or 2-4-C with PTFE to the propeller shaft.

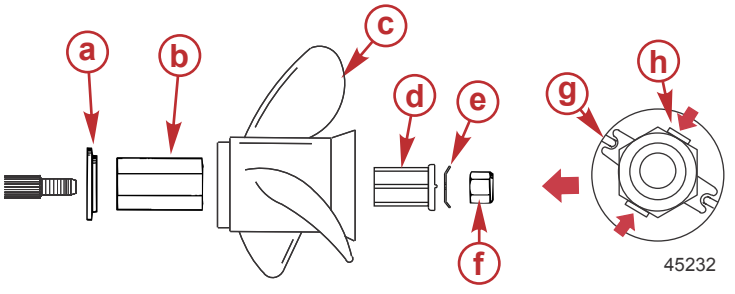


Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Propeller shaft	8M0071842
95	2-4-C with PTFE	Propeller shaft	92-802859A 1

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

Flo-Torq II Propellers—25.4 mm (1 in.) Propeller Shaft

1. Install the propeller onto the shaft with the supplied components as shown.
2. Place the locknut retainer over the raised pins on the drive sleeve adapter and tighten the locknut to the specified torque.
3. Secure the locknut by bending the tabs up against the locknuts.



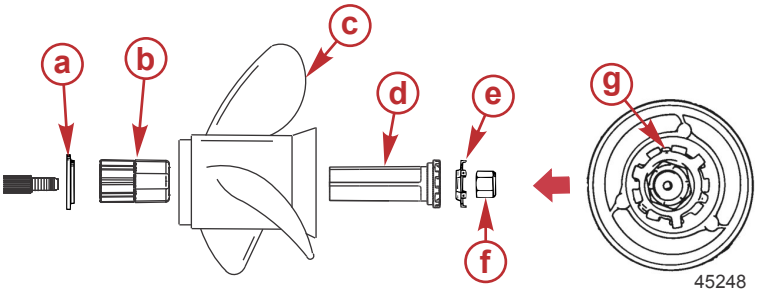
a - Forward thrust washer
b - Drive sleeve
c - Propeller
d - Drive sleeve adapter
e - Locknut retainer
f - Locknut
g - Raised pins
h - Tabs bent against the locknut

Description	Nm	lb-in.	lb-ft
Locknut	75	–	55.3

Flo-Torq IV Propellers—25.4 mm (1 in.) Propeller Shaft

1. Install the propeller onto the shaft with the supplied components as shown.
2. Tighten the locknut to the specified torque.

3. Secure the locknut by bending three of the tabs into the grooves in the drive sleeve adapter.



a - Forward thrust washer
b - Drive sleeve
c - Propeller
d - Drive sleeve adapter
e - Locknut retainer
f - Locknut
g - Tabs bent into grooves

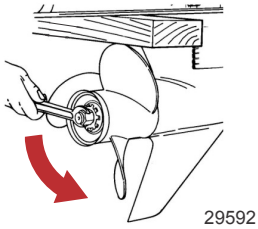
Description	Nm	lb-in.	lb-ft
Locknut	75	–	55.3

Propeller Replacement—31.75 mm (1-1/4 in.) Diameter Propeller Shaft

⚠ 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. Shift the outboard into neutral position.
2. Place a block of wood between the gearcase and the propeller to hold the propeller and remove the propeller nut.

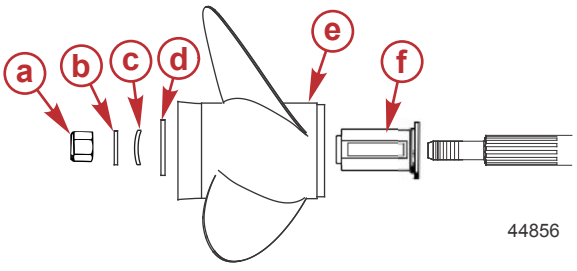


3. Pull the propeller straight off the shaft. If the propeller is seized to the shaft and cannot be removed, have the propeller removed by an authorized dealer.
4. To aid in future removal of the propeller, liberally coat the propeller shaft splines with one of the following Mercury/ Quicksilver products:

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

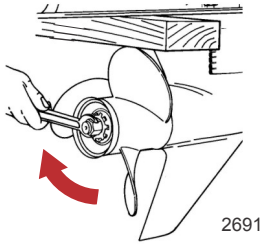
NOTE: *Propellers used on the 31.75 mm (1-1/4 in.) diameter propeller shaft require the heavy-duty propeller hub kit.*

5. **Heavy-duty propeller hub**—Install the propeller hub, propeller, washer, Belleville washer, washer, and propeller nut onto the shaft.



a - Propeller nut
b - Washer
c - Belleville washer
d - Washer
e - Propeller
f - Propeller hub

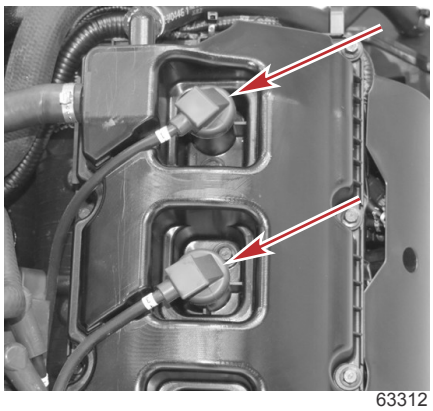
6. Place a block of wood between the gearcase and the propeller. Tighten the propeller nut to the specified torque.



Description	Nm	lb-in.	lb-ft
Propeller nut	75	–	55.3

Spark Plug Inspection and Replacement

1. Remove the top cowl. Refer to **Top Cowl Removal and Installation**.
2. Grasp the spark plug boot and use a twisting motion to assist removing the spark plug boot from the spark plugs.

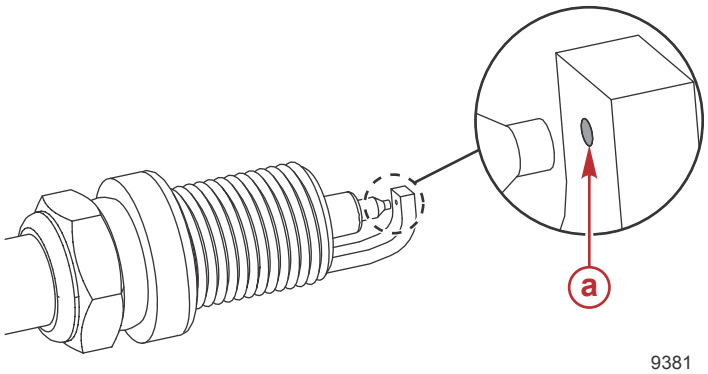


Spark plug boot

3. Remove the spark plug with a 14 mm deep socket.

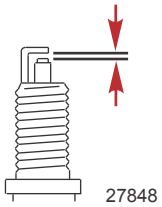
   NOTE: *Replace the spark plug if the electrode is worn; the insulator is rough, cracked, broken, or blistered; or if the precious metal is not visible on the spark plug electrode.*

   IMPORTANT: The color of the plug may not accurately reflect its condition. To accurately diagnose a faulty plug, inspect the precious metal on the plug's electrode. If no precious metal is visible, replace the plug.



a - Precious metal

4. Check the spark plug gap. Refer to **General Information - Specification**.



   a. All of the spark plugs should have the gap checked and corrected as necessary before installation.
   b. Measure the gap with a feeler gauge or pin gauge. Never use a wedge-type gap checking tool to inspect or to adjust the gap.
   c. If an adjustment is necessary, do not pry or apply any force on the center electrode. This is critical with any type of spark plug that has a wear surface, such as platinum or iridium added to either the ground electrode or the center electrode.
   d. When it is necessary to widen the gap, use a tool that only pulls back on the ground electrode without touching the center electrode, the porcelain, or the wear portion of the ground electrode.
   e. When it is necessary to close the gap, gently tap the plug ground electrode on a hard surface.

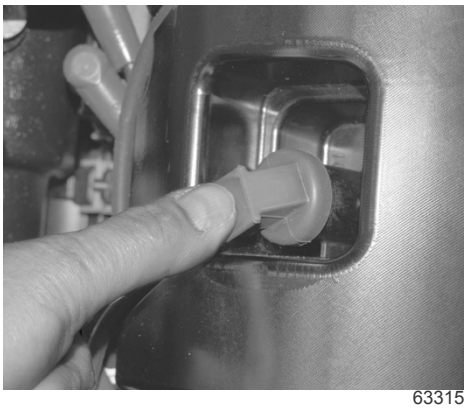
5. Saltwater use—Apply Anti-Seize Compound only onto the threads of the spark plugs.

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

6. Before installing the spark plugs, remove any dirt on the spark plug seat area. Install the plugs finger-tight and then tighten an additional 1/4 turn or tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Spark plug	20	177	–

7. Insert the spark plug boot into the valve cover. The boot is self-aligning with the spark plug.
8. Push on the end of the spark plug boot to ensure the boot is completely engaged and seated onto the spark plug.



Push the spark plug boot

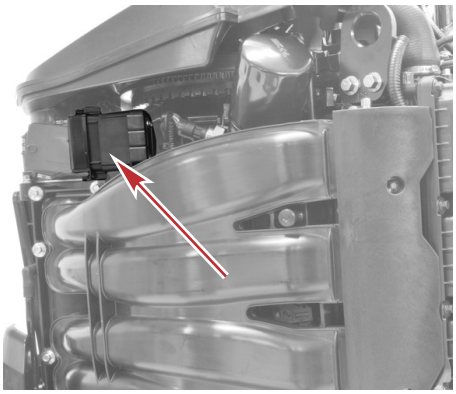
9. Install the top cowl.

Fuses

IMPORTANT: An ATC fuse has the fuse element enclosed or sealed inside the plastic housing. This type of fuse must be used for marine applications. Marine applications are exposed to environments that may have the potential to accumulate explosive vapors. ATO fuses have exposed elements and should never be used in marine applications.

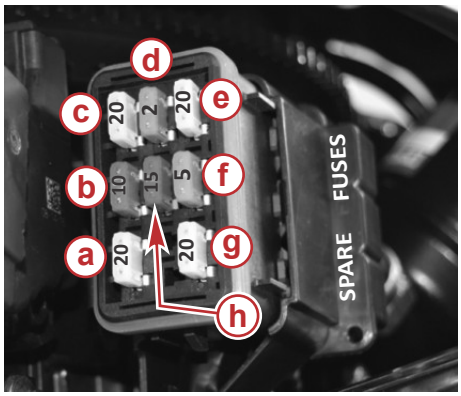
The electrical wiring circuits on the outboard are protected from overload with fuses. If a fuse is open, try to locate and correct the cause of the overload. If the cause is not found, the fuse may open again.

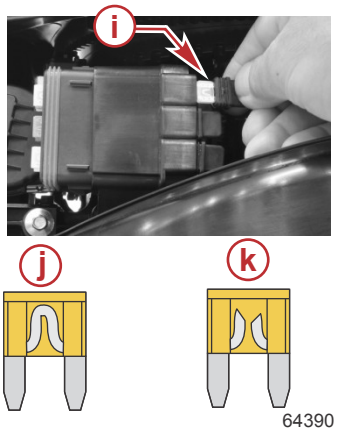
1. Locate the fuse holder on the port side of the engine and remove the cover from the fuse holder.



63317

2. Remove the suspected open fuse and look at the silver band inside the fuse. If the band is broken (open), replace the fuse.
IMPORTANT: Replace the fuse with a new fuse with the same amp rating.





64390

- **a -** Ignition coils - 20 amp
- **b -** Oxygen sensor - 10 amp
- **c -** Fuel pumps - 20 amp
- **d -** Diagnostics - 2 amp
- **e -** Fuel injectors - 20 amp
- **f -** Advanced sound control driver - 5 amp
- **g -** Power driver - 20 amp
- **h -** TVM power -15 amp—DTS products only
- **i -** Spare fuses (3)
- **j -** Good fuse
- **k -** Open fuse

Alternator Drive Belt

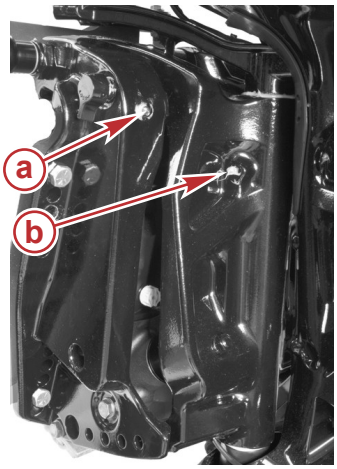
The alternator drive belt is located under the flywheel shroud–intake air induction plenum. The alternator drive belt inspection must be completed by an authorized Mercury dealer at the recommended interval. Refer to **Inspection and Maintenance Schedule**.

Lubrication Points

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

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Swivel bracket, tilt lock, propeller shaft	8M0071842
95	2-4-C with PTFE	Swivel bracket, tilt lock, tilt tube, propeller shaft	92-802859A 1

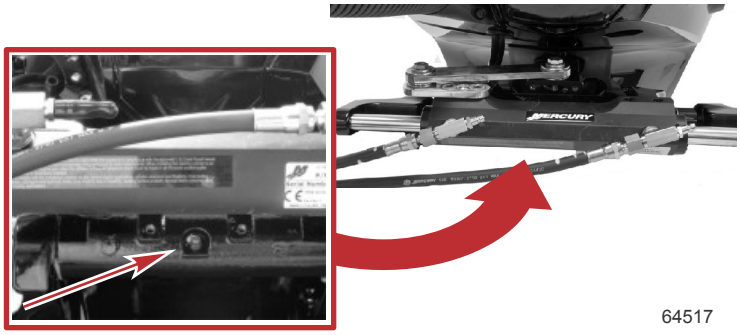
- Lubricate the swivel bracket and tilt lock through the grease fittings.



63792

a - Tilt lock grease fitting
b - Swivel bracket grease fitting

- Lubricate the tilt tube through the grease fitting.



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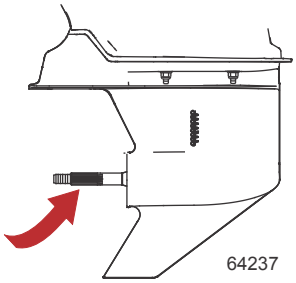
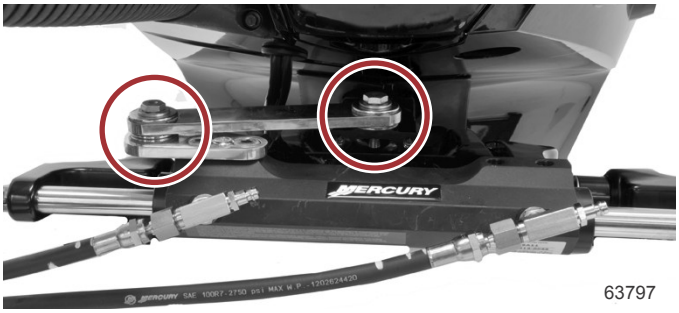
- Propeller shaft—Refer to **Propeller Replacement** for removal and installation of the propeller. Apply a generous amount of lubricant to the entire propeller shaft to prevent the propeller hub from seizing to the shaft.



64237

2. Lubricate the steering linkage with oil.

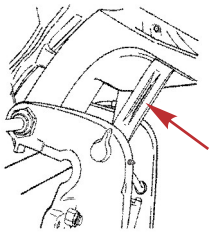


63797

Lubricate with oil

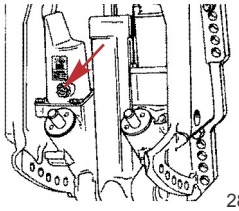
Checking Power Trim Fluid

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



27877

2. Remove the fill cap and check the 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 Hydraulic Steering Fluid

⚠ 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.

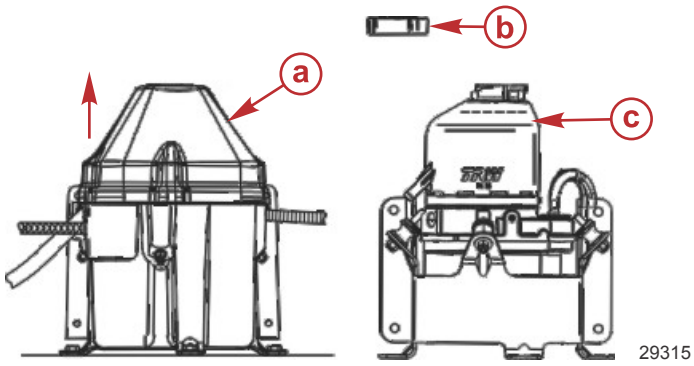
IMPORTANT: Check the hydraulic steering fluid level on a regular basis. The steering system must be full of fluid to ensure the steering helm will not introduce air into the steering system. A hydraulic steering system which has entrained air will have spongy or unresponsive steering control which could compromise the operator's ability to control the boat. On dual helm steering systems, always check the upper steering helm first. If the system must be purged of entrained air, one person may not be able to completely fill and purge the air from the steering system. See your dealer if you have questions on your steering system or refer to the installation instructions included with your steering system.

Checking Power Steering Fluid

⚠ 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.

Remove the power steering cover and fill cap to check the fluid level. The fluid level should be slightly below the bottom of the fill hole. Use Synthetic Power Steering Fluid SAE 0W-30, 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	92-858077K01

Changing Engine Oil and Filter

Engine Oil Capacity

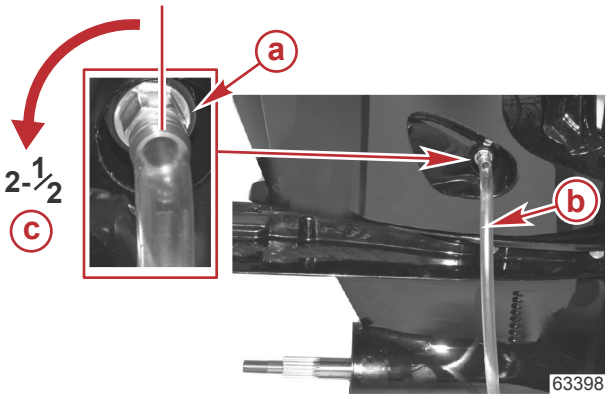
Engine oil capacity is approximately 6.6 Liter (7.0 US qt).

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

Oil Change On Land Procedure

1. Tilt the outboard out/up past vertical for approximately one minute to allow any trapped oil to drain back to the oil sump.
2. Tilt the outboard to a vertical position.
3. Use a 16 mm (5/8 in.) wrench and loosen the oil drain valve so that it can be turned by hand. Be careful not to open the valve too far allowing oil to drain.
4. Attach a 12 mm (7/16 in.) inside diameter drain hose to the oil drain valve. Position the opposite end of the hose into an appropriate container. The container should be large enough to hold more than 9.8 Liter (10 US qt).
5. Loosen the oil drain valve 2-1/2 turns to allow oil to drain. Do not exceed 2-1/2 turns.

   IMPORTANT: Do not loosen the oil drain valve more than 2-1/2 turns out. The oil seal could get damaged beyond 2-1/2 turns.



- **a -** Oil drain valve
- **b -** Drain hose
- **c -** Loosen 2-1/2 turns maximum

6. After the oil has drained, hand-tighten the oil drain valve (clockwise) and remove the oil drain hose.
7. Tighten the oil drain valve to the specified torque. Clean up any oil in the valve area.

Description	Nm	lb-in.	lb-ft
Oil drain valve	15	132.7	–

IMPORTANT: Overtightening the oil drain valve can damage the oil sump.

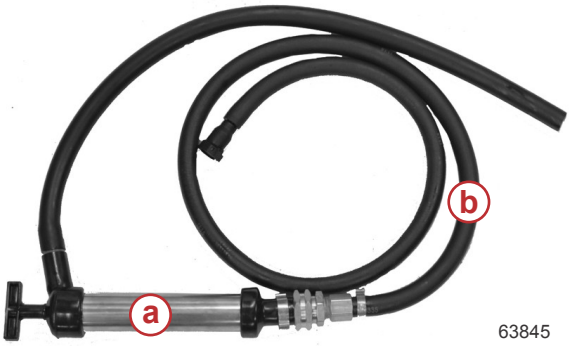
8. Add the appropriate amount of engine oil.

Oil Change On Water Procedure

1. Tilt the outboard out/up past vertical for approximately one minute to allow any trapped oil to drain back to the oil sump.
2. Tilt the outboard to a vertical position.
3. Push down on the port side of the service access door to unlock and open the door.

Push here to unlock

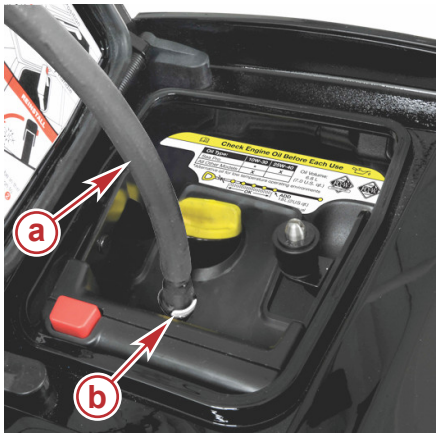
4. Remove the dipstick.
5. Install the oil drain hose onto the crankcase oil pump. Verify the hose is securely attached.



a - Crankcase oil pump
b - Oil drain hose

Crankcase Oil Pump	802889A1
Oil Drain Hose	8M0137866

6. Install the crankcase oil pump assembly onto the dipstick tube. Verify the pump is securely attached to the tube by pulling it up lightly.



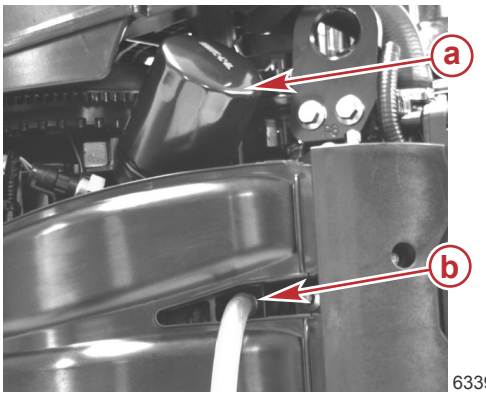
a - Oil drain hose
b - Lock button

7. Place the drain tube of the crankcase oil pump into an appropriate container. The container should be large enough to hold more than 9.8 Liter (10 US qt).
8. Extract the engine oil with the pump.

9. Allow the drain tube to completely drain before removing the oil pump from the dipstick tube.
10. Press on the oil drain hose lock button to release it from the dipstick tube.
11. Install the dipstick. Verify it is completely inserted.
12. Add the appropriate amount of engine oil.

Changing Oil Filter

1. Remove the plug from the oil trough and attach a 12 mm (7/16 in.) I.D. drain hose to the fitting. Place the opposite end of the hose into an appropriate container.
2. Remove the old filter by turning the filter counterclockwise.

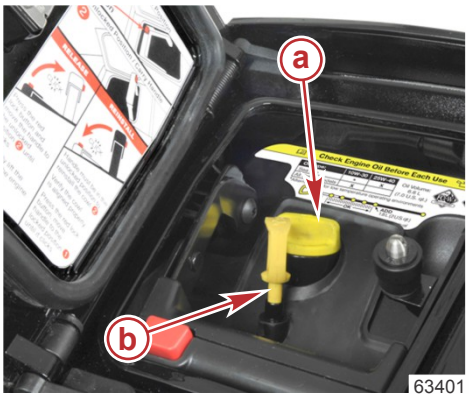


a - Oil filter
b - Drain hose

3. Allow the oil in the trough to drain.
4. Clean the remaining oil from the oil trough and filter mounting base area.
5. Remove the hose and install the plug.
6. Apply a film of clean oil to the filter gasket. Do not use grease. Install the new filter until the gasket contacts the base and then tighten 3/4 to 1 turn.

Oil Filling

Remove the oil fill cap and add approximately 6.6 Liter (7.0 US qt) of the recommended oil. This will bring the oil level within the operating range.



a - Oil fill cap
b - Dipstick

NOTE: *It is not necessary to check the oil level immediately after changing the oil. The engine must be run for a while and then turned off for one hour or longer before checking the oil level. Refer to* ***Checking Engine Oil Level.***

Checking Engine Oil Level

After the engine oil has been changed, the engine should be run for a few minutes and then turned off, allowing one hour or longer before checking the oil level.

IMPORTANT: For an accurate oil level reading, the engine must be vertical for several minutes before removing the dipstick.

1. Remove the dipstick and observe the area of the five beads.

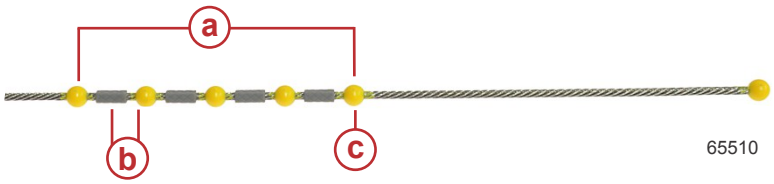
2. The bead or crosshatch which shows oil furthest from the end is the oil level.

Oil level example

Dipstick Bead Oil Level Overview

New oil (level) may be difficult to identify which is why the crosshatch between the beads are part of the dipstick assembly. When checking the oil level, if oil is on any of the five oil range beads or four crosshatch, the oil level is within the safe operating range. When the oil level is only on the lowest oil range bead, the operator can add 1.8 Liter (2 US qt) of oil and the level will remain within the safe operating range. When the oil becomes dark from hours of product use, it will be easier to identify the oil level on the dipstick.

IMPORTANT: Repeated removal and insertion of the dipstick to check the oil level will subsequently deposit oil further up the dipstick tube which potentially may cause an error reading the oil level.

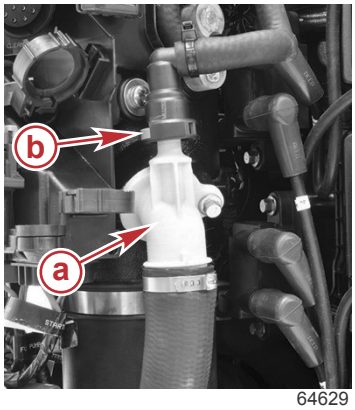


a - Safe operating range
b - General area after an oil change
c - Add 1.8 Liter (2 US qt) of oil

Exhaust Water Strainer Inspection

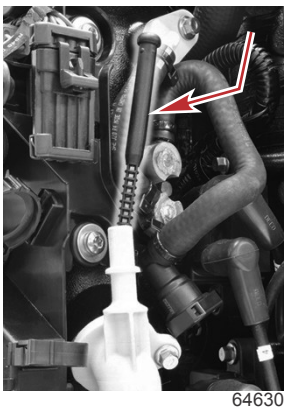
IMPORTANT: The water strainer is an integral component of the cooling system. It should be inspected every 100 hours of operation or once a year, whichever occurs first.

1. Remove the top cowl. Refer to **Top Cowl Removal and Installation**.
2. Remove the hose from the exhaust water spray inlet assembly. Press on the hose lock and pull the hose off the assembly.



a - Exhaust water spray inlet assembly
b - Hose lock

3. Remove the strainer from the assembly.



Strainer

4. Inspect the strainer for debris, blockage, or accumulation of mineral deposits. Flush the strainer with fresh water. Use a nylon bristle brush to help remove debris, blockage, or mineral deposits. If the strainer cannot be cleared of debris, blockage, mineral deposits, or if the strainer is damaged, replace the strainer.


64631

5. Install the strainer into the exhaust water spray inlet assembly.
6. Install the hose onto the assembly. Verify the hose is secure by pulling up on the hose.

Gearcase Lubricant

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.

Recommended Gearcase Lubrication

Mercury or Quicksilver High Performance Gear Lubricant.

Gearcase Lubricant Capacity

NOTE: *Gearcase lubricant capacity is approximate.*

Gearcase Lubricant Capacity		
122 mm (4.8 in.)*	Right-hand rotation	710 mL (24.0 fl oz)
	Left-hand rotation	810 mL (27.4 fl oz)
137 mm (5.44 in.)	Right-hand rotation	720 mL (24.4 fl oz)
	Left-hand rotation	680 mL (23.0 fl oz)
SeaPro 137 mm (5.44 in.)	Right-hand rotation	980 mL (33.1 fl oz)
	Left-hand rotation	
Torque Master	Right-hand rotation	520 mL (17.5 fl oz)

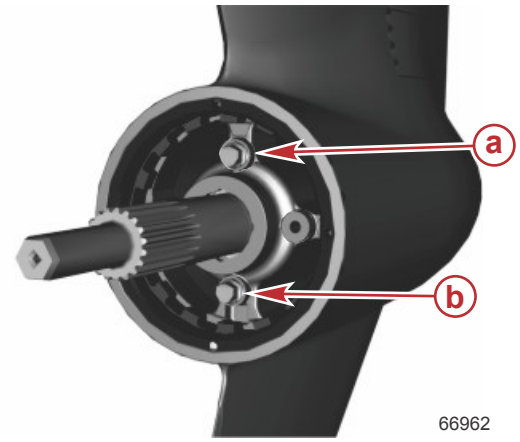
*Early model right-hand 4.8 in. gearcase bearing carriers may have the lubricant level plug located at the 3 o'clock position, requiring a slightly lower volume of gear lubrication.

Draining and Filling the Gearcase - 122 mm (4.8 in.)

Draining Gearcase

1. Place the outboard in a vertical operating position.
2. Remove the propeller. Refer to **Propeller Replacement**.
3. Place a pan below the gear housing to capture the lubricant.

4. Remove the lubricant level plug and fill/drain plug. Allow a sufficient amount of time for the gearcase to drain. Depending on the ambient air temperature, it may take 30 minutes for the gearcase to completely drain.



a - Lubricant level plug
b - Fill/drain plug

Filling the Gearcase

1. After the gearcase has been drained, fill the gearcase through the fill/drain hole.
2. Add the specified gear lubricant.

   IMPORTANT: Replace the sealing washers if damaged.
3. Allow a few minutes for the lubricant level to stabilize in the gearcase before installing the lubricant level plug. Install the lubricant level plug.
4. Remove the tube and install the fill/drain plug.
5. Tighten the plugs to the specified torque.

Description	Nm	lb-in.	lb-ft
Plugs	11.3	100	–

Checking Lubricant Level

1. Place the outboard in a vertical operating position. Allow up to 30 minutes for the lubricant level to stabilize in the gear housing.
2. Remove the lubricant level plug. Verify the sealing washer is not adhered to the bearing carrier. The lubricant should be level with the hole or slowly leak from the hole.

   IMPORTANT: Replace the sealing washers if damaged.
3. If the lubricant is not visible at the lubricant level hole, remove the fill/drain plug and add lubricant until it appears at the lubricant level hole.
4. Stop adding lubricant.
5. Remove the lubricant tube and install the fill/drain plug and sealing washer.
6. Tighten the plugs to the specified torque.

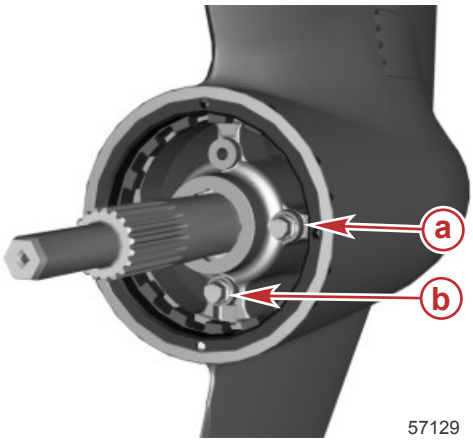
Description	Nm	lb-in.	lb-ft
Plugs	11.3	100	–

Draining and Filling the Gearcase - 137 mm (5.4 in.)

Draining Gearcase

1. Place the outboard in a vertical operating position.
2. Remove the propeller. Refer to **Propeller Replacement**.
3. Place a pan below the gear housing to capture the lubricant.

4. Remove the lubricant level plug and fill/drain plug. Allow a sufficient amount of time for the gearcase to drain. Depending on the ambient air temperature, it may take 30 minutes for the gearcase to completely drain.



a - Lubricant level plug
b - Fill/drain plug

Filling the Gearcase

1. After the gearcase has been drained, fill the gearcase through the fill/drain hole.
2. Add the specified gear lubricant.

   IMPORTANT: Replace the sealing washers if damaged.
3. Allow a few minutes for the lubricant level to stabilize in the gearcase before installing the lubricant level plug. Install the lubricant level plug.
4. Remove the tube and install the fill/drain plug.
5. Tighten the plugs to the specified torque.

Description	Nm	lb-in.	lb-ft
Plugs	11.3	100	–

Checking Lubricant Level

1. Place the outboard in a vertical operating position. Allow up to 30 minutes for the lubricant level to stabilize in the gear housing.
2. Remove the lubricant level plug. Verify the sealing washer is not adhered to the bearing carrier. The lubricant should be level with the hole or slowly leak from the hole.

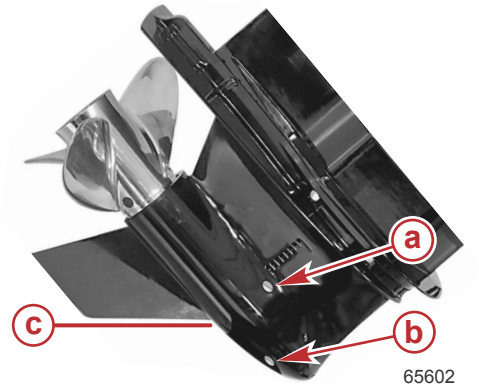
   IMPORTANT: Replace the sealing washers if damaged.
3. If the lubricant is not visible at the lubricant level hole, remove the fill/drain plug and add lubricant until it appears at the lubricant level hole.
4. Stop adding lubricant.
5. Remove the lubricant tube and install the fill/drain plug and sealing washer.
6. Tighten the plugs to the specified torque.

Description	Nm	lb-in.	lb-ft
Plugs	11.3	100	–

Draining and Filling the Gearcase SeaPro Models

1. Tilt the engine so the leading edge of the skeg is level when horizontal, or the engine can be tilted full up.
2. Place a pan below the gear housing to capture the lubricant.

3. Remove the lubricant level plug and fill/drain plug. Allow a sufficient amount of time for the gearcase to drain. Depending on the ambient air temperature, it may take 30 minutes for the gearcase to completely drain.



a - Lubricant level plug
b - Fill/drain plug
c - Leading edge of skeg is level

Filling the Gearcase

1. After the gearcase has been drained, fill the gearcase with the specified gear lubricant through the fill/drain hole.
   IMPORTANT: Replace the sealing washers if damaged.
2. The lubricant must flow out of the lubricant level hole without air bubbles.
3. Allow a few minutes for the lubricant level to stabilize in the gearcase before installing the lubricant level plug. Install the lubricant level plug.
4. Remove the tube and install the fill/drain plug.
5. Tighten the plugs to the specified torque.

Description	Nm	lb-in.	lb-ft
Plugs	11.3	100	–

Checking Lubricant Level

1. Tilt the engine so the leading edge of the skeg is level when horizontal. Allow up to 30 minutes for the lubricant level to stabilize in the gear housing.
2. Remove the lubricant level plug. Do not lose the sealing washer. The lubricant should be level with the hole or slowly leak from the hole.
   IMPORTANT: Replace the sealing washers if damaged.
3. If the lubricant is not visible at the lubricant level hole, remove the fill/drain plug and add lubricant until it appears at the lubricant level hole.
4. Install the lubricant level plug.
5. Remove the lubricant tube and install the fill/drain plug and sealing washer.
6. Tighten the plugs to the specified torque.

Description	Nm	lb-in.	lb-ft
Plugs	11.3	100	–

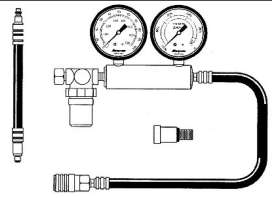
Notes:

Important Information

Section 1C - General Information

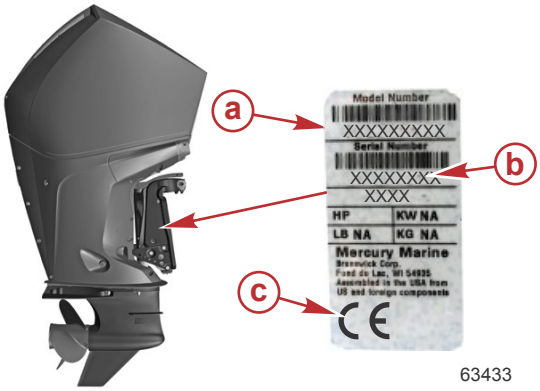
Table of Contents

Special Tools

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.



- **a -** Model designation
- **b -** Serial number
- **c -** Certified Europe insignia (as applicable)

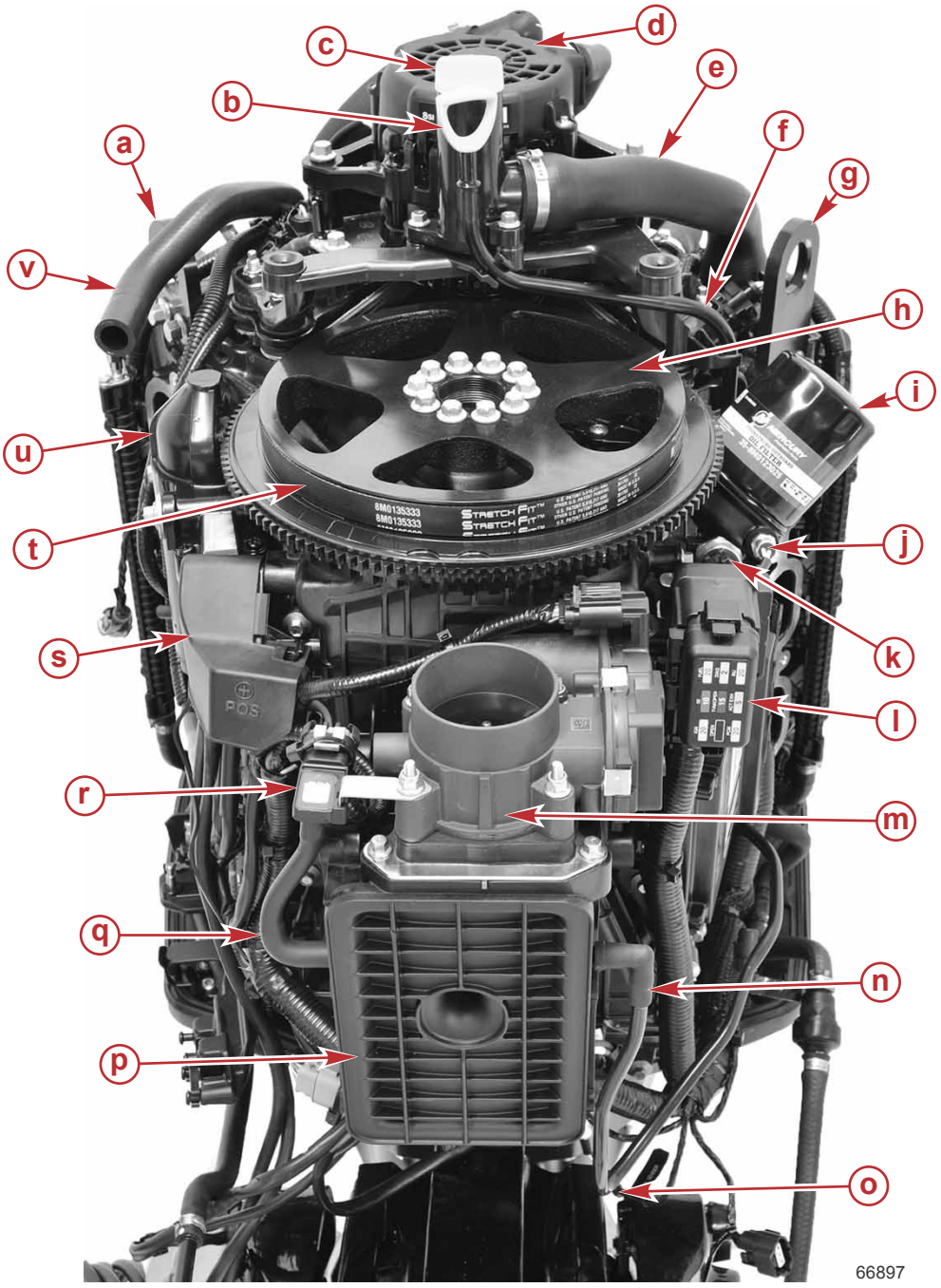
Selecting Accessories for Your Outboard

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 power package and may void warranty. Acquire and read the installation and operation manuals for each selected accessory.

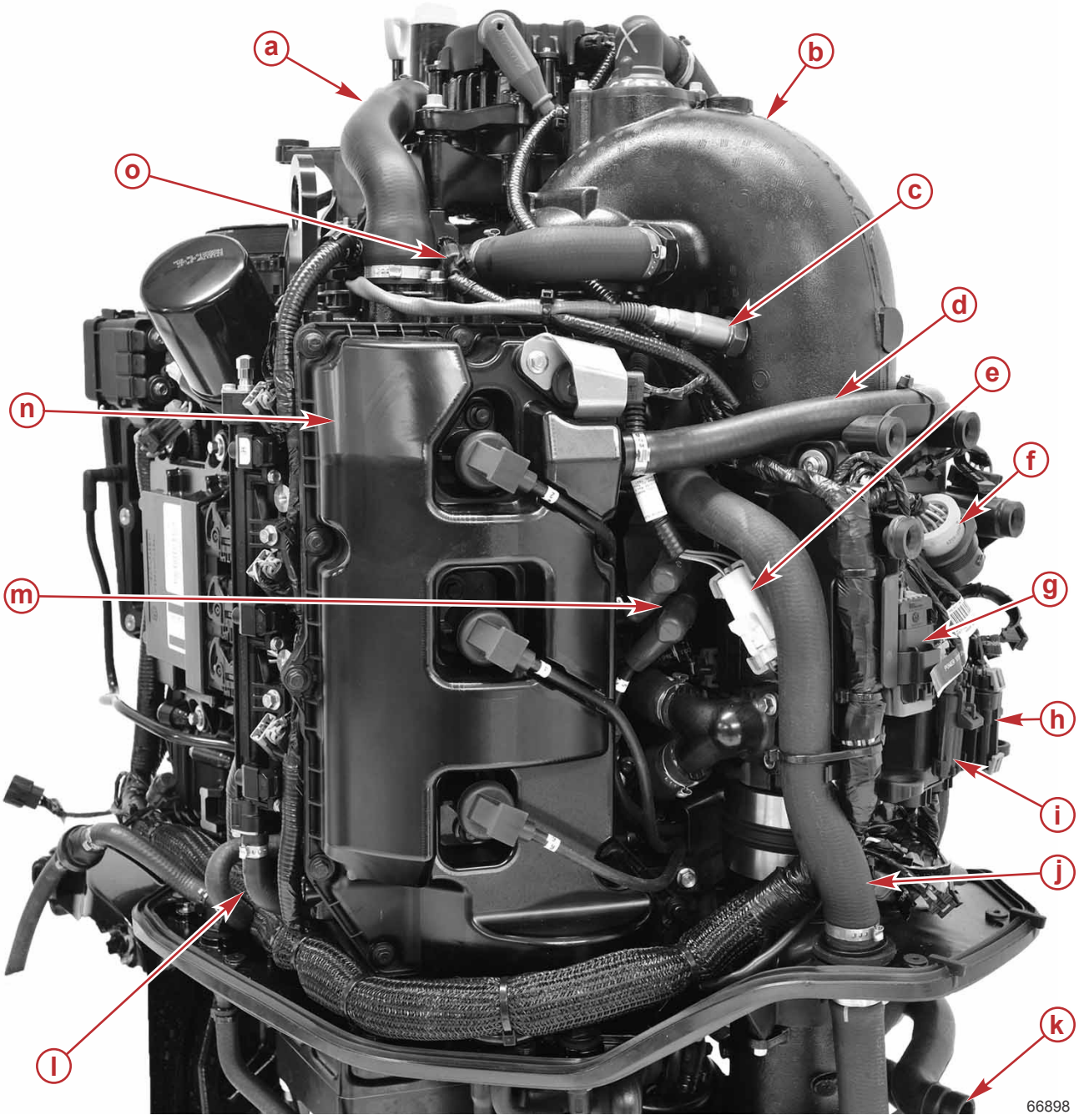
Front View



V6 shown, V8 similar; shown without intake runners, flywheel cover, fuel rail cover, electrical panel cover, and lower cowls

- **a -** Starboard lifting eye
- **b -** Dipstick
- **c -** Oil fill cap
- **d -** Alternator
- **e -** Oil fill hose
- **f -** Dipstick tube
- **g -** Port lifting eye
- **h -** Flywheel
- **i -** Oil filter
- **j -** Oil temperature sensor
- **k -** Oil pressure sensor
- **l -** Fuse block
- **m -** Electronic throttle body
- **n -** Fuel supply module (FSM) reference hose
- **o -** Trim position sensor connector
- **p -** Intake plenum
- **q -** Manifold absolute pressure (MAP) reference hose
- **r -** Manifold absolute pressure (MAP) sensor
- **s -** Battery cable cover
- **t -** Alternator belt
- **u -** Starter motor
- **v -** Breather hose to cold air intake

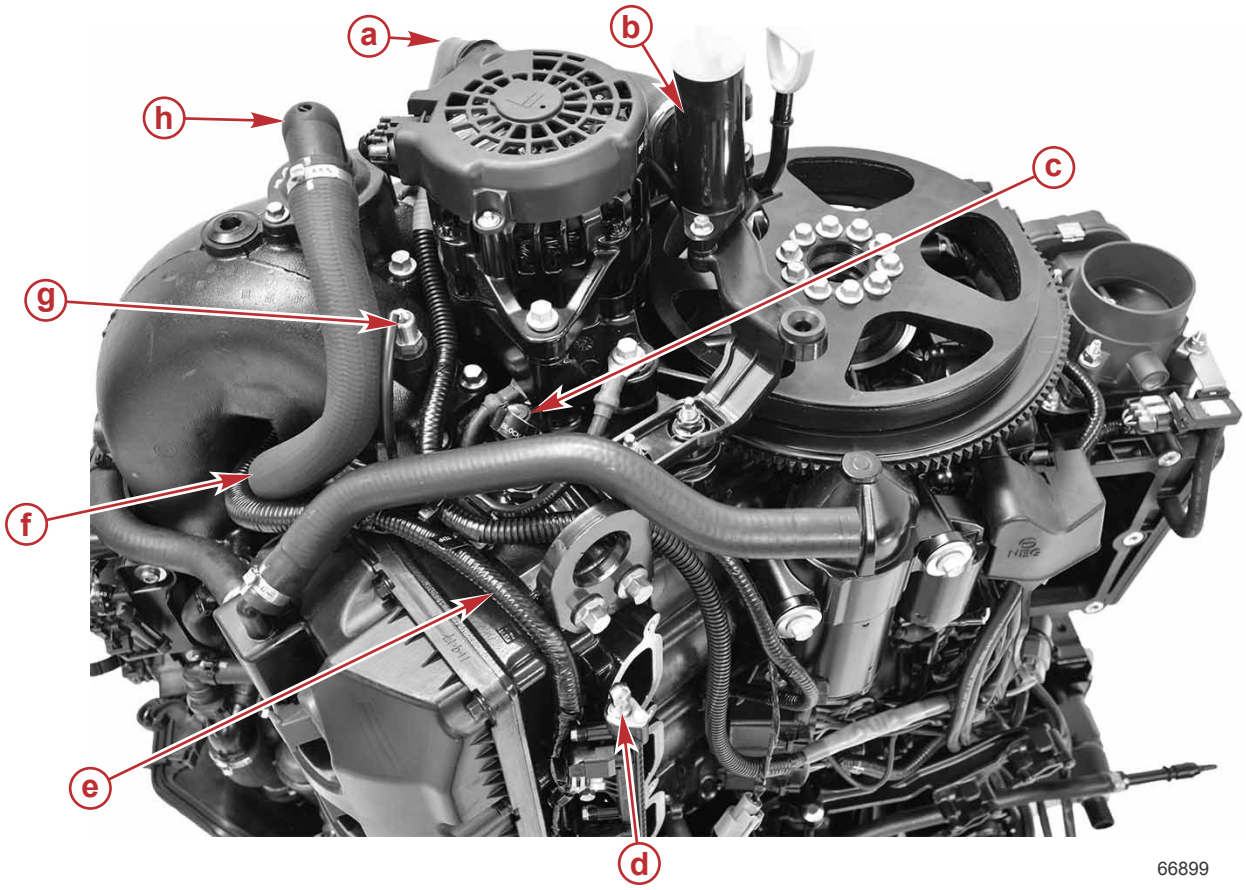
Port Aft View



V6 shown, V8 similar; shown without intake runners, flywheel cover, fuel rail cover, electrical panel cover, and lower cowls

- **a -** Oil fill hose
- **b -** Exhaust tube
- **c -** Oxygen sensor
- **d -** Breather hose
- **e -** Ignition coil primary lead connector
- **f -** 14-pin connector
- **g -** 10-pin CAN terminator
- **h -** 6-pin boat harness connector
- **i -** 3-pin power steering connector
- **j -** Thermostat dump hose
- **k -** Idle exhaust relief
- **l -** Fuel hose from fuel supply module (FSM)
- **m -** #2, #5 ignition coil (V6 model)
- **n -** Port camshaft cover
- **o -** Crankshaft position sensor connector

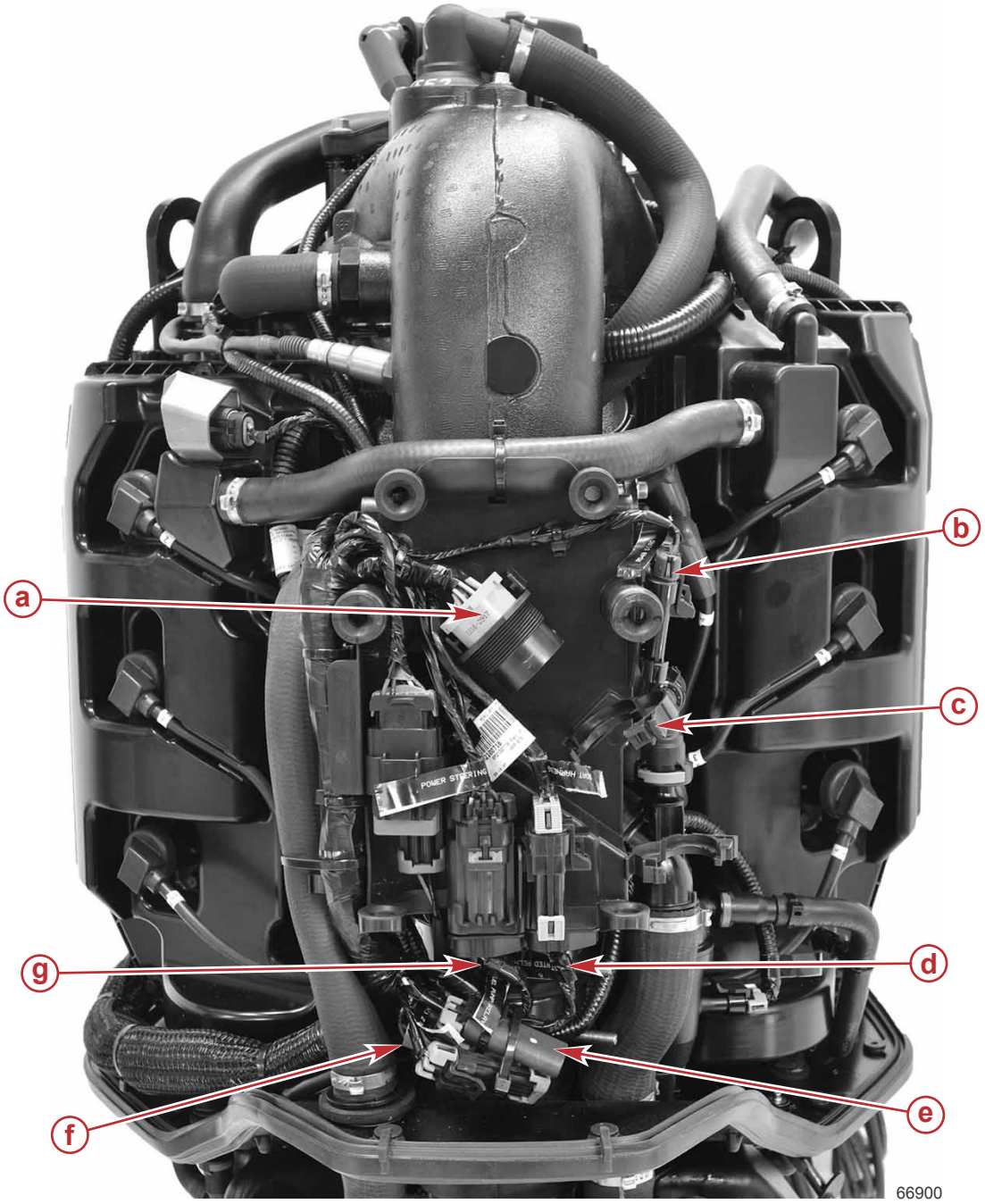
Starboard Aft View from Above



V6 shown, V8 similar; shown without intake runners, flywheel cover, fuel rail cover, electrical panel cover, and lower cowls

- **a -** Positive charge lead from the alternator
- **b -** Oil fill tube
- **c -** Block water pressure sensor shown; Legris fitting with hose is optional
- **d -** Schrader valve on starboard fuel rail
- **e -** Starboard injector harness
- **f -** Thermostat dump hose
- **g -** Water temperature sensor
- **h -** Thermostat housing

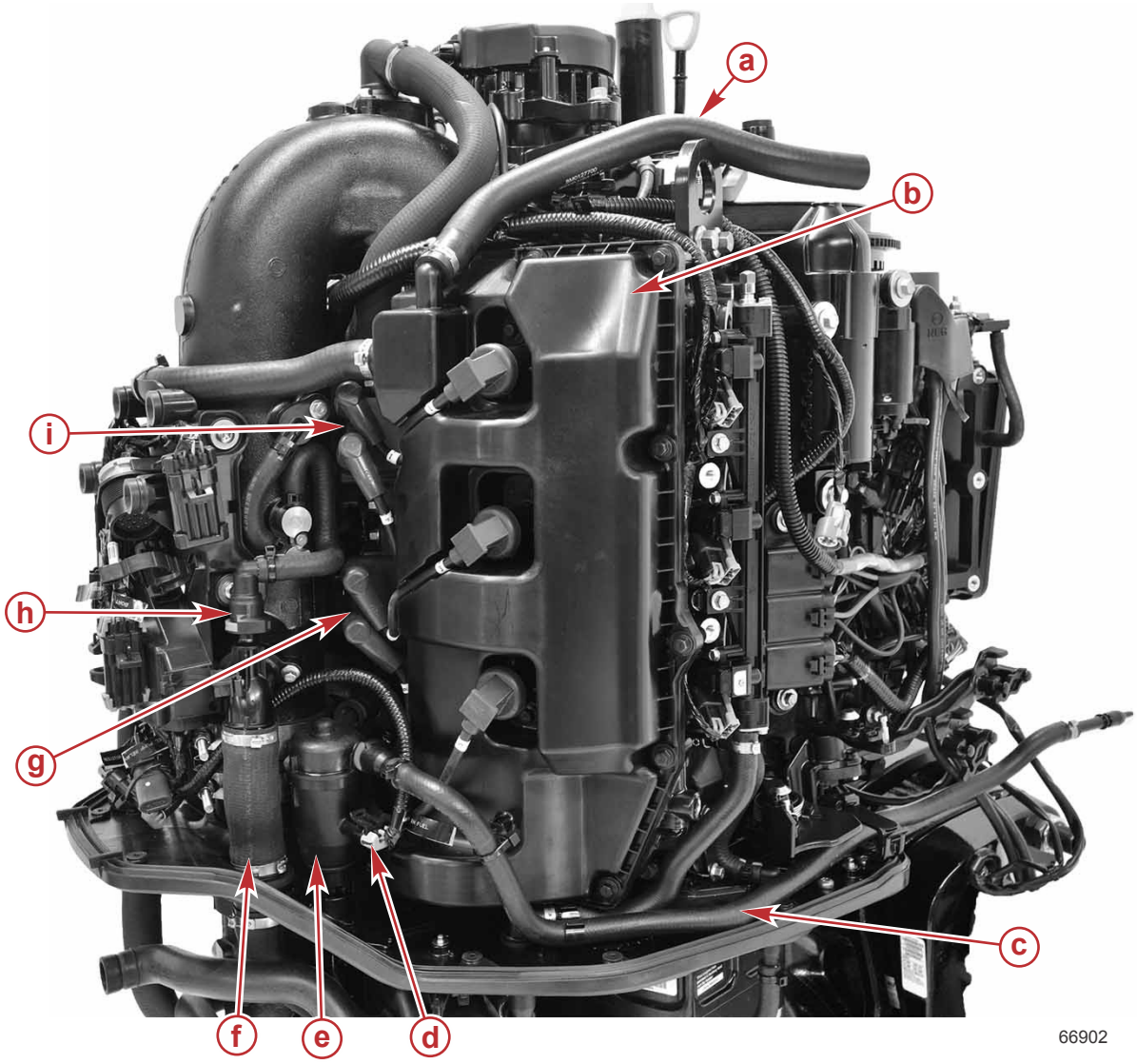
Aft View



V6 shown, V8 similar; shown without intake runners, flywheel cover, fuel rail cover, electrical panel cover, and lower cowls

- **a -** 14-pin connector
- **b -** 4-pin diagnostic
- **c -** Ring clip for 14-pin data harness
- **d -** Start relay
- **e -** CAN X termination resistor
- **f -** Moving propeller (MP) alert connector
- **g -** Fuel pump relay

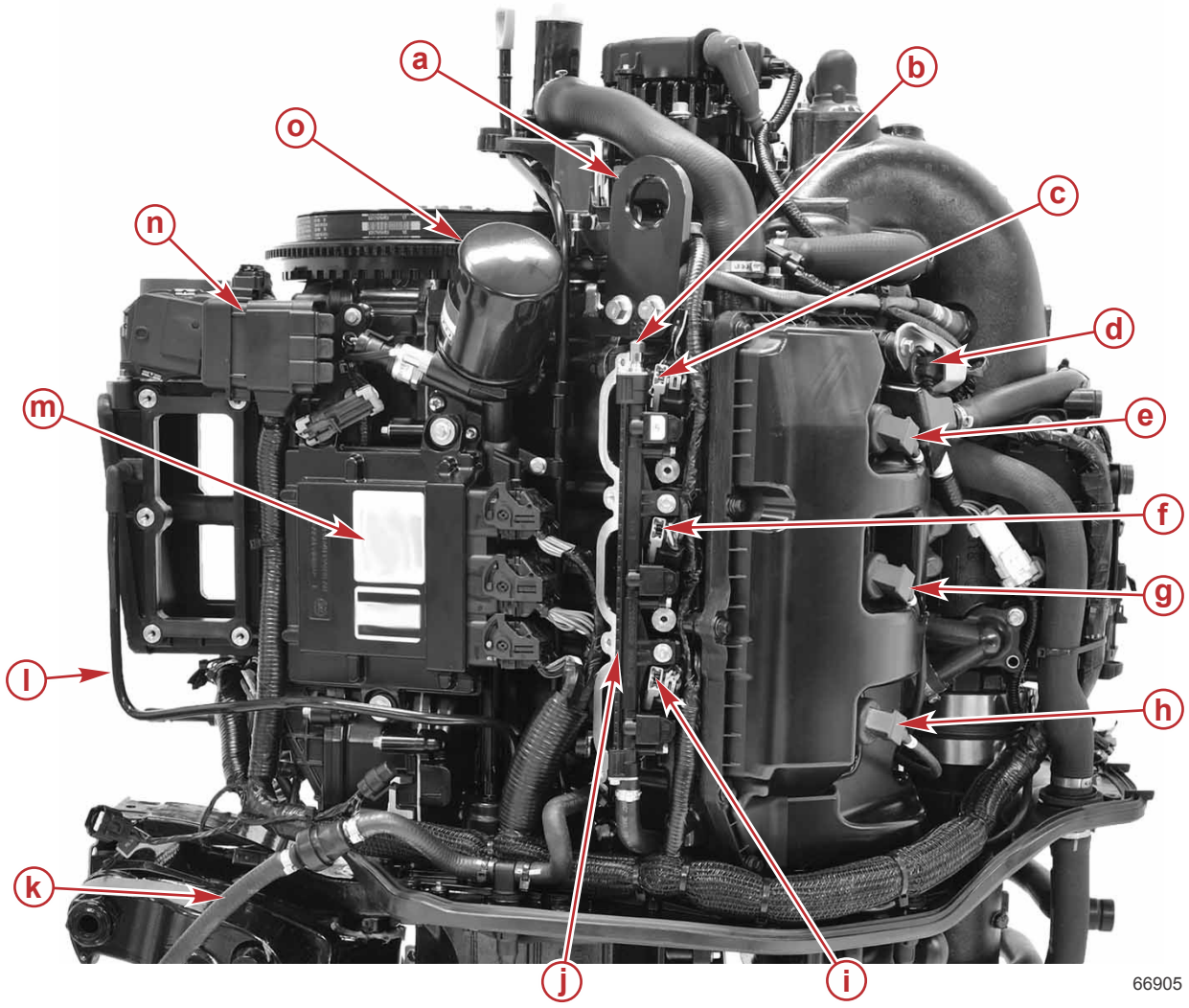
Starboard Aft View



V6 shown, V8 similar; shown without intake runners, flywheel cover, fuel rail cover, electrical panel cover, and lower cowls

- **a -** Breather hose to cold air intake
- **b -** Starboard camshaft cover
- **c -** Fuel hose
- **d -** Water-in-fuel (WIF) sensor connector
- **e -** Fuel filter
- **f -** Cooling water supply hose
- **g -** #3, #6 ignition coil (V6 models)
- **h -** Water strainer fitting
- **i -** #1, #4 ignition coil (V6 models)

Port View

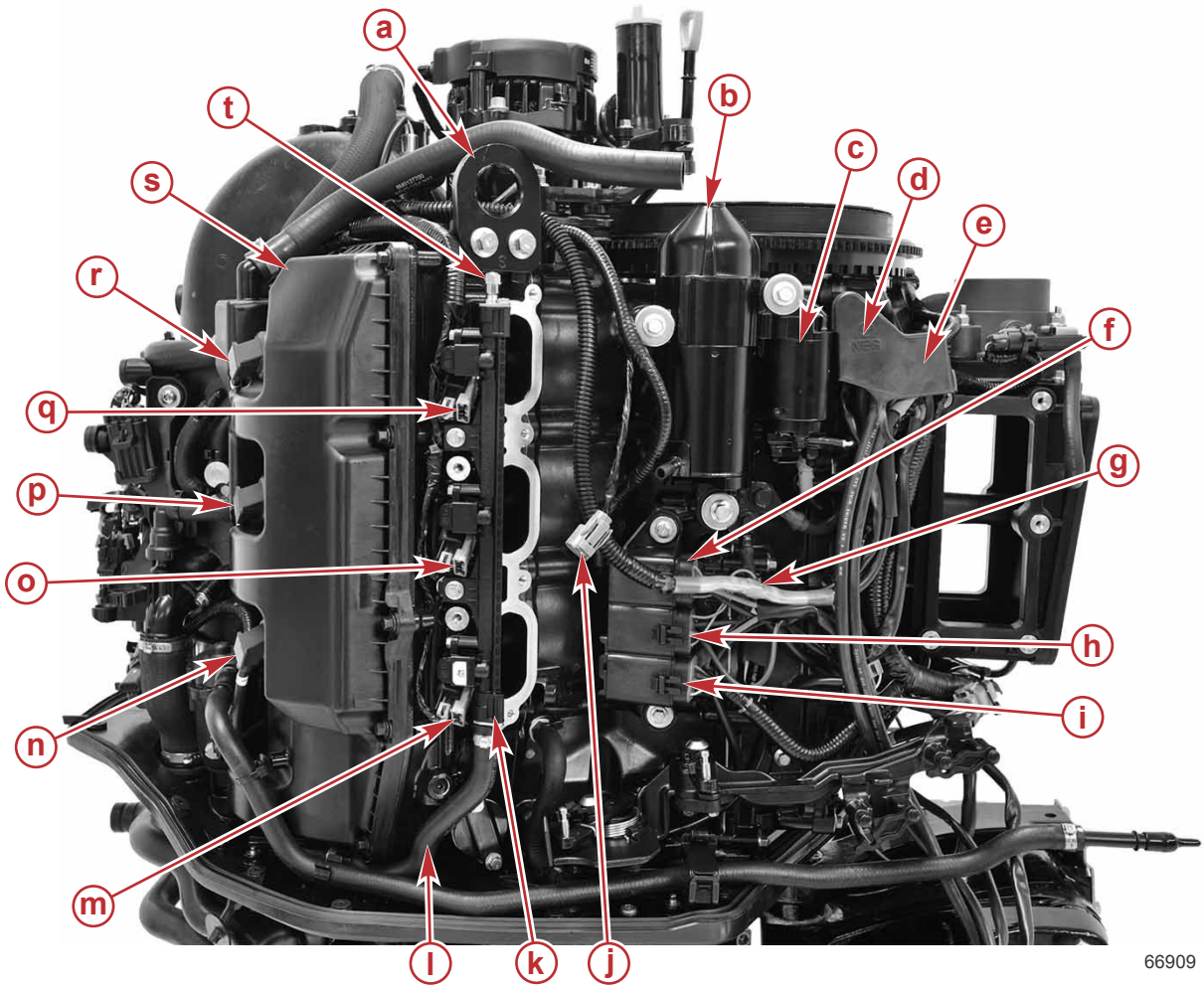


V6 shown, V8 similar; shown without intake runners, flywheel cover, fuel rail cover, electrical panel cover, and lower cowls

- **a -** Port lifting eye
- **b -** Schrader valve
- **c -** Cylinder #2 injector
- **d -** Camshaft position sensor
- **e -** Cylinder #2 high tension lead
- **f -** #4 injector
- **g -** Cylinder #4 high tension lead
- **h -** Cylinder #6 high tension lead
- **i -** #6 injector
- **j -** Port fuel rail
- **k -** Flush hose
- **l -** Fuel supply module (FSM) reference hose
- **m -** PCM
- **n -** Fuse holder
- **o -** Oil filter

IMPORTANT: Cylinder references are for V6 models only. For V8, refer to the appropriate section of this manual.

Starboard View



V6 shown, V8 similar; shown without intake runners, flywheel cover, fuel rail cover, electrical panel cover, and lower cowls

- **a -** Starboard lifting eye
- **b -** Starter motor
- **c -** Starter solenoid
- **d -** Negative battery cable connection (under cover)
- **e -** Positive battery cable connection (under cover)
- **f -** Trim down relay
- **g -** 150-amp fusible link
- **h -** Trim up relay
- **i -** Main power relay
- **j -** Manifold air temperature (MAT) sensor connector (sensor is on intake runner)
- **k -** Starboard fuel rail
- **l -** Fuel hose from fuel supply module (FSM)
- **m -** #5 injector
- **n -** Cylinder #5 high tension lead
- **o -** #3 injector
- **p -** Cylinder #3 high tension lead
- **q -** #1 injector
- **r -** Cylinder #1 high tension lead
- **s -** Starboard camshaft cover
- **t -** Schrader valve

IMPORTANT: Cylinder references are for V6 models only. For V8, refer to the appropriate section of this manual.

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 engine's RPM. An engine with too large of 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 through-the-hull fasteners be coated with a quality marine sealer at time of installation. Water intrusion into the transom core and/or inner hull will result in additional boat weight (reduced boat performance), hull decay, and eventual structural failure.

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 the engine at full trim in.
3. Remove all cowling.
4. Flush the exterior of the outboard with freshwater to remove mud, weeds, etc. Do not attempt to start the engine if sand has entered the powerhead. Disassemble the powerhead, if necessary, to clean components.
5. Remove the spark plugs and get as much water as possible out of the powerhead. Most of the water inside the combustion chambers can be eliminated by rotating the flywheel while the engine is tilted in.
6. Pour approximately one teaspoon of engine oil into each spark plug opening. Rotate the flywheel to distribute oil in the cylinders.
7. 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.
8. Dry all wiring and electrical components using compressed air.

9. Install the spark plugs.
10. Attempt to start the engine, using a fresh fuel source.
    - If the engine starts, run it for at least one hour, to eliminate any water remaining in the engine. Check again for the presence of water in the oil. If water is present, the oil will appear milky. Drain and replace the oil.
    - If the engine fails to start, determine if the cause is fuel, electrical, or mechanical.

      NOTE: *The fuel system is closed to the ambient air at all times when the engine is not running.*

IMPORTANT: 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, completely disassemble the engine and clean all parts. Apply oil as soon as possible.

Saltwater Submersion (Special Instructions)

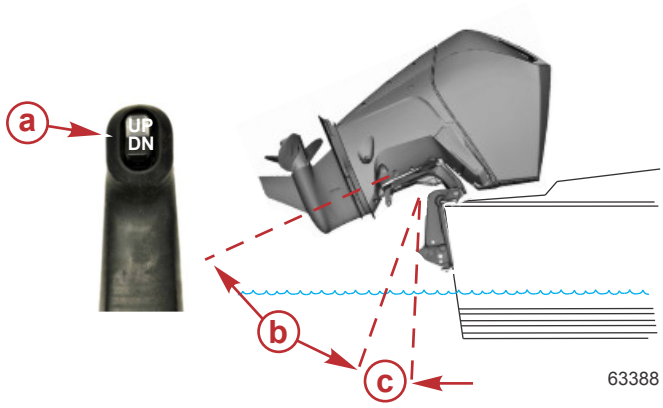
Due to the corrosive effect of saltwater on internal engine components, complete disassembly of the engine is necessary before any attempt is made to start the engine.

Power Trim and Tilt

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. The outboard can be tilted up past the trim range for shallow water operation or loading the boat onto a trailer. With the engine turned off and ignition switch turned on, the outboard can be tilted out of the water.

- Below 2000 RPM the engine can be trimmed or tilted to any range. Caution is advised when operating the engine past the tilt range. Ensure the water pickups are submerged.
- While in the trim range and the engine is above 2000 RPM, you can only trim to the maximum trim range.
- If the engine is below 2000 RPM and is in the trailer range, advancing the throttle will allow the engine to achieve a maximum RPM of 4250. Engine operation in this capacity (above the normal 2000 limit) should only be used for loading or unloading the boat onto or off the trailer. It should not be used during normal boat operation.

  NOTE: *Exceeding 4250 RPMs the engine PCM will begin Engine Guardian protection.*



a - Trim switch
b - Tilt range
c - Trim 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

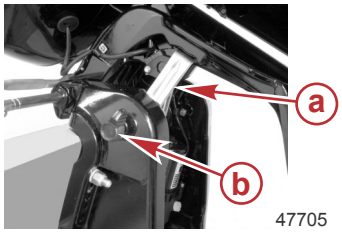
- Result in quicker planing off, especially with a heavy load or a stern heavy boat
- Generally improve the ride in choppy water
- Increase steering torque or pull to the right (with the normal right-hand rotation propeller)
- In excess, can lower the bow of some boats to a point where they begin to 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.

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 Operation

To tilt outboard, shut off the engine and press the trim/tilt switch or auxiliary tilt switch to the up position. The outboard will tilt up until the switch is released or it reaches its maximum tilt position.

1. Engage the tilt support lever by rotating the knob to bring the support lever upward.
2. Lower the 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 lever down. Lower the outboard.



a - Tilt support lever
b - Knob

Manual Tilting

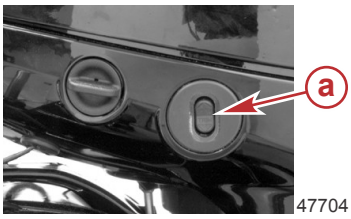
If the outboard cannot be tilted using the power trim/tilt switch, the outboard can be manually tilted.

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.

Auxiliary Tilt Switch

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



a - Auxiliary tilt switch

Operating in Shallow Water

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

1. Reduce the engine speed below 2000 RPM.
2. Tilt the outboard up. Make sure all the cooling water intake holes stay submerged at all times.

- Below 2000 RPM the engine can be trimmed or tilted to any range. Caution is advised when operating the engine past the tilt range. Ensure the water pickups are submerged.
- If the engine is below 2000 RPM and is in the trailer range, advancing the throttle will allow the engine to achieve a maximum RPM of 4250. Engine operation in this capacity (above the normal 2000 limit) should only be used for loading or unloading the boat onto or off the trailer. It should not be used during normal boat operation.

  NOTE: *Exceeding 4250 RPMs the engine PCM will begin Engine Guardian protection.*

Cylinder Leakage Testing

Model	Cylinder Firing Order
V8 models	1-2-7-3-4-5-6-8
V6 models	1-2-3-4-5-6

NOTE: *Cylinder leakage 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 all spark plugs.
2. Rotate the engine clockwise until cylinder #1 is at its compression stroke.
3. Complete the cylinder leak down test on the #1 spark plug hole. Refer to the manufacturer's tester instructions for proper testing procedures.
4. After testing cylinder #1, install a dial indicator on the next firing order sequence cylinder.
5. Rotate the flywheel so the piston is at TDC.
6. Complete the cylinder leak down test.
7. Proceed with the succeeding firing order cylinder TDC and complete the cylinder leak down test.
8. 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

Air Escaping From	Possible Location
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 eyewear, 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 eyewear, 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 the 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.

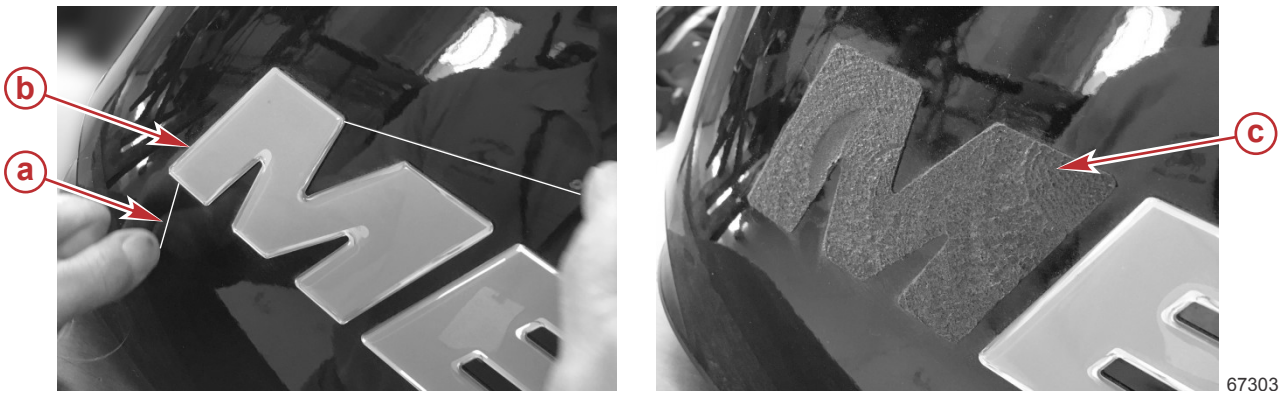
Decal Removal

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.

Raised Decal Removal

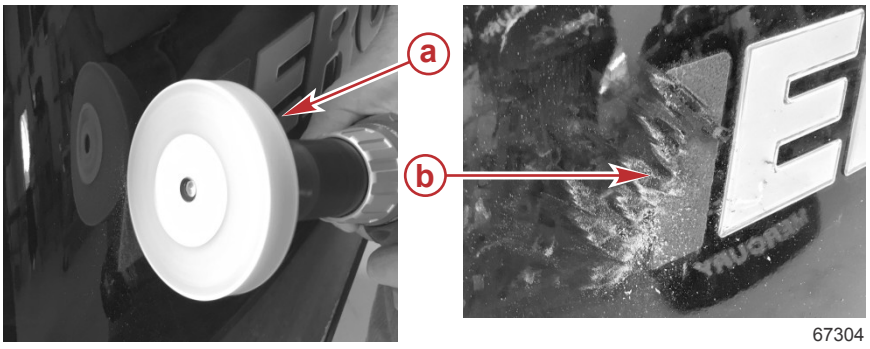
1. Use fishing line (obtain locally) to cut the decal from the foam backing.



67303

a - Fishing line
b - Raised decal
c - Foam backing

2. Remove the foam backing and adhesive with a 3M™ Stripe Off Wheel (obtain locally) and a standard 3/8 in. electric drill. Follow the instructions included with the kit.



67304

a - 3M™ Stripe Off Wheel (obtain locally)
b - Foam backing, partially removed

3. Brush the loose foam debris away with a dry soft cloth.

67305

a - Loose foam debris
b - Intact raised decal

4. Use an adhesive remover, such as acetone, to wipe away any remaining adhesive.

67306

a - Location of removed raised decal, after cleaning with acetone
b - Intact raised decal

Important Information

Section 1D - Outboard Installation

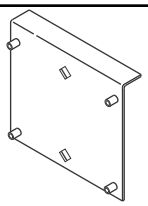
1
D

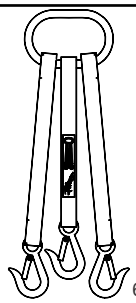
Table of Contents

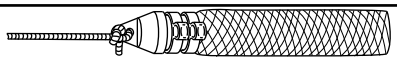
Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Battery connections at the engine	92- 25711 3
120	Corrosion Guard	Battery terminals	92-802878 55

Special Tools

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

Lifting strap	883705T01
 67021	Use with an overhead hoist to lift an engine.

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.

Important Information

Steering System Requirements

⚠ CAUTION

Avoid a possible steering system failure due to incorrect steering cylinder installation. Mercury heavy-duty steering cylinders are designed to be gearcase/propeller rotation specific. Right-hand rotation outboards require a right-hand steering cylinder and left-hand (counterrotation) outboards require a counterrotation steering cylinder. Always confirm that the correct cylinder is paired with the correct outboard.

Mechanical Steering

IMPORTANT: Do not use mechanical steering with these engines.

Hydraulic Steering (Non-Power Steering)

Use Mercury heavy-duty steering cylinders fitted with compression fittings.

Hydraulic Power Steering

Use Mercury heavy-duty steering cylinders fitted with O-ring face seal fittings.

Multiple Engine Steering Installations

Dual Outboard Steering Options

Maximum Combined 500 HP

Single Cylinder/Dual Outboard: One right-hand HD steering cylinder mounted to a right-hand rotation outboard, using a tie bar kit to connect to the left-hand (counterrotation) outboard.

Maximum Combined 600 HP

Dual Cylinder/Dual Outboard: One right-hand HD steering cylinder mounted to the right-hand rotation outboard, and one left-hand HD steering cylinder mounted to the left-hand (counterrotation) outboard. Steering cylinders are connected using a dual outboard tie bar kit.

Triple Outboard Steering

Triple Cylinder/Triple Outboard: One right-hand HD steering cylinder mounted to the right-hand rotation outboard (starboard outboard location), one left-hand HD steering cylinder mounted to the left-hand (counterrotation) outboard (port outboard location), and one HD steering cylinder from the triple outboard tie bar kit mounted to the center outboard. Steering cylinders are connected using tie bars and hardware from the triple outboard tie bar kit.

Notice to Installer - DTS Models

DTS product requires electronic calibration before use.

DTS products 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 (DTS) systems at an authorized Mercury dealership. Improper installation and calibration of the DTS product will result in a system that is inoperable or unsafe for use.

Mercury Marine Validated Engine Mounting Hardware

IMPORTANT: Mercury Marine provides validated fasteners and installation instructions, including torque specifications, with all our outboards so they can be properly secured to boat transoms. Improper installation of the outboard can cause performance and reliability issues which can lead to safety concerns. Follow all of the instructions relating to the outboard installation. DO NOT mount any other accessory onto the boat with the fasteners provided with the outboard. For example, do not mount a tow sports bar or boarding ladder onto the boat using the mounting hardware included with the outboard. Installing other products onto the boat that utilize the outboard mounting hardware will compromise the ability of that hardware to properly and safely secure the outboard to the transom.

Outboards that require validated mounting hardware will have the following decal on the transom clamp.

51965

Fastening Hardware Specification (Not Factory Supplied)

IMPORTANT: Mercury Marine has designed and tested the engine when it is directly mounted to the transom using the mounting hardware included with the engine. Torque requirements have been established using the hardware included with the engine. The use of mounting hardware not supplied by the factory, must be equal to, or greater than the following specifications.

- Screw specifications:

Must be a hex head screw with an unthreaded shank length of not less than 1 in.	
Thread size	0.50-20 in. UNF - 2A thread
Material	Austenitic stainless steel grade 304 or 316
Minimum mechanical properties	90,000 psi ultimate tensile strength/50,000 psi yield strength. This corresponds to a F593C screw head marking per American Society for Testing and Materials (ASTM).

48016

- Nut specifications:

Nut to be a prevailing torque, full height nut, nylon 6/6 or equivalent insert	
Thread size	0.50-20 in. UNF thread
Material	Brass, Grade Cu 613 per ASTM
Minimum mechanical properties	80,000 psi proof stress. This corresponds to a F467F mechanical marking per ASTM.

- Washer specifications:

This washer is for use on the transom bracket side of the application	0.88 x 0.53 x 0.104 in. flat washer, 630 (H1025) hardened stainless steel
This washer is for use on the transom side of the application	1.5 x 0.515 x 0.125 in. flat washer, 302, 304, or 316 stainless steel

Accessories Mounted to the Transom Clamp Bracket

Mercury Marine has been made aware that certain aftermarket marine accessories, such as emergency boarding ladders, shallow water anchors, transom wedge kits, and tow sport attaching devices, have been mounted to the boat by use of the same fasteners that secure the outboard to the transom or jack plate. Using the same fastener to secure both an accessory and the engine to the boat compromises the ability of the fasteners to maintain the proper clamp load. A boat with loose engine mounting fasteners creates the possibility of performance, durability, and safety issues.

⚠ WARNING

Avoid serious injury or death resulting from a loss of boat control. Loose engine fasteners could cause the transom bracket to fail, resulting in a loss of the driver's ability to control the boat. Always ensure that the engine fasteners are tightened to the specified torque.

Acceptable Accessory Mounting to the Transom Clamp Bracket

After the engine is mounted to the transom or jack plate in accordance with the engine installation instructions, it is acceptable to attach an accessory to the boat by use of the unused bolt holes in the transom clamp bracket as shown in Figure 1.

The following list provides additional guidelines for mounting accessories to the transom clamp bracket.

- The accessory fasteners must pass through the boat transom or jack plate.

- The installation must not create interference issues, as would an accessory mounting plate resting in the radius of the transom clamp bracket. Refer to Figure 1.

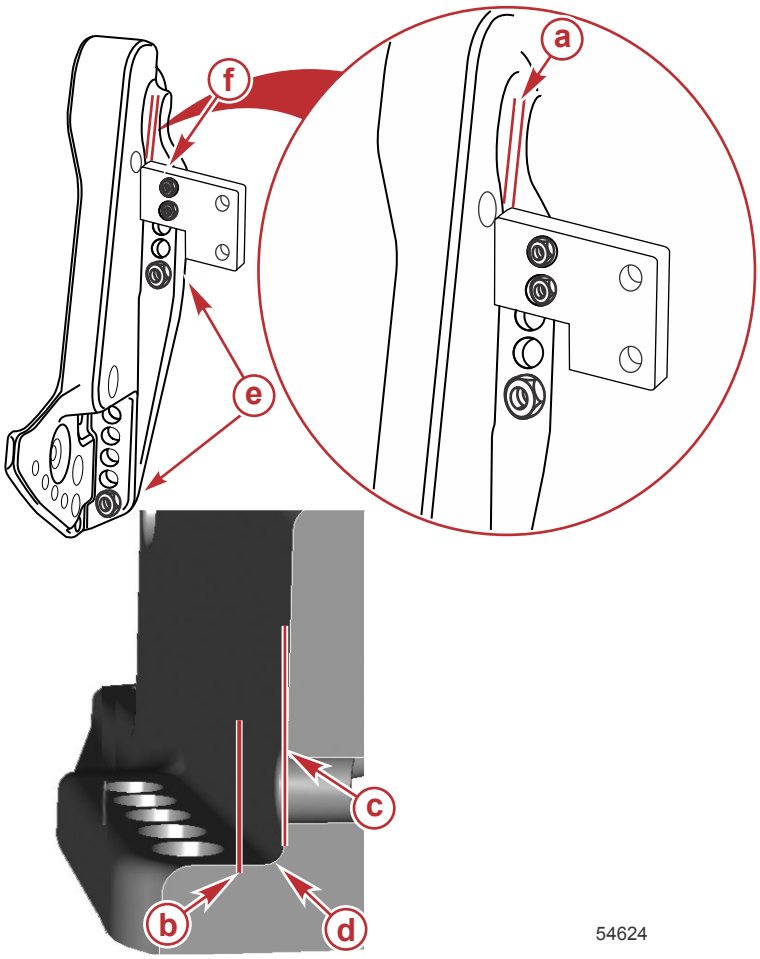


Figure 1

- **a -** Minimum clearance 3.175 mm (0.125 in.)
- **b -** Edge of accessory bracket
- **c -** Transom clamp bracket wall
- **d -** Radius
- **e -** Engine supplied mounting fasteners
- **f -** Fasteners supplied by the accessory manufacturer installed through unused engine mounting bracket holes

Unacceptable Accessory Mounting

IMPORTANT: Do not use the fasteners that secure the engine to the boat (either the transom or the jack plate) for any purpose other than securing the engine to the boat.

1. Do not mount an accessory to the transom clamp bracket in an unsupported condition. Refer to Figure 2.

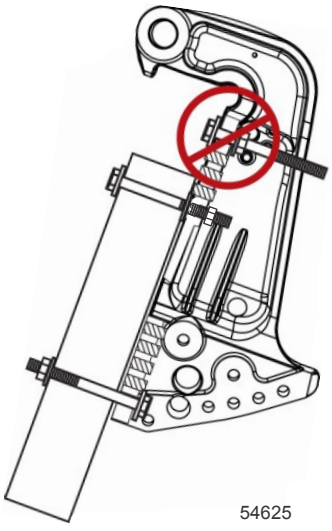


Figure 2

2. Do not attach an accessory to the boat by use of the engine mounting hardware. Refer to Figure 3.

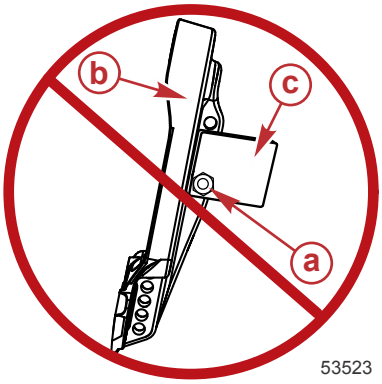


Figure 3
- **a -** Engine supplied mounting fasteners
- **b -** Transom clamp bracket
- **c -** Accessory

3. Do not install wedges or plates between the transom clamp brackets and the transom (or jack plate). Refer to Figure 4.

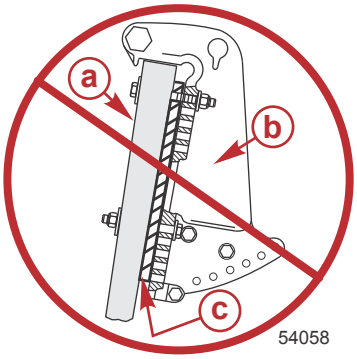


Figure 4
- **a -** Boat transom or jack plate
- **b -** Transom clamp bracket
- **c -** Wedge/plate

Avoiding Loss of Throttle and Shift Control (DTS Engines)

⚠ 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.

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

Battery Requirements

The following specifications are regarding marine battery systems and their connectivity to outboard propulsion systems. Adherence to the following requirements is mandatory for all engine installations. Failure to follow the requirements may result in loss of warranty coverage for electrical components and systems.

Standards

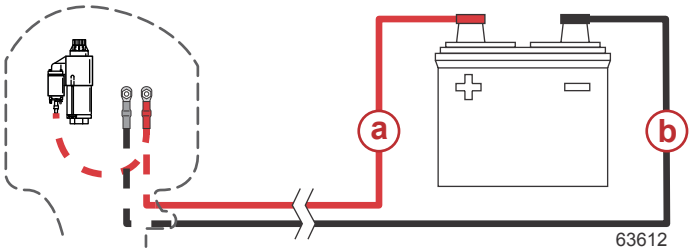
The following Mercury requirements are considered supplemental to existing ABYC Standard E-11 requirements. Refer to the most current standards and recommended practices published by the American Boat and Yacht Council (ABYC).

Overcurrent Protection

All Mercury Marine alternators are current-limiting power sources.

Battery Cables

- Select the proper size positive (+) and negative (–) battery cables by using the following chart.
- Cable length is calculated by adding the total length of the positive cranking circuit to that of the negative cranking circuit (positive battery post to negative battery post). Always round up to the next whole number when determining length.



Cable length = a + b

a - Positive cranking circuit (battery to starter)

b - Negative cranking circuit (battery to engine ground)

- The battery cable terminals must be soldered to the cable ends to ensure continuity. Only use electrical grade resin flux solder on cable terminals. Do not use acid flux. Acid flux will cause corrosion and subsequent failure.
- Apply heat shrink to the cranking circuit terminals and the clean power circuit terminals.
- Color coding must be in compliance with ABYC E-11 electrical standards.

Battery Cable Sizing

Total Cable Length (a + b)		Minimum Cable Size
Minimum	Maximum	
6.8 m (22.3 ft)	7.4 m (24.3 ft)	21.2 mm² (4 AWG)
7.4 m (24.3 ft)	12.2 m (40.0 ft)	33.6 mm² (2 AWG)
12.2 m (40.0 ft)	15.2 m (49.9 ft)	42.4 mm² (1 AWG)
15.2 m (49.9 ft)	19.6 m (64.3 ft)	53.5 mm² (0 AWG)
19.6 m (64.3 ft)	24.4 m (80.0 ft)	67.7 mm² (00 AWG)

Cranking Circuit Cables

1. Cables must be one size throughout the entire cranking circuit.

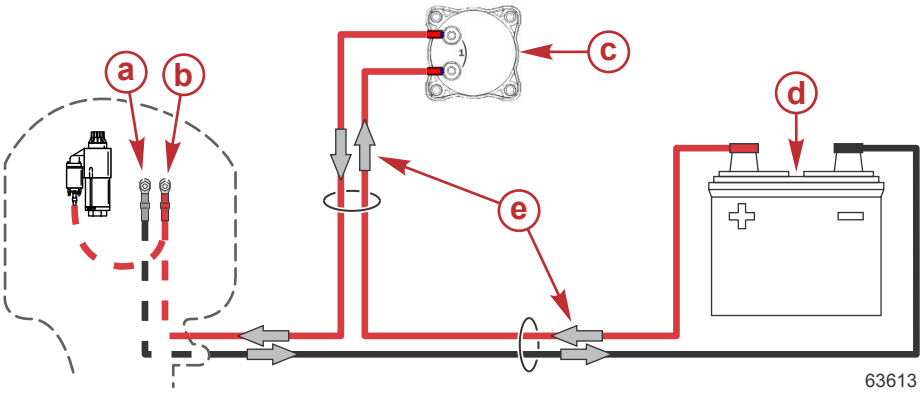
   NOTE: *Cables connecting the starter to the engine positive (+) connection point (hot stud) and cables contained within the engine envelope as part of the engine system are excluded from this requirement.*

2. Two numbers are provided in the preceding minimum cable size chart:
   a. The first number represents the approximate cross sectional area that is equivalent to the American Wire Gauge (AWG) number, expressed in square millimeters (mm²). This equivalent number is used as the minimum cable size when selecting cables not denoted in gauge, such as ISO sizes.

      IMPORTANT: SAE wire size is not the same as AWG.

   b. The number in parentheses is the American Wire Gauge (AWG) cable recommended by Mercury for the indicated cranking circuit length.
3. All cables listed in the preceding chart are sized for engine cranking only.
4. Always route cranking cables with forward and return current carrying conductors as neighboring pairs. Cables may diverge only at connection points such as the battery, engine, switches, or other devices.

NOTE: *Ground cables connecting an engine-to-engine or battery-to-battery are excluded from this requirement.*



Route cables with opposing currents as neighboring pairs

- **a -** Negative (–)
- **b -** Positive (+)
- **c -** Battery switch
- **d -** Battery
- **e -** Pair cables with opposing electrical currents to minimize electromagnetic interference

5. Multiple cables can be run in parallel to reduce voltage drop but not to increase current carrying capacity.

Clean Power Connections

Mercury clean power harnessing must be connected directly to the positive and negative posts of the corresponding propulsion engine's cranking battery.

IMPORTANT: Any deviations from the clean power connection requirement must be approved by Mercury Marine.

Battery Cable Connections

1. Apply Corrosion Guard to the battery terminal connections to prevent corrosion.

Tube Ref No.	Description	Where Used	Part No.
120	Corrosion Guard	Battery terminals	92-802878 55

IMPORTANT: Locking hex nuts are required on battery posts. If the battery is equipped with wing nuts, remove the wing nuts and install hex nuts. Do not use wing nuts on battery post connections.

2. Tighten the battery terminal nuts to the specified torque.

Description	Nm	lb-in.	lb-ft
Battery terminal nuts	13.5	120	–

IMPORTANT: Local laws may require that both battery terminals are covered.

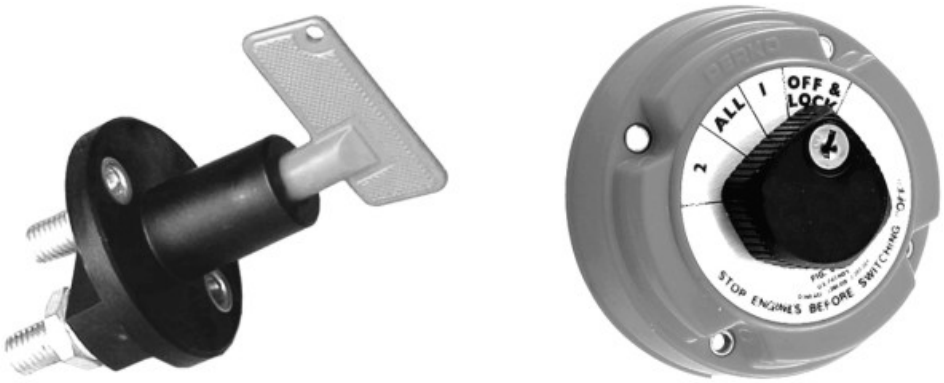
3. Use an insulating sleeve on positive terminal connections to prevent accidental shorts.
4. Additional requirements for positive cranking cables:
   a. One positive cable union (connection at bulkhead or splice) is allowed between the battery and the battery switch.
   b. One positive cable union (connection at bulkhead or splice) is allowed between the battery switch and the engine cranking battery connection.
5. Additional requirements for negative cranking cables:
   a. One negative cable union (connection at the bulkhead or splice) is allowed between the engine ground connection and main vessel DC ground bus.
   b. Bulkhead connections or splicing between the main vessel DC ground bus and the engine cranking battery must not be used.
6. When stacking multiple battery cable connections, observe the following:
   a. There can be a maximum of four connections per battery post/connection point.
   b. Do not use washers between ring terminals on battery post/connections.
   c. Ensure that the highest current carrying conductor is in direct contact with the largest surface area of the battery post conducting surface.
   d. Terminals should be grouped by size. Install largest to smallest ring terminal size.
   e. Ensure that each ring terminal makes full contact with the ring terminal beneath it.

Battery Switches

1. All power sources with a stand-alone or combined cold cranking amps (CCA) of greater than 800 amps must have a battery switch installed in-line for the vessel to remain ABYC compliant.

2. Electrically or mechanically operated switches are allowed for switching the cranking circuit.
3. Electrical control switches require visual indication of the actual battery switch state. This applies to momentary or stationary switches that result in a permanent state change of the electrically controlled battery switch.

   NOTE: *Electrical control switches used for momentary emergency parallel are exempt.*
4. Mechanical control battery switches must have text to indicate the battery switch state, for example: all, off, 1, or 2.
5. Integrated emergency parallel switching is not preferred.
   a. Standard – Each engine will have a separate two-position switch for the cranking battery or a multiposition switch for each battery bank with a separate emergency parallel switch (labeled as such).



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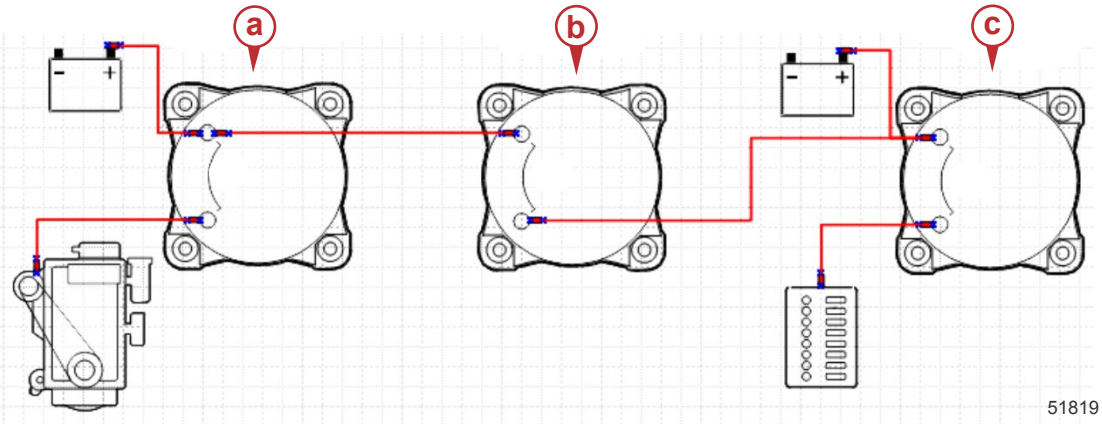
Two-position and multiposition battery switches

   b. An optional emergency parallel switch integrated between the engine and the house switch must be clearly identified, stating that the emergency parallel position should not be used during normal operation.



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Emergency parallel circuit

a - Engine switch
b - Parallel switch
c - House switch

6. Switches with multiple throws must make contact before they break contact (make-before-break).
7. Battery switch positions must be labeled to indicate battery/engine system or location (port engine, house, genset, etc.).
8. For applications requiring battery switches, each propulsion cranking battery must have its own set of switching contacts and cannot be shared with another propulsion cranking system.
   a. Standard – Individual switch housing with individual switch contacts for each cranking battery (On/Off)
   b. Optional – Individual switch housing with multiple switch contacts for all cranking batteries (On/Off/Both)
9. Isolated charging system note: Vessel loads and propulsion loads must have separate contacts, but are allowed to share the same switch housing.

Battery Isolation

Control, Isolation, and Charging Components

Diode/semiconductor isolation is the isolation method supported and recommended by Mercury Marine. Other (nonsupported) isolation methods include low-voltage disconnects (LVDs), voltage sensing relays (VSRs), and automatic closing/charging relays (ACRs). Consult with the device manufacturer for proper use and installation.

NOTE: *Mechanical devices can have unintended operation due to mechanical shock. This is the primary reason solid-state isolation techniques should be chosen over mechanical devices.*

1. The shore power AC-to-DC converter connection to the battery bank must be on an unswitched battery circuit with appropriate circuit protection.
2. When using cranking battery DC chargers (AC-DC or DC-DC) that require specific settings for different battery types, the vessel manufacturer must convey initial charger settings for the cranking batteries in an easily identifiable format. Ensure that the battery charger matches the battery type.
3. Engines that are connected to multiple battery sources must use a control/isolation device capable of charging both batteries automatically from the engine alternator regardless of the battery switch state.

   NOTE: *This requirement does not apply to the emergency parallel circuit, only to the battery selector circuit.*

Isolation Cable Sizing

Observe the following specifications for alternator-to-isolator and isolator-to-battery wiring:

1. Cables for isolator wiring must have a rating of 105 °C (221 °F).

   NOTE: *Refer to ABYC E-11 for all cable insulation requirements.*
2. If the specification in the battery isolator connection chart differs from the specification shown in the battery cable sizing chart, then the ground lead must match the larger of the two specifications.

Use the following charts when selecting cables for battery isolator installations.

Cable Size from Auxiliary Hot Stud to Battery Isolator (10% Allowable Voltage Drop)							
Maximum Alternator Output	**3 m (10 ft)**	**4.5 m (15 ft)**	**6 m (20 ft)**	**7.6 m (25 ft)**	**9.1 m (30 ft)**	**12.2 m (40 ft)**	**15.2 m (50 ft)**
85 A	21.2 mm^2 (4 AWG)	21.2 mm^2 (4 AWG)	21.2 mm^2 (4 AWG)	21.2 mm^2 (4 AWG)	33.6 mm^2 (2 AWG)	33.6 mm^2 (2 AWG)	33.6 mm^2 (2 AWG)
115 A	21.2 mm^2 (4 AWG)	33.6 mm^2 (2 AWG)	33.6 mm^2 (2 AWG)	33.6 mm^2 (2 AWG)	33.6 mm^2 (2 AWG)	33.6 mm^2 (2 AWG)	42.4 mm^2 (1 AWG)

Auxiliary Loads and Power Source

1. The MerCathode controller must be connected to the nonswitched side of the respective engine cranking battery or the house battery pack. It must be protected by a 5-amp fuse or circuit breaker. If switching of the MerCathode power is desired, then a switchable circuit breaker can be used.
2. Trim pumps must be connected to the switched side of the battery if a battery switch is used.

Isolated Battery Architecture

The isolated Mercury battery architecture specification is designed for powering the cranking system and specified critical vessel loads only. If any auxiliary vessel components (loads or other power sources) are connected to the engine power source, they must be connected in a way such that they are not allowed to degrade the propulsion power source to less than 11.5 VDC. The battery system architecture must protect the primary propulsion system voltage from nonessential power drains. Final verification of appropriate cable size for the entire system load is the responsibility of the vessel manufacturer.

Battery connections for **noncritical auxiliary loads** are as follows:

1. Standard connection: Noncritical loads must be connected to an independent battery bank, not to a propulsion cranking battery.
2. Optional connection:
   a. Noncritical vessel loads cannot derive power or ground from the cranking circuit. Both the positive and negative cables associated with noncritical vessel loads must have independent connections to the power source.
   b. The cranking battery can only be used as the reserve capacity power source to the house battery bank if the minimum voltage requirement of 11.5 VDC is maintained.

Battery connections for **critical vessel and propulsion loads** are as follows:

IMPORTANT: The following table identifies components that may source power from the cranking battery. The 11.5 VDC requirement mentioned above does not apply to these components. The components may be connected directly to the battery or anywhere along the cranking circuit.

Components that can be connected to the cranking battery		
Propulsion	**Vessel**	**Charging**
Propulsion cranking motor	Navigation lights	AC/DC converter
Trim pump	Bilge blower	Diode isolator
Steering pump	Bilge pumps	ACR/VSR
Clean power	Wipers	Other load shedding device
Helm/steering engine MPR	Emergency radio	–
MerCathode	Depth sounder	–
Propulsion gauges/sensors	Generator cranking motor	–

IMPORTANT: The generator cranking motor must be connected directly to the battery.

Engine Battery Specifications

IMPORTANT: This engine requires a 12-volt absorbed glass mat (AGM) marine starting battery that meets the minimum ratings.

Do not use flooded (wet cell), gel cell type lead acid batteries or lithium ion batteries for starting marine engines.

Each engine must be equipped with its own starting battery.

If the boat application requires additional battery loads for boat accessories or marine electronics, install an auxiliary battery, or batteries.

Required 12-Volt Absorbed Glass Mat (AGM) Battery Ratings	
USA (SAE) starting battery rating:	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 minutes RC25 rating
International (EN) starting battery rating:	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 the 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.

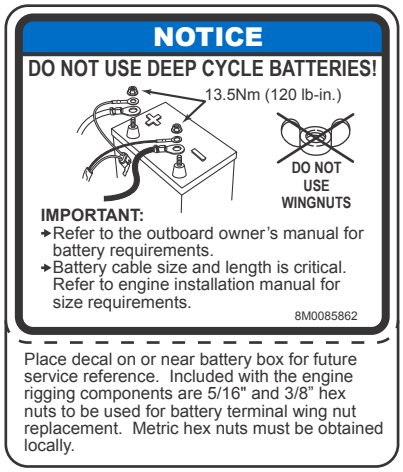
⚠ WARNING

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
Battery hex nuts	13.5	120	–

IMPORTANT: Battery cable size and length is critical. Refer to the Battery Cable Sizing table for size requirements.

A decal advising against using deep cycle batteries and wing nuts should 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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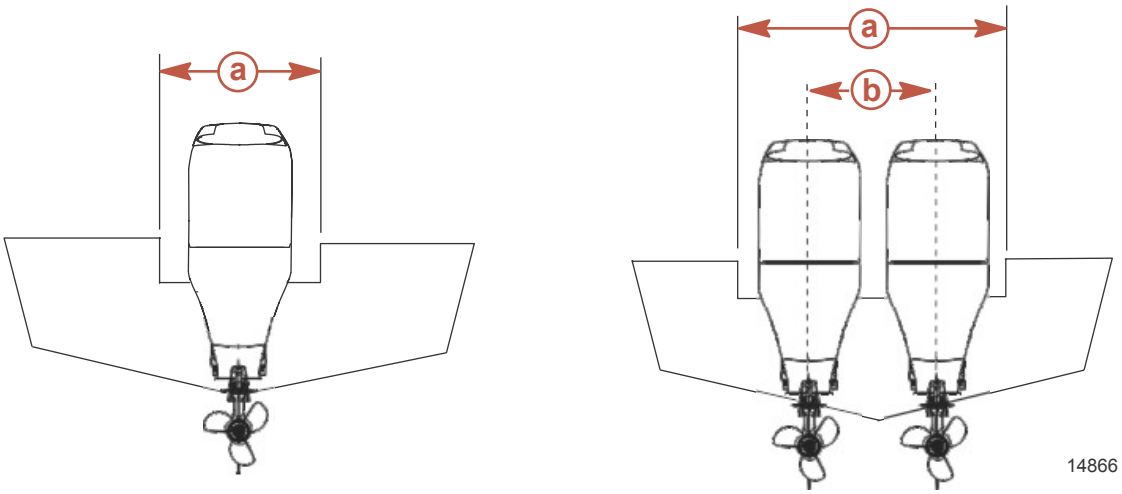
Installing the Outboard

Installation Specifications

NOTICE

Care must be taken to prevent water from entering the cowl. Mounting height and location will affect how water is deflected between engines (multiple applications) and between the engine and transom under hard acceleration or deceleration forces. The installing dealer or boat builder is responsible for proper installation of the engine as explained in the installation instructions for the product. Engine damage resulting from water ingestion is not covered by the product warranty, unless the damage is the result of a defective part supplied by the engine manufacturer.

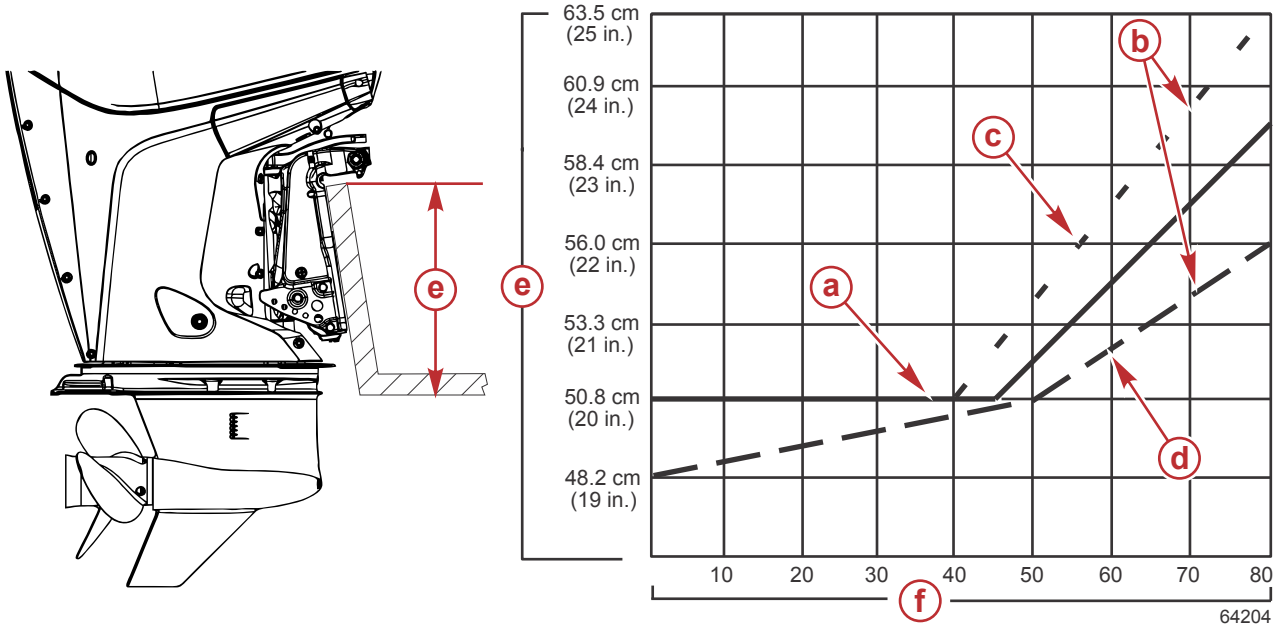


a - Minimum transom opening
b - Minimum engine centerline for multiple engines - 66.0 cm (26 in.)

Minimum Transom Opening	
Single engine	99.0 cm (39 in.)
Dual engine	130.8 cm (51.5 in.)
Triple engine	196.9 cm (77.5 in.)

NOTE: *The minimum transom opening must be 64.8 cm (25.5 in.) greater than the distance between the centerlines of the outer engines.*

Determining Recommended Outboard Mounting Height



a - Solid line: Recommended outboard mounting height
b - Dashed lines: Extremes of known successful outboard mounting heights
c - Short dashes: Preferred outboard mounting height if maximum speed is the only objective
d - Long dashes: Preferred outboard mounting height for dual-outboard installation
e - Outboard mounting height (height of outboard mounting brackets from bottom of boat transom).
f - Maximum boat speed (mph) anticipated

NOTICE
• 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.

For heights over 56.0 cm (22 in.), a propeller designed for surfacing operation is usually preferred.

Increasing the mounting height will usually:

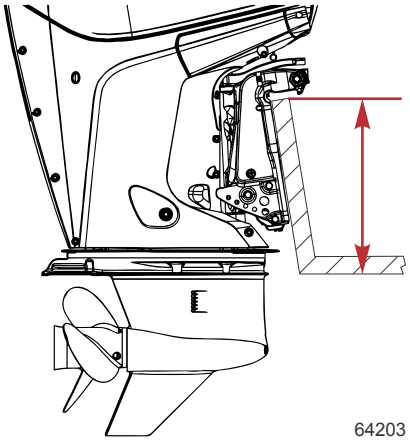
- Increase top speed
- Increase boat stability
- Cause propeller to break loose during planing or turning

Maximum Outboard Mounting Height

The mounting height of the outboard must not exceed the specified maximum:

Model	Maximum Mounting Height
L models	63.5 cm (25 in.)
XL models	76.2 cm (30 in.)

Model	Maximum Mounting Height
XXL models	88.9 cm (35 in.)

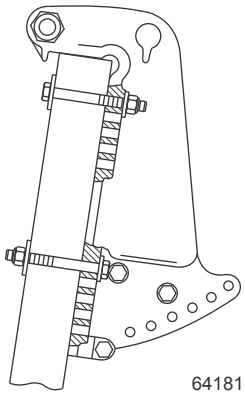


Mounting the outboard higher than the specified maximum may cause damage to the gearcase components.

Before You Drill

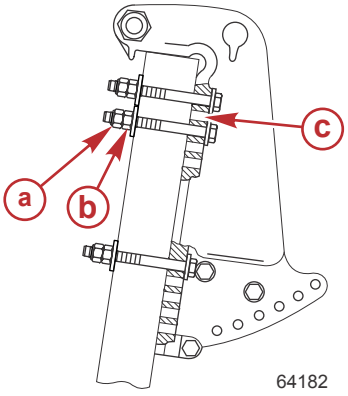
Required Mounting Installation (175–300)

The outboard must be secured to the boat transom with the four 12.7 mm (1/2 in.) diameter mounting screws, locknuts, and washers provided. Install two screws through the upper set of mounting holes and two screws through the lower set of mounting holes.



Alternate Mounting Installation (300 or 300R)

The outboard should be secured to the boat transom with the six 12.7 mm (1/2 in.) diameter mounting screws with two nuts on each screw. The two top screws must have one vacant transom mounting bracket hole between the screws. Only one locknut per screw is allowed.

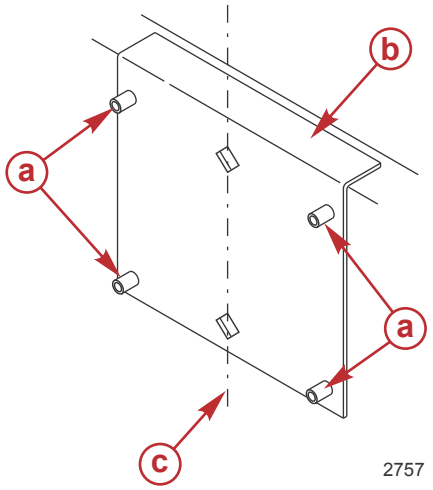


a - Locknut
b - Nut
c - Vacant transom mounting bracket hole

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.

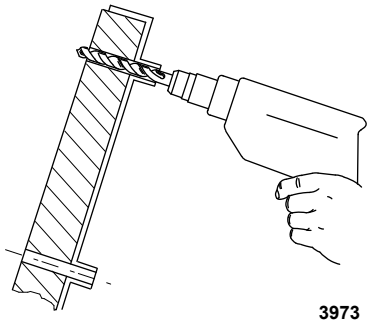
1. Mark four mounting holes on the transom using the transom drilling fixture.



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.



Lifting the Outboard

⚠ CAUTION

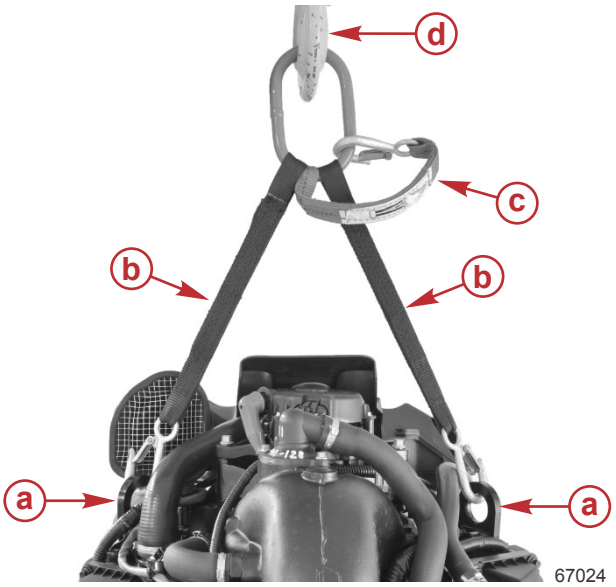
Improper lifting during removal or installation of the engine can cause injury or damage to engine components. Use a hoist, lifting arm, or other approved lifting device. Do not allow the lifting device to hook or compress any engine components.

IMPORTANT: All engine lifting devices (straps, slings, chains, or hoists) must have a minimum capacity of 450 kg (1000 lb).

1. Remove the top cowl from the engine.
2. Attach the two equal length (longer) straps of the lifting strap to the port and starboard lifting eyes on the engine. Secure the third strap (red) out of the way, to avoid damaging engine components.

Lifting strap	883705T01

3. Lift the engine into position with an overhead hoist.



a - Lifting eyes on engine
b - Equal length straps (black)
c - Short strap (red); secure out of the way
d - Overhead hoist

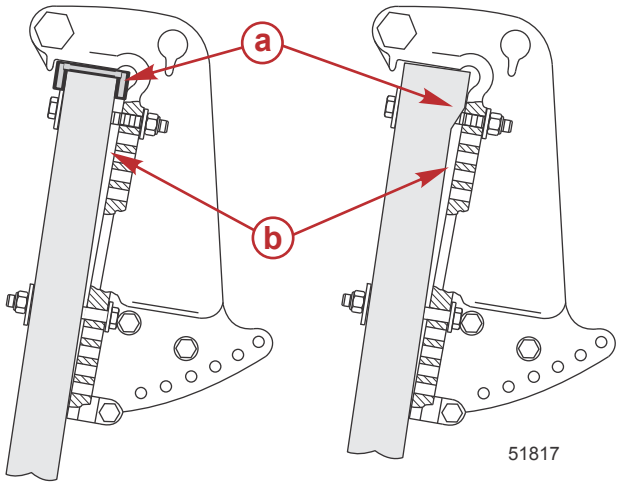
Transom Mounting Hardware

Outboard Transom Mounting Hardware - Supplied with Outboard		
Part Number	**Part Name**	**Description**
8M0038370	Outboard mounting bolt	½-20 x 5.50 in. long (3.25 in. thread)
826711-17	Nylon insert locknut	½-20
28421	Flat washer	1.50 in. diameter
54012	Flat washer	0.875 in. diameter

Available Outboard Mounting Bolts	
Part Number	**Description**
67755005	½-20 x 2.50 in. long (1.25 in. thread)
67755006	½-20 x 3.50 in. long (1.25 in. thread)
814259	½-20 x 4.00 in. long (2.25 in. thread)
67755-1	½-20 x 4.50 in. long (2.25 in. thread)
8M0071543	½-20 x 5.00 in. long (3.25 in. thread)
8M0038370	½-20 x 5.50 in. long (3.25 in. thread)
67755-2	½-20 x 6.50 in. long (2.75 in. thread)
8M0028080	½-20 x 7.50 in. long (2.75 in. thread)
8M0032860	½-20 x 8.00 in. long (2.75 in. thread)

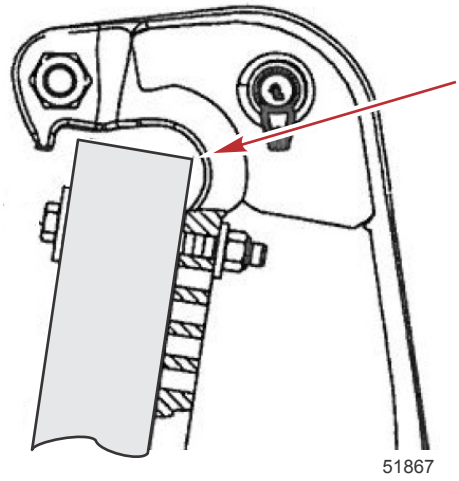
Fastening the Outboard to the Transom

IMPORTANT: The transom mounting surface must be flat within 3.17 mm (0.125 in.). No step in the transom mounting surface is allowed. The inside transom mounting screw washer surface must be flat within 3.17 mm (0.125 in.).



a - Step (not allowed)
b - Gap between transom clamp and boat transom (not allowed)

IMPORTANT: Clearance must be maintained between the vessel transom and the outboard transom bracket relief radius area. Failure to maintain clearance may damage the transom bracket and cause the transom bracket to fail. Adjustments to the position of the Mercury Marine transom drilling fixture may be required to ensure proper clearance of the transom bracket relief radius area.



Steering Cylinder Special Notice

On some applications, the transom opening does not provide sufficient clearance to install the steering cylinder after the outboard has been fastened to the transom. In these instances:

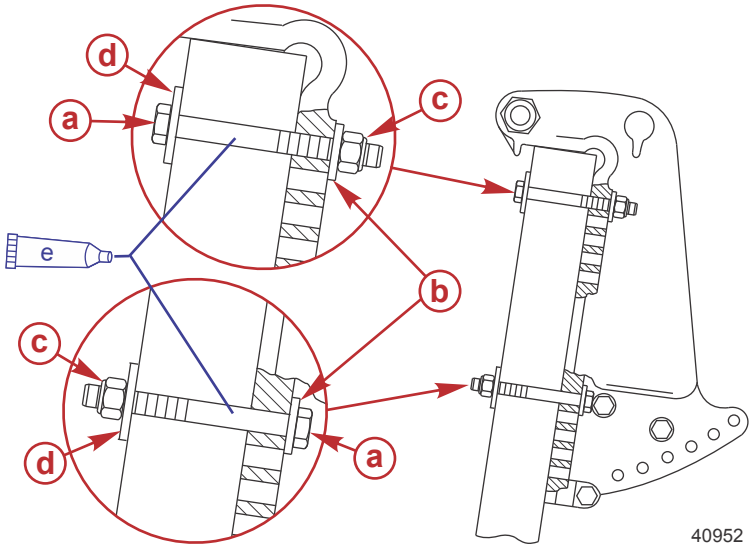
1. Using an overhead hoist, position the outboard so that it is as close to the transom as possible, while still allowing room to install the steering cylinder.
2. Ensure that no personnel are within the pinch points of the engine/transom.
3. Remove the shipping bracket. Refer to **Shipping Bracket Removal**.
4. Attach the steering cylinder to the outboard, per the instructions provided with the steering kit.
5. Carefully lower the outboard to its mounting height, and continue with the installation.

Installation

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

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

NOTE: *For a more accurate torque reading, tighten the mounting locknuts rather than the outboard mounting screws.*



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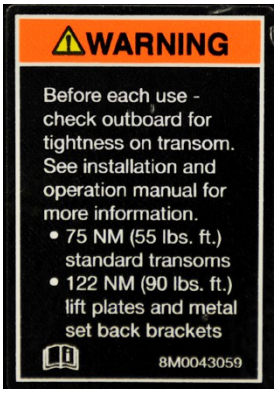
- **a -** 0.500 in. diameter outboard mounting screw (4)
- **b -** 0.875 in. flat washer (4)
- **c -** Nylon insert locknut (4)
- **d -** 1.500 in. flat washer (4)
- **e -** Marine sealer – apply to the shank of the screws, not the threads

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

A decal on the transom bracket reminds the owner to check the fasteners securing the outboard to the transom before each use.



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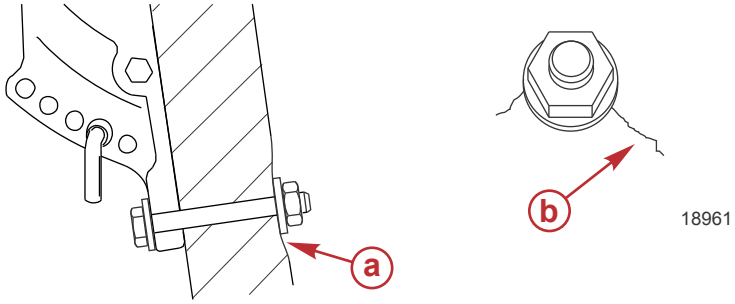
Decal on the transom bracket

Checking Boat Transom Construction

IMPORTANT: Determine the strength of the boat transom. The outboard mounting locknuts and screws should be able to hold 75.0 Nm (55.3 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.



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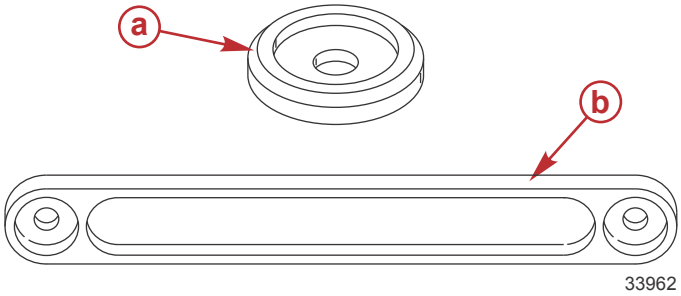
- **a -** Transom yielding under screw torque
- **b -** Transom cracking under screw torque

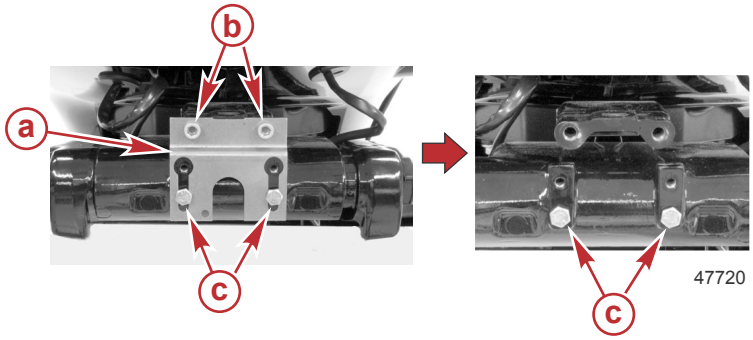
Use a dial torque wrench to determine transom strength. If the screw or nut continues to turn without the torque reading on the dial increasing, it is an indication that the transom is yielding. The load area can be increased by using a larger washer or a transom reinforcement plate.



a - Large transom washer
b - Transom reinforcement plate

Shipping Bracket Removal

1. Remove the two top screws and loosen the two bottom screws.
2. Slide the shipping bracket off the bottom screws.
3. Tighten the bottom screws to the specified torque.



a - Shipping bracket
b - Top screws
c - Bottom screws

Description	Nm	lb-in.	lb-ft
Bottom screws	7.9	70	–

Wiring Guidelines

DTS Special Notices and 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.

⚠ 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.

⚠ 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.

- Never attempt to connect, network, tie into, switch, or sink source voltage or current from the DTS wiring harnesses.
- Never attempt to tap directly into any of the DTS electrical wiring harnesses for a source of power.
- Never attempt to connect any type of communication or navigation equipment into the DTS wiring harnessing other than at the designated connection point.

Harness and Connector Guidelines

Harness Installation Guidelines

- Locate a routing path for the harness connections so they reach their installation points.
- 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 the electrical system.
- Ensure that all connections are tight, and seal all unused connectors with weather caps.

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. On round, 14-pin connectors, rotate the locking collar to secure the electrical connection.

Data Harness Pulling Procedure

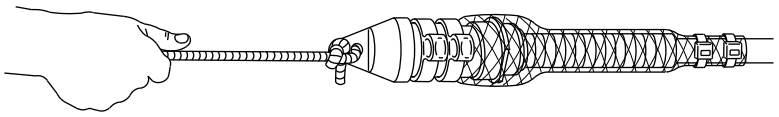
IMPORTANT: Do not route data harness near engine ignition components (coils, spark plug leads, and spark plugs), high power VHF coax, or radios. An electrical field generated from these components could cause interference with data transmission.

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.



3836

Data Cable Puller	888462A 1

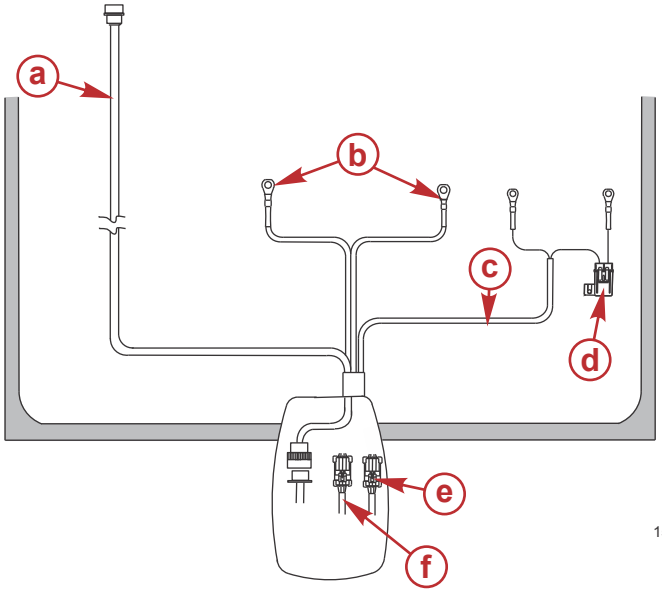
IMPORTANT: Carefully inspect data harness pins to ensure that all pins are securely fastened to data harness connector end following installation.

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

System Wiring Reference Points

- **14-pin data harness** - Connects between the command module harness at the helm and the engine.
- **Battery cables** - Connect to the engine starting battery.
- **2-pin clean power harness** - Requires connection to the engine starting battery. Provides 12 V power to the engine control module. If the starting battery is located at the helm, a clean power accessory power harness kit is required to minimize voltage drop. Use cable ties to secure the power harness leads to the battery cables, beginning within 15 cm (6 in.) of the battery posts and continuing along the entire length of the harness.
- **3-pin power steering pump harness plug** - The power steering pump harness connects between the connector on the engine and the power steering pump, if equipped.

- **6-pin vessel sensor harness plug** - The vessel sensor harness connects between the connector on the engine and the main fuel tank sensor, auxiliary fuel tank, and the paddle wheel speed/temperature sensor, if equipped.



a - 14-pin data harness
b - Battery cables
c - 2-pin clean power harness
d - 5-amp fuse
e - 3-pin power steering pump harness connector
f - 6-pin vessel sensor harness connector

Wiring Accessories

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

Rigging the Engine

IMPORTANT: Leave sufficient slack in wiring harnesses, battery cables, and hoses that are routed between the rigging grommet and engine attachment points, to relieve stress and prevent hoses from being kinked or pinched.

Rigging Tube and Rigging Adapter

IMPORTANT: A rigging tube is recommended, but is not required.

The use of the rigging adapter and rigging grommet is mandatory.

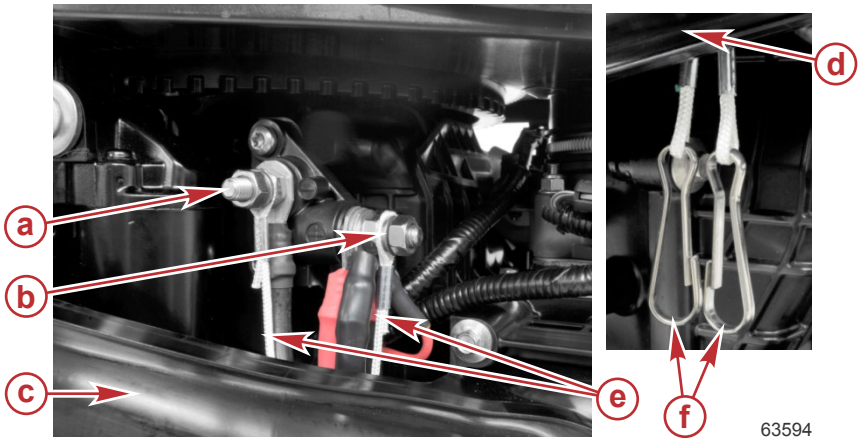
1. If you are using a rigging tube, thread the rigging adapter onto the end of the rigging tube.
2. Ensure that all applicable items are routed through the rigging tube (if used) and the rigging adapter, allowing enough slack to make the connections on the engine:
   - Battery cables
   - 14-pin data harness
   - 2-pin clean power harness
   - 3-pin power steering harness (optional)
   - 10-pin network device harness (optional; refer to device instruction sheet)
   - 6-pin boat harness
   - Fuel line
   - Throttle and shift cables (mechanical engines only)
   - Speedometer water pickup tubing (black)
   - Block water pressure tubing (gray) (mechanical engines only)

Connections at the Engine

Especially for mechanical models, the space available for rigging is tight. Follow these guidelines to ensure a trouble-free rigging process.

1. Connect the battery cables to the engine.
   - Pro XS models are shipped with the cables installed.

- Models without installed cables have fish lines with clips secured to the power and ground studs, to allow the cables to be easily fed behind the intake runners. Remove the lines from the engine, prior to securing the cables to the appropriate studs.

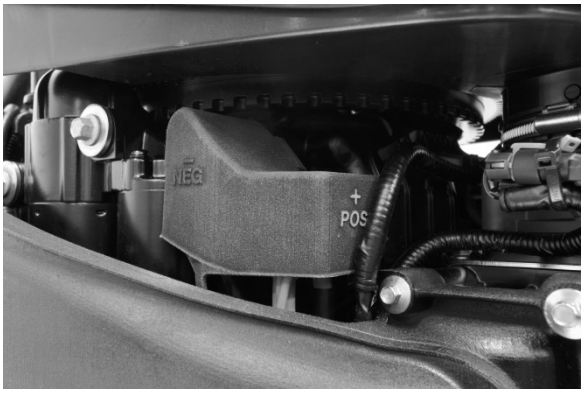


a - Ground (–) stud
b - Power (+) stud
c - Top of intake runners
d - Bottom of intake runners
e - Lines for feeding battery cables behind intake runners
f - Clips

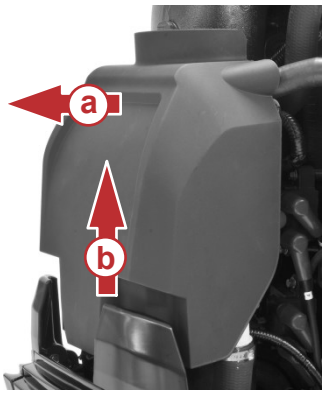
2. Tighten the nuts on the battery connections to the specified torque, apply Liquid Neoprene to the connections, and install the cover.

Description	Nm	lb-in.	lb-ft
Battery connection nuts	17	150	–

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Battery connections at the engine	92- 25711 3



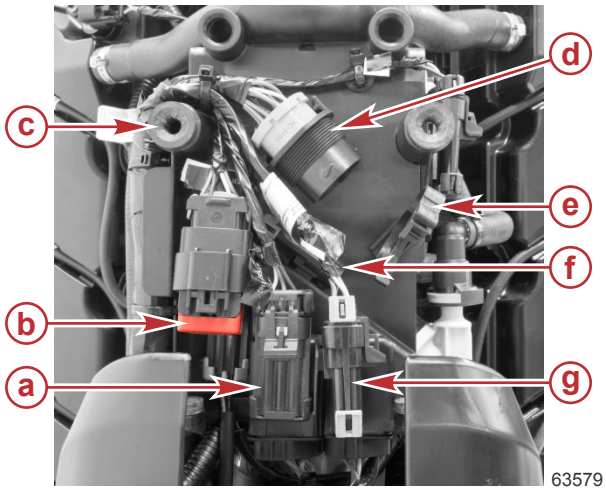
3. Remove the electrical panel cover.
   - On V8 models, pull the top rearward until the pins are clear of the grommets, and then lift up.



V8 models
a - Pull rearward
b - Lift up

   - On V6 models, pull the panel aft.

4. Remove the weather caps from the boat harness connector and the power steering connector, if applicable.

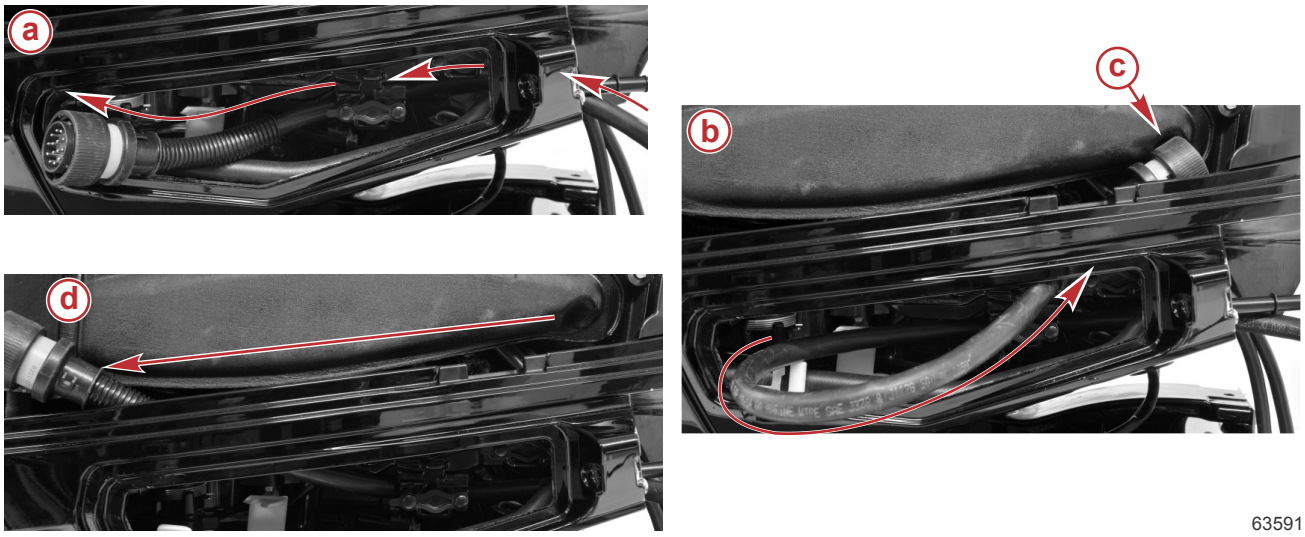


V8 model shown, V6 similar

- **a -** 3-pin optional power steering harness connector
- **b -** 10-pin CAN terminator

  NOTE: *Remove only if an optional network cable or device is being connected. Refer to the instruction sheet accompanying the device or cable.*
- **c -** Electrical panel cover grommet (one of four)
- **d -** 14-pin connector
- **e -** Ring clip for 14-pin data harness (one of two)
- **f -** 2-pin clean power harness connector (behind power steering connector wires)
- **g -** 6-pin boat harness connector with weather cap

5. On mechanical models, unlatch and open the cable keeper.
6. Route the 14-pin data harness to the rear of the engine. On mechanical models:
   a. Feed the connector through the inboard side of the ingress, route the harness behind the throttle bracket, and pull the connector out through the rigging access hole.
   b. Turn the connector back to the front of the engine, making a loop, and feed the connector back up by the intake runners.
   c. Pull the harness up past the notch in the lower intake runner.
   d. With the connector above the top of the lower cowling, pull the harness around the engine until the connector has reached the electrical panel.

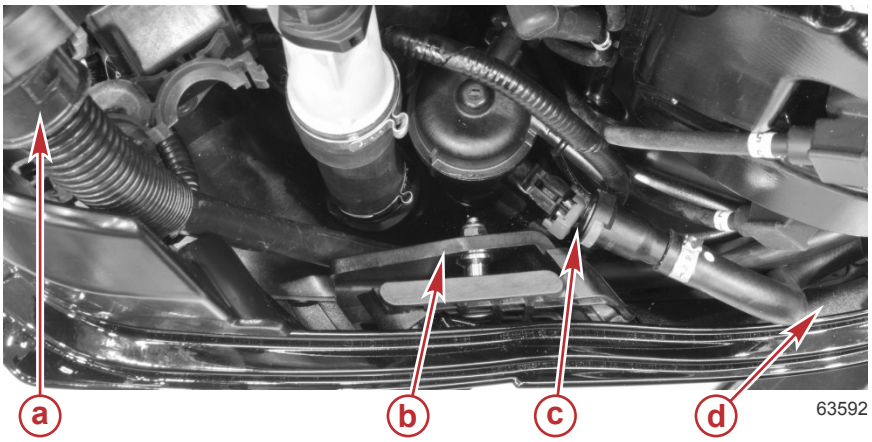


- **a -** Feed the harness through the ingress, behind the throttle bracket, and out the rigging access hole
- **b -** Loop the harness and feed it up by the intake runner
- **c -** Notch in the intake runner
- **d -** Pull the harness rearward

7. Connect the 14-pin data harness at the electrical panel.

   IMPORTANT: There may be some residual fuel in the fuel line, from manufacturer testing of the engine. Be certain to capture and properly dispose of any spilled fuel.
   a. Disconnect the fuel line from the fuel filter, and route the harness beneath the fuel line.

b. Ensure that the harness lies beneath the throttle bracket, passes through the cable keeper, and passes below the cowl latch.



a - 14-pin data harness connector
b - Cowl latch
c - Fuel line disconnected at fuel filter
d - 14-pin data harness routed from rigging ingress

c. Connect the 14-pin data harness. Secure the harness with the two ring clips.

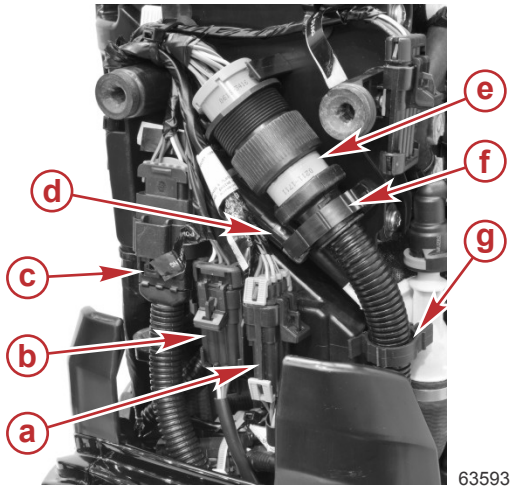
NOTE: *On some models, it may be necessary to pull a little extra slack to make the connection. Be certain to remove the slack after the harness is secured.*

d. Reconnect the fuel line.

IMPORTANT: When routing and connecting the harnesses:

- **On mechanical models, all harnesses must route behind or beneath the throttle and shift brackets.**
- **On mechanical models, all harnesses must route through the cable keeper. Keeping the fuel hose and 14-pin data harness toward the outside edge leaves the smaller harnesses to easily tuck under components.**
- **All harnesses must route beneath the rear cowl latch.**
- **As each connection is made, secure it to the appropriate tab on the electrical panel.**

8. Route the remaining harnesses to the rear of the engine and connect to the appropriate engine harness connectors. It is easiest to route the harnesses according to connector size, from largest to smallest:
   a. 10-pin harness, if required
   b. 6-pin boat harness
   c. Optional 3-pin power steering harness
   d. 2-pin clean power harness

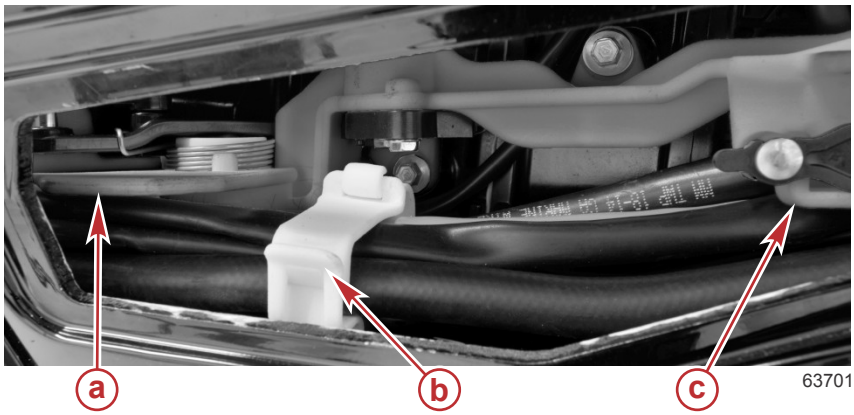


V8 model shown, V6 similar

a - 6-pin boat harness
b - 3-pin power steering harness (optional)
c - 10-pin harness for network cable or device; refer to instruction sheet
d - 2-pin clean power harness
e - 14-pin data harness
f - Large ring clip
g - Small ring clip

9. Ensure that the fuel line is connected at the fuel filter.

10. On mechanical models, ensure that all harnesses and the fuel line run through the cable keeper. Close and latch the cable keeper.



Some items shown lighter than actual coloring, for clarity

- **a -** Throttle arm guard (part of the throttle bracket)
- **b -** Cable keeper latch
- **c -** Throttle bracket

11. Connect the remote fuel line to the fitting at the ingress.
    - The minimum fuel hose inside diameter (ID) is 9.5 mm (3/8 in.), with a separate fuel hose/fuel tank pickup for each engine.
    - Fasten the hose with a clamp. Position the clamp so that it will not chafe or cut into the adjacent wiring harness.

NOTICE
Inspect the position of the hose clamp to ensure that it will not chafe or cut into the adjacent wiring harnesses.

Connections at the Remote Control (Mechanical Engines)

IMPORTANT: For remote control installation, refer to the instruction sheet accompanying the remote control.

Attach the throttle and shift cables to the remote control, following the instructions provided with the remote control.

Water Tubing Connections

Speedometer Tubing Connection (All Models)

This outboard has a speedometer water pickup located in the leading edge of the gearcase. To use this water pickup for the speedometer, feed the black tubing through the accessories opening in the rigging grommet, as shown. Remove the plug from the coupler fitting, and make the connection to the tubing that runs to the speedometer.

If the tubing will not be used for a gauge:

1. Tuck the tubing inside the front of the engine cowling.
2. On mechanical engines, keep the tubing clear of the throttle and shift cabling.
3. Ensure that the plug remains locked into the coupler fitting.

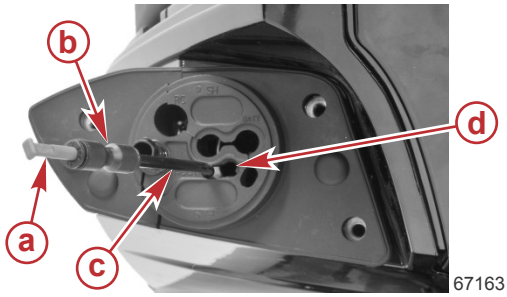
Block Water Pressure Tubing Connection (Mechanical Models)

For mechanical models: If the boat is equipped with a block water pressure gauge, the gray tubing can be used to operate the gauge. Feed the gray tubing through the accessories opening in the rigging grommet, as shown. Remove the plug from the coupler fitting, and make the connection to the tubing that runs to the block water pressure gauge.

If the tubing will not be used for a gauge:

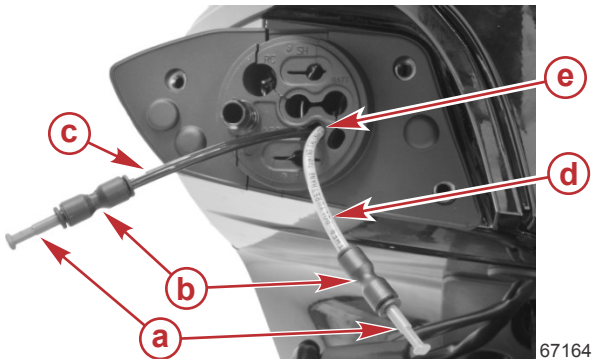
1. Tuck the tubing inside the front of the engine cowling.
2. Keep the tubing clear of the throttle and shift cabling.
3. Ensure that the plug remains locked into the coupler fitting.

Connections at Rigging Tube



DTS models

- **a -** Plug
- **b -** Coupler fitting
- **c -** Water pickup tubing (black)
- **d -** Accessories opening in rigging grommet



Mechanical models

- **a -** Plug
- **b -** Coupler fitting
- **c -** Water pickup tubing (black)
- **d -** Block water pressure tubing (gray)
- **e -** Accessories opening in rigging grommet

Throttle Cable Installation

1. Identify the throttle cable. The shift cable is the first cable to move when the remote control is moved out of neutral/idle; the throttle cable moves second.
2. Set the remote control to the neutral/idle position.

Typical

3. Feed the throttle cable through the ingress, and attach the throttle cable to the throttle arm. Snap the latch into place to secure the connection.
4. Adjust the cable barrel so that the installed throttle cable will hold the throttle arm at idle stop (fully rotated rearward).
5. Place the cable barrel into the barrel retainer.

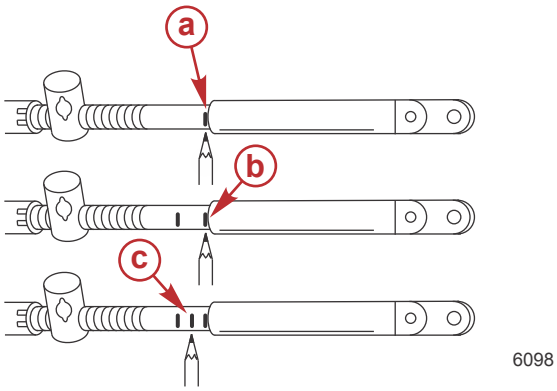
6. Lock the cable in place with the cable latch.

Some items shown lighter than actual coloring, for clarity

- **a -** Throttle arm
- **b -** Latch
- **c -** Cable barrel
- **d -** Cable latch (rotate clockwise to lock)

Shift Cable Installation

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



3. Position the remote control and the outboard into their neutral positions. Without the cable attached, the shift arm on the outboard has a noticeable detent.
4. Align the shift cable end guide with the center mark made in step 2. Place the shift cable on the shift arm's anchor pin, and secure it with the latch.
5. Adjust the cable barrel so it slips freely into the barrel retainer.

6. Lock the barrel in place with the cable latch.

a - Anchor pin on shift arm (shown in neutral position with some components removed, for clarity)
b - Anchor pin latch
c - Shift arm (bottom view)
d - Cable barrel positioned in the barrel retainer
e - Cable latch (rotate clockwise to secure)

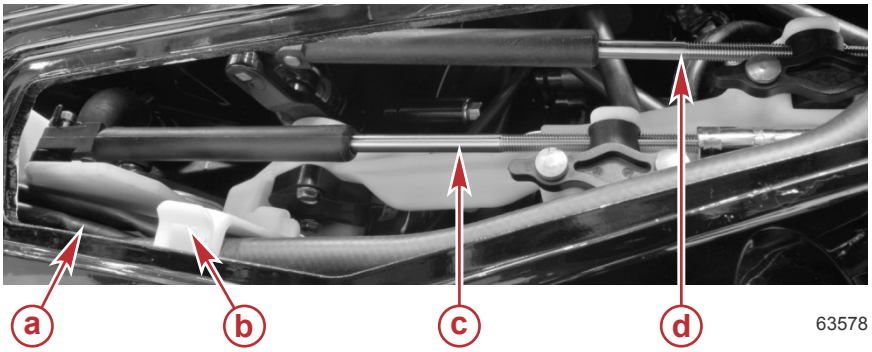
IMPORTANT: After the engine installation is complete and before commissioning the engine, check the shift cable adjustments for neutral and reverse (forward cannot be checked with the engine off) with the key switch on, but the engine off, as follows:

1. **Start with the remote control in neutral.**
2. **Shift the remote control into reverse while turning the propeller. The propeller shaft should be locked in gear. If not, adjust the barrel away from the cable end, and repeat steps 1 and 2.**
3. **Shift the remote control back to neutral. The propeller shaft should turn freely without drag. If not, adjust the barrel closer to the cable end, and repeat steps 1 through 3.**

Rigging Access Panel

Install the rigging access panel.

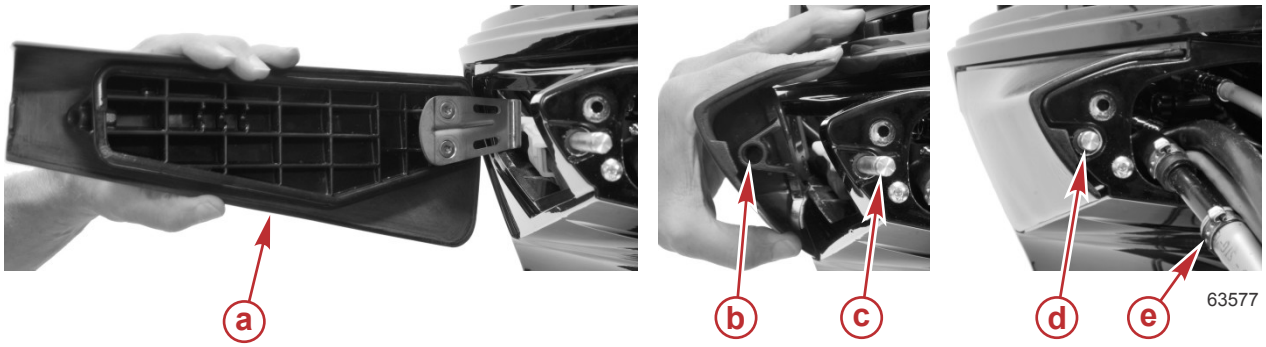
1. Ensure that all electrical cables and fuel line are routed under the throttle arm guard and through the cable keeper. Ensure that they do not interfere with the throttle and shift cables.



Some items shown lighter than actual coloring, for clarity
a - Cables routed under the throttle arm guard and through the cable keeper
b - Cable keeper latch
c - Throttle cable (mechanical engines only)
d - Shift cable (mechanical engines only)

2. Latch the rear end of the panel inside the rigging access opening in the lower cowl, and swing the panel inward.

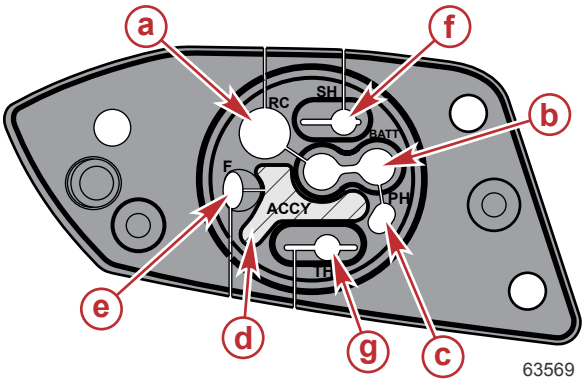
3. Secure the rigging access panel with the retaining pin. Ensure that the pin is fully seated.



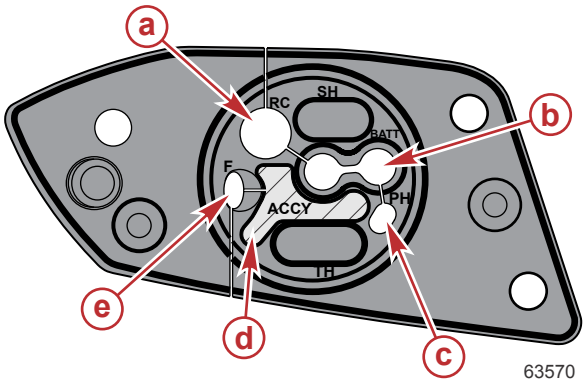
a - Rigging access panel
b - Socket in rigging access panel for retaining pin
c - Retaining pin
d - Retaining pin fully seated
e - Hose clamp on remote fuel line

Rigging Grommet

IMPORTANT: A rigging tube is recommended, but is not required.
The use of the rigging adapter and rigging grommet is mandatory.



Mechanical models



DTS models

Ref	Marking	Opening used for
a.	RC	14-pin data harness (from helm harness or remote control)
b.	BATT	Battery cables
c.	PH	2-pin clean power harness
d.	ACCY	Boat harness, power steering harness, CAN link harness, other accessories Analog block water pressure tubing (mechanical models), analog speedometer tubing ***NOTE:*** *Use a knife to remove the material from this opening, and create an access slit from the fuel (F) opening.*
e.	F	Fuel line ***NOTE:*** *The fuel line fitting should be inserted into the grommet, with the hose and hose clamp on the outside of the grommet.*
f.	SH	Shift cable (mechanical models)
g.	TH	Throttle cable (mechanical models)

1. Use a knife to remove the material from the **ACCY** portion (cross-hatched in the preceding illustration) of the grommet. Cut an access slit from the fuel hose hole (**F**) to the new hole.
2. Arrange the harnesses, cables, and fuel hose in the approximate positions they will occupy in the rigging grommet.
3. Work the grommet around the harnesses, cables, and fuel hose. Start with the inboard and innermost items, and work outward and toward the outboard. One possible sequence follows:
   a. 2-pin clean power harness

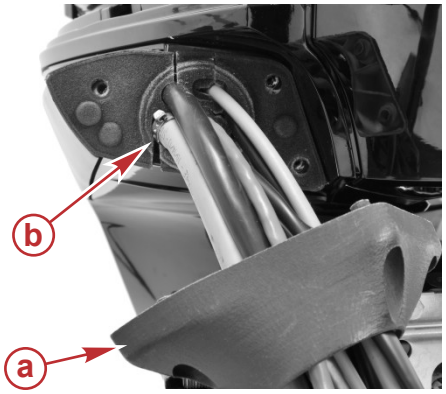
b. Battery cables
c. 6-pin boat harness, power steering harness, CAN link harness, and accessories
d. Throttle cable
e. Shift cable
f. 14-pin data harness (from remote control)
g. Fuel line fitting (flange should sit flush with the outside surface of the grommet)

4. Press the rigging grommet into the opening.

NOTICE

Inspect the position of the hose clamp located on the fuel hose to ensure that it will not chafe or cut into the adjacent wiring harnesses.

5. Slide the rigging adapter and rigging tube (if used) into place over the grommet.



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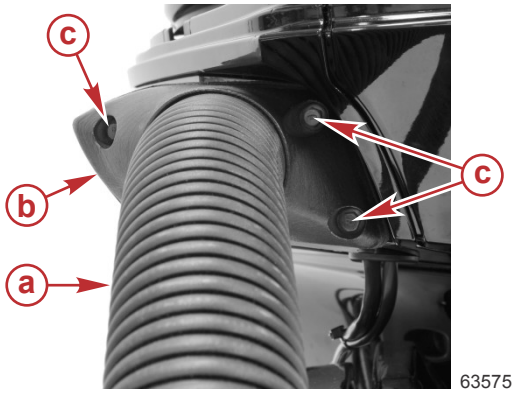
a - Rigging adapter
b - Clamp on fuel line, outside of rigging grommet

6. Fasten the rigging grommet and rigging adapter with three screws. Tighten the screws to the specified torque.



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a - Rigging tube (optional)
b - Rigging adapter
c - Screws (3)

Description	Nm	lb-in.	lb-ft
Screws for attaching the rigging adapter	6	53.1	–

7. If a rigging tube is not used, secure the wiring, hoses, and cables together with a cable tie.


63574

Installing the Steering System

Refer to the instruction sheet that accompanied your steering kit.

Battery Connections

⚠ 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.

IMPORTANT: The engine electrical system is negative (–) ground.

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.

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

Order of Connection

Connect the battery cables in the following order:

1. All jumpers between parallel, multiple battery packs
2. From the batteries to the positive (+) engine lead
3. From the batteries to the positive (+) clean power
4. From the batteries to the negative (–) engine lead
5. From the batteries to the negative (–) clean power
6. From the batteries or main ground (–) bus to the negative (–) starboard helm main power relay

Connecting Battery Cables and Clean Power Harness

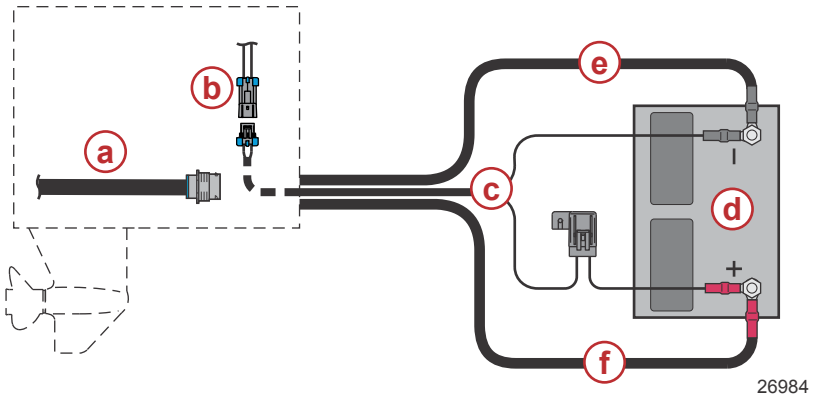
⚠ CAUTION

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.

NOTE: *Do not extend the lead length of the clean power harness.*

1. Connect the clean power harness directly to the starting battery.

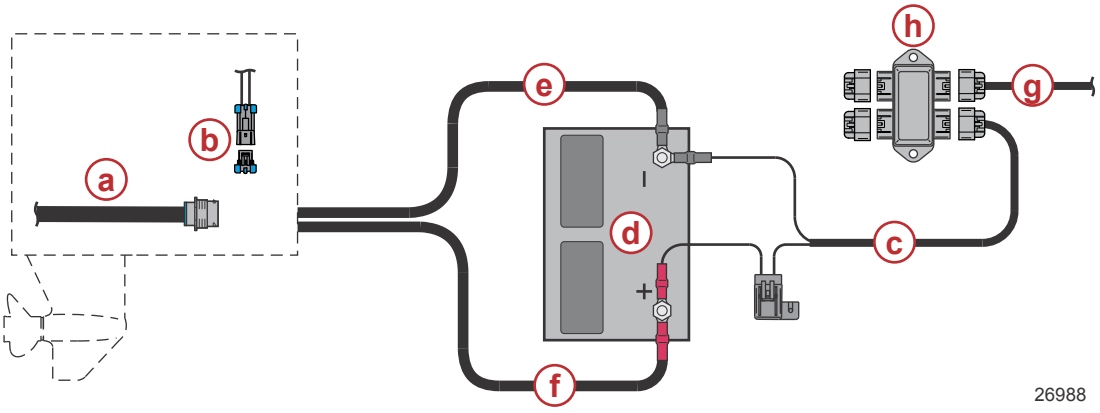
   NOTE: *The clean power harness is provided with the 20 in. L models. For XL and XXL models, refer to the* ***Mercury Precision Parts Accessories Guide*** *for the required clean power harness kit.*



Battery located at the stern

- **a -** 14-pin data harness
- **b -** 2-pin clean power harness connector
- **c -** Clean power harness
- **d -** Battery
- **e -** Negative engine battery cable
- **f -** Positive engine battery cable

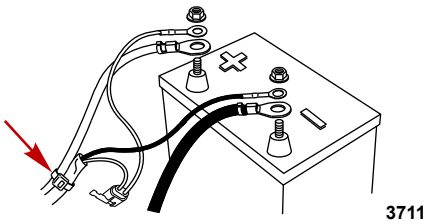
NOTE: *For batteries located at the helm, refer to the* ***Mercury Precision Parts Accessories Guide*** *for an optional clean power harness connection kit.*



Battery located at the helm

- **a -** 14-pin data harness
- **b -** 2-pin clean power harness connector - weather cap
- **c -** Helm clean power harness (optional)
- **d -** Battery
- **e -** Negative engine battery cable
- **f -** Positive engine battery cable
- **g -** DTS command module harness
- **h -** Junction box

2. Fasten the clean power harness to one of the battery cables with a cable tie.



Fuel System

Accessory Electric Fuel Pump

IMPORTANT: Do not install an accessory electric fuel pump into the fuel system of this engine.

Avoiding Fuel Flow Restriction

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

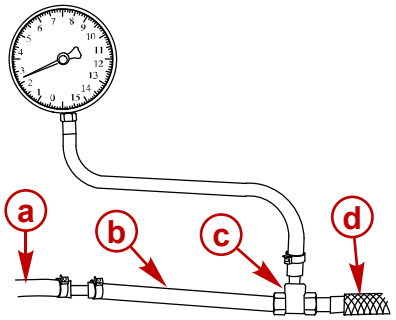
IMPORTANT: Because of the high fuel flow rates at WOT, engines with horsepower ratings of 300 hp and higher are especially susceptible to fuel flow restrictions. If your application encounters difficulty in achieving the stated specification at WOT, consider replacing the stock fuel filter with a high capacity, lower restriction filter and increasing the boat fuel line diameter to 13 mm (0.5 in.).

Description	Specification
Maximum fuel system inlet vacuum (see NOTE)	10.16 kPa (3.0 in. Hg) (1.47 psi)

NOTE: *This maximum value applies only to measurements taken at the engine, not to measurements taken elsewhere in the boat. The maximum value is with the fuel tank at half volume.*

The following configuration can be used to test the fuel system inlet vacuum. Make the T-fitting connection between the engine and the boat fuel line. The measurement should be taken at the elevation where the fuel line enters the cowl.

NOTE: *1 kPa of vacuum is equal to approximately 13 cm (5 in.) of gasoline.*
1 psi of vacuum is equal to approximately 94 cm (37 in.) of gasoline.



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

A restriction in the fuel system will result in a vacuum reading higher than the allowable maximum. Some common causes of excessive vacuum include:

- Restricted antisiphon valve
- Restricted or malfunctioning primer bulb
- Kinked or collapsed fuel hose
- Plugged water-separating fuel filter (in the boat)
- Restriction in the fuel line through-the-hull fitting
- Restriction in the fuel tank switching valves
- Plugged fuel tank pick-up screen

Low Permeation Fuel Hose Requirement

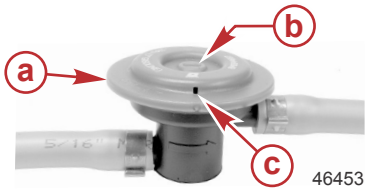
Required for outboards manufactured for sale, sold, or offered for sale in the United States.

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

Fuel Demand Valve

Some boat fuel systems incorporate a fuel demand valve between the fuel tank and the engine and others do not. This engine can be operated with or without a fuel demand valve.

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



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

Fuel Supply Module Priming Procedure

The fuel supply module (FSM) is not vented to the ambient air. The air trapped in the FSM, fuel lines, and fuel rail, will be slightly compressed during the initial ignition key "ON" with a dry or drained fuel system. Additional key "ON" events under these conditions, will not compress the air further to finish the priming of the FSM. Excessive number of key "ON" events may eventually damage the fuel pumps. The volume of air trapped in the FSM must be purged to prime the fuel system. This can be achieved by connecting a tool to the fuel rail Schrader valve fitting to quickly purge the system into an approved container, or by cranking the engine.

Priming the FSM with a Purge Tool

The use of a purge tool for priming the FSM is the preferred method, but is not always practical. The objective is to purge the air entrained in the fuel system through a purge tool connected to the fuel rail Schrader valve test port. During the key "ON," opening the dump valve will allow the air to be purged from the FSM and fuel rail. This method should be used on vessels where the fuel inlet system to the outboard is restrictive; anti-siphon valve or holds a relatively large volume of fuel because of a long fuel supply line or water separating fuel filter. If a primer bulb is installed, it can be used during the priming event to shorten the amount of time required to start the engine.

1. Verify the engine is in a level vertical position.

2. Verify the vessel fuel supply line is connected to the outboard fuel system inlet fitting.
3. Connect a fuel pressure gauge to the fuel rail Schrader valve.
4. Secure the fuel pressure gauge purge hose into an appropriate fuel container to collect excess fuel.
5. Open the fuel pressure gauge purge valve and turn the ignition key "ON." The fuel pumps will run for approximately five seconds.
6. Turn the ignition key "OFF" and then back "ON." The fuel pumps will run for approximately five seconds. Continue this ignition key cycle until the purged fuel is relatively clear of air bubbles.

   NOTE: *If the outboard fuel system does not prime within 15 key "ON" events, check for leaks in the fuel supply line to the outboard. Repair as needed. If no leak is found, the fuel supply system to the outboard may be too restrictive. Correct the condition and try again.*
7. Remove the fuel pressure gauge.
8. Turn the ignition key "ON." When the fuel pumps stop running, start the engine. The engine may not start on the first attempt. The engine will run rough at idle for up to two minutes while the residual air is purged from the fuel system.

Priming the FSM (Ran out of Fuel Condition)

The use of a purge tool for priming the FSM is the preferred method, but is not always practical. When the vessel fuel system is void of fuel volume, it can be primed without the use of a purge tool. The objective is to purge the air entrained in the fuel system through the fuel injectors during engine cranking to allow fuel to enter the fuel module. This method can be used on vessels where the fuel inlet system to the outboard is less restrictive and holds a relatively small volume of fuel; a short fuel supply line, no water separating fuel filter, or water separating fuel filter is already primed. If a primer bulb is installed, it can be used during the priming event to shorten the amount of time required to start the engine.

1. Verify the engine is in a level vertical position.
2. Verify the vessel fuel supply line is connected to the outboard fuel system inlet fitting.
3. Turn the ignition key "ON." The fuel pumps will run for approximately five seconds.
4. Turn the ignition key to the "START" position and release the key. The ECM controls the activation of the starter. The starter may continue cranking for up to eight seconds.

   NOTE: *When priming a drained fuel system, residual fuel may cause the engine to flare and stall which shortens the engine cranking event.*
5. Continue with the ignition key "ON" and "START" sequence until the engine continues to run.

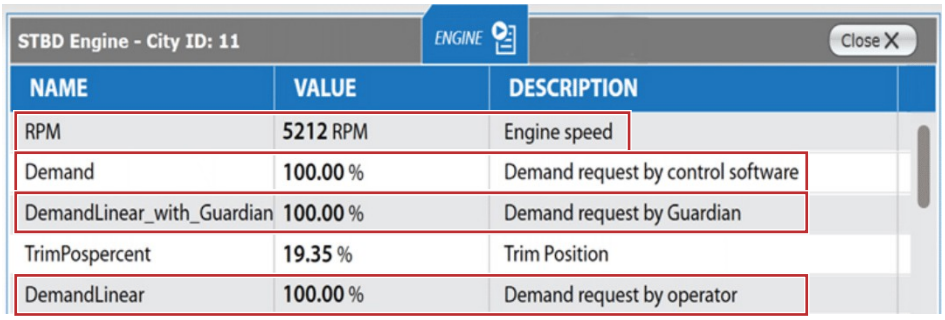
   IMPORTANT: Allow the starter motor to cool for 20 to 30 seconds between full eight second crank events. Limit the number of events to a maximum of 10 full eight second cranking events.
6. Once the engine starts, it may run rough at idle for up to two minutes while the residual air is purged from the fuel system.
7. If the fuel system will not prime within 10 full eight second cranking events, use the previous procedure **Priming the FSM with a Purge Tool** to prime the fuel system.

Adaptive Speed Control (ASC) Propping with CDS G3

A special propping procedure using CDS G3 should be used for optimum propping.

1. Install the best guess propeller.
2. Connect CDS G3 to the engine, and monitor the following values:
   - **RPM** - engine speed. In this example, for a new boat with a new engine, the ideal RPM is at the upper end of the RPM range.
   - **DemandLinear** - requested handle position. This should be at 100% at wide-open throttle. If this value is not at 100% when the handle is in the full forward position, the throttle cable needs to be adjusted (mechanical engine) or the helm config needs to be performed (DTS engine).
   - **DemandLinear_with_Guardian** - software controlled limit with any engine protection/Guardian limits applied. This value should also be at 100% when underway and with the handle in the full forward position. If this value is less than the **DemandLinear** value, check faults for Guardian cause and correct the issue.

- **Demand** - the final demand value requested by the software. If the engine is propped correctly, with engine speed at wide-open throttle falling within the operating range at optimum trim, this value should be at 100%.



3. Run the engine with the handle at wide-open throttle (100% **DemandLinear**) at optimum trim. Use the following chart to aid in final propeller selection.

Scenario		Engine Speed (see NOTE 1.)				
#	Description	<5,200 RPM	At or Just Above 5,200 RPM	Within Operating Range	At or Just Below 6,000 RPM	>6,000 RPM
1	DemandLinear = 100% DemandLinear with Guardian = 100% Demand = 100%	Decrease propeller pitch until engine speed falls within operating range.	Consider a slightly lower pitch propeller. (See NOTE 2.)	No change needed.	Consider a slightly higher pitch propeller. (See NOTE 3 and 4.)	N/A
2	DemandLinear = 100% DemandLinear with Guardian = 100% Demand < 100%	N/A	N/A	N/A	N/A	Increase propeller pitch until engine speed falls within operating range.
3	DemandLinear < 100% with throttle lever at max	Adjust throttle cable or reconfigure DTS handle so that 100% DemandLinear can be reached.				
4	DemandLinear = 100% DemandLinear with Guardian < 100%	Check faults for cause of Guardian condition.				

NOTE: *Refer to the following notes:*

1. *The range of 5,200–6,000 RPM is an example only. Actual RPM ranges vary by model. Refer to the applicable specifications for your particular engine model.*
2. *Lowering the pitch of the propeller will increase the engine speed above the 5,200 RPM lower threshold, to account for variations in loading and ambient conditions.*
3. *Increasing the pitch of the propeller will decrease the engine speed below the 6,000 RPM upper threshold, to account for variations in loading and ambient conditions.*
4. *Demand may be slightly less than 100%.*

Adaptive Speed Control (ASC) Propping without CDS G3

IMPORTANT: Boat propping can be performed using the normal method used for Mercury Outboards. To achieve optimum propeller selection, however, follow the Adaptive Speed Control (ASC) Propping with CDS G3 procedure.

IMPORTANT: To operate the engine at full throttle before the break-in period is complete, follow this procedure.

1. Place the remote control in neutral, idle speed and start engine.
2. Slowly advance the throttle until the engine reaches 1300 RPM (± 100 RPM).
3. Watch all gauges for normal readings.
4. When the engine reaches normal operating temperature, run the boat up on plane.
5. Advance the engine RPM (in 200 RPM increments) until the engine reaches its maximum rated RPM. Refer to the appropriate outboard owner's manual or service manual for the engines full throttle RPM range.
6. To test if the correct propeller has been installed, operate the boat (with normal load on board) at WOT and check RPM with an accurate tachometer. The engine RPM should be near the top of the specified range so that, under a heavy load, the engine speed will not fall below specifications. If the engine speed is too high, replace the propeller with a higher pitch propeller. Normally a 25 mm (1 in.) propeller pitch change causes an RPM change of 150 RPM.

7. Return to idle speed.
8. Shut off the engine.

System Wiring Installation Checklist

Complete the following checks as appropriate for a mechanical (**Mech**) or Digital Throttle and Shift (**DTS**) engine:

Data/Key Switch Harness

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

Junction Box (if equipped)

Mech	DTS	Check
N/A	☐	Ensure the harness connections are fastened within 25.4 cm (10 in.) of the junction box.
N/A	☐	Verify that all unused receptacles are covered with a weather cap.

Non-Mercury Marine Supplied Ignition Key Switch

Mech	DTS	Check
☐	☐	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

Mech	DTS	Check
N/A	☐	Ensure electronic remote control (ERC) connections are completed following ERC installation instructions prior to engine operation.

DTS Command Module Harness

Mech	DTS	Check
N/A	☐	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).
N/A	☐	Verify that while moving the remote control handle (full forward and full reverse) the harness has unobstructed movement (moves freely).
N/A	☐	Verify that the lanyard stop switch is wired into the system correctly.
N/A	☐	Verify that the harness is fastened along the routing path.
N/A	☐	Verify that all unused connectors have weather caps to prevent corrosion.

Battery

Mech	DTS	Check
☐	☐	Verify that wing nuts have been replaced with hex nuts, provided. Verify that the hex nuts have been tightened to the proper torque.
☐	☐	Verify that all engine battery cables are connected to the correct terminals.
☐	☐	Verify that the clean power harness leads are connected to the starting battery and secured with locknuts.
☐	☐	Ensure the 5 amp fuse for the clean power harness is accessible.

Lanyard Stop Switch

Mech	DTS	Check
☐	☐	Verify that the switch is installed.
☐	☐	Verify that the switch is connected to the DTS command module harness or key switch harness.

Important Information

Section 1E - Storage

Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
119	Storage Seal Rust Inhibitor	Spark plug holes	92-858081K03
120	Corrosion Guard	External metal surfaces	92-802878 55
124	Quickstor Fuel Stabilizer	Fuel tank	92-8M0047932

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 Quickstor Fuel 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 Quickstor Fuel 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	Quickstor Fuel Stabilizer	Fuel tank	92-8M0047932

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 the high tension spark plug leads 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	92-858081K03

- 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 the high tension spark plug leads.

Gearcase

- Drain and refill the gearcase lubricant.

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 charging.
- Remove the battery from the boat and check water level. Charge if necessary.
- Store the battery in a cool, dry place.
- Periodically check the water level and charge the battery during storage.

Notes:

Important Information

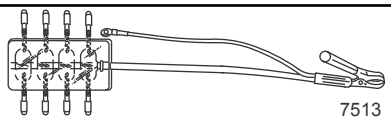
Section 1F - General Troubleshooting

Table of Contents

Lubricant, Sealant, Adhesives

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

Special Tools

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

Troubleshooting without the Computer Diagnostic System (CDS G3)

Troubleshooting without the computer diagnostic system (CDS G3) is limited to checking resistance on some of the sensors.

Typical failures do not involve the propulsion control module (PCM). Faulty connectors, improper setup, and mechanical wear are more likely to be the cause of failure.

- Verify that the spark plug wires are securely installed onto the ignition coils and the spark plugs.
- Verify that the correct spark plugs are 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 CDS G3 to view the PCM fault history when troubleshooting and repair is completed.

- If all cylinders exhibit similar symptoms, the problem is with a sensor or harness input to the PCM.
- If a problem is speed related or intermittent, it is probably connector or contact related. Inspect connectors for corrosion, loose wires, or pins pushed back into the connector. Verify the connectors are properly seated.
- Inspect the harness for damage, including pinched or cut wires and chafing.
- Secure the ground connections 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 the connector.
- Check the fuel pump pressure.

Troubleshooting with the Computer Diagnostic System (CDS G3)

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

About CDS G3

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

While the engine is operating, the PCM records various data, including the state of engine sensors. The recorded information can be reviewed with CDS G3, to help diagnose intermittent engine problems. Refer to the documentation included within the CDS G3 program, for additional details.

Additional Information

For additional information about the CDS G3 diagnostic tool, refer to the documentation within the tool and to the **Diagnostic Manual**.

Troubleshooting Guide

Spark Gap Tester	91-850439T 1

IMPORTANT: This is a quick troubleshooting guide, only. For complete troubleshooting information, refer to the Diagnostics Manual.

1. Engine Will Not Crank

	Cause	Action
1.1	Lanyard stop switch is in the wrong position	Reset the lanyard stop switch.
1.2	Open start circuit fuse	Check for an open 20-amp fuse.
1.3	Defective main power relay	Test the relay for proper operation; replace if defective.
1.4	Clean power fuse open	Check for an open clean power fuse.
1.5	Low battery voltage	Check battery voltage.

2. Engine Cranks, But Will Not Start

	Cause	Action
2.1	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 the battery. Inspect the condition of starter motor. Check the condition of the battery terminals and cables.
2.2	No fuel	Key-on the engine to verify that the fuel pump runs for 3 seconds. If the pump is not heard running, inspect the fuel pump fuse as well as the fuel pump relay and its mating electrical connector. **IMPORTANT: Running the fuel pump for up to 180 seconds due to lack of fuel will damage the fuel pump.**
2.3	Low fuel pressure	Measure the fuel pressure at the Schrader valve on top of the fuel rail. Fuel pressure at engine key-up should be between 340–370 kPa (49.3–53.7 psi).
2.4	Flywheel dowel not installed	Remove the flywheel and inspect.
2.5	Open fuse	Inspect the 20-amp fuse in fuse holder and replace if open.
2.6	Main power relay not functioning	Listen for the relay to click when the key switch is turned on. If the relay does not click, inspect the harness and connector pins for damage.
2.7	Spark plugs (see NOTE)	1. Remove the fuel pump fuse. 2. Remove the spark plugs from each cylinder. 3. Connect the spark gap tester to each ignition coil (two cylinders per coil). 4. Crank the engine and observe spark. If no spark is present, replace the appropriate ignition coil. If spark is present, replace the spark plugs.
	NOTE: *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 a single pair of spark plug wires (both plugs associated with a given ignition coil) connected to the spark gap tool at a time.*	
2.8	Propulsion control module (PCM) not functioning	Fuel injection system: Listen for injector ticking when cranking or connect spare injector to each respective harness
		Ignition system: • Install spark gap tool between ignition coil and engine ground. Check for a purple/white colored spark while cranking the engine. • Check for battery voltage (red/yellow lead) at ignition coils. • Check for open 20-amp fuse. • Check for shorted stop wire (black/yellow lead).
		Power supply: Inspect and clean the remote control male and female harness connectors.
		Defective PCM

	Cause	Action
2.9	Crankshaft position sensor not functioning	Check that magnet is not missing from end of sensor. Perform a resistance check of sensor (300 to 350 ohms between red and white leads). Defective crankshaft position sensor.

3. Engine Cranks, Starts, and Stalls

	Cause	Action
3.1	Low fuel pressure in fuel rail	See 2.3
3.2	Air in fuel system/lines	Crank and start engine several times to purge.
3.3	Remote control to engine harness connection is poor	Clean and inspect male and female connections.
3.4	Defective electronic throttle	• Refer to the **Diagnostic Manual** to determine proper functioning of the electronic throttle. • Replace the throttle body assembly.
3.5	Flywheel misaligned during installation	Flywheel dowel pin is missing.
3.6	Abnormally high friction in engine	Check for scuffed piston or other sources of high friction.
3.7	MAP sensor hose is disconnected	Connect the MAP sensor hose.

4. Engine Idle Is Rough

	Cause	Action
4.1	Fouled spark plug	Replace the spark plug if: • Carbon bridges electrode gap or if it is completely black • It is not firing and is wet with fuel ***NOTE:*** *A spark plug that is gray or completely black with aluminum specks indicates a scuffed piston.*
4.2	Failed fuel injector	Refer to the **Diagnostic Manual** for resistance test.
4.3	Bad ignition coil/weak spark	Refer to the **Diagnostic Manual** for resistance test.
4.4	Flywheel misaligned during installation	Flywheel dowel pin is missing.
4.5	Engine not running on all cylinders	Inspect for mechanical damage.
4.6	Bad spark plug wire	Replace spark plug wire.

5. Engine Idles Fast (RPM Above 700) or Surges

	Cause	Action
5.1	Defective electronic throttle	• Refer to the **Diagnostic Manual** to determine proper functioning of the electronic throttle. • Replace the throttle body assembly.
5.2	Vacuum leak in the intake tract, downstream from the throttle	Inspect the throttle body isolator for tears, loose connections, or other leaks.

6. Engine Runs Rough (RPM Below 3000)

	Cause	Action
6.1	Fouled spark plug	Replace the spark plug if: • Carbon bridges electrode gap or if it is completely black • It is not firing and is wet with fuel ***NOTE:*** *A spark plug that is gray or completely black with aluminum specks indicates a scuffed piston.*
6.2	Low fuel pressure in fuel rail	Measure the fuel pressure (valve on top of the fuel rail). Fuel pressure should be 290–340 kPa (42.1–49.3 psi).
6.3	Defective electronic throttle	• Refer to the **Diagnostic Manual** to determine proper functioning of the electronic throttle. • Replace the throttle body assembly.

	Cause	Action
6.4	Bad ignition coil/weak spark	Refer to the **Diagnostic Manual** for the resistance test.
6.5	Engine not running on all cylinders	Inspect for mechanical damage.
6.6	Bad spark plug wire	Replace the spark plug wire.
6.7	Air in the fuel system	Purge air from the fuel system.
6.8	Aerated fuel	Tighten all fuel line connections.

7. Engine Runs Rough (RPM Above 3000)

	Cause	Action
7.1	Fouled spark plug	Replace the spark plug if: • Carbon bridges electrode gap or if it is completely black • It is not firing and is wet with fuel ***NOTE:*** *A spark plug that is gray or completely black with aluminum specks indicates a scuffed piston.*
7.2	Defective electronic throttle	• Refer to the **Diagnostic Manual** to determine proper functioning of the electronic throttle. • Replace the throttle body assembly.
7.3	Low fuel pressure in fuel rail	Measure the fuel pressure (valve on top of the fuel rail). Fuel pressure should be 290–340 kPa (42.1–49.3 psi)
7.4	Speed reduction	Refer to SmartCraft gauges for low oil, engine overheat, or sensor/actuator out of range. Refer to the **Diagnostic Manual** to identify proper functioning of sensors/actuator.
7.5	Defective crankshaft position sensor	Refer to the **Diagnostic Manual** for fault identification.
7.6	Fuel restriction	Inspect all fuel lines, remove primer bulb, and check filters.
7.7	Aerated fuel	Tighten all fuel line connections.

8. Speed Reduction (RPM Reduced to Idle)

	Cause	Action
8.1	Engine communication/remote control failure	Refer to the **Diagnostic Manual** for fault identification.
8.2	Sensor/actuator is out of range	Refer to the **Diagnostic Manual** for fault identification.
8.3	Low oil pressure	Check the oil dipstick for proper oil level.
8.4	Engine overheat	Check the engine cooling system for proper functioning.

9. Speed Reduction (RPM Reduced to 75%)

	Cause	Action
9.1	Sensor/actuator is out of range	Refer to the **Diagnostic Manual** for fault identification.
9.2	Low oil pressure	Check the oil dipstick for proper oil level.
9.3	Engine overheat	Check the engine cooling system for proper functioning.

Audio Warning System

IMPORTANT: The audio warning system alerts the operator that a problem has occurred. It does not protect the engine from damage.

Most faults cause the warning horn circuit to activate. How the warning horn activates depends upon the severity of the problem.

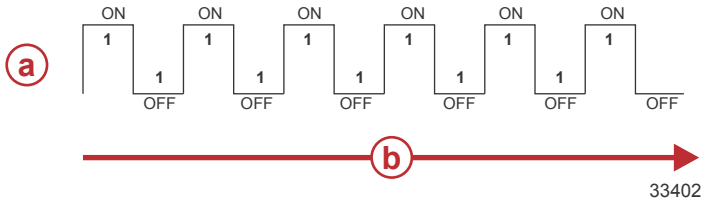
There are two warning horn states:

- Caution
- Critical

There is also an alarm that sounds if the helm has not been properly configured using the G3 service tool.

Caution

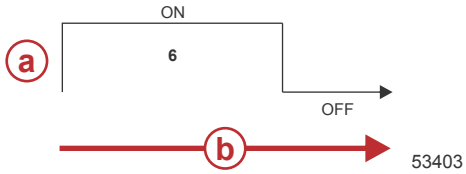
If a caution state is detected, the audio warning system will sound for six one-second intervals.



a - Horn (on or off)
b - Time (in seconds)

Critical

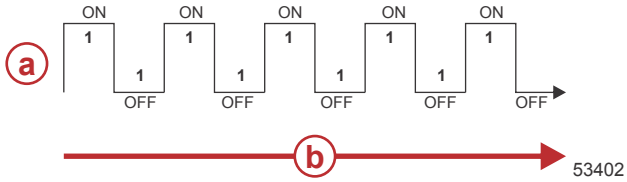
If a critical state is detected, the audio warning system sounds for six seconds and then turns off.



a - Horn (on or off)
b - Time (in seconds)

Nonconfigured Alarm

If the helm has not been properly configured using the G3 service tool, the audio warning system will sound for five one-second intervals.



a - Horn (on or off)
b - Time (in seconds)

Testing the Audio Warning System

1. Turn the key switch to the on position without cranking the engine.
2. Listen for the audio alarm. The alarm will sound if the system is functioning correctly.
   IMPORTANT: Horn strategy is dependent upon software and calibration levels.

Electrical

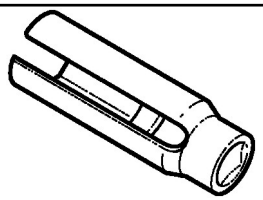
Section 2A - Ignition

Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Camshaft position sensor O-ring	8M0071842

Special Tools

Kent-Moore Oxygen Sensor Socket	J-38756
 32314	Kent-Moore socket (or equivalent 7/8 in. automotive oxygen sensor socket) Aids in the removal and installation of oxygen sensors on products equipped with Emissions Control.

Electrical Component Replacement Procedures

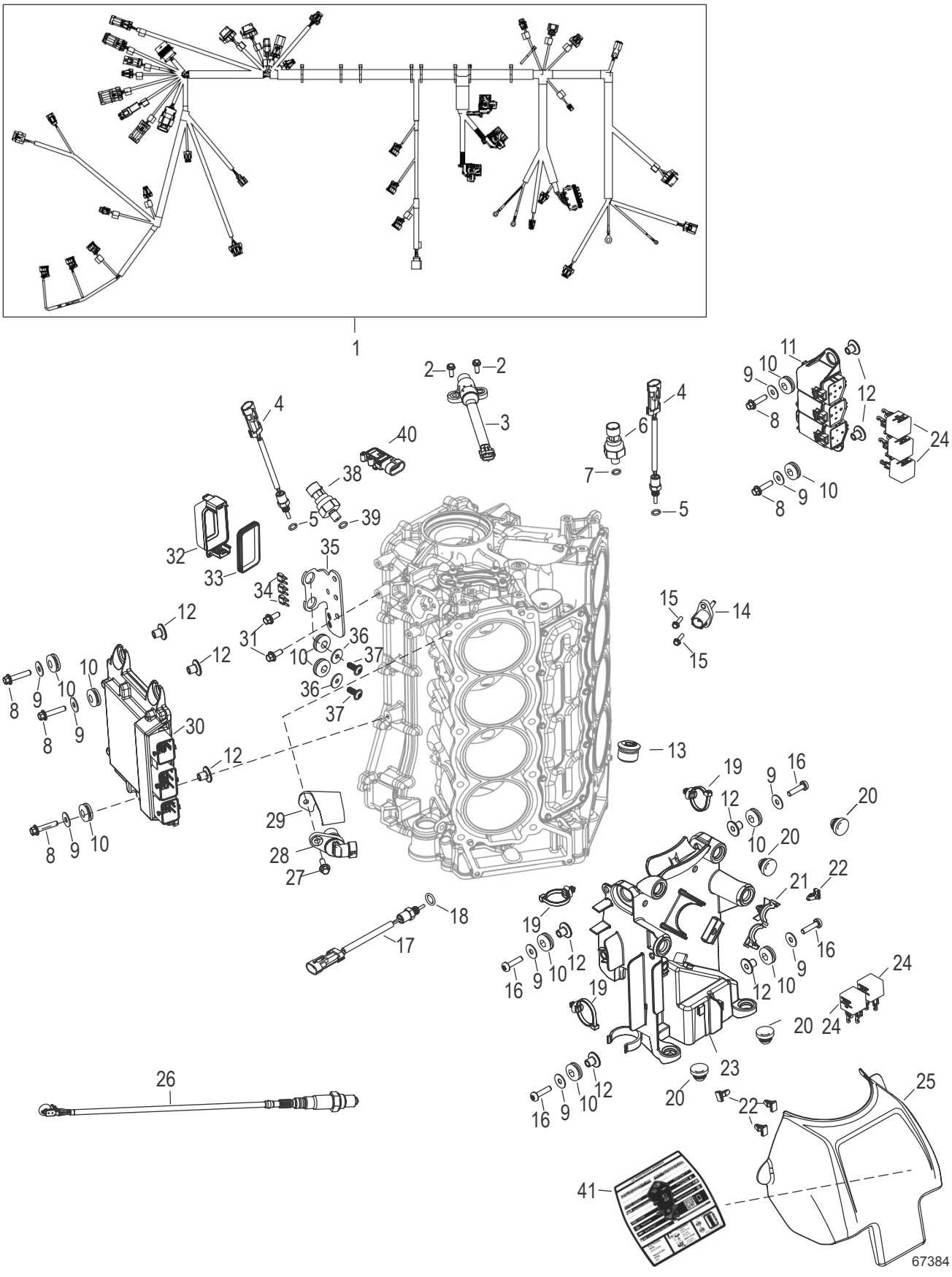
This section covers replacement procedures for the components related to the ignition system. To troubleshoot any part of the electrical system, refer to the **Diagnostics Manual**.

To replace other electrical components, refer to the appropriate section of this manual, as identified in the following chart:

To replace this component...	Refer to this section...
Alternator and belt	2B - Charging and Starting System
Block water pressure sensor	4E - Cooling
Electrical accessories	2C - Accessories
Electronic throttle body	3B - Service Procedures
Engine coolant temperature sensor	4E - Cooling
Engine harness	4A - Cylinder Block/Crankcase
Exhaust gas temperature (EGT) sensor	4E - Cooling
Fuel injectors	3B - Service Procedures
Fuel pump relay	3B - Service Procedures
Fuel supply module (FSM)	5A - Clamp/Swivel Brackets and Driveshaft Housing
Oil pressure sensor	4D - Lubrication
Oil temperature sensor	4D - Lubrication
Shift actuator	2D - Throttle and Shift
Shift demand sensor	2D - Throttle and Shift
Spark plugs	1B - Maintenance
Start relay	2B - Charging and Starting System
Starter motor	2B - Charging and Starting System
Throttle demand sensor	2D - Throttle and Shift
Trim relays	5B - Conventional Midsection (CMS) Power Trim
Water-in-fuel sensor	3B - Service Procedures

Notes:

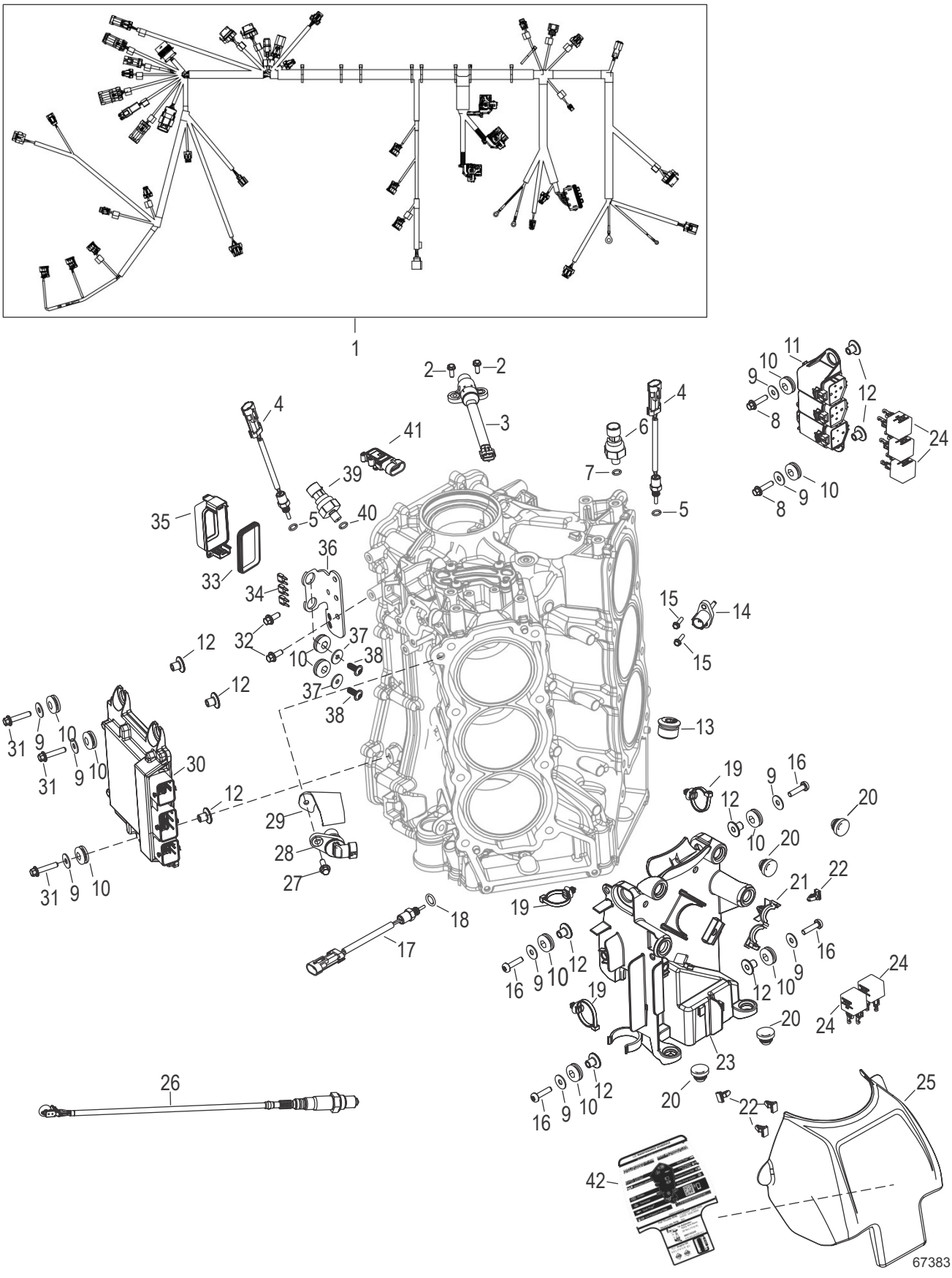
Engine Harness and Sensors - V8



Engine Harness and Sensors - V8

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Engine harness			
2	2	M5 x 13 hex washer head screw	5	44.3	–
3	1	Crankshaft position sensor			
4	2	Temperature sensor (coolant and oil)	15	132.8	–
5	2	O-ring			
6	1	Block water pressure sensor	15	132.8	–
7	1	O-ring			
8	5	M6 x 25 hex flange head screw	10	88.5	–
9	9	Washer			
10	11	Grommet			
11	1	Relay housing			
12	9	Bushing			
13	1	18 mm plug			
14	1	Manifold air temperature sensor			
15	2	M4 x 16 screw	1.7	15	–
16	4	M6 x 25 Torx® pan head screw	10	88.5	–
17	1	Exhaust gas temperature sensor	15	132.8	–
18	1	O-ring			
19	3	Cable tie and anchor			
20	4	Grommet			
21	1	Clip			
22	4	Clip			
23	1	Electrical plate			
24	5	Relay			
25	1	Electrical plate cover			
26	1	Wideband O2 sensor	18	159.3	–
27	1	M6 x 20 hex flange head screw	10	88.5	–
28	1	Camshaft position sensor			
29	1	Camshaft position sensor bracket			
30	1	Propulsion control module (PCM)			
31	2	M6 x 16 hex flange head screw	10	88.5	–
32	1	Fuse box cover			
33	1	Fuse box seal			
34	3	Spare fuse			
35	1	Fuse box bracket			
36	2	Washer			
37	2	Self-tapping screw	5	44.3	–
38	1	Oil pressure sensor	15	132.8	–
39	1	O-ring			
40	1	Manifold absolute pressure (MAP) sensor			
41	1	Maintenance decal			

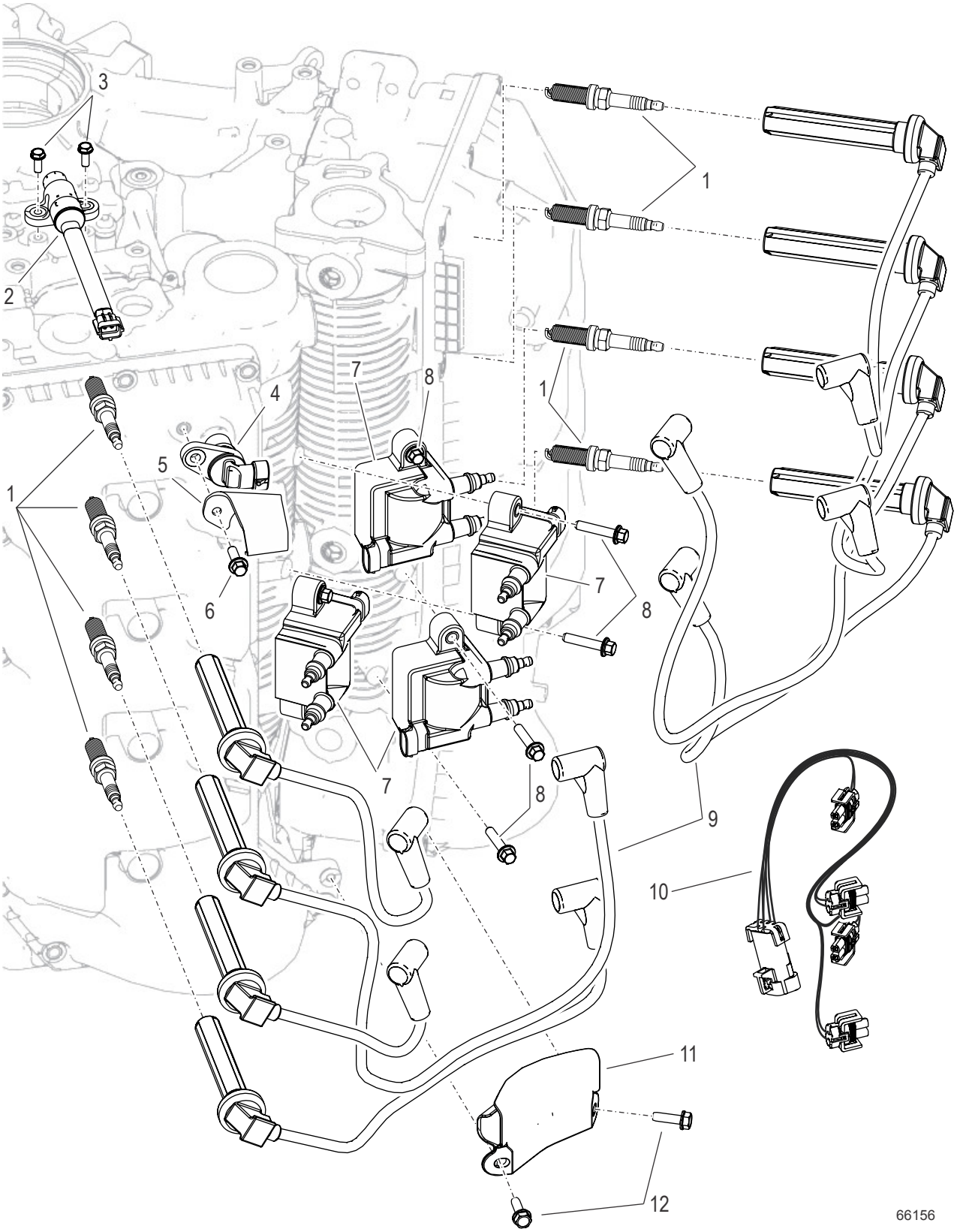
Engine Harness and Sensors - V6



Engine Harness and Sensors - V6

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Engine harness			
2	2	M5 x 13 hex washer head screw	5	44.3	–
3	1	Crankshaft position sensor			
4	2	Temperature sensor (coolant and oil)	15	132.8	–
5	2	O-ring			
6	1	Block water pressure sensor	15	132.8	–
7	1	O-ring			
8	2	M6 x 25 hex flange head screw	10	88.5	–
9	9	Washer			
10	11	Grommet			
11	1	Relay housing			
12	9	Bushing			
13	1	18 mm plug			
14	1	Manifold air temperature sensor			
15	2	M4 x 16 screw	1.7	15	–
16	4	M6 x 25 Torx® pan head screw	10	88.5	–
17	1	Exhaust gas temperature sensor	15	132.8	–
18	1	O-ring			
19	3	Cable tie and anchor			
20	4	Grommet			
21	1	Clip			
22	4	Clip			
23	1	Electrical plate			
24	5	Relay			
25	1	Electrical plate cover			
26	1	Wideband O2 sensor	18	159.3	–
27	1	M6 x 20 hex flange head screw	10	88.5	–
28	1	Camshaft position sensor			
29	1	Camshaft position sensor bracket			
30	1	Propulsion control module (PCM)			
31	3	M6 x 30 hex flange head screw	10	88.5	–
32	2	M6 x 16 hex flange head screw	10	88.5	–
33	1	Fuse box seal			
34	3	Spare fuse			
35	1	Fuse box cover			
36	1	Fuse box bracket			
37	2	Washer			
38	2	Self-tapping screw	5	44.3	–
39	1	Oil pressure sensor	15	132.8	–
40	1	O-ring			
41	1	Manifold absolute pressure (MAP) sensor			
42	1	Maintenance decal			

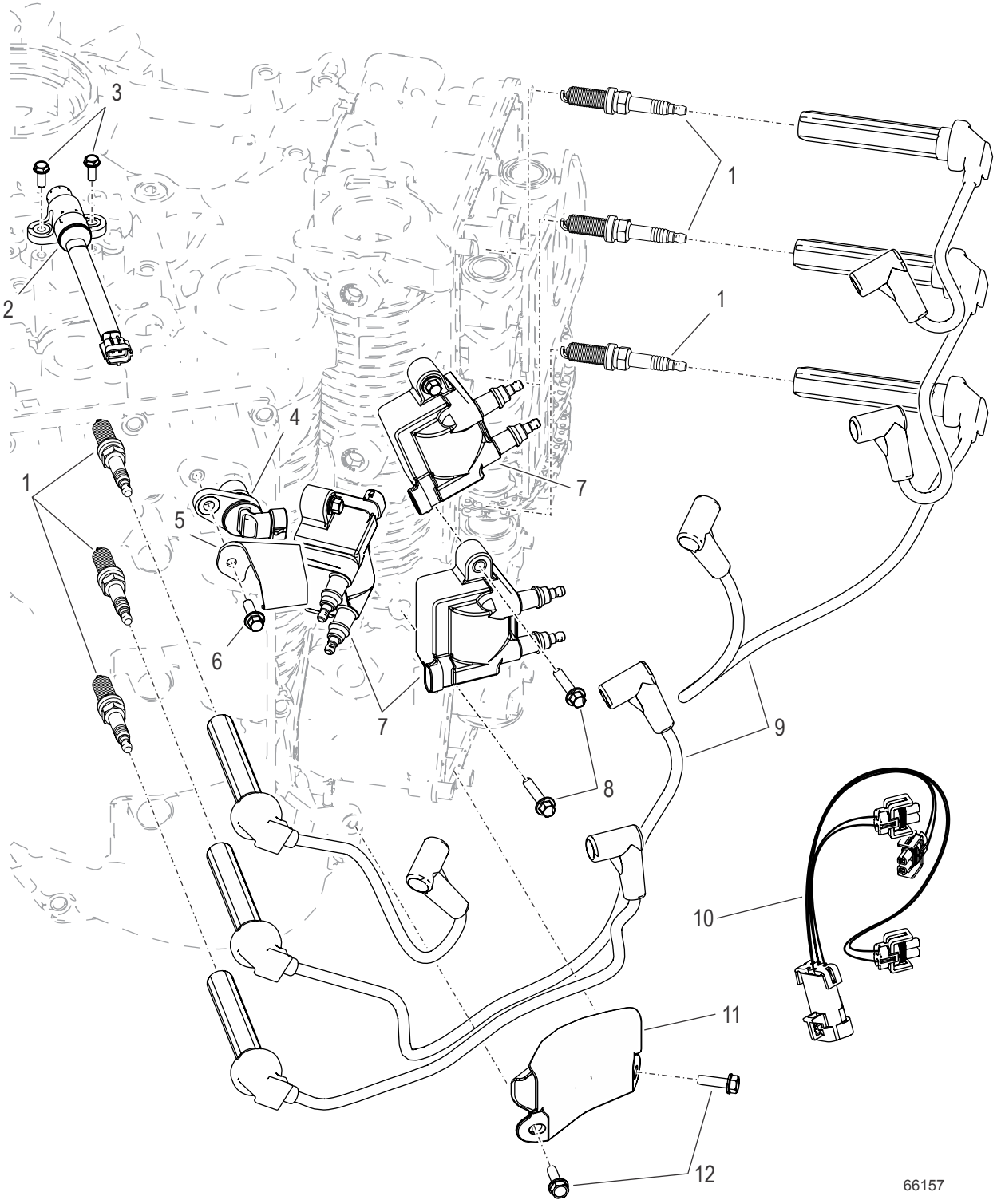
Ignition Components - V8



Ignition Components - V8

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	8	Spark plug	20.0	177	–
2	1	Crankshaft position sensor (CPS)			
3	2	M5 x 13 hex washer head screw	5.0	44.3	–
4	1	Camshaft position sensor			
5	1	Camshaft position sensor bracket			
6	1	M6 x 20 hex flange head screw	8.0	70.8	–
7	4	2-post ignition coil			
8	8	M6 x 30 hex flange head screw (2 per coil)	10.17	90	–
9	1	Set of 8 spark plug (high tension) wires			
10	1	V8 ignition coil harness			
11	1	High-tension lead tray			
12	2	M6 x 20 screw	7.0	62	–

Ignition Components - V6



Ignition Components - V6

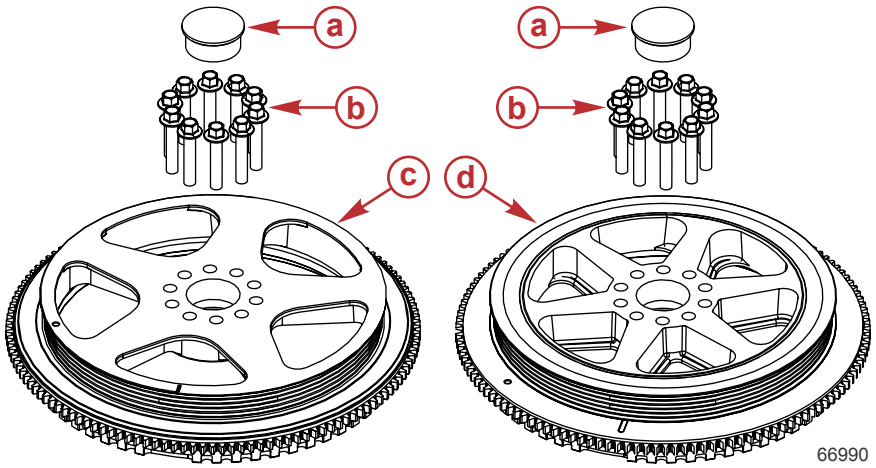
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	6	Spark plug	20.0	177	–
2	1	Crankshaft position sensor (CPS)			
3	2	M5 x 13 hex washer head screw	5.0	44.3	–
4	1	Camshaft position sensor			
5	1	Camshaft position sensor bracket			
6	1	M6 x 20 hex flange head screw	8.0	70.8	–
7	3	2-post ignition coil			
8	6	M6 x 30 hex flange head screw (2 per coil)	10.17	90	–
9	1	Set of 6 spark plug (high tension) wires			
10	1	V6 ignition coil harness			
11	1	High tension lead tray			
12	2	M6 x 20 screw	7.0	62	–

Flywheel

The flywheel is weighted and balanced to improve engine running characteristics. The flywheel is secured to the crankshaft by ten M8 x 1 x 42 mm hex flange head screws. 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 58 teeth, with a single gap (two missing teeth) to indicate position. 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 provides crankshaft location information to the PCM. The PCM uses this information to regulate ignition and fuel injector timing.

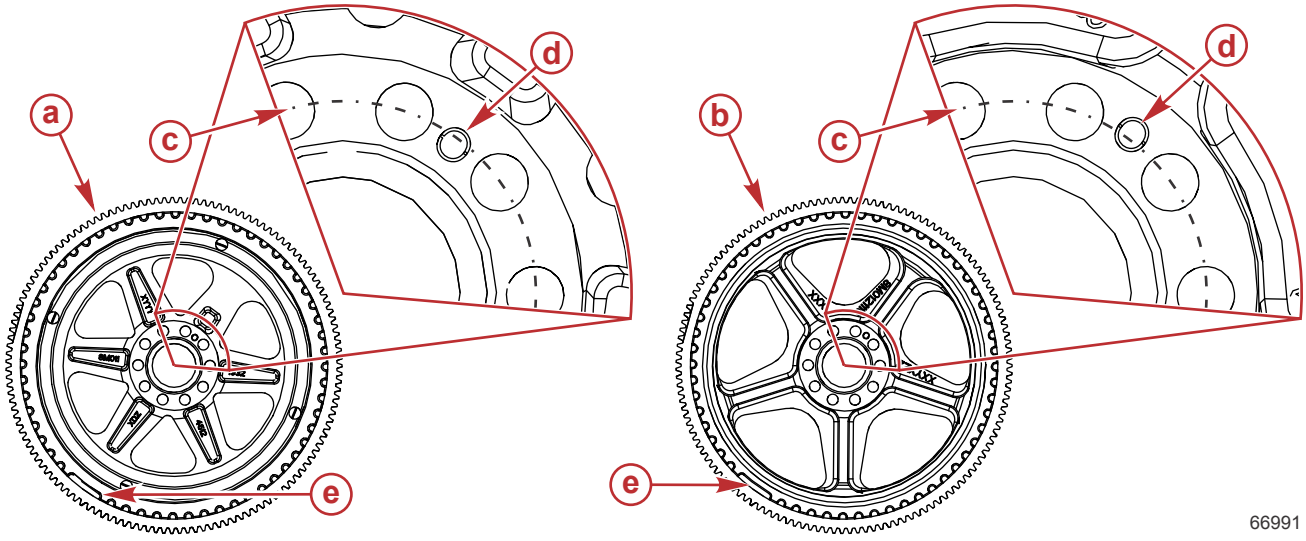
Flywheel Identification

The V6 and V8 outboards use different flywheels, as shown following.



- **a -** Flywheel plug
- **b -** M8 x 1 x 42 mm hex flange head screw (10)
- **c -** V6 flywheel
- **d -** V8 flywheel

The V8 flywheel has six spokes and incorporates a damper (greater mass). The V6 flywheel has five spokes and does not have a damper. The location of the dowel pin prevents the accidental use of the wrong flywheel.



- **a -** Underside of V8 flywheel
- **b -** Underside of V6 flywheel
- **c -** Screw hole centerline
- **d -** Dowel pin hole: closer to the hub on V8, further away on V6
- **e -** Gap in ring gear

Flywheel Removal

1. Remove the cold air intake assembly. Refer to **Section 3A - Induction System**.
   a. Remove the oil level dipstick.
   b. Loosen the hose clamp at the top of the throttle body assembly.
   c. Lift the assembly up to disengage the two pins from the grommets on the oil fill bracket.

d. Swing the assembly out of the way.

2. Remove the oil fill bracket, alternator, and alternator belt. Refer to **Section 2B - Alternator Removal**.
3. Remove the ten flywheel screws, and remove the flywheel from the crankshaft.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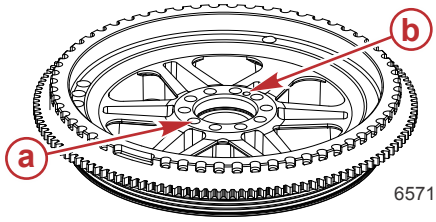
Flywheel Installation

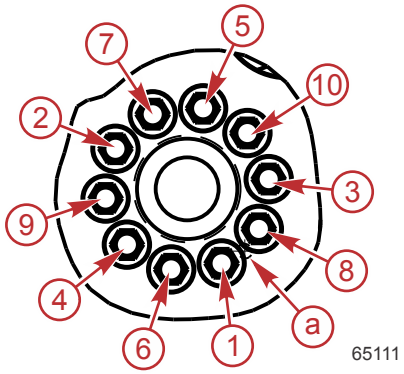
1. Align the crankshaft dowel pin with the dowel pin hole on the bottom of the flywheel. Install the flywheel onto the crankshaft.



65713

a - Flywheel mounting holes
b - Dowel pin location

2. Start the flywheel screws by hand to prevent cross-threading.
3. Starting with the screw closest to the dowel pin (furthest from the gap in the ring gear), tighten the screws to the specified torque in the sequence shown.



65111

Flywheel screw torque sequence
a - Dowel pin location (underside of flywheel, 180° opposite of gap in ring gear)

Description	Nm	lb-in.	lb-ft
Flywheel mounting screw (M8 x 1 x 42)	40	–	29.5

4. Install the alternator, alternator belt, and oil fill bracket. Refer to **Section 2B - Alternator Installation**.
5. Install the cold air intake assembly. Refer to **Section 3A - Induction System**.
   - Ensure that the reference hose is secured to the assembly with a cable tie.
   - Ensure that the hose clamp is securely tightened.
   - Ensure that the oil level dipstick is properly inserted into the dipstick tube.

Propulsion Control Module (PCM)

IMPORTANT: Refer to the Diagnostic Manual.

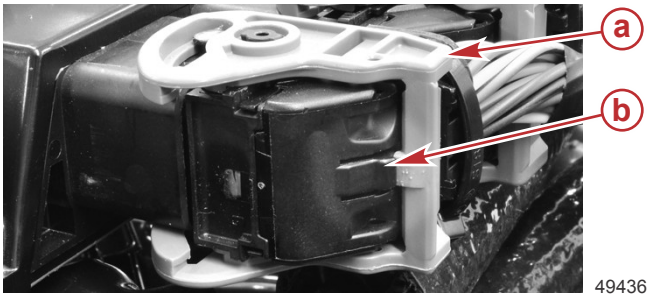
The propulsion control module requires 9.5 VDC minimum to operate. If the PCM should fail, the engine will stop running.

The PCM controls the following functions and components:

- Electronic shift control
- Electronic throttle control
- Main power relay
- Fuel injectors
- Ignition coils
- Power steering
- Trim up
- Trim down
- Start relay
- Fuel pump
- Diagnostics
- Engine Guardian
- Tachometer link (analog tachometer output or link gauge driver)
- CAN communications with helm controller
- Moving propeller (MP) alert (optional)

PCM Removal

1. Disconnect the battery.
2. Remove the port intake manifold runner assembly. Refer to **Section 3A - Intake Runners**.
3. Disconnect the three engine harness connectors:
   a. Push in the tab on the side of PCM connector A and rotate the locking lever 90°, or until it clicks. Remove the connector from the PCM.



49436

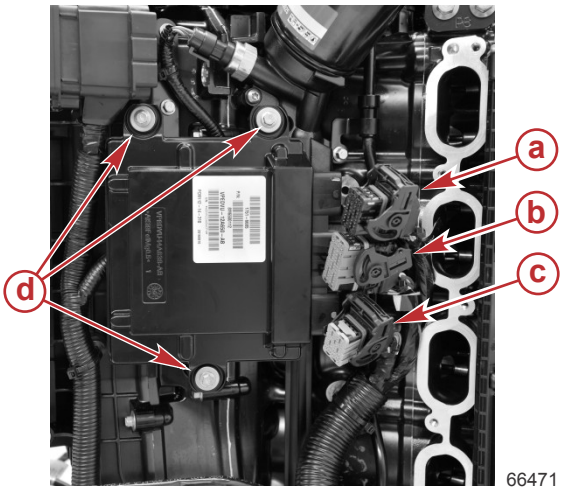
a - PCM connector locking lever
b - Locking lever tab

NOTE: *When reinstalling the connectors, you will hear two clicks: once as you engage the locking mechanism on the harness connector to the pin on the PCM connector, and a second time as you rotate the lock to a full 90° to secure the connector.*

   b. Remove connector B in the same manner.
   c. Remove connector C in the same manner.

NOTE: *When installing the PCM, attach the connectors in the reverse order: connector C first, followed by connector B, and finally, connector A.*

4. Remove the three M6 x 30 screws that secure the PCM to the engine, and remove the PCM.



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a - Connector A
b - Connector B
c - Connector C
d - M6 x 30 screws (3)

PCM Installation

NOTE: *Refer to the illustrations in* ***PCM Removal****, as required.*

1. Ensure that the bushings and grommets are in place on the PCM.
2. Install the PCM onto the engine with three M6 x 30 screws and washers. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M6 x 30 screws	5	44.3	–

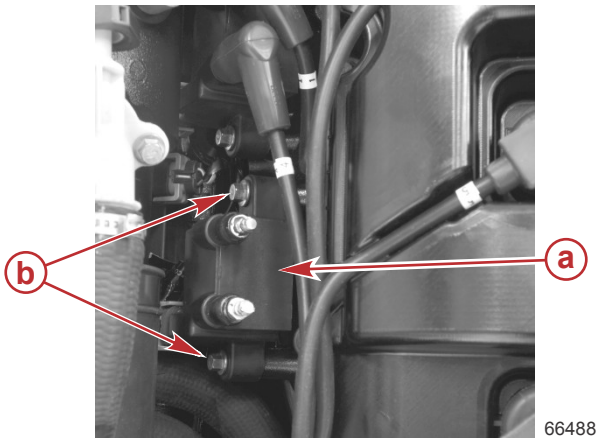
3. Connect and lock the electrical connectors to the PCM. Do not touch the connector pins.
4. Install the port intake manifold runner assembly. Refer to **Section 3A - Intake Runners**.

Ignition Coil Removal and Installation

IMPORTANT: The ignition coils can be removed and installed without removing any other components. A ratcheting wrench simplifies removal and installation.

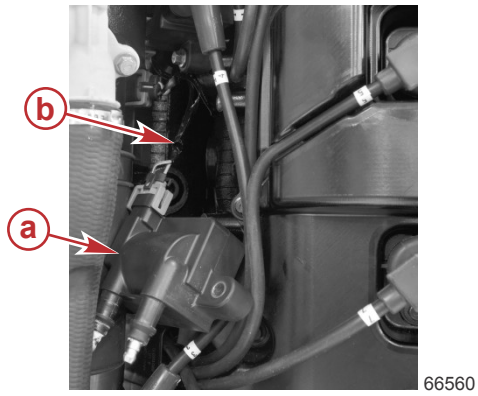
Removal

1. Disconnect the spark plug leads from the coil. Be certain to mark the cylinder numbers on the ignition coils or another suitable location, to aid in reinstallation.
2. Completely loosen the two M6 x 30 hex flange head screws that secure the coil, and carefully slide the coil from its position on the engine.



Typical
a - Ignition coil with spark plug leads removed
b - M6 x 30 hex flange head screws (2)

3. Disconnect the coil from the coil harness.



Typical
a - Ignition coil
b - Coil harness

Installation

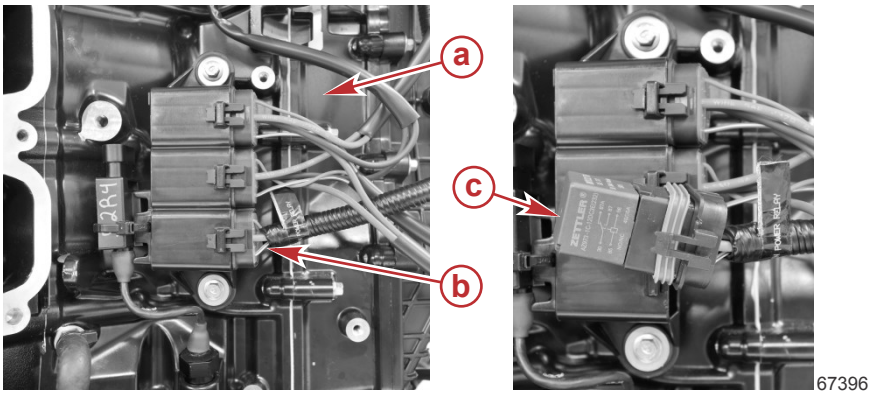
1. Connect the coil to the coil harness.
2. Slide the coil into position.
3. Insert the two M6 x 30 hex flange head screws into the slots in the coil. It may be necessary to move the coil slightly out of position to allow enough access for the screws.
4. Start the two screws by hand, and then tighten them to the specified torque.

Description	Nm	lb-in.	lb-ft
M6 x 30 hex flange head screw	10.17	90	–

5. Connect the coil to the corresponding spark plugs, using the appropriate spark plug leads.

Main Power Relay (MPR)

The main power relay (MPR) is located behind the starboard intake runner. To remove and install the starboard intake runner, refer to **Section 3A - Intake Runners**.



a - Starboard side of powerhead, intake runner removed
b - MPR socket on the engine harness
c - MPR

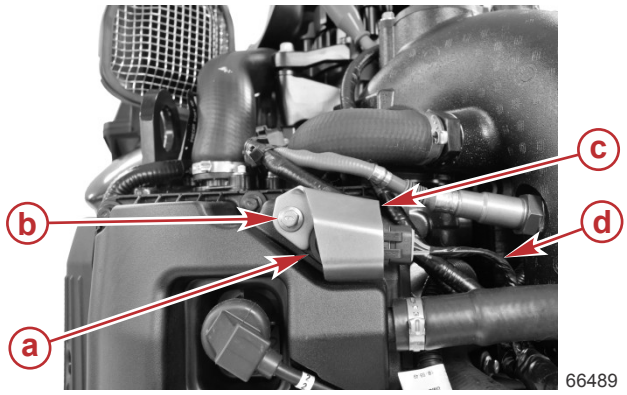
Sensor Replacement Procedures

Camshaft Position Sensor

The camshaft position sensor is located at the top of the port valve cover.

Camshaft Position Sensor Removal

1. Disconnect the sensor from the engine harness.
2. Remove the M6 x 20 screw securing the camshaft position sensor, and remove the sensor and sensor bracket.



a - Camshaft position sensor
b - M6 x 20 screw
c - Sensor bracket
d - Engine harness

Camshaft Position Sensor Installation

1. Apply Extreme Grease to the sensor O-ring.

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Camshaft position sensor O-ring	8M0071842

2. Install the sensor into the valve cover.
3. Place the bracket over the sensor, and secure both items with an M6 x 20 screw.
4. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
M6 x 20 screw	8	70.8	–

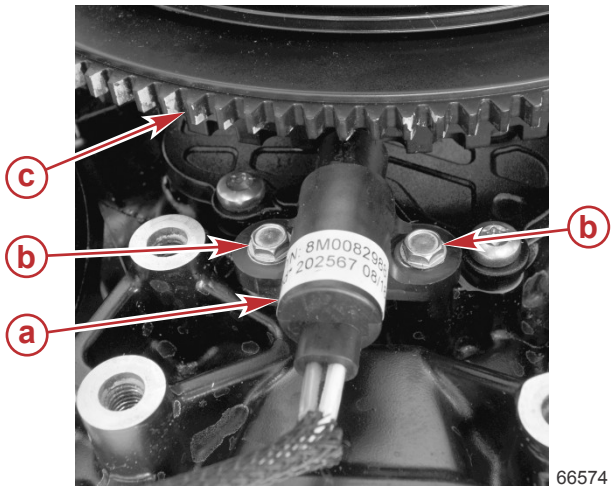
5. Connect the engine harness to the sensor.

Crankshaft Position Sensor (CPS)

The crankshaft position sensor (CPS) is located at the top of the cylinder block next to the flywheel. If the crankshaft position sensor fails, the engine will run rough or stop running.

Crankshaft Position Sensor Removal

1. Remove the cold air intake assembly. Refer to **Section 3A - Induction System**.
   a. Remove the oil level dipstick.
   b. Loosen the hose clamp at the top of the throttle body assembly.
   c. Lift the assembly up to disengage the two pins from the grommets on the oil fill bracket.
   d. Swing the assembly out of the way.
2. Remove the oil fill bracket, alternator, and alternator belt. Refer to **Section 2B - Alternator Removal**.
3. Disconnect the sensor from the engine harness.
4. Remove the two M5 x 13 hex washer head screws securing the sensor, and remove the sensor.



a - Crankshaft position sensor
b - M5 x 13 hex washer head screws (2)
c - Flywheel

Crankshaft Position Sensor Installation

1. Position the sensor on the engine, and secure the sensor with two M5 x 13 hex washer head screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M5 x 13 hex washer head screw	5	44.3	–

2. Connect the sensor to the engine harness.
3. Install the alternator, alternator belt, and oil fill bracket. Refer to **Section 2B - Alternator Installation**.
4. Install the cold air intake assembly. Refer to **Section 3A - Induction System**.
   - Ensure that the reference hose is secured to the assembly with a cable tie.
   - Ensure that the hose clamp is securely tightened.
   - Ensure that the oil level dipstick is properly inserted into the dipstick tube.

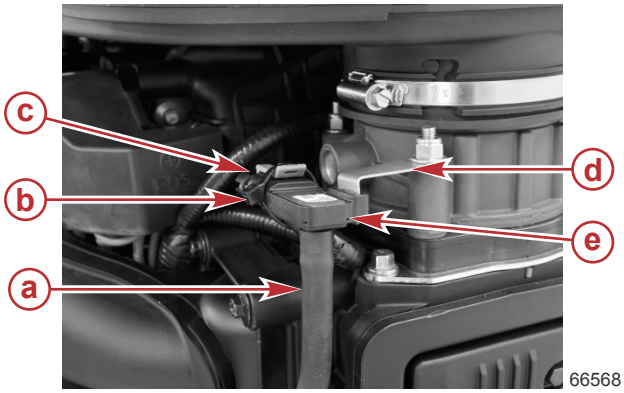
Manifold Absolute Pressure (MAP) Sensor

The MAP sensor is located at the top of the intake manifold.

Manifold Absolute Pressure (MAP) Sensor Removal

1. Cut the cable tie, and disconnect the engine harness connector.
2. Disconnect the hose from the sensor.

3. Remove the sensor from the bracket.



a - Sensor hose
b - Cable tie
c - Engine harness connector
d - Sensor bracket
e - MAP sensor

Manifold Absolute Pressure (MAP) Sensor Installation

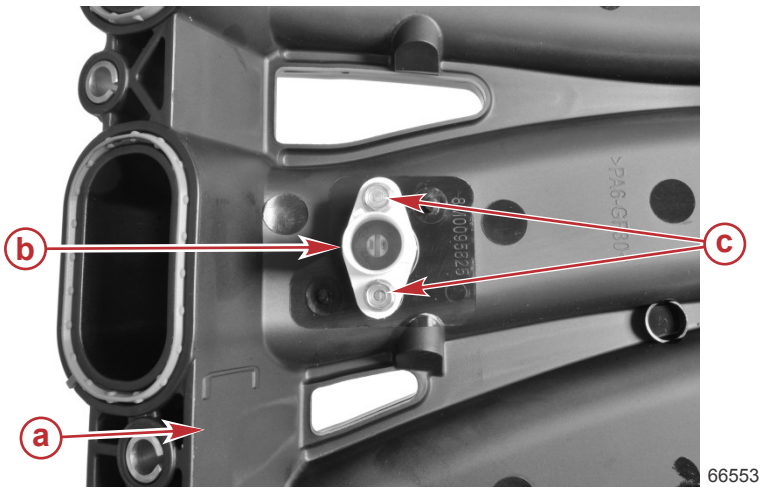
1. Install the sensor onto the bracket.
2. Connect the hose to the sensor.
3. Connect the engine harness connector to the sensor.
4. Secure the harness connection with a cable tie.

Manifold Air Temperature (MAT) Sensor

The MAT sensor is located in the middle of the starboard intake manifold close to the fuel rail.

Manifold Air Temperature (MAT) Sensor Removal

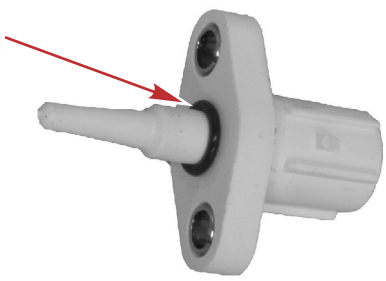
1. Remove the starboard air intake runner. Refer to **Section 3A - Intake Runners**.
2. Disconnect the engine harness from the MAT sensor.
3. Remove two M4 x 16 screws securing the sensor and remove the sensor.



a - Starboard air intake runner
b - MAT sensor
c - M4 x 16 screws (2)

Manifold Air Temperature (MAT) Sensor Installation

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



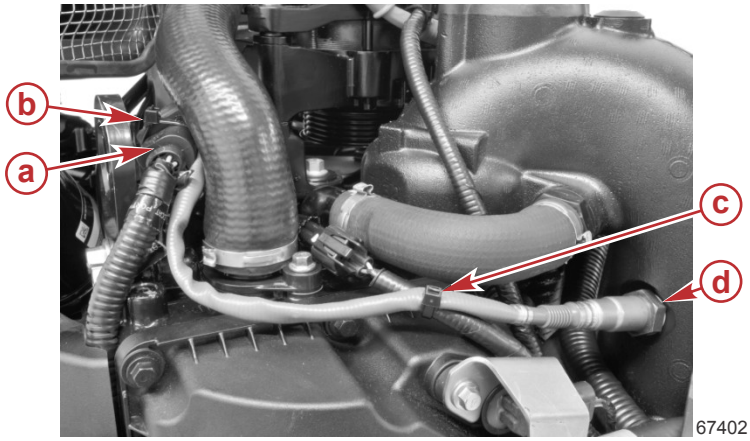
2. Install the sensor into the starboard intake runner. Tighten the M4 x 16 screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M4 x 16 screw	1.7	15	–

3. Connect the engine harness to the sensor.
4. Install the starboard air intake runner. Refer to **Section 3A - Intake Runners**.

Oxygen (O2) Sensor

The oxygen (O2) sensor is located at the top of the engine, in the port side of the exhaust tube.



- **a -** O2 sensor connector on the engine harness
- **b -** Cable tie securing the O2 sensor harness to the connector
- **c -** Cable tie securing the O2 sensor harness to the crankshaft position sensor leg of the engine harness
- **d -** O2 sensor

Sensor Removal

1. Cut the cable tie that secures the O2 sensor harness to the harness connector.
2. Cut the cable tie that secures the O2 sensor harness to the crankshaft position sensor (CPS) leg of the engine harness.
3. Disconnect the O2 sensor harness from the engine harness.
4. Remove the O2 sensor from the exhaust tube.

Kent-Moore Oxygen Sensor Socket	J-38756

Sensor Installation

1. Ensure that the O2 sensor O-ring is installed on the sensor and is in good condition.
2. Carefully thread the O2 sensor into the exhaust tube, and tighten to the specified torque.

Kent-Moore Oxygen Sensor Socket	J-38756

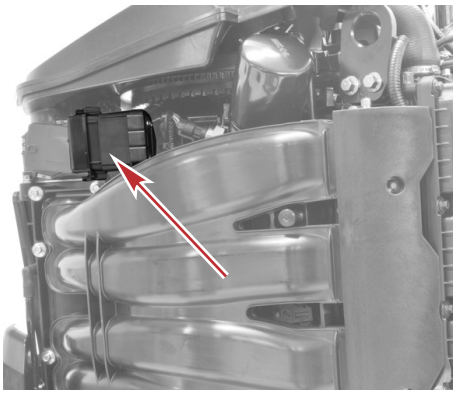
Description	Nm	lb-in.	lb-ft
O2 sensor	18	159.3	–

3. Connect the O2 sensor harness to the engine harness. Route the harness as shown in the preceding illustration.
4. Secure the O2 sensor harness to the connector with a cable tie.
5. Secure the O2 sensor harness to the CPS leg of the engine harness with a cable tie.

Fuses

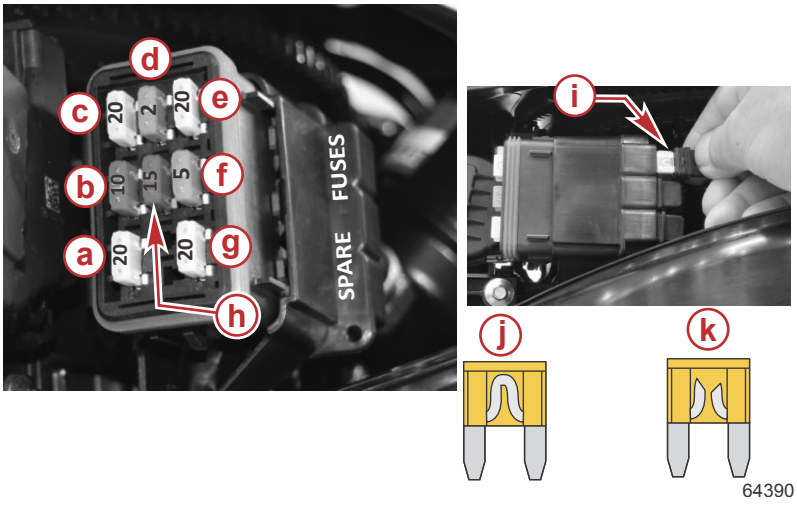
Fuses protect the electrical circuits on the outboard from overload. If a fuse is open, try to locate and correct the cause of the overload. If the cause is not found, the fuse may open again.

1. Remove the top cowl. Locate the fuse holder on the port side of the engine.



63317

2. Remove the plastic cover from the fuse holder.
3. Remove the suspected open fuse to determine if the metal band is broken.
4. If necessary, replace the fuse with a new fuse of the same amperage rating.



64390

- **a -** Ignition coils—20 amp
- **b -** Oxygen sensor—10 amp
- **c -** Fuel pump—20 amp
- **d -** Diagnostics—2 amp
- **e -** Fuel injectors—20 amp
- **f -** Advanced sound control—5 amp (not used on all models)
- **g -** Driver power—20 amp (start relay, fuel pump relay, PCM drivers)
- **h -** TVM power—15 amp (not used on all models)
- **i -** Spare fuses (3)
- **j -** Good fuse
- **k -** Open fuse

Electrical

Section 2B - Charging and Starting System

2
B

Table of Contents

Battery Specifications

Required Starting Battery

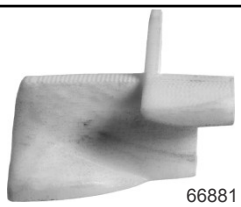
Description		Specification
Battery type		12-volt absorbed glass mat (AGM) battery
Rating	USA and Canada (SAE)	800 minimum marine cranking amps (MCA) with a minimum reserve capacity of 135 RC25 rating
	International (EN)	975 minimum cold cranking amps (CCA) with a minimum of 65 ampere hour (Ah)

For additional details, refer to **Section 1D - Battery Requirements**.

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Alternator output connection	92- 25711 3
		Starter electrical connections	
66	Loctite 242 Threadlocker	Alternator mounting screws	92-809821
		M8 x 45 hex flange head screws	
		M6 x 16 hex flange head screws	
		M8 x 80 hex flange head screws	
		M8 x 45 hex flange head screw	
		M8 x 1.25 screw	
		M6 x 13 hex washer head screw	

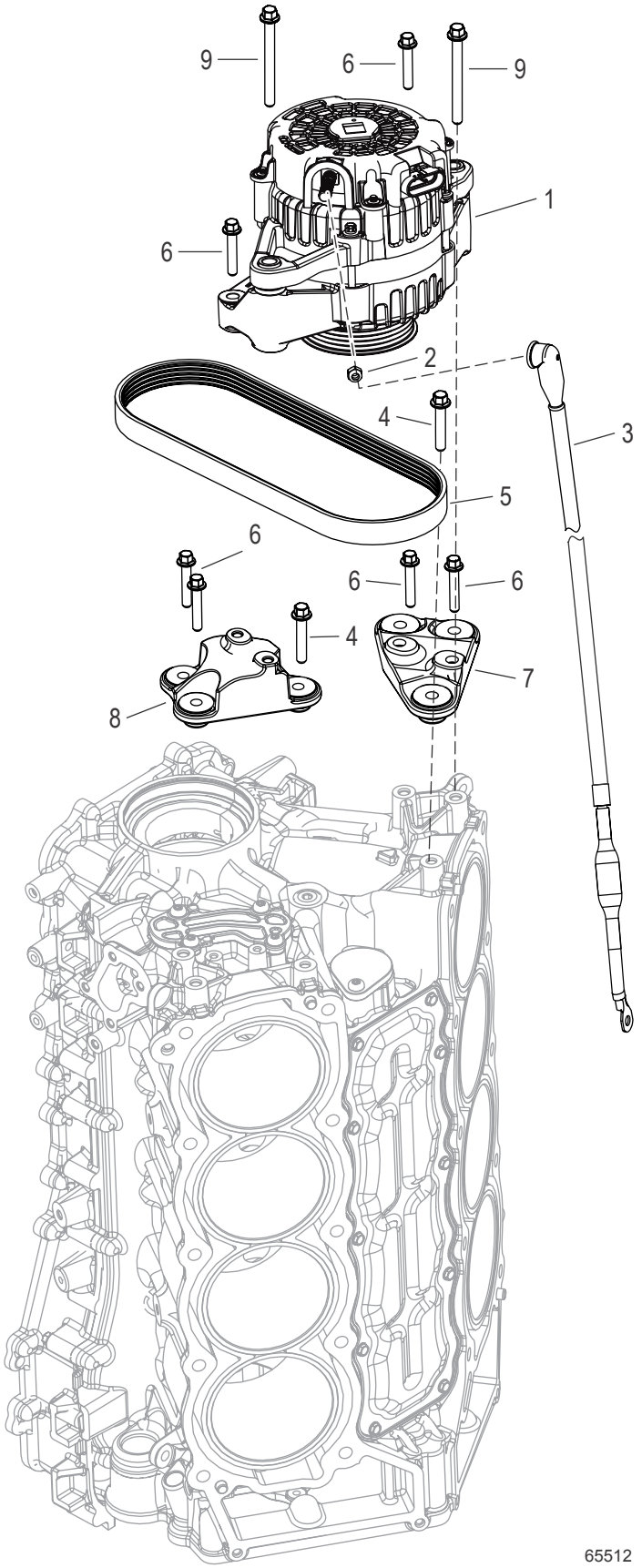
Special Tools

Alternator Belt Shoe	8M0146862
 66881	Aids in the installation and removal of the alternator belt on V6/V8 fourstroke outboards. Tool ID number 8M0140323.

Flywheel Socket	8M0146861
 66882	Aids in the manual rotation of the flywheel, especially for alternator belt removal and installation. Tool ID number 8M0144583

Notes:

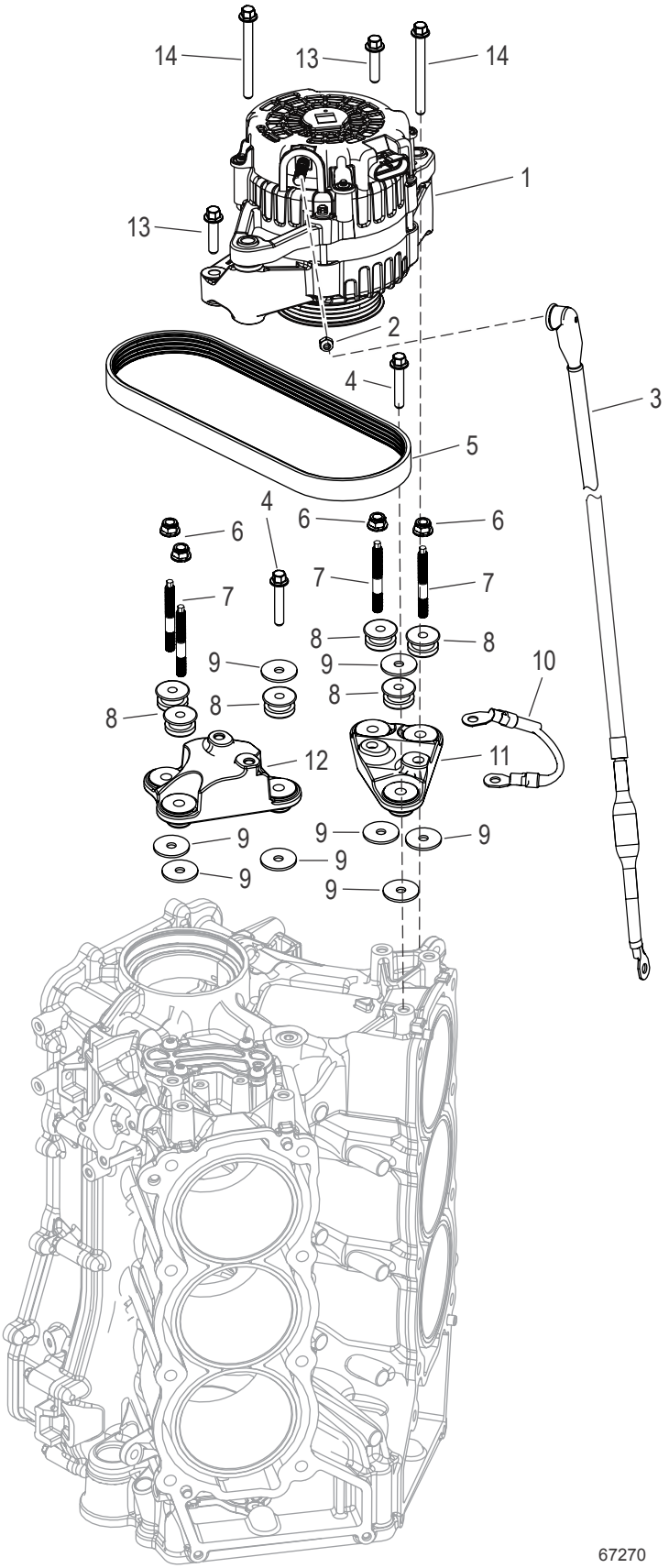
Alternator, Belt, and Mounting Components - V8



Alternator, Belt, and Mounting Components - V8

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Alternator			
2	1	M8 locknut			
3	1	Cable with 150 A fusible link			
4	2	M8 hex flange head screw	30	–	22.1
5	1	Belt			
6	6	M8 x 45 hex flange head screw	30	–	22.1
7	1	Starboard alternator bracket			
8	1	Port alternator bracket			
9	2	M8 x 85 hex flange head screw	30	–	22.1

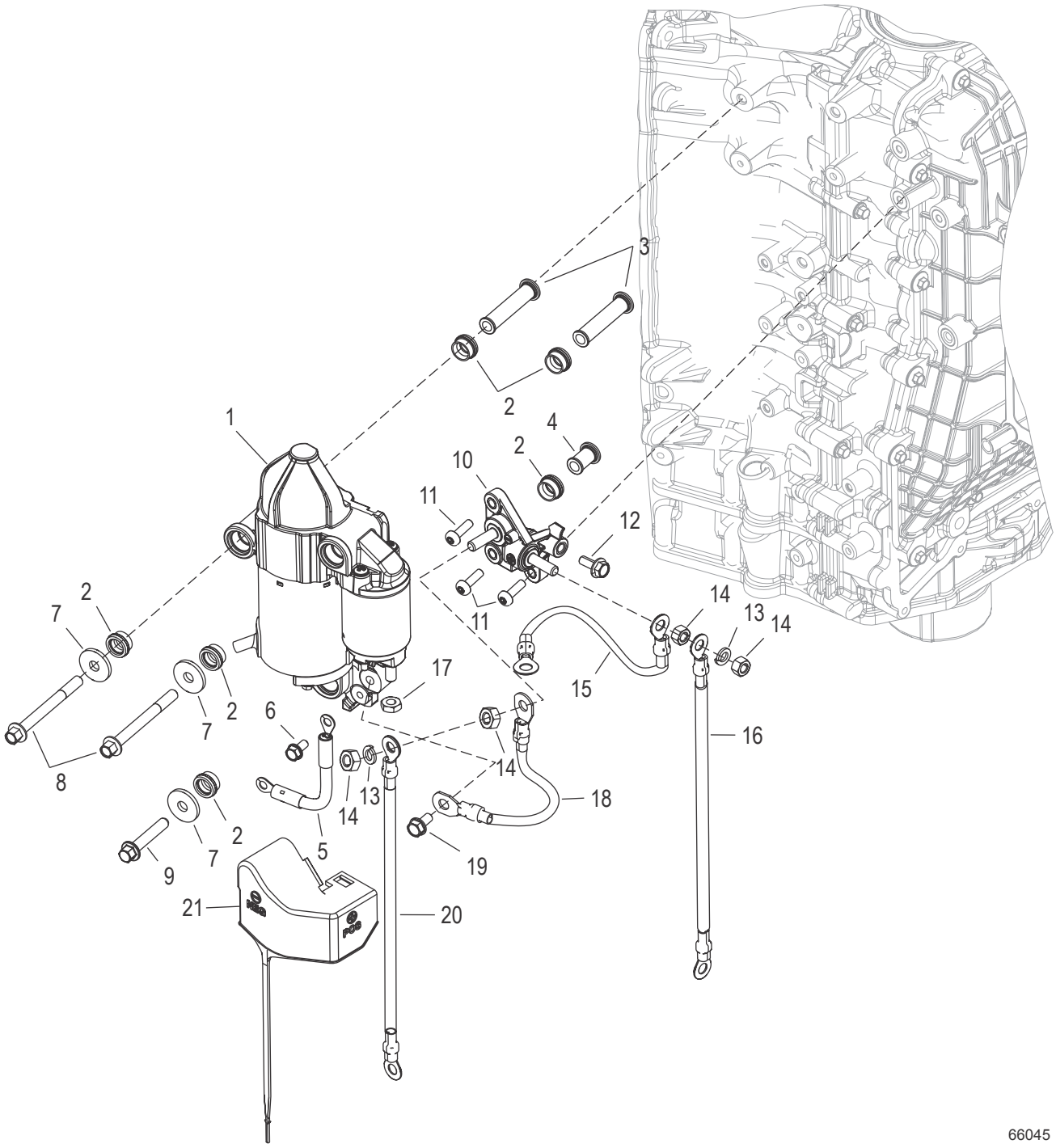
Alternator, Belt, and Mounting Components - V6



Alternator, Belt, and Mounting Components - V6

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Alternator			
2	1	M8 locknut			
3	1	Cable with 150 A fusible link			
4	2	M8 x 45 hex flange head screw	30	–	22.1
5	1	Belt			
6	4	M8 x 1.25 locknut	28	–	20.65
7	4	M8 x 1.25 x 71.5 stud			
8	6	Mount			
9	8	Washer			
10	1	Ground continuity cable			
11	1	Starboard alternator bracket			
12	1	Port alternator bracket			
13	2	M8 x 45 hex flange head screw	30	–	22.1
14	2	M8 x 85 hex flange head screw	30	–	22.1

Starter Motor and Hot Stud Components



Starter Motor and Hot Stud Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Isolation mount starter motor			
2	6	8 mm tubular mount			
3	2	Long spacer			
4	1	Short spacer			
5	1	Starter ground jumper cable			
6	1	M6 x 13 hex washer head stainless steel screw	11.3	100	–
7	3	Washer			
8	2	M8 x 80 hex flange head screw	24	–	17.7
9	1	M8 x 45 hex flange head screw	24	–	17.7
10	1	Battery cable stud bracket			
11	3	M6 x 20 Torx® pan head screw	10	88.5	–
12	1	8 mm screw	17	150.5	–
13	2	Lockwasher			
14	4	M8 x 1.25 hex nut	17	150.5	–
15	1	Starter positive lead			
16	1	Positive battery cable			
17	1	M8 x 1.25 hex nut	17	150.5	–
18	1	Starter ground (negative) lead			
19	1	M8 x 1.25 screw	17	150.5	–
20	1	Negative battery cable			
21	1	Hot stud cover			

Battery

For battery requirements, refer to **Section 1D - Battery Requirements**. The following topics are covered therein:

- Battery Cables
- Battery Switches
- Battery Isolation
- Engine Battery Specifications

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.

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.

Charging System

Charging System Precautions

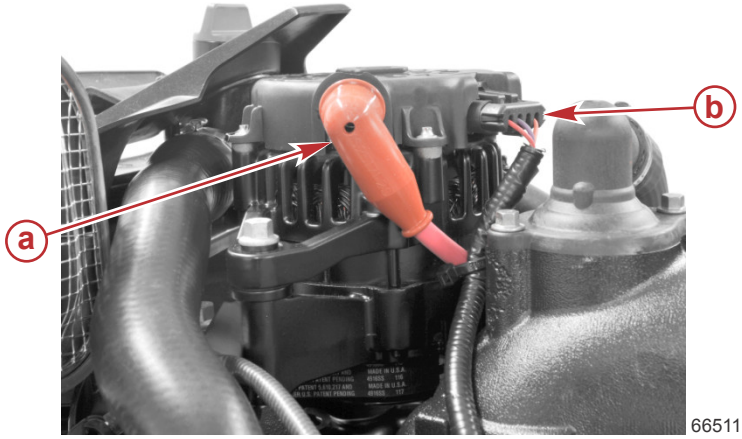
Observe the following precautions when working on the charging system. Failure to observe these precautions may result in serious damage to the charging system.

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, engine 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 charging system.
5. When installing the battery, be sure to connect the negative (–) 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 melt 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).

Charging System Inspection

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

   IMPORTANT: The alternator output lead (black with red sleeve) connection must be tight. A darkened red sleeve indicates the lead was loose and became hot. Verify the output lead attaching nut is tightened to the specified torque.

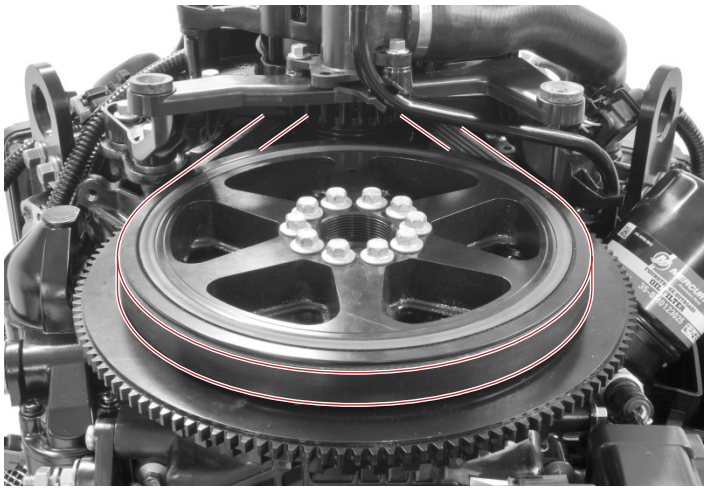


66511

a - Alternator output lead/fusible link, to hot stud
b - Alternator connection to engine harness (excitation and sense leads)

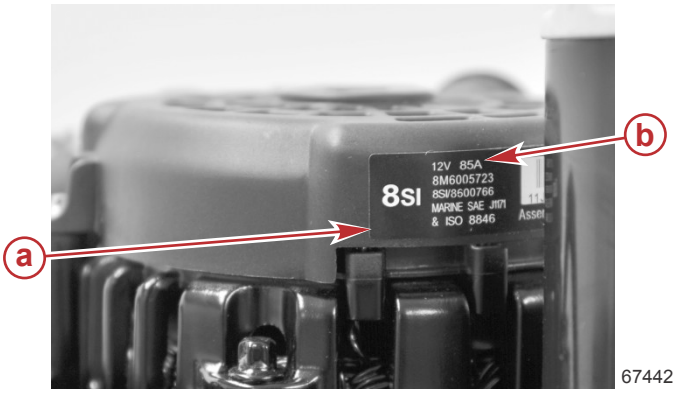
Description	Nm	lb-in.	lb-ft
Nut	7	62	–

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


66510

Alternator Identification

There are two different alternators used on the V6/V8 FourStroke engines. They are visually similar, but one has a 85-amp output rating, while the other has a 115-amp output rating. When removing an alternator, refer to the decal on the cover for its output rating, to avoid inadvertently installing an alternator with the wrong output rating.



67442

85-amp alternator shown, 115-amp alternator similar

a - Rating decal on the alternator cover

b - Output rating

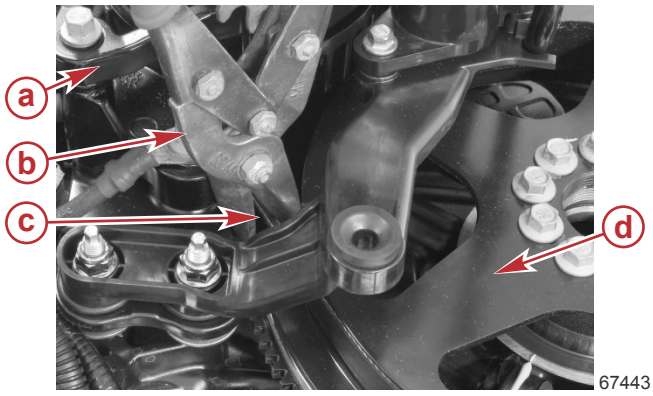
Alternator Removal

⚠ 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.

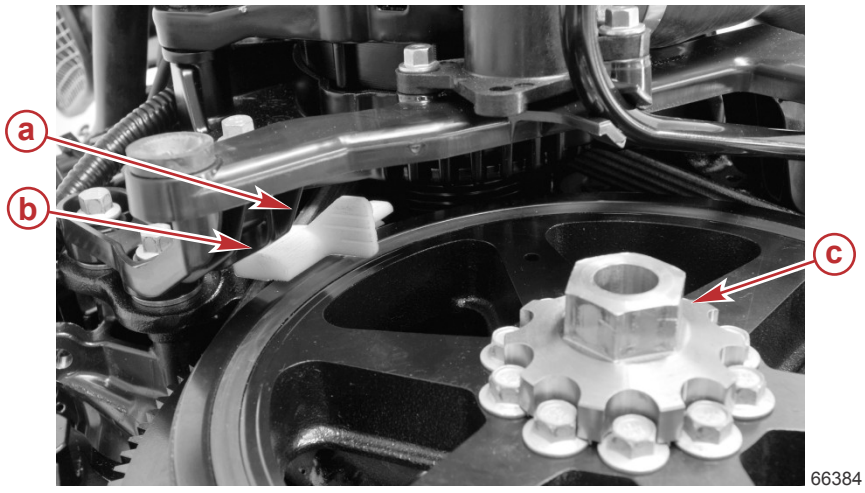
1. Disconnect the battery leads from the battery.
2. Remove the cold air intake assembly. Refer to **Section 3A - Induction System**.
   a. Remove the oil level dipstick.
   b. Loosen the hose clamp at the top of the throttle body assembly.
   c. Lift the assembly up to disengage the two pins from the grommets on the oil fill bracket.
   d. Swing the assembly out of the way.

3. If the alternator belt is to be replaced, use a pair of tin snips (or equivalent) to cut the belt free of the alternator and flywheel.



a - Alternator bracket
b - Tin snips (or equivalent)
c - Alternator belt
d - Flywheel

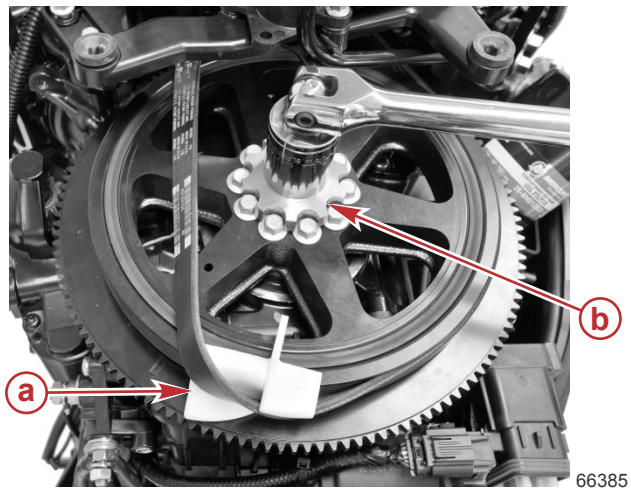
4. If the alternator belt is to be reused, use the alternator belt shoe to remove it, as follows:
   a. Position the alternator belt shoe between the flywheel and the alternator belt, as shown.



a - Alternator belt
b - Alternator belt shoe
c - Flywheel socket

Alternator Belt Shoe	8M0146862

   b. Use a breaker bar, 1-1/8 in. socket, and the flywheel socket to turn the flywheel counterclockwise until the belt comes free of the flywheel.

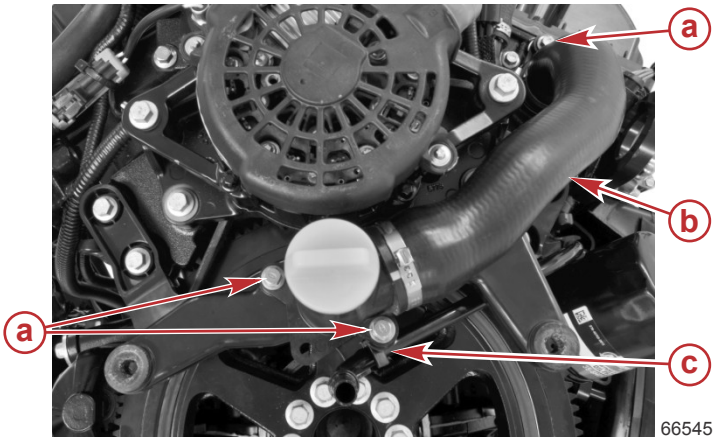


a - Alternator belt shoe
b - Flywheel socket

Flywheel Socket	8M0146861

5. Unclip the oil dipstick tube and swivel it out of the way.

6. Remove three screws to remove the oil fill hose.

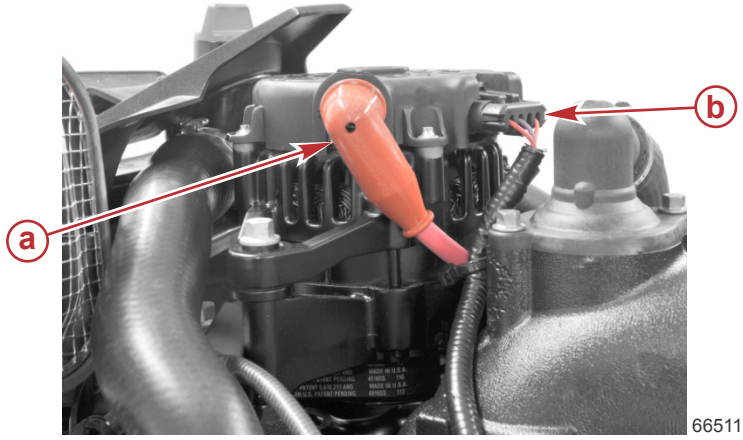


a - M6 x 16 hex flange head screws (3)
b - Oil fill hose
c - Oil dipstick tube clip

7. Remove four screws (V8) or four locknuts (V6) and remove the oil fill bracket.

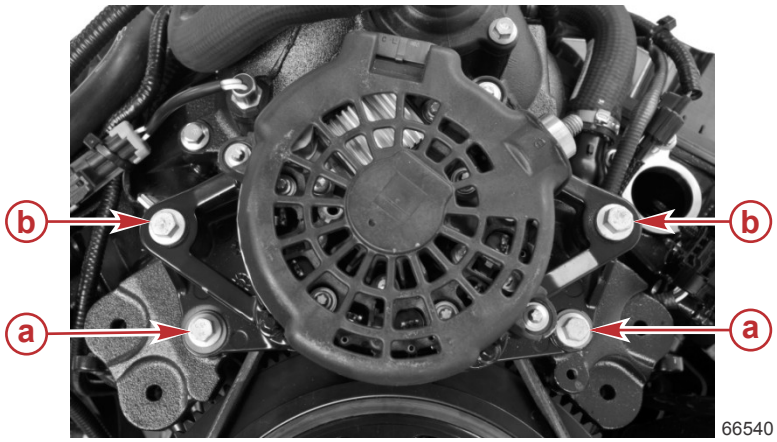
V8 shown, V6 similar
a - M8 x 45 hex flange head screws (4, V8) or M8 locknuts (4, V6)
b - Oil fill bracket

8. Disconnect the alternator output lead from the alternator.
9. Disconnect the engine harness connector from the alternator.



a - Alternator output
b - Engine harness connector

10. Remove the four screws (two M8 x 45 and two M8 x 85) securing the alternator to two brackets, and remove the alternator and alternator belt from the engine.

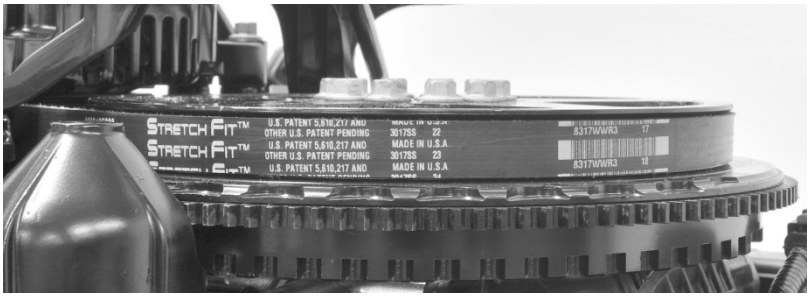


66540

a - M8 x 45 screw (2)
b - M8 x 85 screw (2)

Alternator Installation

1. Place the alternator in position, and slip the alternator belt around the alternator pulley. Ensure that the text on the belt is right-side up, as shown.

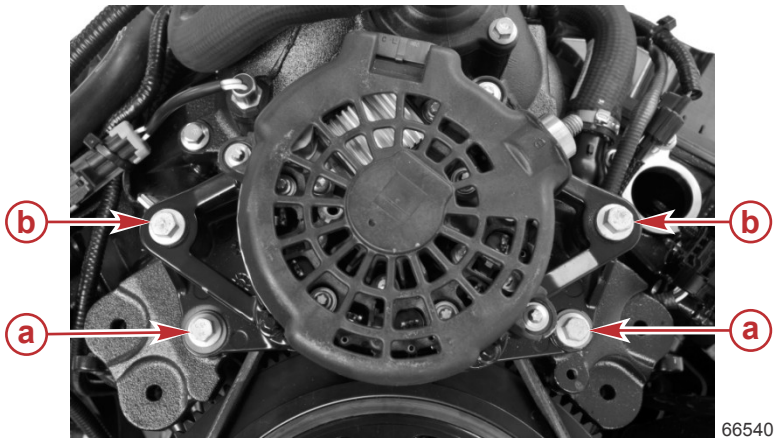


67458

Belt installed with text right-side up

IMPORTANT: There is insufficient room to install the alternator belt with the alternator fully installed. Ensure that the belt is in the proper position around the alternator pulley prior to attaching the alternator to the two brackets.

2. Apply Loctite® 242 Threadlocker to two M8 x 45 and two M8 x 85 alternator mounting screws, and attach the alternator to the two brackets.



66540

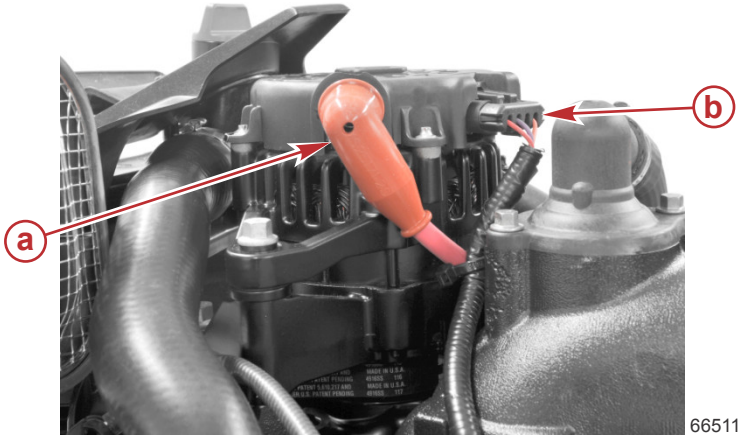
a - M8 x 45 hex flange head screws (2)
b - M8 x 85 hex flange head screws (2)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Alternator mounting screws	92-809821

3. Tighten all four alternator mounting screws to the specified torque.

Description	Nm	lb-in.	lb-ft
Alternator mounting screws	30	–	22.1

4. Connect the engine harness to the alternator.
5. Secure the alternator output lead to the alternator with a nut. Tighten the nut to the specified torque, coat the connection with Liquid Neoprene, and cover the connection with the rubber boot.



a - Rubber boot covering the alternator output lead and nut
b - Engine harness connection

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

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

6. V8 models: Apply Loctite 242 Threadlocker to four M8 x 45 hex flange head screws, and install the oil fill bracket. Tighten the screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M8 x 45 hex flange head screws	92-809821

Description	Nm	lb-in.	lb-ft
M8 x 45 hex flange head screw	30	–	22.1

7. V6 models: Install the oil fill bracket, and secure it to the alternator brackets with four M8 locknuts. Tighten the locknuts to the specified torque.

V8 shown, V6 similar
a - M8 x 45 hex flange head screws (4, V8) or M8 locknuts (4, V6)
b - Oil fill bracket

Description	Nm	lb-in.	lb-ft
M8 locknut	28	–	20.65

8. Inspect the O-ring on the oil fill hose. Replace, if necessary.

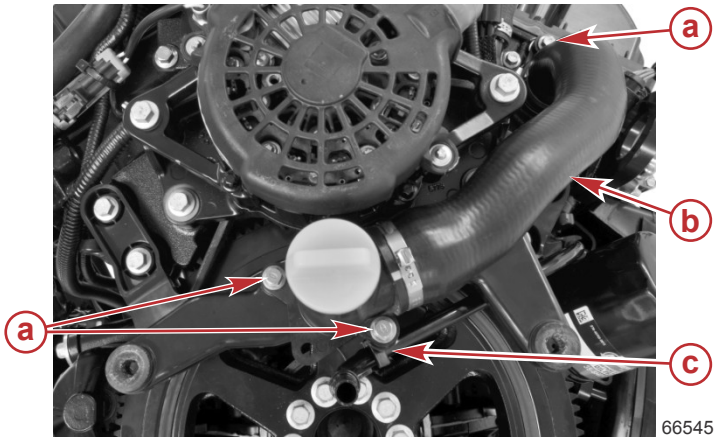
a - O-ring
b - Oil fill hose

9. Apply Loctite 242 Threadlocker to three M6 x 16 hex flange head screws, and install the oil fill hose. Tighten the screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange head screws	92-809821

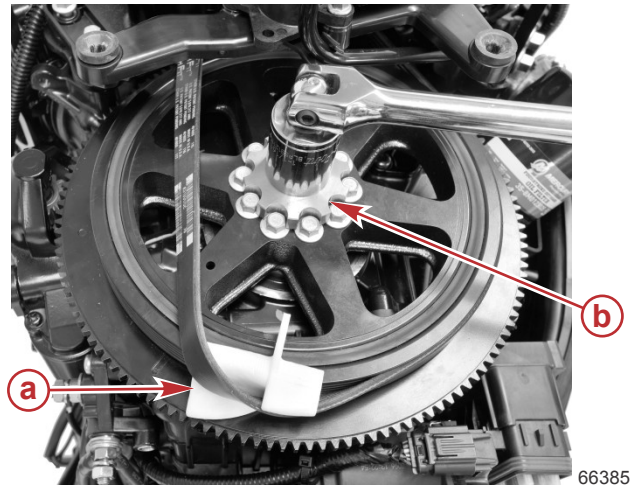
Description	Nm	lb-in.	lb-ft
M6 x 16 hex flange head screw	10	88.5	–

10. Ensure that the oil dipstick tube is still seated in its extension, and rotate the tube until it clicks into position in the clip on the oil fill bracket.



a - M6 x 16 hex flange head screws (3)
b - Oil fill hose
c - Oil dipstick tube in position in the clip on the oil fill bracket

11. Install the alternator belt onto the flywheel:
    a. Place the alternator belt partially around the flywheel, ensuring that it remains seated on the alternator pulley.
    b. Position the alternator belt shoe between the flywheel and the belt.
    c. Using a breaker bar, 1-1/8 in. socket, and the flywheel socket, turn the flywheel clockwise until the belt is fully installed.



a - Alternator belt shoe
b - Flywheel socket

Alternator Belt Shoe	8M0146862

Flywheel Socket	8M0146861

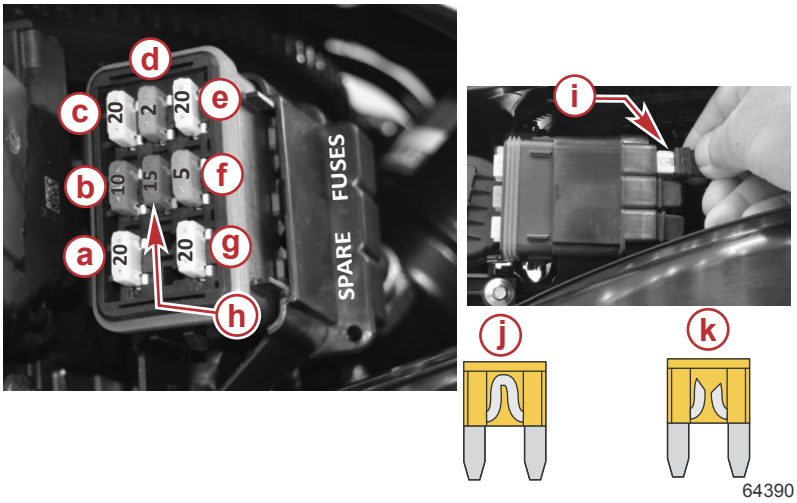
12. Install the cold air intake assembly. Refer to **Section 3A - Induction System**.
    - Ensure that the reference hose is secured to the assembly with a cable tie.
    - Ensure that the hose clamp is securely tightened.
    - Ensure that the oil level dipstick is properly inserted into the dipstick tube.

Starting System

Starting System Visual Checks

The following are quick visual checks of some starting system components. For additional procedures, refer to the **Diagnostic Manual**.

1. Inspect the 20-amp driver power fuse.



- **a -** Ignition coils - 20 amp
- **b -** Oxygen sensor - 10 amp
- **c -** Fuel pump - 20 amp
- **d -** Diagnostics - 2 amp
- **e -** Fuel injectors - 20 amp
- **f -** Advanced sound control - 5 amp (not used on all models)
- **g -** Driver power - 20 amp (start relay, fuel pump relay, PCM drivers)
- **h -** TVM power - 15 amp (not used on all models)
- **i -** Spare fuses (3)
- **j -** Good fuse
- **k -** Open fuse

2. Inspect the 5-amp clean power fuse located near the engine starting battery.
3. Inspect all power and ground connections at the battery, start relay, starter solenoid, starter motor, and the engine wiring harness connector for tightness and corrosion. Clean or repair as necessary.

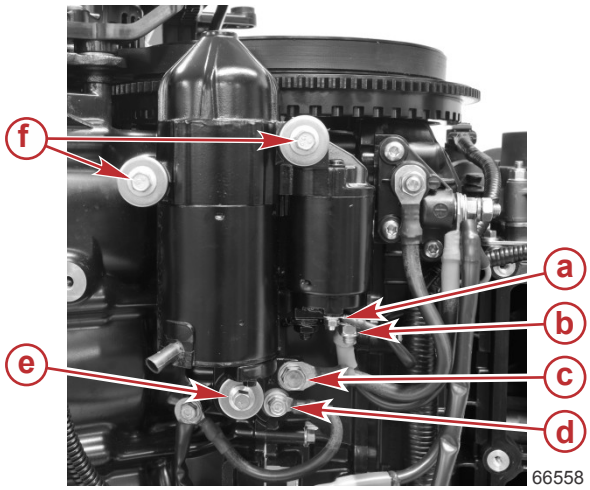
Starter Removal

⚠ 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 the cold air intake assembly.
    a. Remove the oil level dipstick.
    b. Loosen the hose clamp at the top of the throttle body assembly.
    c. Lift the assembly up to disengage the two pins from the grommets on the oil fill bracket.
    d. Swing the assembly out of the way.
3. Remove the starboard intake manifold runner assembly. Refer to **Section 3A - Intake Runners**.
4. Remove the positive (+) lead from the starter solenoid.
5. Remove the yellow/red lead from the starter solenoid.
6. Remove two screws to remove the starter ground (–) jumper cable and the starter ground (–) lead from the starter.

7. Remove the three screws (two M8 x 80 and one M8 x 45) and washers securing the starter motor assembly to the engine.



- **a -** Yellow/red lead
- **b -** Positive (+) lead
- **c -** Starter ground (–) lead
- **d -** Starter ground (–) jumper cable
- **e -** M8 x 45 hex flange head screw and washer
- **f -** M8 x 80 hex flange head screws (2) and washers (2)

Starter Installation

1. Apply Loctite 242 Threadlocker to two M8 x 80 hex flange head screws and one M8 x 45 hex flange head screw. Install the starter motor assembly onto the engine, using the three screws and three washers. Tighten the screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M8 x 80 hex flange head screws	92-809821
66	Loctite 242 Threadlocker	M8 x 45 hex flange head screw	92-809821

Description	Nm	lb-in.	lb-ft
M8 x 80 hex flange head screws	17	150.5	–
M8 x 45 hex flange head screw	17	150.5	–

2. Apply Loctite 242 Threadlocker to one M8 x 1.25 screw and one M6 x 13 hex washer head screw.

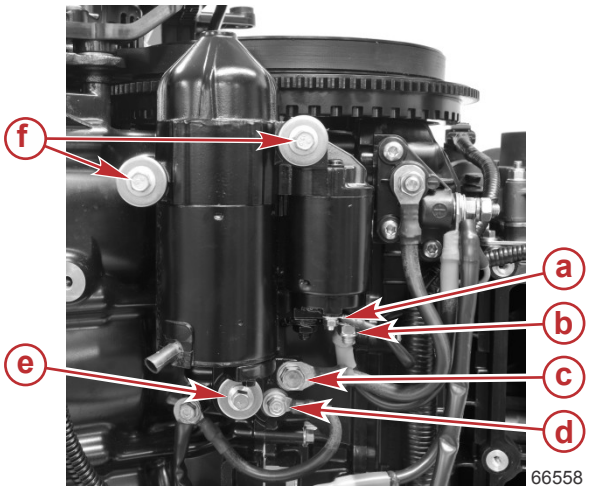
Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M8 x 1.25 screw	92-809821
66	Loctite 242 Threadlocker	M6 x 13 hex washer head screw	92-809821

3. Install the starter ground (–) lead onto the starter motor assembly using the M8 x 1.25 screw. Tighten the screw to the specified torque.
4. Install the starter ground (–) jumper cable onto the starter motor assembly, using the M6 x 13 hex washer head screw. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
M8 x 1.25 screw	17	150.5	–
M6 x 13 hex washer head screw	11.3	100	–

5. Install the yellow/red lead onto the starter solenoid, and secure it with a nut. Tighten the nut to the specified torque.

6. Install the positive (+) lead onto the starter solenoid, and secure it with a nut. Tighten the nut to the specified torque.



- **a -** Yellow/red lead connection
- **b -** Positive (+) lead connection
- **c -** Starter ground (–) lead connection
- **d -** Starter ground (–) jumper cable connection
- **e -** M8 x 45 hex flange head screw and washer
- **f -** M8 x 80 hex flange head screws (2) and washers (2)

Description	Nm	lb-in.	lb-ft
Yellow/red lead nut	4.5	39.8	–
Positive (+) lead nut	17	150.5	–

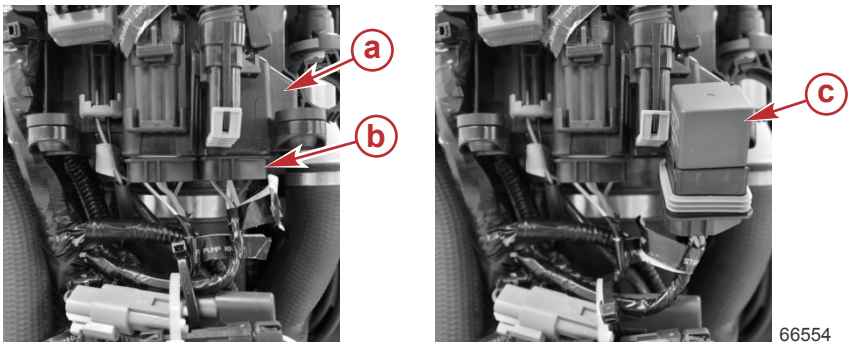
7. Coat all starter electrical connections with Liquid Neoprene.

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Starter electrical connections	92- 25711 3

8. Install the starboard intake manifold runner assembly. Refer to **Section 3A - Intake Runners**.
9. Install the cold air intake assembly. Refer to **Section 3A - Induction System**.
   - Ensure that the reference hose is secured to the assembly with a cable tie.
   - Ensure that the hose clamp is securely tightened.
   - Ensure that the oil level dipstick is properly inserted into the dipstick tube.

Start Relay

The start relay is located in the bottom of the electrical panel, at the rear of the engine.



- **a -** Electrical panel
- **b -** Start relay socket on the engine harness
- **c -** Start relay

Electrical

Section 2C - Accessories

Table of Contents

Lubricants, Sealants, Adhesives

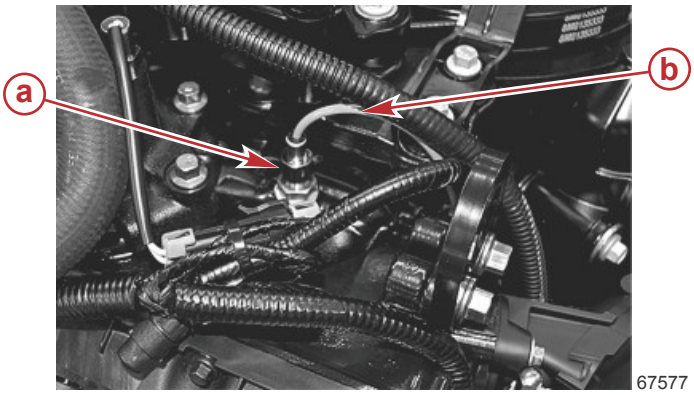
Tube Ref No.	Description	Where Used	Part No.
	Marine sealant	Three holes drilled in the rear cowl	Obtain Locally

Analog Block Water Pressure Adapter Installation

1. Thread the water pressure adapter fitting into the cylinder head. Tighten the fitting to the specified torque.

Description	Nm	lb-in.	lb-ft
Fitting assembly	15	132.8	–

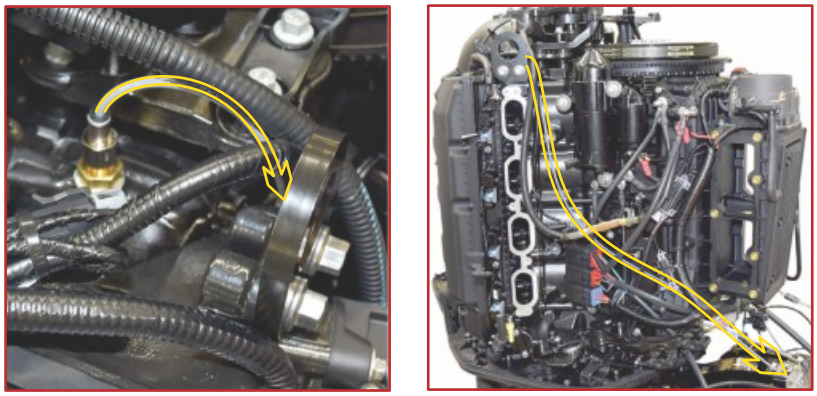
2. Insert the water pressure hose into the adapter fitting.



67577

a - Adapter fitting
b - Water pressure hose

3. Ensure that the water pressure hose is routed behind the intake manifold runner and down toward the back side of the rigging grommet, as shown.

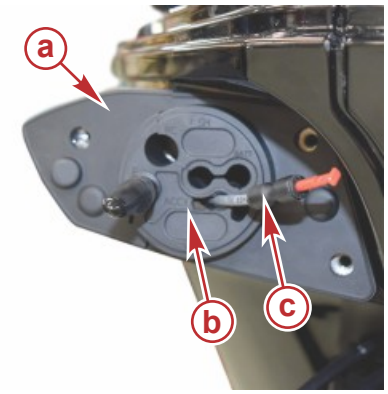


66847

Water pressure hose routing—intake manifold runner removed for clarity

4. If the water pressure hose was removed:
   a. Route the water pressure hose through the ACCY area of the rigging grommet.

b. Connect the water pressure hose to the dash-mounted water pressure gauge legris hose that is routed through the boat and rigging tube (if equipped).

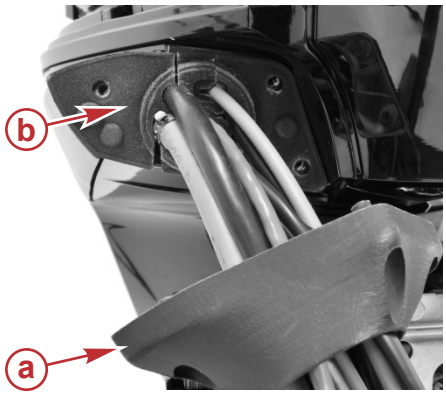


66880

CMS DTS model shown—rigging harnesses and cables removed for clarity

a - Rigging grommet
b - ACCY area
c - Water pressure hose

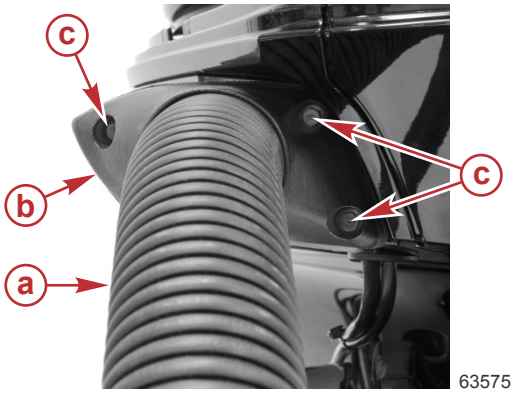
c. Slide the rigging adapter and rigging tube (if used) into place over the grommet.



66883

a - Rigging adapter
b - Rigging grommet

d. Fasten the rigging grommet and rigging adapter with three screws. Tighten the screws to the specified torque.



63575

a - Rigging tube (optional)
b - Rigging adapter
c - Screws (3)

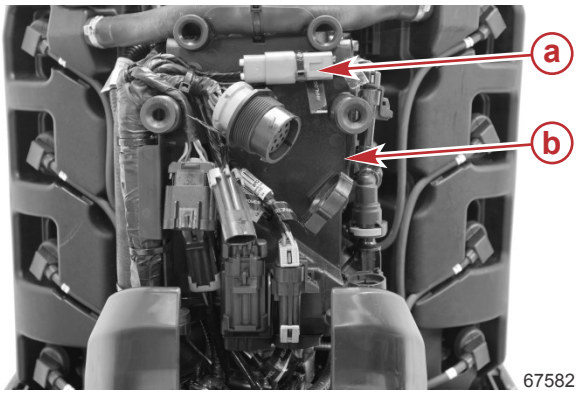
Description	Nm	lb-in.	lb-ft
Screws for attaching the rigging adapter	6	53.1	–

Analog Gauges (DTS Models)

On DTS models, the propulsion control module has outputs to drive four analog gauges at the helm:

- Engine coolant temperature
- Oil pressure
- Tachometer
- Trim position

A 4-pin Deutsch connector is located at the top of the electrical panel. An analog gauge harness (purchased as an option) completes the connections to the corresponding analog gauges at the helm.



a - Analog gauges connector
b - Electrical panel

Moving Propeller (MP) Alert

Note on Removal

IMPORTANT: The MP alert harness connector will not fit through the hole in the rear cowl. To completely remove the MP alert from the cowl, the harness must be depinned.

Installation

IMPORTANT: To complete the wiring connections, the lower cowls must be removed on V6 models.

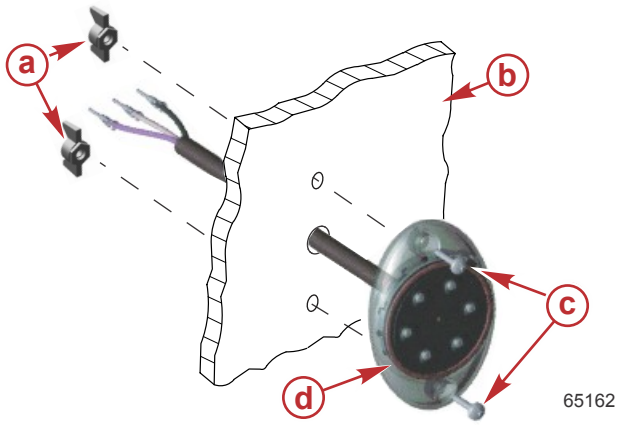
1. Remove the electrical panel cover at the rear of the outboard.
2. Route the light assembly harness through the center hole in the rear cowl.
3. Apply Marine sealant (obtain locally) to seal the three holes in the rear cowl.

Tube Ref No.	Description	Where Used	Part No.
	Marine sealant	Three holes drilled in the rear cowl	Obtain Locally

NOTICE

Do not overtighten the screws. Overtightening the screws may crack the lens, allowing water to enter the light assembly.

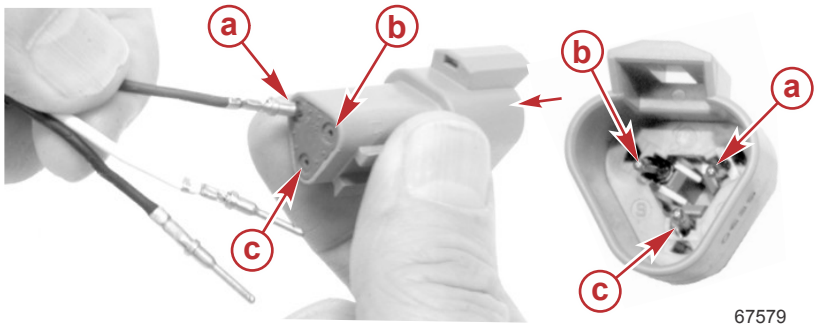
4. Fasten the system light assembly with two screws and nylon wing nuts.



a - Nylon wing nuts (2)
b - Rear cowl
c - Screws (2)
d - Light assembly

5. Install the 3-pin connector onto the MP alert harness as follows:

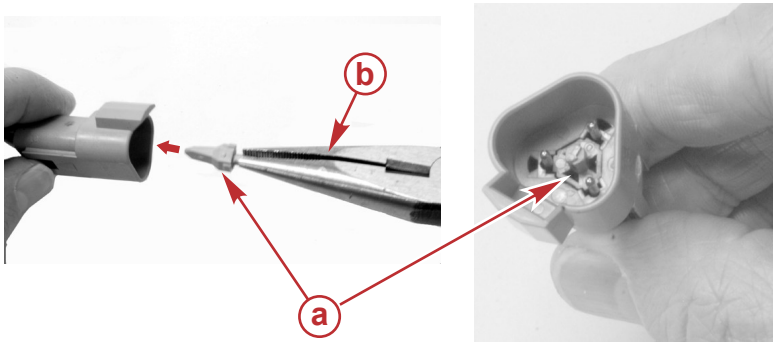
a. Insert the wire terminals through the seal and into the connector. Push the wire terminals in until they snap into place.



67579

a - Pin A - purple wire
b - Pin B - white wire
c - Pin C - black wire

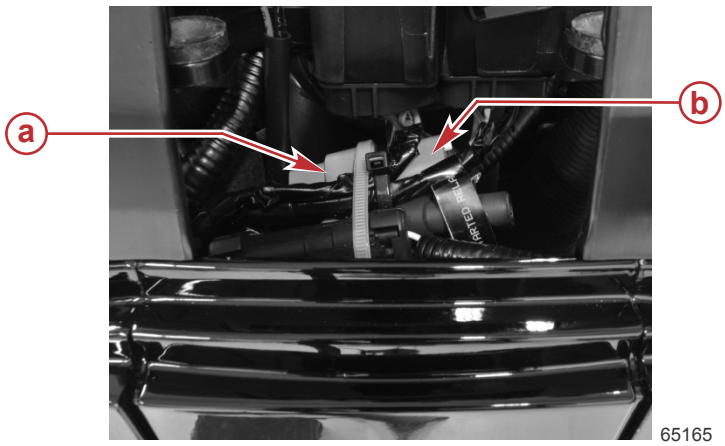
b. Insert the secondary lock into the connector.



46350

a - Secondary lock
b - Needle-nose pliers

6. Connect the MP alert harness connector to the MP alert connector on the engine harness.



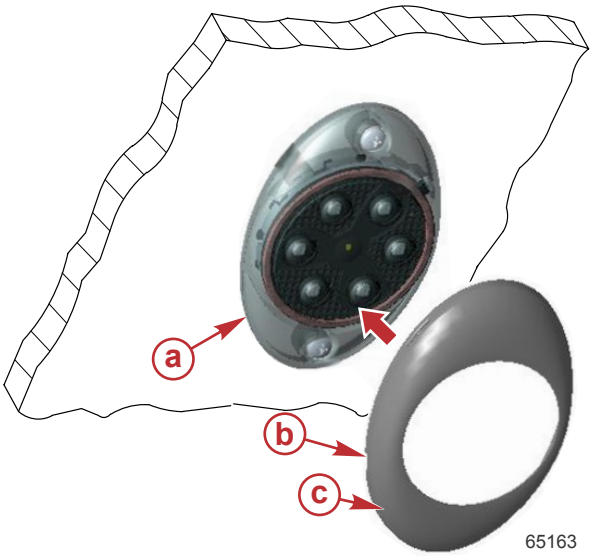
65165

Some wiring not shown for clarity
a - MP alert connector on the engine harness
b - MP alert harness connector

7. **V6 models**—install the lower cowls.
8. Install the electrical panel cover at the rear of the outboard.

Bezel

To install the bezel, snap it onto the light assembly.



a - Light assembly
b - Slot (2 per bezel)
c - Bezel

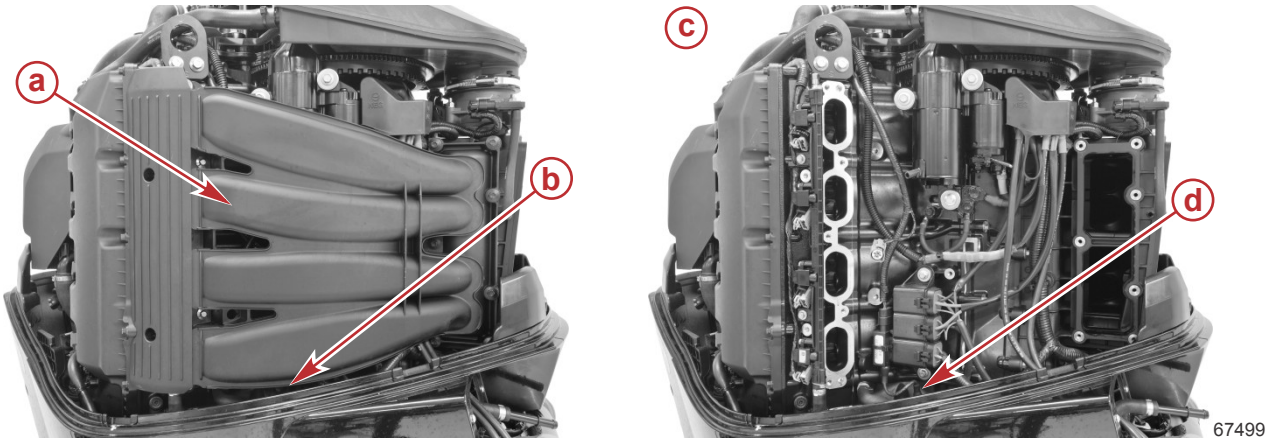
To remove the bezel, insert a small flat-blade screwdriver into the slots in the bezel, and twist.

Operational Check

- When the engine is being started, the lights should flash for approximately five seconds.
- The lights should remain lit whenever the engine is running in neutral.
- When the engine is shifted into forward or reverse gear, the lights should rotate clockwise to indicate propeller rotation.
  IMPORTANT: The lights rotate clockwise regardless of the direction of propeller rotation.
- Shutting off the engine will shut off the lights.

Oil Level Sensor

The oil level sensor, if equipped, is located on the starboard side of the powerhead, at the base of the cylinder block. The starboard air intake runner must be removed to access the oil level sensor.

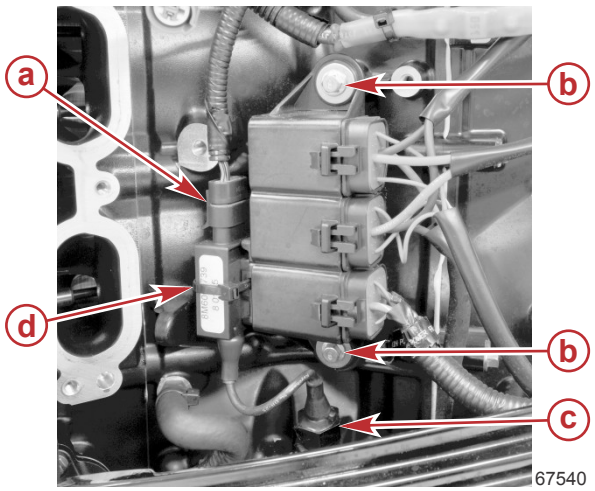


a - Starboard air intake runner
b - Location of the oil level sensor
c - Starboard view of engine with intake runner removed
d - Top of the oil level sensor

Oil Level Sensor Removal

1. Remove the starboard air intake runner. Refer to **Section 3A - Intake Runners**.
2. Cut the cable tie that secures the oil level sensor module to the relay bracket.

3. Remove two screws and remove the relay bracket from the engine.
4. Disconnect the oil level sensor harness from the engine harness.
5. Remove the oil level sensor from the engine.



a - Oil level sensor harness connection to engine harness
b - Screws (2)
c - Oil level sensor
d - Cable tie around the oil level sensor module

Oil Level Sensor Installation

1. Insert the oil level sensor into the engine, and tighten it to the specified torque.

Description	Nm	lb-in.	lb-ft
Oil level sensor	20	177	–

2. Use two screws to attach the relay bracket to the engine. Tighten the screws to the specified torque.

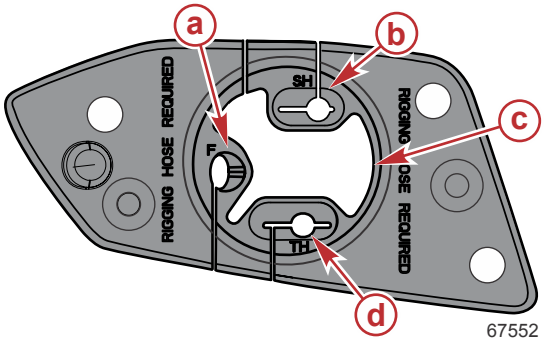
Description	Nm	lb-in.	lb-ft
Screws	10	88.5	–

3. Use a cable tie to secure the oil level sensor module to the relay bracket.
4. Connect the oil level sensor harness to the engine harness.
5. Install the starboard air intake runner. Refer to **Section 3A - Intake Runners**.

Open Rigging Grommet (Optional Accessory)

Mechanical Rigging Grommet Installation

IMPORTANT: Refer to Section 1D - Outboard Installation for complete disassembly and assembly procedures.
A rigging tube is required when using the open rigging grommet.



Ref	Marking	Opening used for
a.	F	Fuel line ***NOTE:*** *Fuel hose must be secured through the designated opening. Insert the fuel line fitting into the grommet with the hose and hose clamp on the outside of the grommet.*

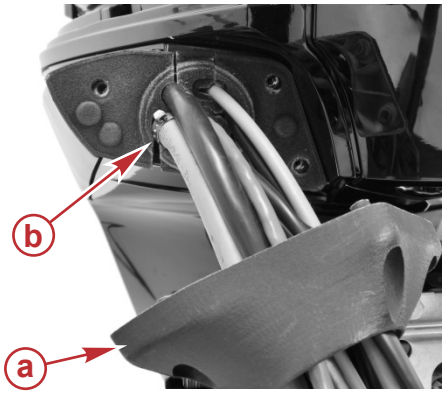
Ref	Marking	Opening used for
b.	SH	Shift cable ***NOTE:*** *Shift cable must be secured through the designated opening.*
c.	none	Remaining rigging
d.	TH	Throttle cable ***NOTE:*** *Throttle cable must be secured through the designated opening.*

1. Arrange the harnesses, fuel hose, shift cable, and throttle cables in the approximate positions they will occupy in the rigging grommet.
2. Work the grommet around the harnesses, fuel hose, shift cable, and throttle cables. Start with the inboard and innermost items, and work outward.
3. Press the rigging grommet into the opening.

NOTICE

Inspect the position of the hose clamp located on the fuel hose to ensure that it will not chafe or cut into the adjacent wiring harnesses.

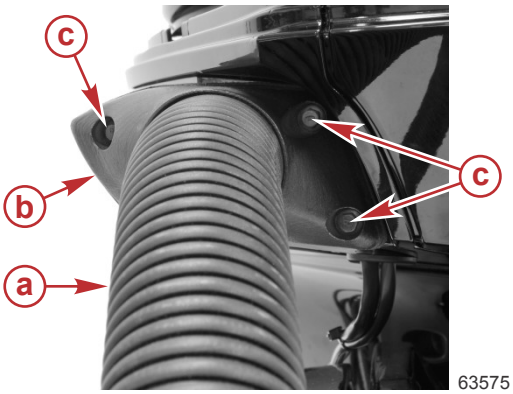
4. Slide the rigging adapter and rigging tube into place over the grommet.



63576

a - Rigging adapter
b - Clamp on fuel line, outside of rigging grommet

5. Fasten the rigging grommet and rigging adapter with three screws. Tighten the screws to the specified torque.



63575

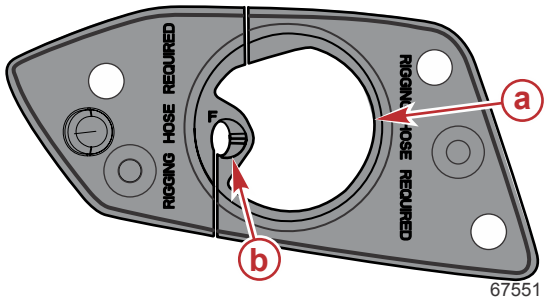
a - Rigging tube
b - Rigging adapter
c - Screws (3)

Description	Nm	lb-in.	lb-ft
Screws for attaching the rigging adapter	6	53.1	–

DTS Rigging Grommet Installation

IMPORTANT: Refer to Section 1D - Outboard Installation for complete disassembly and assembly procedures.

A rigging tube is required when using the open rigging grommet.



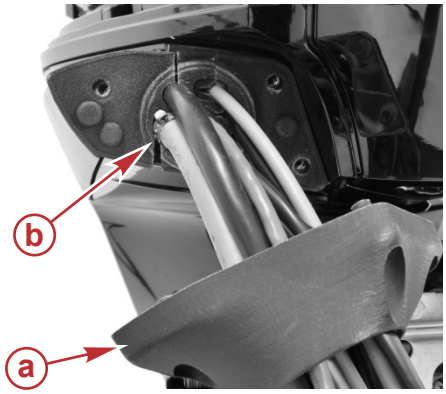
Ref	Marking	Opening used for
a.	none	Remaining rigging
b.	F	Fuel line ***NOTE:*** *Fuel hose must be secured through the designated opening. Insert the fuel line fitting into the grommet with the hose and hose clamp on the outside of the grommet.*

1. Arrange the harnesses and fuel hose in the approximate positions they will occupy in the rigging grommet.
2. Work the grommet around the harnesses and fuel hose. Start with the inboard and innermost items, and work outward.
3. Press the rigging grommet into the opening.

NOTICE

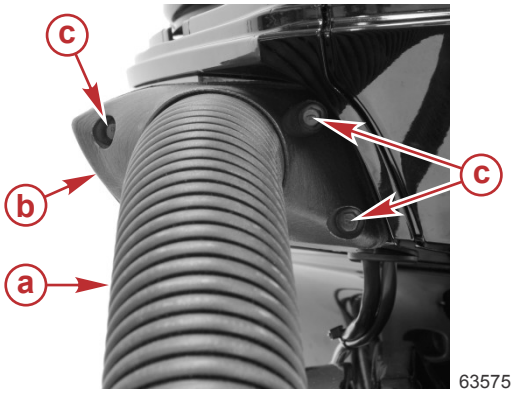
Inspect the position of the hose clamp located on the fuel hose to ensure that it will not chafe or cut into the adjacent wiring harnesses.

4. Slide the rigging adapter and rigging tube into place over the grommet.



a - Rigging adapter
b - Clamp on fuel line, outside of rigging grommet

5. Fasten the rigging grommet and rigging adapter with three screws. Tighten the screws to the specified torque.



a - Rigging tube
b - Rigging adapter
c - Screws (3)

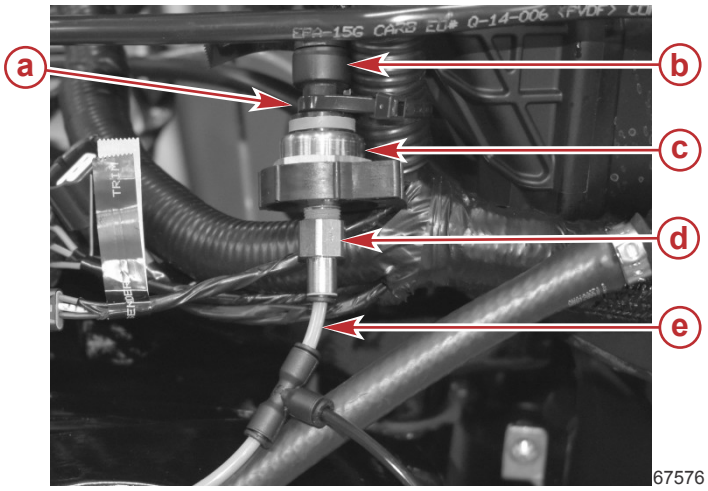
Description	Nm	lb-in.	lb-ft
Screws for attaching the rigging adapter	6	53.1	–

Pitot Pressure Sensor Removal and Installation

The pitot pressure sensor is located on the port side of the engine, near the flush hose and behind the intake runner.

Removal

1. Remove the port intake runner. Refer to **Section 3A - Intake Runners**.
2. Disconnect the pitot tube from the sensor adapter.
3. Disconnect the engine harness from the sensor connector.
4. Cut the cable tie to remove the sensor and adapter from the engine.
5. Remove the sensor adapter from the pitot pressure sensor.



Items removed for clarity

- **a -** Cable tie
- **b -** Sensor connector
- **c -** Pitot pressure sensor
- **d -** Sensor adapter
- **e -** Pitot tube

Installation

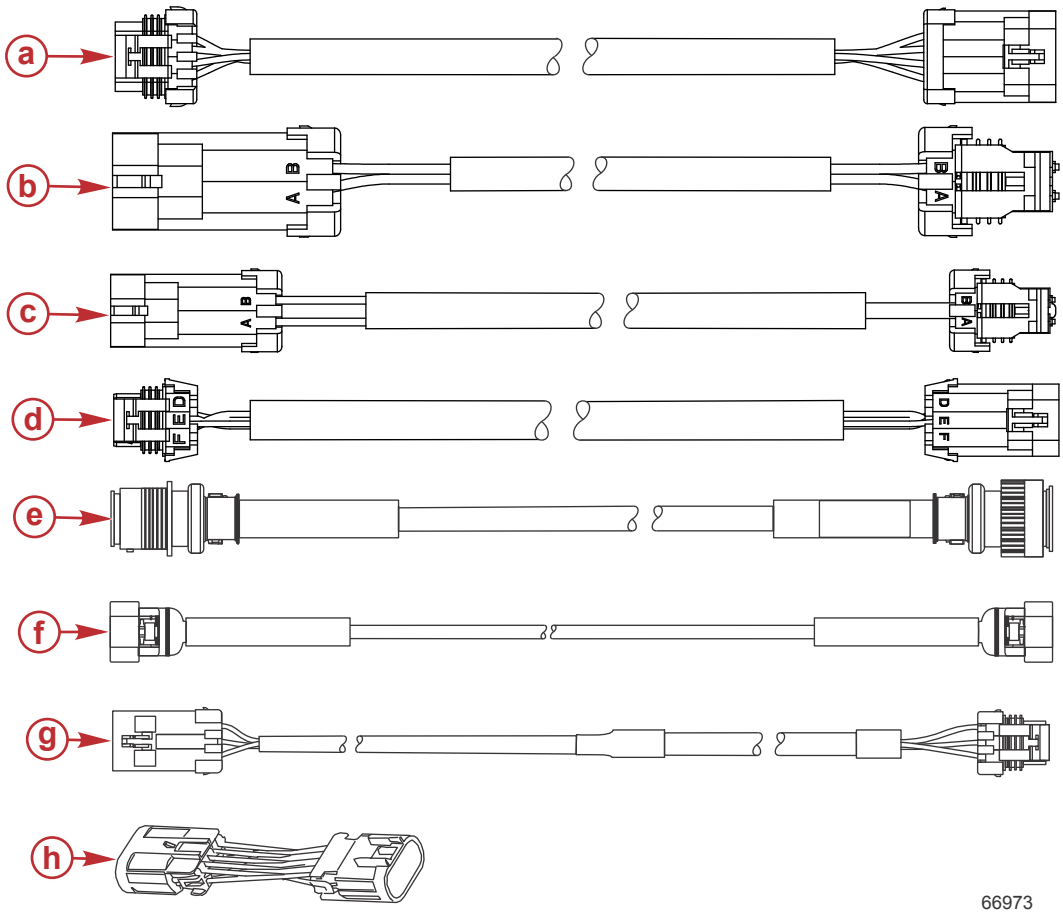
1. Install the sensor adapter onto the pitot pressure sensor.
2. Tighten the sensor adapter to ensure the adapter will not leak.

- **a -** Pitot pressure sensor
- **b -** Sensor adapter

3. Connect the engine harness to the sensor connector.
4. Install the pitot tube into the sensor adapter.
5. Use a cable tie to secure the sensor and adapter to the engine harness.
6. Install the port intake runner. Refer to **Section 3A - Intake Runners**.

Repower Extension Harnesses

When an engine is installed as a repower, some existing harnesses may not reach the correct location on the engine. The repower harness kit includes extension harnesses to rectify that situation. The following extension harnesses may be used:



a - 4-pin depth extension harness
b - 2-pin clean power extension harness
c - 2-pin water-in-fuel extension harness
d - 6-pin fuel/paddle wheel extension harness
e - 14-pin data cable extension harness
f - 10-pin SmartCraft extension harness
g - 3-pin power steering extension harness
h - 10-pin male-to-male gender adapter

When extension harnesses are used, adhere to the following:

- Existing harnesses requiring the use of the extension harness must be pulled inside the vessel transom and secured with cable ties or D-rings in a dry location within 8 inches of the connector.

  IMPORTANT: Extension connections are not allowed in the rigging tube or inside the cowl.
- Connections between the extension harnesses and the existing harnesses must be made inside of the vessel.
- The extension harnesses must be secured to the vessel or other harnesses with cable ties or D-rings within 8 inches of the connector.

Notes:

Electrical

Section 2D - Throttle and Shift

Table of Contents

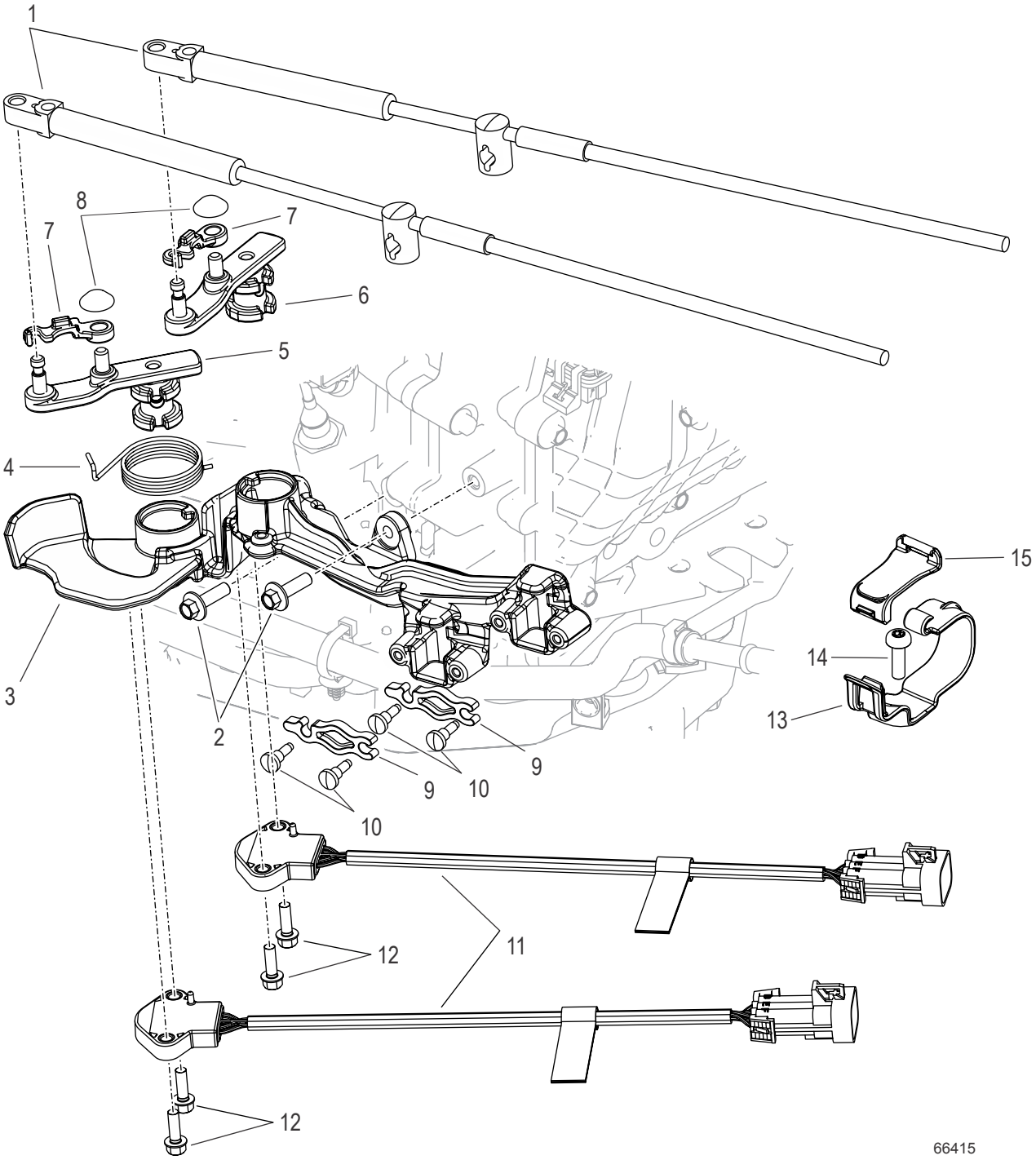
2
D

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Loctite 242 Threadlocker	M6 x 20 Torx socket head screws	92-809821

Notes:

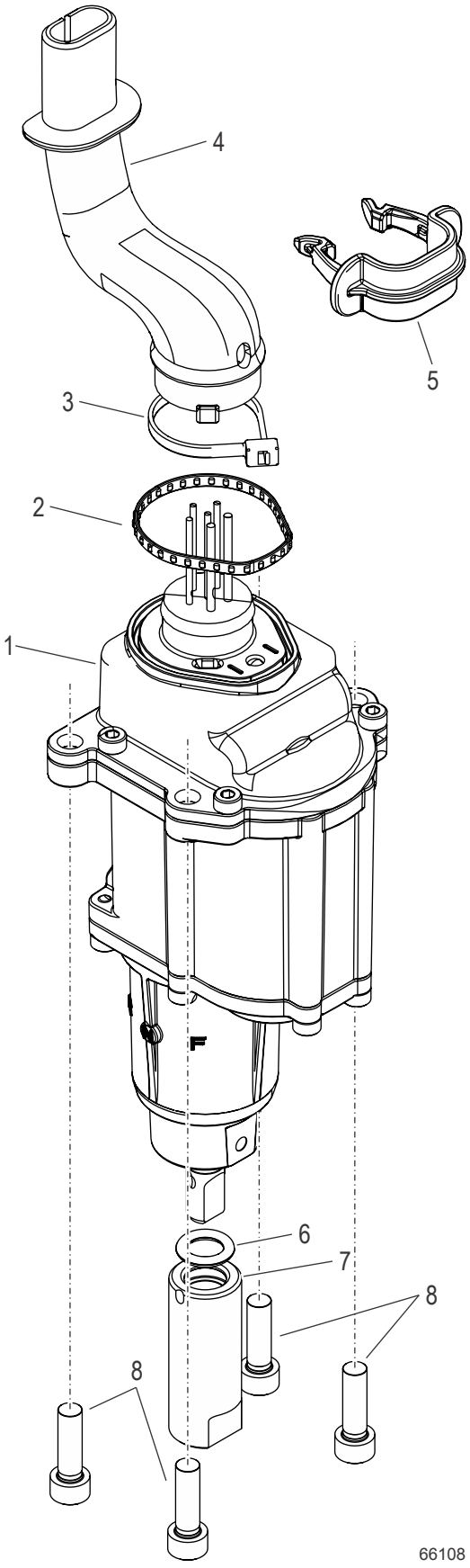
Mechanical Throttle and Shift Components



Mechanical Throttle and Shift Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Remote control cable assembly			
2	2	M6 x 20 hex flange screw	11	97.4	–
3	1	Mechanical throttle and shift bracket and sensor assembly			
4	1	Torsion spring			
5	1	Throttle arm assembly			
6	1	Shift arm assembly			
7	2	Remote control cable retainer			
8	2	Push nut			
9	2	Latch			
10	4	Drive screw			
11	2	Demand sensor and harness assembly			
12	4	M5 x 16 hex washer head screw	1.7	15.0	–
13	1	Cable keeper bottom			
14	1	M6 x 20 Torx® pan head screw	6.0	53.1	–
15	1	Cable keeper latch			

Shift Actuator Components



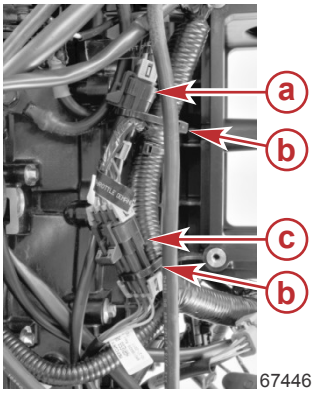
Shift Actuator Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Shift actuator			
2	1	Seal			
3	1	Cable tie			
4	1	Boot			
5	1	C-clip			
6	1	O-ring			
7	1	Shift shaft coupling			
8	4	M6 x 20 Torx® socket head screw	11	97.4	–

Throttle and Shift Bracket

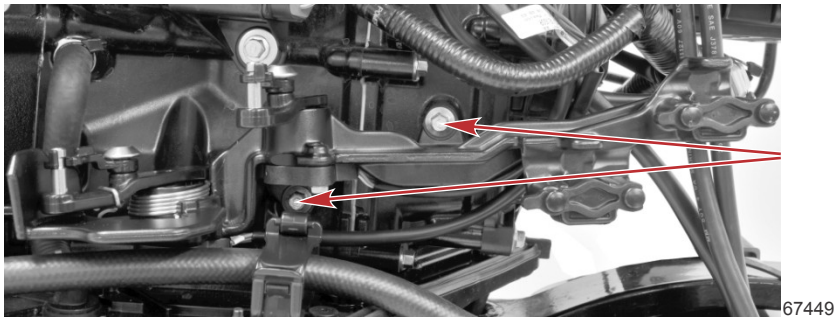
Bracket Removal

1. Cut the cable ties that secure the demand sensor harnesses to the engine harness.
2. Disconnect the throttle and shift demand sensor harnesses from the engine harness.



a - Shift demand sensor connection
b - Cable ties (2)
c - Throttle demand sensor connection

3. Remove the two M6 x 20 hex flange screws and the throttle and shift bracket assembly from the engine.



M6 x 20 hex flange screws (2)

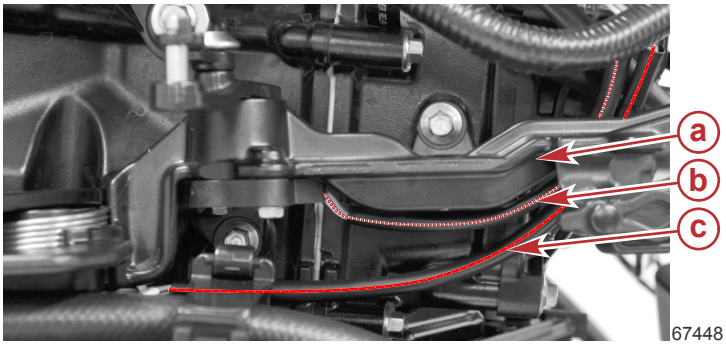
Bracket Installation

NOTE: *Refer to previous illustrations as required.*

1. Attach the throttle and shift bracket assembly to the engine with two M6 x 20 hex flange screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M6 x 20 hex flange screws	11	97.4	–

2. Route the demand sensor harnesses between the throttle and shift bracket and the engine block.



a - Throttle and shift bracket
b - Shift demand sensor harness
c - Throttle demand sensor harness

3. Connect the demand sensor harnesses to the engine harness. Use cable ties to secure the connections to the engine harness.

Throttle Arm

The throttle arm can be removed and installed with the throttle and shift bracket installed on the engine. However, it is easiest to install the arm with the bracket removed from the engine.

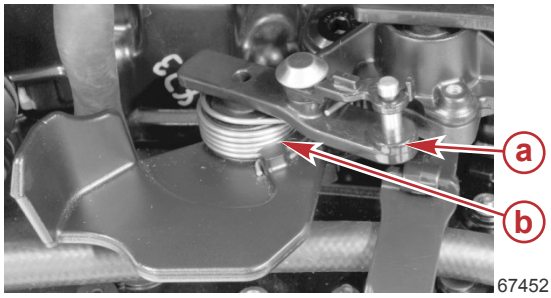
Removal

IMPORTANT: The torsion spring is under tension. Use care to prevent the spring and throttle arm from flying loose.

1. Rotate the throttle arm as far counterclockwise as the bracket will allow. This will align the two notches in the arm with a tab in the bracket.

Throttle arm (removed from bracket)
- **a -** Upper notch
- **b -** Lower notch

2. Carefully lift the throttle arm and torsion spring from the bracket.

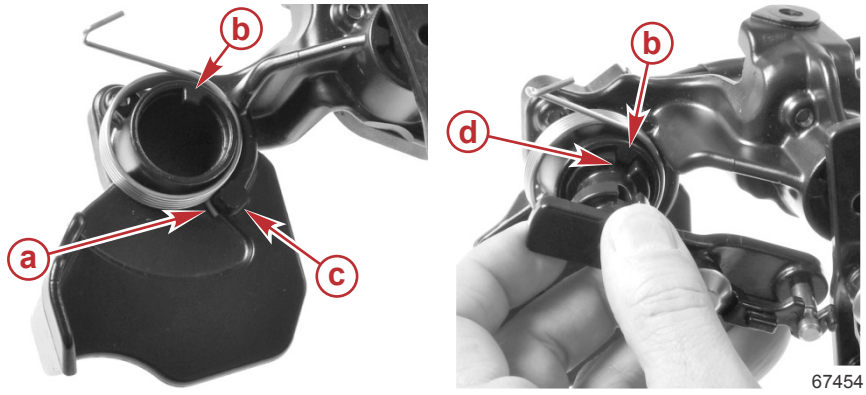


- **a -** Throttle arm rotated fully counterclockwise
- **b -** Torsion spring

Installation

NOTE: *The following installation instructions assume that the throttle and shift bracket assembly has been removed from the engine.*

1. Place the torsion spring onto the throttle and shift bracket so that the small hook rests against the stop on the bracket.
2. Insert the throttle arm into the bracket until the lower notch has passed below the tab in the bracket.



- **a -** Small hook on torsion spring
- **b -** Tab in throttle and shift bracket
- **c -** Stop on throttle and shift bracket
- **d -** Lower notch in throttle arm

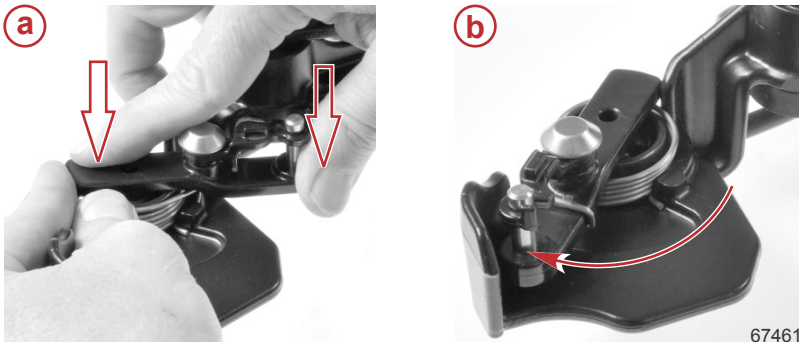
3. Rotate the arm counterclockwise, hooking the torsion spring with the arm.

4. Continue to rotate the arm until the notches again align with the tab in the bracket.

a - Rotate arm to hook torsion spring
b - Torsion spring
c - Rotate arm until notches align with tab in bracket

NOTE: *With the spring under tension, it may be necessary to guide the top winding of the torsion spring down over the boss on the bracket.*

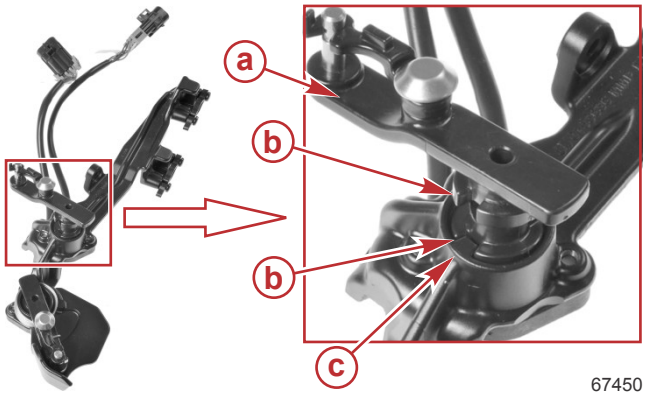
5. Press down evenly on the arm and spring until the upper notch clears the tab in the bracket.
6. Allow the arm to rotate clockwise to the idle position.



a - Press down evenly
b - Rotate clockwise to idle position

Shift Arm

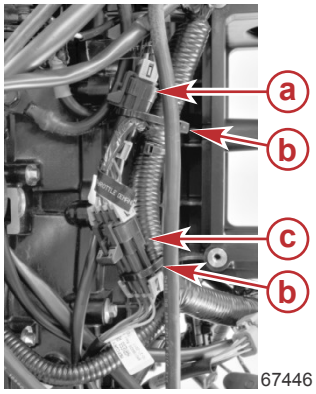
The shift arm cannot be removed or installed while the throttle and shift bracket is installed on the engine. To remove or install the shift arm, the arm must be rotated 180° from the neutral detent position. This will align the two notches in the shift arm with the tab in the throttle and shift bracket. The shift arm can then be easily pulled up to remove or pushed down to install. Refer to the following illustration.



a - Shift arm rotated 180° from neutral detent position
b - Two notches in the shift arm
c - Tab in the throttle and shift bracket

Demand Sensors

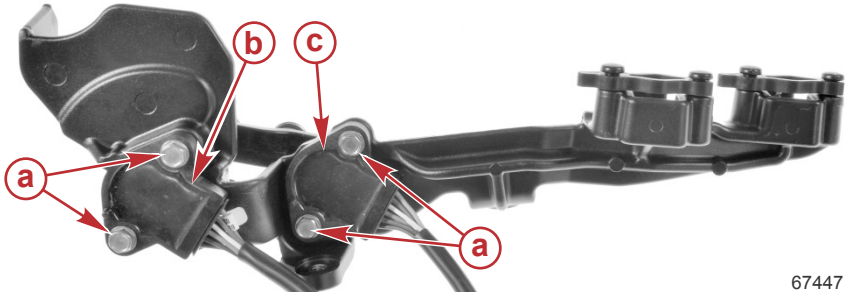
The demand sensors used for the throttle and shift demand are identical. Because they are identical and interchangeable, special care must be taken to ensure that the connections to the engine harness are correct.



a - Shift demand sensor connection
b - Cable ties (2)
c - Throttle demand sensor connection

Sensor Removal

1. Cut the cable tie that secures the demand sensor harness to the engine harness.
2. Disconnect the demand sensor harness from the engine harness.
3. Remove the two M5 x 16 hex washer head screws that secure the sensor to the underside of the throttle and shift bracket, and remove the sensor.



Throttle and shift bracket, shown removed for clarity
a - M5 x 16 hex washer head screws (2 per sensor, 4 total)
b - Throttle demand sensor
c - Shift demand sensor

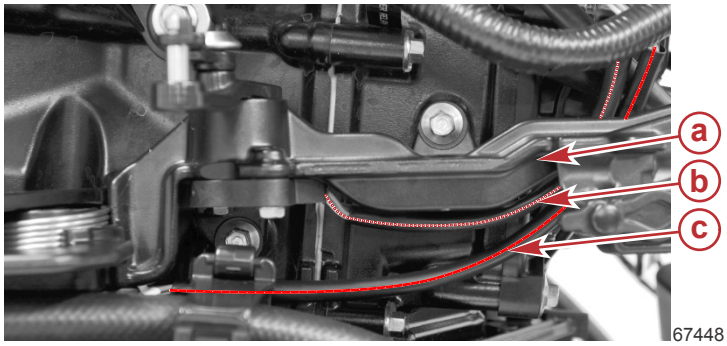
Sensor Installation

NOTE: *Refer to previous illustrations as required.*

1. Attach the sensor to the underside of the throttle and shift bracket, using two M5 x 16 hex washer head screws. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M5 x 16 hex washer head screw	1.7	15	–

2. Route the demand sensor harness between the throttle and shift bracket and the engine block.



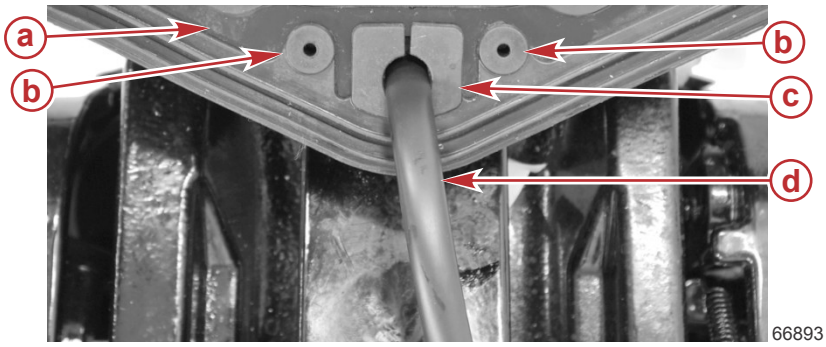
a - Throttle and shift bracket
b - Shift demand sensor harness
c - Throttle demand sensor harness

3. Connect the demand sensor harness to the engine harness. Use a cable tie to secure the connection to the engine harness.

Shift Actuator

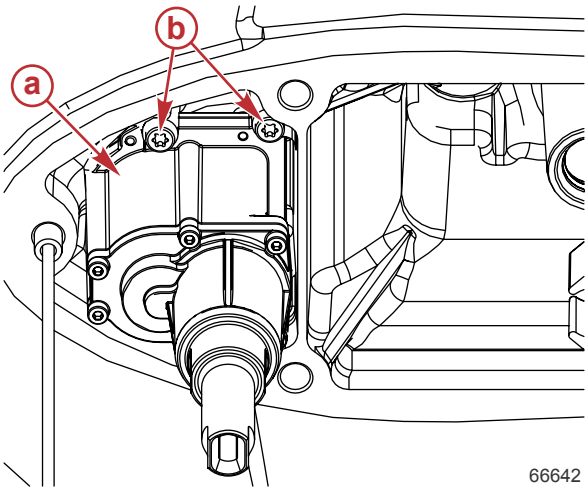
Shift Actuator Removal

1. Remove all cowling. Refer to **Section 5C - Upper and Lower Cowls**.
2. Remove the gearcase. Refer to **Section 6 - Gear Housing**.
3. Disconnect the shift actuator from the engine harness. Release two pins in the chap plate seal to allow the shift actuator harness a large enough opening to pass through.



Items removed for clarity
- **a -** Chap plate
- **b -** Pins in chap plate seal
- **c -** Grommet in chap plate seal
- **d -** Shift actuator harness

4. Remove the four M6 x 20 Torx socket head screws that secure the shift actuator to the underside of the driveshaft housing.



- **a -** Shift actuator
- **b -** M6 x 20 Torx socket head screws (4 total, 2 shown)

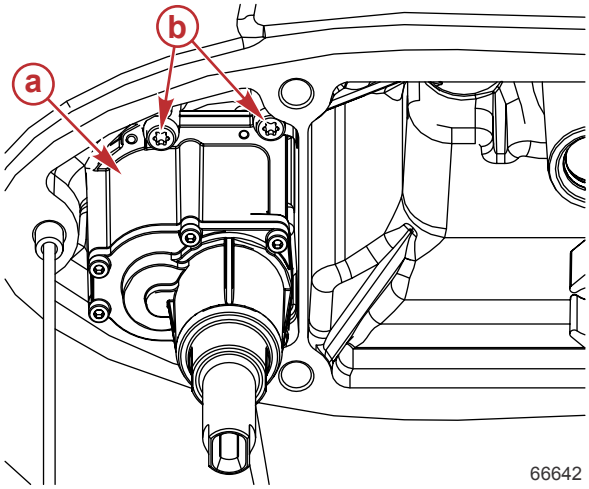
5. Remove the shift actuator, and carefully feed the harness through the swivel tube.

Shift Actuator Installation

1. Ensure that the shift actuator harness connector is covered. Use a weather cap, tape, or other suitable material.
2. Carefully feed the harness through the swivel tube.
3. Apply Loctite® 242 Threadlocker to four M6 x 20 Torx® socket head screws.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 20 Torx socket head screws	92-809821

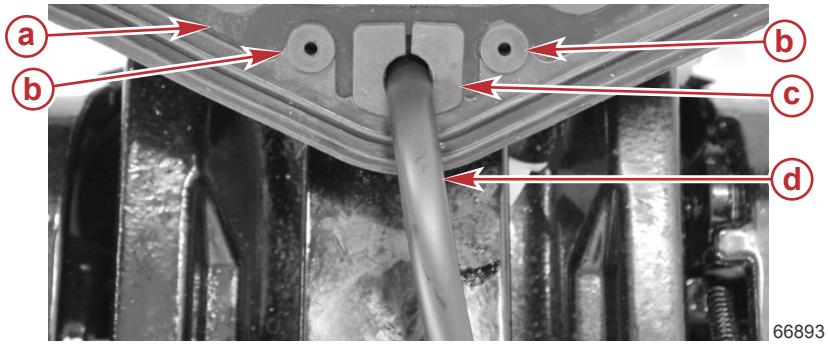
4. Use a T30 wrench to install the shift actuator. Tighten the four screws to the specified torque.



a - Shift actuator
b - M6 x 20 Torx socket head screws (4 total, 2 shown)

Description	Nm	lb-in.	lb-ft
M6 x 20 Torx socket head screws	11	97.4	–

5. Feed the shift actuator harness through the grommet in the chap plate seal, and fully install the seal into the chap plate, with the harness passing through the grommet.



a - Chap plate
b - Pins to secure chap plate seal; lubricate with soapy water to ease installation
c - Grommet in chap plate seal
d - Shift actuator harness

6. Connect the shift actuator harness to the engine harness.
7. Install the gearcase. Refer to **Section 6 - Gear Housing**.
8. Install all cowling. Refer to **Section 5C - Upper and Lower Cowls**.

Notes:

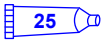
Fuel System

Section 3A - Induction System

Table of Contents

3A

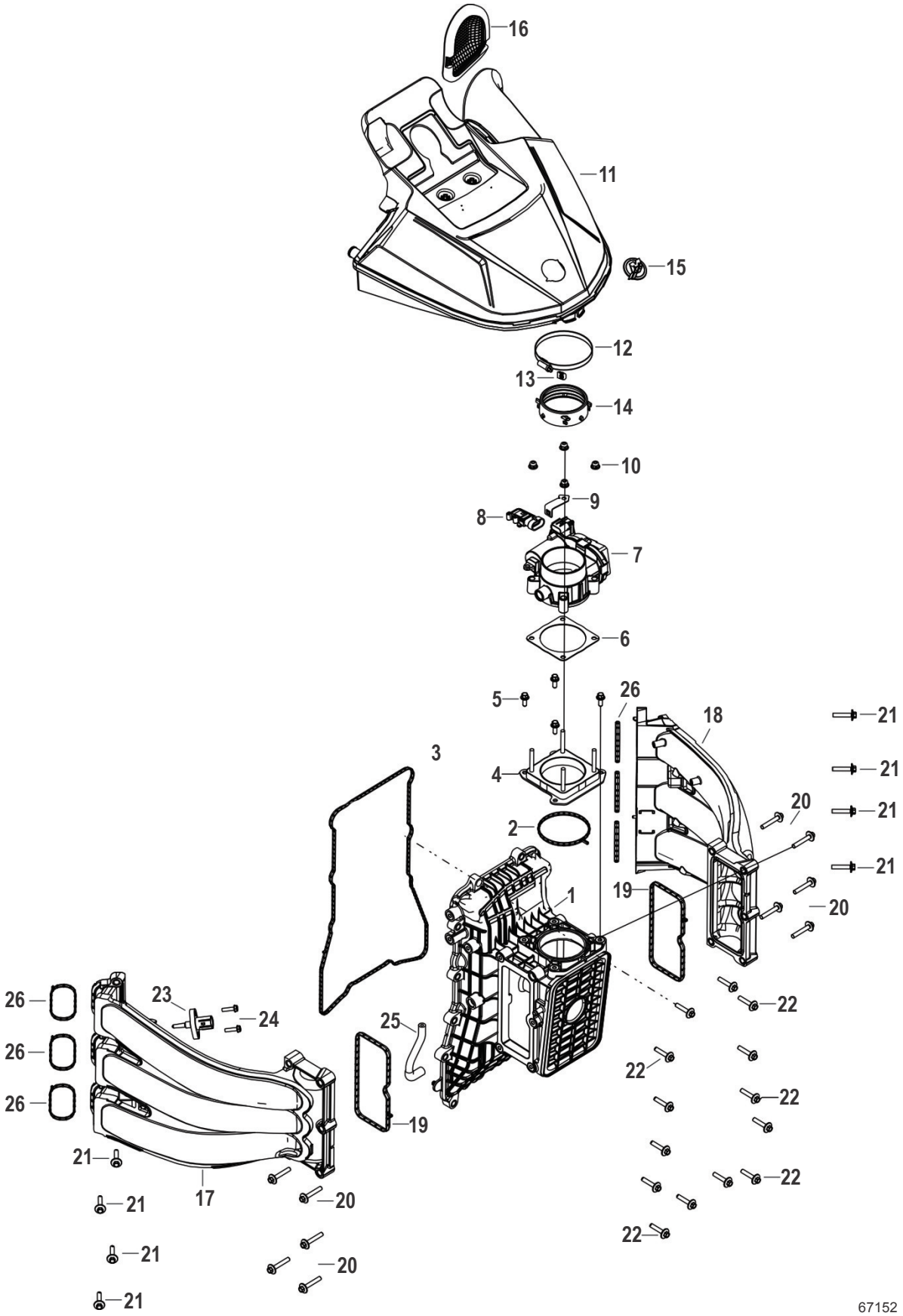
Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Liquid Neoprene	Battery cable connections	92- 25711 3
	Loctite 242 Threadlocker	Intake plenum screws M6 x 16 hex flange screws	92-809821

Notes:

Exploded Views

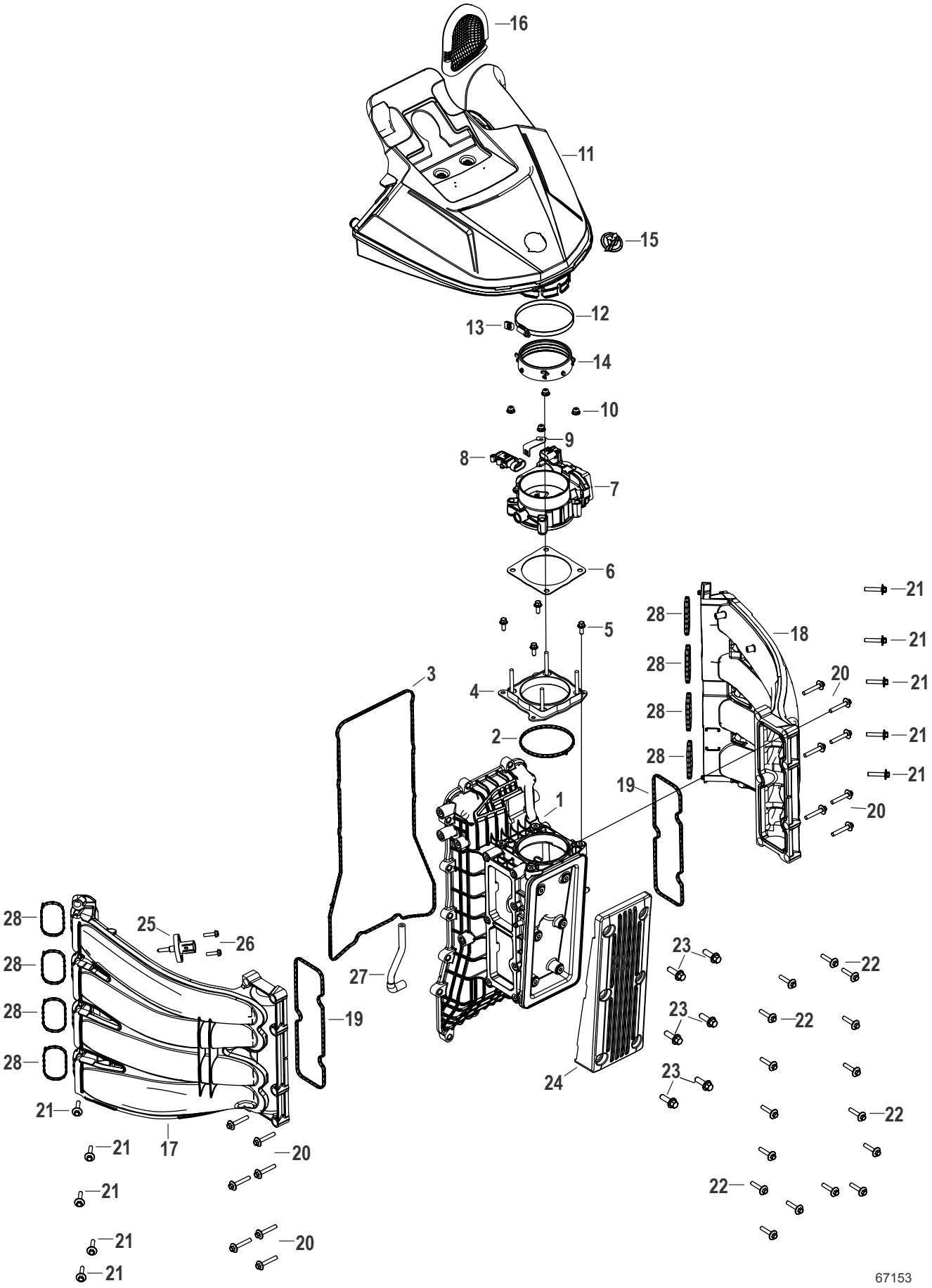
V6 Intake System



V6 Intake System

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Plenum			
2	1	Throttle body gasket			
3	1	Crankcase cover gasket			
4	1	Isolator assembly			
5	4	Screw (M6 x 16 hex flange)	10	88.5	–
6	1	Throttle body gasket (top)			
7	1	Throttle body assembly			
8	1	MAP sensor			
9	1	MAP sensor bracket			
10	4	M6 nylock nut	7	62	–
11	1	Cold air intake			
12	1	Hose clamp	3	26.6	–
13	1	Hose clamp cover			
14	1	Throttle body seal			
15	1	Decal			
16	1	Intake screen			
17	1	Starboard intake runner			
18	1	Port intake runner			
19	2	Gasket			
20	10	Screw (M6 x 1 x 37 hex flange)	10	88.5	–
21	8	Screw (M6 x 1 x 30 hex flange)	10	88.5	–
22	14	Screw (M6 x 1 x 30 hex flange)	10	88.5	
23	1	Air temperature sensor			
24	2	Screw (M4 1.75 x 16 hex washer)	2	17.7	–
25	1	MAP sensor hose			
26	6	Intake port gasket			

V8 Intake System



V8 Intake System

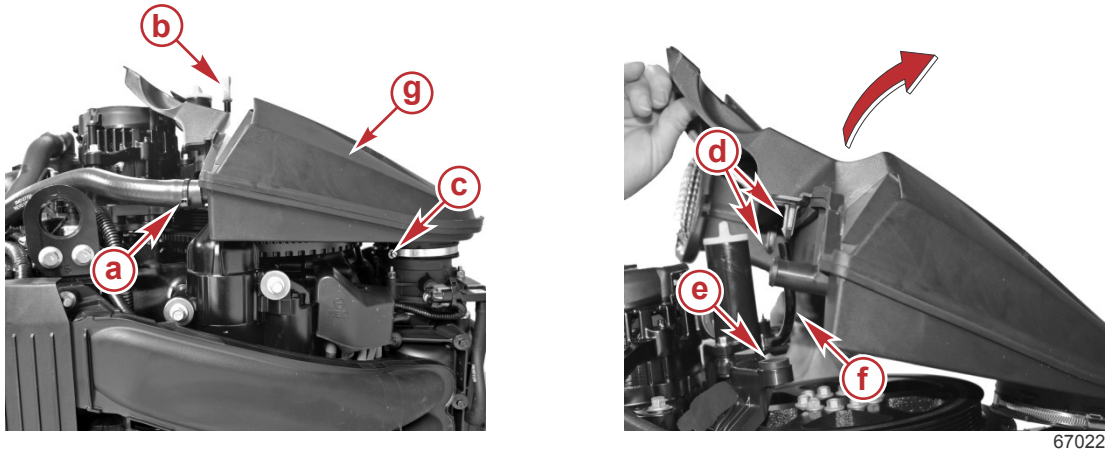
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Plenum			
2	1	Throttle body gasket			
3	1	Crankcase cover gasket			
4	1	Isolator assembly			
5	4	Screw (M6 x 16 hex flange)	10	88.5	–
6	1	Throttle body gasket (top)			
7	1	Throttle body assembly			
8	1	MAP sensor			
9	1	MAP sensor bracket			
10	4	M6 nylock nut	7	62	–
11	1	Cold air intake			
12	1	Hose clamp	3	26.6	–
13	1	Hose clamp cover			
14	1	Throttle body seal			
15	1	Decal			
16	1	Intake screen			
17	1	Starboard intake runner			
18	1	Port intake runner			
19	2	Gasket			
20	14	Screw (M6 x 1 x 37 hex flange)	10	88.5	–
21	10	Screw (M6 x 1 x 30 hex flange)	10	88.5	–
22	16	Screw (M6 x 1 x 30 hex flange)	10	88.5	–
23	6	Screw (M6 x 1 x 20) hex flange)	7	62	–
24	1	Plenum cover			
25	1	Air temperature sensor			
26	2	Screw (M4 1.75 x 16 hex washer)	2	17.7	–
27	1	MAP sensor hose			
28	8	Intake port gasket			

Induction Components

Cold Air Intake

Removal

1. Remove the cable tie from the breather hose and remove the breather hose from the cold air intake.
2. Remove the dipstick from the dipstick tube.
3. Loosen the throttle body hose clamp.
4. Lift the cold air intake alignment fasteners out of the two grommets and off of the engine.

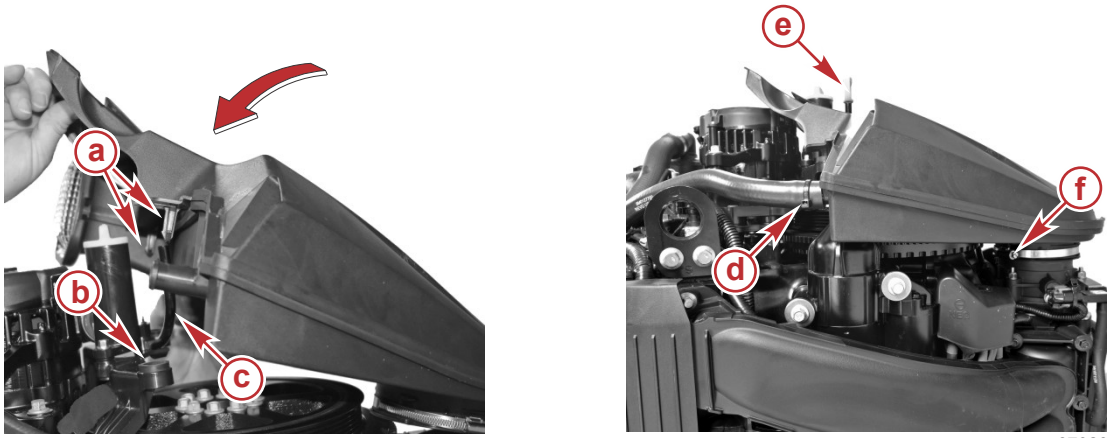


- **a -** Cable tie
- **b -** Dipstick
- **c -** Throttle body hose clamp
- **d -** Alignment fasteners (2)
- **e -** Grommet (2)
- **f -** Dipstick tube
- **g -** Cold air intake

Installation

1. Align the large throttle body hose at the front of the cold air intake with the throttle body and lower the cold air intake into position. Ensure that the dipstick tube is aligned with the oil fill grommet on top of the cold air intake and that the two alignment fasteners are aligned with the two grommets on either side of the powerhead.

2. Firmly press the cold air intake into position.



67023

a - Alignment fasteners (2)
b - Grommet (2)
c - Dipstick tube
d - Cable tie
e - Dipstick
f - Throttle body hose clamp

3. Slide the breather hose onto the cold air intake hose bib and secure it with a cable tie.
4. Ensure that the large throttle body hose is completely seated over the throttle body and tighten the hose clamp to the specified torque.

Description	Nm	lb-in.	lb-ft
Hose clamp	3.0	26.6	–

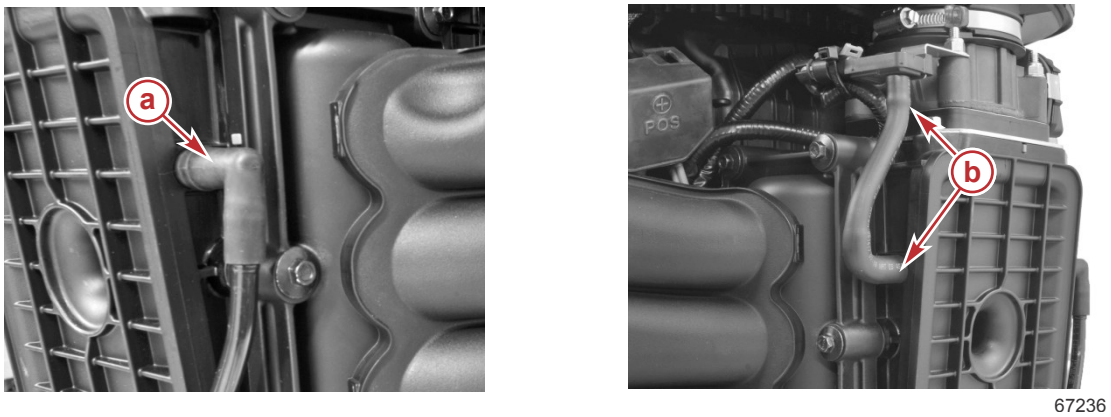
5. Install the dipstick.

Intake Runners

Removal

IMPORTANT: Intake runner screws are different lengths. Do not intermix the hardware.

1. Remove the manifold reference hose from the port side of the plenum and remove the MAP sensor reference hose from the starboard side of the plenum.

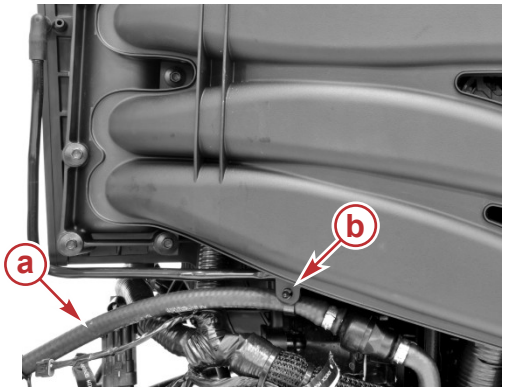


67236

Port side **Starboard side**

a - Manifold reference hose
b - MAP sensor reference hose

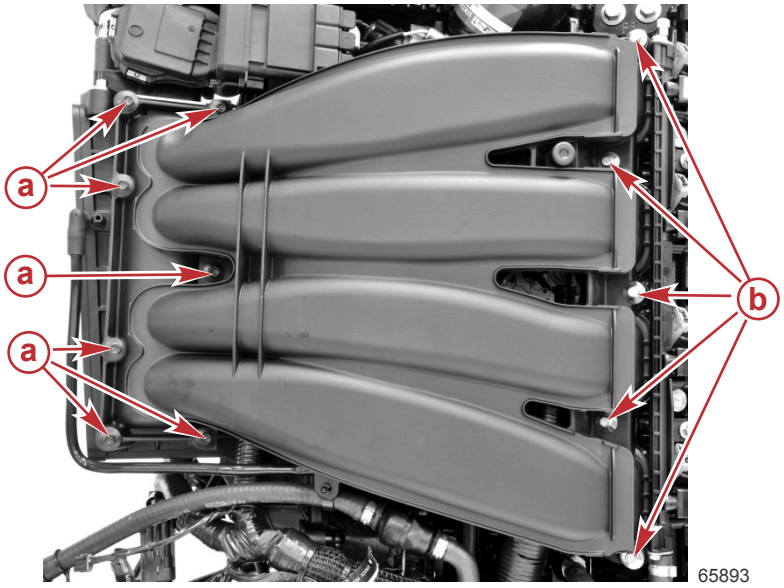
2. Remove the flush hose from the hose clip on the bottom of the port intake runner.



67297

a - Flush hose
b - Hose clip

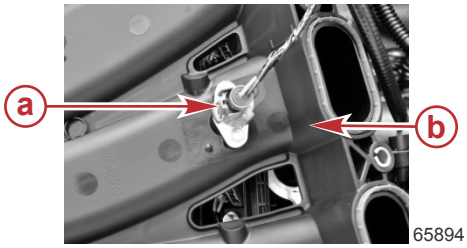
3. Remove the screws securing the intake runners to each side of the powerhead. Remove the intake runner.



65893

a - M6 x 37 screws (7 on V8 models, 5 on V6 models)
b - M6 x 30 screws (5 on V8 models, 4 on V6 models)

4. Disconnect the air temperature sensor connector from behind the starboard intake runner.

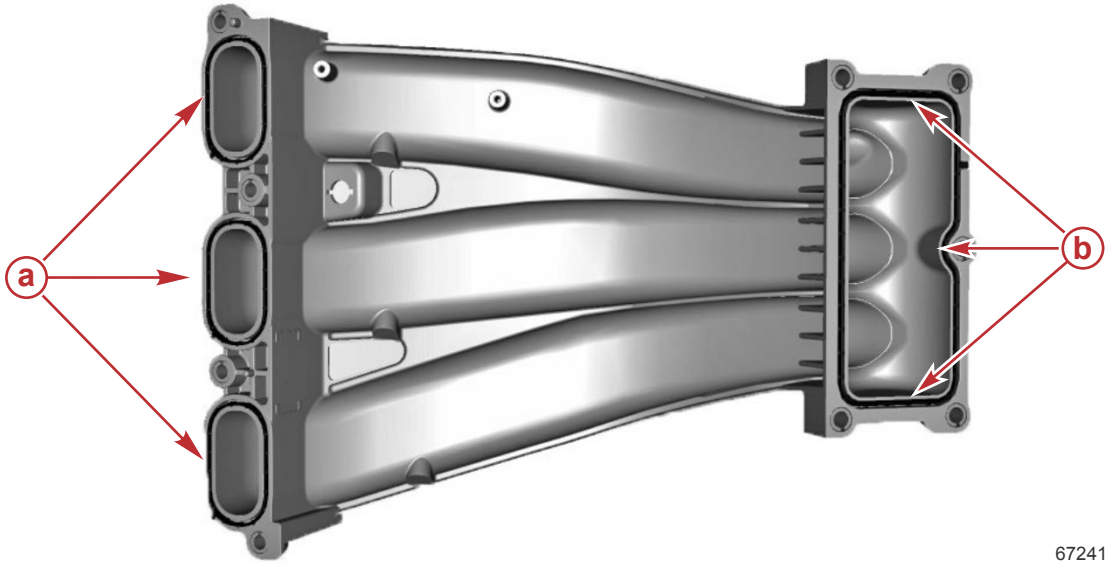


65894

a - Air temperature sensor connector
b - Starboard intake runners

V6 Intake Runner Gaskets

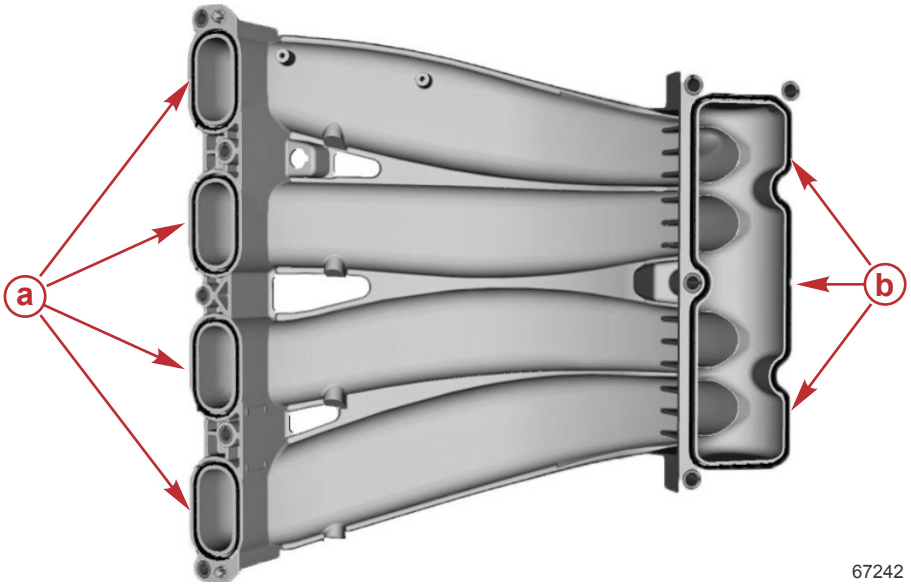
IMPORTANT: Inspect the intake runner and plenum gaskets before installing the intake runner. Ensure that each gasket is in place and that the gaskets are not damaged.



a - Gaskets (facing cylinder head)
b - Gasket (facing plenum)

V8 Intake Runner Gaskets

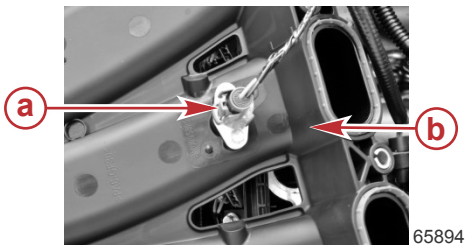
IMPORTANT: Inspect the intake runner and plenum gaskets before installing the intake runner. Ensure that each gasket is in place and that the gaskets are not damaged.



a - Gaskets (facing cylinder head)
b - Gaskets (facing plenum)

Installation

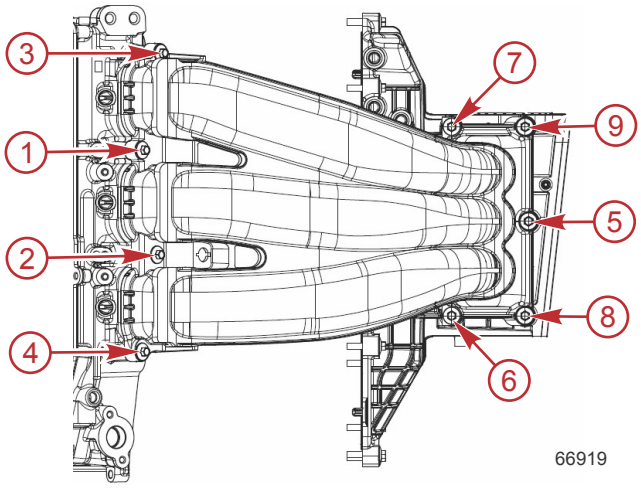
1. Plug in the manifold air temperature (MAT) sensor connector. The MAT sensor is located behind the starboard intake runner.



a - MAT sensor
b - Starboard intake runners

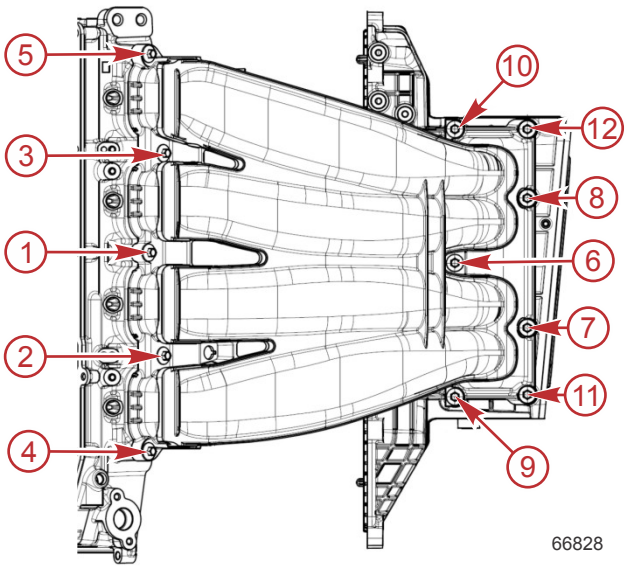
2. Install the starboard intake runner. Tighten the screws to the specified torque in the sequence shown.

IMPORTANT: Intake runner screws are different lengths. Do not intermix the hardware.



V6 starboard intake runner

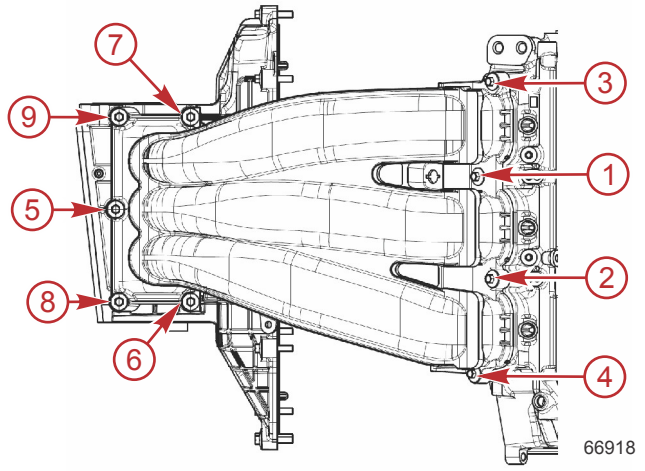
Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–4)	10	88.5	–
M6 x 37 screws (5–9)	10	88.5	–



V8 starboard intake runner

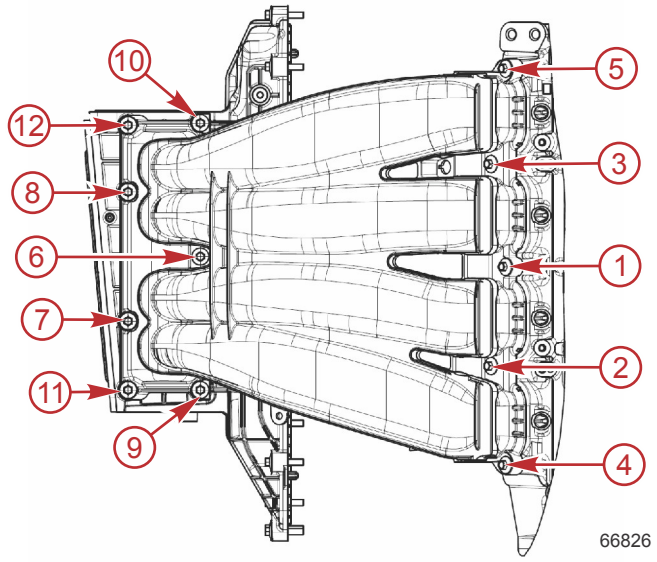
Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–5)	10	88.5	–
M6 x 37 screws (6–12)	10	88.5	–

3. Install the port intake runner. Tighten the screws to the specified torque in the sequence shown.
IMPORTANT: Intake runner screws are different lengths. Do not intermix the hardware.



V6 port intake runner

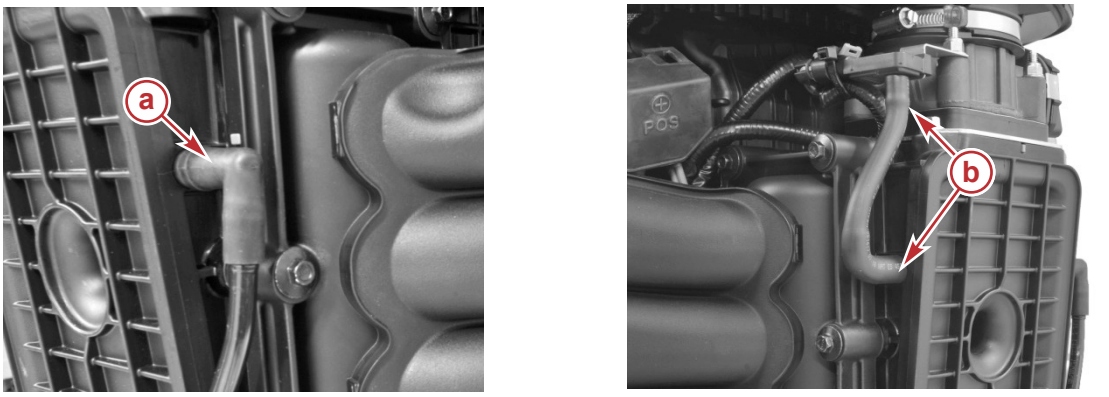
Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–4)	10	88.5	–
M6 x 37 screws (5–9)	10	88.5	–



V8 port intake runner

Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–5)	10	88.5	–
M6 x 37 screws (6–12)	10	88.5	–

4. Connect the manifold reference hose to the port side of the plenum and connect the MAP sensor reference hose to the bottom of the MAP sensor and starboard side of the plenum.

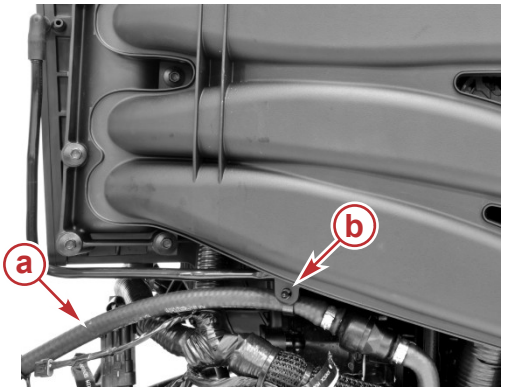


67236

Port side **Starboard side**

a - Manifold reference hose
b - MAP sensor reference hose

5. Secure the flush hose to the hose clip on the bottom of the port intake runner.



67297

a - Flush hose
b - Hose clip

Intake Plenum

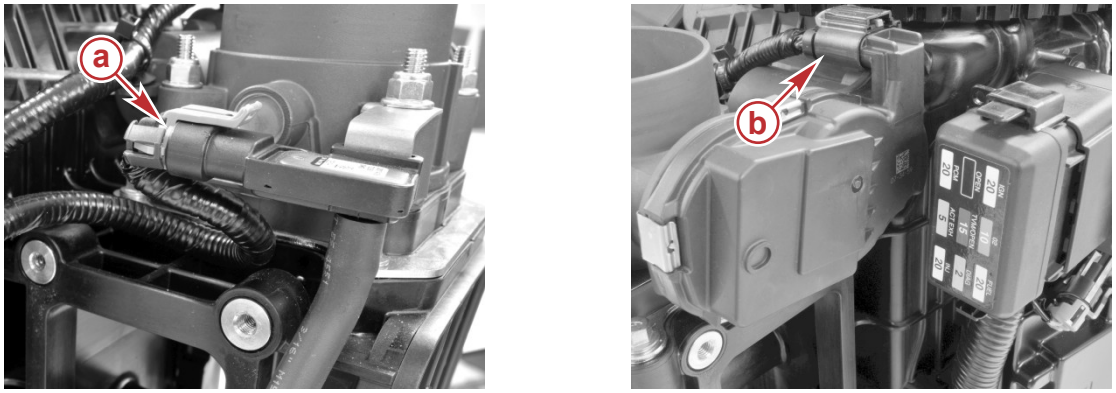
Removal

⚠ 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 motor starting. Always disconnect the battery cables from the battery before maintaining, servicing, installing, or removing motor components.

1. Remove the lower engine cowl. Refer to **Section 5C - Upper and Lower Cowls**.
2. Remove the intake runners. Refer to **Intake Runners**.
3. Remove the flywheel. Refer to **Section 2A - Ignition**.

4. Disconnect the MAP sensor connector and disconnect the ETC connector.



67177

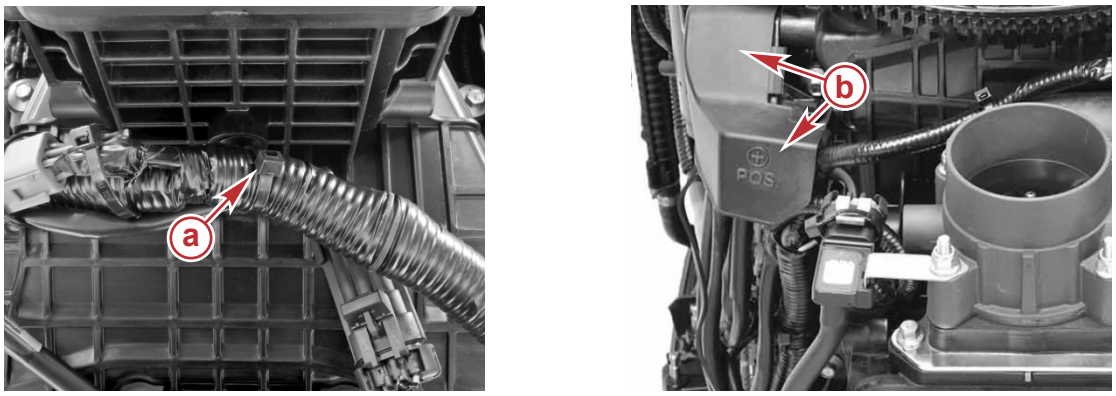
a - MAP sensor connector
b - ETC connector

5. Cut the wiring harness cable tie on the starboard side of the plenum and cut the wiring harness cable tie on the port side of the plenum.

67173

a - Cable tie—starboard side
b - Cable tie—port side

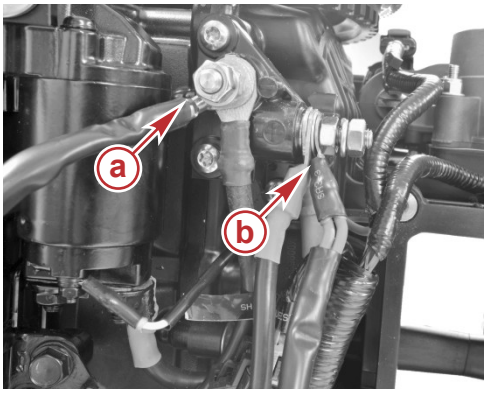
6. Cut the cable tie securing the wiring harness to the bottom of the intake plenum.
7. Remove the battery cable connection bracket cover.

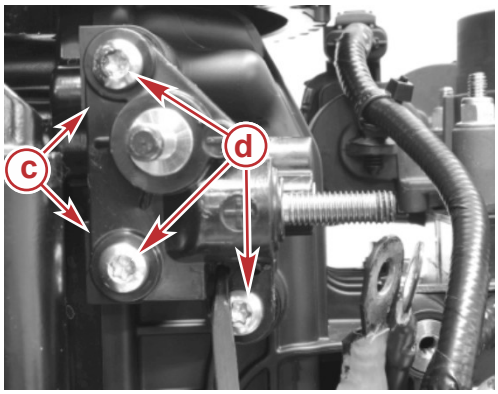


a - Cable tie
b - Battery cable connection bracket cover

8. Remove the positive and negative battery cables from their terminals, or loosen the terminal nuts sufficiently to access the three stud bracket T30 Torx® retaining screws.

9. Remove the battery cable stud bracket from the plenum.



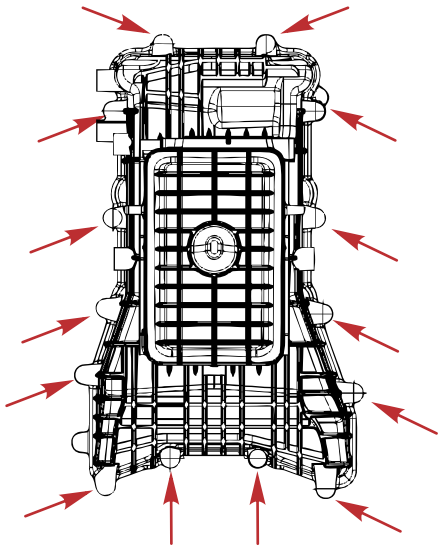


67183

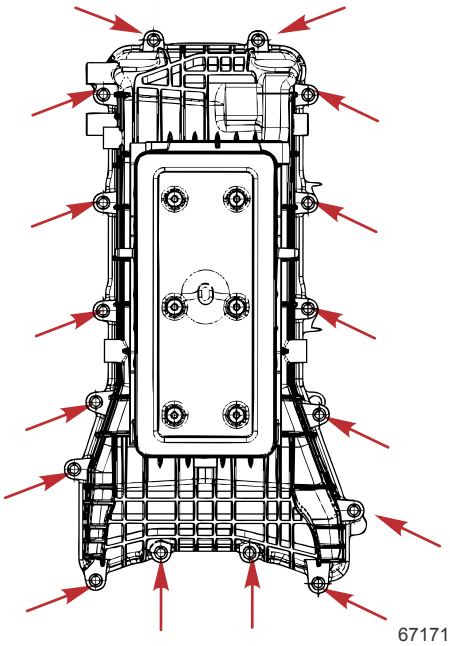
a - Negative battery terminal
b - Positive battery terminal
c - Battery cable stud bracket
d - T30 Torx® retaining screws (3)

NOTE: *The intake plenum and throttle body can be removed as an assembly.*

10. Remove the intake plenum screws and remove the intake plenum. Inspect the rubber plenum gasket for damage.



V6 intake plenum screws

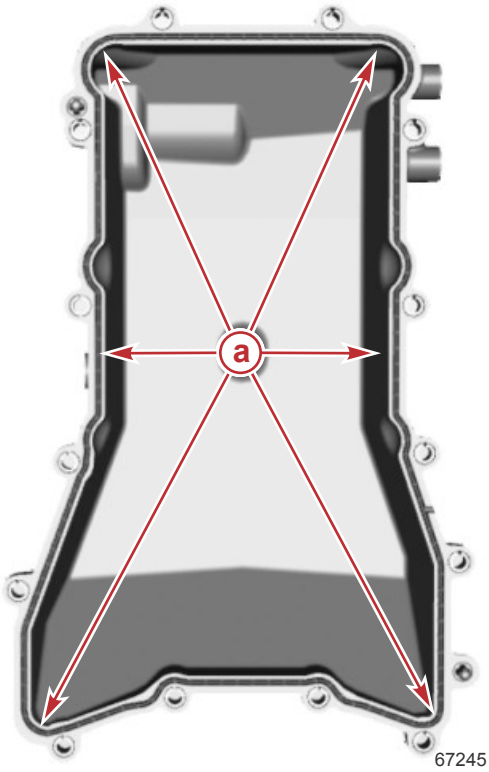


67171

V8 intake plenum screws

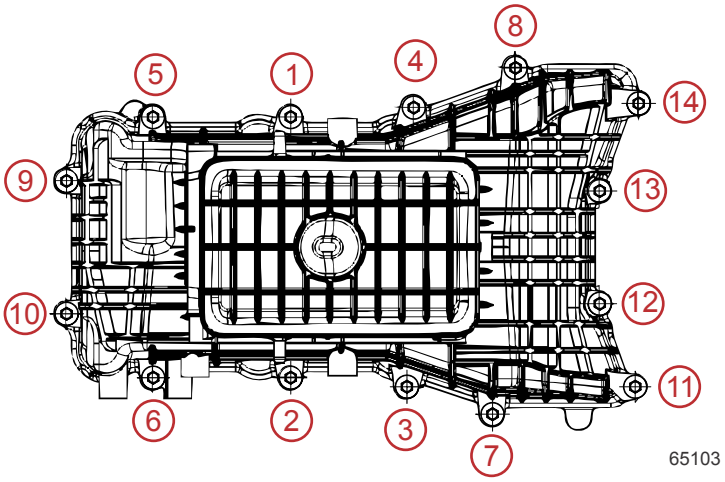
Plenum Installation

1. Inspect the intake plenum gasket. Replace the gasket if damage is found.

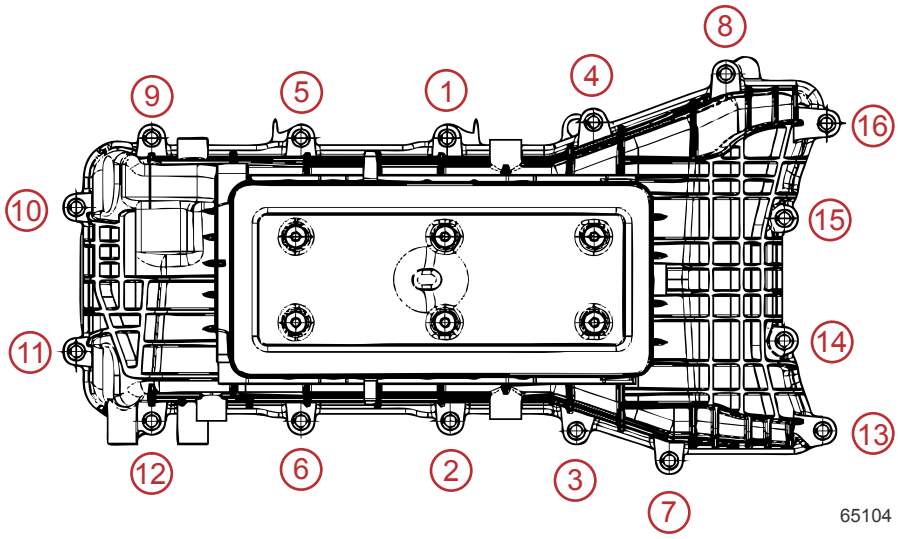


a - Gasket

2. Place the intake plenum onto the cylinder block and apply Loctite 242 Threadlocker to the intake plenum screws. Tighten the screws to the specified torque in the sequence shown.



V6 intake plenum torque sequence

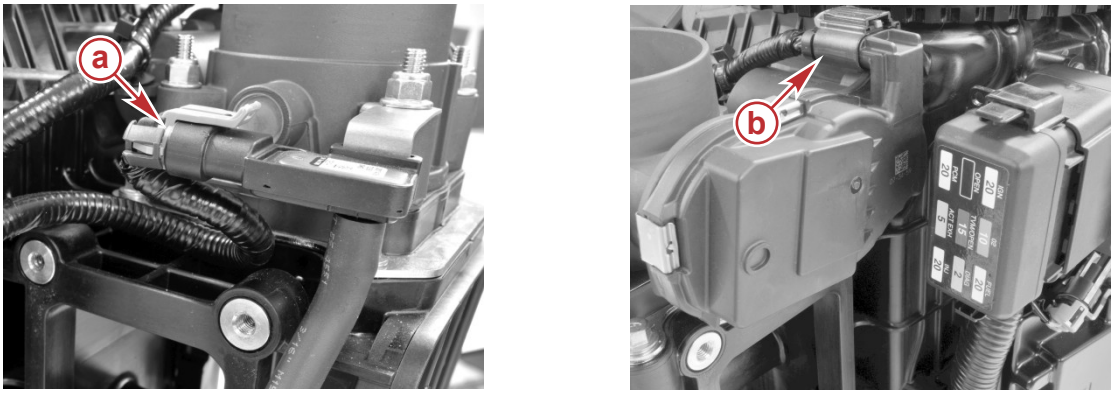


V8 intake plenum torque sequence

Description	Nm	lb-in.	lb-ft
Intake plenum screws (M6 x 1 x 30)	10	88.5	–

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Intake plenum screws	92-809821

3. Connect the MAP sensor connector and ETC connector.



a - MAP sensor connector
b - ETC connector

4. Secure the wiring harness to the plenum with cable ties on the port and starboard sides of the plenum.

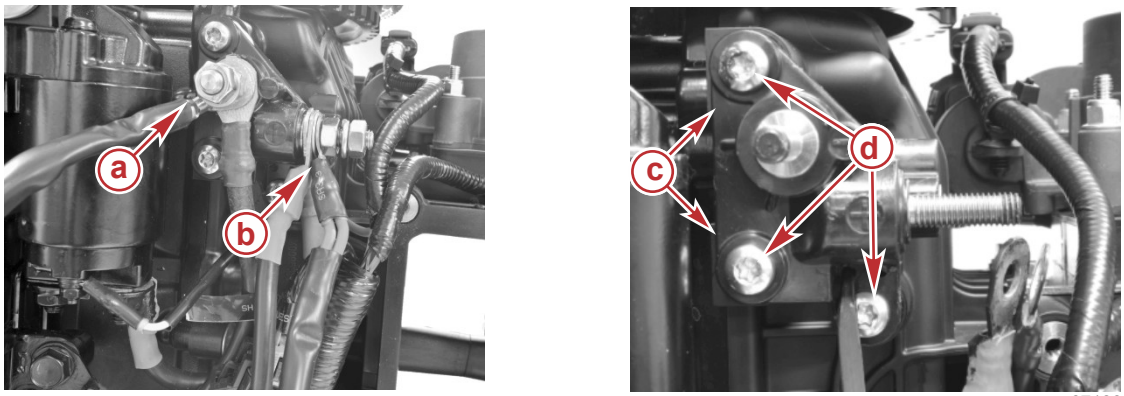
67173

a - Cable tie—starboard side
b - Cable tie—port side

5. Install the battery cable stud bracket to the plenum and tighten the three T30 Torx® retaining screws to the specified torque.

Description	Nm	lb-in.	lb-ft
T30 Torx retaining screws	10	88.5	–

6. If removed, install the battery cables onto the terminals according to the following table. Tighten the nuts to the specified torque. Cover the connections with Liquid Neoprene.



67183

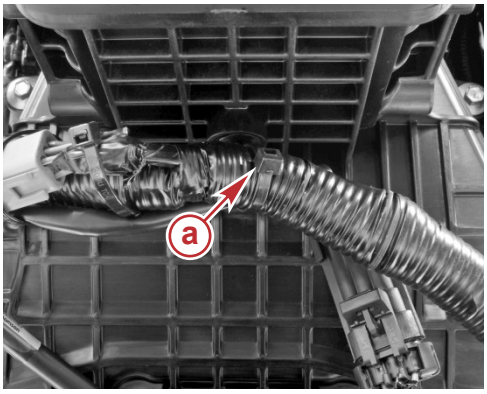
a - Negative battery terminal
b - Positive battery terminal
c - Battery cable stud bracket
d - T30 Torx® retaining screws (3)

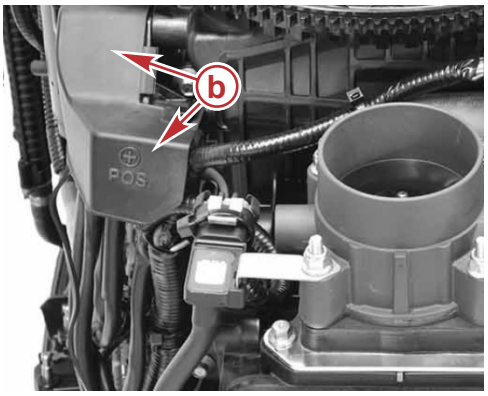
Installation Order	Positive (+) Battery Terminal Connections	Negative (–) Battery Terminal Connections
1st	Starter positive (+) cable	Starter ground (–)
2nd	Alternator fusible link	Relay ground (–)
3rd	Positive (+) ring terminal to relays	Negative (–) battery cable
4th	Postive (+) battery cable	–

Description	Nm	lb-in.	lb-ft
Battery cable nuts	17	150.5	–

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

7. Place the battery cable connection bracket cover over the terminal connections and secure the wiring harness to the bottom of the plenum with a cable tie.





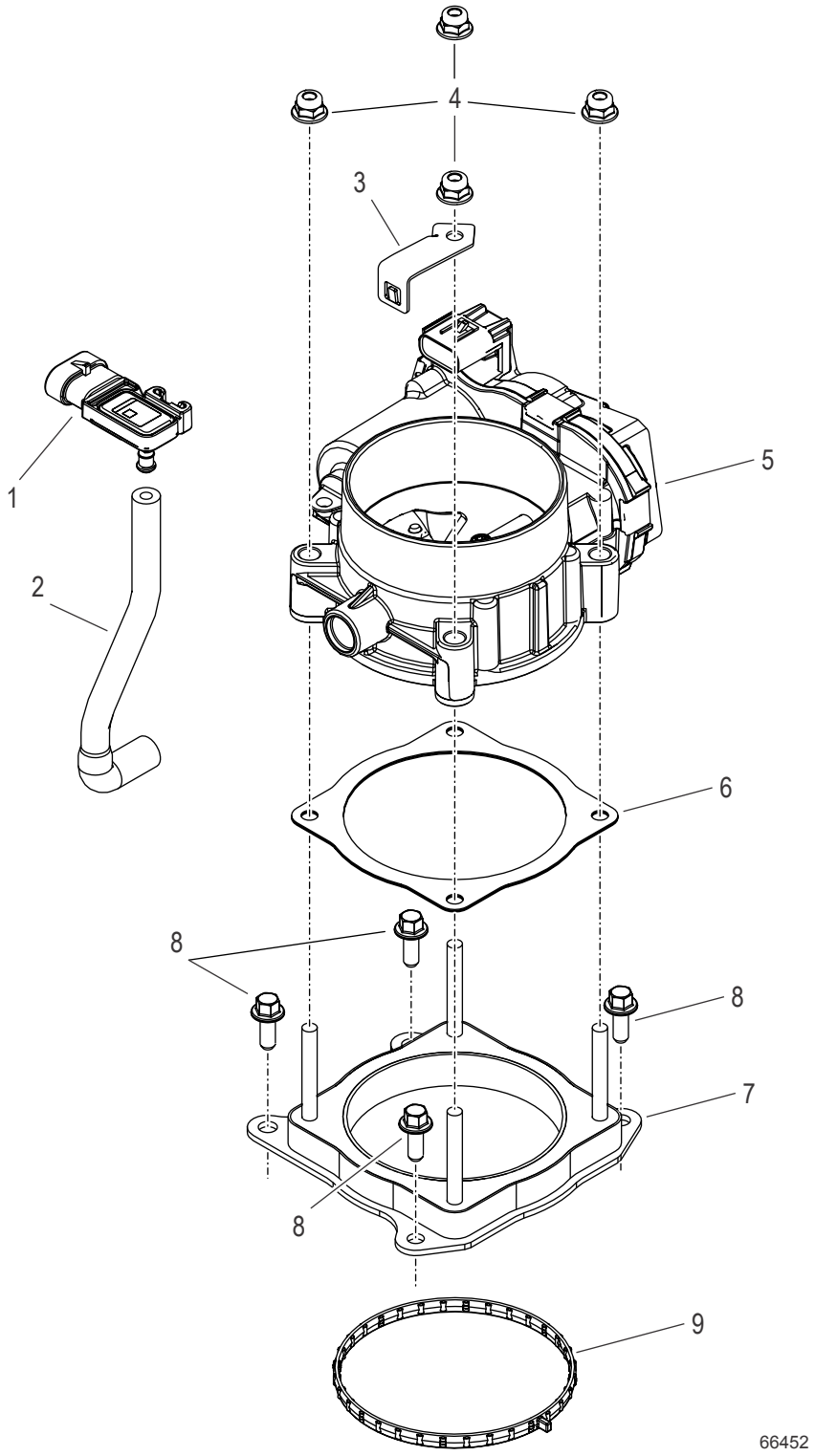
a - Cable tie
b - Battery cable connection bracket cover

8. Install the intake runners. Refer to **Intake Runners**.
9. Install the lower engine cowl. Refer to **Section 5C - Upper and Lower Cowls**.
10. Install the flywheel. Refer to **Section 2A - Ignition**.

Notes:

Throttle Body

Throttle Body Components

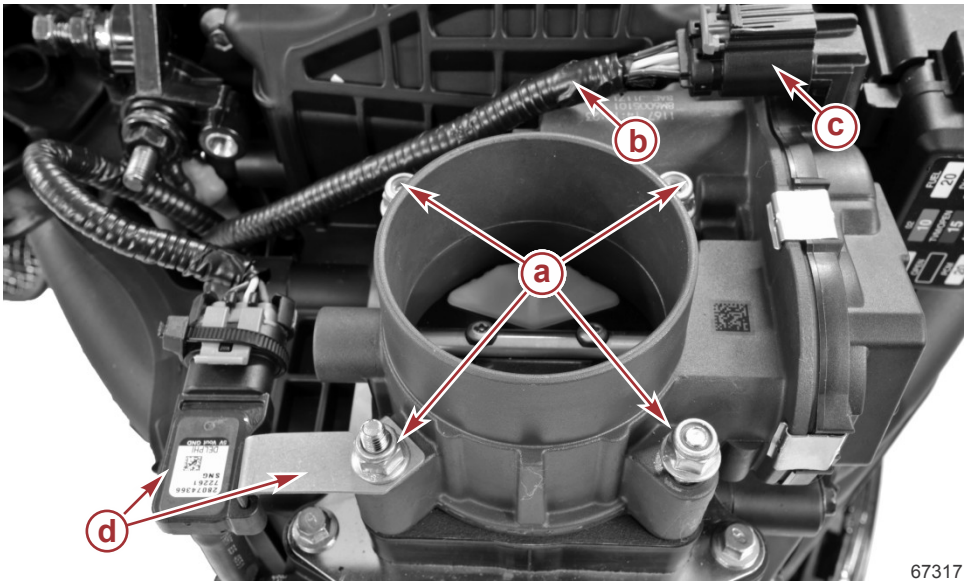


Throttle Body Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Manifold absolute pressure (MAP) sensor			
2	1	MAP sensor hose			
3	1	MAP sensor bracket			
4	4	M6 flange head locknut	7	62	–
5	1	Throttle body assembly			
6	1	Throttle body gasket			
7	1	Isolator assembly			
8	4	M6 x 16 hex flange head screw	10	88.5	–
9	1	Gasket			

Throttle Body Assembly Removal

1. Remove the cold air intake assembly. Refer to **Induction Components**.
2. Remove the flywheel. Refer to **Section 2A - Ignition**.
3. Disconnect the electronic throttle control (ETC) connector from the ETC by sliding the locking tab to release the connector.
4. Cut the cable tie that secures the engine harness to the throttle body assembly and move the harness connector out of the way.
5. Remove the four M6 flange head locknuts that secure the throttle body assembly to the isolator assembly.

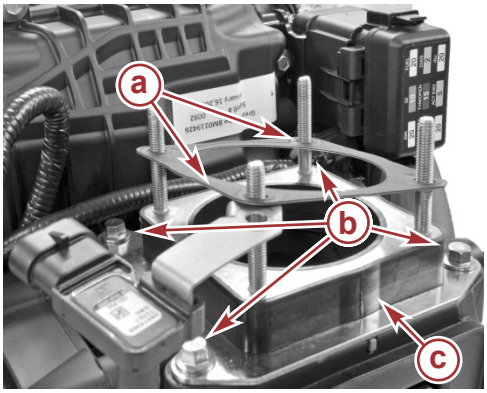


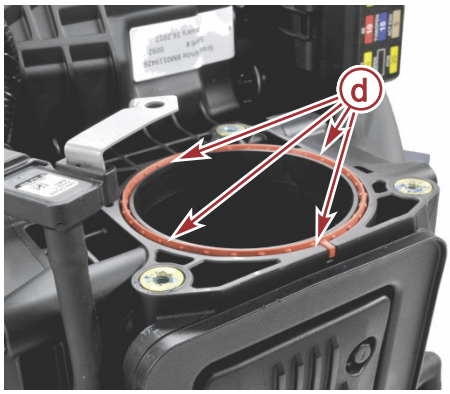
67317

Throttle body and ETC assembly

- **a -** M6 flange head locknuts
- **b -** Cable tie
- **c -** ETC connector
- **d -** MAP sensor and bracket

6. Remove the manifold absolute pressure (MAP) sensor bracket and MAP sensor from the throttle body assembly.
7. Lift the throttle body and ETC assembly off of the isolator studs.
8. Remove the four M6 x 16 isolator hex flange screws and the throttle body gasket.





67320

- **a -** Throttle body gasket
- **b -** M6 x 16 isolator hex flange screws (4)
- **c -** Isolator
- **d -** Isolator base gasket

9. Discard the throttle body gasket.
10. Lift the isolator base off of the plenum.
11. Inspect the isolator base gasket for damage. Discard the isolator base gasket if it is damaged.

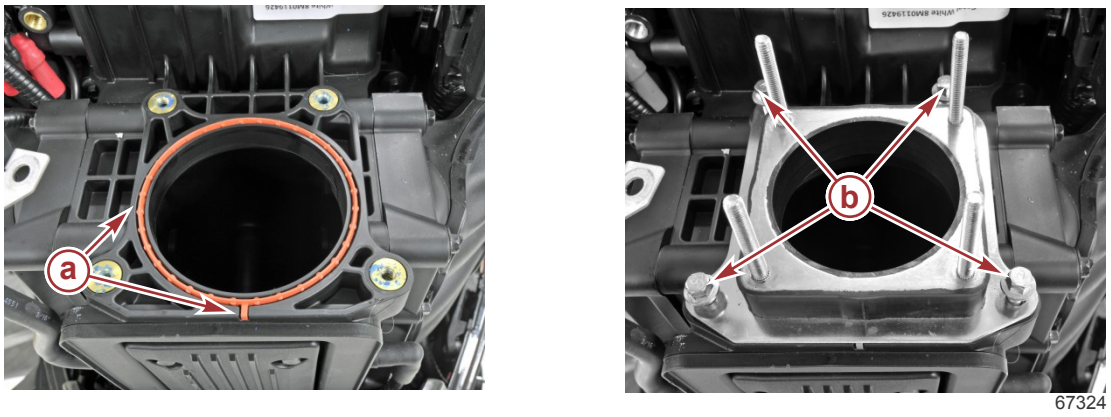
Throttle Body Assembly Installation

1. Ensure that the isolator base gasket is seated in the plenum groove in the correct orientation and lower the isolator onto the plenum.
2. Apply Loctite 242 Threadlocker to four M6 x 16 hex flange screws.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange screws	92-809821

3. Secure the isolator with four M6 x 16 hex flange screws, and tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M6 x 16 hex flange screw	10	88.5	–

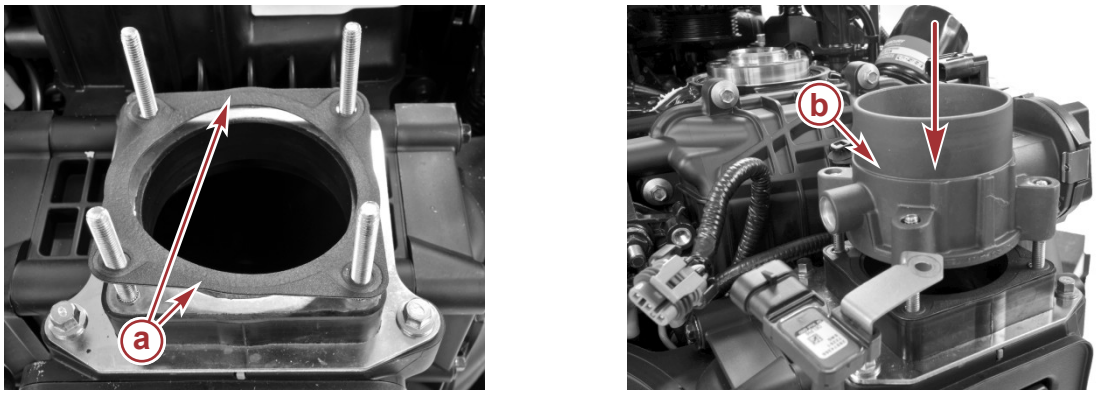


67324

Isolator and base gasket

a - Isolator base gasket
b - M6 x 16 hex flange screw (4)

4. Place a new throttle body gasket over the studs of the isolator.
5. Lower the throttle body onto the isolator assembly.



67325

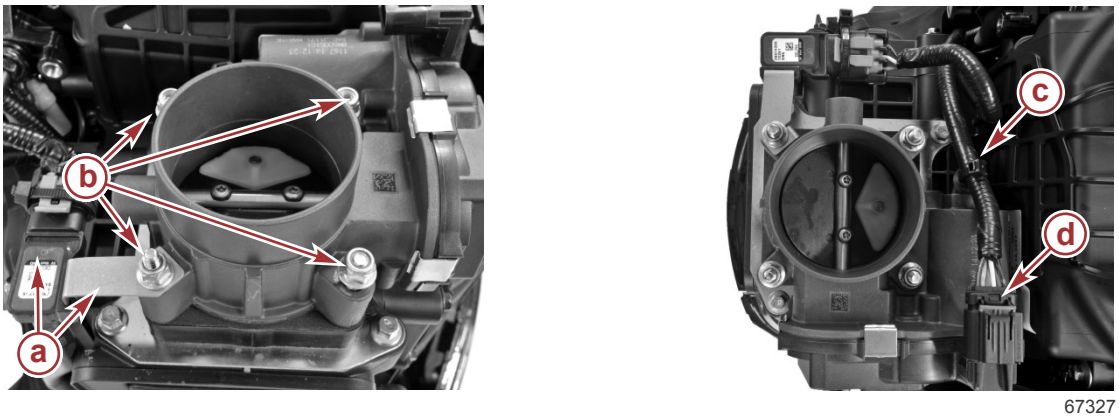
a - Throttle body gasket
b - Throttle body

6. Place the MAP sensor bracket (with MAP sensor attached) over the forward starboard stud.
7. Secure the throttle body assembly and MAP sensor bracket with four M6 flange head locknuts. Tighten the locknuts to the specified torque.

Description	Nm	lb-in.	lb-ft
M6 flange head locknut	7	62	–

8. Connect the ETC to the engine harness.
9. Use a cable tie to secure the engine harness to the cable tie anchor on the throttle body assembly.

10. Ensure that the MAP sensor is properly mounted on its bracket, that it is connected to the engine harness and secured with a cable tie, and that the MAP sensor hose is in place.



67327

a - MAP sensor and bracket
b - M6 flange head locknut (4)
c - Cable tie
d - ETC connector

11. Install the flywheel. Refer to **Section 2A - Ignition**.
12. Install the cold air intake assembly. Refer to **Induction Components**.

Fuel System

Section 3B - Service Procedures

Table of Contents

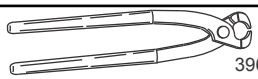
Fuel System Specifications

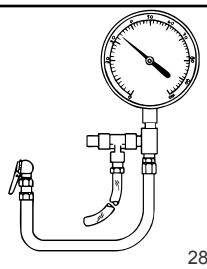
Fuel System Specifications	
Recommended fuel octane rating	87 (R+M)/2, 91 RON
Approximate fuel pressure at idle	290–340 kPa (42.1–43.9 psi)
Approximate fuel pressure engine not running	340–370 kPa (49.3–53.7 psi)
Fuel filtration	
Inlet filter, engine mounted	10 microns
Inlet filter, remote boat mounted	10 microns
High-pressure, at fuel rail inlet	46 microns
Fuel pump current draw	12 A ± 2 A (at 14.4 V)
Maximum fuel system inlet vacuum	10.16 kPa (3.0 in. Hg), (1.47 psi)

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Fuel filter grommet	92-802859A 1
		O-rings	
		Seal grommet	
		Both seal grommets	
		Fuel pressure regulator O-rings	
		O-rings and seal grommets	
136	Lubriplate SPO 255	Fuel injector O-ring, damper O-ring	Obtain Locally
		Schrader valve and fuel inlet tube O-rings	
		Fuel injector O-rings and cylinder head bores	

Special Tools

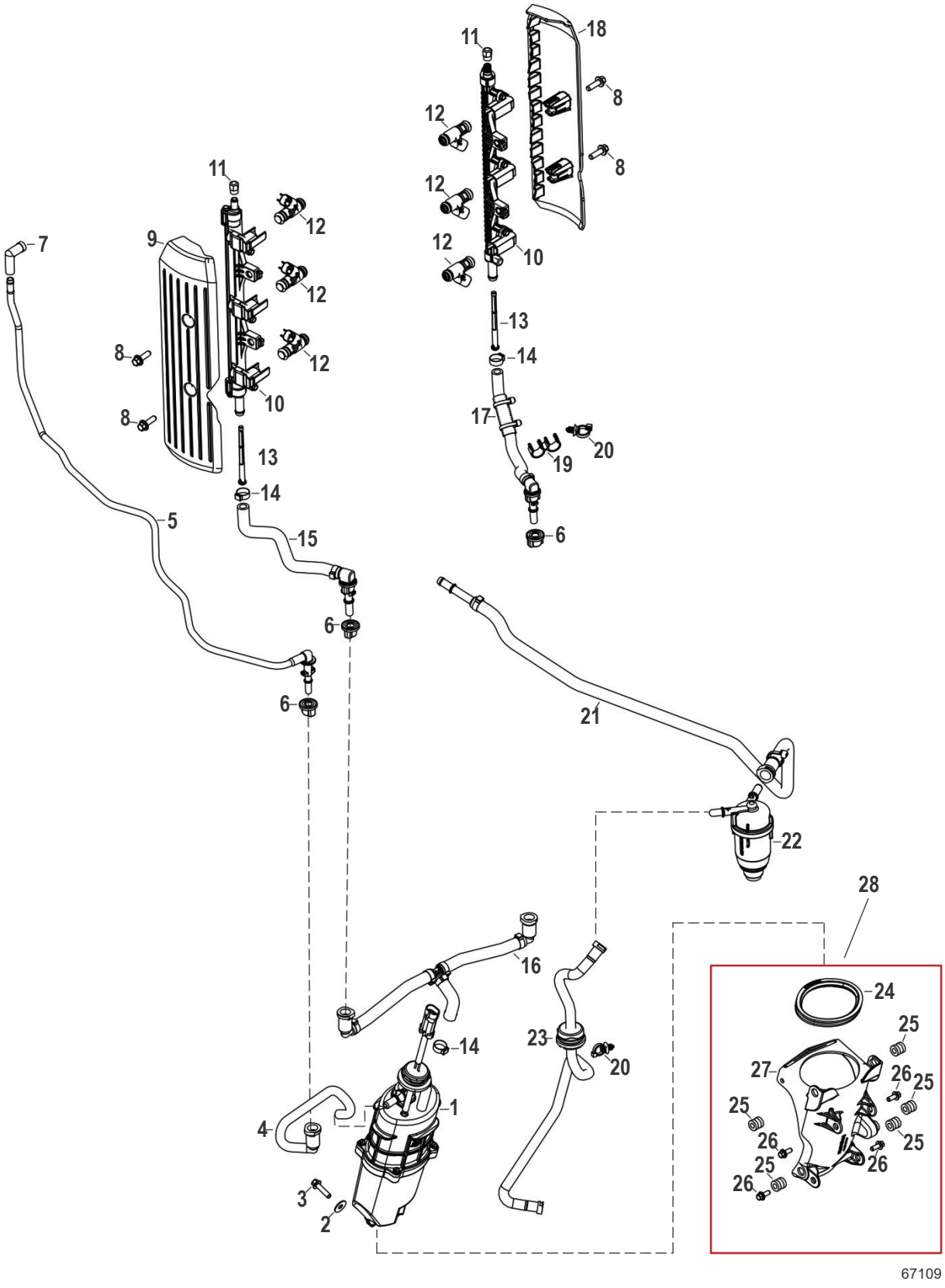
Clamp Tool	91-803146T
 39648	Used to clamp high pressure (Oetiker ®) hose clamps. Part of Clamp Tool Kit (91-803146A4).

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

Notes:

Exploded Views

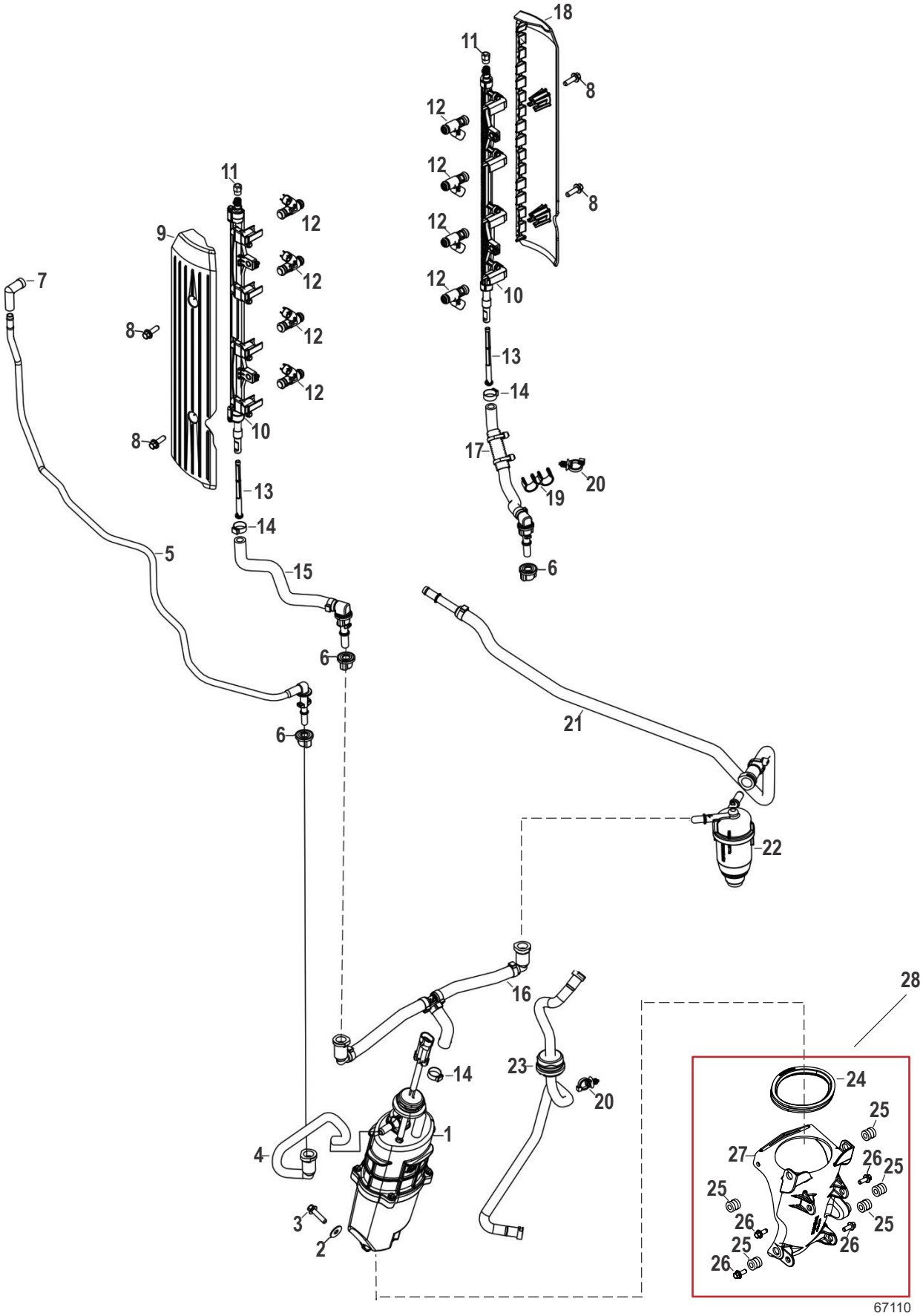
Fuel System—V6 Exploded View



Fuel System—V6 Exploded View

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Fuel supply module			
2	1	Special fastener with grommet			
3	1	Screw (M6 x 25)	10	88.5	–
4	1	Reference hose			
5	1	Reference hose (upper)			
6	3	Grommet			
7	1	Elbow			
8	4	Screw (hex flange—special)	10	88.5	–
9	1	Cover, fuel rail—port			
10	1	Fuel rail—port			
11	1	Cap			
12	6	Injector			
13	2	Filter			
14	3	Clamp			
15	1	Hose—port fuel rail			
16	2	Hose—FSM T			
17	1	Hose—starboard fuel rail with conduit			
18	1	Cover, fuel rail—starboard			
19	1	Clip			
20	2	Cable tie/retainer			
21	1	Hose—fuel inlet			
22	1	Water-separating fuel filter			
23	1	Grommet			
24	1	Grommet FSM retaining			
25	5	Grommet			
26	4	Retention pin			
27	1	FSM bracket			
28	1	FSM bracket assembly			

Fuel System—V8 CMS Exploded View



Fuel System—V8 CMS Exploded View

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Fuel supply module			
2	1	Special fastener with grommet			
3	1	Screw (M6 x 25)	10	88.5	–
4	1	Reference hose			
5	1	Reference hose (upper)			
6	3	Grommet			
7	1	Elbow			
8	4	Screw (hex flange—special)	10	88.5	–
9	1	Cover, fuel rail—port			
10	1	Fuel rail—port			
11	1	Cap			
12	8	Injector			
13	2	Filter			
14	3	Clamp			
15	1	Hose—port fuel rail			
16	2	Hose—FSM T			
17	1	Hose—starboard fuel rail with conduit			
18	1	Cover, fuel rail—starboard			
19	1	Clip			
20	2	Cable tie/retainer			
21	1	Hose—fuel inlet			
22	1	Water-separating fuel filter			
23	1	Grommet			
24	1	Grommet FSM retaining			
25	5	Grommet			
26	4	Retention pin			
27	1	FSM bracket			
28	1	FSM bracket assembly			

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

The water-separating fuel filter can be serviced as a general maintenance item when the water-in-fuel alarm is activated.

⚠ WARNING

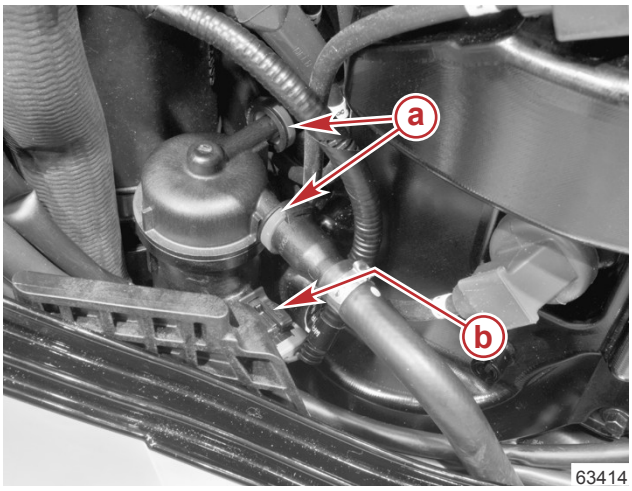
Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for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

Removal

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 container.

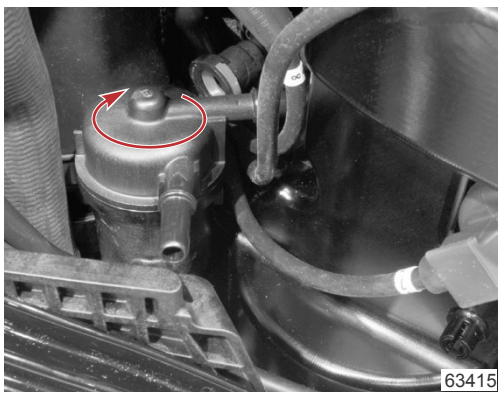
1. Verify the ignition key switch is in the OFF position and that the lanyard switch is positioned so the engine cannot start.
2. Remove the top cowl.
3. Locate the fuel filter on the starboard aft side of the engine near the bottom spark plug.
4. Push in on the fuel hose release tabs and disconnect the fuel hoses from the fuel filter.
5. Disconnect the water-in-fuel sensor harness.

   NOTE: *If there is a boat mounted water-separating fuel filter with a water-in-fuel sensor installed, the sensor harness would be connected to the boat mounted filter.*



a - Fuel hose release tabs
b - Water-in-fuel sensor harness

6. Rotate the filter clockwise approximately 1/4 of a turn and lift the filter out.



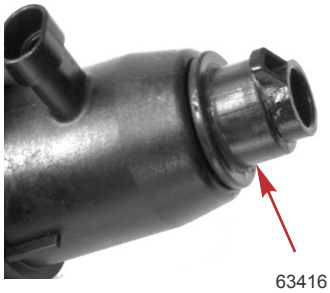
Filter rotated 1/4 turn

7. Empty the fuel filter contents into an approved container and dispose according to local regulations.

8. Wipe up any spilled fuel.

Installation

1. Apply a small amount of 2-4-C with PTFE to the fuel filter grommet.



63416

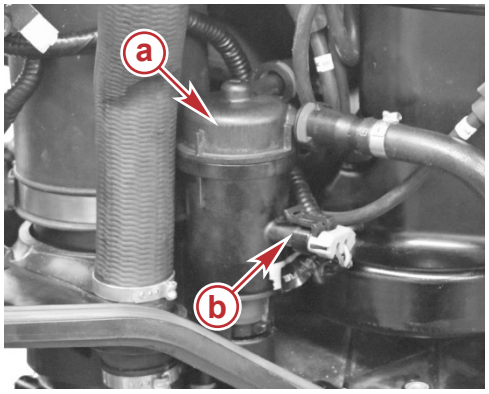
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Fuel filter grommet	92-802859A 1

2. Install the fuel filter and rotate counterclockwise 1/4 turn to retain the filter.
3. Connect the water-in-fuel sensor harness.

   NOTE: *If there is a boat mounted water-separating fuel filter with a water-in-fuel sensor installed, the sensor harness would be connected to the boat mounted filter.*
4. Connect the fuel hoses to the fuel filter securely with the locking hose connections.
5. Turn the key to the RUN position and inspect for fuel leaks. Repair any fuel leaks if necessary.
6. Install the top cowl.

Water-in-Fuel (WIF) Sensor

The water-separating fuel filter has a WIF sensor in it.



65106

a - Water-separating fuel filter
b - WIF sensor connector (engine)
c - WIF sensor connector (vessel mounted water-separating fuel filter)

IMPORTANT: The engine mounted water-separating fuel filter WIF sensor is not replaceable as an individual component. It must be replaced as part of the fuel filter assembly. SeaPro models are equipped with a vessel mounted water-separating fuel filter that has a WIF sensor located on the filter drain knob. The engine mounted WIF sensor on SeaPro models is disconnected and is not used. Refer to Water-Separating Fuel Filter and Vessel Mounted Water-Separating Fuel Filter for filter assembly replacement procedures.

Vessel Mounted Water-Separating Fuel Filter

Maintenance

⚠ WARNING

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

Always check for fuel leakage after replacing the filter assembly.

Frequency of water draining or filter assembly replacement is determined by contamination level in the fuel. Inspect or service the collection bowl for water daily. Replace the filter assembly at least once a year or if a loss of power is noticed.

To Drain Water

IMPORTANT: Draining the filter assembly may result in some fuel spillage. Use an approved container to collect fuel. Wipe up any fuel spillage immediately. Material used to contain spillage must be disposed of in an approved container.

1. Place a drain pan under the fuel filter to catch any spilled fuel.
2. Attach a 1/4 in. I.D. drain hose to the fitting on the water drain knob.
3. Open the water drain knob three turns counterclockwise to drain the collection bowl of water.
4. Close the water drain knob.
5. Run the engine to purge any air from the fuel system. Refer to **Filling the Fuel System**. Check that there are no fuel leaks.

a - Drain hose
b - Water drain knob
c - Open—counterclockwise
d - Close—clockwise

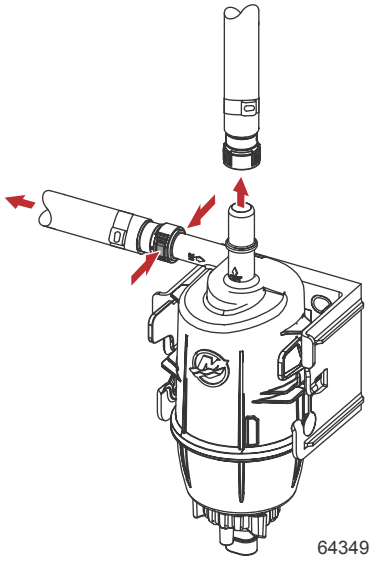
To Replace the Fuel Filter Assembly

IMPORTANT: Removing the filter assembly may result in some fuel spillage. Use an approved container to collect fuel. Wipe up any fuel spillage immediately. Material used to contain spillage must be disposed of in an approved container.

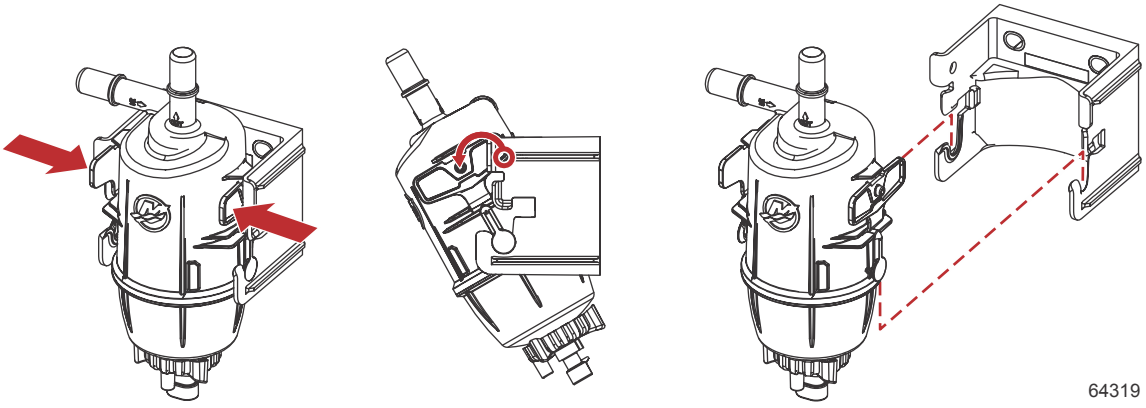
1. Disconnect the water-in-fuel sensor connector from the old fuel filter assembly.
2. Place a drain pan under the fuel filter to catch any spilled fuel.
3. Attach a 1/4 in. I.D. drain hose to the fitting on the water drain knob.
4. Open the water drain knob three turns counterclockwise to drain the fuel filter contents.
5. Close the water drain knob.
6. Remove the drain hose from the water drain knob.

a - Water-in-fuel sensor connector
b - Drain hose
c - Water drain knob
d - Open—counterclockwise
e - Close—clockwise

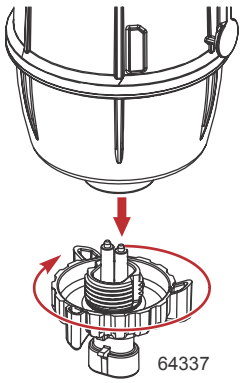
7. Disconnect the fuel hoses from the filter assembly by pressing on the fuel hose release tabs.



8. Remove the old filter assembly from the mounting bracket by pressing the fuel filter release tabs inward, tipping the filter assembly outward, and pulling the assembly out.

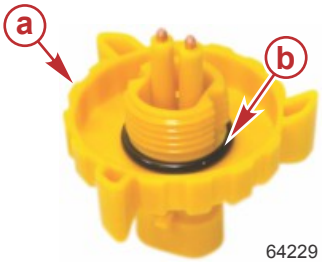


9. Remove the water drain knob from the filter assembly by turning counterclockwise. Retain the knob for reassembly on the new filter.



10. Inspect the water drain knob and O-ring for damage. Replace as needed.

IMPORTANT: The water drain knob is reusable. Retain the undamaged water drain knob for reassembly on the new filter.

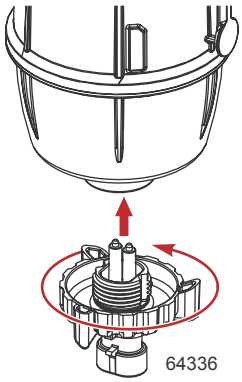


a - Water drain knob
b - O-ring

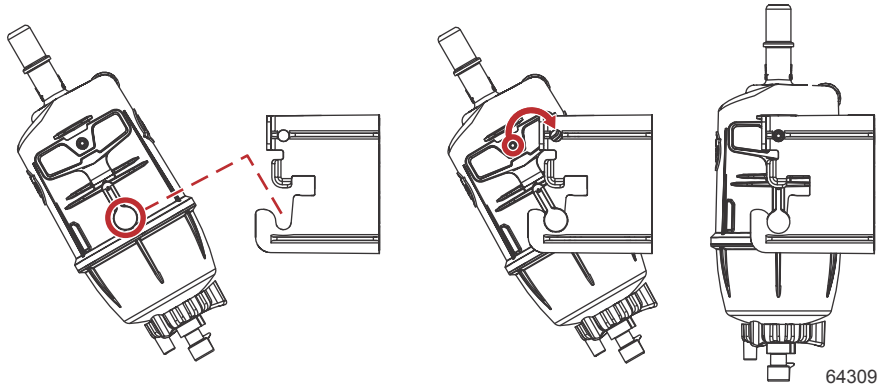
11. Empty any remaining fuel filter contents into an approved container and dispose according to local regulations.
12. Wipe up any spilled fuel.
13. Remove and discard the three plastic shipping plugs from the new fuel filter assembly.

Remove shipping plugs

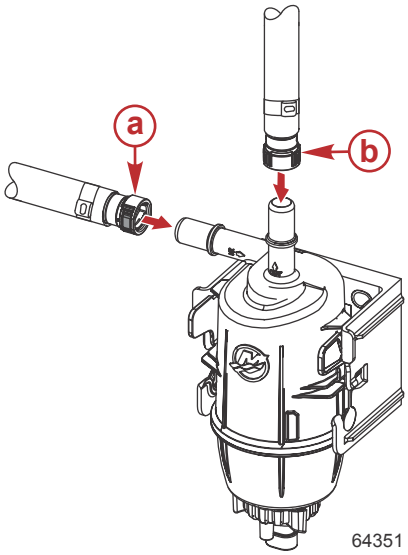
14. Install the water drain knob by turning clockwise until hand-tight.



15. Install the new fuel filter assembly into the mounting bracket.



16. Connect the fuel hoses at the top of the filter assembly. Push the inlet and outlet quick-connect fittings onto the filter until they click.



a - Fuel inlet quick-connect fitting
b - Fuel outlet quick-connect fitting

17. Install the water-in-fuel sensor connector.

a - Water-in-fuel sensor connector

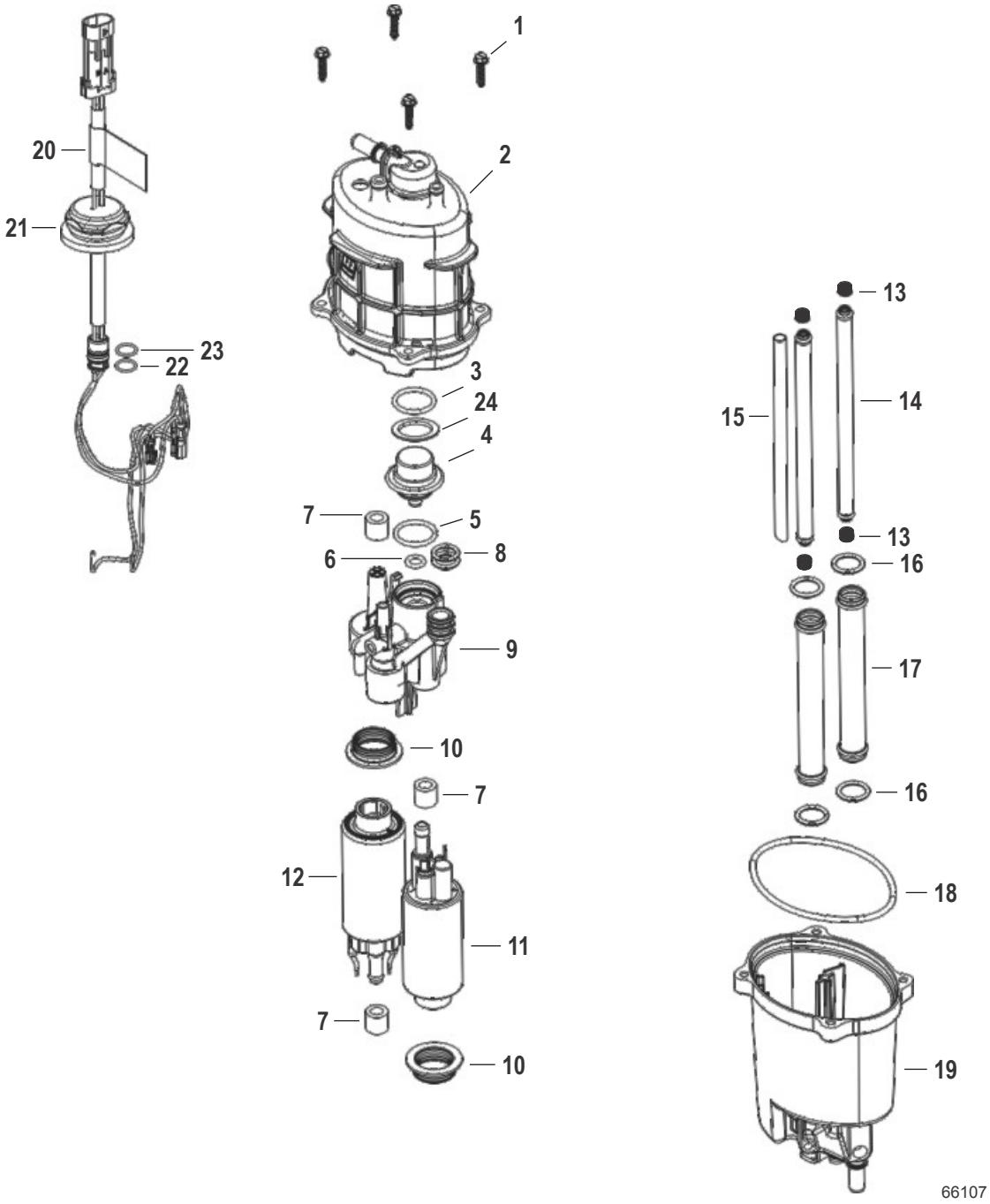
18. Run the engine to purge any air from the fuel system. Refer to **Filling the Fuel System**. Check that there are no leaks.

Filling the Fuel System

Turn the ignition key switch to the RUN position for approximately five seconds to operate the fuel pumps. Start and operate the engine to purge any remaining air from the fuel system. The engine may run rough while the air is purging through the fuel injectors. Purging air may take longer if the vessel mounted fuel filter is installed further away from the engine. Increasing the throttle during engine operation will purge air from the fuel system more quickly.

Fuel Supply Module (FSM)

Fuel Supply Module (FSM) Components



Fuel Supply Module (FSM) Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	4	Screw	10	88.5	–
2	1	FSM top housing			
3	1	O-ring			
4	1	Regulator assembly			
5	1	O-ring			
6	1	O-ring			
7	3	Seal			
8	2	O-ring			
9	1	FSM cap			
10	2	Seal			
11	1	Low-pressure pump assembly			
12	1	High-pressure pump assembly			
13	4	Seal			
14	2	Fuel tube			
15	1	Suction tube			
16	4	O-ring			
17	2	Water tube			
18	1	Seal			
19	1	FSM bottom housing			
20	1	Electrical harness assembly			
21	1	Grommet			
22	1	O-ring			
23	1	O-ring			
24	1	Spacer			

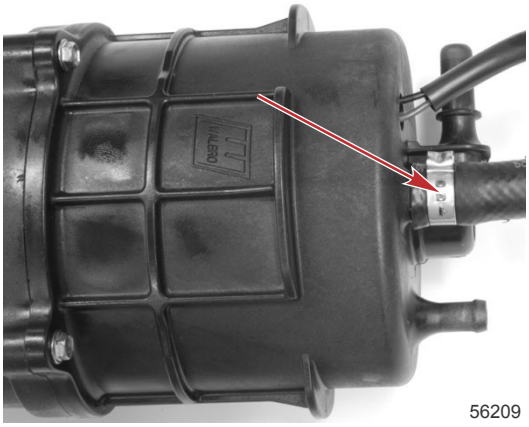
FSM Removal and Installation

Refer to **Section 5 - Midsection** for FSM removal and installation procedures.

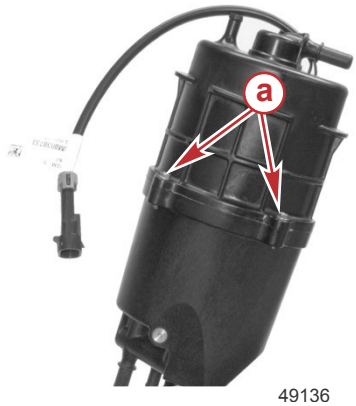
FSM Disassembly

NOTE: *The FSM cannot be completely drained of fuel prior to disassembly. Use appropriate containers to capture fuel during the disassembly process. Wipe up fuel spills immediately and dispose of in an appropriate container.*

1. Place the FSM in an appropriate container to capture any fuel that will spill.
2. Remove the metal hose clamp securing the high-pressure hose to the FSM upper housing and remove the hose.



3. Remove the four 1/4 in. hex head screws securing the upper housing to the lower housing.



a - Screws (4) 1/4 in. hex head

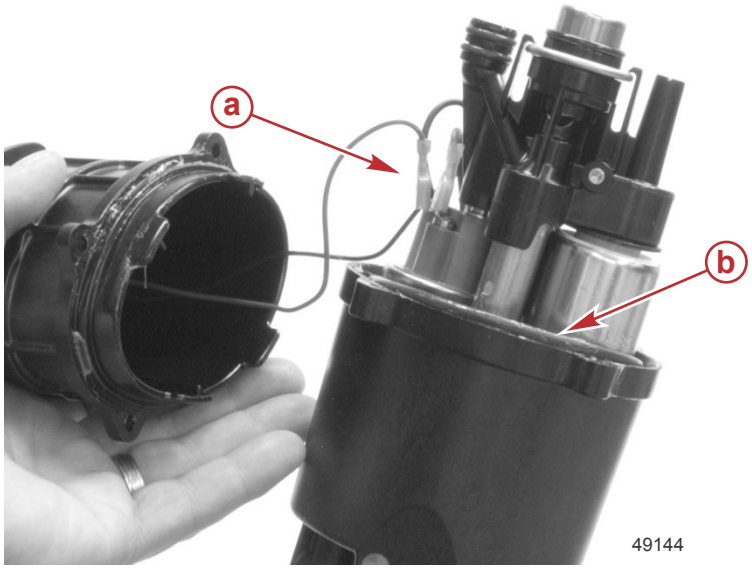
NOTE: *Use caution when separating the housing. The lower housing may be completely filled with fuel.*

4. Grasp the lower housing and the upper housing and pull the upper housing slightly to partially separate the upper housing from the lower housing. The O-ring seal is extremely tight, a putty knife or similar tool may be needed to start the separation process.

5. When a gap between the upper and lower housing is achieved insert two pry tools on opposite sides of the unit, between the upper and lower housing, and carefully separate the housing.


49141

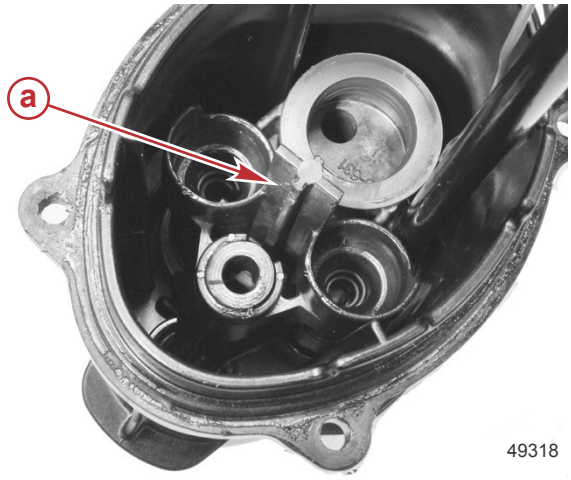
6. Carefully lift the upper housing to access the power wire connections.
7. Disconnect the upper housing power wires from the fuel pump connectors and remove the O-ring.



49144

a - Power wires
b - O-ring

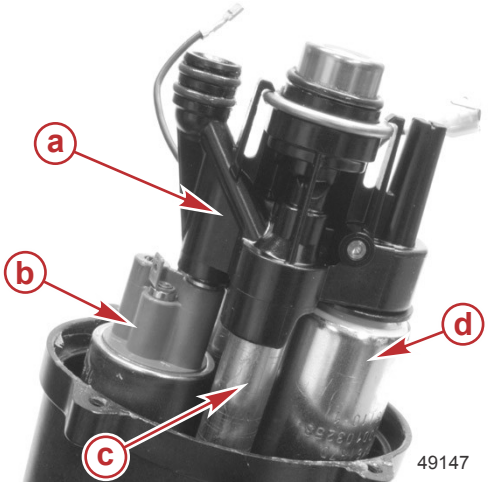
NOTE: *Some of the internal components may be adhering to the upper housing when separated. Remove the fuel pumps with an appropriate tool. Use caution not to twist the fuel pumps when removing them. Use a vice grip tool to clamp onto the manifold webbing and pull the manifold out of the upper housing.*



49318

a - Manifold webbing

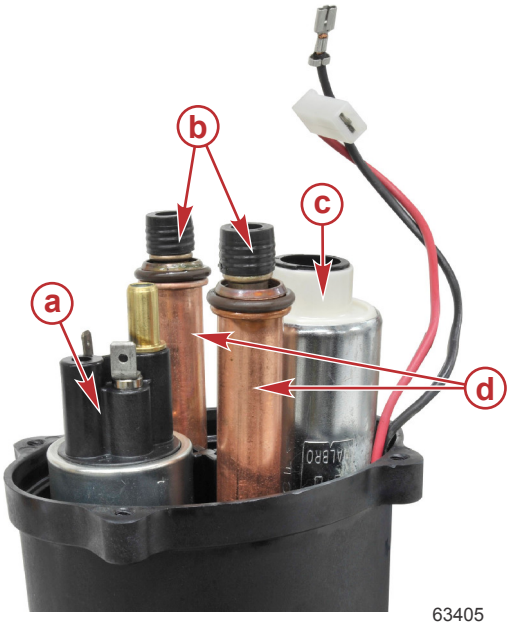
8. Remove the manifold from the tubes and fuel pumps.



- **a -** Manifold
- **b -** Fuel lift pump
- **c -** Tubes (4)
- **d -** High-pressure fuel pump

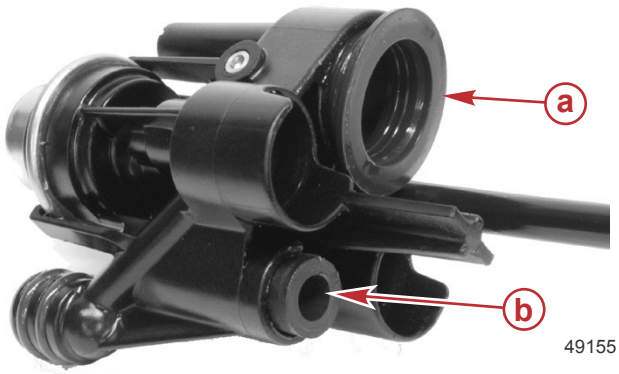
9. Remove the tubes and fuel pumps from the lower housing.

IMPORTANT: If the fuel pumps are difficult to remove, use an appropriate tool to extract them. Use caution not to twist the fuel pumps when removing.



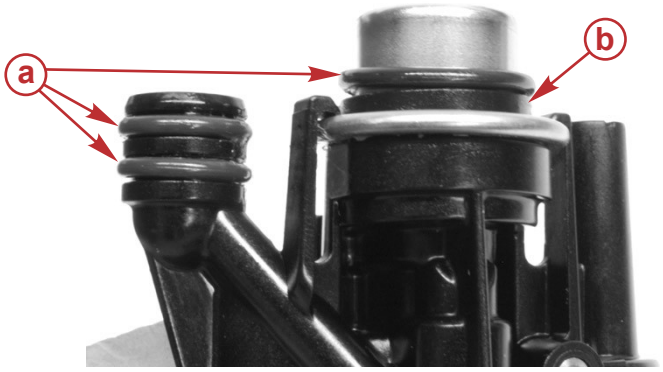
- **a -** Fuel lift pump
- **b -** Fuel tubes
- **c -** High-pressure fuel pump
- **d -** Water tubes

10. Remove the seal grommets from the manifold.



- **a -** High-pressure fuel pump seal grommet
- **b -** Fuel lift pump seal grommet

11. Remove three O-rings and a spacer from the manifold.



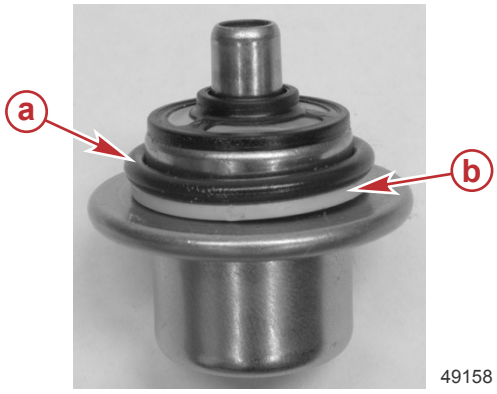
49156

a - O-rings
b - Spacer on fuel pressure regulator

12. Carefully spread the retainers and remove the fuel pressure regulator.

    IMPORTANT: Use extreme care not to spread the retainers excessively. Spreading the retainers excessively will cause the retainer to break off the manifold.

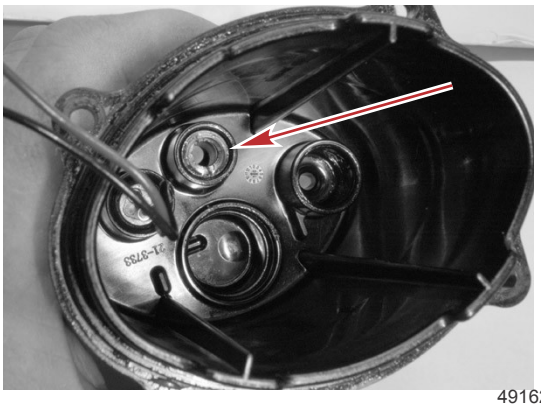
13. Remove the O-ring and spacer from the fuel pressure regulator.



49158

a - O-ring
b - Spacer

14. Inspect the inside of the upper and lower housings for seal grommets, O-rings, or seals and remove them.



49162

15. Remove the fuel pump wire harness seal grommet from the upper housing by pushing on the seal grommet from the outside of the upper housing with a blunt tool.

16. Guide the wiring through the housing.

63715

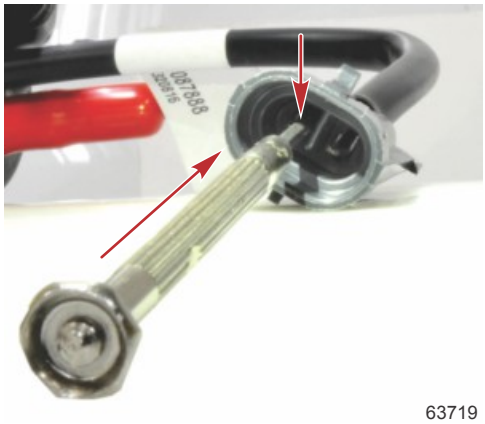
17. Remove any grommets or wire retainers from the harness.

63717

18. Remove the wire retainer from the rear of the connector.

63718

19. Using a micro screwdriver or similar tool, pry the wire pin off of the holding tab of the connector and push the wire pin free of the holding tab. Repeat for the second wire.



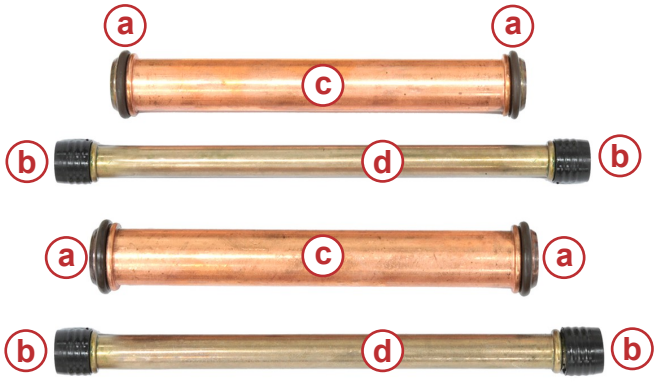
63719

20. Carefully remove the wires from the connector and remove the harness from the fuel module housing. Make a note as to the proper position of the wire colors in respect to the connector.

63720

FSM Assembly

1. Install the O-rings and seals onto the water tubes and fuel tubes.
2. Lubricate the O-rings and seals on the tubes with 2-4-C with PTFE.



63404

a - O-rings
b - Seals
c - Water tube
d - Fuel tube

3. Install the fuel tubes into the lower housing.

63410

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	O-rings	92-802859A 1

4. Install the water tubes.

63411

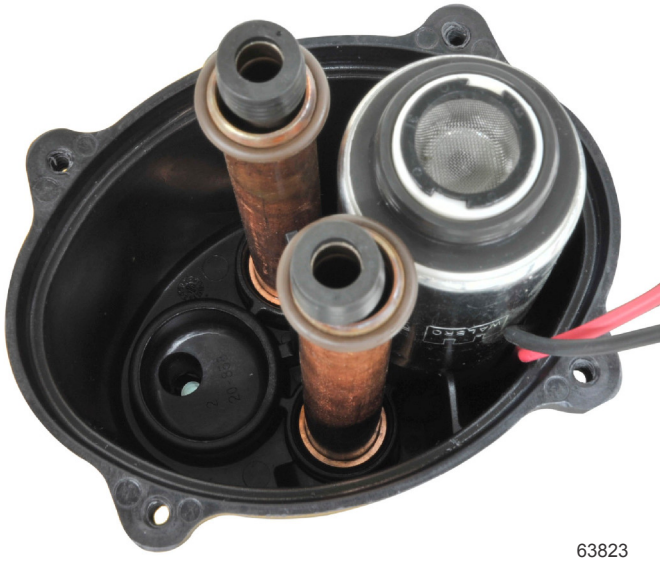
a - Water tubes
b - Fuel tubes

5. Install the seal grommet halfway onto the high-pressure fuel pump outlet. Install the bottom seal grommet on the high-pressure fuel pump.

49206

6. Lubricate the seal grommet with 2-4-C with PTFE and install the high-pressure fuel pump into the lower housing so the wires are between the fuel pump and the housing.

63822



63823

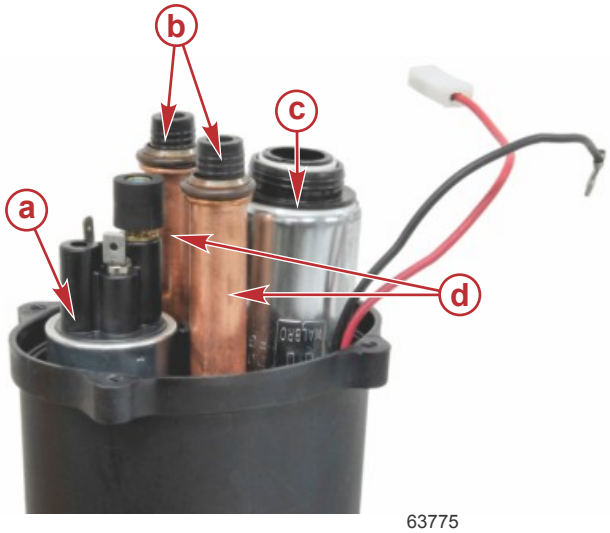
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Seal grommet	92-802859A 1

7. Install the bottom seal grommet and the outlet seal grommet halfway onto the fuel lift pump and lubricate with 2-4-C with PTFE.

63826

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Seal grommet	92-802859A 1

8. Install the fuel lift pump into the lower housing so the outlet port of the pump faces towards the center of the FSM.



63775

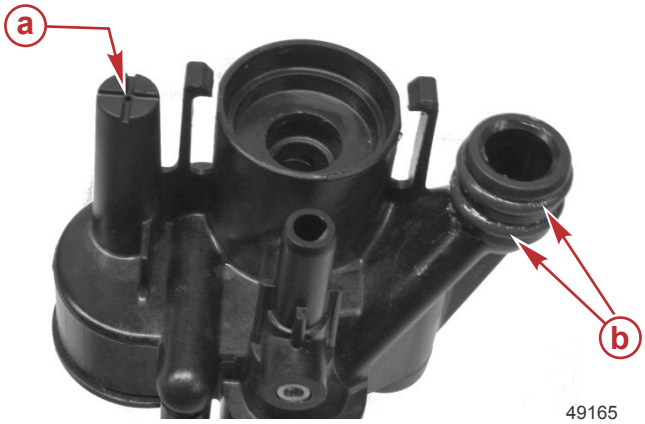
a - Fuel lift pump
b - Fuel tubes
c - High-pressure pump
d - Water tubes

9. Lubricate both seal grommets with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Both seal grommets	92-802859A 1

10. Install two O-rings onto the manifold.
11. Verify that the hole in the manifold is open and that no debris partially blocks the hole.

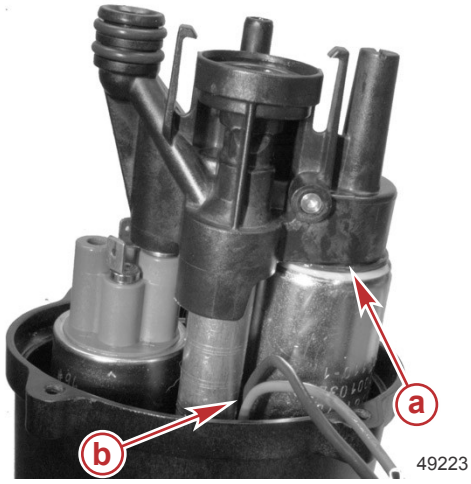
IMPORTANT: Use only appropriate solvents and compressed air to remove debris which may be blocking the hole. Do not use wire or any ridged material that may damage the hole.



49165

a - Hole in manifold
b - O-rings

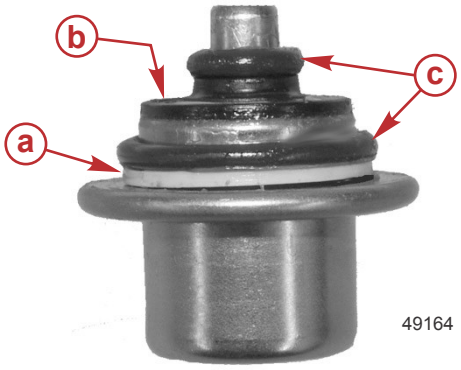
12. Carefully install the manifold while aligning the fuel pumps and tubes. Verify that the manifold is seated on the fuel pumps. Ensure that the fuel pump wires are not binding between the water tube and the fuel pump.



a - Manifold seated on fuel pump
b - Wires are not binding

13. Verify that the spacer is installed onto the fuel pressure regulator.
14. Verify that the fuel pressure regulator filter is clear of debris.

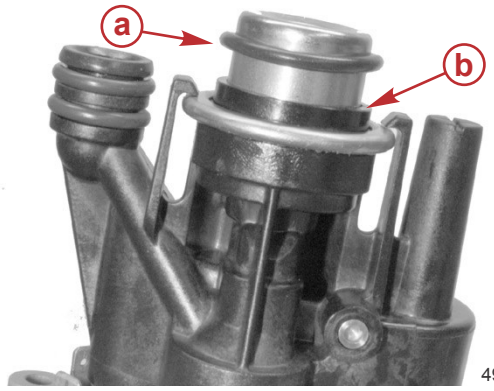
    NOTE: *The fuel pressure regulator filter is not a serviceable part, but can be cleared of debris with a mild solvent and low-pressure compressed air.*
15. Install the O-rings onto the fuel pressure regulator and lubricate them with 2-4-C with PTFE.



a - Spacer
b - Filter
c - O-rings

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Fuel pressure regulator O-rings	92-802859A 1

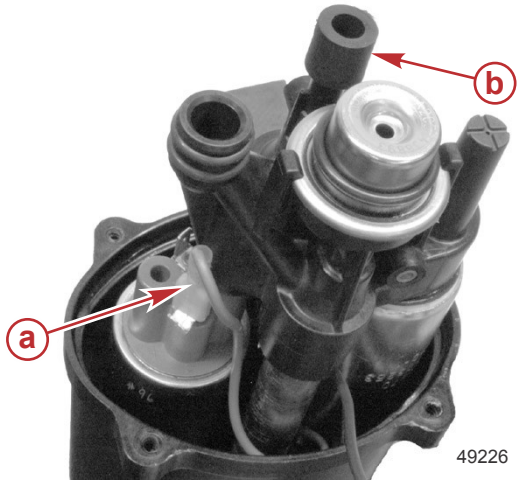
16. Install the fuel pressure regulator onto the manifold.
17. Install the spacer and O-ring onto the fuel pressure regulator.



a - O-ring
b - Spacer

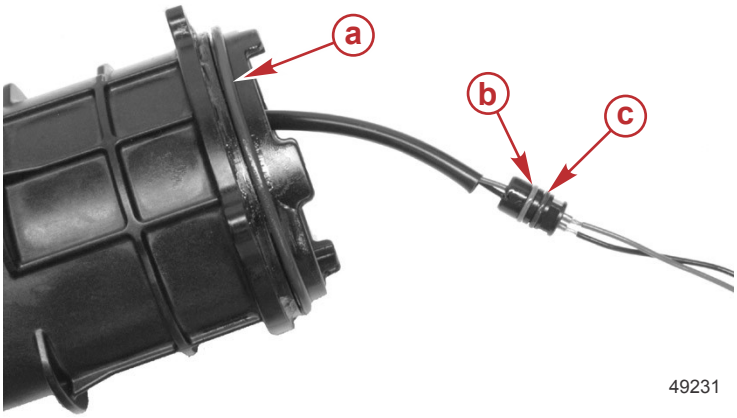
18. Install the seal grommet halfway onto the manifold.

19. Insert the red wire harness connector onto the fuel lift pump positive terminal.



a - Red wire
b - Seal grommet

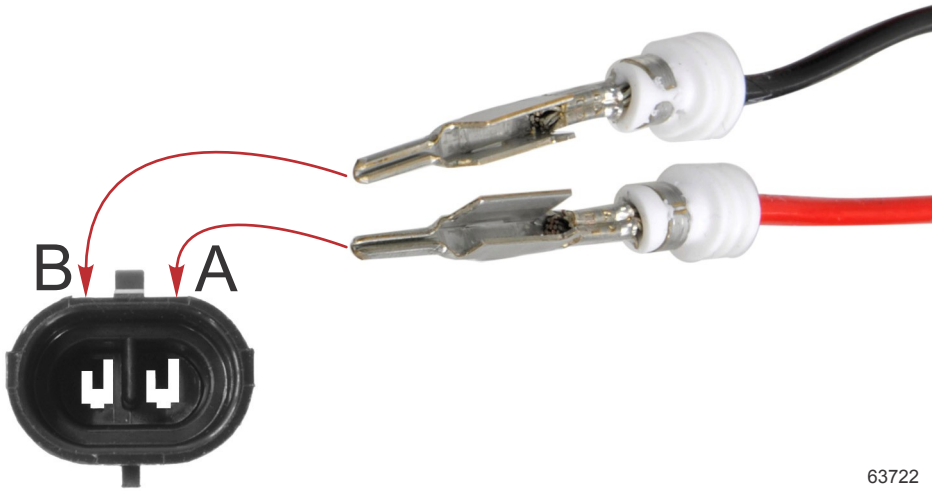
20. Install the O-ring onto the upper housing.
21. Install new O-rings onto the fuel pump wire harness seal grommet. Verify that the blue O-ring is installed on the upper groove of the seal grommet. Lubricate the O-rings with 2-4-C with PTFE.
22. Pull on the wire harness to seat the seal grommet into the upper housing. A gentle push on the seal grommet on the inside of the housing with a blunt tool will ensure it is properly seated.



a - Upper housing O-ring
b - Blue O-ring
c - Second O-ring on seal grommet

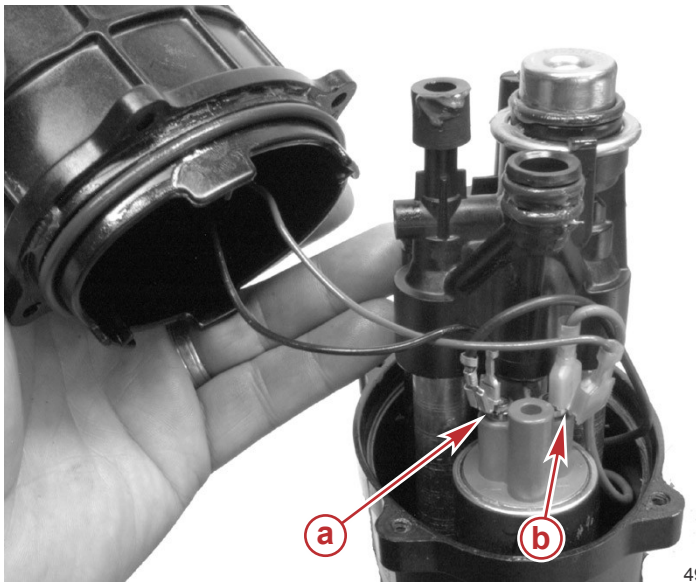
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	O-rings	92-802859A 1

23. Align the wire pins with the mounting tabs in the connector and insert the wire pins into the connector. Snap the wire retainer onto the end of the connector.



63722

24. Connect the red wire from the upper housing to the positive terminal on the fuel lift pump.
25. Connect the black wire from the upper housing to the negative terminal on the fuel lift pump.
26. Connect the high-pressure fuel pump black wire to the terminal on the fuel lift pump.
27. Lubricate all the visible O-rings and seal grommets with 2-4-C with PTFE.



49234

a - Black wires
b - Red wires

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	O-rings and seal grommets	92-802859A 1

28. Verify that the wires will not become pinched and install the upper housing.

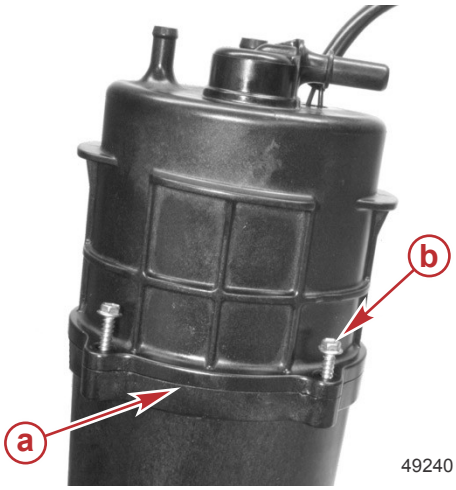
49237

29. Carefully push the upper housing into the lower housing until there is no gap between the upper and lower housing. A soft jawed bench vice and a channel lock pliers may be needed to completely squeeze the unit together.

    IMPORTANT: Do not use the screws to close the unit. This can result in stripping of the plastic bosses and cause the unit to separate.

    IMPORTANT: If the gap between the upper and lower housing cannot be closed, the wires may be pinched or a seal grommet is not properly aligned.

30. Install the screws and tighten the screws to the specified torque.

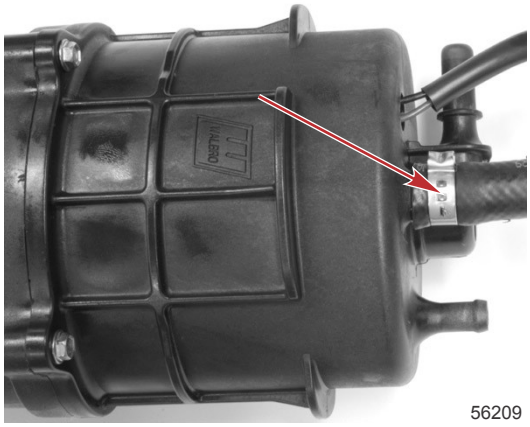


49240

a - No gap
b - Screw (4)

Description	Nm	lb-in.	lb-ft
Screw	10	88.5	–

31. Install a 16.2 mm (0.75 in.) metal hose clamp onto the high-pressure hose and install the hose onto the FSM upper housing. Use the hose clamp tool to secure the hose to the FSM.



Clamp Tool	91-803146T

Fuel Supply Module Priming Procedure

The fuel supply module (FSM) is not vented to the ambient air. The air trapped in the FSM, fuel lines, and fuel rail, will be slightly compressed during the initial ignition key "ON" with a dry or drained fuel system. Additional key "ON" events under these conditions, will not compress the air further to finish the priming of the FSM. Excessive number of key "ON" events may eventually damage the fuel pumps. The volume of air trapped in the FSM must be purged to prime the fuel system. This can be achieved by connecting a tool to the fuel rail Schrader valve fitting to quickly purge the system into an approved container, or by cranking the engine.

Priming the FSM with a Purge Tool

The use of a purge tool for priming the FSM is the preferred method, but is not always practical. The objective is to purge the air entrained in the fuel system through a purge tool connected to the fuel rail Schrader valve test port. During the key "ON," opening the dump valve will allow the air to be purged from the FSM and fuel rail. This method should be used on vessels where the fuel inlet system to the outboard is restrictive; anti-siphon valve or holds a relatively large volume of fuel because of a long fuel supply line or water separating fuel filter. If a primer bulb is installed, it can be used during the priming event to shorten the amount of time required to start the engine.

1. Verify the engine is in a level vertical position.
2. Verify the vessel fuel supply line is connected to the outboard fuel system inlet fitting.
3. Connect a fuel pressure gauge to the fuel rail Schrader valve.
4. Secure the fuel pressure gauge purge hose into an appropriate fuel container to collect excess fuel.
5. Open the fuel pressure gauge purge valve and turn the ignition key "ON." The fuel pumps will run for approximately five seconds.
6. Turn the ignition key "OFF" and then back "ON." The fuel pumps will run for approximately five seconds. Continue this ignition key cycle until the purged fuel is relatively clear of air bubbles.

   NOTE: *If the outboard fuel system does not prime within 15 key "ON" events, check for leaks in the fuel supply line to the outboard. Repair as needed. If no leak is found, the fuel supply system to the outboard may be too restrictive. Correct the condition and try again.*
7. Remove the fuel pressure gauge.
8. Turn the ignition key "ON." When the fuel pumps stop running, start the engine. The engine may not start on the first attempt. The engine will run rough at idle for up to two minutes while the residual air is purged from the fuel system.

Priming the FSM (Ran out of Fuel Condition)

The use of a purge tool for priming the FSM is the preferred method, but is not always practical. When the vessel fuel system is void of fuel volume, it can be primed without the use of a purge tool. The objective is to purge the air entrained in the fuel system through the fuel injectors during engine cranking to allow fuel to enter the fuel module. This method can be used on vessels where the fuel inlet system to the outboard is less restrictive and holds a relatively small volume of fuel; a short fuel supply line, no water separating fuel filter, or water separating fuel filter is already primed. If a primer bulb is installed, it can be used during the priming event to shorten the amount of time required to start the engine.

1. Verify the engine is in a level vertical position.
2. Verify the vessel fuel supply line is connected to the outboard fuel system inlet fitting.

3. Turn the ignition key "ON." The fuel pumps will run for approximately five seconds.
4. Turn the ignition key to the "START" position and release the key. The ECM controls the activation of the starter. The starter may continue cranking for up to eight seconds.

   NOTE: *When priming a drained fuel system, residual fuel may cause the engine to flare and stall which shortens the engine cranking event.*
5. Continue with the ignition key "ON" and "START" sequence until the engine continues to run.

   IMPORTANT: Allow the starter motor to cool for 20 to 30 seconds between full eight second crank events. Limit the number of events to a maximum of 10 full eight second cranking events.
6. Once the engine starts, it may run rough at idle for up to two minutes while the residual air is purged from the fuel system.
7. If the fuel system will not prime within 10 full eight second cranking events, use the previous procedure **Priming the FSM with a Purge Tool** to prime the fuel system.

Fuel Rail Removal/Installation—V6

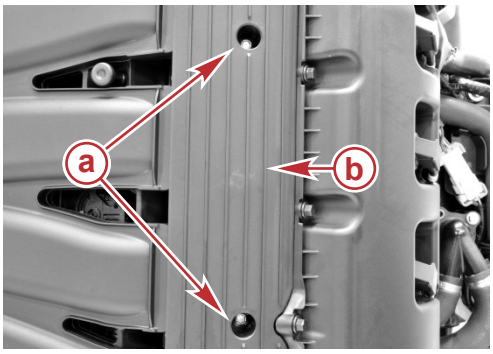
Fuel Rail Removal

⚠ 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.

IMPORTANT: Alternately loosen each fastener until both fasteners spin freely in the cover recess. Note that both fasteners are retained by features in the cover. Pay close attention to the fuel injector harness routing and wire retention to avoid damage during fuel rail cover installation.

1. Loosen the two fasteners that secure the fuel rail cover to the cylinder head and remove the cover.



66187

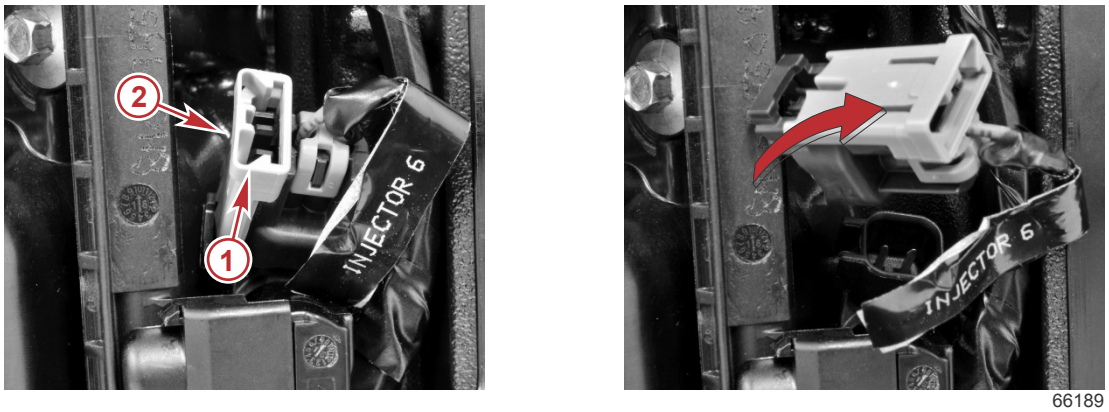
a - Fuel rail cover fasteners (2)
b - Fuel rail cover

2. Remove the Schrader valve cap at the top of either fuel rail and attach a fuel pressure gauge to the Schrader valve. Relieve the pressurized fuel into an approved container and dispose of the fuel according to local regulations.

Fuel Pressure Gauge Kit	91-881833A03

3. Remove the fuel pressure gauge and install the Schrader valve cap.

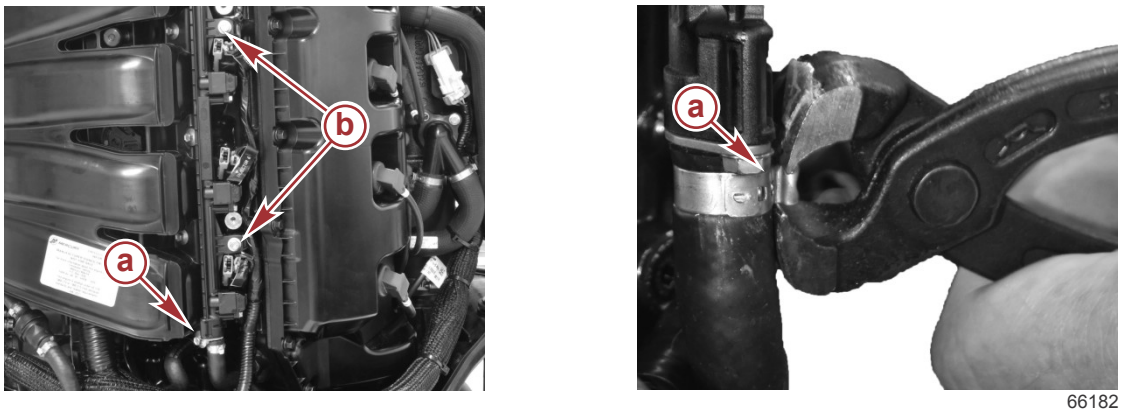
4. Slide the injector clips out and press/squeeze the end of each injector clip in until it clicks to remove the harness connectors from the injectors.



66189

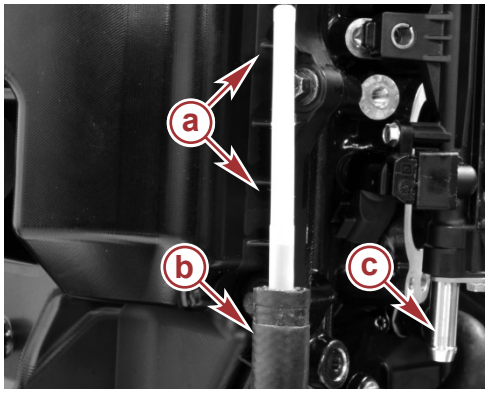
1 - Slide
2 - Press/squeeze

5. Cut the metal hose clamp that secures the high-pressure hose to the bottom of the fuel rail.
6. Place a rag or shop towel under the high-pressure fuel hose and remove the high-pressure hose and filter screen (if equipped).



66182

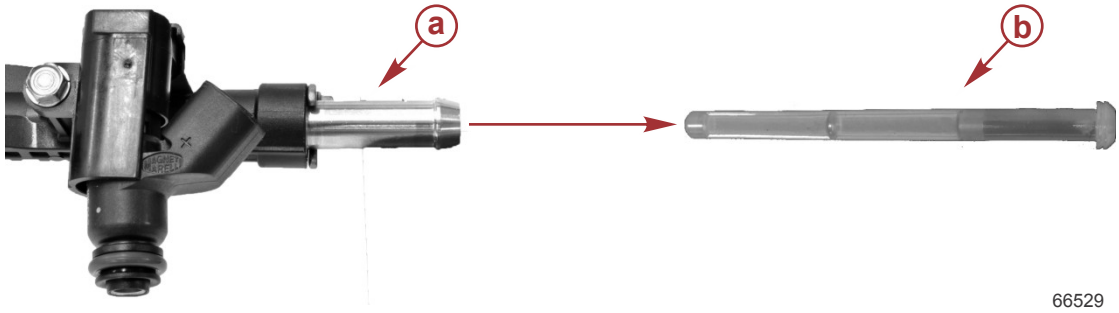
a - Metal hose clamp
b - Fuel rail fasteners (2)



66323

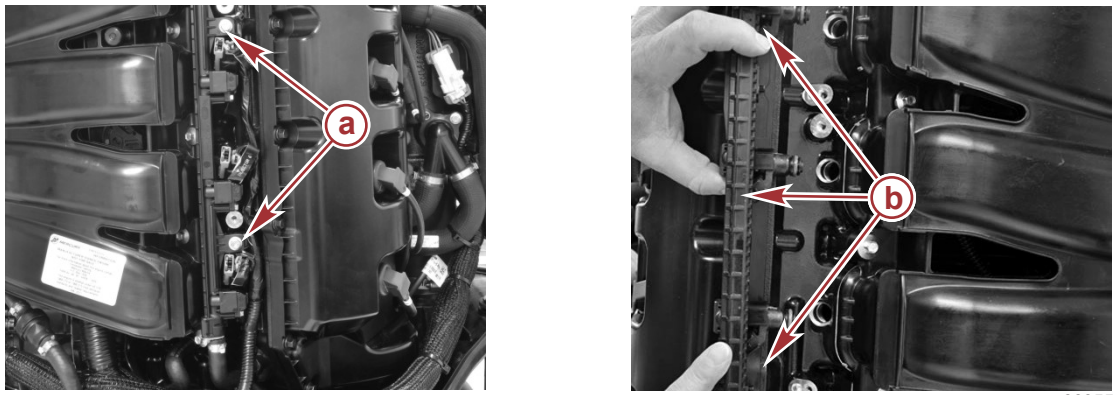
a - Fuel rail filter screen
b - High-pressure fuel hose
c - Bottom of the fuel rail

7. Inspect the fuel rail filter screen (if equipped) and discard the filter if particles or debris are present.



a - Fuel inlet tube
b - Fuel rail filter screen

8. Dispose of the fuel soaked rag/shop towel into an approved container.
9. Remove the two fasteners that secure the fuel rail to the cylinder head.
10. Pull the entire fuel rail and injector assemblies out of the cylinder head with uniform force while supporting the top, center, and bottom of the fuel rail assembly.

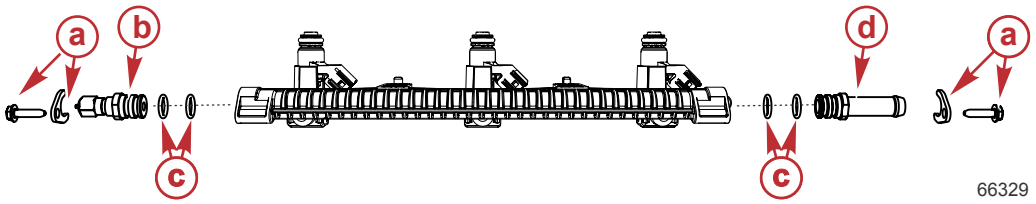


Fuel rail removal

a - Fuel rail fasteners (2)
b - Fuel rail

Fuel Rail Disassembly

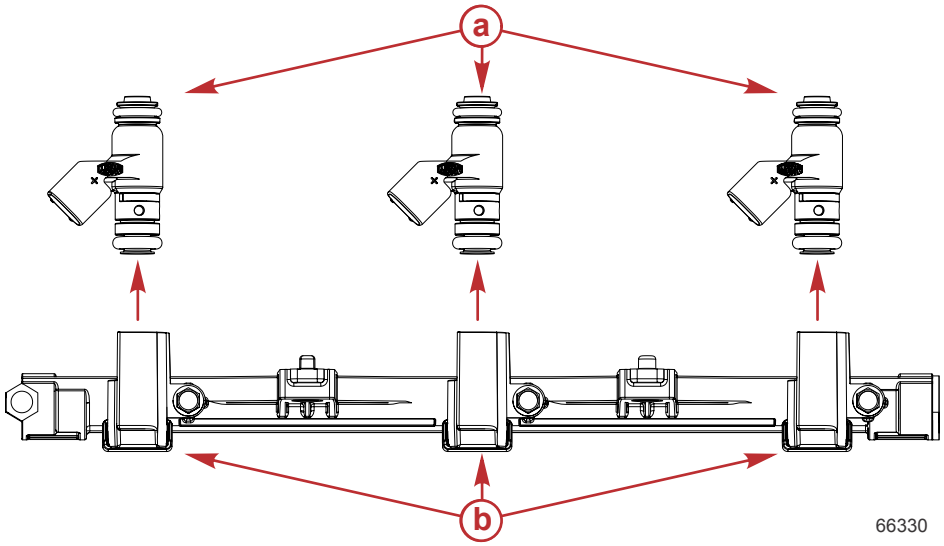
1. Remove each retaining bracket and screw from both ends of the fuel rail.
2. Remove the Schrader valve and fuel inlet tube, inspect the O-rings. Replace the O-rings if they are damaged.



a - Retaining bracket (2) and screw (2)
b - Schrader valve
c - O-ring (4)
d - Fuel inlet tube

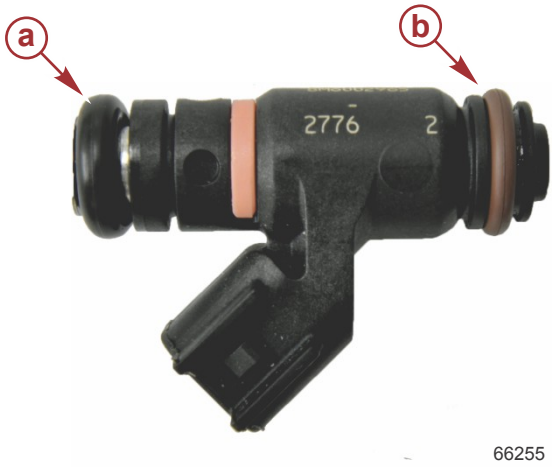
NOTE: *It is not necessary to remove the injector cups from the fuel rail assembly. Individual injectors can be removed from the fuel rail as necessary by pulling them directly out of the corresponding injector cup.*

3. Remove the injectors from the fuel rail injector cups.



a - Injectors
b - Injector cups

4. Inspect the O-rings on the fuel injectors. Replace the O-rings if they are damaged.



a - O-ring (rail)
b - O-ring (nozzle)

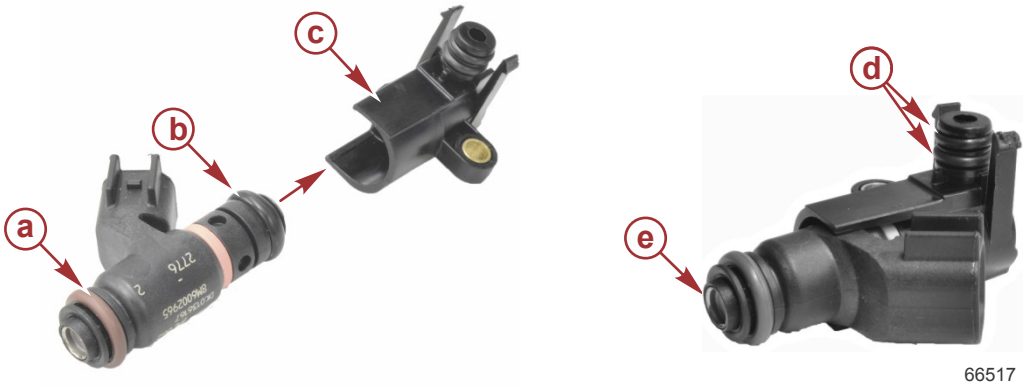
Injector, Schrader Valve, and Fuel Inlet Tube Installation

1. Use a solvent and compressed air to remove any debris from the inside of the fuel rail.
2. Lubricate the fuel injector O-rings with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Fuel injector O-ring, damper O-ring	Obtain Locally

3. Push the fuel injectors into the injector cups.

NOTE: *Shown with injector cup removed from the fuel rail assembly for clarity.*



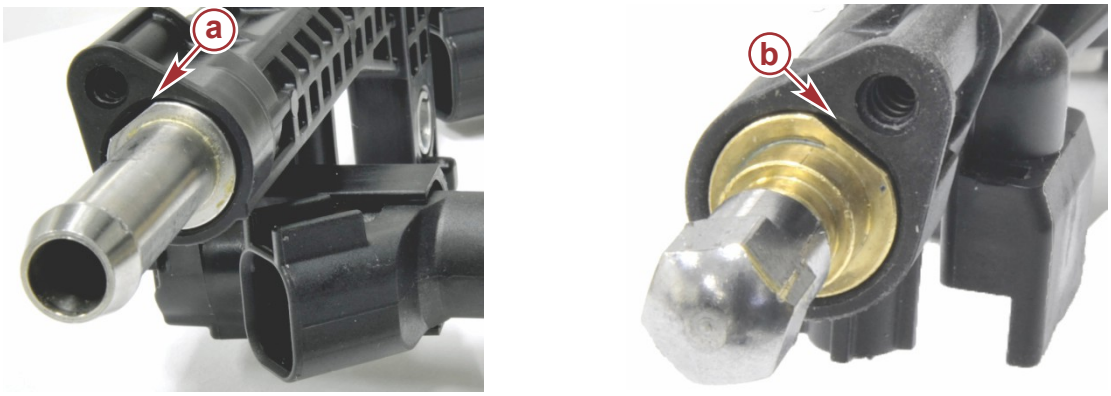
66517

a - O-ring (nozzle)
b - O-ring (rail)
c - Injector cup
d - Injector cup O-rings
e - Injector nozzle

4. Lubricate the Schrader valve and fuel inlet tube O-rings with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Schrader valve and fuel inlet tube O-rings	Obtain Locally

IMPORTANT: Observe the orientation of the fuel inlet tube and Schrader valve during installation. Ensure that the flat edge of each component is aligned with the keyway in the fuel rail bore.



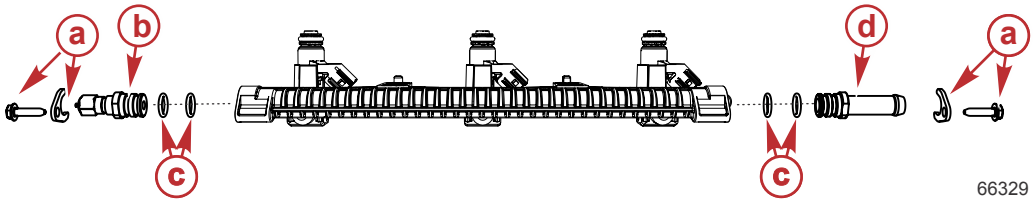
66521

Fuel inlet tube **Schrader valve**

a - Flat side of fuel inlet tube aligned with keyway
b - Flat side of Schrader valve aligned with keyway

5. Push the fuel inlet tube into the bottom of the fuel rail until it is seated.

6. Install the fuel inlet tube retaining bracket. Tighten the retaining bracket hex screw to the specified torque.



a - Retaining bracket (2) and screw (2)
b - Schrader valve
c - O-ring (4)
d - Fuel inlet tube

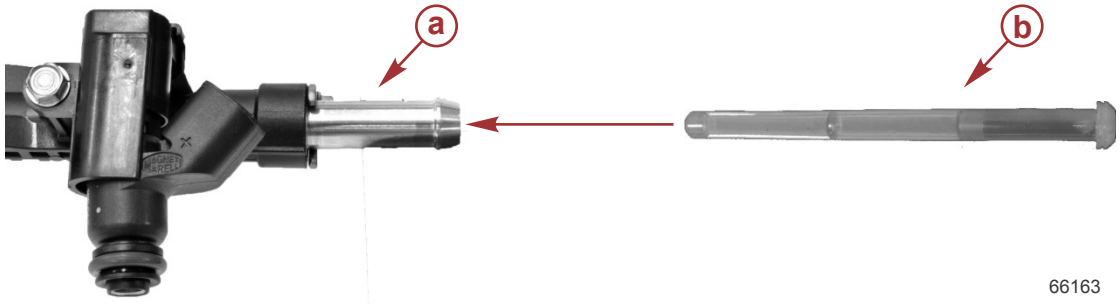
Description	Nm	lb-in.	lb-ft
Retaining bracket hex screw	1.7	15	–

7. Push the Schrader valve into the top of the fuel rail until it is seated.
8. Install the Schrader valve retaining bracket. Tighten the retaining bracket hex screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Retaining bracket hex screw	1.7	15	–

Fuel Rail Installation

1. Install the fuel rail filter screen (if equipped).



a - Fuel inlet tube
b - Fuel rail filter screen

2. Lubricate the fuel injector O-rings and cylinder head bores with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Fuel injector O-rings and cylinder head bores	Obtain Locally

3. Push the entire fuel rail and injector assemblies into the cylinder head with uniform force while supporting the top, center, and bottom of the fuel rail assembly.

67196

a - Fuel rail
b - Fuel rail fasteners (2)
c - Oetiker clamp (16.2 mm)

4. Tighten the fuel rail fasteners to the specified torque.

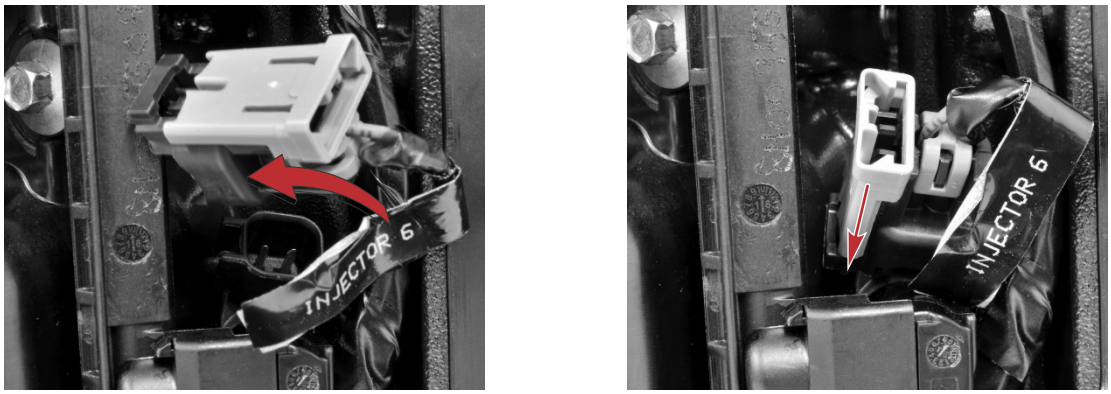
Description	Nm	lb-in.	lb-ft
Fuel rail fasteners	10	88.5	–

5. Connect the fuel line to the fuel inlet tube and secure it with a 16.2 mm Oetiker clamp.

Clamp Tool	91-803146T

NOTE: *Listen for an audible click when the connector engages, pull slightly on the lead to ensure a secure connection, push the locking tab into place. Pay close attention to fuel injector wire routing to prevent damage during fuel rail cover installation.*

6. Connect the injector harness connectors to the injectors and slide the injector locking clips down.

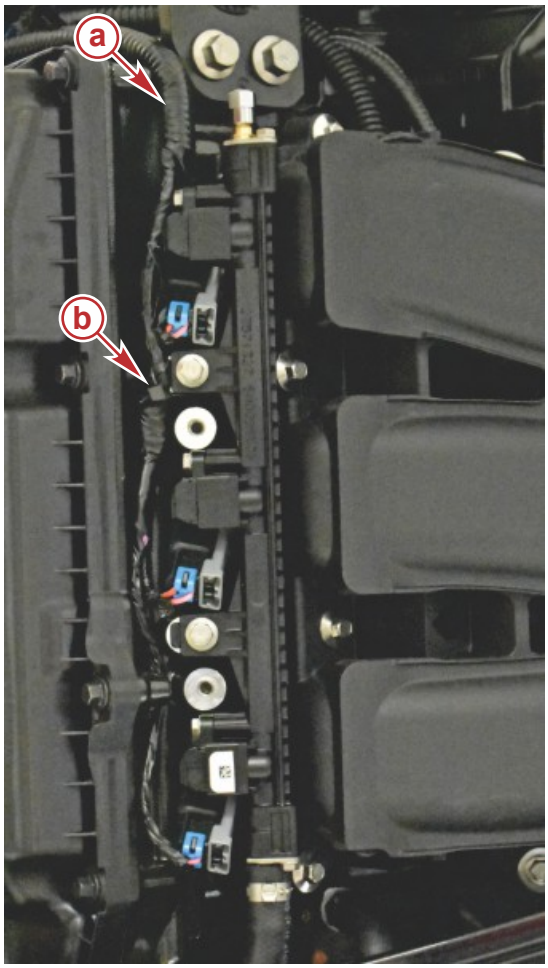


66322

⚠ 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.

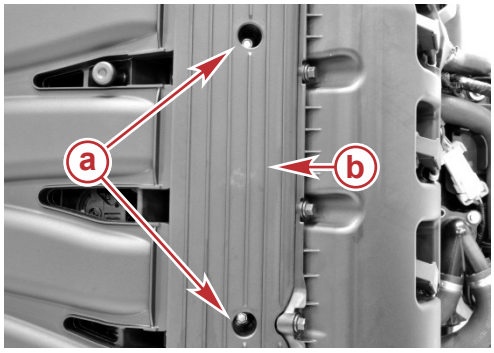
7. Tuck the injector harness between the cylinder head cover and the fuel rail as pictured below. Carefully observe the harness routing to ensure that it will not be damaged when the fuel rail cover is installed. Secure the harness with one cable tie.



66532

a - Conduit
b - Cable tie

8. Install the fuel rail cover and tighten the two fasteners to the specified torque.



66187

a - Fuel rail cover fasteners (2)
b - Fuel rail cover

Description	Nm	lb-in.	lb-ft
Fuel rail cover fasteners	10	88.5	–

Fuel Rail Removal/Installation—V8

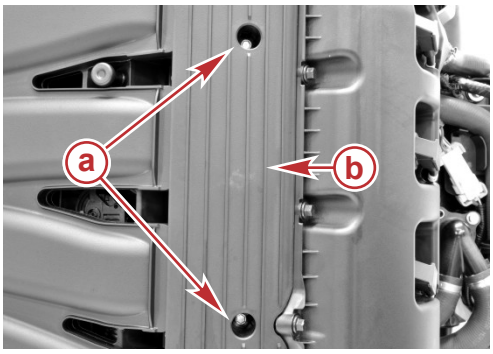
Fuel Rail Removal

⚠ 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.

IMPORTANT: Alternately loosen each fastener until both fasteners spin freely in the cover recess. Note that both fasteners are retained by features in the cover. Pay close attention to the fuel injector harness routing and wire retention to avoid damage during fuel rail cover installation.

1. Loosen the two fasteners that secure the fuel rail cover to the cylinder head and remove the cover.



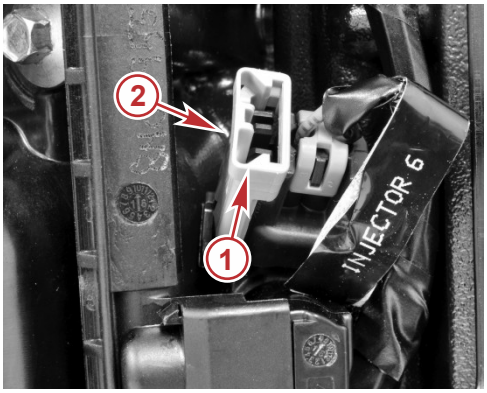
66187

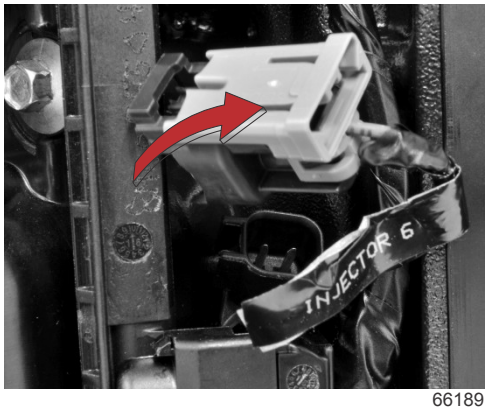
a - Fuel rail cover fasteners (2)
b - Fuel rail cover

2. Remove the Schrader valve cap at the top of either fuel rail and attach a fuel pressure gauge to the Schrader valve. Relieve the pressurized fuel into an approved container and dispose of the fuel according to local regulations.

Fuel Pressure Gauge Kit	91-881833A03

3. Remove the fuel pressure gauge and install the Schrader valve cap.
4. Slide the injector clips out and press/squeeze the end of each injector clip in until it clicks to remove the harness connectors from the injectors.



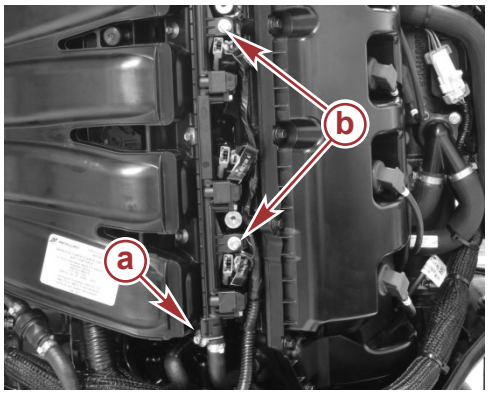


66189

1 - Slide
2 - Press/squeeze

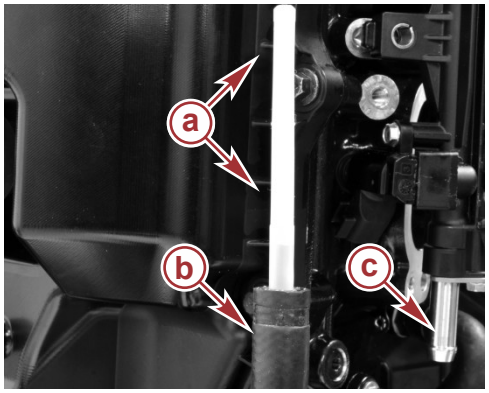
5. Cut the metal hose clamp that secures the high-pressure hose to the bottom of the fuel rail.

6. Place a rag or shop towel under the high-pressure fuel hose and remove the high-pressure hose and filter screen (if equipped).



66182

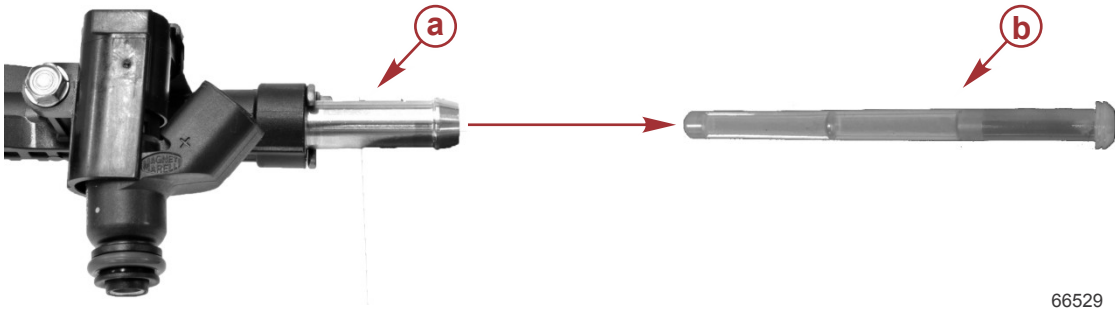
a - Metal hose clamp
b - Fuel rail fasteners (2)



66323

a - Fuel rail filter screen
b - High-pressure fuel hose
c - Bottom of the fuel rail

7. Inspect the fuel rail filter screen (if equipped) and discard the filter if particles or debris are present.

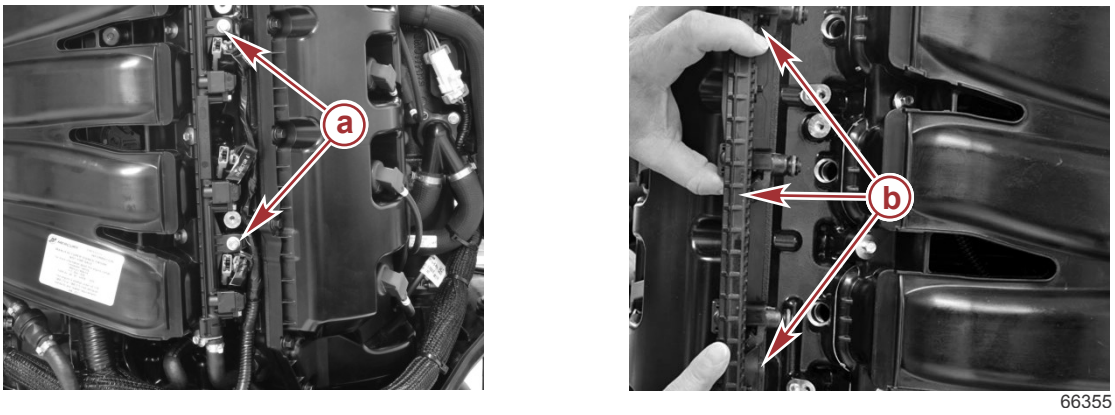


66529

a - Fuel inlet tube
b - Fuel rail filter screen

8. Dispose of the fuel soaked rag/shop towel into an approved container.
9. Remove the two fasteners that secure the fuel rail to the cylinder head.

10. Pull the entire fuel rail and injector assemblies out of the cylinder head with uniform force while supporting the top, center, and bottom of the fuel rail assembly.

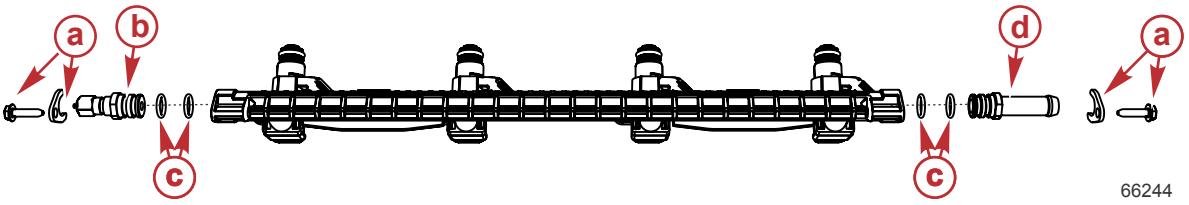


Fuel rail removal

a - Fuel rail fasteners (2)
b - Fuel rail

Fuel Rail Disassembly

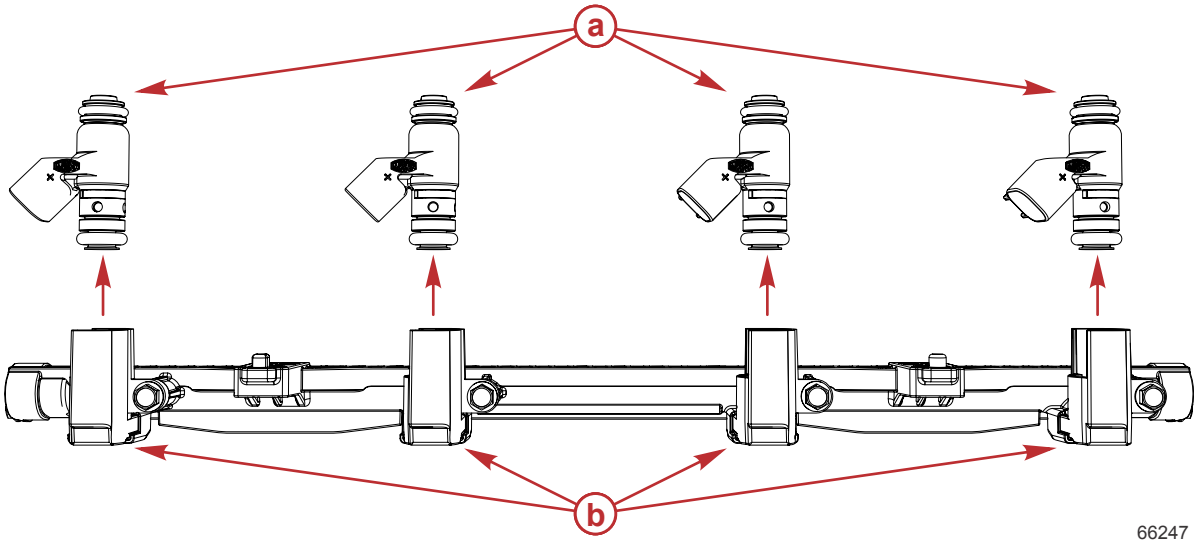
1. Remove each retaining bracket and screw from both ends of the fuel rail.
2. Remove the Schrader valve and fuel inlet tube, inspect the O-rings. Replace the O-rings if they are damaged.



a - Retaining bracket (2) and screw (2)
b - Schrader valve
c - O-ring (4)
d - Fuel inlet tube

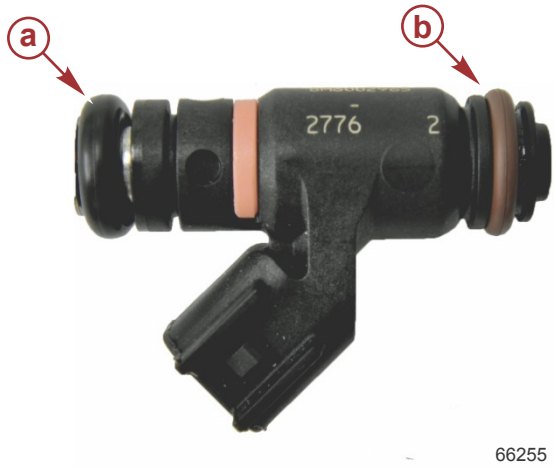
NOTE: *It is not necessary to remove the injector cups from the fuel rail assembly. Individual injectors can be removed from the fuel rail as necessary by pulling them directly out of the corresponding injector cup.*

3. Remove the injectors from the fuel rail injector cups.



a - Injectors
b - Injector cups

4. Inspect the O-rings on the fuel injectors. Replace the O-rings if they are damaged.



a - O-ring (rail)
b - O-ring (nozzle)

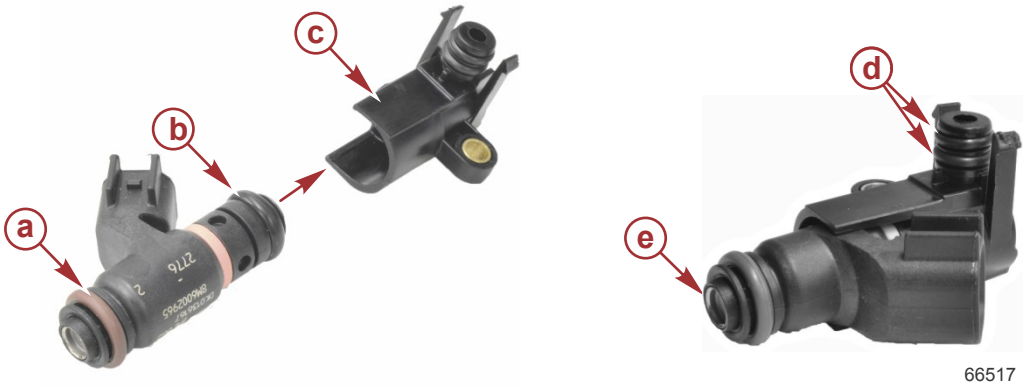
Injector, Schrader Valve, and Fuel Inlet Tube Installation

1. Use a solvent and compressed air to remove any debris from the inside of the fuel rail.
2. Lubricate the fuel injector O-rings with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Fuel injector O-ring, damper O-ring	Obtain Locally

3. Push the fuel injectors into the injector cups.

NOTE: *Shown with injector cup removed from the fuel rail assembly for clarity.*

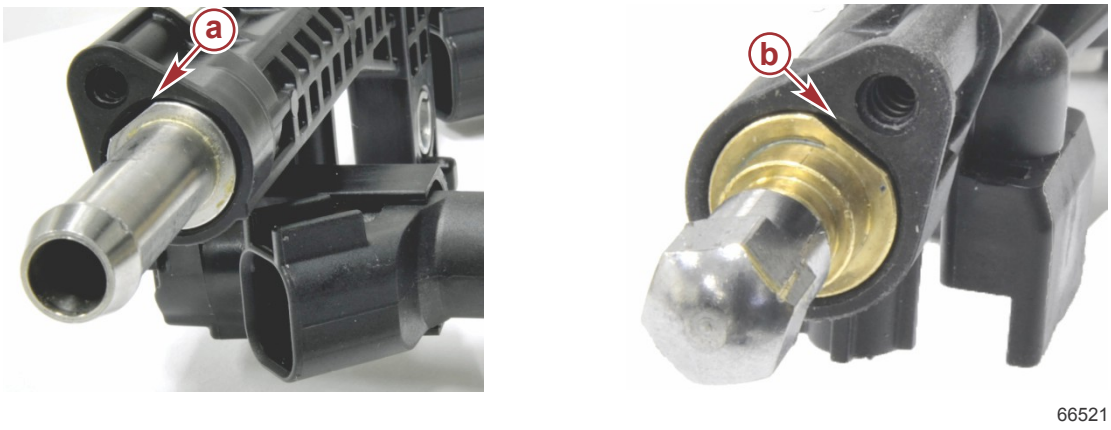


a - O-ring (nozzle)
b - O-ring (rail)
c - Injector cup
d - Injector cup O-rings
e - Injector nozzle

4. Lubricate the Schrader valve and fuel inlet tube O-rings with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Schrader valve and fuel inlet tube O-rings	Obtain Locally

IMPORTANT: Observe the orientation of the fuel inlet tube and Schrader valve during installation. Ensure that the flat edge of each component is aligned with the keyway in the fuel rail bore.

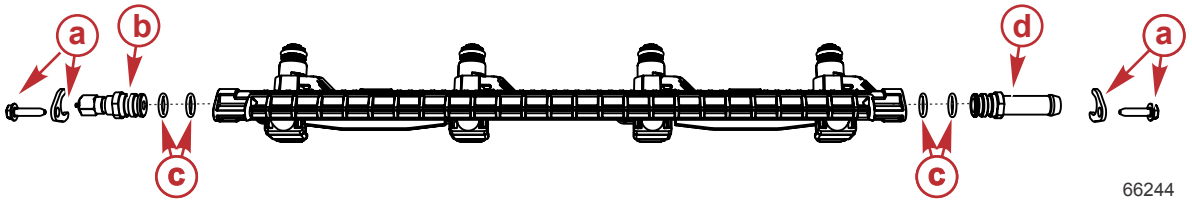


Fuel inlet tube **Schrader valve**

a - Flat side of fuel inlet tube aligned with keyway
b - Flat side of Schrader valve aligned with keyway

5. Push the fuel inlet tube into the bottom of the fuel rail until it is seated.

6. Install the fuel inlet tube retaining bracket. Tighten the retaining bracket hex screw to the specified torque.



a - Retaining bracket (2) and screw (2)
b - Schrader valve
c - O-ring (4)
d - Fuel inlet tube

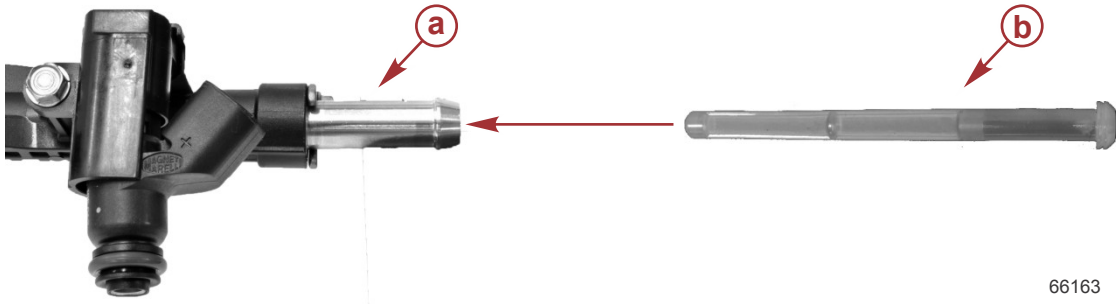
Description	Nm	lb-in.	lb-ft
Retaining bracket hex screw	1.7	15	–

7. Push the Schrader valve into the top of the fuel rail until it is seated.
8. Install the Schrader valve retaining bracket. Tighten the retaining bracket hex screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Retaining bracket hex screw	1.7	15	–

Fuel Rail Installation

1. Install the fuel rail filter screen (if equipped).



a - Fuel inlet tube
b - Fuel rail filter screen

2. Lubricate the fuel injector O-rings and cylinder head bores with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Fuel injector O-rings and cylinder head bores	Obtain Locally

3. Push the entire fuel rail and injector assemblies into the cylinder head with uniform force while supporting the top, center, and bottom of the fuel rail assembly.

67196

a - Fuel rail
b - Fuel rail fasteners (2)
c - Oetiker clamp (16.2 mm)

4. Tighten the fuel rail fasteners to the specified torque.

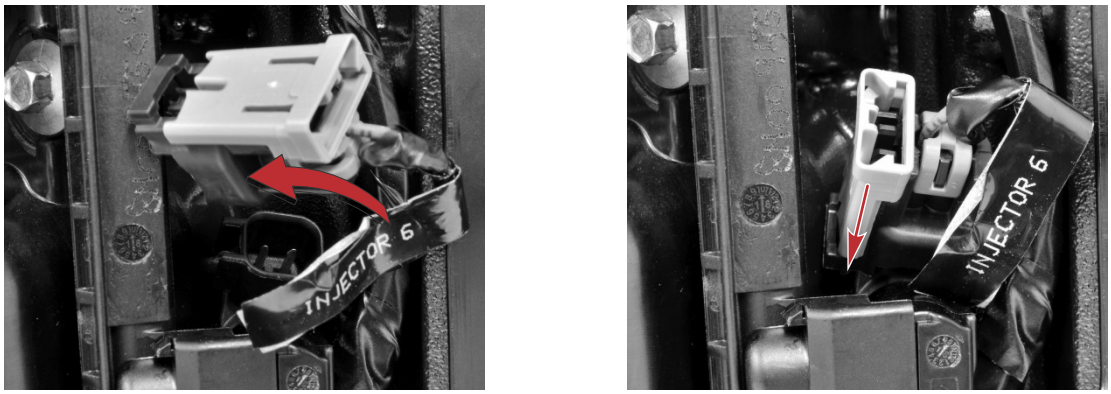
Description	Nm	lb-in.	lb-ft
Fuel rail fasteners	10	88.5	–

5. Connect the fuel line to the fuel inlet tube and secure it with a 16.2 mm Oetiker clamp.

Clamp Tool	91-803146T

NOTE: *Listen for an audible click when the connector engages, pull slightly on the lead to ensure a secure connection, push the locking tab into place. Pay close attention to fuel injector wire routing to prevent damage during fuel rail cover installation.*

6. Connect the injector harness connectors to the injectors and slide the injector locking clips down.

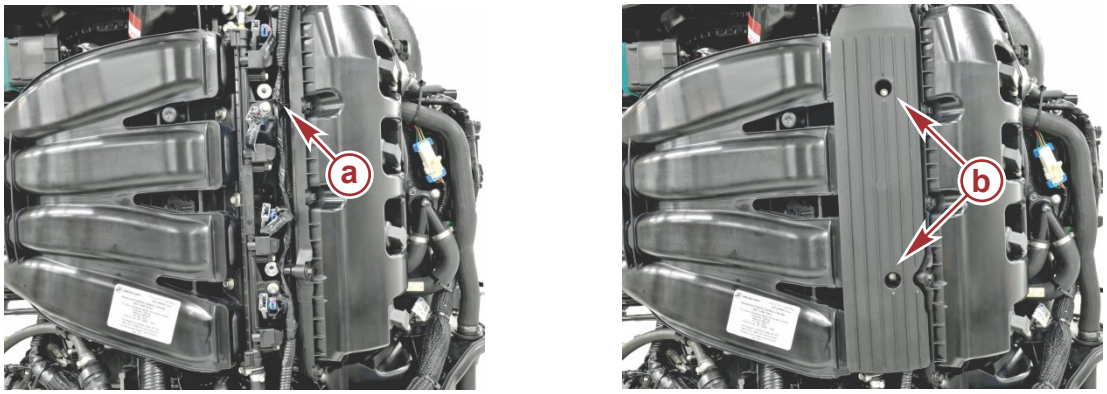


66322

⚠ 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.

7. Tuck the injector harness between the cylinder head cover and the fuel rail as pictured below. Carefully observe the harness routing to ensure that it will not be damaged when the fuel rail cover is installed. Secure the harness with one cable tie.



66559

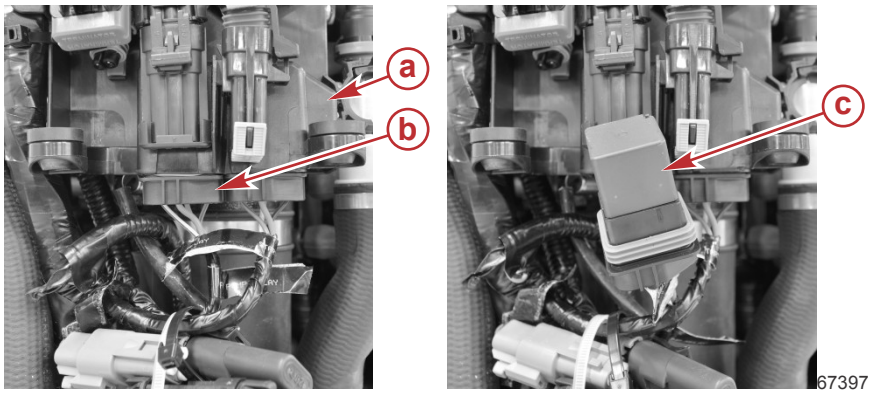
a - Cable tie
b - Fasteners (2)

8. Install the fuel rail cover and tighten the two fasteners to the specified torque.

Description	Nm	lb-in.	lb-ft
Fuel rail cover fasteners	10	88.5	–

Fuel Pump Relay

The fuel pump relay is located in the bottom of the electrical panel, at the rear of the engine.



67397

a - Electrical panel
b - Fuel pump relay socket on the engine harness
c - Fuel pump relay

Notes:

Fuel System

Section 3C - Emissions

Table of Contents

3C

Exhaust Emission Standards

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

What Are Emissions?

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

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

Hydrocarbons – HC

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

Carbon Monoxide – CO

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

Oxides of Nitrogen – NOx

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

Controlling Emissions

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

Stoichiometric (14.7:1) Air/Fuel Ratio

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

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

Emissions Information

Manufacturer's Responsibility

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

Dealer Responsibility

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

Adjustments must be kept within published factory specifications.

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

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

Exceptions include manufacturer's prescribed changes, such as that for altitude adjustments. Also included would be factory authorized:

- Installation of performance style gear housings by Mercury Marine.
- Service replacement parts modified, changed, or superceded by Mercury Marine.

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.

Single engine exceptions may be allowed with permission from the EPA for racing and testing.

EPA Emission Regulations

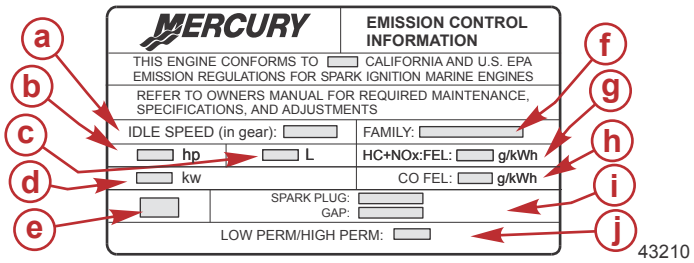
All 1998 and newer outboards manufactured by Mercury Marine are certified to the United States Environmental Protection Agency as conforming to the requirements of the regulations for the control of air pollution from new outboard motors. This certification is contingent on certain adjustments being 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 location:

EPA INTERNET WEB SITE: http://www.epa.gov/

Manufacturer's Certification Label

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



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

Service Replacement EPA Decal

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

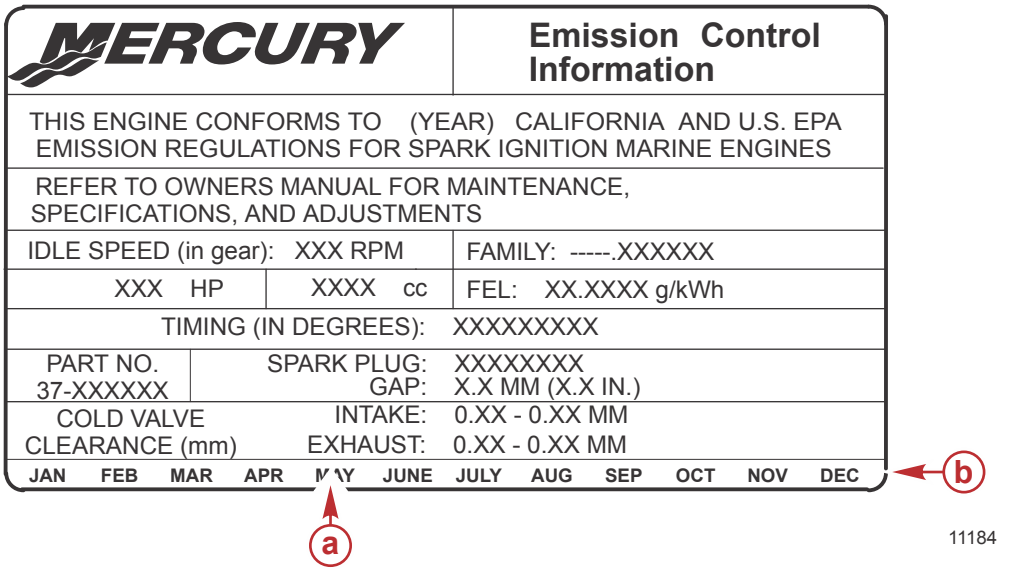
Removal

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

NOTE: *If the original decal surface is in good condition, it is acceptable to clean the surface and apply the new decal over the original.*

Date Code Identification

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



11184

a - "V" notch
b - Month of manufacture

Installation

Apply the decal on a clean surface in the original factory location.

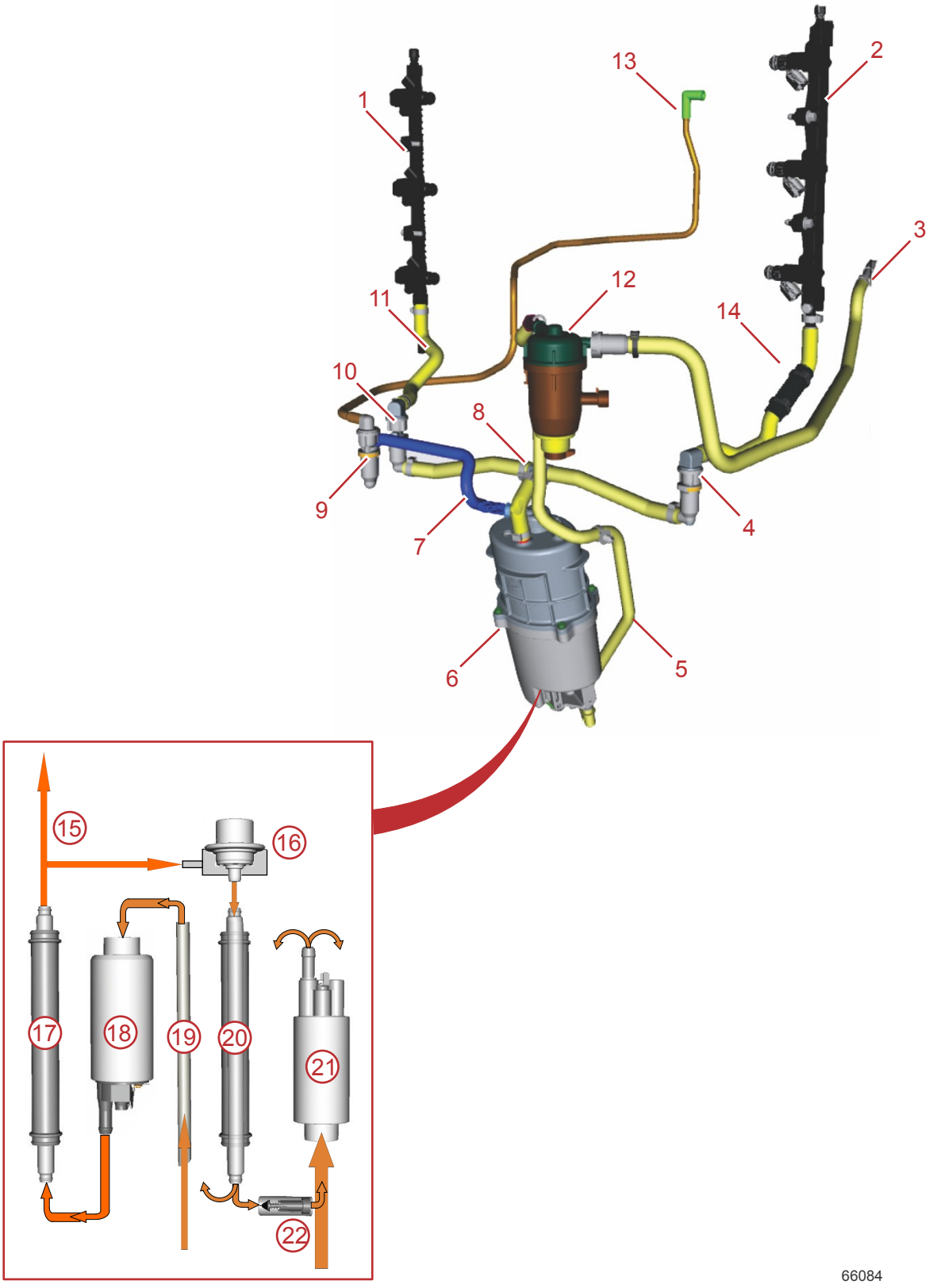
Fuel System

Section 3D - Fuel Flow Diagrams

Table of Contents

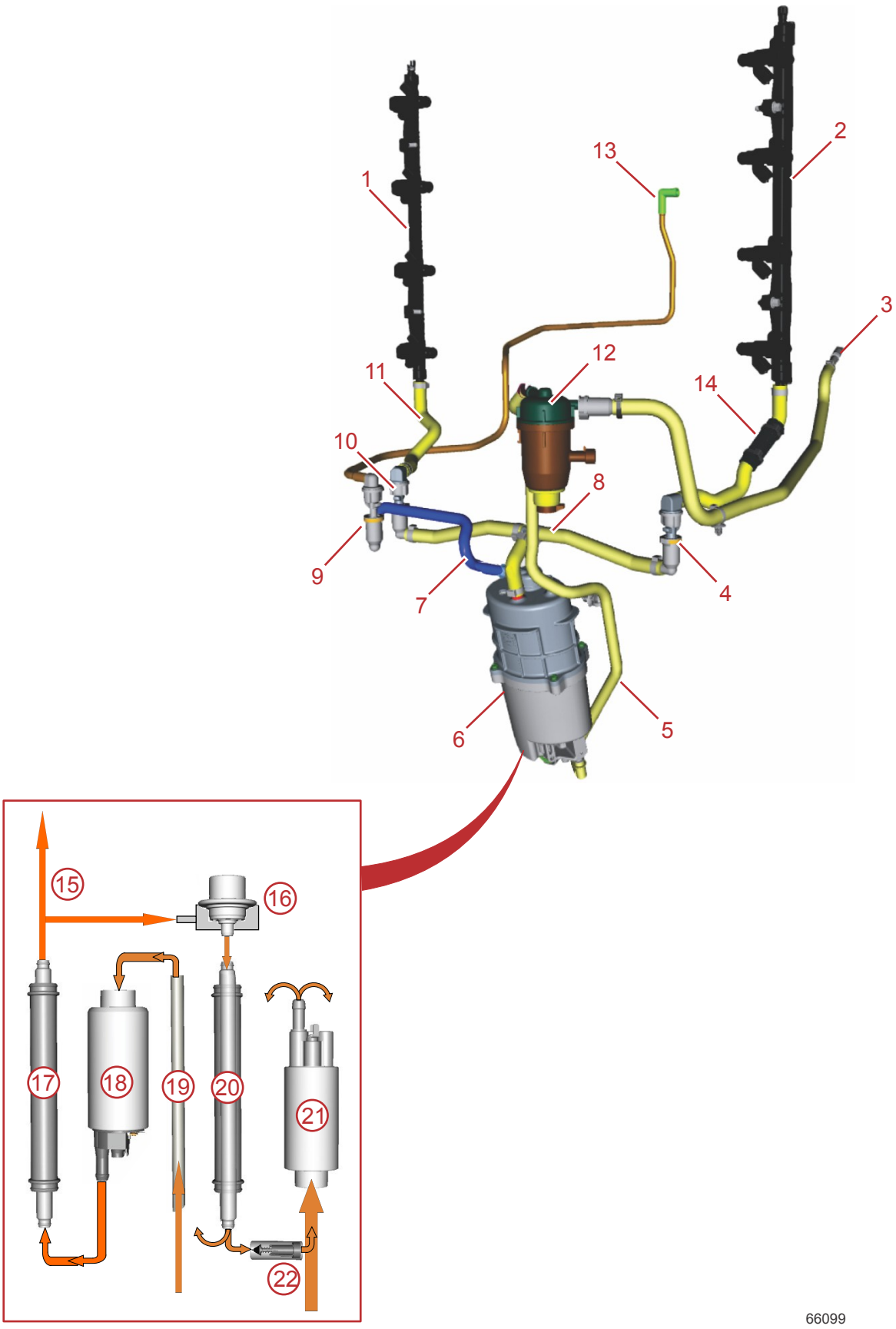
3
D

V6 Fuel Flow Diagram



1 - Port fuel rail
2 - Starboard rail and injectors
3 - Fuel inlet from vessel
4 - Starboard rail hose quick-connect
5 - Filter to fuel supply module (FSM) hose
6 - FSM
7 - Manifold reference base hose
8 - FSM T-fitting
9 - Manifold reference quick-connect
10 - Port rail hose quick-connect
11 - Port rail hose
12 - Water-separating fuel filter
13 - Manifold reference
14 - Starboard rail hose
15 - High-pressure to fuel rails
16 - Fuel pressure regulator
17 - Fuel cooler
18 - High-pressure fuel pump
19 - Siphon tube
20 - Fuel cooler
21 - Fuel lift pump
22 - Recirculation check valve

V8 Fuel Flow Diagram



1 - Port fuel rail
2 - Starboard rail and injectors
3 - Fuel inlet from vessel
4 - Starboard rail hose quick-connect
5 - Filter to fuel supply module (FSM) hose
6 - FSM
7 - Manifold reference base hose
8 - FSM T-fitting
9 - Manifold reference quick-connect
10 - Port rail hose quick-connect
11 - Port rail hose
12 - Water-separating fuel filter
13 - Manifold reference
14 - Starboard rail hose
15 - High-pressure to fuel rails
16 - Fuel pressure regulator
17 - Fuel cooler
18 - High-pressure fuel pump
19 - Siphon tube
20 - Fuel cooler
21 - Fuel lift pump
22 - Recirculation check valve

Notes:

Powerhead

Section 4A - Cylinder Block/Crankcase

Table of Contents

V6 Cylinder Block/Crankcase Specifications

V6 Cylinder Block/Crankcase Specifications	
Number of cylinders	6
V-angle	64°
Displacement	3432 cc/3.4 L (209.4 cid)
Compression ratio	10:1
Standard bore	92.00 mm (3.6220 in.)
Standard bore service limit	92.015 mm (3.6226 in.)
Stroke	86.00 mm (3.386 in.)
Cylinder bore maximum taper	0.02 mm (0.0007 in.)
Cylinder bore maximum out of round	0.015 mm (0.0006 in.)
Cylinder block main bearing bore	74.988–75.012 mm (2.9523–2.953 in.)
Crankshaft main bearing journal	69.984–70.000 mm (2.7552–2.7559 in.)
Connecting rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)
Crankshaft end play	0.00–0.432 mm (0.000–0.017 in.)
Crankshaft runout	0.05 mm (0.002 in.)
Crankshaft main bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.054–0.088 mm (0.0022–0.0034 in.)
Connecting rod bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.046–0.074 mm (0.0019–0.0029 in.)
Crankshaft thrust bearing surface width	23.95–24.05 mm (0.9429–0.9468 in.)
Connecting rod wrist pin bore diameter	20.014–20.022 mm (0.7880–0.7882 in.)
Connecting rod crankshaft pin diameter	57.000–57.016 mm (2.2441–2.2447 in.)
Piston skirt standard diameter	91.927–91.937 mm (3.6192–3.6195 in.)
Piston wrist pin bore diameter	20.005–20.010 mm (0.7876–0.7878 in.)
Wrist pin diameter	19.996–20.001 mm (0.7873–0.7874 in.)
Top ring groove width	1.22–1.25 mm (0.0480–0.0492 in.)
Second ring groove width	1.01–1.03 mm (0.0398–0.0405 in.)
Third ring groove width	2.01–2.03 mm (0.0791–0.799 in.)
Top ring thickness—maximum	1.20 mm (0.0472 in.)
Second ring thickness—maximum	1.00 mm (0.0393 in.)
Top ring side clearance	0.02–0.05 mm (0.0008–0.0019 in.)
Second ring side clearance	0.01–0.03 mm (0.0004–0.0011 in.)
Top ring end gap	0.20–0.215 mm (0.008–0.0084 in.)
Second ring end gap	0.40–0.425 mm (0.016–0.0167 in.)
Oil ring end gap (top and bottom) (expander not applicable)	0.40–0.425 mm (0.016–0.0167 in.)

V8 Cylinder Block/Crankcase Specifications

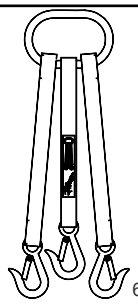
V8 Cylinder Block/Crankcase Specifications	
Number of cylinders	8
V-angle	64°
Displacement	4576 cc/4.6 L (279.2 cid)
Compression ratio	10:1
Standard bore	92.00 mm (3.6220 in.)
Standard bore service limit	92.015 mm (3.6226 in.)
Stroke	86.00 mm (3.386 in.)
Cylinder bore maximum taper	0.02 mm (0.0007 in.)
Cylinder bore maximum out of round	0.015 mm (0.0006 in.)
Cylinder block main bearing bore	64.988–65.012 mm (2.5586–2.5595 in.)
Crankshaft main bearing journal	59.984–60.000 mm (2.3616–2.3622 in.)
Connecting rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)
Crankshaft end play	0.00–0.432 mm (0.000–0.017 in.)
Crankshaft runout	0.05 mm (0.002 in.)
Crankshaft main bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.036–0.070 mm (0.0015–0.0027 in.)
Connecting rod bearing oil clearance—measured at 20 °C (68 °F), 90° from the split line	0.046–0.074 mm (0.0019–0.0029 in.)
Crankshaft thrust bearing surface width	25.95–26.05 mm (1.0217–1.0255 in.)
Connecting rod wrist pin bore diameter	20.014–20.022 mm (0.7880–0.7882 in.)
Connecting rod bore diameter (without bearing inserts)	57.000–57.016 mm (2.2441–2.2447 in.)
Piston skirt standard diameter	91.927–91.937 mm (3.6192–3.6195 in.)
Piston wrist pin bore diameter	20.005–20.010 mm (0.7876–0.7878 in.)
Wrist pin diameter	19.996–20.001 mm (0.7873–0.7874 in.)
Top ring groove width	1.22–1.25 mm (0.0480–0.0492 in.)
Second ring groove width	1.01–1.03 mm (0.0398–0.0405 in.)
Third ring groove width	2.01–2.03 mm (0.0791–0.799 in.)
Top ring thickness—maximum	1.20 mm (0.0472 in.)
Second ring thickness—maximum	1.00 mm (0.0393 in.)
Top ring side clearance	0.02–0.05 mm (0.0008–0.0019 in.)
Second ring side clearance	0.01–0.03 mm (0.0004–0.0011 in.)
Top ring end gap	0.20–0.215 mm (0.008–0.0084 in.)
Second ring end gap	0.40–0.425 mm (0.016–0.0167 in.)
Oil ring end gap (top and bottom) (expander not applicable)	0.40–0.425 mm (0.016–0.0167 in.)

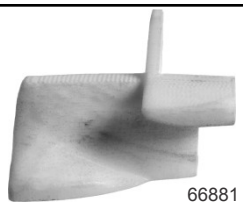
Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Torco MPZ® Engine Assembly Lube HP	Outer thrust bearing surfaces	Obtain Locally

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Ground connections	92- 25711 3
		Starter motor electrical connections	
		Ground wire connection	
		Alternator output connection	
		Battery connections at the engine	
66	Loctite 242 Threadlocker	Balance shaft retainer screw threads	92-809821
		Sprocket screw threads	
		Threads of bedplate perimeter bolts	
		Threads of the starboard intake runner screws	
		Threads of the port intake runner screws	
81	Anti-Seize Compound	Spark plug threads	92-898101389
91	Engine Coupler Spline Grease	Inside lip of the crankshaft seal	8M0071842
		Oil pump seals and O-rings	
		Driveshaft splines	
95	2-4-C with PTFE	Inner thrust bearing surfaces	92-802859A 1
99	Isopropyl Alcohol	Mating surfaces of the cylinder block and bedplate	Obtain Locally
110	10W-30 4-Stroke Marine Engine Oil	O-rings	92-8M0078625
		Double O-ring balance shaft top cover	
		Oil tube O-rings	
		Cylinder bores	
		Threads of the special left-hand thread screw	
		Oil fill hose fitting O-ring	
		Oil pump	
		Dipstick grommet	
		Upper dipstick O-ring	
135	Three Bond® 1217F	Mating surface of balance shaft cover	92-858005K02
		Bedplate sealing surface	
136	Lubriplate SPO 255	Balance shaft bushing and bottom bore	Obtain Locally
		Threads and under the heads of all main bearing bolts	
		Main bearing halves	
		Bolt holes, threads, and mating area around holes	
		Piston pin	
		Inside diameter of the connecting rod bearing halves	
		Piston skirts and rings	
		Rod cap mating surfaces, bearing halves, rod bolt threads, and under the connecting rod bolt heads	
		Camshaft bearing surfaces, lifter buckets, camshaft bearing journals, and camshaft thrust surfaces	
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Piston ring grooves and piston rings	92-8M0078629

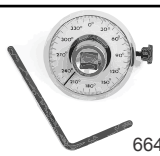
Special Tools

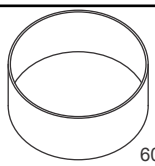
Lifting strap	883705T01
 67021	Use with an overhead hoist to lift an engine.

Alternator Belt Shoe	8M0146862
 66881	Aids in the installation and removal of the alternator belt on V6/V8 fourstroke outboards. Tool ID number 8M0140323.

Flywheel Socket	8M0146861
 66882	Aids in the manual rotation of the flywheel, especially for alternator belt removal and installation. Tool ID number 8M0144583

Rod Guide Dowels	8M0148866
 67517	Protects the cylinder bore and crankshaft from damage while removing or installing the connecting rods.

Angle Gauge	Obtain Locally
 66470	Aids in locating a specific degree when incorporating a torque and turn process into the assembly process.

ARP Piston Ring Compressor	ARP 901-9200
 60579	Compresses piston ring into ring grooves during installation of piston into cylinder bore. 92 mm (3.622 in.)

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.

Timing Chain Holding Tool	8M0148867
 67513	Holds the timing chain on the crankshaft sprocket during timing chain installation.

Removing Powerhead Components and Powerhead Removal

Removing Powerhead Components Individually

This section explains where to look for information about removing and installing engine components individually.

If removing engine components for purposes of powerhead repair such as internal engine service, refer to **Removing Powerhead Components as an Assembly**.

To remove this component individually...	Refer to ...
Alternator	**2B**
Alternator belt	**1B**
Camshaft position sensor	**2A**
Crankshaft position sensor (CPS)	**2A**
Flywheel	**2A**
Fuel filter	**1B**
Fuel injectors	**3B**
Fuel rail	**3B**
Fuel supply module (FSM)	**3B**
Ignition coils	**2A**
Intake runners	**3A**
Main power relay	**2A**
Manifold absolute pressure (MAP) sensor	**2A**
Manifold air temperature (MAT) sensor	**2A**
Spark plugs	**1B**
Starter motor	**2B**
Start relay	**2B**
Thermostat	**4D**
Throttle body	**3A**
Trim relays	**Diagnostic Manual**
Oil level sensor	**2C**
Oil pump	**4C**
Oil pressure sensor	**4C**
Oxygen sensor	**2A**
Propulsion control module (PCM)	**2A**
Water temperature sensor	**4D**
Water pressure sensor	**4D**

Removing Powerhead Components as an Assembly

If removing engine components for purposes of powerhead repair such as internal engine service or long block replacement, refer to the following procedures to undress and remove the powerhead. This procedure applies to V6 and V8 outboards. Differences between V6 and V8 are noted.

Refer to **Removing Powerhead Components Individually** to locate individual component removal procedures.

Electrical Harness and Component 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.

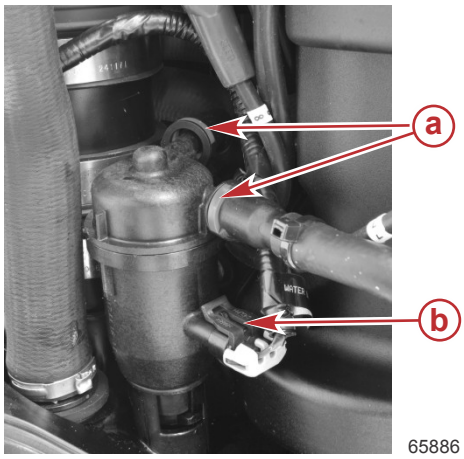
This procedure will remove the engine electrical harness, PCM, fuse box, and electrical plate as an assembly to protect it from damage and oil exposure while servicing the powerhead.

1. Remove the upper and lower cowls. Refer to **Section 5C - Upper and Lower Cowls.**
2. Drain the engine oil. Refer to **Section 1B - Changing Engine Oil and Filter**.
3. Relieve the fuel pressure. Refer to **Section 3 - Fuel System**.

⚠ 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.

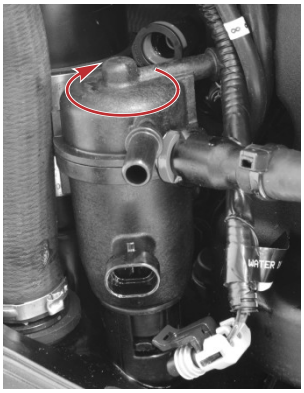
4. Disconnect the fuel hose and the water-in-fuel (WIF) sensor connector from the fuel filter.



65886

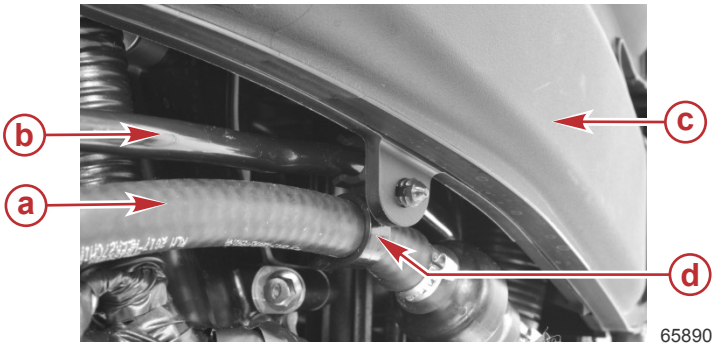
a - Fuel hose release tabs
b - WIF sensor connector

5. Remove the fuel filter from the adapter plate by turning it one quarter turn clockwise and pulling up.



65887

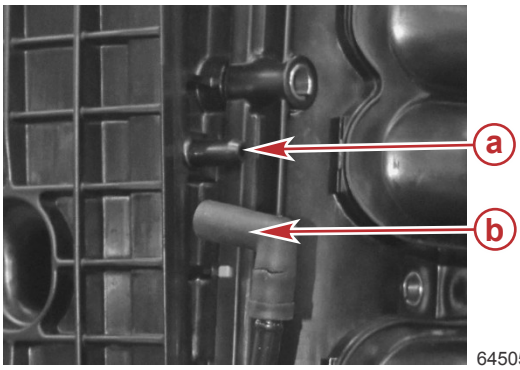
6. Remove the manifold reference hose and flush hose from their retainer.



65890

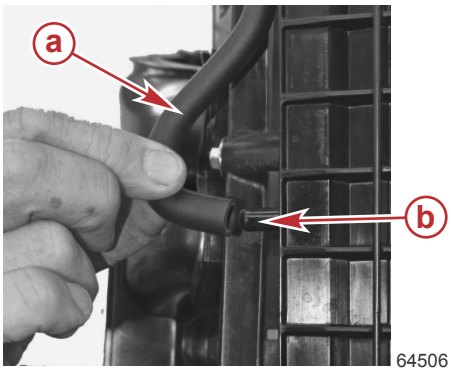
a - Flush hose
b - Manifold reference hose
c - Port intake runner
d - Retainer

7. Remove the manifold reference hose from the fitting near the port intake runners.



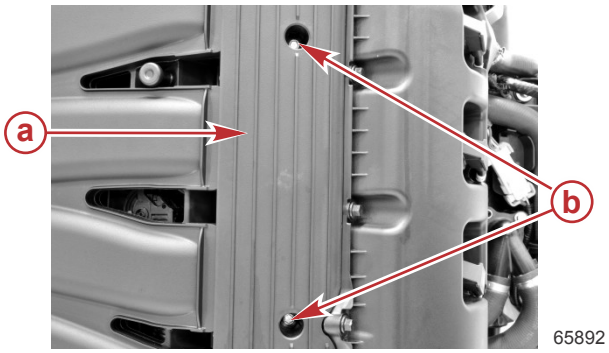
a - Fitting
b - Manifold reference hose

8. Remove the manifold reference hose from the fitting near the starboard intake runners.



a - Manifold reference hose
b - Fitting

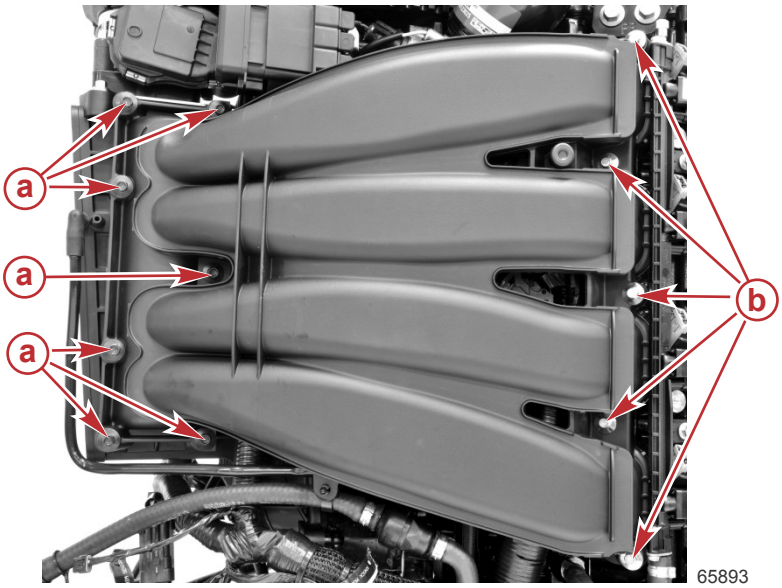
9. Remove the two screws securing the fuel rail covers. Remove the covers.
NOTE: *The screws are captured in the fuel rail covers.*



V8 port side shown; starboard and V6 similar
a - Fuel rail cover
b - Screws (2 per side)

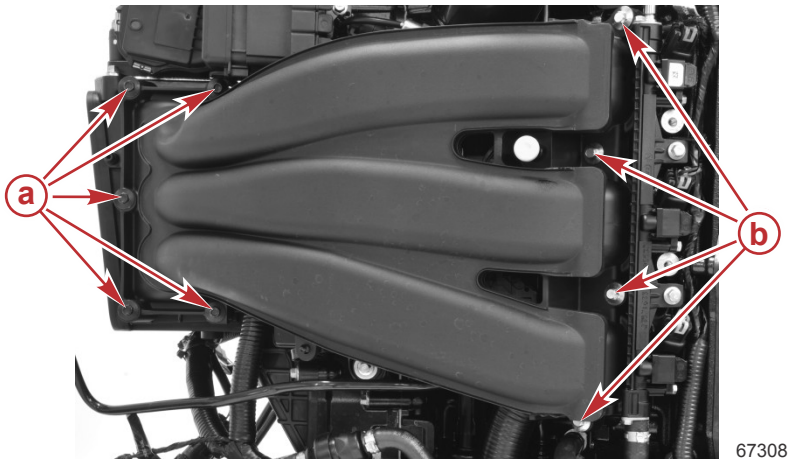
10. Remove the screws securing the intake runners from each side of the powerhead. Remove the intake runners.

NOTE: *Intake runner screws are different lengths. Do not intermix the hardware.*



V8 port side shown—starboard similar

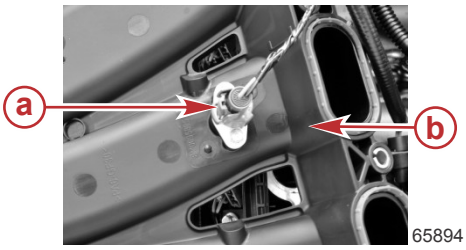
a - M6 x 37 screws (7 on V8 models)
b - M6 x 30 screws (5 on V8 models)



V6 port side shown—starboard similar

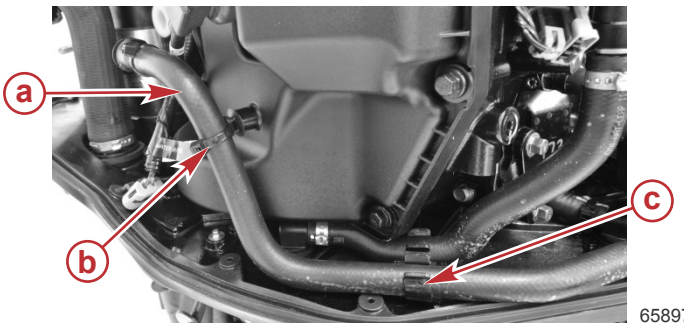
a - M6 x 37 screws (5 on V6 models)
b - M6 x 30 screws (4 on V6 models)

11. Disconnect the air temperature sensor connector from behind the starboard intake runners.



a - Air temperature sensor connector
b - Starboard intake runners

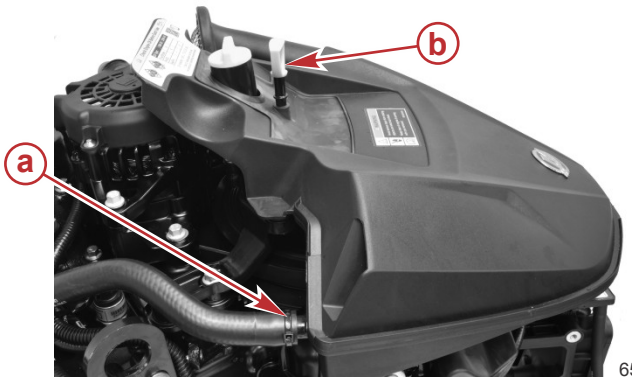
12. Cut the cable tie securing the fuel hose. Remove the fuel hose from its retainer and remove the hose.



a - Fuel hose
b - Cable tie
c - Retainer

13. Remove the engine oil dipstick.

14. Cut the cable tie and remove the breather hose from the flywheel cover/air box.



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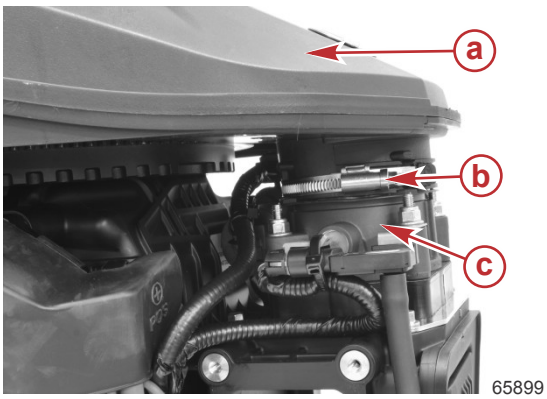
a - Cable tie securing the breather hose
b - Engine oil dipstick

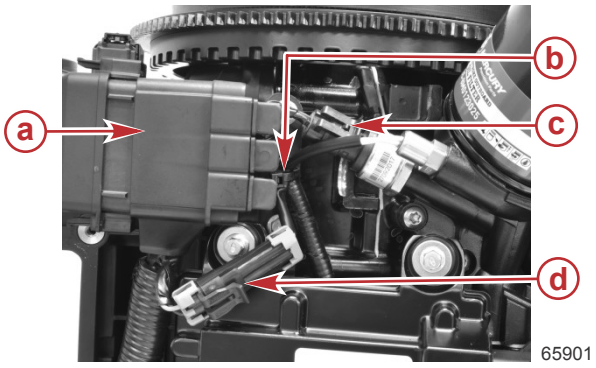
15. Loosen the throttle body clamp and remove the flywheel cover/air box.



65899

a - Flywheel cover/air box
b - Throttle body clamp
c - Throttle body

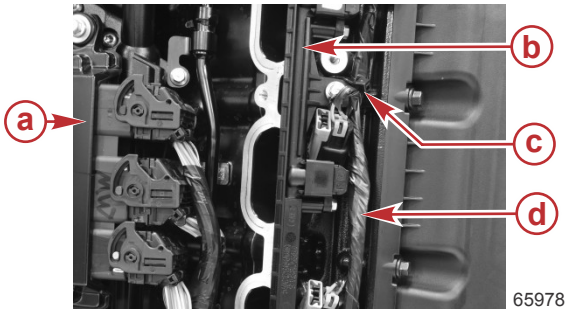
16. Cut the cable tie securing the wiring harness behind the fuse box.
17. Unplug the oil pressure and oil temperature sensor connectors.



65901

a - Fuse box
b - Cable tie
c - Oil pressure sensor connector
d - Oil temperature sensor connector

18. Cut the cable tie securing the injector harness to the port fuel rail.

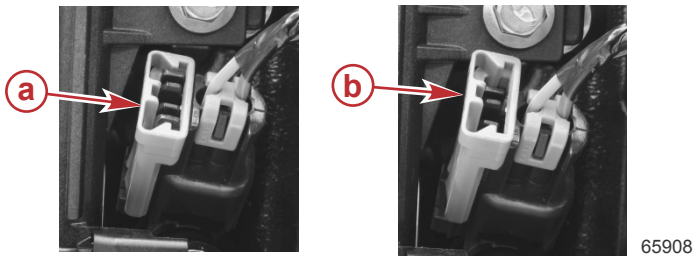


65978

a - Propulsion control module (PCM)
b - Port fuel rail
c - Cable tie
d - Injector harness

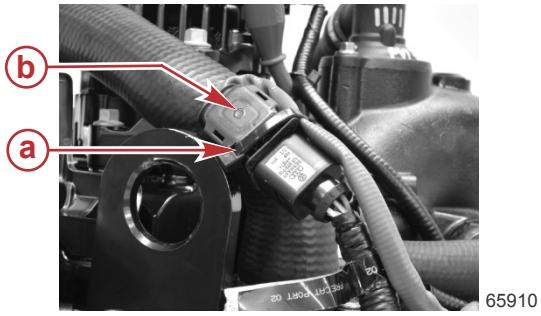
19. Unplug the fuel injector connectors from the port fuel rail. To disconnect the fuel injector harness connectors:
    a. Slide the gray lock tab up.

b. Press the gray lock tab and pull the connector away from the injector.



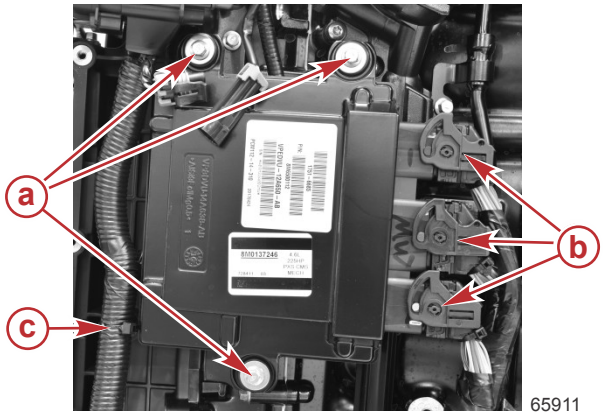
a - Gray lock tab (slide up)
b - Gray lock tab (press here)

20. Cut the cable tie and unplug the oxygen sensor connector.



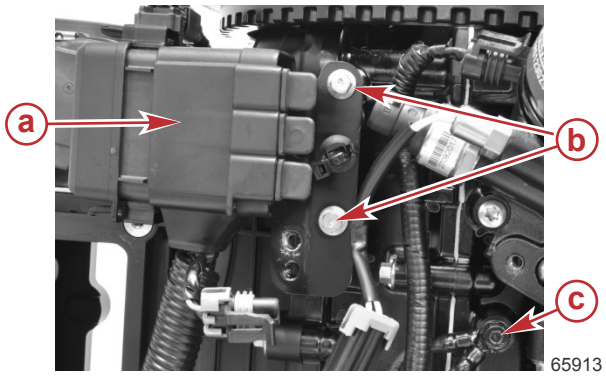
a - Cable tie
b - Oxygen sensor connector

21. Cut the cable tie securing the harness next to the propulsion control module (PCM).
22. Remove the three screws securing the PCM to the powerhead. Remove the PCM.
NOTE: *The three main PCM connectors can remain attached to the PCM.*



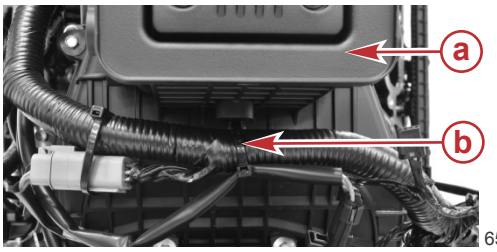
a - Screws (3)
b - PCM connectors (3)
c - Cable tie

23. Remove the two screws securing the fuse box to the powerhead. Remove the fuse box.
24. Remove the ground wire connections behind where the PCM was mounted.



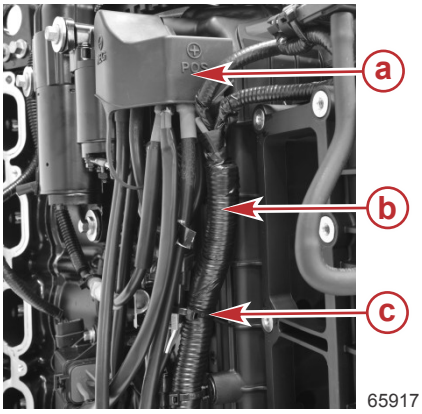
a - Fuse box
b - Screws (2)
c - Ground wire connection

25. Cut the cable tie securing the wiring harness under the intake plenum.



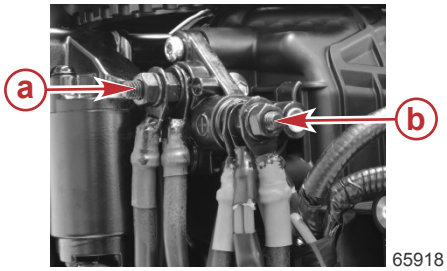
a - Intake plenum
b - Cable tie

26. Cut the cable tie securing the wiring harness. Remove the battery terminal cover.



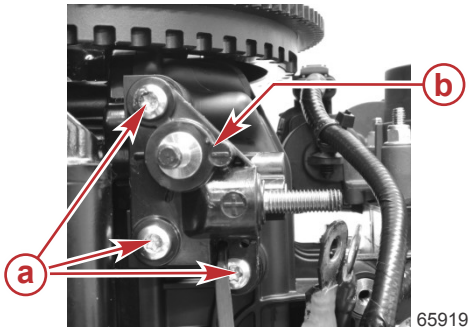
V8 shown—V6 similar
a - Battery terminal cover
b - Wiring harness
c - Cable tie

27. Remove the battery cables from their terminals.



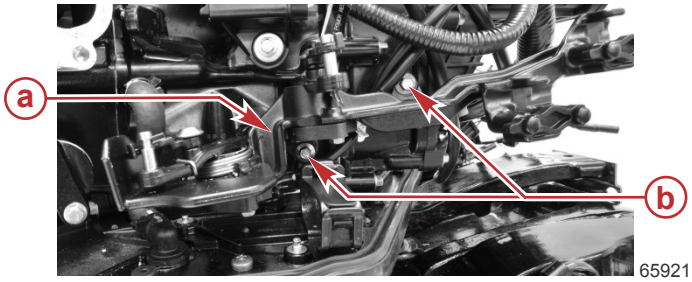
a - Negative (–) battery terminal
b - Positive (+) battery terminal

28. Remove the three T30 Torx® screws securing the battery cable terminal block to the powerhead. Remove the battery cable terminal block.



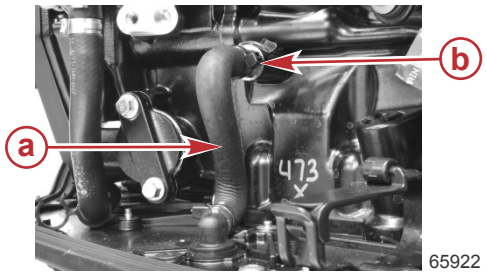
a - Torx screws (3)
b - Battery cable terminal block

29. **Mechanical throttle and shift models—**Remove the two screws securing the cable bracket to the powerhead. Move the cable bracket and wiring out of the way.



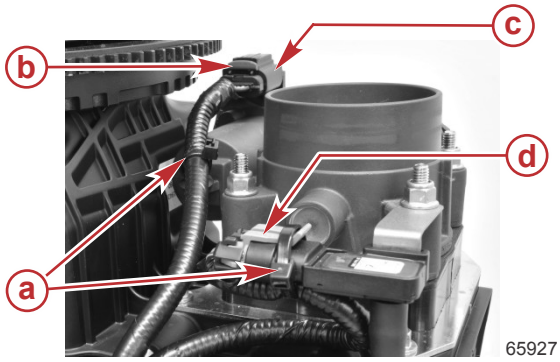
a - Cable bracket
b - Screws (2)

30. Cut the cable tie and remove the drain hose from the fitting on the starboard side of the powerhead.



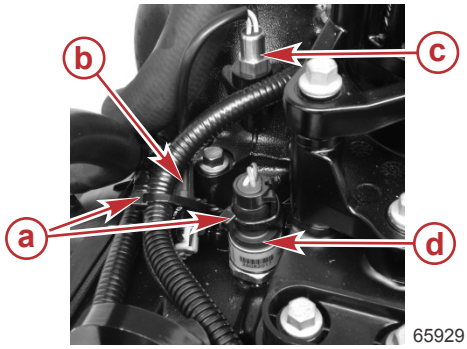
a - Drain hose
b - Cable tie

31. Cut the cable tie securing the manifold absolute pressure (MAP) sensor. Unplug the MAP sensor connector.
32. Cut the cable tie behind the electronic throttle body.
33. Remove the electronic throttle body connector by pulling out the red lock tab, then gently pulling on the connector.



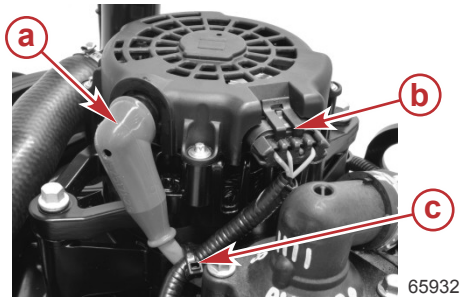
a - Cable ties
b - Red lock tab
c - Electronic throttle body connector
d - MAP sensor connector

34. Cut the cable ties on the top of the starboard cylinder head.
35. Unplug the water temperature sensor connector.
36. Unplug the block water pressure sensor connector.



a - Cable ties
b - Water temperature sensor connector
c - Water temperature sensor
d - Block water pressure sensor

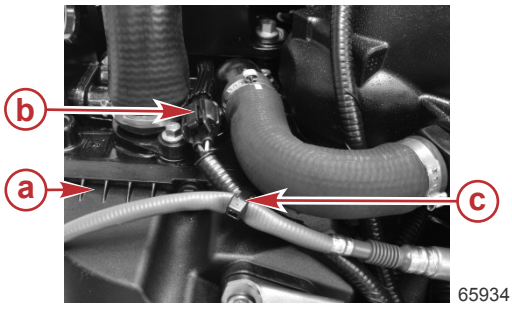
37. Cut the cable tie near the alternator.
38. Unplug the alternator wire connector.
39. Move the cable boot and remove the positive (+) lead from the alternator. Retain the spacer from behind the positive (+) lead.



a - Cable boot
b - Alternator wire connector
c - Cable tie

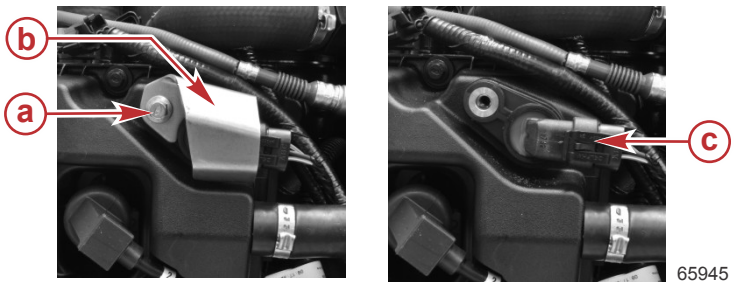
40. Cut the cable tie securing the oxygen sensor harness and crankshaft position sensor harness.

41. Unplug the crankshaft position sensor connector.



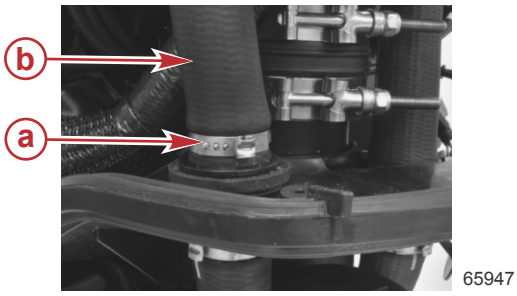
a - Port valve cover
b - Crankshaft position sensor connector
c - Cable tie

42. Remove the screw and sensor guard from the camshaft position sensor. Unplug the camshaft position sensor connector and remove the sensor.



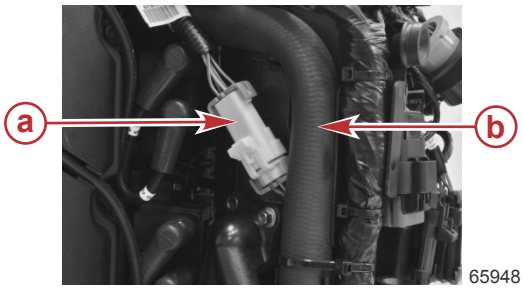
a - Screw
b - Sensor guard
c - Camshaft position sensor connector

43. Remove the 31.6 mm Oetiker® clamp securing the thermostat dump hose to the adapter plate. Remove the hose from the adapter plate.



a - 31.6 mm Oetiker clamp
b - Thermostat dump hose

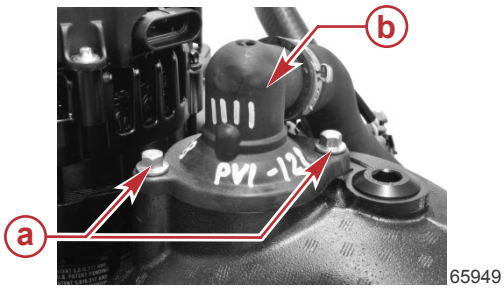
44. Unplug the ignition coil primary lead connector.



a - Ignition coil primary lead connector
b - Thermostat dump hose

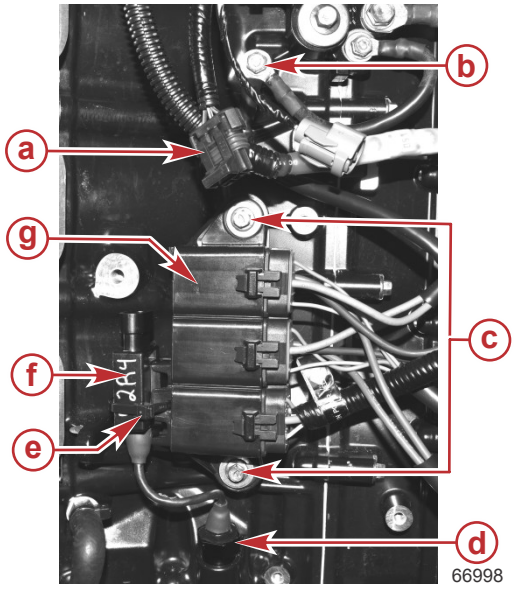
45. Remove the thermostat housing screws and remove the thermostat housing.

IMPORTANT: Do not pry on the thermostat housing to remove it. Rotate the housing back and forth while pulling upward to remove.



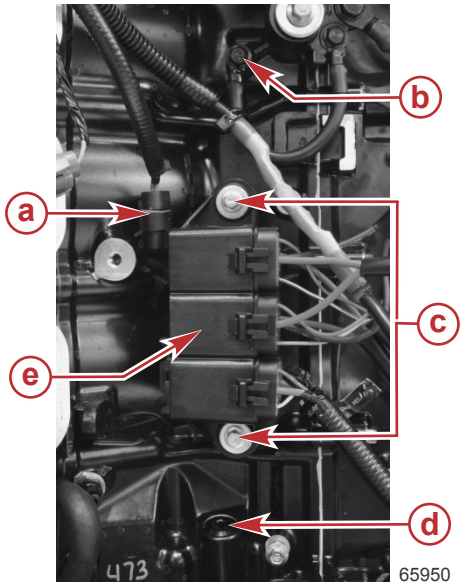
a - Screws
b - Thermostat housing

46. **If equipped with a digital oil level sensor—**Unplug and remove the digital oil level sensor and module.



- **a -** Harness connector
- **b -** Ground wire connection
- **c -** Relay bracket screws
- **d -** Digital oil level sensor
- **e -** Cable tie
- **f -** Digital oil level sensor module
- **g -** Relay bracket

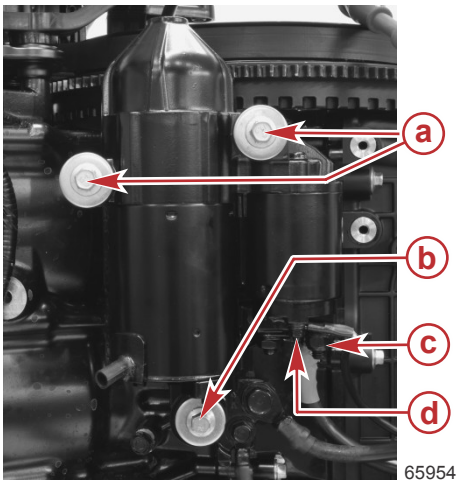
47. **If not equipped with a digital oil level sensor—**Remove the harness connector and weather cap from the relay bracket.
48. Remove the two screws securing the relay bracket. Remove the relay bracket.
49. Remove the ground wire connection near the starter motor.



- **a -** Harness connector
- **b -** Ground wire connection
- **c -** Relay bracket screws
- **d -** Digital oil level sensor location (not equipped in this example)
- **e -** Relay bracket

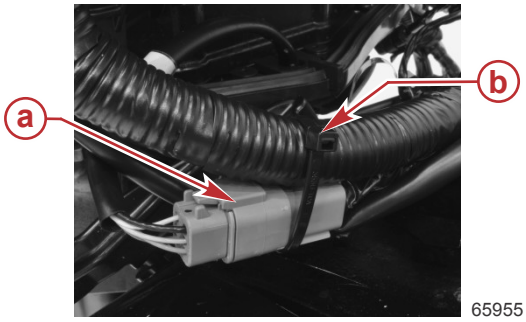
50. Remove the starter solenoid wire (yellow/red) and positive (+) battery cable from the starter solenoid.

51. Remove the three screws and washers securing the starter motor. Remove the starter motor.



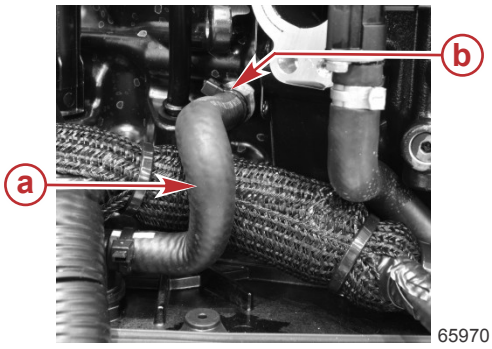
a - M8 x 80 screws and washers
b - M8 x 45 screws and washers
c - Positive (+) battery cable
d - Starter solenoid wire (yellow/red)

52. Cut the cable tie and unplug the shift actuator connector located below the intake plenum.



a - Shift actuator connector
b - Cable tie

53. Cut the cable tie securing the port side drain hose. Remove the water drain hose from the powerhead.



a - Drain hose
b - Cable tie

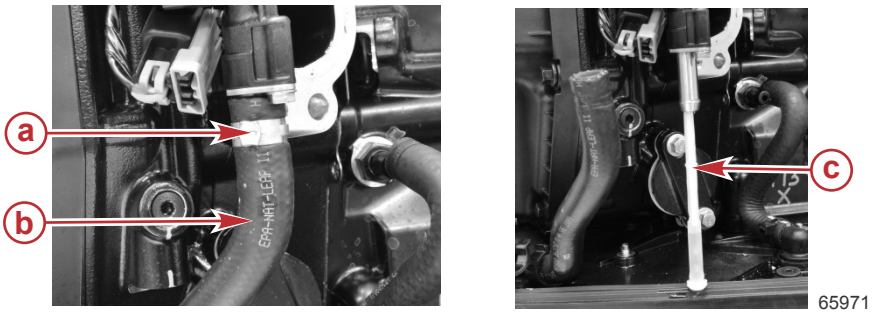
54. Ensure that the fuel pressure is relieved from the fuel system. Refer to **Section 3 - Fuel System**.

⚠ 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.

55. Remove the 16.2 mm Oetiker clamps from the fuel rails.
56. Remove the fuel hoses and fuel line filters from the fuel rails.

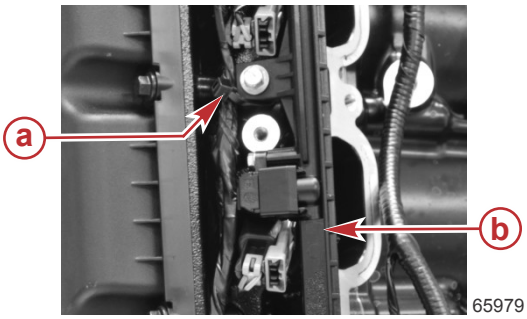
IMPORTANT: Fuel will be present in the fuel rails and fuel hoses. Collect as much fuel as possible and prevent fuel from contacting the harness.



Starboard side shown, port side similar

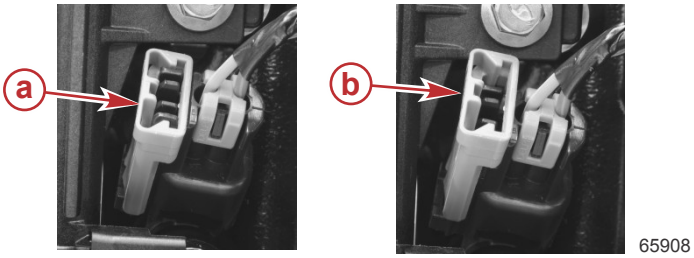
- **a -** 16.2 mm Oetiker clamp (one per fuel rail)
- **b -** Fuel hose (one per fuel rail)
- **c -** Fuel line filter (one per fuel rail)

57. Cut the cable tie securing the injector harness to the starboard fuel rail.



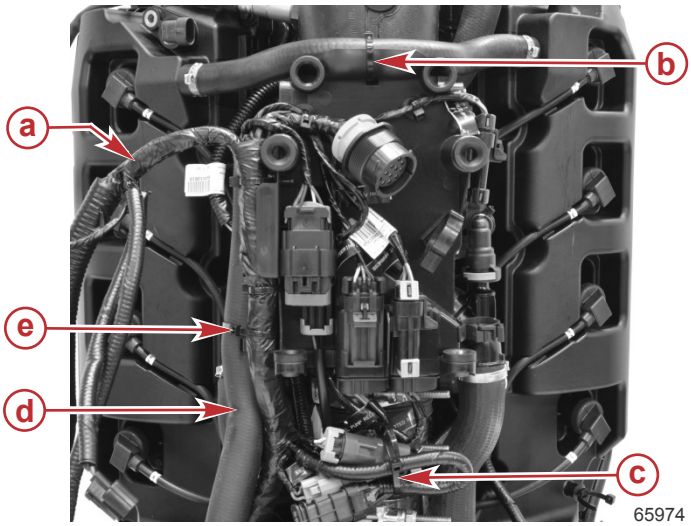
- **a -** Cable tie
- **b -** Starboard fuel rail

58. Unplug the fuel injector connectors from the starboard fuel rail. To disconnect the fuel injector harness connectors:
    a. Slide the gray lock tab up.
    b. Press the gray lock tab and pull the connector away from the injector.



- **a -** Gray lock tab (slide up)
- **b -** Gray lock tab (press here)

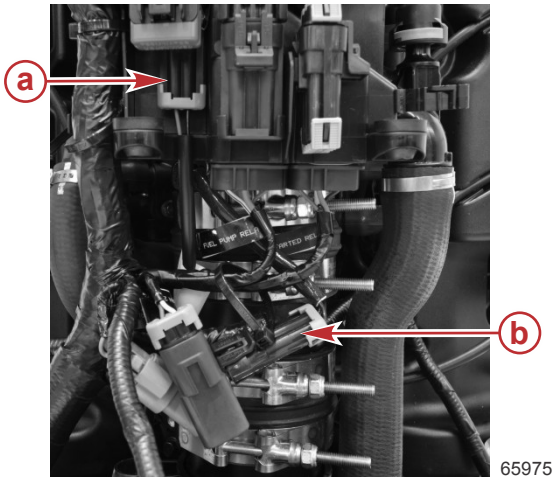
59. Pull the electrical harness with the starboard side fuel injector connections behind the exhaust tube.
60. Cut the cable tie securing the aft wiring bundle together.
61. Cut the cable tie securing the thermostat dump hose to the electrical plate.
62. Cut the cable tie securing the breather hose to the electrical plate.
63. Remove the thermostat dump hose and thermostat housing by pulling the assembly upward, behind the exhaust tube.



V8 shown—V6 similar

- **a -** Electrical harness from starboard side
- **b -** Cable tie securing the breather hose
- **c -** Cable tie securing the aft wiring bundle
- **d -** Thermostat dump hose
- **e -** Cable tie securing thermostat dump hose

64. Push the fuel pump connector upward to free the connector from the electrical plate. Unplug the fuel pump connector.
65. Unplug the exhaust gas temperature (EGT) sensor connector.

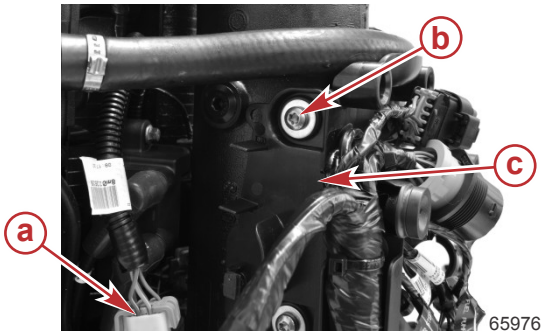


65975

V8 shown—V6 similar

- **a -** Fuel pump connector
- **b -** EGT sensor connector

66. Remove the top two T30 Torx screws and washers securing the electrical plate to the exhaust tube.
67. Push the ignition coil harness connector upward to free it from the electrical plate.



65976

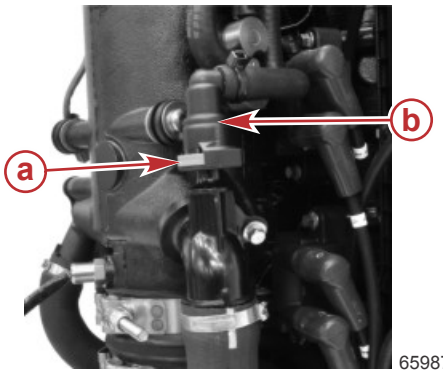
V8 shown—V6 similar

- **a -** Ignition coil harness connector
- **b -** T30 Torx screws and washers (one each per side)
- **c -** Electrical plate

68. Tilt the top of the electrical plate aft, then pull upward to remove.
69. Remove the harness, electrical plate, and PCM as an assembly.

Exhaust Tube Removal

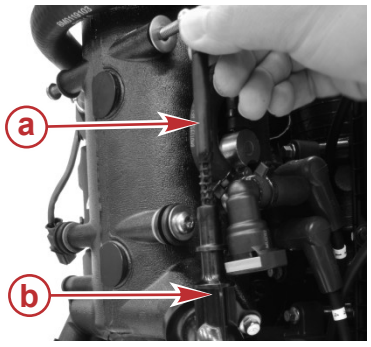
1. Press the blue tab on the water hose connector with a screwdriver and pull the water hose connector up to disconnect. Rotate the water hose out of the way.



65987

- **a -** Blue tab
- **b -** Water hose connector

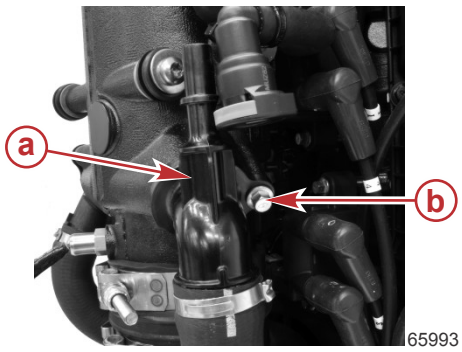
2. Remove the strainer by pulling it up out of the water hose fitting.



65991

a - Strainer
b - Water hose fitting

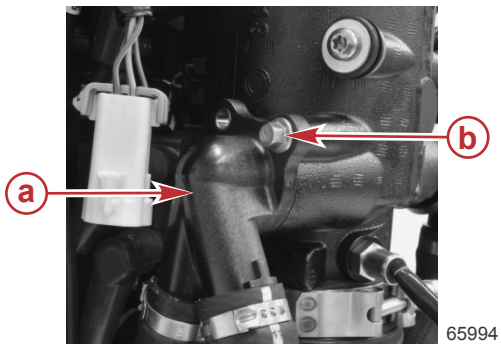
3. Remove the screw securing the water strainer fitting to the starboard side of the exhaust tube. Rotate the fitting back and forth while pulling away from the exhaust tube to remove.



65993

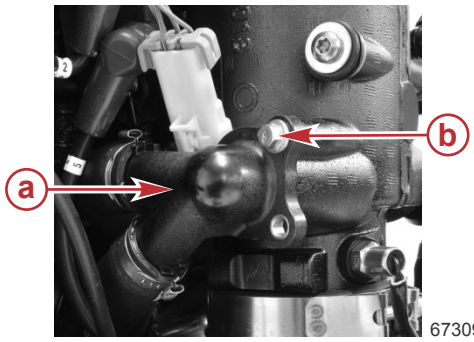
a - Water strainer fitting
b - Screw

4. Remove the screw securing the water supply fitting to the port side of the exhaust tube. Rotate the fitting back and forth while pulling away from the exhaust tube to remove.



65994

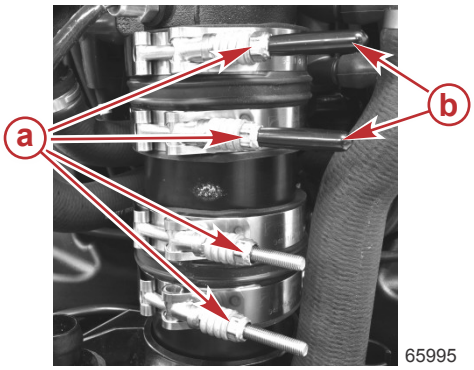
V8
a - Water supply fitting
b - Screw



67309

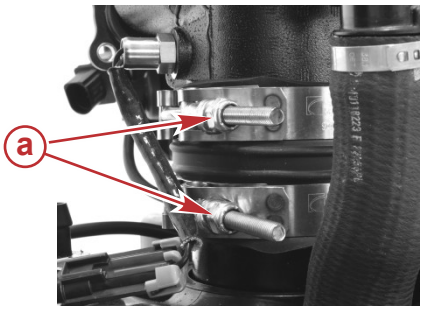
V6
a - Water supply fitting
b - Screw

5. Remove the thread protector and loosen the exhaust boot clamp nuts.



V8

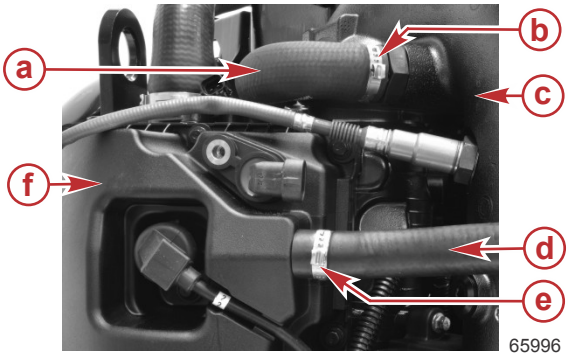
a - Exhaust boot clamp nuts
b - Thread protectors



V6—thread protectors not shown

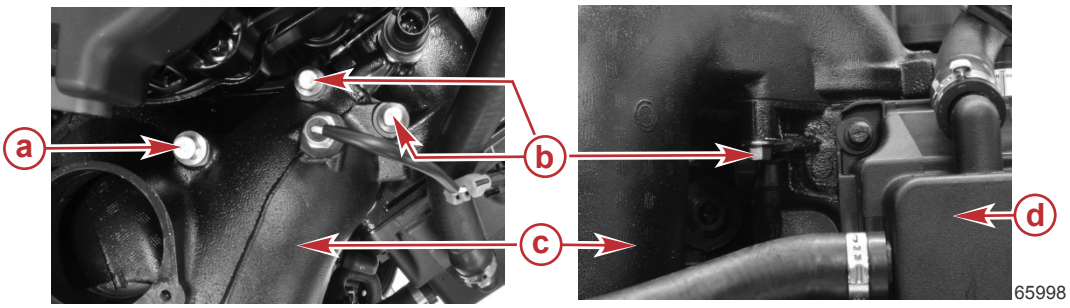
a - Exhaust boot clamp nuts

6. Remove the 25.6 mm Oetiker clamp securing the breather tube to the port camshaft cover. Remove the breather hose from the port camshaft cover.
7. Remove the 31.6 mm Oetiker clamp securing the water hose to the fitting on the exhaust tube. Remove the water hose from the fitting.



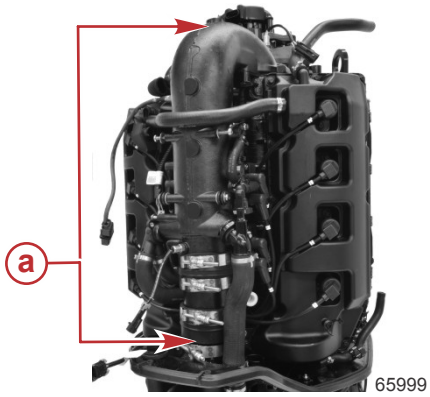
a - Water hose
b - 31.6 mm Oetiker clamp
c - Exhaust tube
d - Breather hose
e - 25.6 Oetiker clamp
f - Port camshaft cover

8. Remove the four stainless steel screws securing the exhaust tube to the powerhead.



a - M8 x 85 screw
b - M8 x 45 screws (3)
c - Exhaust tube
d - Starboard camshaft cover

9. Lift the exhaust tube assembly up while rotating back and forth to remove.

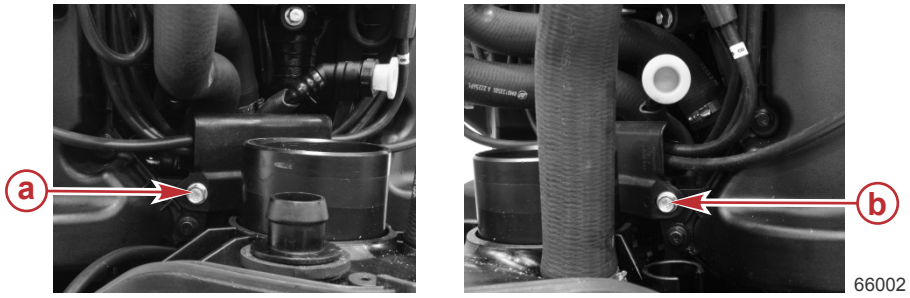


V8 shown, V6 similar

a - Exhaust tube assembly

Component Removal

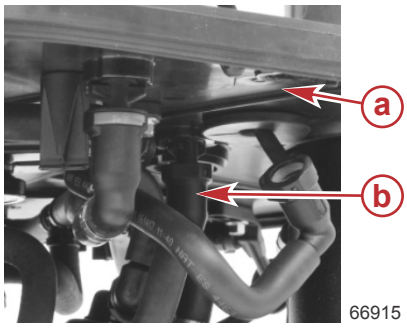
1. Remove the spark plug wire retainer screws. Tilt the wire retainer out of the way.



a - Spark plug retainer screw on the port side

b - Spark plug retainer screw on the starboard side

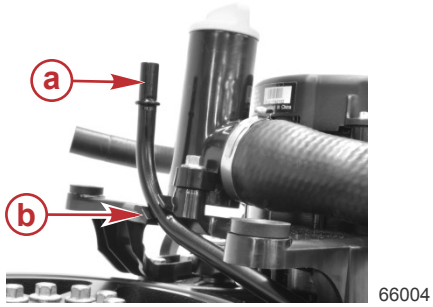
2. Disconnect the quick-connect fitting from the drain fitting under the chap plate.



a - Chap plate

b - Quick-connect fitting

3. Remove the upper dipstick tube from the retainer.

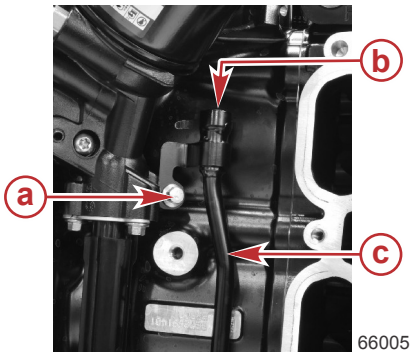


a - Upper dipstick tube

b - Retainer

4. Remove the screw securing the dipstick tube to the powerhead.

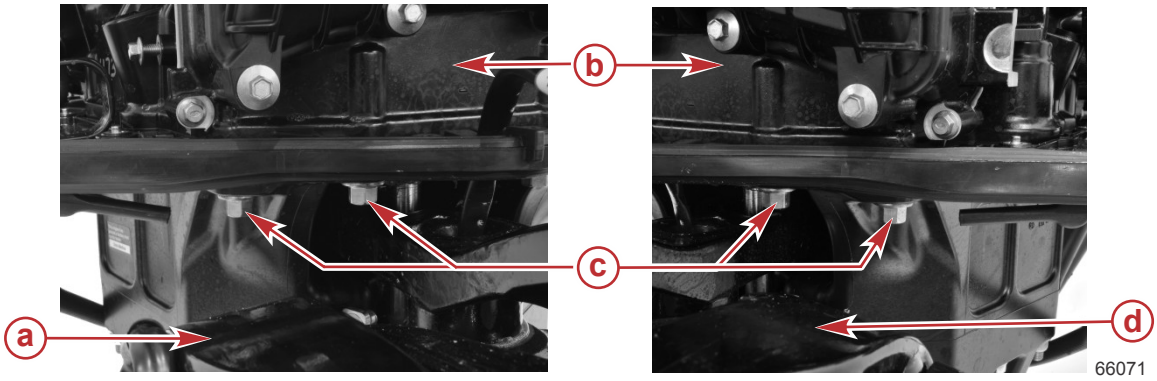
5. Remove the dipstick tube by turning it while pulling up. Remove the O-ring.



a - Screw
b - O-ring location
c - Dipstick tube

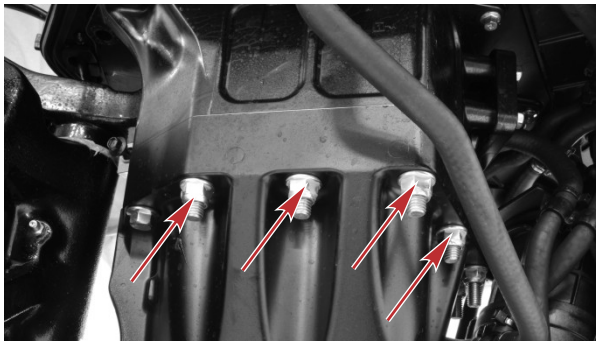
Powerhead Removal from Conventional Midsection (CMS)

1. Ensure that the engine oil is drained. Refer to **Section 1B - Changing Engine Oil and Filter**.
2. Remove the four 12 mm bolts securing the front of the powerhead to the midsection.



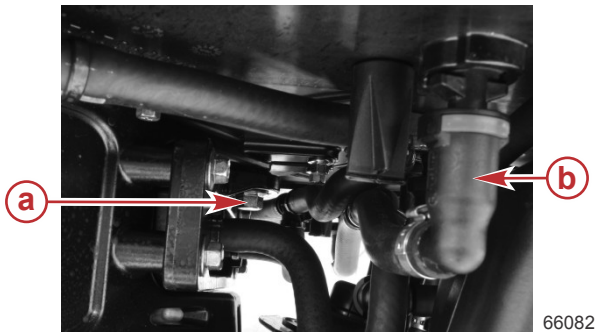
a - Starboard transom bracket
b - Front of powerhead
c - 12 mm bolts (4)
d - Port transom bracket

3. Remove the four 15 mm nuts from each side.



Port side shown, starboard similar

4. Remove the 12 mm bolt from the aft end under the powerhead.



As seen from port side

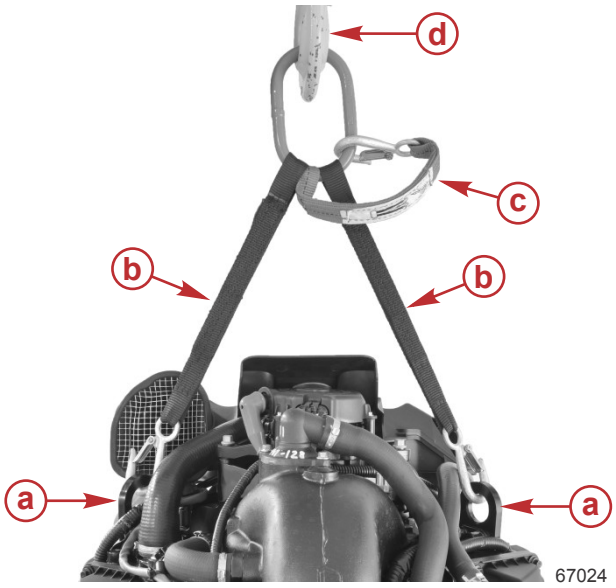
a - 12 mm bolt
b - Fuel line quick-connect fitting to port fuel rail

⚠ CAUTION

Improper lifting during removal or installation of the engine can cause injury or damage to engine components. Use a hoist, lifting arm, or other approved lifting device. Do not allow the lifting device to hook or compress any engine components.

5. Attach the lifting strap to the lifting eyes. Attach the lifting strap to a hoist with a capacity of at least 450 kg (1000 lb).

IMPORTANT: All engine lifting devices (straps, slings, chains, or hoists) must have a minimum capacity of 450 kg (1000 lb).



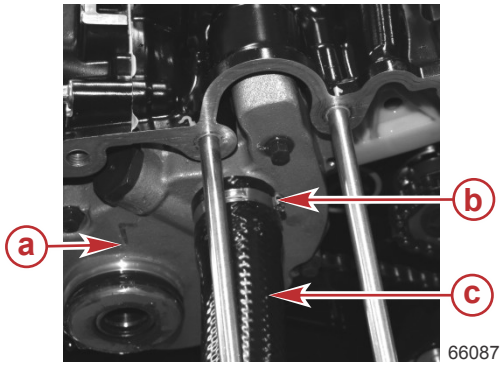
a - Lifting eyes on the engine
b - Equal length straps (black)
c - Short strap (red); secure out of the way
d - Overhead hoist

Lifting strap	883705T01

6. Lift the powerhead off of the midsection.

IMPORTANT: Ensure that the fuel hose from the FSM does not snag while lifting the powerhead or damage to the hose or FSM may result.

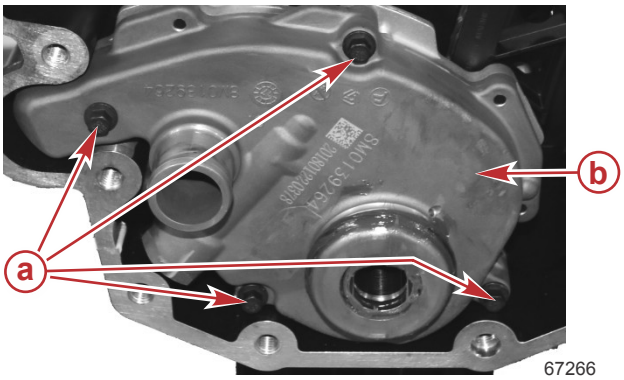
7. Remove the 39.6 mm Oetiker clamp to remove the oil pickup hose from the oil pump.



a - Oil pump
b - 39.6 mm Oetiker clamp
c - Oil pickup hose

8. Mount the powerhead on a suitable engine stand.

9. Remove the four screws securing the oil pump to the powerhead. Remove the oil pump.



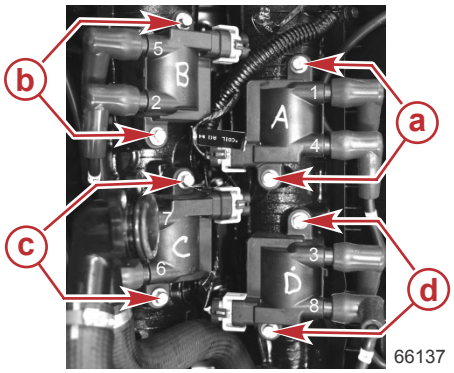
67266

a - Screws (4)
b - Oil pump

10. Mark the ignition coils with their corresponding cylinder numbers to aid reassembly.
11. Remove the spark plug wires from the spark plugs.
12. Remove the screws securing the ignition coils to the powerhead. Remove the ignition coils with the spark plug wires and ignition coil primary harness attached.

NOTE: *The letters on the ignition coils correspond with the tags on the ignition coil primary harness wires.*

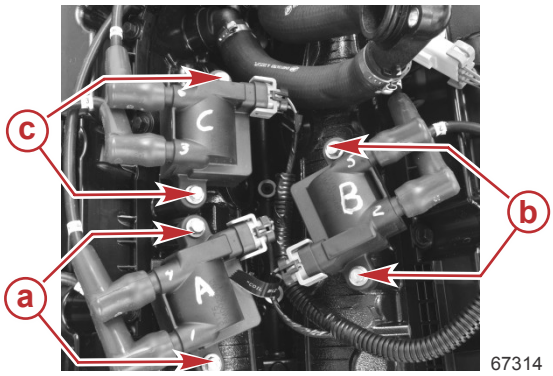
NOTE: *V8 engines have four ignition coils, V6 engines have three ignition coils.*



66137

V8

a - Screws securing ignition coil A
b - Screws securing ignition coil B
c - Screws securing ignition coil C
d - Screws securing ignition coil D



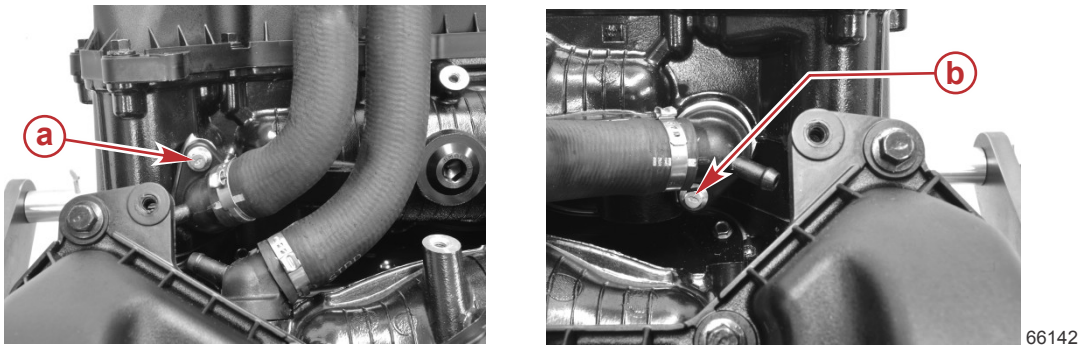
67314

V6

a - Screws securing ignition coil A
b - Screws securing ignition coil B
c - Screws securing ignition coil C

13. Remove the water supply fittings from each cylinder head.

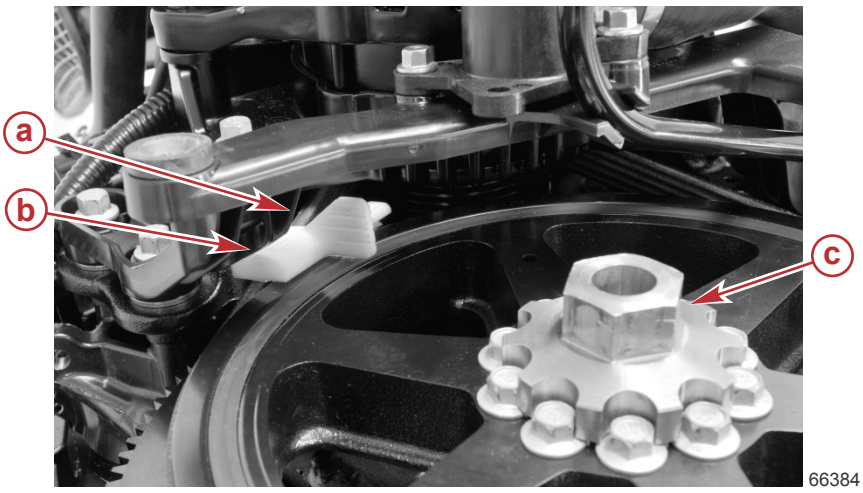
NOTE: *Remove the water supply fitting from the port cylinder head first to access the starboard water supply fitting.*



V8 shown—V6 similar

a - Screw securing the port water supply fitting
b - Screw securing the starboard water supply fitting

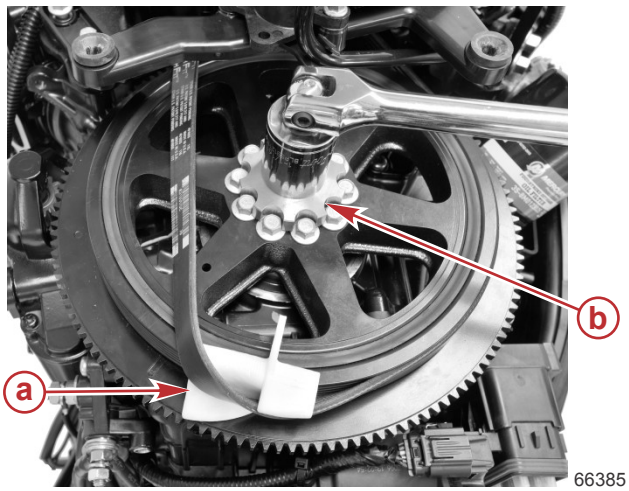
14. Remove the alternator belt:
    a. Position the alternator belt shoe between the flywheel and the alternator belt, as shown.



V8 shown—V6 similar

a - Alternator belt
b - Alternator belt shoe
c - Flywheel socket

    b. Use the flywheel socket to turn the flywheel counterclockwise until the belt comes free of the flywheel.

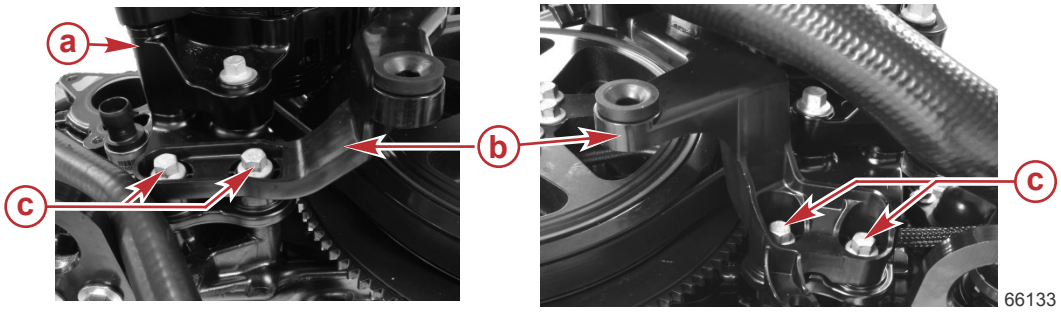


V8 shown—V6 similar

a - Alternator belt shoe
b - Flywheel socket

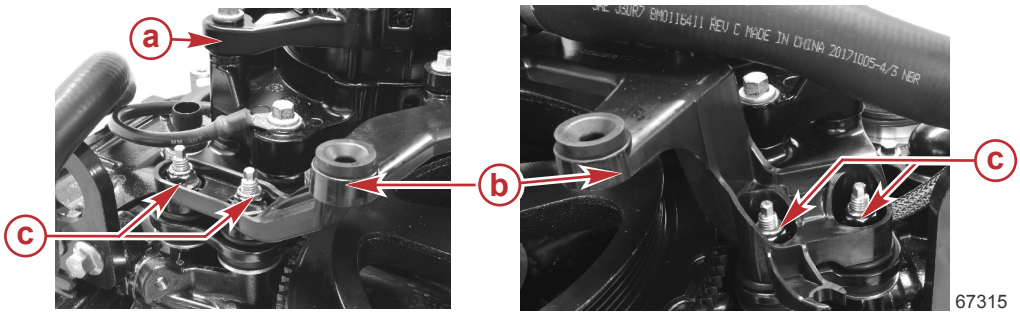
Alternator Belt Shoe	8M0146862
Flywheel Socket	8M0146861

15. **V8 models—**Remove the four screws securing the oil fill bracket to the powerhead.



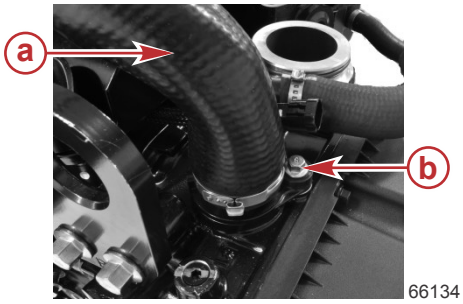
a - Alternator
b - Oil fill bracket
c - Screws (4)

16. **V6 models—**Remove the four nuts securing the oil fill bracket to the powerhead.



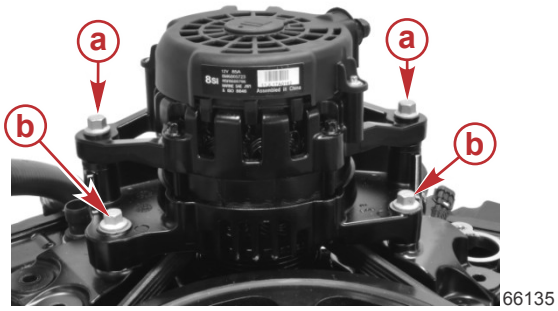
a - Alternator
b - Oil fill bracket
c - Nuts (4)

17. Remove the screw securing the oil fill hose fitting to the cylinder head. Remove the oil fill hose and bracket.

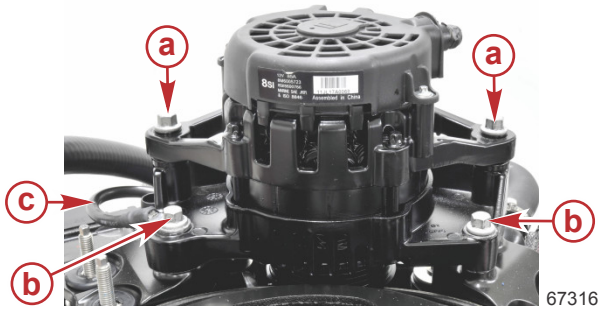


a - Oil fill hose
b - Screw

18. Remove the screws securing the alternator. Remove the ground cable (V6 models only) and remove the alternator.



V8
a - M8 x 80 screws (2)
b - M8 x 45 screws (2)



V6
- a - M8 x 80 screws (2)
- b - M8 x 45 screws (2)
- c - Ground cable

Powerhead Disassembly

Cylinder Head Removal

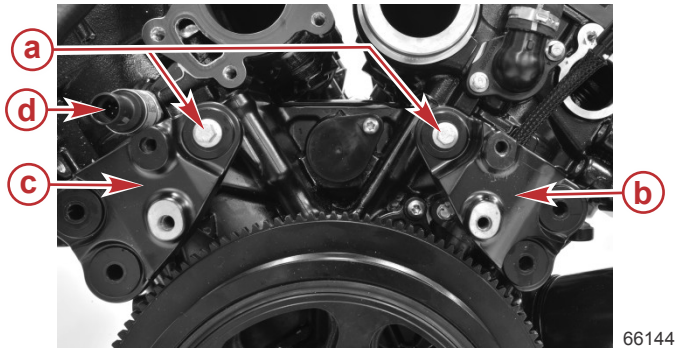
IMPORTANT: The removal and disassembly procedure of the cylinder head and camshafts must be strictly followed. Failure to follow the removal procedure may damage the valve train components.

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.

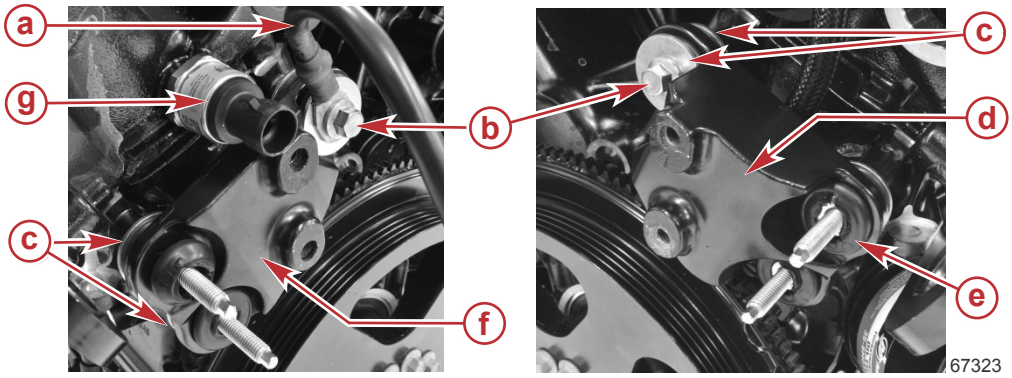
NOTE: *The cylinder heads can be removed with the fuel rails attached.*

1. Remove the powerhead. Refer to **Removing Powerhead Components as an Assembly**.
2. **V8 models—**Remove the screws securing the alternator brackets. Remove the alternator brackets.



V8
- a - Screws (2)
- b - Port alternator bracket
- c - Starboard alternator bracket
- d - Block water pressure sensor

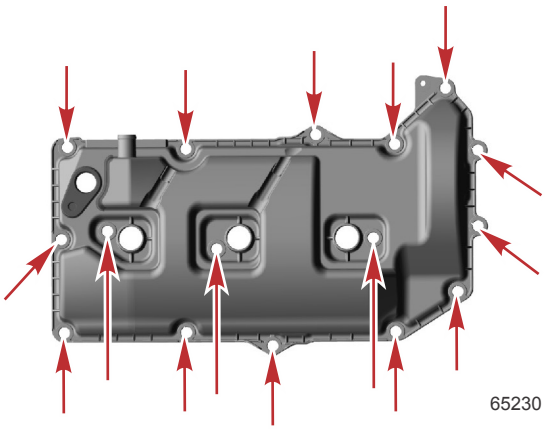
3. **V6 models—**Remove the screws securing the alternator brackets. Remove the alternator brackets, rubber isolators, washers, and ground cable.



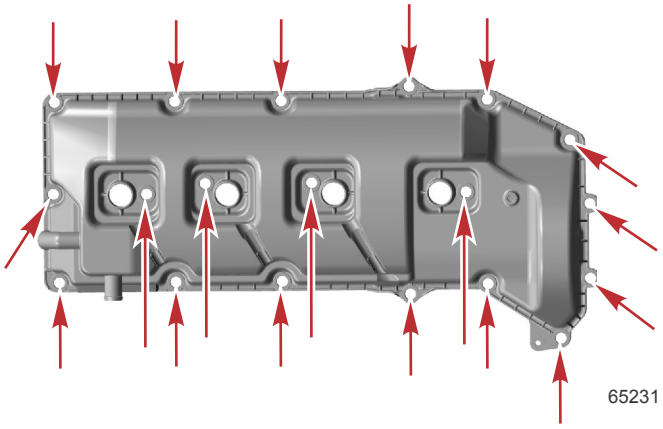
V6

- **a -** Ground cable
- **b -** Screws (2)
- **c -** Washers (4 per bracket)
- **d -** Port alternator bracket
- **e -** Rubber isolators (3 per bracket)
- **f -** Starboard alternator bracket
- **g -** Block water pressure sensor

4. Remove the spark plugs.
5. Remove the camshaft cover screws. Remove the camshaft covers.

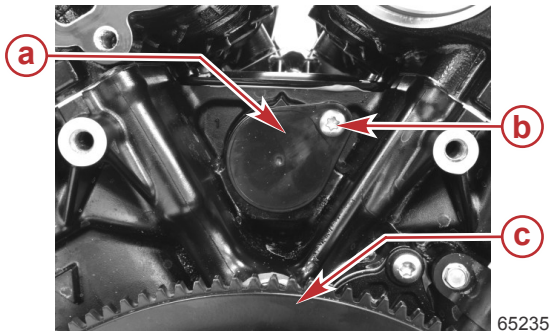


V6 (port side shown—starboard similar)



V8 (starboard side shown—port similar)

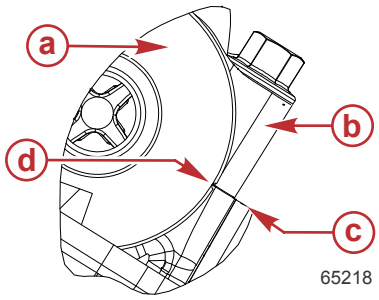
6. **V8 models—**Remove the balance shaft plug.



a - Balance shaft plug
b - Screw
c - Flywheel

7. Rotate the flywheel/crankshaft so the cylinder 1 is at top dead center (TDC) on the compression stroke:
   a. **V8 models—**Ensure that the green dot (punch mark) aligns with the match line of the cylinder 4 intake camshaft cap. This camshaft cap is identified with the marks SI4 with an arrow pointing to the top of the powerhead.

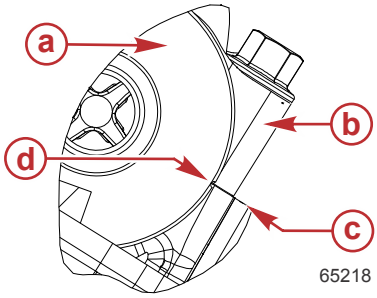
   IMPORTANT: The camshaft caps are marked with the letters P or S (for port or starboard), the letters I or E (for intake or exhaust), the cylinder number for each bank (cylinder 1 at the top), and an arrow pointing to the top of the powerhead.



Cylinder 4 intake camshaft, starboard bank
a - Camshaft lobe
b - Camshaft cap
c - Match line of the camshaft cap
d - Green dot (punch mark) aligns with the match line of the camshaft cap

   b. **V6 models—**Ensure that the green dot (punch mark) aligns with the match line of the cylinder 6 intake camshaft cap. This camshaft cap is identified with the marks PI3 with an arrow pointing to the top of the powerhead.

IMPORTANT: The camshaft caps are marked with the letters P or S (for port or starboard), the letters I or E (for intake or exhaust), the cylinder number for each bank (cylinder 1 at the top), and an arrow pointing to the top of the powerhead.

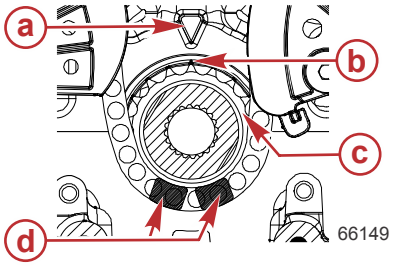


Cylinder 6 intake camshaft, port bank

- **a -** Camshaft lobe
- **b -** Camshaft cap
- **c -** Match line of the camshaft cap
- **d -** Green dot (punch mark) aligns with the match line of the camshaft cap

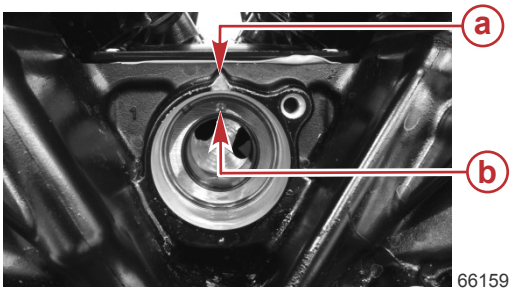
c. Ensure that the yellow marks on the timing chain are positioned as shown.

d. Ensure that the timing mark on the crankshaft is aligned with the timing pointer cast into the bottom of the cylinder block.



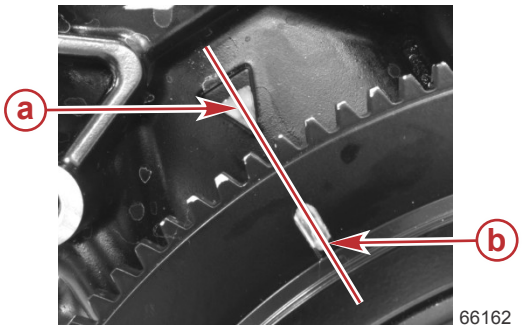
- **a -** Timing pointer cast into the bottom of the cylinder block
- **b -** Timing mark on the crankshaft
- **c -** Crankshaft sprocket
- **d -** Yellow marks on the timing chain

e. **V8 models—**Ensure that the balance shaft timing mark aligns with the timing pointer cast into the cylinder block.



- **a -** Timing pointer
- **b -** Balance shaft timing mark

f. Ensure that the line on the flywheel aligns with the timing pointer on the top of the cylinder block.

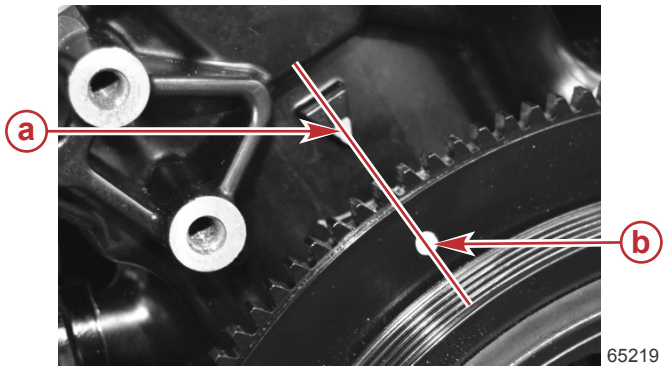


Timing marks aligned at cylinder 1 TDC (V8 flywheel shown—V6 similar)

- **a -** Timing pointer
- **b -** Line on the flywheel

8. After the engine has been set with cylinder 1 in the TDC position of the compression stroke, rotate the crankshaft until the dot on the flywheel is aligned with the pointer (known as the **service position**).

IMPORTANT: Piston or valve damage can occur if the timing marks are not aligned in the service position.

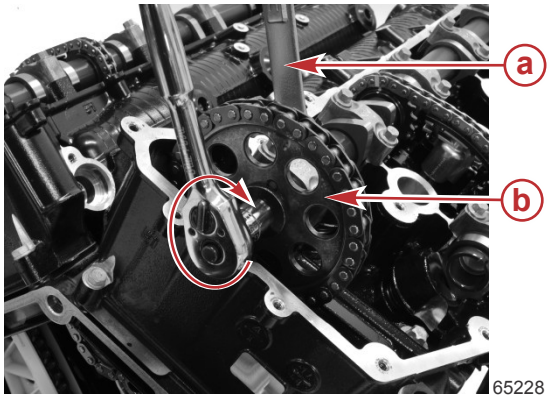


Timing marks aligned in the service position (V8 flywheel shown—V6 similar)

- **a -** Pointer on cylinder block (starboard bank)
- **b -** Dot on flywheel (identified with yellow paint for visibility)

9. Hold the camshaft in position with a wrench on the hex located behind the camshaft sprocket.
10. Loosen the camshaft sprocket screws.

IMPORTANT: The camshaft sprocket screws are left-hand thread.

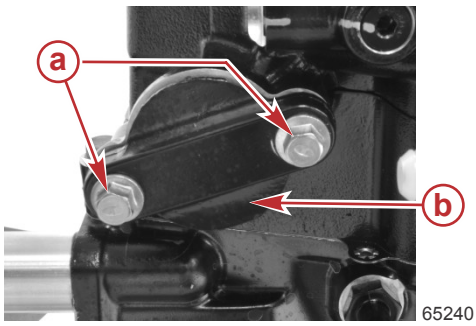


Starboard side shown

- **a -** Wrench on the camshaft hex
- **b -** Camshaft sprocket

11. Remove the timing chain tensioner cover.

IMPORTANT: The tensioner can fall out after the cover is removed. Place your hand over the tensioner cover during removal to catch the tensioner.



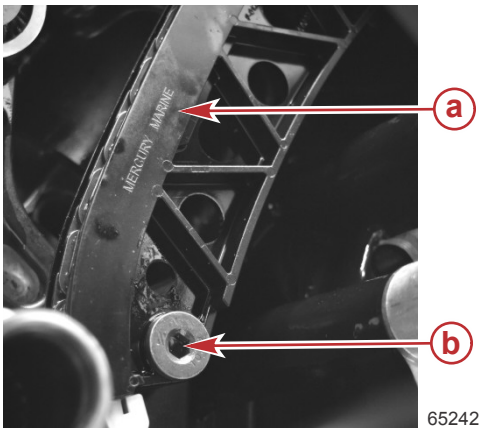
- **a -** Screws
- **b -** Timing chain tensioner cover

12. Remove the timing chain tensioner from the cylinder block.

Timing chain tensioner

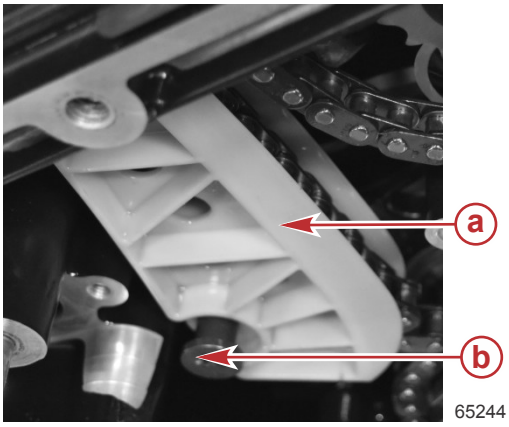
13. Remove the movable timing chain guide first.

NOTE: *The movable timing chain guide is black and located on the starboard side.*



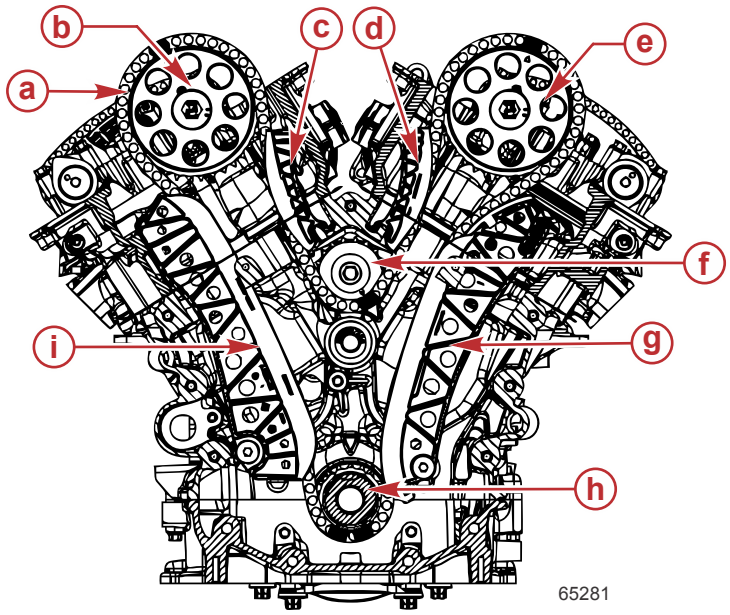
- **a -** Movable timing chain guide
- **b -** Special flange head screw (6 mm hex)

14. Remove the fixed timing chain guide.



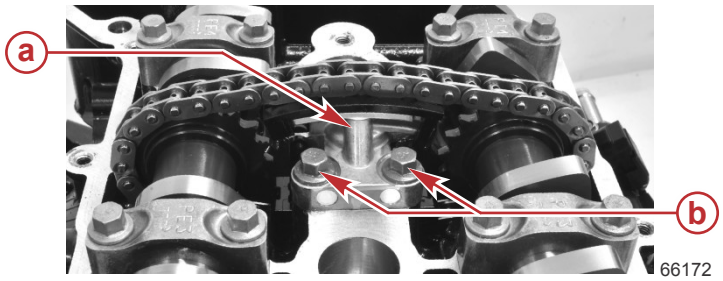
- **a -** Fixed timing chain guide
- **b -** Special flange head screw

15. Remove the port camshaft sprocket. The port timing chain guide will fall.
    IMPORTANT: The camshaft sprocket screws are left-hand thread.
16. Pull the port timing chain guide up and remove it from the cylinder block.
17. Remove the starboard camshaft sprocket. The starboard timing chain guide will fall.
    IMPORTANT: The camshaft sprocket screws are left-hand thread.
18. Pull the starboard timing chain guide up and remove it from the cylinder block.
19. Remove the timing chain from the engine.



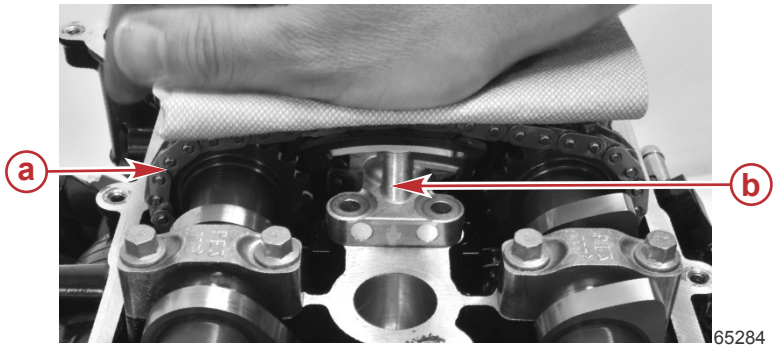
- **a -** Timing chain
- **b -** Port camshaft sprocket
- **c -** Port timing chain guide
- **d -** Starboard timing chain guide
- **e -** Starboard camshaft sprocket
- **f -** Balance shaft sprocket (V8) or idler sprocket (V6)
- **g -** Movable timing chain guide
- **h -** Crankshaft sprocket
- **i -** Fixed timing chain guide

20. Remove the two screws securing the camshaft-to-camshaft timing chain tensioner.



a - Camshaft-to-camshaft timing chain tensioner
b - Screws (2)

21. Compress the tensioner by pressing down with your hand to allow oil to escape from the tensioner. Press down several times to compress the tensioner. The timing chain will slacken.



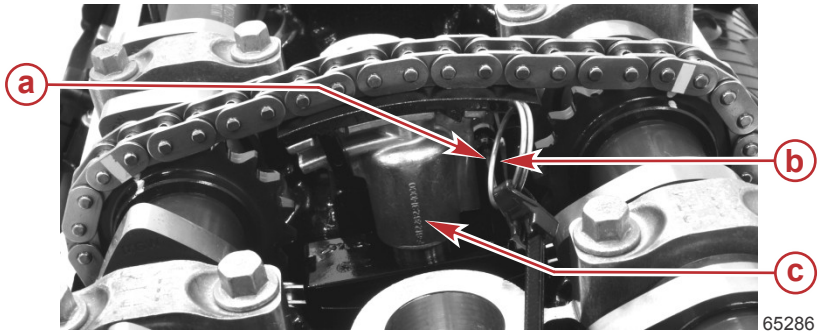
a - Camshaft-to-camshaft timing chain
b - Camshaft-to-camshaft timing chain tensioner

22. After compressing the tensioner, insert a pin or small drill bit (1.2 mm [0.47 in.]) through the slots of the tensioner to keep the tensioner compressed.

NOTE: *If the tensioner will not compress enough to insert the pin through the slots, the tensioner can be removed without the pin inserted.*

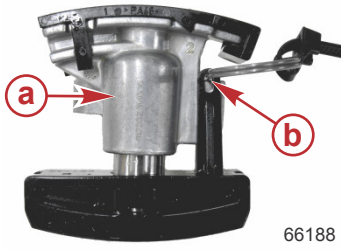
23. Remove the camshaft-to-camshaft timing chain tensioner from each cylinder head by tilting the top of the tensioner toward the bottom of the powerhead, then lifting.

NOTE: *You may need to hold the timing chain to allow for tensioner removal.*



a - Slots of the timing chain tensioner
b - Pin inserted through the slots
c - Timing chain tensioner

24. If the tensioner was removed without the pin installed, compress the tensioner by hand and install the pin to keep the tensioner compressed.

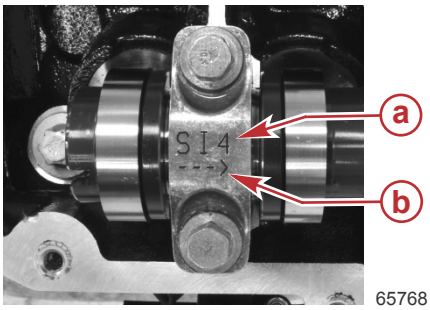


a - Tensioner
b - Pin inserted through slots

25. Identify the markings on the camshaft caps so they can be installed in the same location and orientation as removed.

IMPORTANT: Do not intermix the location of the valve train parts. Severe engine damage will result if the camshaft caps are not installed in their original position and orientation.

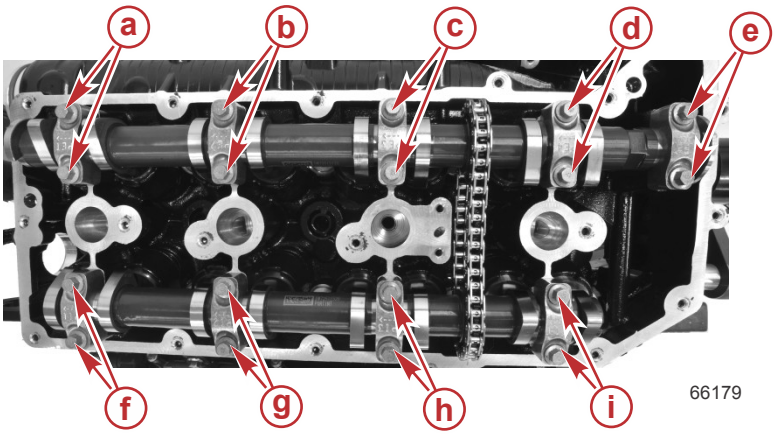
IMPORTANT: The camshaft caps are marked with the letters P or S (for port or starboard), the letters I or E (for intake or exhaust), the cylinder number for each bank (cylinder 1 at the top), and an arrow pointing to the top of the powerhead.



65768

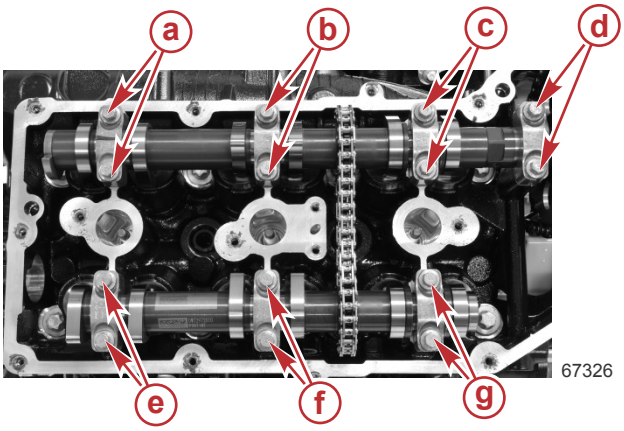
a - Identification mark—starboard intake, cylinder 4 of the starboard bank in this example
b - Directional arrow—points to top of powerhead

26. Loosen the camshaft cap screws 1/4 turn at a time until the camshafts are loose. Remove the camshaft cap screws and camshaft caps.
27. Remove the camshafts and camshaft-to-camshaft timing chain from the cylinder heads as an assembly.



66179

V8 port cylinder head shown; starboard similar
a - Screws securing camshaft cap PE1
b - Screws securing camshaft cap PE2
c - Screws securing camshaft cap PE3
d - Screws securing camshaft cap PE4
e - Screws securing camshaft cap PE5
f - Screws securing camshaft cap PI1
g - Screws securing camshaft cap PI2
h - Screws securing camshaft cap PI3
i - Screws securing camshaft cap PI4

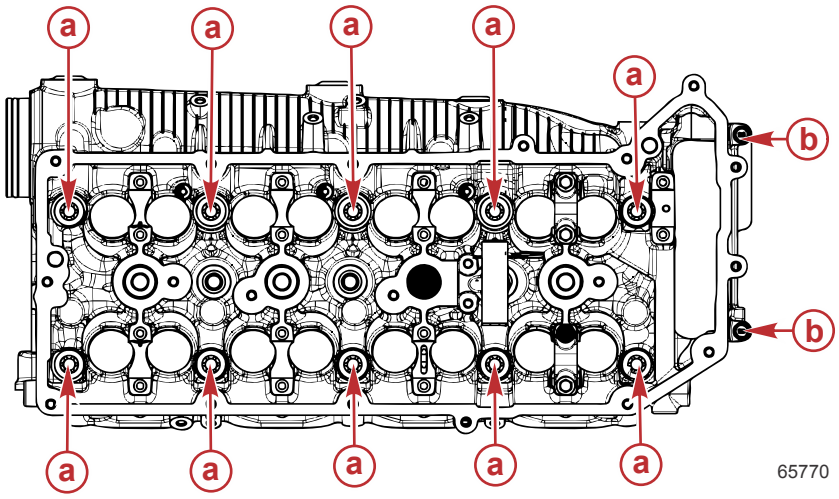


67326

V6 port cylinder head shown; starboard similar
a - Screws securing camshaft cap PE1
b - Screws securing camshaft cap PE2
c - Screws securing camshaft cap PE3
d - Screws securing camshaft cap PE4
e - Screws securing camshaft cap PI1
f - Screws securing camshaft cap PI2
g - Screws securing camshaft cap PI3

28. Remove the two M6 screws from the bottom of each cylinder head.

29. **V8 models—**Remove the ten E14 external Torx® screws securing each cylinder head to the cylinder block.

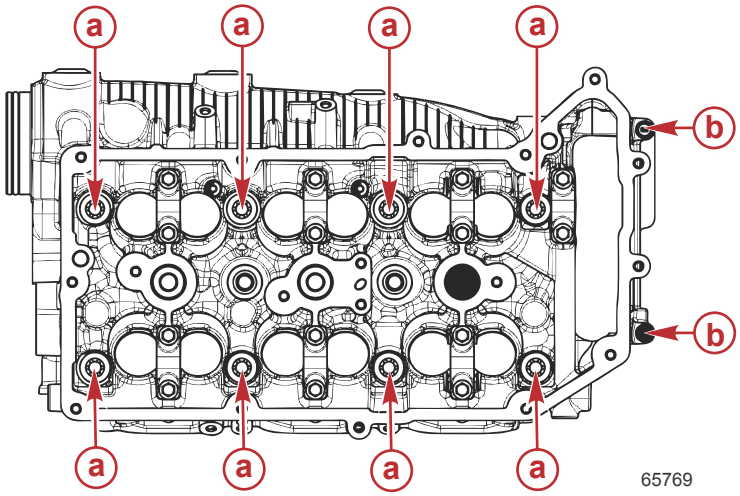


Port cylinder head shown; starboard similar

a - E14 external Torx screws

b - M6 screws at bottom of cylinder head

30. **V6 models—**Remove the eight E14 external Torx® screws securing each cylinder head to the cylinder block.

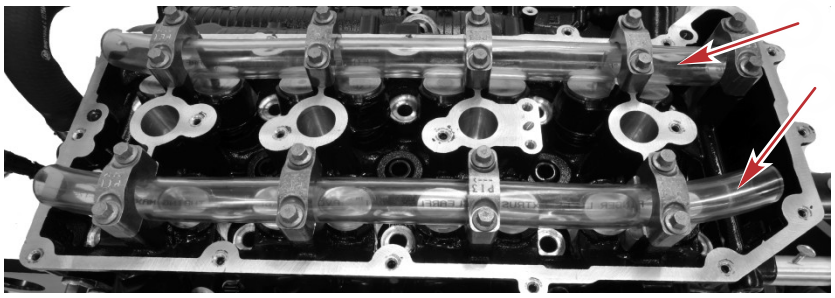


Port cylinder head shown; starboard similar

a - E14 external Torx screws

b - M6 screws at bottom of cylinder head

31. Install 25.4 mm (1 in.) outside diameter Tygon® tubing into the camshaft bores and secure the tubing by installing the camshaft caps in their correct location. This will keep the valve train components in place while removing the cylinder head.



Tygon tubing installed (V8 shown—V6 similar)

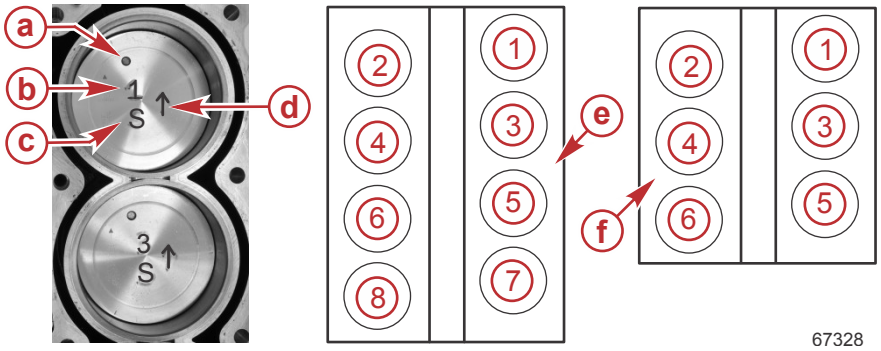
32. Remove the cylinder heads from the cylinder block.

33. Remove the two dowel pins from each bank of the cylinder block.

Dowel pins (two per bank) (V8 shown—V6 similar)

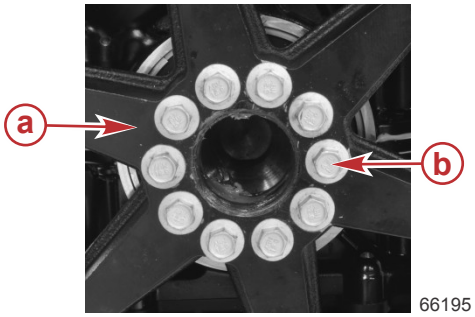
Crankcase and Crankshaft Disassembly/Removal

1. Mark each piston with its corresponding cylinder number and top/bottom orientation.



a - Dot on the piston (toward top of powerhead)
b - Cylinder number
c - "S" for starboard bank
d - Arrow pointing to top of powerhead
e - Cylinder numbers (V8)
f - Cylinder numbers (V6)

2. Remove the ten screws securing the flywheel to the crankshaft.

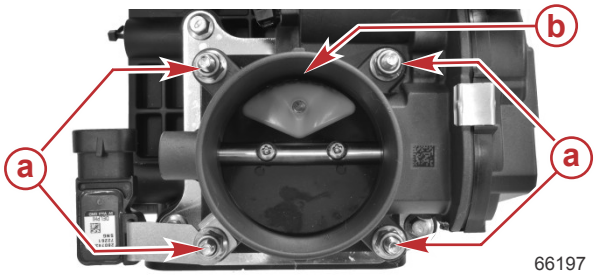


a - Flywheel
b - Screws (10)

3. Remove the flywheel.

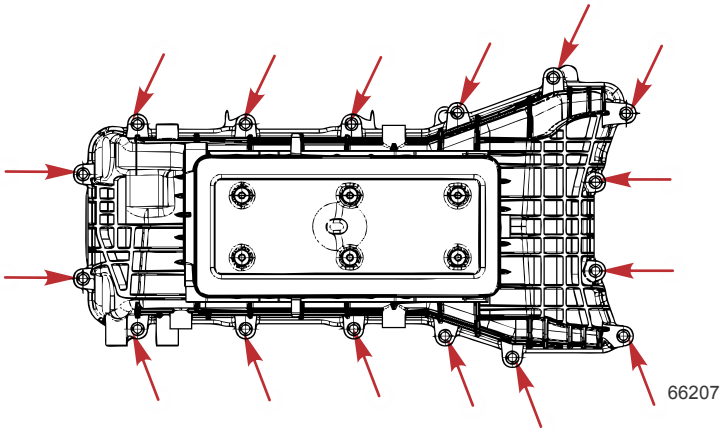
   NOTE: *The flywheel must be removed to remove the throttle body.*

4. Remove the throttle body from the intake plenum if necessary by removing the four mounting nuts.

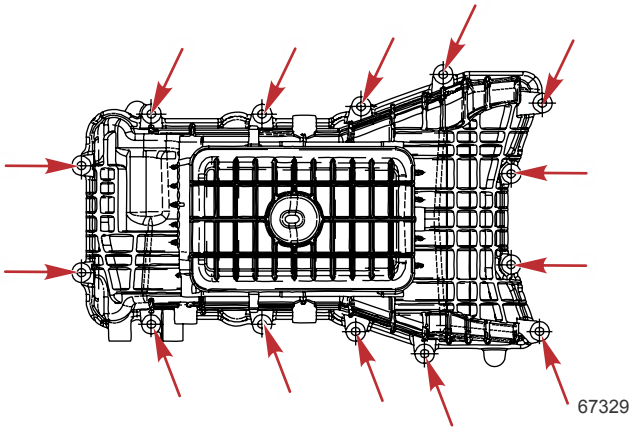


a - Nuts (4)
b - Throttle body

5. Remove the intake plenum screws and remove the intake plenum. Inspect the rubber plenum gasket for damage.

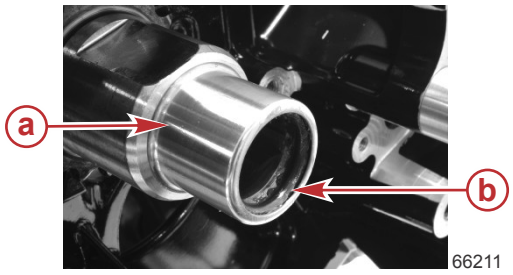


V8 intake plenum screws



V6 intake plenum screws

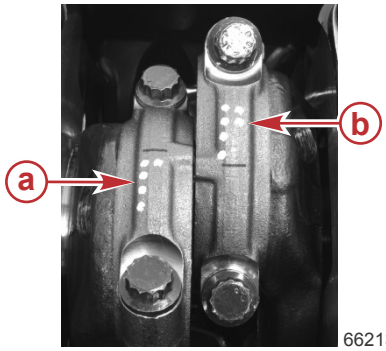
6. Inspect the O-ring in the bottom of the crankshaft inside the stainless steel sleeve.



a - Stainless steel sleeve
b - O-ring

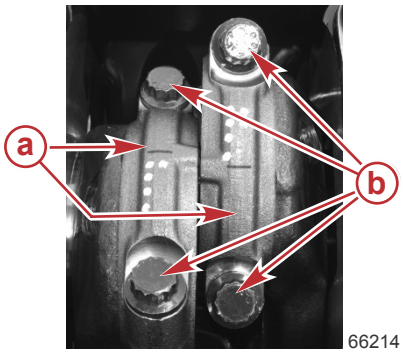
7. Mark each connecting rod cap with the corresponding cylinder number.

NOTE: *Install two flywheel screws into the flywheel end of the crankshaft 180° apart and use a long screwdriver to rotate the crankshaft.*



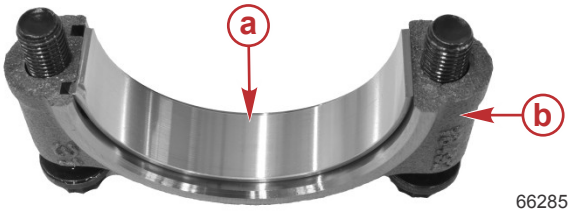
V8 shown
a - Cylinder 5 connecting rod cap (identified with five paint dots)
b - Cylinder 6 connecting rod cap (identified with six paint dots)

8. Perform the following steps one cylinder at a time:
   a. Loosen both connecting rod cap screws 1/4 turn.
   b. Remove the connecting rod cap screws and remove the connecting rod cap.



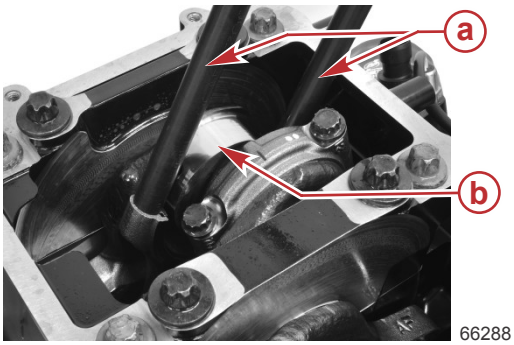
V8 shown
a - Connecting rod cap
b - Connecting rod cap screws (10 mm)

   c. Inspect the connecting rod bearing for debris.



a - Connecting rod bearing
b - Connecting rod cap

   d. Install rod guide dowels onto the connecting rod to protect the bearing journal during removal.

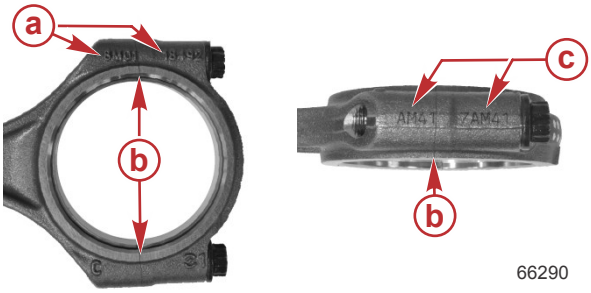


V8 shown
a - Connecting rod guides
b - Bearing journal

Rod Guide Dowels	8M0148866

   e. Push the connecting rod guides to remove the connecting rod and piston assembly from the cylinder block.
   f. Install the cap onto the connecting rod in the correct orientation and install the screws finger-tight.

   IMPORTANT: The connecting rod parting line must match. If the parting line does not line up exactly, the connecting rod cap is not installed correctly. The part number and identification number on the connecting rod will align when installed correctly.



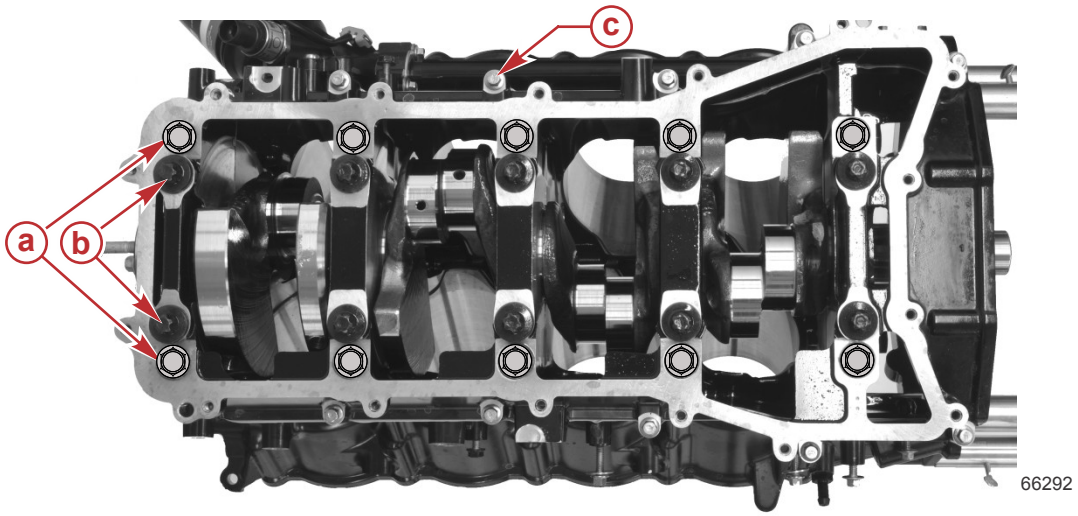
a - Connecting rod part number
b - Parting line
c - Identification number

9. Loosen the main bearing bedplate screws 1/4 turn each.

   IMPORTANT: Each main bearing cap has two 10 mm bolts and two 11 mm bolts. The 10 mm bolts are on the outside of the cap (furthest from the crankshaft) and have hex heads. The 11 mm bolts are nearest to the crankshaft and have 12-point heads. Do not intermix these bolts as cylinder block thread damage will result.

10. Loosen the bedplate perimeter screws 1/4 turn each.

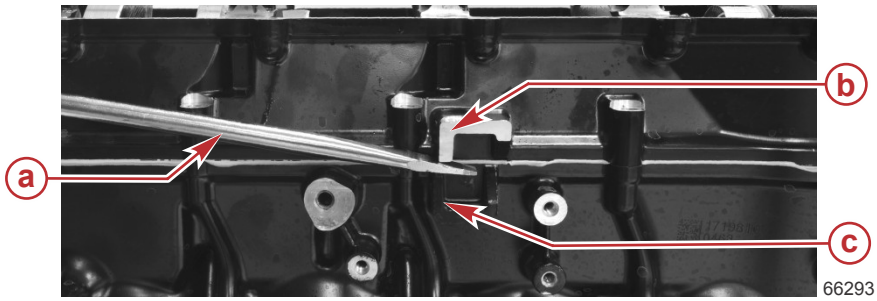
11. Remove the main bearing bedplate screws.
12. Remove the bedplate perimeter screws.



V8 shown

a - 10 mm hex head screws
b - 11 mm 12-point head screws
c - Perimeter screws

13. Remove the bedplate from the crankcase by gently prying at the two pry points.



V8 shown—V6 similar

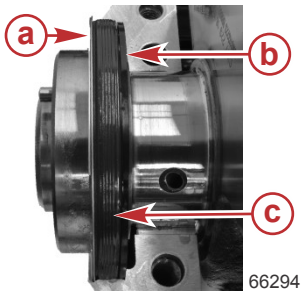
a - Screwdriver
b - Pry point on the bedplate
c - Pry point on the cylinder block

14. Remove the snap ring, seal, and spacer from the top of the crankshaft.

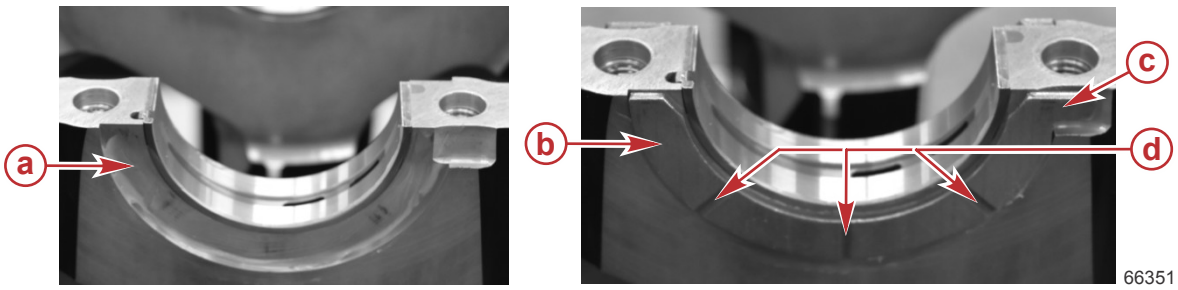
IMPORTANT: Ensure that the oil drain for the top seal is clear of debris or sealant.

NOTE: *During assembly, the seal spacer can be placed on the other side of the top seal if the crankshaft has a groove worn in it from the top seal. Moving the spacer will move the contact/sealing area away from the groove.*

NOTE: *Note the orientation of the two half-moon thrust bearings, care should be taken to ensure that the thrust bearings do not spin out of the cylinder block if the crankshaft is rotated after the bedplate is removed.*



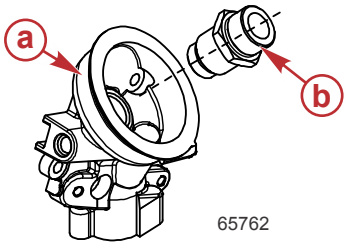
a - Snap ring
b - Spacer
c - Seal



Thrust bearings shown for reference

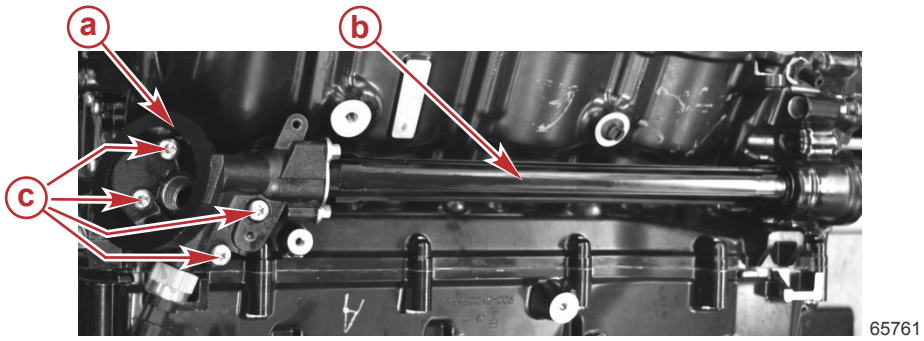
- **a -** Inner thrust bearing surface
- **b -** Outer thrust bearing surface
- **c -** Bearing tab
- **d -** Thrust bearing grooves

15. Remove the crankshaft from the crankcase. Secure the crankshaft in a fixture so it will not be damaged.
    NOTE: *Check the oil passage from end to end.*
16. Remove the oil filter and oil filter fitting from the oil filter adapter.



- **a -** Oil filter adapter
- **b -** Oil filter fitting

17. Remove the four T30 Torx screws securing the oil filter adapter and tube. Remove the oil filter adapter and tube. Inspect the O-ring at the bottom of the oil tube.
    IMPORTANT: Use care to avoid dropping the fasteners into the oil tube. The oil tube has a metal gasket on the top and an O-ring on the bottom of the oil tube.



V8 shown—V6 similar

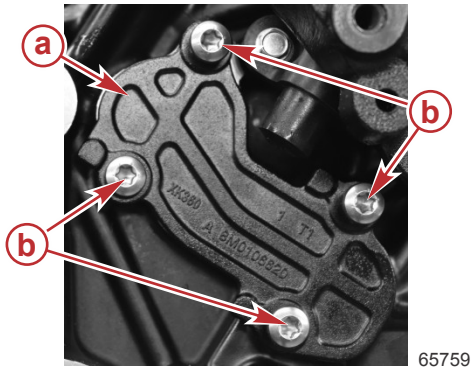
- **a -** Filter adapter
- **b -** Oil tube
- **c -** T30 Torx screws (4)

18. **V8 models—**Remove the balance shaft cover screws.
19. **V8 models—**Remove the balance shaft cover by gently prying the cover with a gasket scraper.

IMPORTANT: Do not bend the balance shaft cover or damage the sealing surfaces while removing the cover.

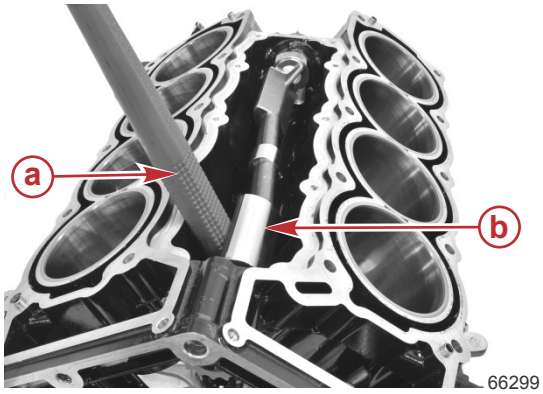
Balance shaft cover screws (V8 models)

20. Remove the oil gallery cover screws and remove the cover.



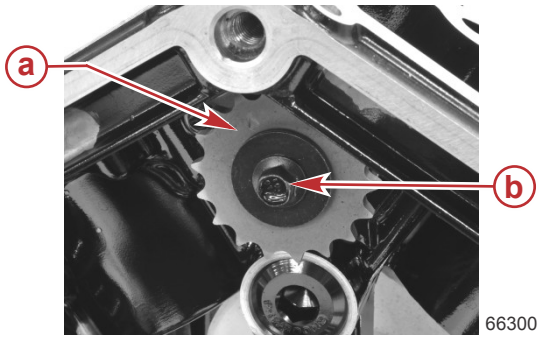
a - Oil gallery cover
b - T30 Torx screws (4)

21. **V8 models—**Insert a rubber coated tool to hold the balance shaft as shown.



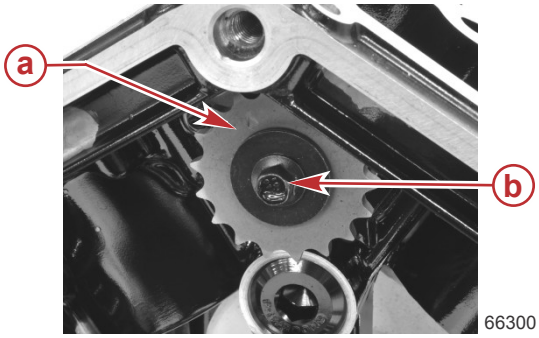
V8 models
a - Rubber coated tool
b - Balance shaft

22. **V8 models—**Remove the balance shaft sprocket screw and washer. Remove the balance shaft sprocket.



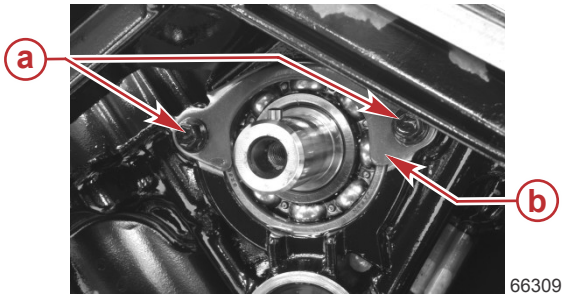
a - Balance shaft sprocket
b - Screw and washer

23. **V6 models—**Remove the idler sprocket screw and washer. Remove the idler sprocket.



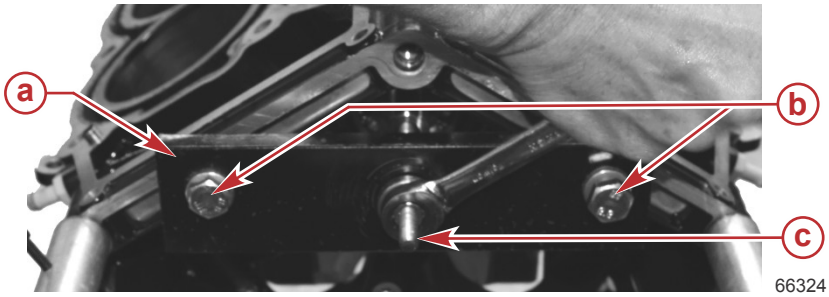
a - Idler sprocket
b - Screw and washer

24. **V8 models—**Remove the two screws securing the balance shaft retainer from the bottom of the balance shaft.
NOTE: *The balance shaft has a plain bearing on the top and a ball bearing on the bottom.*



V8 models
a - Screws (2)
b - Balance shaft retainer

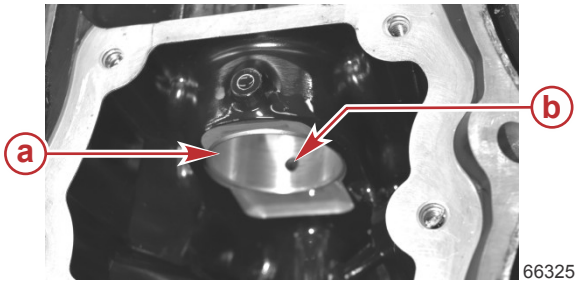
25. **V8 models—**Construct a puller plate to remove the balance shaft and lower bearing from the cylinder block.



V8 models
a - Steel puller plate
b - M10 x 1.5 screws and washers (secures puller plate to block)
c - M8 x 1.25 stud, nut, and washer (stud threads into the balance shaft, tighten the nut to pull the shaft and bearing)

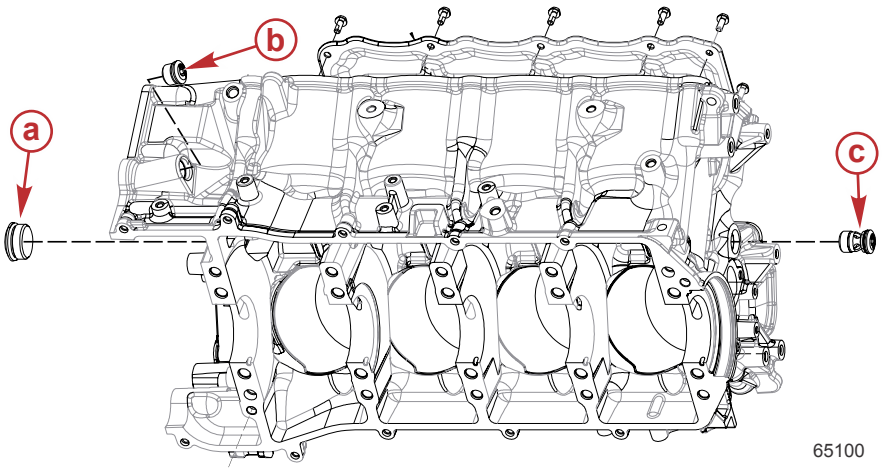
26. **V8 models—**Remove the balance shaft and bearing from the cylinder block. Rotate the balance shaft while removing to free the shaft from the block. The balance shaft must be properly oriented to remove it from the cylinder block.
27. **V8 models—**Inspect the upper balance shaft bearing for damage or debris. Ensure that the oil hole of the bearing is aligned with the oil gallery of the cylinder block.

IMPORTANT: If the oil hole of the bearing is not aligned with the oil gallery of the cylinder block, catastrophic engine damage can occur due to oil starvation of the upper bearing.



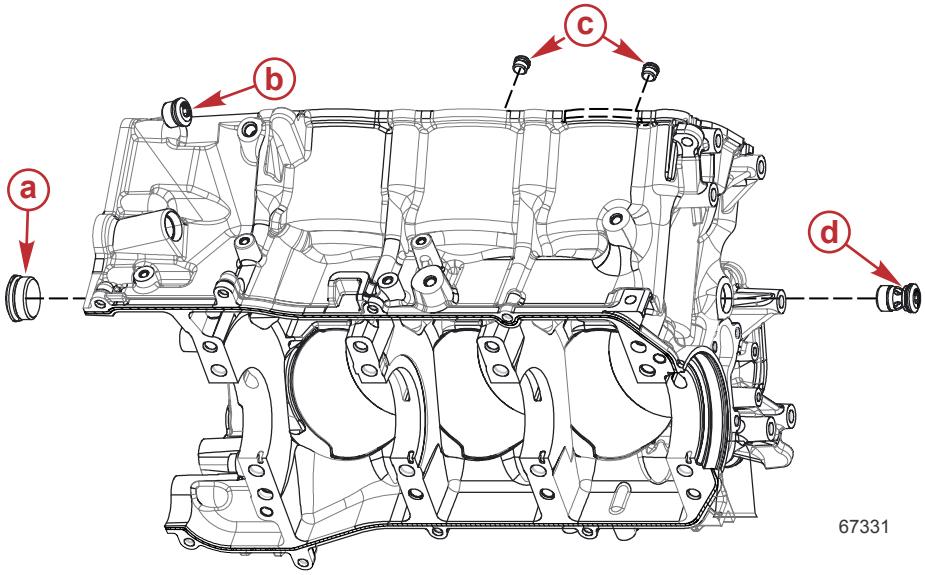
V8 models
a - Bearing
b - Oil hole aligned with oil gallery

28. Remove the oil gallery plugs from the cylinder block.



V8 models

- **a -** 30 mm oil gallery plug
- **b -** 18 mm oil gallery plug
- **c -** 18 mm special oil gallery plug



V6 models

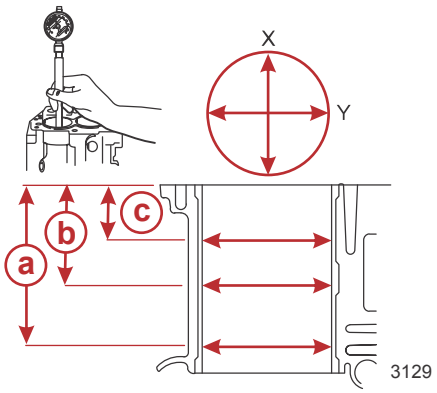
- **a -** 30 mm oil gallery plug
- **b -** 18 mm oil gallery plug
- **c -** 10 mm oil gallery plug
- **d -** 18 mm special oil gallery plug

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.)

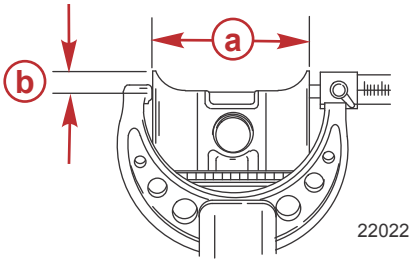
Cylinder Bore Specification (V6 and V8 models)	
Standard bore finish hone	92.0 mm (3.622 in.)
Standard (service limit)	92.015 mm (3.6226 in.)
Out of round	0.015 mm (0.0006 in.)
Taper	0.02 mm (0.0007 in.)

Measuring Piston

Inspect each piston for wear or damage. Replace the piston if necessary.

Piston Diameter

1. Measure the piston at a point 9.6 mm (0.378 in.) from the bottom, 90° to the piston pin. Replace the piston if it is out of specification.



a - Piston diameter
b - Measure point 9.6 mm (0.378 in.) from bottom of piston

Piston (V6 and V8 Models)	
Diameter (production)	91.927–91.937 mm (3.6192–3.6195 in.)
Diameter (minimum)	91.927 mm (3.6192 in.)

2. Measure piston to cylinder wall clearance. If out of specification, examine the piston and cylinder bore further to determine repair/replacement options.

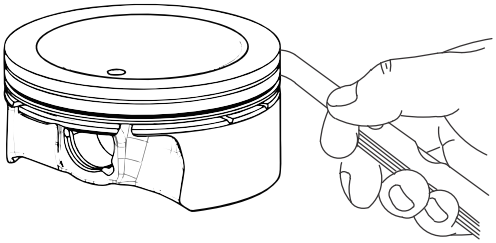
The minimum piston to cylinder wall clearance is defined by the formula: **Minimum cylinder bore measurement – Maximum piston diameter measurement = Minimum Piston to Cylinder Clearance.**

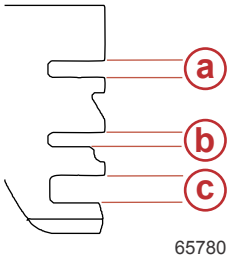
The maximum piston to cylinder wall clearance is defined by the formula: **Maximum cylinder bore measurement – Minimum piston diameter measurement = Maximum Piston to Cylinder Clearance.**

Piston to Cylinder Wall Clearance (V6 and V8 Models)	
Minimum clearance	0.063 mm (0.0025 in.)
Maximum clearance	0.088 mm (0.0035 in.)

Piston Ring Groove

Measure the piston ring grooves. Replace the piston if out of specification.



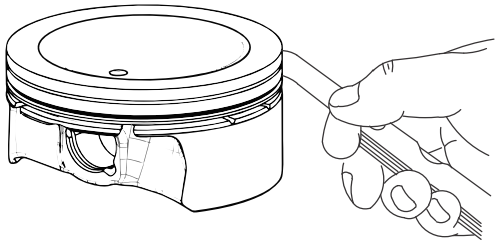


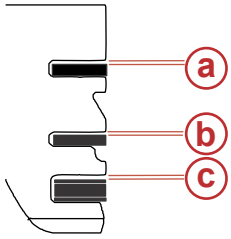
a - Top ring groove
b - Middle ring groove
c - Oil ring groove

Piston Ring Groove (Maximum Dimensions)	
Top "a"	1.25 mm (0.049 in.)
Middle "b"	1.03 mm (0.041 in.)
Oil "c"	2.03 mm (0.080 in.)

Piston Ring Side Clearance

Measure the first and second piston ring side clearance. The side clearance for the third ring (oil) is not a valid measurement because of ring movement during the measurement process. Replace the piston rings as a set if they are out of specification.





65789

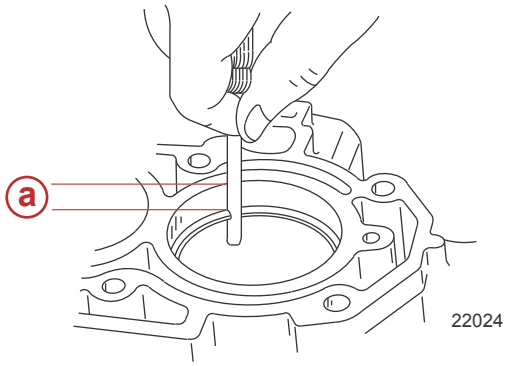
a - Top ring
b - Middle ring
c - Oil ring

Piston Ring Side Clearance	
Top "a"	0.02–0.05 mm (0.0008–0.0019 in.)
Middle "b"	0.01–0.03 mm (0.0004–0.0011 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.*



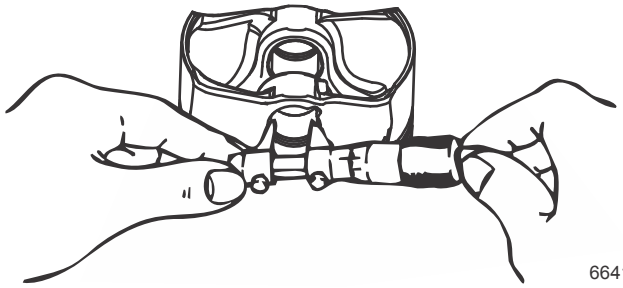
22024

a - 25.4 mm (1.0 in.)

Piston Ring End Gap	
Top	0.20–0.215 mm (0.008–0.0084 in.)
Middle	0.40–0.425 mm (0.016–0.0167 in.)
Oil rings (top and bottom) (expander not applicable)	0.40–0.425 mm (0.016–0.0167 in.)

Piston Pin Bore Diameter

Measure the piston pin bore diameter. Replace the piston if out of specification.

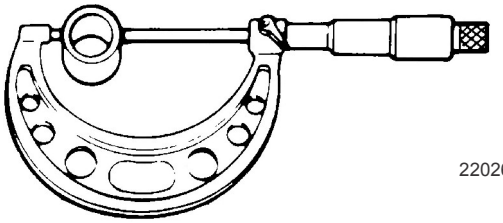


66412

Piston Pin	
Bore diameter	20.005–20.010 mm (0.7876–0.7878 in.)

Piston Pin

Measure the piston pin diameter. Replace the piston pin if out of specification.



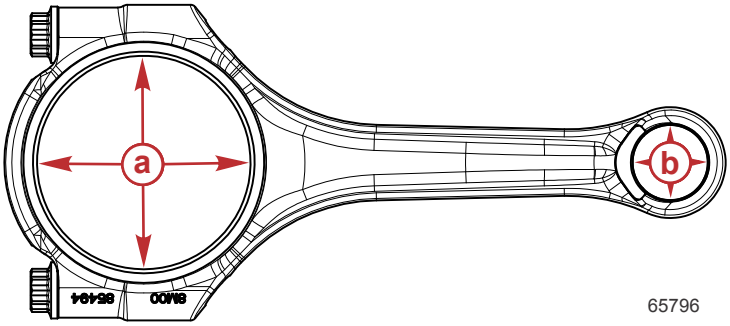
Piston Pin	
Diameter	19.996–20.001 mm (0.7873–0.7874 in.)

Measuring the Connecting Rods

1. Ensure that the rod cap fits perfectly. Tighten the connecting rod cap bolts to the specified torque.

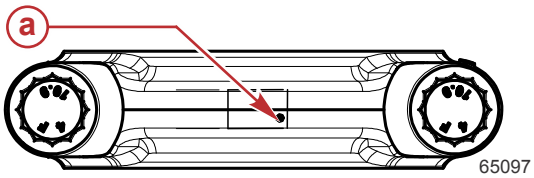
Description	Nm	lb-in.	lb-ft
Rod cap bolts	10	88.5	–

2. Measure the small (piston pin) and large (crankshaft journal) ends of the connecting rod.



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.



Connecting rod cap
a - Connecting rod bearing grade (**I** or **0**)

Connecting Rod Bore Diameter		
	Dimension (at 20 °C (68 °F)	Mark
Connecting rod bore diameter	57.000–57.008 mm (2.2441–2.2444 in.)	I
	57.008–57.016 mm (2.2444–2.2447 in.)	0

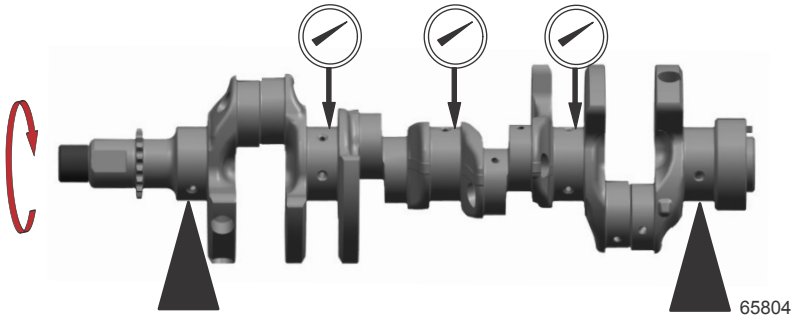
Piston Pin Bore Diameter
20.014–20.022 mm (0.7880–0.7882 in.)

Measuring Crankshaft

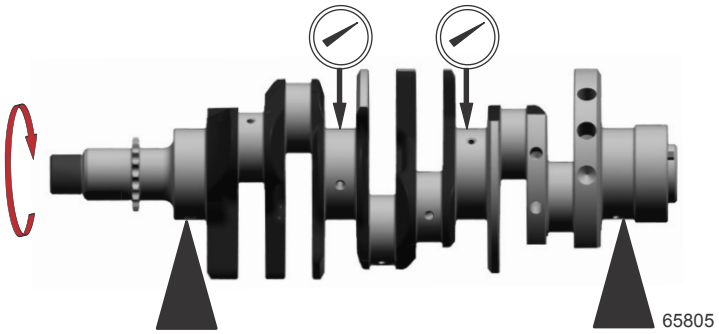
Crankshaft Runout

1. Thoroughly clean the crankshaft and inspect the bearing surfaces. Replace the crankshaft if the bearing surfaces are pitted, scored, or discolored.
2. Measure runout on all of the main bearing journals. Replace the crankshaft if it is out of specification.

3. Clean all of the oil holes in the crankshaft.



V8

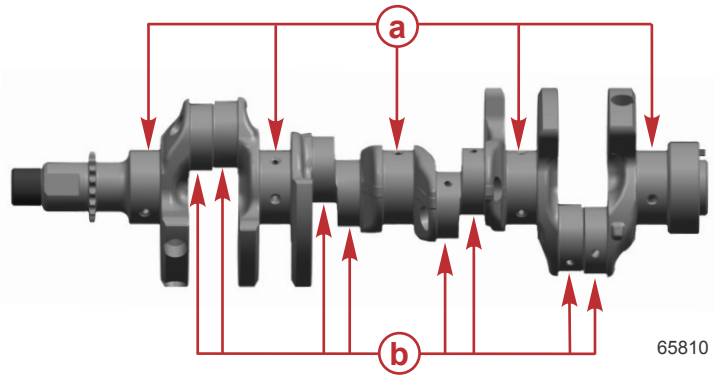


V6

Crankshaft Runout Limit—V6 and V8	
Runout limit	0.05 mm (0.002 in.)

Crankshaft Main Bearing and Crankpin Measurement

1. Measure the crankshaft main bearing journal diameter and crankpin journal diameter. Replace the crankshaft if it is out of specification.

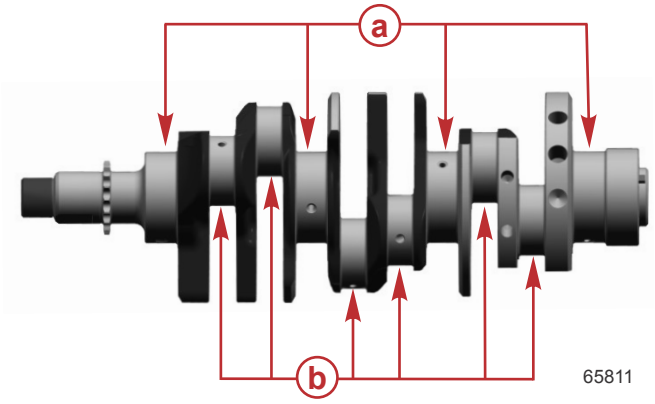


V8

a - Main bearing journals

b - Crankpin journals

V8 Crankshaft Journal Diameter Identification Marks			
	Dimension (at 20 °C (68 °F)		Mark
Main bearing journal	59.984–60.000 mm (2.3616–2.3622 in.)	59.992–60.000 mm (2.3619–2.3622 in.)	A
		59.984–59.992 mm (2.3616–2.3619 in.)	B
Rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)	53.992–54.000 mm (2.1257–2.1259 in.)	C
		53.984–53.992 mm (2.1254–2.1257 in.)	D



V6
- **a -** Main bearing journals
- **b -** Crankpin journals

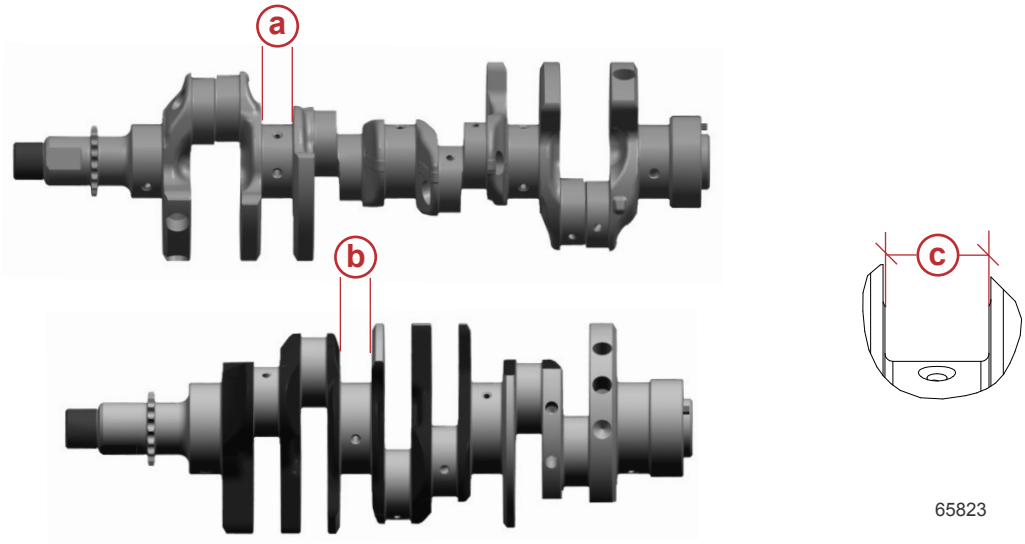
V6 Crankshaft Journal Diameter Identification Marks			
	Dimension (at 20 °C (68 °F)		Mark
Main bearing journal	69.984–70.000 mm (2.7552–2.7559 in.)	69.992–70.000 mm (2.7556–2.7559 in.)	A
		69.984–69.992 mm (2.7552–2.7556 in.)	B
Rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)	53.992–54.000 mm (2.1257–2.1259 in.)	C
		53.984–53.992 mm (2.1254–2.1257 in.)	D

2. Refer to **Selecting New Crankshaft and Connecting Rod Bearings** to determine the correct bearing grades.

Measuring Crankshaft Thrust Bearing Surface Width

1. Locate the crankshaft thrust bearing surfaces.
2. Measure the width between the crankshaft thrust bearing surfaces. Replace the crankshaft if it is out of specification.

   IMPORTANT: Ensure that the measurement is taken between the machined thrust bearing surfaces, not the crankshaft counterweights.



- **a -** V8 crankshaft thrust bearing surface
- **b -** V6 crankshaft thrust bearing surface
- **c -** Thrust bearing surface width—measure between the machined surfaces

Crankshaft Thrust Bearing Surface Width	
V6	23.95–24.05 mm (0.9429–0.9468 in.)
V8	25.95–26.05 mm (1.0217–1.0255 in.)

3. Verify the crankshaft end play after the crankshaft is installed into the cylinder block.

Crankshaft End Play	
V6	0.000–0.432 mm (0.000–0.017 in.)
V8	0.000–0.432 mm (0.000–0.017 in.)

Selecting New Crankshaft and Connecting Rod Bearings

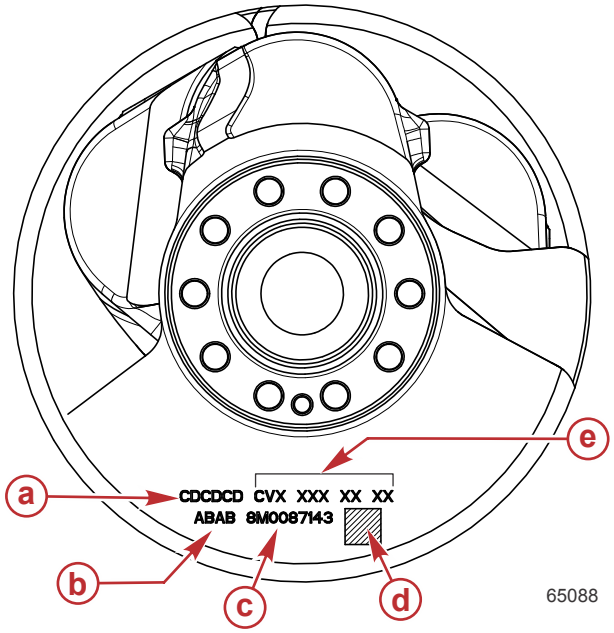
When replacing the crankshaft main bearings and connecting rod bearings, select the suitable bearing from the bearing grade identifier located at the flywheel end of the crankshaft and on the port side of the cylinder block near the oil tube.

NOTE: *When reading the main bearing journal grade on the crankshaft, the journal grade is in sequential order from J1 to J4 (for V6) and J1 to J5 (for V8) from top to bottom.*

NOTE: *When reading the connecting rod bearing journal grade on the crankshaft, the journal grade is in sequential order from J1 to J6 (for V6) and J1 to J8 (for V8) from top to bottom.*

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 main bearing.*

V6 Crankshaft

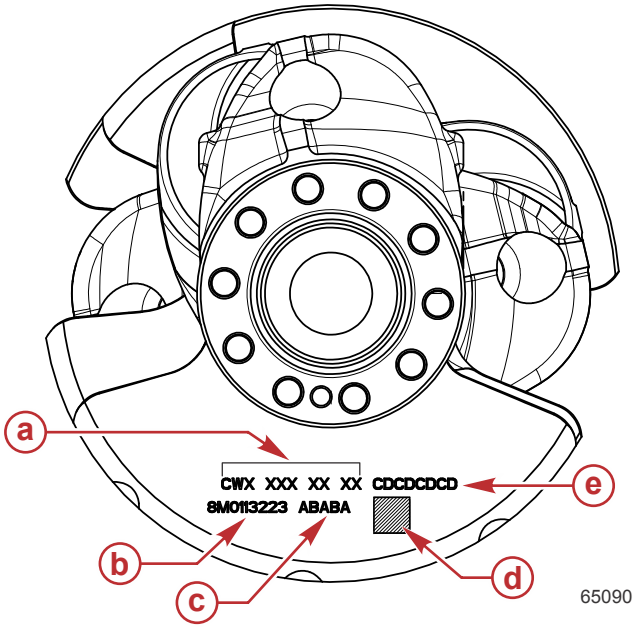


V6 crankshaft

- **a -** Connecting rod bearing journal grade (from top to bottom; **CDCDCD** in this example)
- **b -** Main bearing journal grade (from top to bottom; **ABAB** in this example)
- **c -** Part number
- **d -** Barcode
- **e -** Date code

V6 Crankshaft Journal Diameter Identification Marks			
	Dimension (at 20 °C (68 °F)		Mark
Main bearing journal	69.984–70.000 mm (2.7552–2.7559 in.)	69.992–70.000 mm (2.7556–2.7559 in.)	A
		69.984–69.992 mm (2.7552–2.7556 in.)	B
Rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)	53.992–54.000 mm (2.1257–2.1259 in.)	C
		53.984–53.992 mm (2.1254–2.1257 in.)	D

V8 Crankshaft



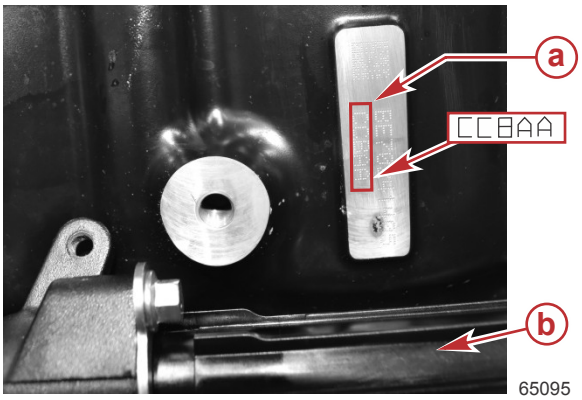
V8 crankshaft

- **a -** Date code
- **b -** Part number
- **c -** Main bearing journal grade (from top to bottom; **ABABA** in this example)
- **d -** Barcode
- **e -** Connecting rod bearing journal grade (from top to bottom; **CDCDCDCD** in this example)

V8 Crankshaft Journal Diameter Identification Marks			
	Dimension (at 20 °C (68 °F)		Mark
Main bearing journal	59.984–60.000 mm (2.3616–2.3622 in.)	59.992–60.000 mm (2.3619–2.3622 in.)	A
		59.984–59.992 mm (2.3616–2.3619 in.)	B
Rod bearing journal	53.984–54.000 mm (2.1254–2.1259 in.)	53.992–54.000 mm (2.1257–2.1259 in.)	C
		53.984–53.992 mm (2.1254–2.1257 in.)	D

V6 and V8 Cylinder Blocks

Cylinder block main bearing codes are located on a machined surface on the port side of the cylinder block near the oil tube.



- **a -** Cylinder block main bearing journal grade (from top to bottom, **CCBAA** in this example)
- **b -** Oil tube

Selecting Main Bearings

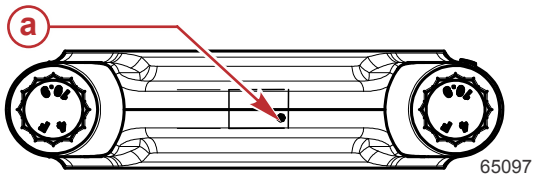
Select the main bearing color for each main bearing journal from the following chart. Refer to the preceding procedures to locate the journal codes on the crankshaft and cylinder block.

V6 and V8

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

V6 and V8 Connecting Rod Bearings

Select the connecting rod bearing color for each connecting rod from the following chart. Refer to the **V6 Crankshaft** or **V8 Crankshaft** to locate the connecting rod bearing journal codes.



Connecting rod cap

a - Connecting rod bearing grade (**I** or **0**)

Connecting Rod Bore Diameter		
	Dimension (at 20 °C (68 °F)	Mark
Connecting rod bore diameter	57.000–57.008 mm (2.2441–2.2444 in.)	I
	57.008–57.016 mm (2.2444–2.2447 in.)	0

Connecting Rod Journal Code	Crankshaft Journal Code	Bearing Color Selection
I	C	Green
I	D	Blue
0	C	Blue
0	D	White

Powerhead Assembly

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.

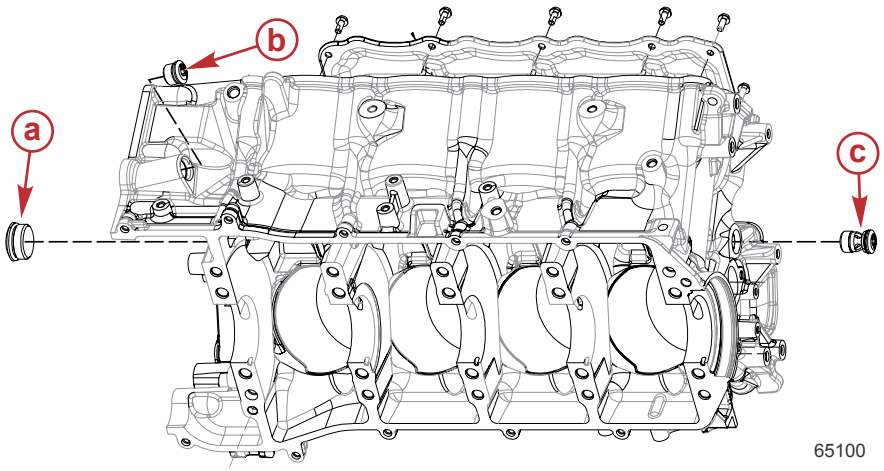
Wash the cylinder block and crankcase cover with hot soapy water to remove debris and honing compound. Dry the cylinder block with compressed air. Failure to thoroughly clean the cylinder block of honing compound and/or debris will result in premature engine failure.

Installing Oil Gallery Plugs

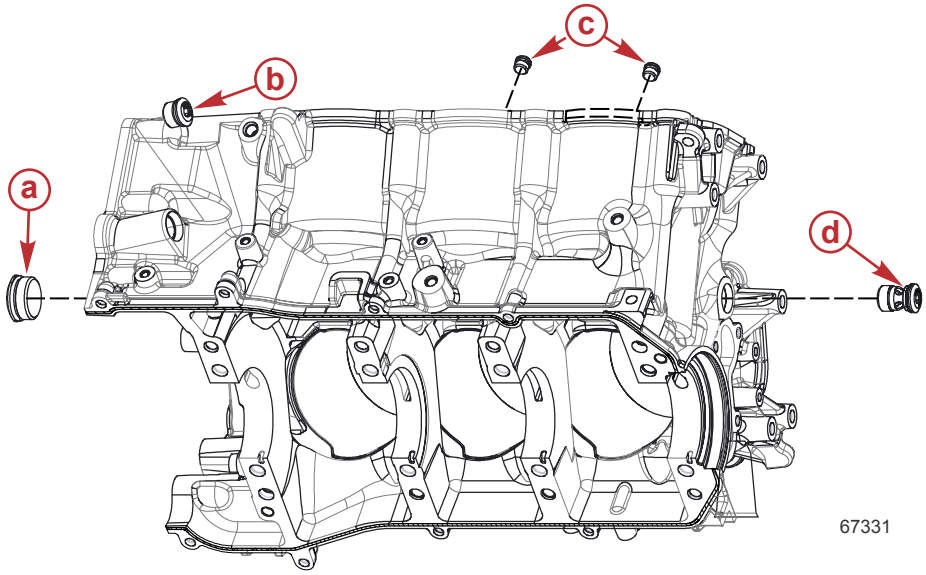
1. Install new O-rings onto the oil gallery plugs or install new oil gallery plugs. Lubricate the new O-rings with 10W-30 4-Stroke Marine Engine Oil.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	O-rings	92-8M0078625

2. Install the oil gallery plugs. Tighten the plugs to the specified torque.



V8
- a - 30 mm oil gallery plug
- b - 18 mm oil gallery plug
- c - 18 mm special oil gallery plug



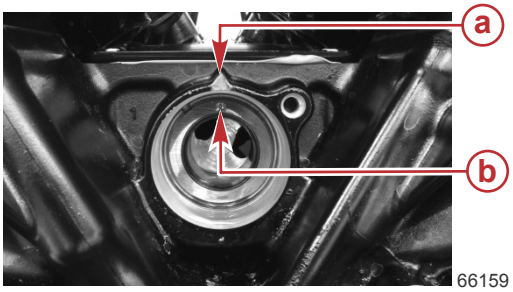
V6
- a - 30 mm oil gallery plug
- b - 18 mm oil gallery plug
- c - 10 mm oil gallery plug
- d - 18 mm special oil gallery plug

Description	Nm	lb-in.	lb-ft
30 mm oil gallery plug	55	–	40.6
18 mm oil gallery plug	15	132.8	–
18 mm special oil gallery plug	15	132.8	–
10 mm oil gallery plug	9	–	79.7

Balance Shaft (V8 Only) and Oil Filter Adapter Installation

NOTE: *Only V8 models are equipped with balance shafts.*

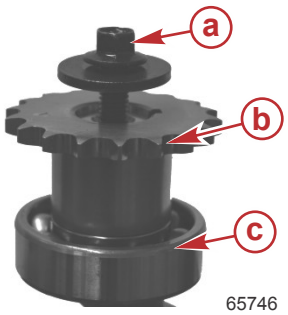
NOTE: *Balance shaft timing can be verified before disassembly by removing the alternator and balance shaft top cover. Check the timing mark alignment as shown.*



V8 only
- a - Timing pointer
- b - Balance shaft timing mark

NOTE: The balance shaft turns at the same speed and rotates in the opposite direction of the crankshaft.

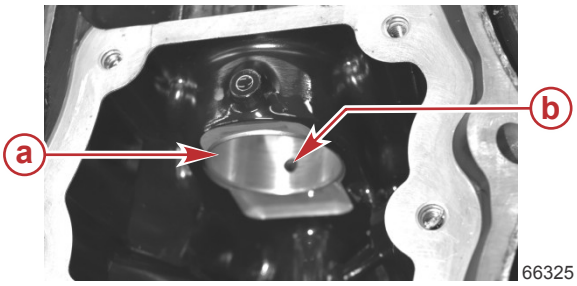
1. **V8 models**—Use a balance shaft sprocket and screw to press the lower ball bearing if replacement is necessary.



a - Screw and washer
b - Balance shaft sprocket
c - Bearing

2. **V8 models**—Apply Lubriplate SPO 255 to the balance shaft upper bearing and bottom bore. Ensure that the oil hole of the bearing is aligned with the oil gallery of the cylinder block.

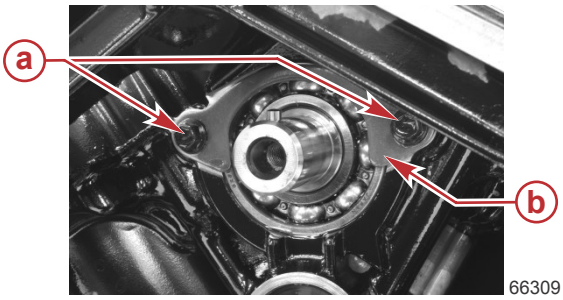
IMPORTANT: If the oil hole of the bearing is not aligned with the oil gallery of the cylinder block, catastrophic engine damage can occur due to oil starvation of the upper bearing.



a - Bearing
b - Oil hole aligned with oil gallery

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Balance shaft bushing and bottom bore	Obtain Locally

3. **V8 models**—Install the balance shaft from the bottom of the cylinder block. The balance shaft must be rotated as it enters the block, with the counterweight down when inserted through the bore, then rotate.
4. **V8 models**—Press the lower balance shaft ball bearing into the block (the bearing is already installed on the shaft).
5. **V8 models**—Apply Loctite 242 Threadlocker to the balance shaft retainer screw threads and tighten the two screws to the specified torque.



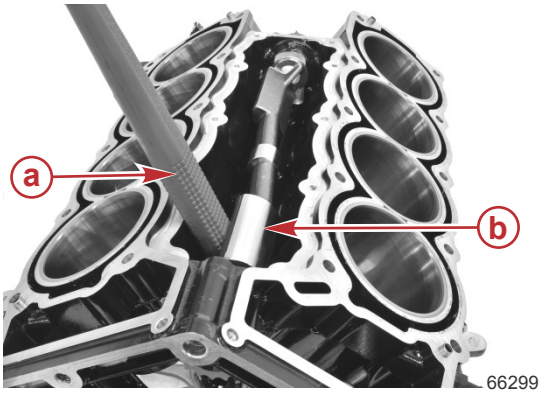
a - M5 x 12 screws (2)
b - Balance shaft retainer

Description	Nm	lb-in.	lb-ft
Balance shaft retainer screws (M5 x 12)	8.5	75.2	–

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Balance shaft retainer screw threads	92-809821

6. **V8 models**—Turn the shaft by hand to ensure smooth rotation.

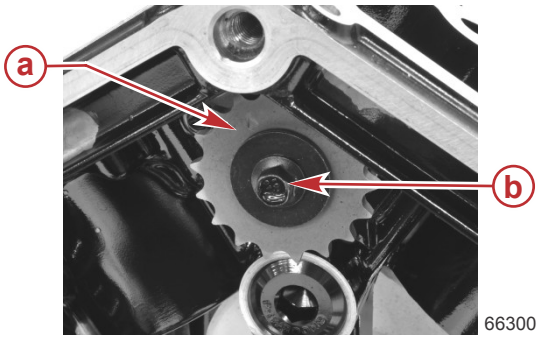
7. **V8 models**—Prevent the balance shaft from rotating by using a rubber coated tool as shown.



a - Rubber coated tool
b - Balance shaft

8. **V8 models**—Install the balance shaft sprocket. Apply Loctite 242 Threadlocker to the sprocket screw threads and tighten the sprocket screw to the specified torque.

NOTE: *The balance shaft sprocket is keyed and it has a timing mark that must be verified after final powerhead assembly.*

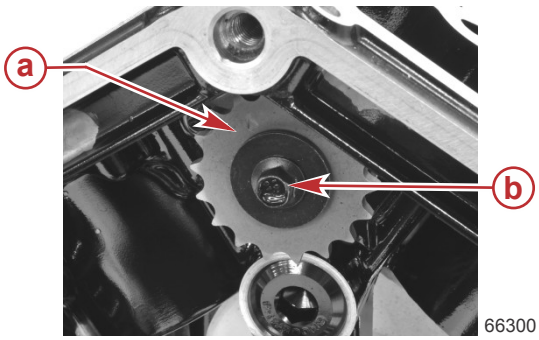


a - Balance shaft sprocket
b - Screw and washer

Description	Nm	lb-in.	lb-ft
Balance shaft sprocket screw	40	–	29.5

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Sprocket screw threads	92-809821

9. **V6 models**—Install the idler sprocket. Apply Loctite 242 Threadlocker to the sprocket screw threads and tighten the sprocket screw to the specified torque.

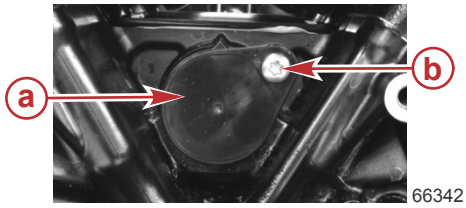


a - Idler sprocket
b - Screw and washer

Description	Nm	lb-in.	lb-ft
Balance shaft sprocket screw	28	–	20.7

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Sprocket screw threads	92-809821

10. **V8 models**—Apply 10W-30 4-Stroke Marine Engine Oil or equivalent to the double O-ring balance shaft top cover and install the cover. Tighten the T30 Torx® screw to the specified torque.

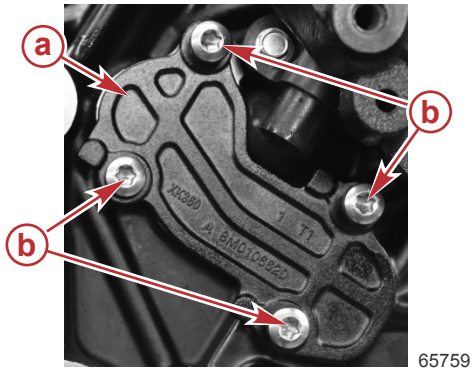


a - Balance shaft top cover
b - Screw

Description	Nm	lb-in.	lb-ft
T30 Torx screw	10	88.5	–

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Double O-ring balance shaft top cover	92-8M0078625

11. Install a new oil gallery cover gasket onto the cylinder block.
12. Install the oil gallery cover and tighten the four T30 Torx screws to the specified torque.

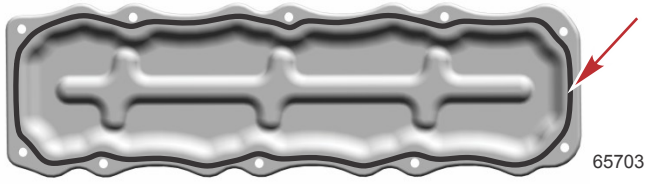


a - Oil gallery cover
b - T30 Torx screws (4)

Description	Nm	lb-in.	lb-ft
T30 Torx screws	10	88.5	–

13. **V8 models**—Apply a 2 mm bead of Three Bond® 1217F or equivalent to the mating surface and install the balance shaft cover.

NOTE: *Guide studs may be helpful to align the balance shaft cover with the cylinder block.*



Tube Ref No.	Description	Where Used	Part No.
135	Three Bond® 1217F	Mating surface of balance shaft cover	92-858005K02

14. **V8 models**—Starting from the center and working outward, tighten the ten M5 x 13 screws to the specified torque in a crossing pattern.

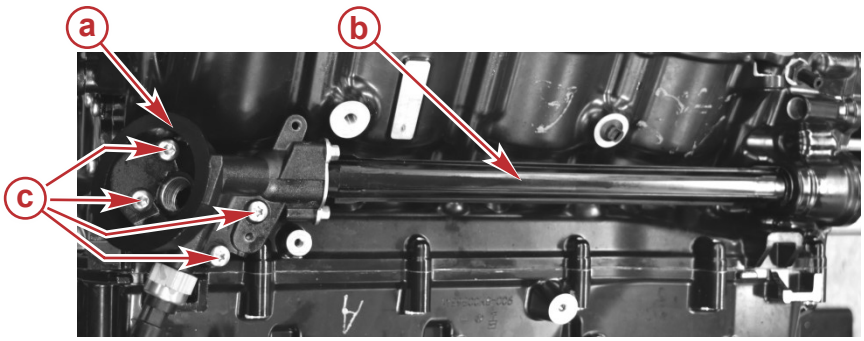
Description	Nm	lb-in.	lb-ft
M5 x 13 balance shaft cover screws (10)	5	44.3	–

15. Lubricate the oil tube O-rings with 10W-30 4-Stroke Marine Engine Oil.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Oil tube O-rings	92-8M0078625

16. Install a new oil filter adapter gasket onto the cylinder block.
17. Install the oil tube and filter adapter and secure with four T30 Torx screws. Tighten the screws to the specified torque.

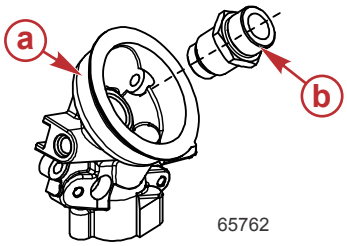
IMPORTANT: Do not drop the oil tube flange screws into the oil circulation passage.



V8 shown—V6 similar
- **a -** Filter adapter
- **b -** Oil tube
- **c -** T30 Torx screws (4)

Description	Nm	lb-in.	lb-ft
M6 x 20 T30 Torx screws (4)	10	88.5	–

18. Install the oil filter fitting. Tighten the fitting to the specified torque.



- **a -** Oil filter adapter
- **b -** Oil filter fitting

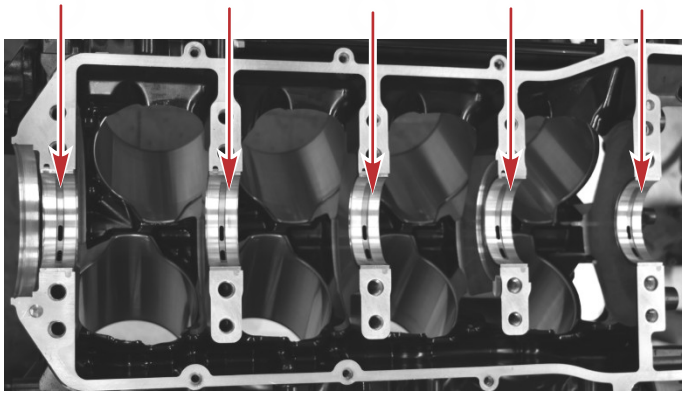
Description	Nm	lb-in.	lb-ft
Oil filter fitting	40	–	29.5

Crankshaft Installation

IMPORTANT: Use the old main bearing bolts to tighten the bedplate when checking the main bearing oil clearance. Install new main bearing bolts for the final assembly.

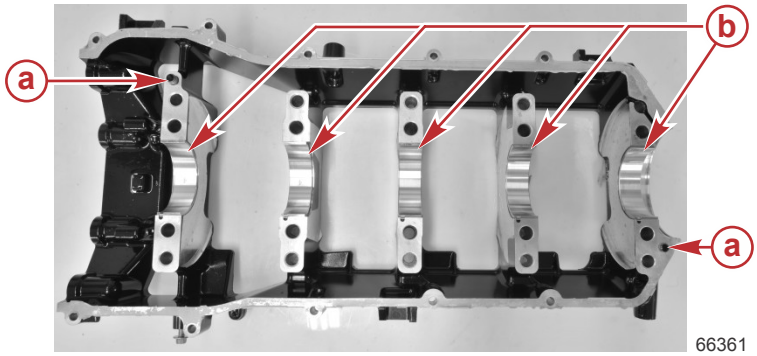
1. Ensure that the cylinder block, bedplate, main bearing bore, and sealing surfaces are absolutely clean and free of debris.
2. Install the new crankshaft main bearing halves into the cylinder block. Ensure that the bearing tabs are fully seated. Refer to **Selecting New Crankshaft and Connecting Rod Bearings** to select the proper size bearings.

IMPORTANT: Ensure that the bearing halves with the oil holes are installed into the cylinder block. Installing the wrong bearing halves will cause catastrophic engine damage.



V8 shown—V6 similar

3. Install the new crankshaft main bearing halves into the bedplate. Ensure that the bearing tabs are fully seated and the two dowel pins are installed.

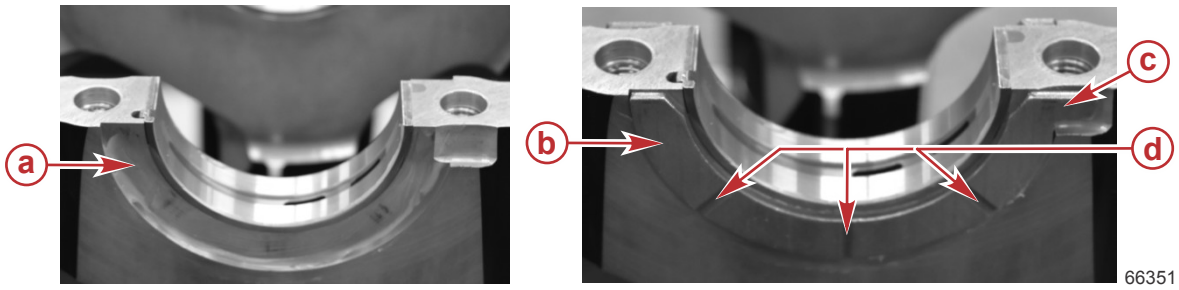


V8 shown—V6 similar
- **a -** Dowel pins
- **b -** Main bearing halves installed in the bedplate

4. Apply 2-4-C with PTFE to the inner thrust bearing surfaces to hold them to the crankcase while installing the crankshaft.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Inner thrust bearing surfaces	92-802859A 1

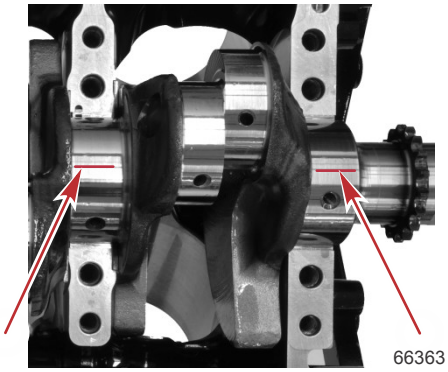
5. Install the thrust bearings into the crankcase. Ensure that the thrust bearing grooves are facing outward. Apply Torco MPZ® Engine Assembly Lube HP to the outer thrust bearing surfaces.



V8 shown—V6 similar
- **a -** Inner thrust bearing surface (apply 2-4-C with PTFE)
- **b -** Outer thrust bearing surface
- **c -** Bearing tab
- **d -** Thrust bearing grooves

Tube Ref No.	Description	Where Used	Part No.
	Torco MPZ® Engine Assembly Lube HP	Outer thrust bearing surfaces	Obtain Locally

6. Install the crankshaft into the crankcase.
7. Install a piece of Plastigauge® parallel to the crankshaft on the main bearing journals.



V8 shown

8. Install the bedplate onto the cylinder block. Apply Lubriplate SPO 255 to the threads and under the heads of all main bearing bolts.

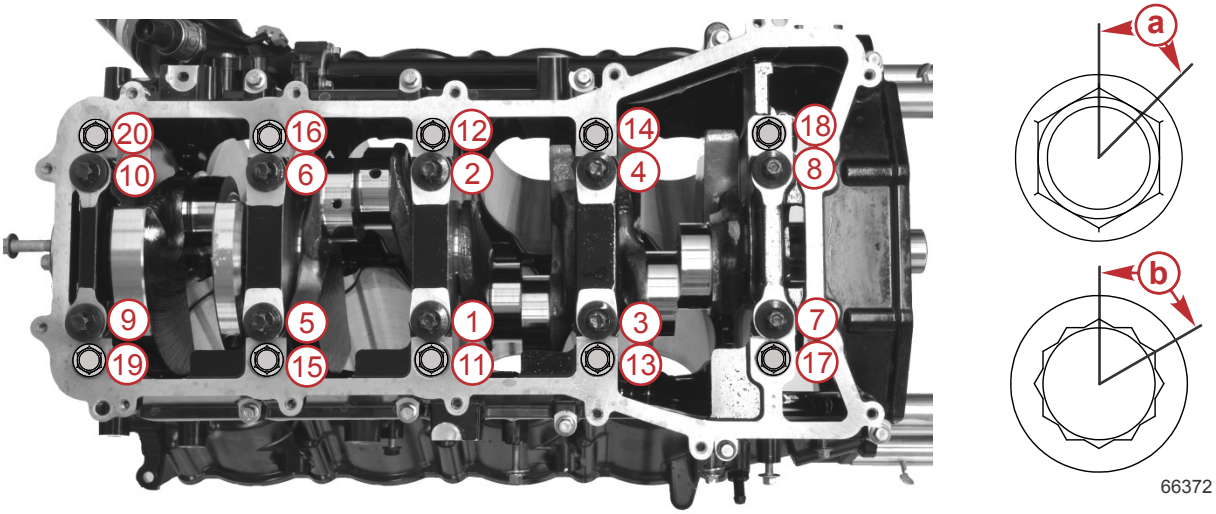
IMPORTANT: Do not allow the crankshaft to rotate when checking the bearing clearance with Plastigauge.

IMPORTANT: Use the old main bearing bolts to tighten the bedplate when checking the main bearing oil clearance. Install new main bearing bolts for the final assembly.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Threads and under the heads of all main bearing bolts	Obtain Locally

9. Tighten each main bearing bolt to the specified torque. For the third and final steps of the torque sequence, tighten the bolt to the specified torque, then tighten the bolt to the degree indicated before moving to the next bolt in the sequence. Refer to the following table and follow the sequence exactly.

IMPORTANT: Each main bearing cap has two 10 mm bolts and two 11 mm bolts. The 10 mm bolts are on the outside of the cap (furthest from the crankshaft) and have hex heads. The 11 mm bolts are nearest to the crankshaft and have 12-point heads. Do not intermix these bolts as cylinder block thread damage will result.

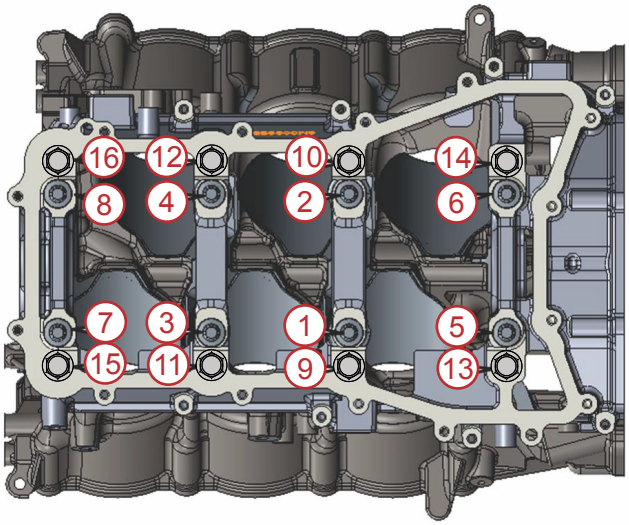


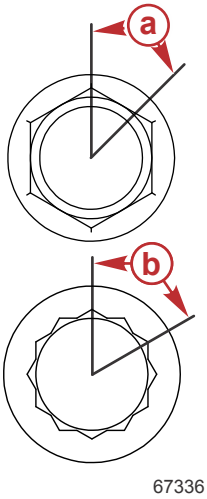
V8

a - 45°

b - 60°

V8 Main Bearing Bolt Torque Sequence	Nm	lb-in.	lb-ft
First—Inner main bearing/bedplate bolts (1–10)	20	177	–
Second—Outer main bearing/bedplate bolts (11–20)	20	177	–
Third—Inner main bearing/bedplate bolts (1–10)	40 + 60°	–	29.5 + 60°
Final—Outer main bearing/bedplate bolts (11–20)	25 + 45°	–	18.4 + 45°



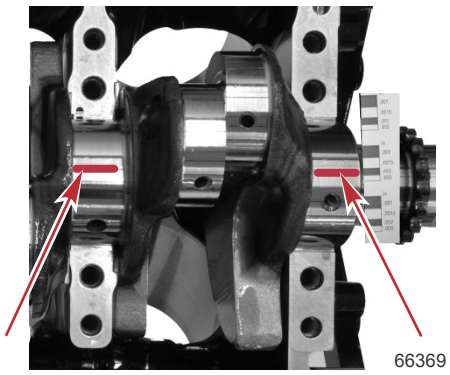


V6
a - 45°
b - 60°

V6 Main Bearing Bolt Torque Sequence	Nm	lb-in.	lb-ft
First—Inner main bearing/bedplate bolts (1–8)	20	177	–
Second—Outer main bearing/bedplate bolts (9-16)	20	177	–
Third—Inner main bearing/bedplate bolts (1–8)	40 + 60°	–	29.5 + 60°
Final—Outer main bearing/bedplate bolts (9–16)	25 + 45°	–	18.4 + 45°

Angle Gauge	Obtain Locally

10. Remove the bedplate and measure the Plastigauge width. If the compressed Plastigauge measurement is not within the following specification, check the crankshaft code and measurement, cylinder block main bearing code, and the bearing grade selection.

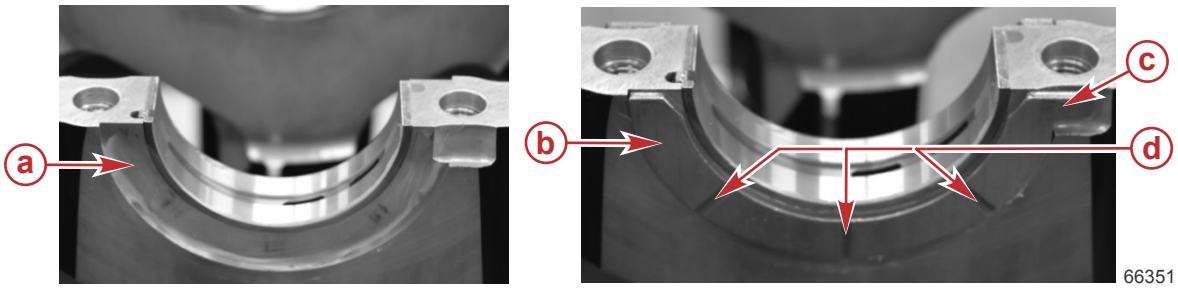


V8 shown

Main Bearing Oil Clearance (V6 and V8)	
Oil clearance	0.036–0.070 mm (0.0015–0.0027 in.)

11. If the measurement is within specification, remove all Plastigauge material from the bearing and crankshaft surfaces.
12. Remove the crankshaft from the crankcase.

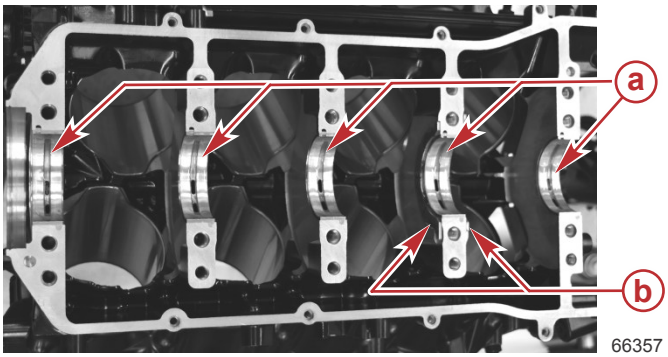
13. Apply Torco MPZ® Engine Assembly Lube HP to the outer thrust bearing surfaces.



a - Inner thrust bearing surface (apply 2-4-C with PTFE)
b - Outer thrust bearing surface (apply Torco MPZ® Engine Assembly Lube HP)
c - Bearing tab
d - Thrust bearing grooves

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Inner thrust bearing surfaces	92-802859A 1
	Torco MPZ® Engine Assembly Lube HP	Outer thrust bearing surfaces	Obtain Locally

14. Apply Lubriplate SPO 255 to the main bearing halves in the cylinder block.



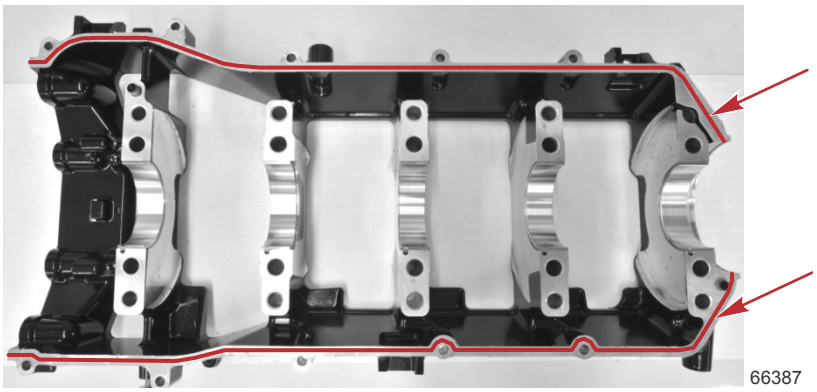
V8 shown
a - Main bearing halves lubricated with Lubriplate SPO 255
b - Thrust bearings lubricated with Torco MPZ® Engine Assembly Lube HP

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Main bearing halves	Obtain Locally
	Torco MPZ® Engine Assembly Lube HP	Outer thrust bearing surfaces	Obtain Locally

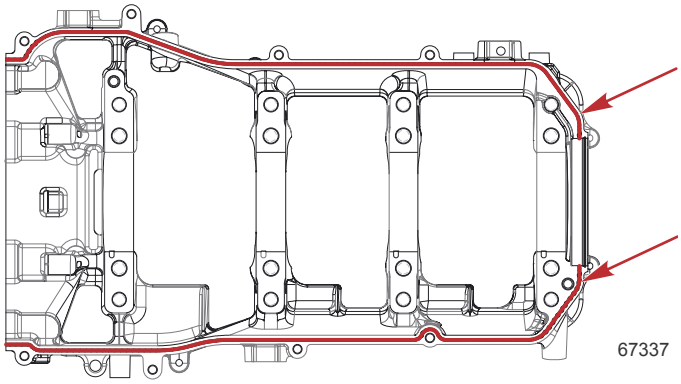
15. Install the crankshaft into the cylinder block. Use care to prevent dislodging the thrust bearings.
16. Use Isopropyl Alcohol to clean the mating surfaces of the cylinder block and bedplate.

Tube Ref No.	Description	Where Used	Part No.
99	Isopropyl Alcohol	Mating surfaces of the cylinder block and bedplate	Obtain Locally

17. Apply a 2 mm (0.08 in.) bead of Three Bond® 1217F to the bedplate sealing surface. Ensure that the two dowel pins are fully installed.



V8



V6

Tube Ref No.	Description	Where Used	Part No.
135	Three Bond® 1217F	Bedplate sealing surface	92-858005K02

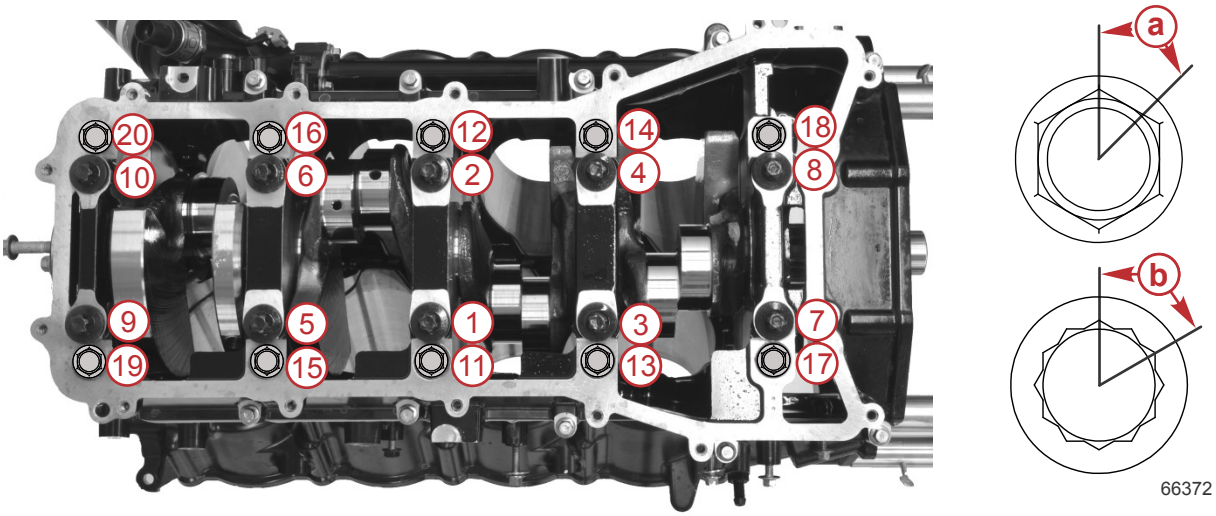
18. Install the bedplate onto the cylinder block. Ensure that the dowel pins engage with the holes in the crankcase.
19. Apply Lubriplate SPO 255 to the bolt holes, bolt threads, and mating area around holes.

IMPORTANT: Install new main bearing bolts for the final assembly.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Bolt holes, threads, and mating area around holes	Obtain Locally

20. Tighten each main bearing bolt to the specified torque. For the third and final steps of the torque sequence, tighten the bolt to the specified torque, then tighten the bolt to the degree indicated before moving to the next bolt in the sequence. Refer to the following table and follow the sequence exactly.

IMPORTANT: Each main bearing cap has two 10 mm bolts and two 11 mm bolts. The 10 mm bolts are on the outside of the cap (furthest from the crankshaft) and have hex heads. The 11 mm bolts are nearest to the crankshaft and have 12-point heads. Do not intermix these bolts as cylinder block thread damage will result.

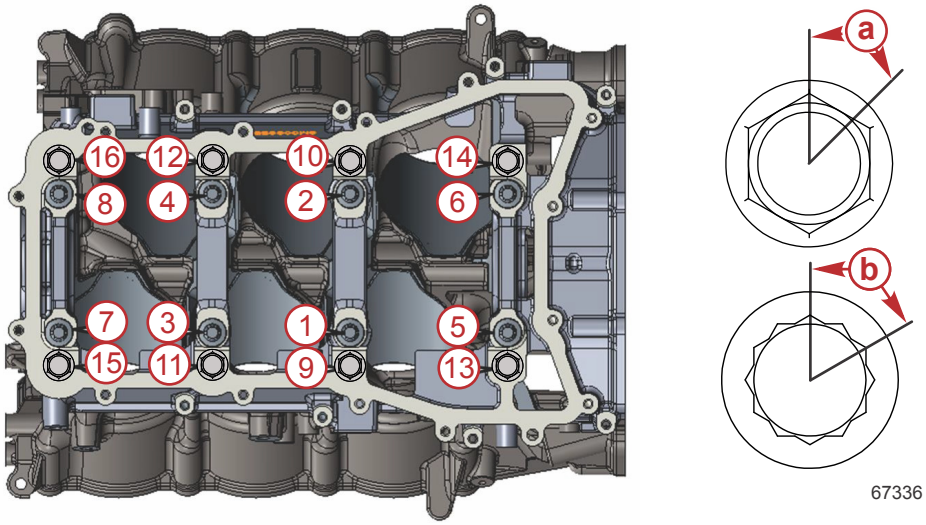


V8

a - 45°

b - 60°

Main Bearing Bolt Torque Sequence	Nm	lb-in.	lb-ft
First—Inner main bearing/bedplate bolts (1-10)	20	177	–
Second—Outer main bearing/bedplate bolts (11-20)	20	177	–
Third—Inner main bearing/bedplate bolts (1-10)	40 + 60°	–	29.5 + 60°
Final—Outer main bearing/bedplate bolts (11-20)	25 + 45°	–	18.4 + 45°



V6

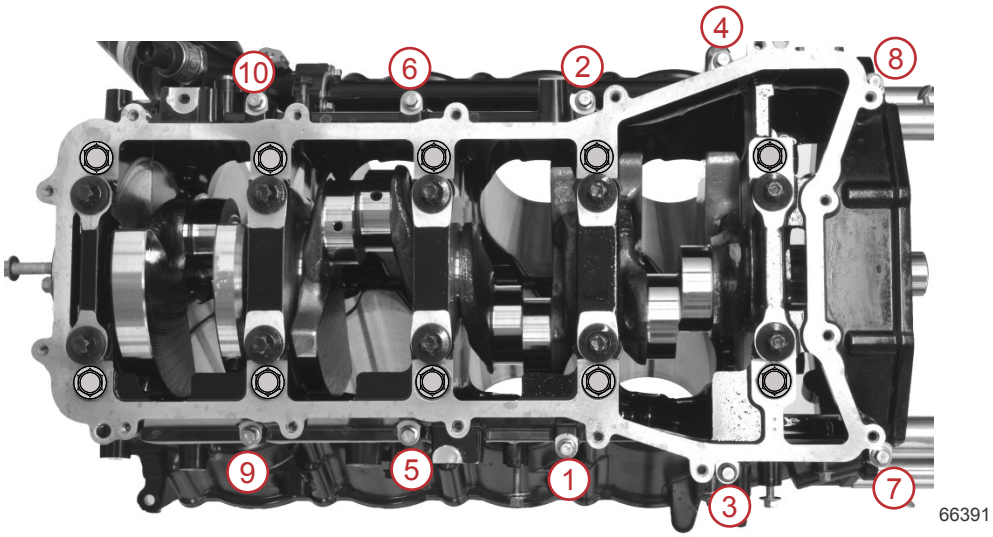
a - 45°

b - 60°

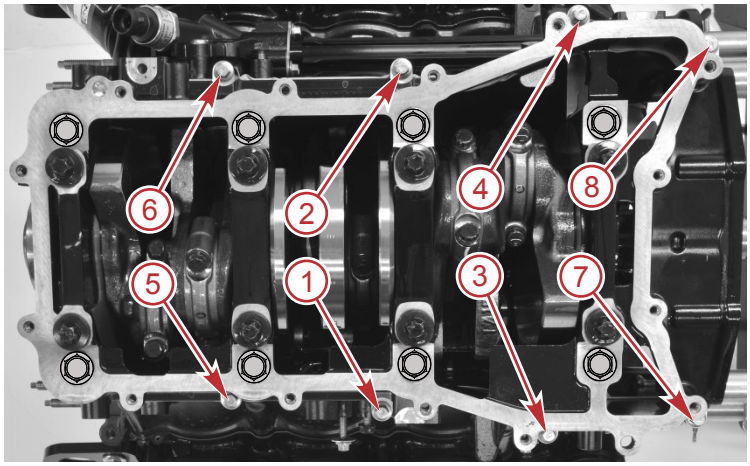
V6 Main Bearing Bolt Torque Sequence	Nm	lb-in.	lb-ft
First—Inner main bearing/bedplate bolts (1–8)	20	177	–
Second—Outer main bearing/bedplate bolts (9-16)	20	177	–
Third—Inner main bearing/bedplate bolts (1–8)	40 + 60°	–	29.5 + 60°
Final—Outer main bearing/bedplate bolts (9–16)	25 + 45°	–	18.4 + 45°

Angle Gauge	Obtain Locally

21. Apply Loctite 242 Threadlocker to the bedplate perimeter bolt threads and tighten to the specified torque in the sequence shown.



V8



V6

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Threads of bedplate perimeter bolts	92-809821

Description	Nm	lb-in.	lb-ft
Bedplate perimeter bolts (M6 x 40)	10	88.5	–

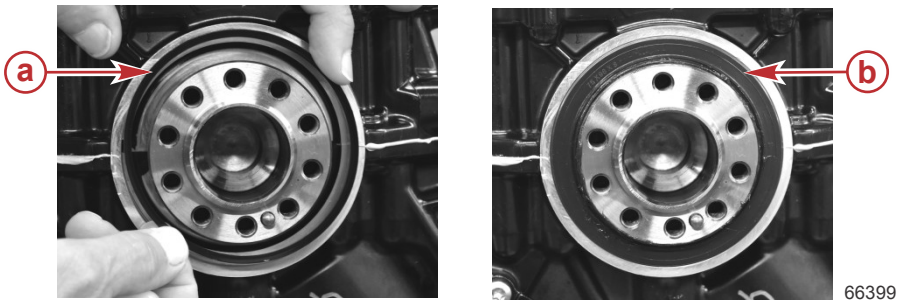
22. Clean the top area around the crankshaft seal bed and remove any sealant that has squeezed out during assembly.
23. Rotate the crankshaft. It should rotate smoothly with no dragging or catching.
24. Check the crankshaft end play with a dial indicator.

Crankshaft end play	0.00–0.432 mm (0.000–0.017 in.)

25. Lubricate the inside lip of the crankshaft seal with Engine Coupler Spline Grease.

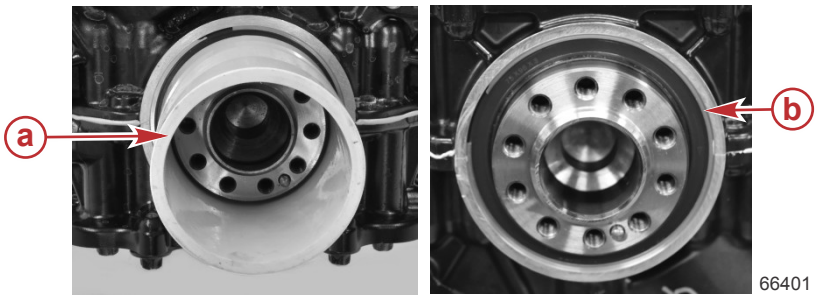
Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Inside lip of the crankshaft seal	8M0071842

26. Install the spacer and crankshaft seal into the cylinder block. The spacer can be installed on either side of the seal to move the seal lip location if the crankshaft has a groove caused by the seal.



a - Spacer
b - Crankshaft seal

27. Use a short length of 8.89 cm (3.5 in.) outside diameter PVC pipe to press the crankshaft seal into the cylinder block.
28. Install the snap ring to retain the crankshaft seal and spacer.

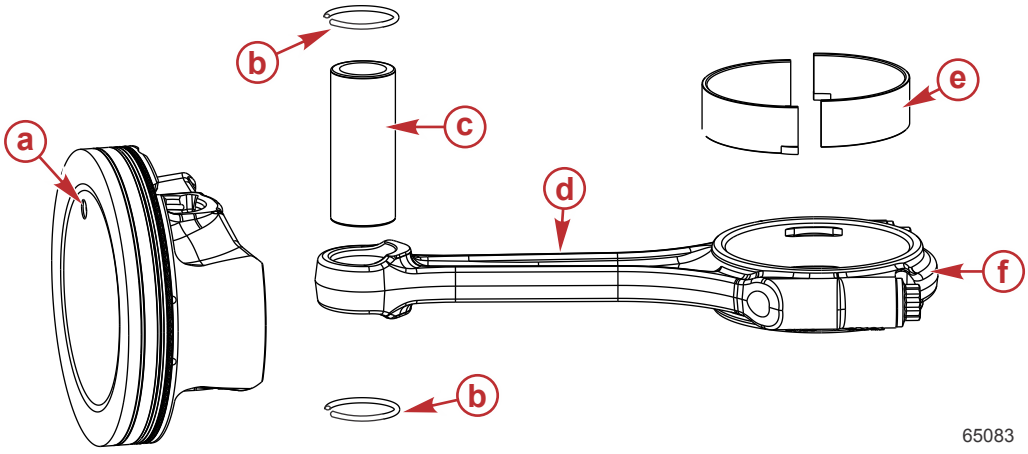


a - 8.89 cm (3.5 in.) outside diameter PVC pipe
b - Snap ring

Piston/Connecting Rod Assembly

1. Lubricate the piston pin with Lubriplate SPO 255.
2. Assemble the piston, connecting rod, piston pin, and new piston pin retaining clips.

IMPORTANT: Always install new piston pin retaining clips.
Ensure that the piston pin retaining clip gap faces the crown of the piston (12 o'clock position).
Ensure that the piston and connecting rod are assembled in the same orientation as removed.
The dot on the piston crown faces the top of the powerhead.



a - Dot on piston crown (faces top of powerhead)
b - Piston pin retaining clips (gap faces crown of piston, 12 o'clock position)
c - Piston pin
d - Connecting rod
e - Connecting rod bearings
f - Rod cap

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Piston pin	Obtain Locally

3. Ensure that both sides of the bearing are free of debris before installing the bearing halves.
4. Ensure that the connecting rod and cap bearing areas are free of debris before installing the bearing halves.
5. Install the bearing halves into the connecting rod and cap.

   IMPORTANT: Ensure that the bearing tabs are seated into the connecting rod and the rod cap.
6. Lubricate the inside diameter of the connecting rod bearing halves with Lubriplate SPO 255.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Inside diameter of the connecting rod bearing halves	Obtain Locally

Piston Ring Installation

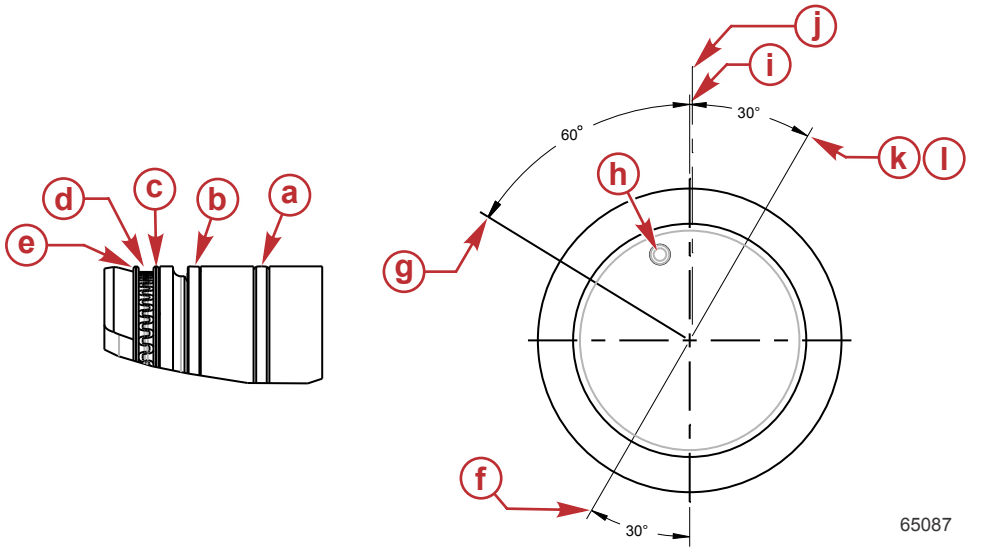
IMPORTANT: Do not reuse the original rings during reassembly. Always install new rings when rebuilding the engine.

IMPORTANT: Use caution when installing piston rings to avoid scratching the piston.

1. Apply Synthetic Blend 4-Stroke Outboard Oil 25W-40 engine oil to the piston ring grooves and the piston rings.
2. Install the oil ring expander into the lower ring groove of the piston.

   NOTE: *Ensure that the oil ring expander 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.
5. Install the second compression ring.
6. Install the top compression ring.
7. Position the piston ring gaps as shown.

   IMPORTANT: The second and top piston compression rings must be installed with the identifying marks facing up. Spread the rings just enough to slip over the piston.



- **a -** Top compression ring
- **b -** Second compression ring
- **c -** Top oil ring
- **d -** Expander ring
- **e -** Bottom oil control ring
- **f -** Second ring gap
- **g -** Top oil ring gap
- **h -** Dot on piston crown (faces top of powerhead)
- **i -** Expander ring gap
- **j -** Piston pin axis
- **k -** Top ring gap
- **l -** Bottom oil control ring gap

Tube Ref No.	Description	Where Used	Part No.
139	Synthetic Blend 4-Stroke Outboard Oil 25W-40	Piston ring grooves and piston rings	92-8M0078629

Piston Assembly Installation

IMPORTANT: Use the old connecting rod cap bolts to tighten the connecting rod caps when checking the connecting rod bearing oil clearance. Install new connecting rod cap bolts for the final assembly.

1. Apply 10W-30 4-Stroke Marine Engine Oil to the cylinder bores.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Cylinder bores	92-8M0078625

2. Ensure that the piston ring orientation is correct. Refer to **Piston Ring Installation**.

3. Apply Lubriplate SPO 255 to the piston skirts and rings.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Piston skirts and rings	Obtain Locally

4. Compress the piston rings with a ring compressor.

ARP Piston Ring Compressor	ARP 901-9200

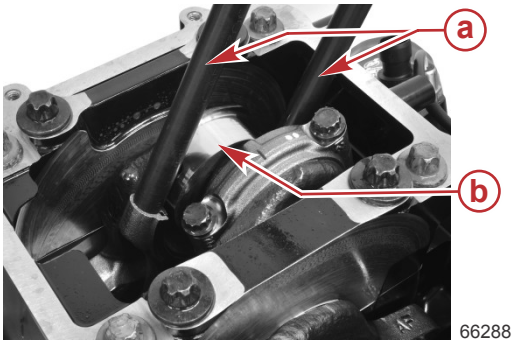
5. Install rod guide dowels onto the connecting rods to prevent bearing journal damage when installing the pistons.

a - Ring compressor
b - Rod guide dowels

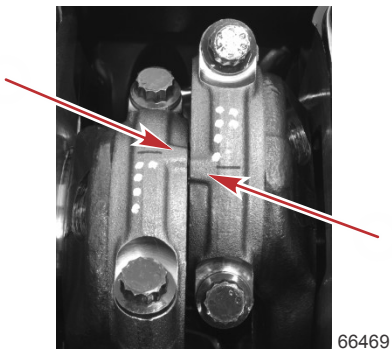
Rod Guide Dowels	8M0148866

6. Install the piston and connecting rod assemblies into their respective bores in the correct orientation. The piston dot faces the top of the powerhead, with orientation marks on the connecting rod caps facing each other.

NOTE: *On certain cylinders, it may be necessary to use only one rod guide dowel due to interference with the cylinder block.*

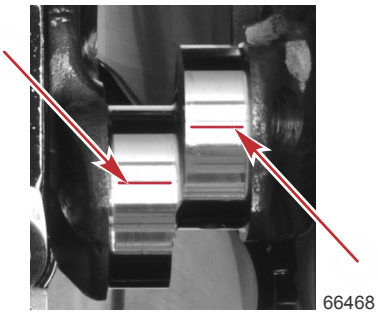


V8 shown
a - Connecting rod guides
b - Bearing journal



Note the connecting rod cap orientation marks (V8 only)

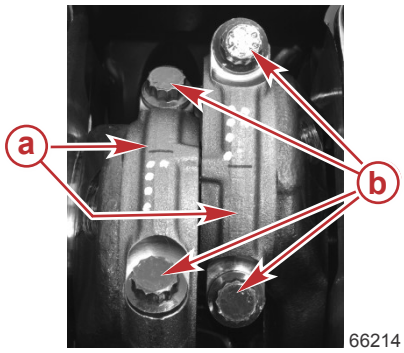
7. Install a piece of Plastigauge® parallel to the crankshaft on the connecting rod bearing journals.



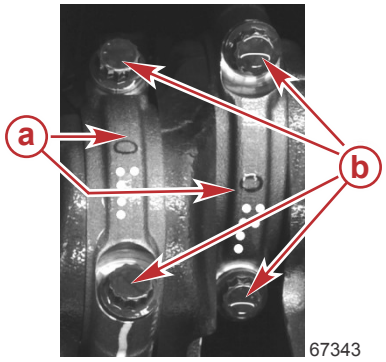
V8 shown

8. Install the connecting rod caps in the correct orientation.
9. Tighten the connecting rod cap bolts to the specified torque.

IMPORTANT: Use the old connecting rod cap bolts to tighten the connecting the rod caps when checking the connecting rod bearing oil clearance. Install new connecting rod cap bolts for the final assembly.



V8
- a - Connecting rod caps
- b - Connecting rod cap bolts (10 mm)

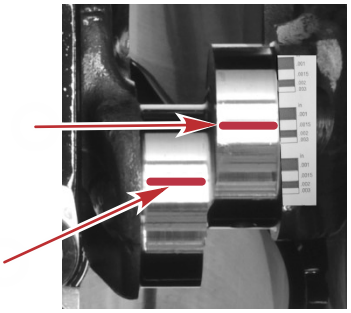


V6
- a - Connecting rod caps
- b - Connecting rod cap bolts (10 mm)

Description		Nm	lb-in.	lb-ft
Connecting rod cap bolts	**First**	10	88.5	–
	Second	25	–	18.4
	Final	Tighten an additional 90 degrees		

Angle Gauge	Obtain Locally

10. Remove the connecting rod caps and measure the Plastigauge width. If the compressed Plastigauge measurement is not within the following specification, check the crankshaft code and measurement, cylinder block main bearing code, and the bearing grade selection.


66472

V8 shown

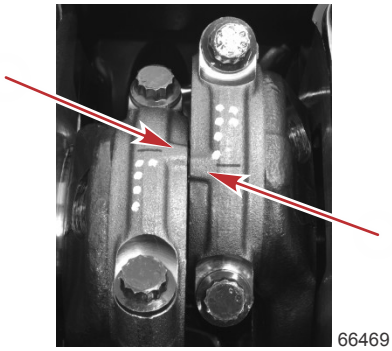
Connecting Rod Bearing Oil Clearance (V6 and V8)	
Oil clearance	0.046–0.074 mm (0.0019–0.0029 in.)

11. If the measurement is within specification, remove all Plastigauge material from the bearing and crankshaft surfaces.
12. Push the connecting rod and piston assemblies away from the bearing journals.
13. Apply Lubriplate SPO 255 to the rod cap mating surfaces, connecting rod bearing halves, connecting rod bolt threads, and under the connecting rod bolt heads.

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Rod cap mating surfaces, bearing halves, rod bolt threads, and under the connecting rod bolt heads	Obtain Locally

IMPORTANT: Install new connecting rod cap bolts for the final assembly.

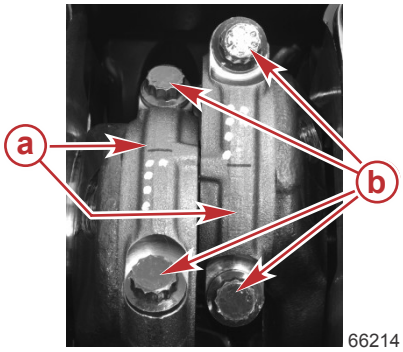
14. Install the connecting rod caps in the correct orientation.


66469

Note the connecting rod cap orientation marks (V8 only)

15. Tighten the connecting rod cap bolts to the specified torque.

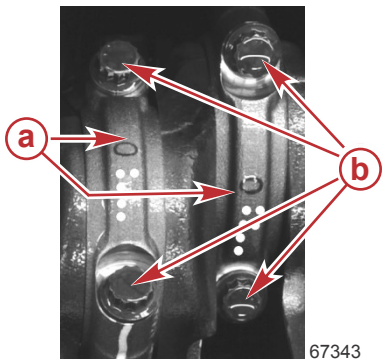
IMPORTANT: Install new connecting rod cap bolts for the final assembly.



66214

V8

a - Connecting rod caps
b - Connecting rod cap bolts



V6
- **a -** Connecting rod caps
- **b -** Connecting rod cap bolts

Description		Nm	lb-in.	lb-ft
Connecting rod cap bolts	**First**	10	88.5	–
	Second	25	–	18.4
	Final	Tighten an additional 90 degrees		

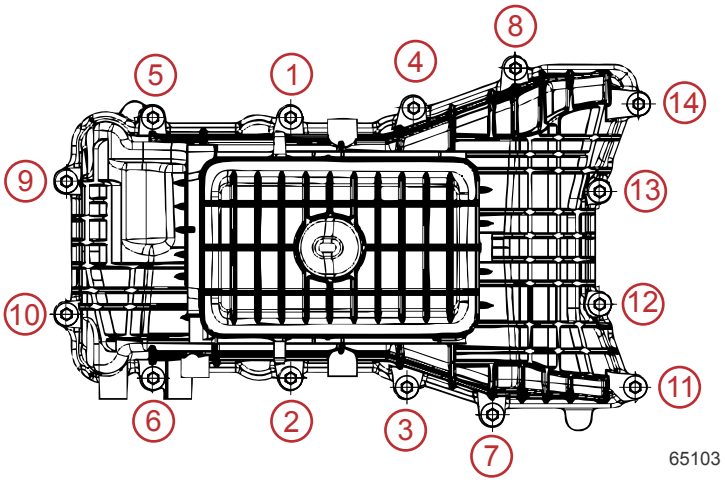
Angle Gauge	Obtain Locally

Intake Plenum, Throttle Body, and Flywheel Installation

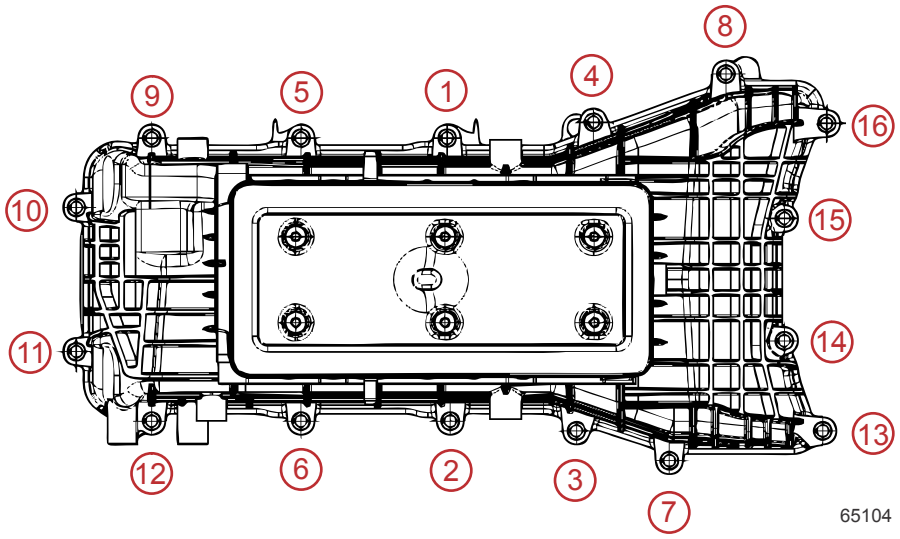
IMPORTANT: The intake plenum and throttle body must be installed before the flywheel.

Plenum Installation

1. Inspect the intake plenum seal. Replace the seal if damage is found.
2. Install the intake plenum onto the cylinder block. Tighten the screws to the specified torque in the sequence shown.



V6 intake plenum torque sequence

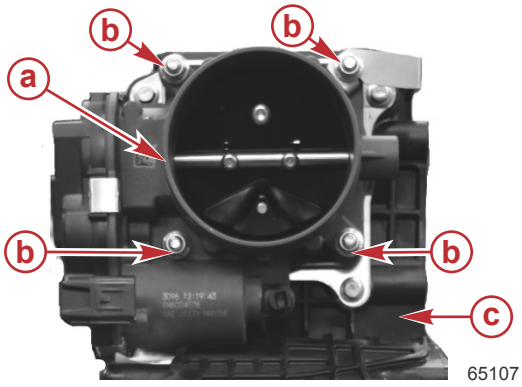


V8 intake plenum torque sequence

Description	Nm	lb-in.	lb-ft
Intake plenum screws (M6 x 1 x 30)	10	88.5	–

Throttle Body Installation

If removed, install the throttle body onto the intake plenum studs before installing the flywheel. Install a gasket between the throttle body and intake plenum. Tighten the nylon locking nuts to the specified torque.



a - Throttle body
b - Nylon locking nuts (4)
c - Intake plenum

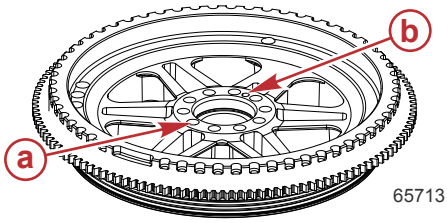
Description	Nm	lb-in.	lb-ft
M6 nylon locking nut (4)	7	62	–

Flywheel Installation

IMPORTANT: The intake plenum and throttle body must be installed before the flywheel.

IMPORTANT: V6 and V8 flywheels are not interchangeable.

1. Align the crankshaft dowel pin with the dowel pin hole on the bottom of the flywheel. Install the flywheel onto the crankshaft.

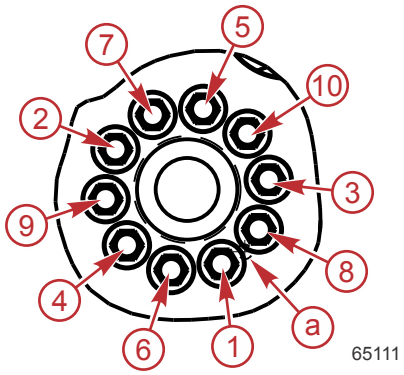


V8 shown; V6 similar
a - Flywheel mounting holes
b - Dowel pin hole

2. Start the flywheel screws by hand to prevent crossthreading.
3. Prevent the flywheel from turning by using a flywheel holding tool.

Flywheel Holding Tool	91- 52344

4. Starting with the screw closest to the dowel pin, tighten the screws to the specified torque in the sequence shown.



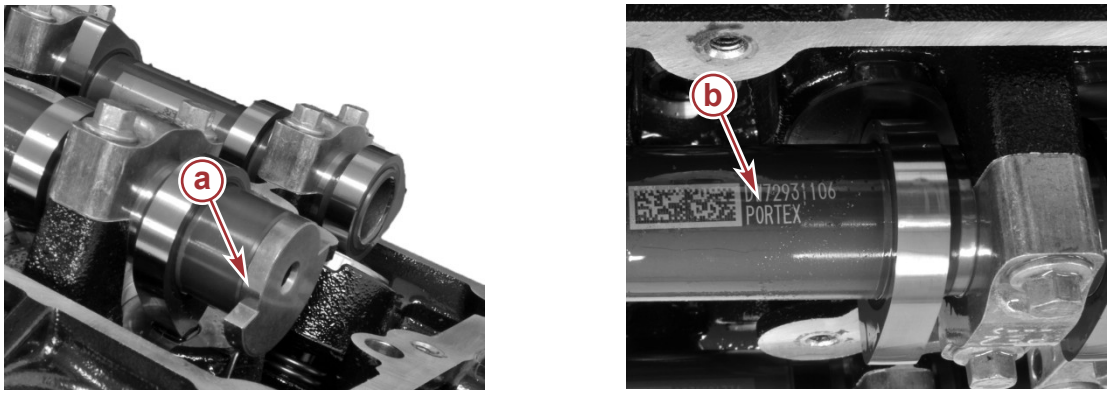
V6 and V8 flywheel screw torque sequence
a - Dowel pin location

Description	Nm	lb-in.	lb-ft
Flywheel mounting screw (M8 x 1 x 42)	40	–	29.5

Cylinder Head Installation

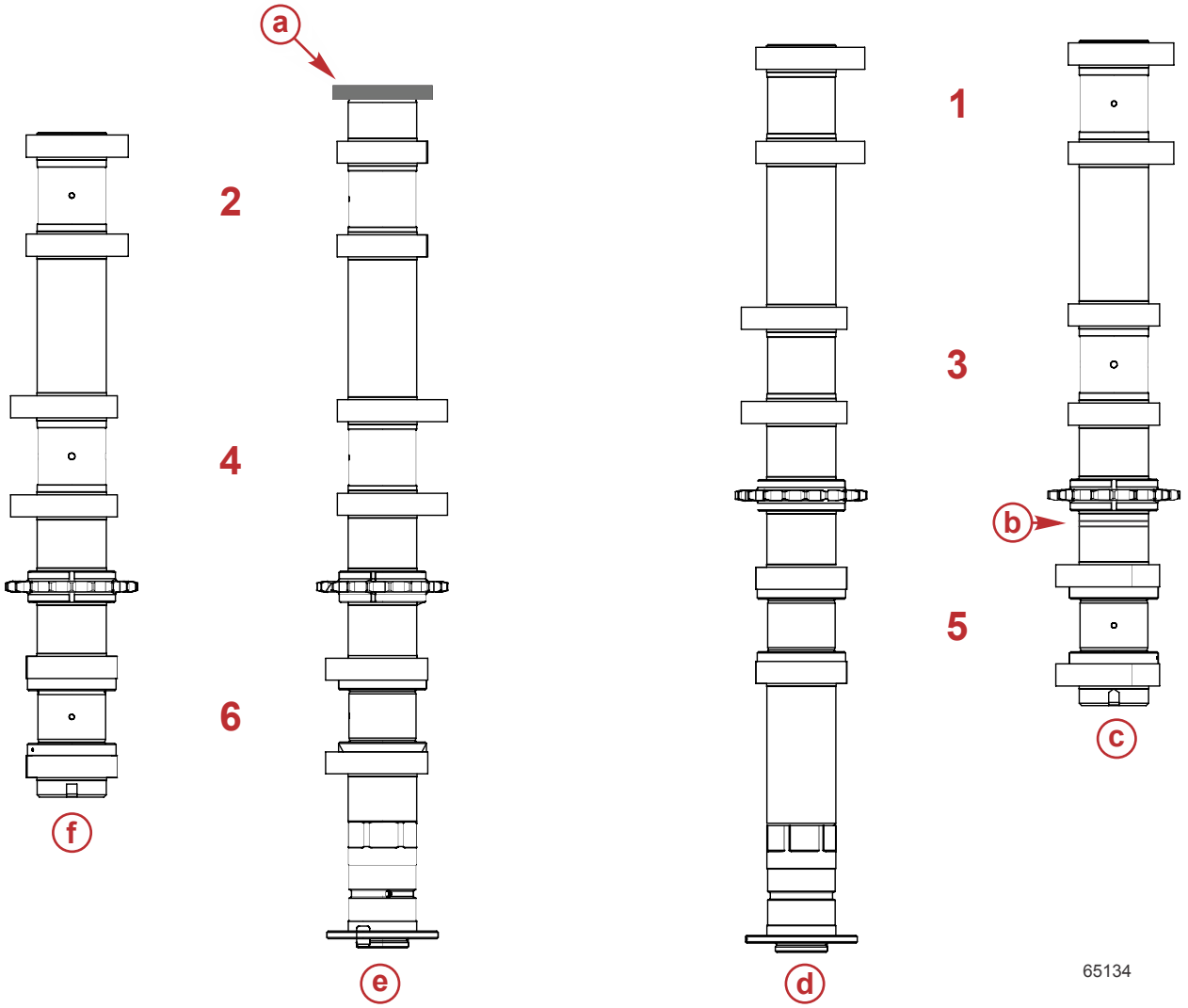
FourStroke V6 DOHC—Camshaft Identification

The port exhaust camshaft can be identified by the sensor target at the top of the camshaft. The starboard intake camshaft can be identified by the groove below the chain gear. Each camshaft has an identification mark.



a - Sensor target
b - Camshaft identification mark—port exhaust camshaft

NOTE: Observe the camshafts identification marks during powerhead assembly to ensure that each camshaft is installed in the correct location.



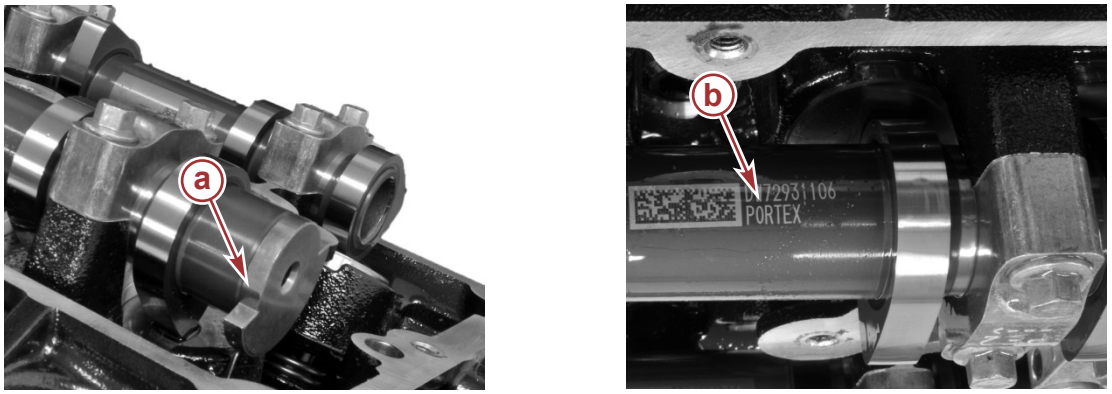
Camshaft identification

- **a -** Sensor target
- **b -** Groove below the chain gear (starboard intake camshaft only)
- **c -** Starboard intake camshaft
- **d -** Starboard exhaust camshaft
- **e -** Port exhaust camshaft
- **f -** Port intake camshaft

Ref.	Description
1	Cylinder number 1
2	Cylinder number 2
3	Cylinder number 3
4	Cylinder number 4
5	Cylinder number 5
6	Cylinder number 6

FourStroke V8 DOHC—Camshaft Identification

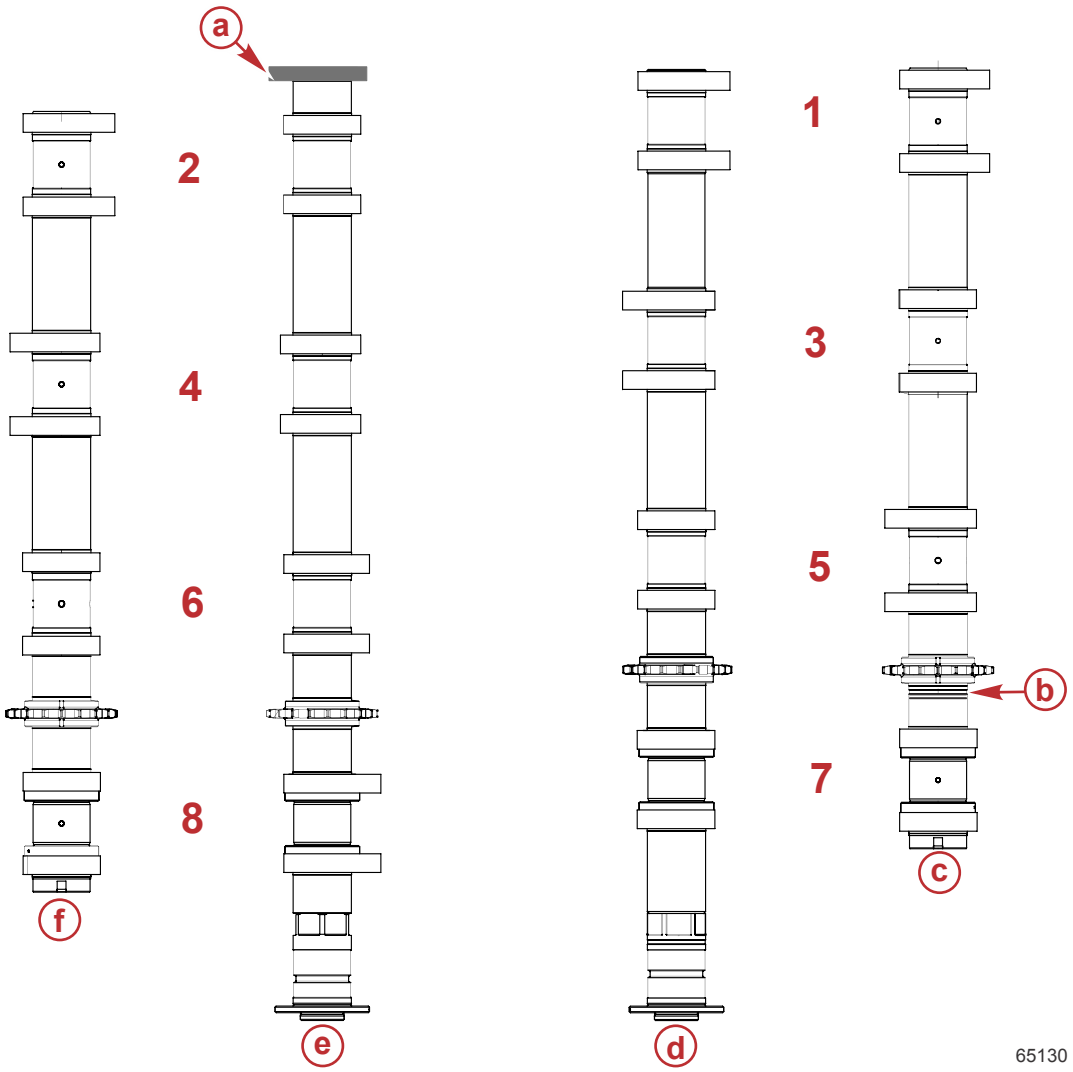
The port exhaust camshaft can be identified by the sensor target at the top of the camshaft. The starboard intake camshaft can be identified by the groove below the chain gear. Each camshaft has an identification mark.



67354

a - Sensor target
b - Camshaft identification mark

NOTE: Observe the camshafts identification marks during powerhead assembly to ensure that each camshaft is installed in the correct location.



Camshaft identification

- **a -** Sensor target
- **b -** Port intake camshaft
- **c -** Port exhaust camshaft
- **d -** Starboard exhaust camshaft
- **e -** Starboard intake camshaft
- **f -** Groove below the chain gear (starboard intake camshaft only)

Ref.	Description
1	Cylinder number 1
2	Cylinder number 2
3	Cylinder number 3
4	Cylinder number 4
5	Cylinder number 5
6	Cylinder number 6
7	Cylinder number 7
8	Cylinder number 8

IMPORTANT: The installation of the cylinder head must be strictly followed. Failure to follow the installation outline procedure may damage the valve train components.

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 piston damage.

IMPORTANT: The crankshaft must be in the service position during cylinder head installation and the balance shaft cover must be installed prior to cylinder head installation.

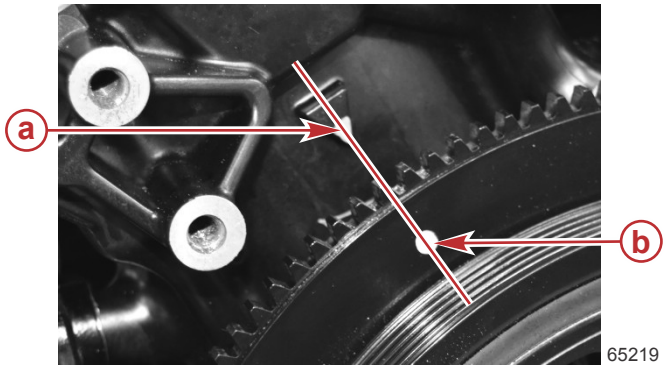
IMPORTANT: The cylinder head must be installed onto the block with the camshafts removed and the lifter buckets installed, with a length of rubber hose installed to prevent the lifter buckets from falling out of the cylinder heads.

IMPORTANT: V8 models only—Ensure that the balance shaft cover is installed prior to installing the cylinder heads.

1. Inspect the cylinder block and cylinder head mating surfaces for cleanliness and flatness per specification. Refer to **Section 4B - V6 Cylinder Head Specifications** or **Section 4B - V8 Cylinder Head Specifications**.
2. Ensure that two alignment dowels are installed into each bank of the cylinder block.

Dowel pins (two per bank) (V8 shown—V6 similar)

3. Rotate the engine to the service position.



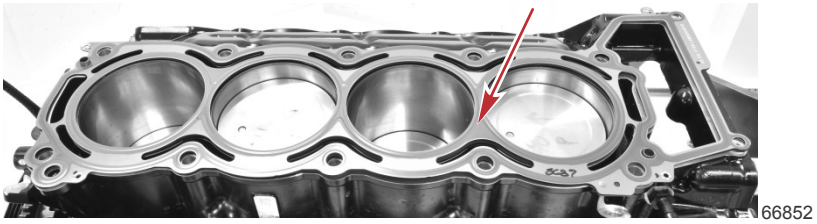
Timing marks aligned in the service position

a - Pointer on cylinder block (starboard bank)

b - Dot on flywheel (identified with yellow paint for visibility)

4. Place the port side head gasket onto the cylinder block.

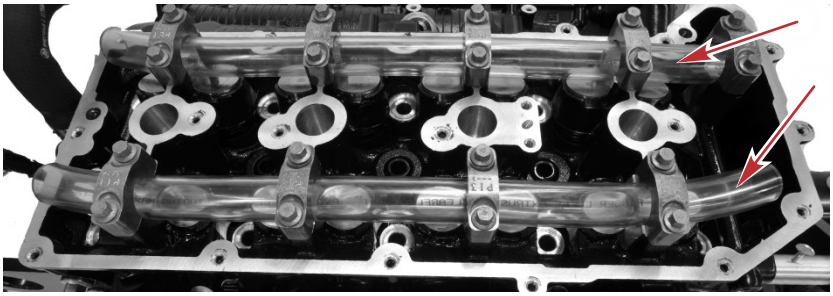
   IMPORTANT: No dressing or sealant is required on the head gaskets or head bolts.



V8 shown—V6 similar

5. Place the port side cylinder head onto the cylinder block.

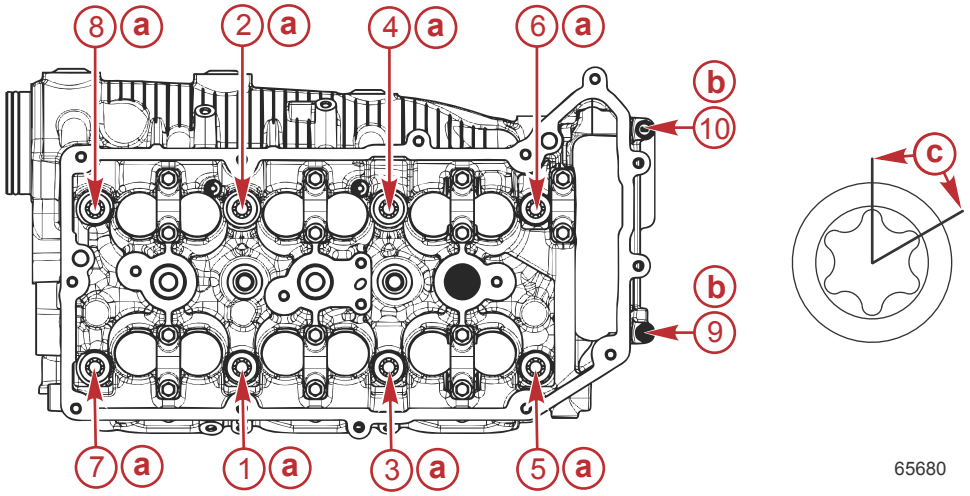
6. Remove the Tygon tubing.



66184

V8 shown—V6 similar

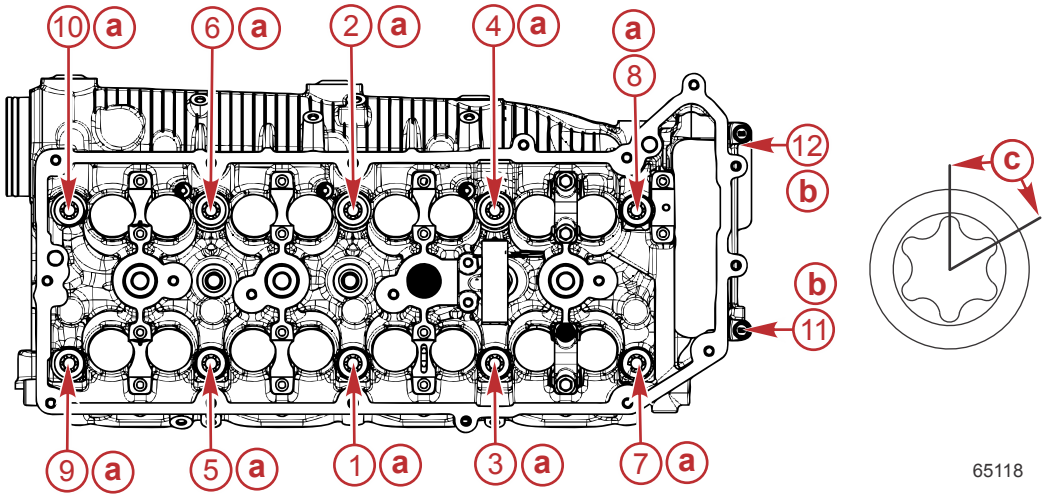
7. Install and tighten the E14 external Torx® cylinder head bolts to the specified torque in the sequence shown.
8. Install and tighten the two M6 x 1 x 35 bolts at the bottom of the cylinder head to the specified torque.



65680

V6 port side cylinder head

- **a -** E14 External Torx cylinder head bolts
- **b -** M6 x 1 x 35 bolts
- **c -** 60°



65118

V8 port side cylinder head

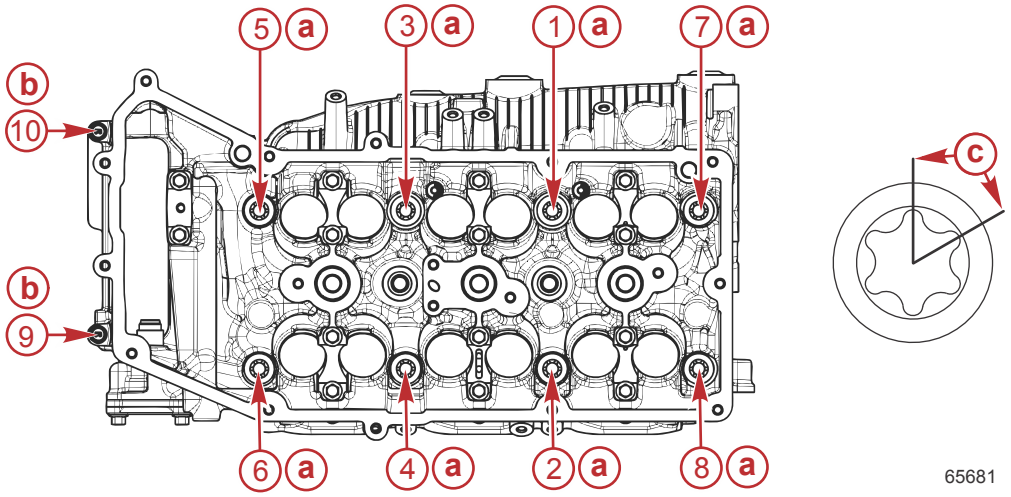
- **a -** E14 External Torx cylinder head bolts
- **b -** M6 x 1 x 35 bolts
- **c -** 60°

Description		Nm	lb-in.	lb-ft
E14 external Torx cylinder head bolts	**First**	15	132.8	–
	Second	35	–	25.8
	Final	Tighten an additional 60°		

Description	Nm	lb-in.	lb-ft
M6 x 1 x 35 bolts	12	106.2	–

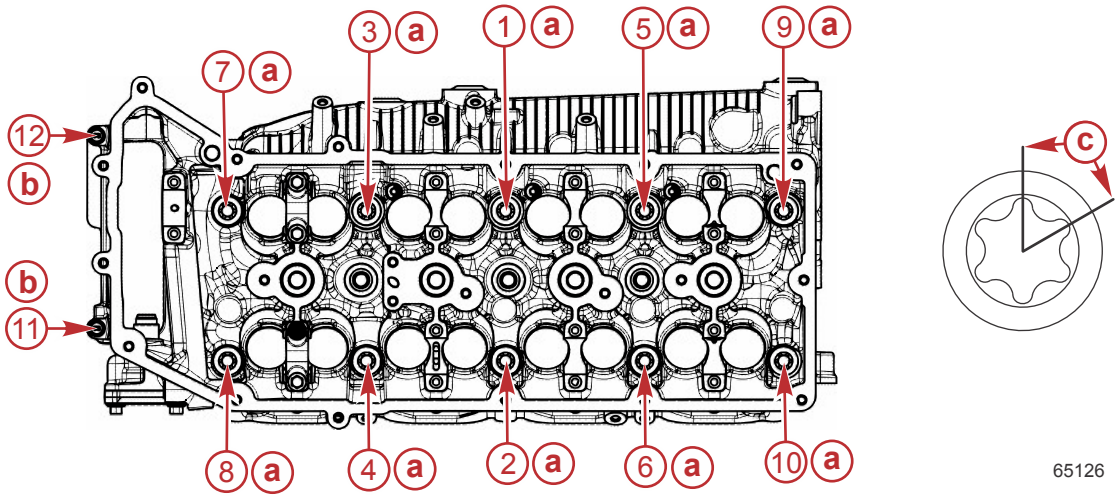
Angle Gauge	Obtain Locally

9. Place the starboard side cylinder head gasket onto the cylinder block.
10. Place the starboard side cylinder head onto the cylinder block. Remove the tygon tubing.
11. Install and tighten the E14 external Torx® cylinder head bolts to the specified torque in the sequence shown.
12. Install and tighten the two M6 x 1 x 35 bolts at the bottom of the cylinder head to the specified torque.



V6 starboard cylinder head

a - E14 External Torx cylinder head bolts
b - M6 x 1 x 35 bolts
c - 60°



V8 starboard cylinder head

a - E14 External Torx cylinder head bolts
b - M6 x 1 x 35 bolts
c - 60°

Description		Nm	lb-in.	lb-ft
E14 external Torx cylinder head bolts	**First**	15	132.8	–
	Second	35	–	25.8
	Final	Tighten an additional 60°		

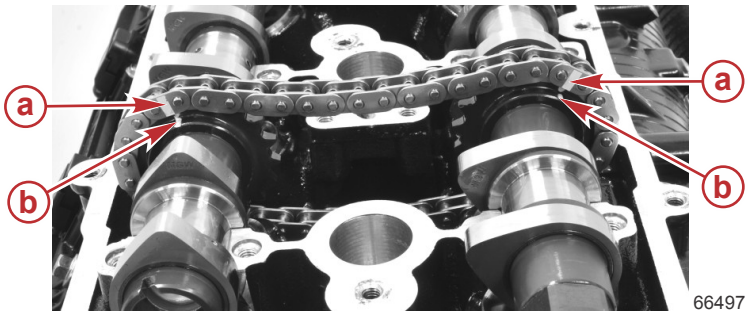
Description	Nm	lb-in.	lb-ft
M6 x 1 x 35 bolts	12	106.2	–

Angle Gauge	Obtain Locally

13. Apply Lubriplate SPO 255 to the camshaft bearing surfaces, lifter buckets, camshaft bearing journals, and camshaft thrust surfaces on the port and starboard cylinder heads.

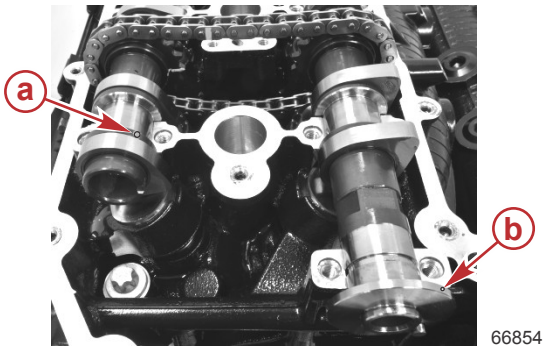
Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Camshaft bearing surfaces, lifter buckets, camshaft bearing journals, and camshaft thrust surfaces	Obtain Locally

14. Align the port intake camshaft, port exhaust camshaft, and camshaft-to-camshaft timing chain as shown.
15. Place the port camshafts and timing chain into the port cylinder head. Ensure that the timing marks on the camshaft sprockets and timing chain are aligned as shown. Finesse the camshafts into the bearing journals to prevent damage to the bearing surfaces.



Port camshafts in TDC position (V8 shown—V6 similar)
- **a -** Timing marks on timing chain
- **b -** Timing marks on camshaft sprockets

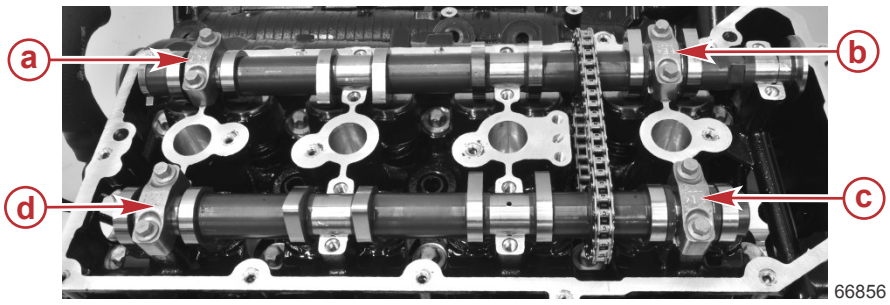
16. Turn the camshafts and timing chain clockwise (as viewed from the bottom of the cylinder block) to the assembly position. Note the locations of the camshaft timing marks. Finesse the camshafts into the bearing journals to prevent damage to the bearing surfaces.



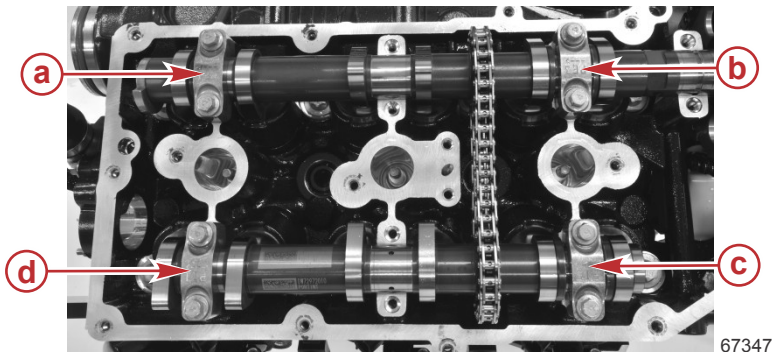
V8 shown—V6 similar
- **a -** Port intake camshaft timing mark in the assembly position
- **b -** Port exhaust camshaft timing mark in the assembly position

17. Place the four camshaft caps into position and tighten the screws until they are snug. Alternate tightening the screws to draw the camshafts down evenly.

IMPORTANT: The directional arrow on each camshaft cap points to the top of the powerhead.



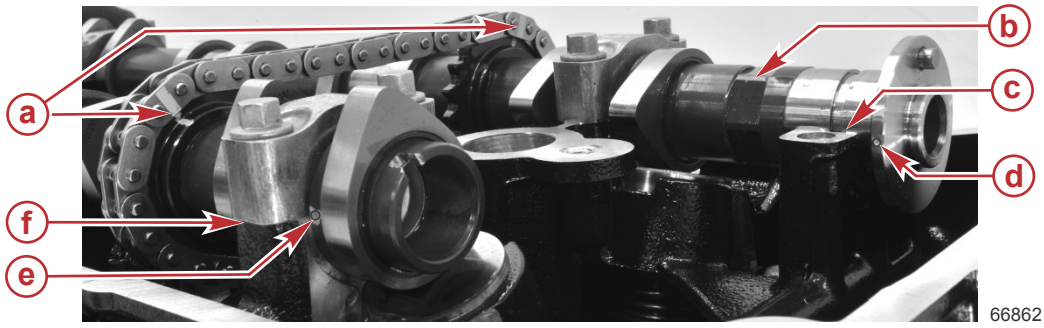
V8
- **a -** Camshaft cap PE1
- **b -** Camshaft cap PE4
- **c -** Camshaft cap PI4
- **d -** Camshaft cap PI1



V6

- **a -** Camshaft cap PE1
- **b -** Camshaft cap PE3
- **c -** Camshaft cap PI3
- **d -** Camshaft cap PI1

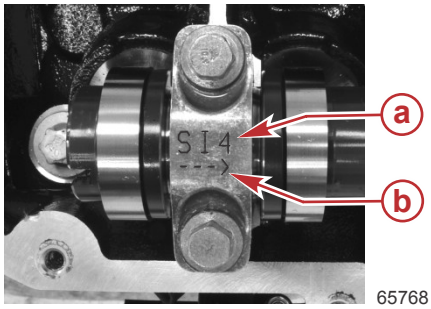
18. Use a wrench on the camshaft hex to turn the camshafts back to the TDC position. The camshaft timing marks must align with the camshaft cap parting lines.



Port camshafts in TDC position (V8 shown—V6 similar)

- **a -** Timing marks on timing chain
- **b -** Camshaft hex
- **c -** Camshaft cap parting line
- **d -** Timing mark on port exhaust camshaft aligned with camshaft cap parting line
- **e -** Timing mark on port intake camshaft aligned with camshaft cap parting line
- **f -** Camshaft cap parting line

19. Install the camshaft caps in the correct position and orientation. Tighten the screws until they are snug.

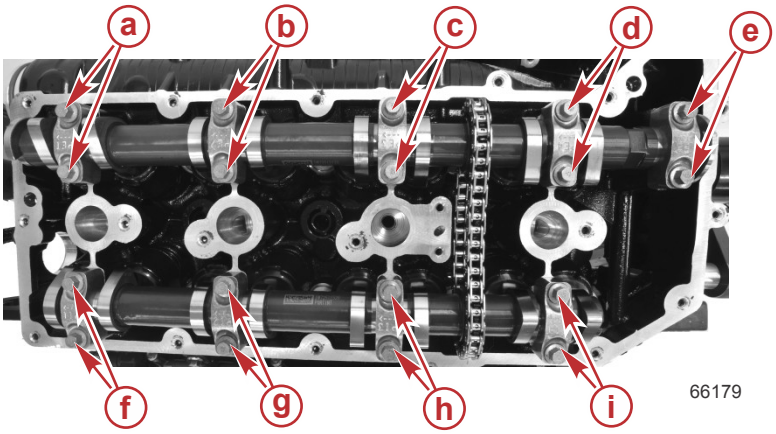


V8 shown

- **a -** Identification mark—starboard intake, cylinder 4 of the starboard bank in this example
- **b -** Directional arrow—points to top of powerhead

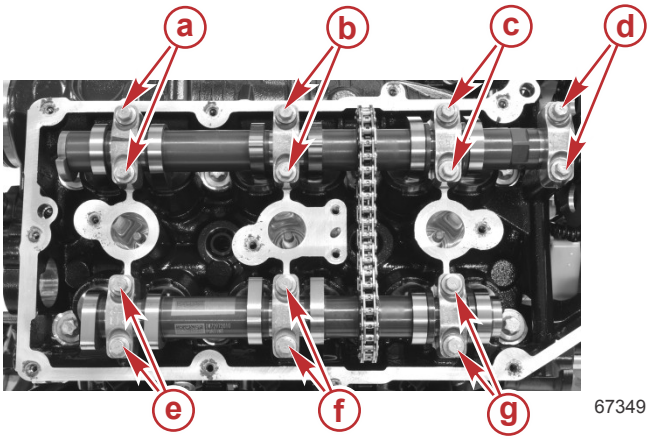
20. Install and tighten the camshaft cap screws to the specified torque.

IMPORTANT: Complete both stages of the torque specification on each camshaft cap before moving to the next cap.



V8 port cylinder head

- **a -** Screws securing camshaft cap PE1
- **b -** Screws securing camshaft cap PE2
- **c -** Screws securing camshaft cap PE3
- **d -** Screws securing camshaft cap PE4
- **e -** Screws securing camshaft cap PE5
- **f -** Screws securing camshaft cap PI1
- **g -** Screws securing camshaft cap PI2
- **h -** Screws securing camshaft cap PI3
- **i -** Screws securing camshaft cap PI4

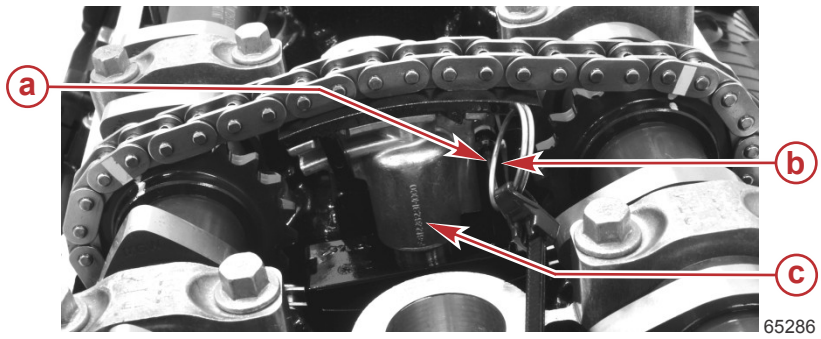


V6 port cylinder head

- **a -** Screws securing camshaft cap PE1
- **b -** Screws securing camshaft cap PE2
- **c -** Screws securing camshaft cap PE3
- **d -** Screws securing camshaft cap PE4
- **e -** Screws securing camshaft cap PI1
- **f -** Screws securing camshaft cap PI2
- **g -** Screws securing camshaft cap PI3

Description		Nm	lb-in.	lb-ft
Camshaft cap screws (M6 x 35 hex flange)	**First**	6	53.1	–
	Final	12	106.2	–

21. Install the timing chain tensioner. Do not release the pin or drill bit until the tensioner is secured.

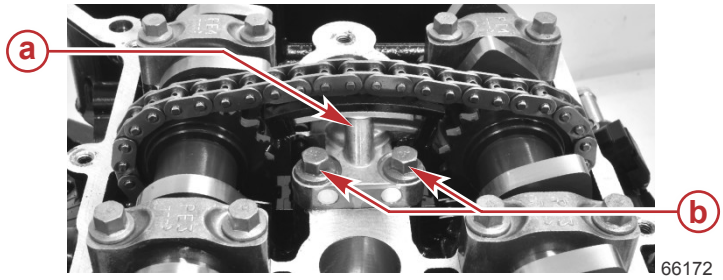


V8 shown—V6 similar

- **a -** Slots of the timing chain tensioner
- **b -** Pin or drill bit inserted through the slots
- **c -** Timing chain tensioner

22. Install the two screws securing the timing chain tensioner. Tighten the screws to the specified torque.

IMPORTANT: Remove the pin from the tensioner after the screws are tightened. Failure to remove the pin will cause engine damage.



V8 shown—V6 similar

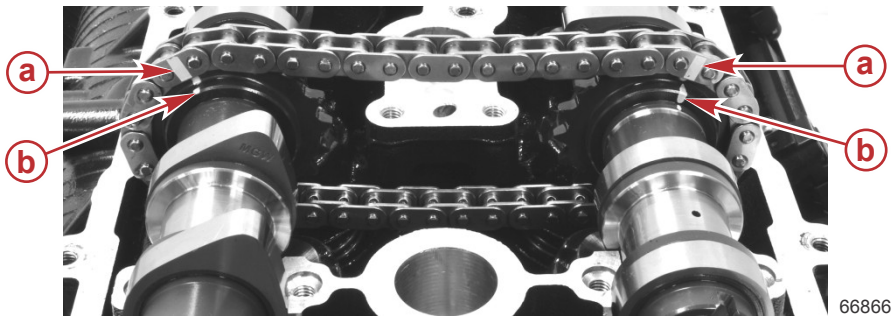
- **a -** Camshaft-to-camshaft timing chain tensioner
- **b -** Screws (2)

Description		Nm	lb-in.	lb-ft
Timing chain tensioner screws (M6 x 30 hex flange)	**First**	6	53.1	–
	Final	12	106.2	–

23. Remove the pin from the tensioner.
24. Apply Torco MPZ® Engine Assembly Lube HP to each camshaft lobe, including the base circle of each camshaft lobe.

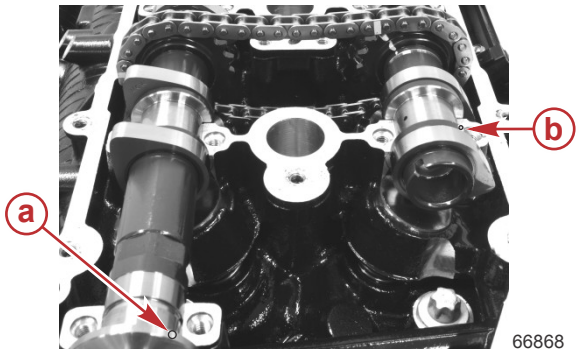
Tube Ref No.	Description	Where Used	Part No.
	Torco MPZ® Engine Assembly Lube HP	Each camshaft lobe, including the base circle of each camshaft lobe	Obtain Locally

25. Align the starboard intake camshaft, starboard exhaust camshaft, and camshaft-to-camshaft timing chain as shown.



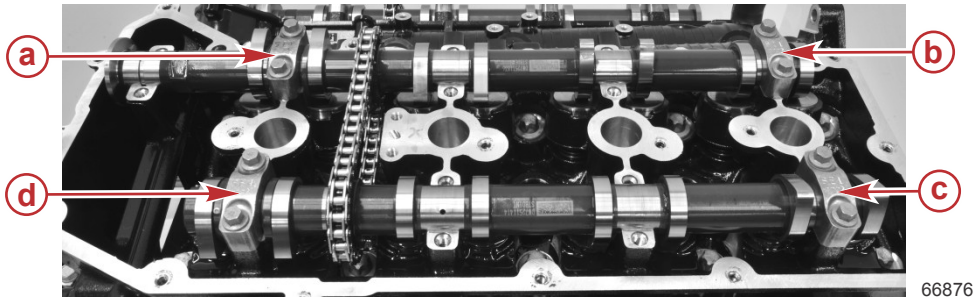
Starboard camshafts in TDC position (V8 shown—V6 similar)
- **a -** Timing marks on timing chain
- **b -** Timing marks on camshaft sprockets

26. Turn the camshafts and timing chain counterclockwise (as viewed from the bottom of the cylinder block) to the assembly position. Note the locations of the camshaft timing marks. Finesse the camshafts into the bearing journals to prevent damage to the bearing surfaces.

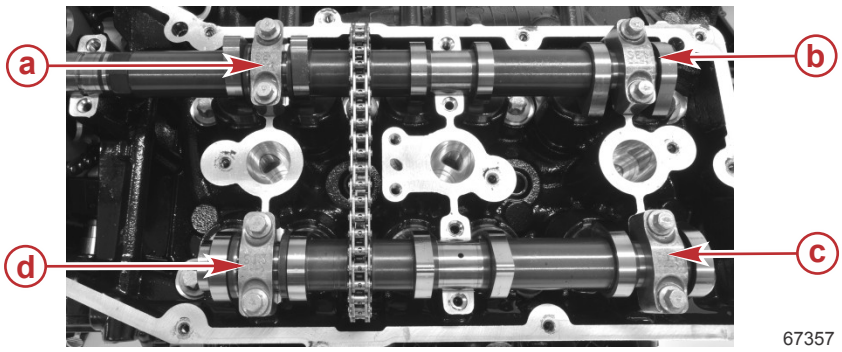


V8 shown—V6 similar
- **a -** Starboard exhaust camshaft timing mark in the assembly position
- **b -** Starboard intake camshaft timing mark in the assembly position

27. Place the four camshaft caps into position and tighten the screws until they are snug. Alternate tightening the screws to draw the camshafts down evenly.



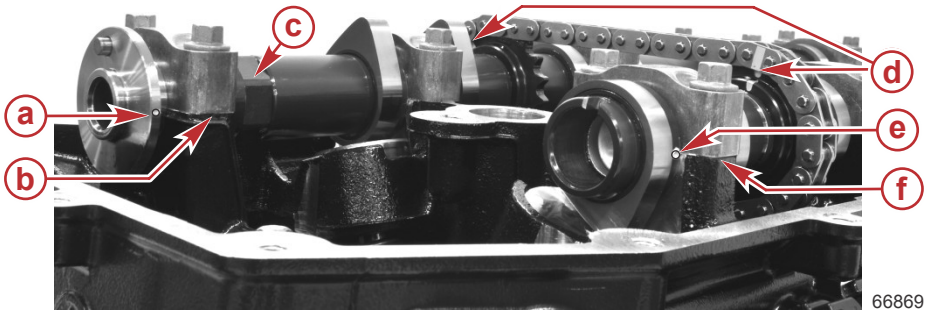
V8 starboard cylinder head
- **a -** Camshaft cap SE4
- **b -** Camshaft cap SE1
- **c -** Camshaft cap SI1
- **d -** Camshaft cap SI4



V6 starboard cylinder head

- **a -** Camshaft cap SE3
- **b -** Camshaft cap SE1
- **c -** Camshaft cap SI1
- **d -** Camshaft cap SI3

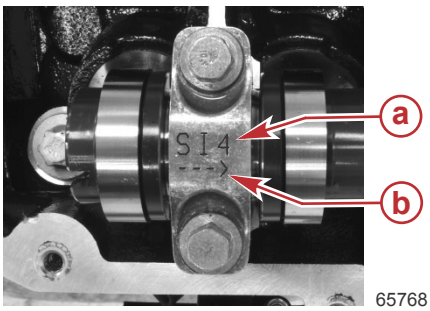
28. Use a wrench on the camshaft hex to turn the camshafts back to the TDC position. The camshaft timing marks must align with the camshaft cap parting lines.



Starboard camshafts in TDC position (V8 shown—V6 similar)

- **a -** Timing mark on starboard exhaust camshaft aligned with camshaft cap parting line
- **b -** Camshaft cap parting line
- **c -** Camshaft hex
- **d -** Timing marks on timing chain
- **e -** Timing mark on starboard intake camshaft aligned with camshaft cap parting line
- **f -** Camshaft cap parting line

29. Install the camshaft caps in the correct position and orientation. Tighten the screws until they are snug.

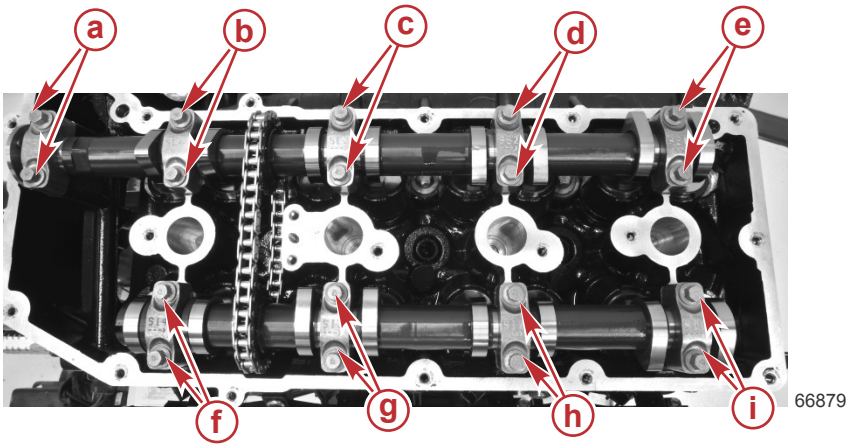


V8 shown

- **a -** Identification mark—starboard intake, cylinder 4 of the starboard bank in this example
- **b -** Directional arrow—points to top of powerhead

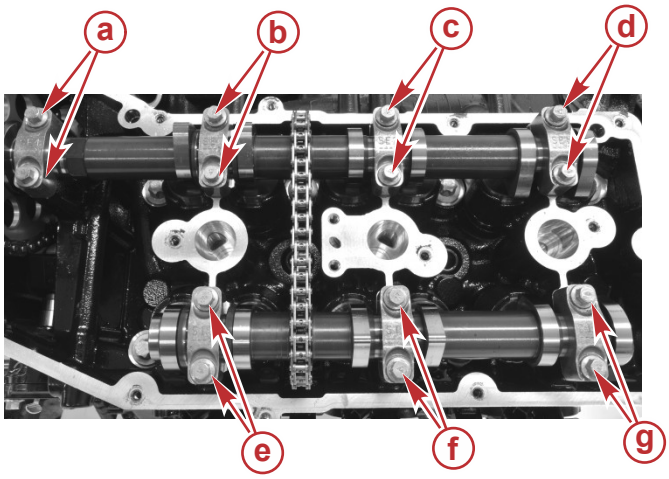
30. Install and tighten the camshaft cap screws to the specified torque.

IMPORTANT: Complete both stages of the torque specification on each camshaft cap before moving to the next cap.



V8 starboard cylinder head

- **a -** Screws securing camshaft cap SE5
- **b -** Screws securing camshaft cap SE4
- **c -** Screws securing camshaft cap SE3
- **d -** Screws securing camshaft cap SE2
- **e -** Screws securing camshaft cap SE1
- **f -** Screws securing camshaft cap SI4
- **g -** Screws securing camshaft cap SI3
- **h -** Screws securing camshaft cap SI2
- **i -** Screws securing camshaft cap SI1



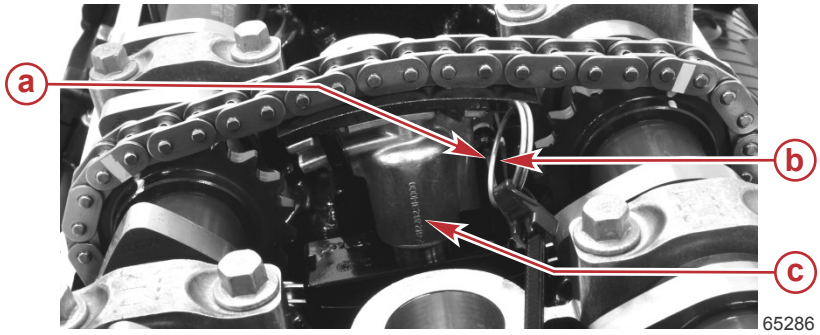
V6 starboard cylinder head

- a - Screws securing camshaft cap SE4
- b - Screws securing camshaft cap SE3
- c - Screws securing camshaft cap SE2
- d - Screws securing camshaft cap SE1
- e - Screws securing camshaft cap SI3
- f - Screws securing camshaft cap SI2
- g - Screws securing camshaft cap SI1

Description		Nm	lb-in.	lb-ft
Camshaft cap screws (M6 x 35 hex flange)	First	6	53.1	–
	Final	12	106.2	–

31. Install the camshaft-to-camshaft timing chain tensioner.

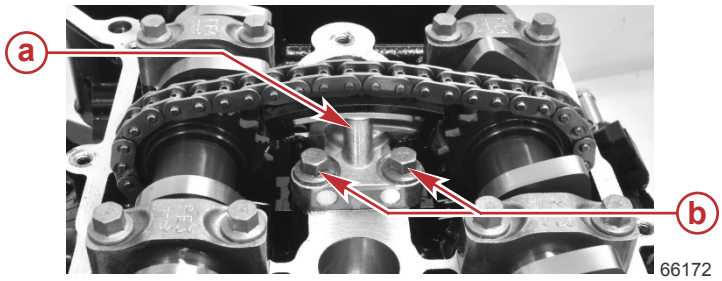
IMPORTANT: Remove the pin from the tensioner after the screws are tightened. Failure to remove the pin will cause engine damage.



V8 port side shown, starboard side and V6 similar

- a - Slots of the timing chain tensioner
- b - Pin inserted through the slots
- c - Timing chain tensioner

32. Install the two screws securing the timing chain tensioner. Tighten the screws to the specified torque.



V8 port side shown, starboard side and V6 similar

- a - Timing chain tensioner
- b - Screws (2)

Description		Nm	lb-in.	lb-ft
Timing chain tensioner screws (M6 x 30 hex flange)	First	6	53.1	–
	Final	12	106.2	–

33. Ensure that the pins are removed from the tensioners.
34. Refer to **Section 4B - Valve Clearance and Adjustments** to verify the valve lash specifications. Valve lash must be verified with the cylinder heads, camshafts, and timing chain tensioners installed.
35. Apply Torco MPZ® Engine Assembly Lube HP to each camshaft lobe, including the base circle of each camshaft lobe.

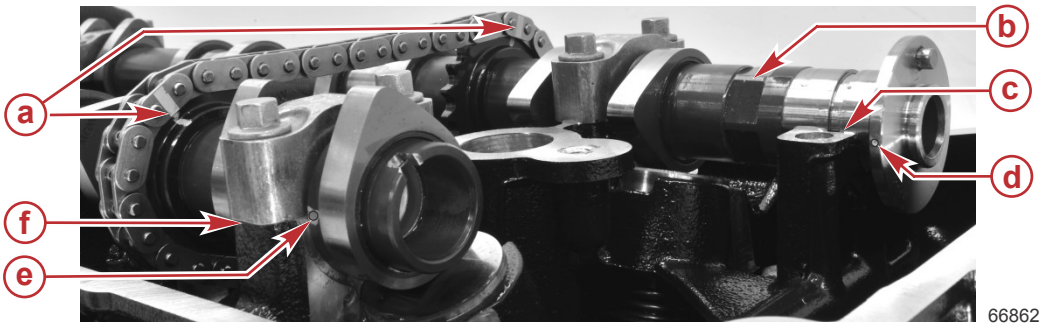
Tube Ref No.	Description	Where Used	Part No.
	Torco MPZ® Engine Assembly Lube HP	Each camshaft lobe, including the base circle of each camshaft lobe	Obtain Locally

Timing Chain 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 piston damage.

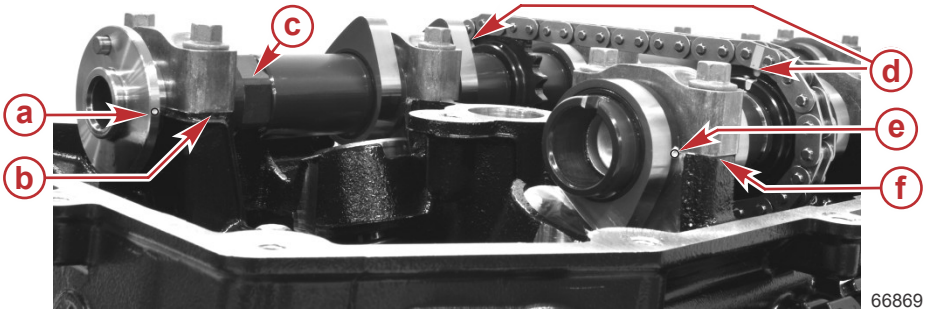
IMPORTANT: The removal, disassembly, reassembly, and installation procedure of the heads and cams must be strictly followed. Failure to follow the removal outline procedure may damage the valve train components.

1. Ensure that the camshaft timing marks of the port and starboard cylinder heads are in the TDC position.



Port camshafts in TDC position (V8 shown—V6 similar)

- **a -** Timing marks on timing chain
- **b -** Camshaft hex
- **c -** Camshaft cap parting line (camshaft cap not shown for clarity)
- **d -** Timing mark on port exhaust camshaft aligned with camshaft cap parting line
- **e -** Timing mark on port intake camshaft aligned with camshaft cap parting line
- **f -** Camshaft cap parting line

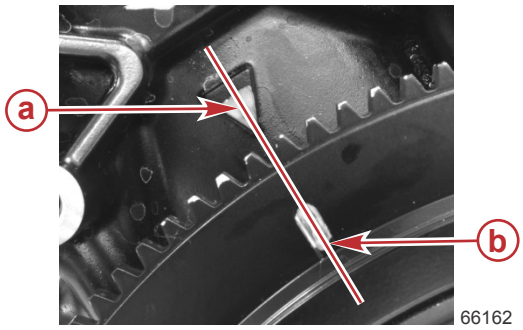


Starboard camshafts in TDC position (V8 shown—V6 similar)

- **a -** Timing mark on starboard exhaust camshaft aligned with camshaft cap parting line
- **b -** Camshaft cap parting line
- **c -** Camshaft hex
- **d -** Timing marks on timing chain
- **e -** Timing mark on starboard intake camshaft aligned with camshaft cap parting line
- **f -** Camshaft cap parting line

2. Turn the flywheel 45° clockwise to the TDC position. Ensure that the line on the flywheel aligns with the timing pointer on the top of the cylinder block.

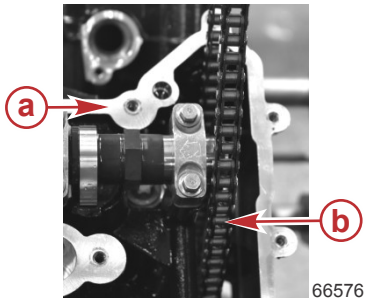
IMPORTANT: Do not rotate the flywheel 315° counterclockwise to reach the TDC position. Valve and piston damage will occur.



Timing marks aligned at cylinder 1 TDC (V8 shown—V6 similar)

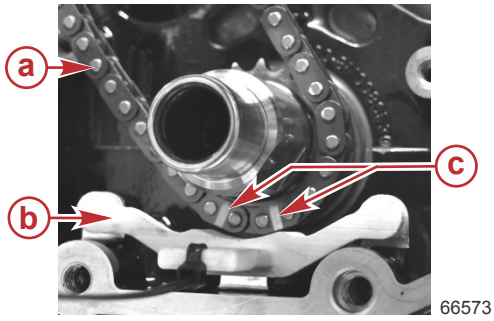
- **a -** Timing pointer
- **b -** Line on the flywheel

3. Place the timing chain into the cylinder block as shown.



- **a -** Port cylinder head
- **b -** Timing chain

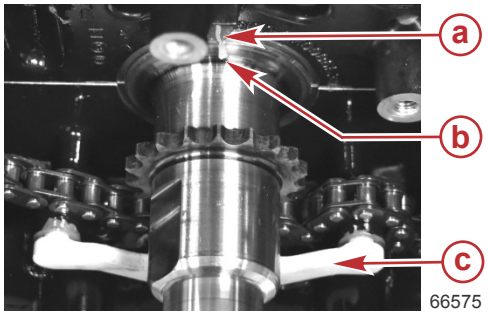
4. Install the timing chain onto the crankshaft sprocket with the timing marks positioned as shown.
5. Install the timing chain holding tool to prevent the timing chain from falling off of the crankshaft sprocket.



- **a -** Timing chain
- **b -** Timing chain holding tool
- **c -** Timing marks on timing chain

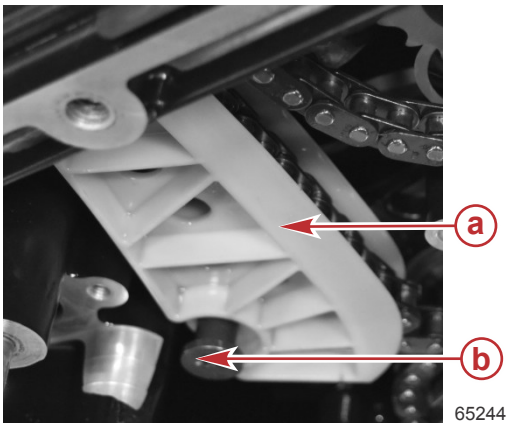
Timing Chain Holding Tool	8M0148867

6. Verify that the timing mark on the crankshaft is aligned with the timing pointer on the cylinder block.



- **a -** Timing pointer on the cylinder block
- **b -** Timing mark on the crankshaft
- **c -** Timing chain holder

7. Install the fixed timing chain guide into the cylinder block through the opening at the bottom of the cylinder head. Secure with the special flange head screw and tighten the screw to the specified torque.



a - Fixed timing chain guide
b - Special flange head screw

Description	Nm	lb-in.	lb-ft
Special flange head screw (M8 x 1.25)	24	–	17.7

8. Ensure that the timing chain is within the rails of the fixed timing chain guide.
9. Lubricate the threads of the special left-hand thread screw with 10W-30 4-Stroke Marine Engine Oil.

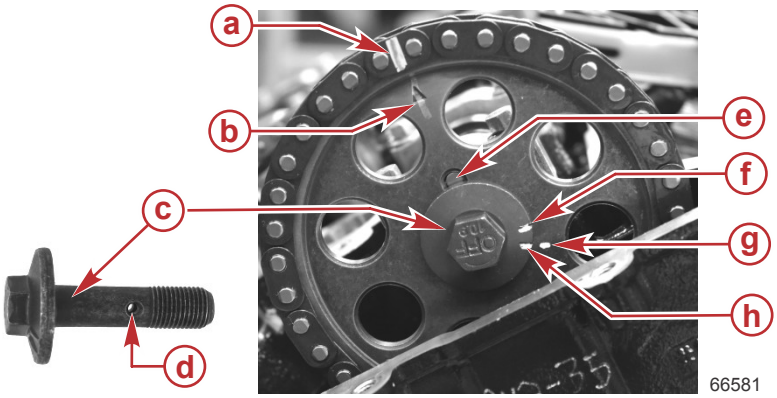
Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Threads of the special left-hand thread screw	92-8M0078625

10. Install the port camshaft sprocket with the special left-hand thread screw. Use a wrench on the camshaft hex to hold the camshaft, then tighten the screw to the specified torque:

IMPORTANT: The special left-hand thread screw has a port in it for oil flow. Do not substitute a similar screw from other Mercury engines or catastrophic engine damage will occur.

NOTE: *The special left-hand thread screw has two identifying marks 20° apart.*

a. Tighten the special left-hand thread screw to the first stage of the torque specification.
b. Place a paint mark on the sprocket adjacent to the first identifying mark of the special screw.
c. Tighten the screw an additional 20°. The second identifying mark will align with the paint mark on the sprocket.

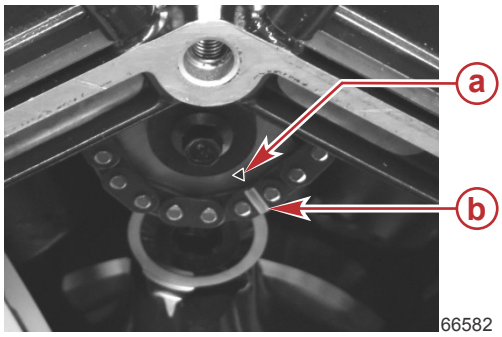


a - Timing mark on the timing chain
b - Timing mark on the camshaft sprocket
c - Special left-hand thread screw
d - Oil port in the special left-hand thread screw
e - Dowel pin
f - First identifying mark on special left-hand thread screw
g - Paint mark on the sprocket
h - Second identifying mark on special left-hand thread screw

Description		Nm	lb-in.	lb-ft
Special left-hand thread screw	First	45	–	33.2
	Final	Tighten an additional 20°		

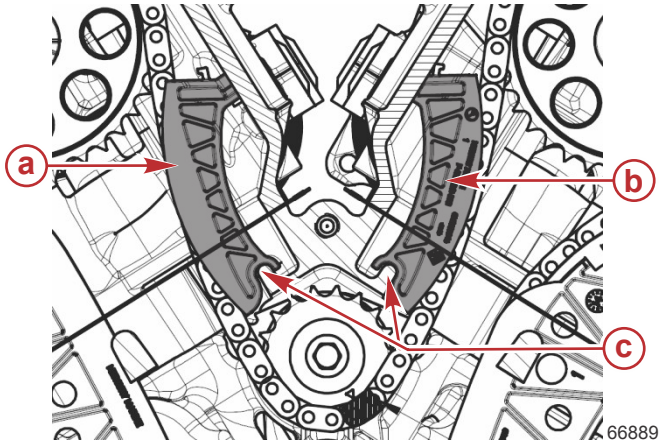
11. Install the port timing chain guide into the cylinder block from below the camshaft sprocket. Ensure that the port timing chain guide is seated on the ridge and ensure that the timing chain is within the rails of the port timing chain guide.

12. Install the timing chain onto the sprocket. Ensure that the timing mark on the timing chain aligns with the timing mark on the sprocket.



a - Timing mark on the sprocket
b - Timing mark on the timing chain

13. Install the port and starboard timing chain guides into the cylinder block. Ensure that the timing chain guides are seated on the ridges.



a - Port timing chain guide
b - Starboard timing chain guide
c - Ridges

14. Lubricate the threads of the special left-hand thread screw with 10W-30 4-Stroke Marine Engine Oil.

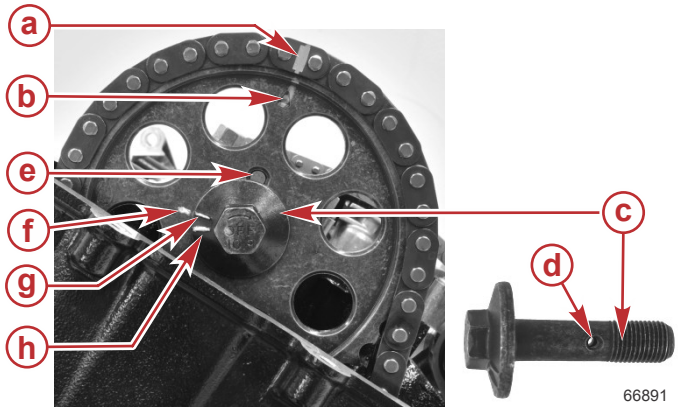
Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Threads of the special left-hand thread screw	92-8M0078625

15. Install the starboard camshaft sprocket with the special left-hand thread screw. Tighten the screw to the specified torque:

IMPORTANT: The special left-hand thread screw has a port in it for oil flow. Do not substitute a similar screw from other engines or catastrophic engine damage will occur.

NOTE: *The special left-hand thread screw has two identifying marks 20° apart.*

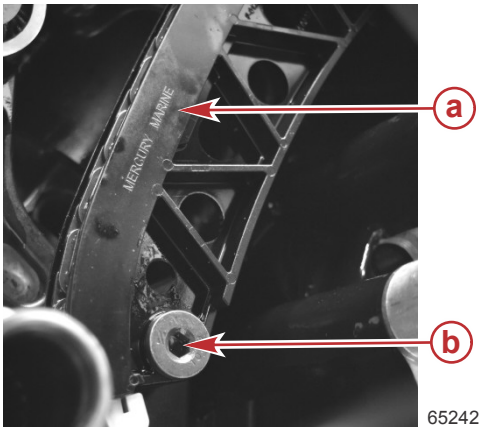
a. Tighten the special left-hand thread screw to the first stage of the torque specification.
b. Place a paint mark on the sprocket adjacent to the first identifying mark of the special screw.
c. Tighten the screw an additional 20°. The second identifying mark will align with the paint mark on the sprocket.



a - Timing mark on the timing chain
b - Timing mark on the camshaft sprocket
c - Special left-hand thread screw
d - Oil port in the special left-hand thread screw
e - Dowel pin
f - Paint mark on the sprocket
g - Second identifying mark on special left-hand thread screw
h - First identifying mark on special left-hand thread screw

Description		Nm	lb-in.	lb-ft
Special left-hand thread screw	First	45	–	33.2
	Final	Tighten an additional 20°		

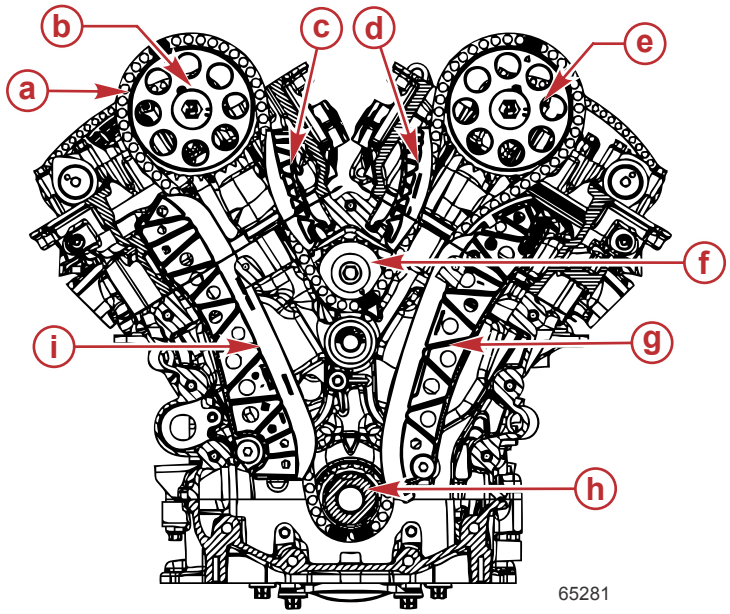
16. Install the movable timing chain guide onto the cylinder block. Tighten the special flange head screw to the specified torque.



a - Movable timing chain guide
b - Special flange head screw

Description	Nm	lb-in.	lb-ft
Special flange head screw (M8 x 1.25)	24	–	17.7

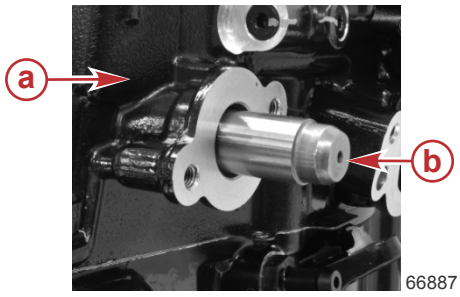
17. Verify all timing marks and ensure that the timing chain is within the rails of all timing chain guides.



a - Timing chain
b - Port camshaft sprocket
c - Port timing chain guide
d - Starboard timing chain guide
e - Starboard camshaft sprocket
f - Balance shaft sprocket (V8) or idler sprocket (V6)
g - Movable timing chain guide
h - Crankshaft sprocket
i - Fixed timing chain guide

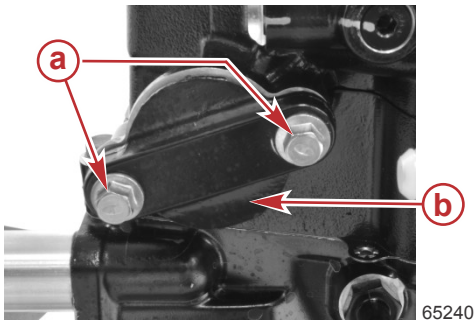
18. Install the timing chain tensioner:
    a. Compress the tensioner by hand on a bench to purge all remaining oil from the tensioner.
    b. Ensure that the tensioner cover O-ring is in place.

c. Install the tensioner into the starboard cylinder head as shown, then secure the tensioner with the timing chain tensioner cover and two screws.



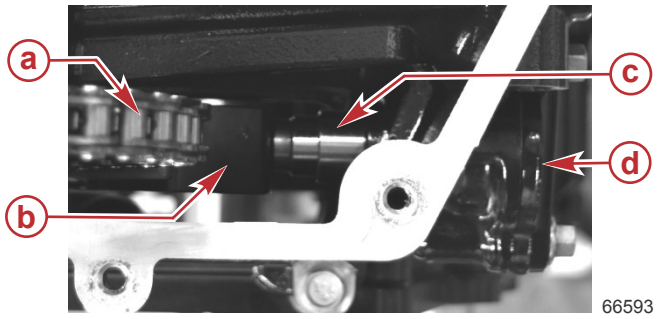
a - Starboard cylinder head
b - Tensioner

d. Tighten the screws to the specified torque.



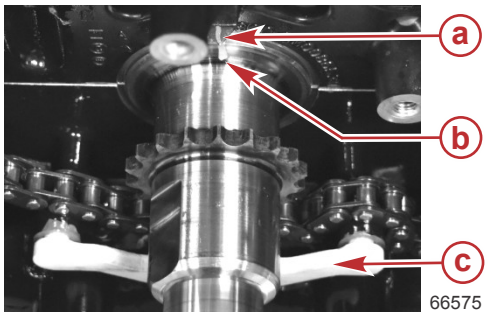
a - Screws
b - Timing chain tensioner cover

Description	Nm	lb-in.	lb-ft
Timing chain tensioner cover screws (M6 x 25 hex flange)	10	88.5	–



Tensioner installed
a - Timing chain
b - Movable timing chain guide
c - Timing chain tensioner
d - Tensioner cover

19. Remove the timing chain holder tool.

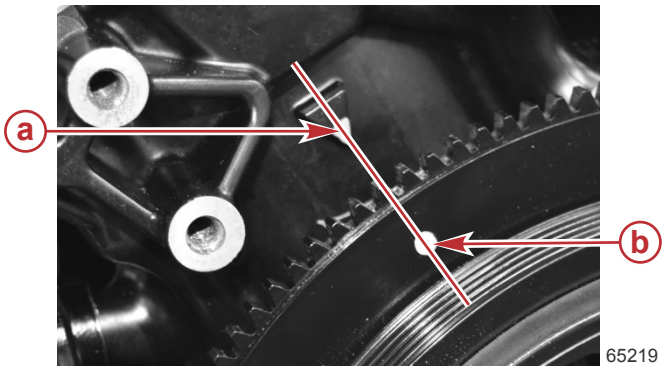


a - Timing pointer on the cylinder block
b - Timing mark on the crankshaft
c - Timing chain holder

20. Reset the timing chain tensioner:

IMPORTANT: The timing chain tensioner must be reset or engine damage will occur.

a. Turn the crankshaft counterclockwise (as viewed from the flywheel end) to the service position.

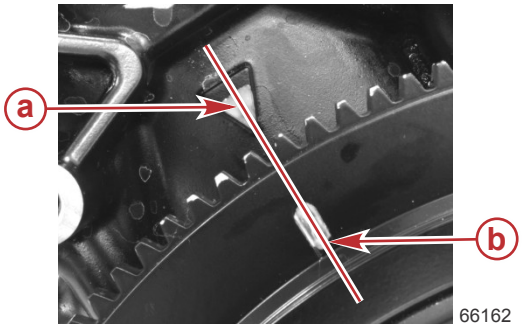


Timing marks aligned in the service position (V8 shown—V6 similar)

a - Pointer on cylinder block (starboard bank)

b - Dot on flywheel (identified with yellow paint for visibility)

21. Turn the crankshaft clockwise back to the cylinder 1 TDC position.



Timing marks aligned at cylinder 1 TDC (V8 shown—V6 similar)

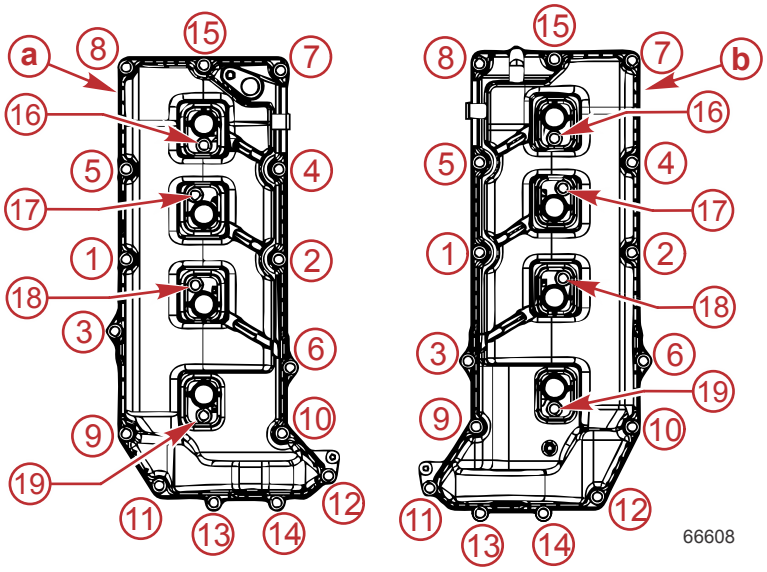
a - Timing pointer

b - Line on the flywheel

22. Apply Torco MPZ® Engine Assembly Lube HP to each camshaft lobe, including the base circle of each camshaft lobe.

Tube Ref No.	Description	Where Used	Part No.
	Torco MPZ® Engine Assembly Lube HP	Each camshaft lobe, including the base circle of each camshaft lobe	Obtain Locally

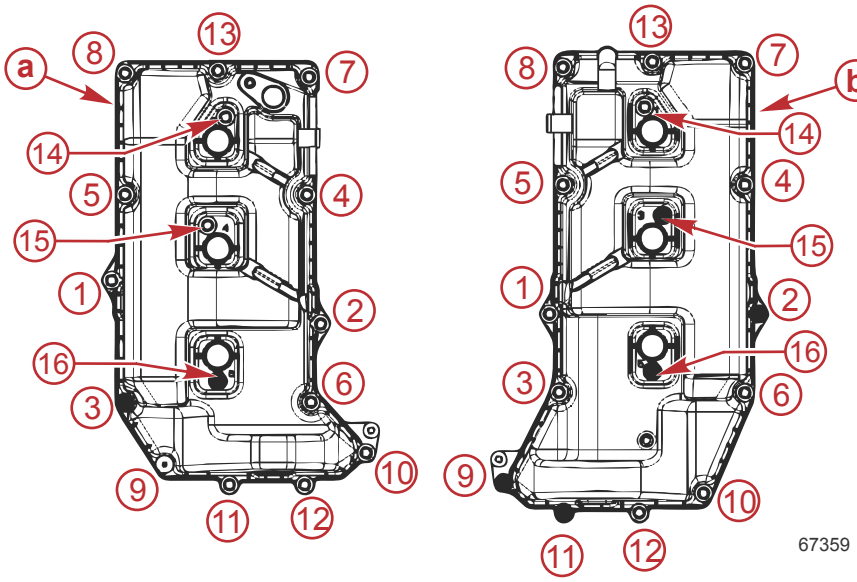
23. Inspect the camshaft cover seals at the perimeter of the cover and at each spark plug hole.
24. Install the camshaft covers and tighten the screws to the specified torque.



V8

a - Port camshaft cover

b - Starboard camshaft cover



V6
a - Port camshaft cover
b - Starboard camshaft cover

Description	Nm	lb-in.	lb-ft
Camshaft cover screws (M6 x 25 hex flange)	10	88.5	–

25. Apply Anti-Seize Compound to the spark plug threads.

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

26. Install the spark plugs. Tighten the spark plugs to the specified torque.

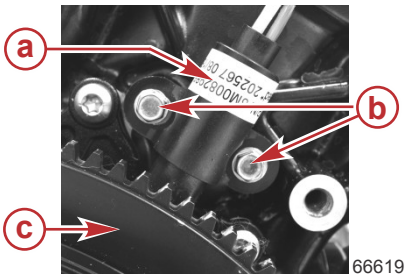
Description	Nm	lb-in.	lb-ft
Spark plug	22	–	16.2

Installing Powerhead Components and Powerhead Installation

Component Installation Prior to Powerhead Installation

Some components can be installed prior to installing the powerhead onto the midsection. Refer to the following steps to install components before installing the powerhead to save time during assembly.

1. Install the crankshaft position sensor onto the cylinder head. Tighten the screws to the specified torque.



a - Crankshaft position sensor
b - M5 x 13 screws (2)
c - Flywheel

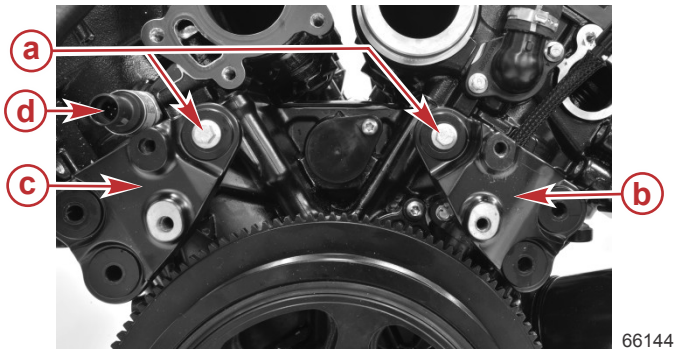
Description	Nm	lb-in.	lb-ft
Crankshaft position sensor screws (M5 x 13)	5	44.3	–

2. Install the block water pressure sensor. Tighten the sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
Block water pressure sensor	15	132.7	–

3. **V8 models—**Install the port and starboard alternator brackets onto the cylinder head.

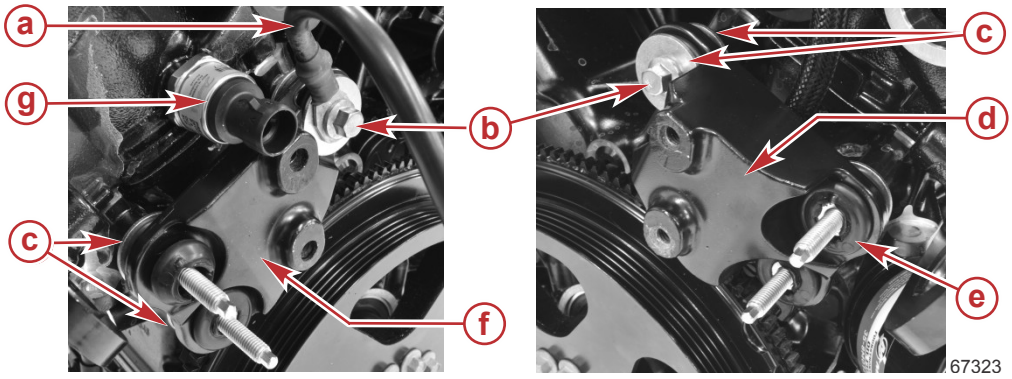
NOTE: Install two fill bracket screws into the outermost holes of the alternator brackets to keep the brackets aligned while tightening the screws. Remove the fill bracket screws after the alternator bracket screws have been tightened.



V8
- a - Alternator bracket screws (2)
- b - Port alternator bracket
- c - Starboard alternator bracket
- d - Block water pressure sensor

Description	Nm	lb-in.	lb-ft
Alternator bracket screws (M8 x 35)	30	–	22.1

4. **V6 models—**Install the washers, rubber isolators, alternator brackets, ground cable, and screws. Tighten the screws to the specified torque.

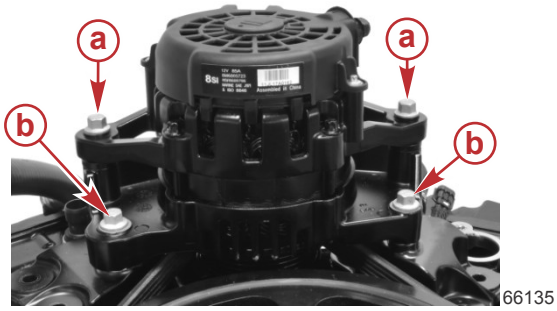


V6
- a - Ground cable
- b - Screws (2)
- c - Washers (4 per bracket)
- d - Port alternator bracket
- e - Rubber isolators (3 per bracket)
- f - Starboard alternator bracket
- g - Block water pressure sensor

Description	Nm	lb-in.	lb-ft
Alternator bracket screws (M8 x 45)	30	–	22.1

5. **V8 models—**Install the alternator. Tighten the screws to the specified torque.

IMPORTANT: Place the alternator belt onto the alternator pulley before installing the alternator.

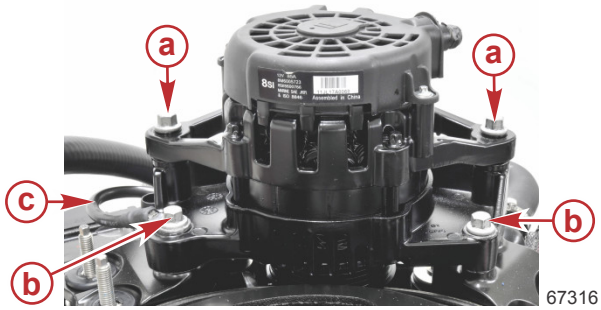


V8
- a - M8 x 80 screws (2)
- b - M8 x 45 screws (2)

Description	Nm	lb-in.	lb-ft
Alternator screws (M8 x 80 and M8 x 45)	30	–	22.1

6. **V6 models—**Install the alternator and ground cable. Tighten the screws to the specified torque.

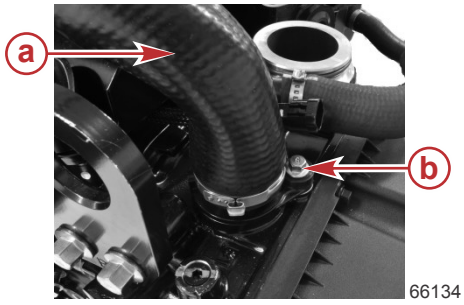
IMPORTANT: Place the alternator belt onto the alternator pulley before installing the alternator.



V6
- a - M8 x 80 screws (2)
- b - M8 x 45 screws (2)
- c - Ground cable

Description	Nm	lb-in.	lb-ft
Alternator screws (M8 x 80 and M8 x 45)	30	–	22.1

7. Lubricate the oil fill hose fitting O-ring with 10W-30 4-Stroke Marine Engine Oil. Install the oil fill hose fitting onto the cylinder head. Tighten the screw to the specified torque.

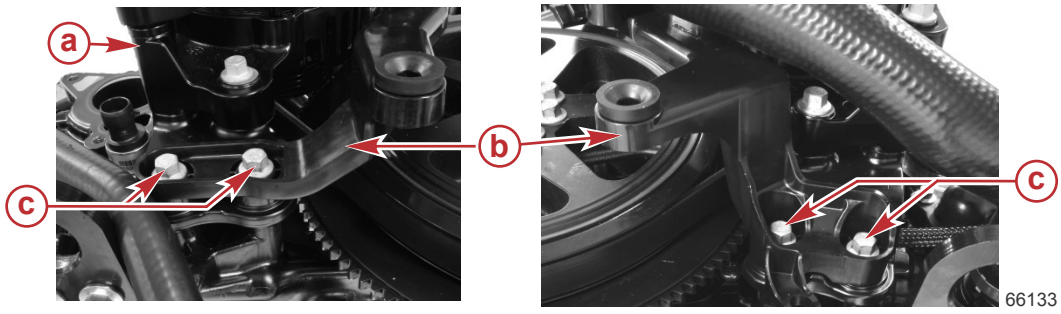


- a - Oil fill hose
- b - M6 x 20 screw

Description	Nm	lb-in.	lb-ft
Oil fill hose fitting screw (M6 x 20)	10	88.5	–

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Oil fill hose fitting O-ring	92-8M0078625

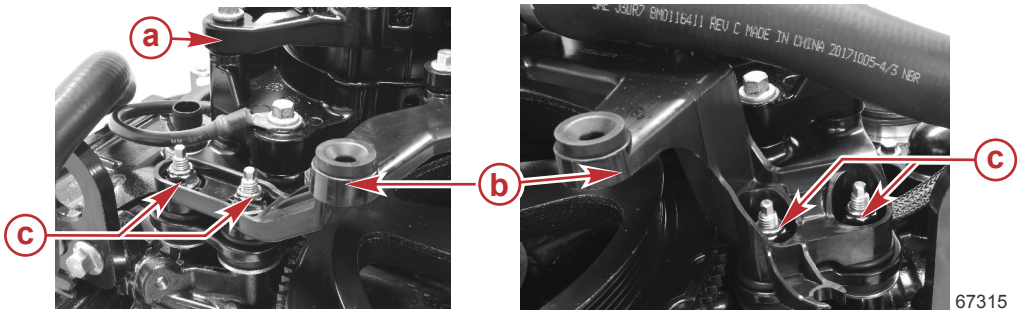
8. **V8 models—**Install the oil fill bracket onto the powerhead. Tighten the four screws to the specified torque.



V8
- a - Alternator
- b - Oil fill bracket
- c - M8 x 45 screws (4)

Description	Nm	lb-in.	lb-ft
Oil fill bracket screws (M8 x 45)	30	–	22.1

9. **V6 models—**Install the oil fill bracket onto the powerhead. Tighten the four locknuts to the specified torque.

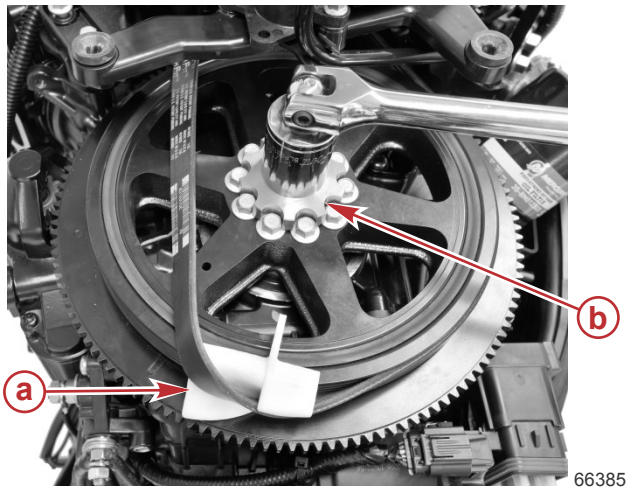


V6

a - Alternator
b - Oil fill bracket
c - M8 x 1.25 locknuts (4)

Description	Nm	lb-in.	lb-ft
M8 x 1.25 locknuts	28	–	20.7

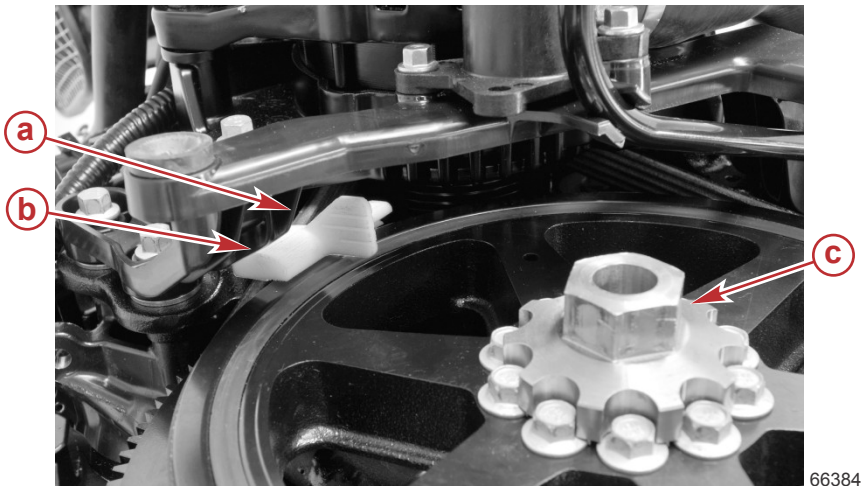
10. Install the alternator belt onto the flywheel. Ensure that the belt is seated on the alternator pulley. Use the flywheel socket and alternator belt shoe to install the belt onto the flywheel.



a - Alternator belt shoe
b - Flywheel socket

Flywheel Socket	8M0146861
Alternator Belt Shoe	8M0146862

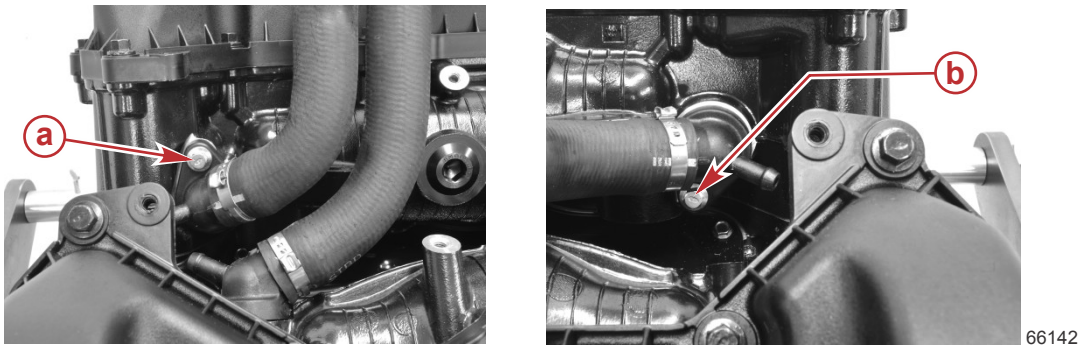
11. Remove the flywheel socket and alternator belt shoe.



V8 shown—V6 similar

a - Alternator belt
b - Alternator belt shoe
c - Flywheel socket

12. Install the water supply fittings and hoses onto each cylinder head. Tighten the screws to the specified torque.

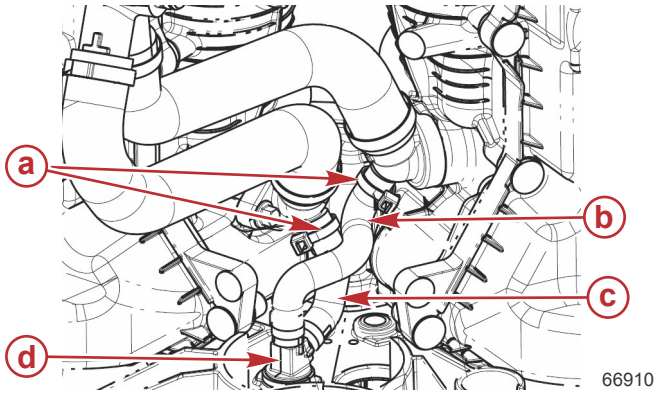


V8 shown—V6 similar

a - Screw securing the port water supply fitting
b - Screw securing the starboard water supply fitting

Description	Nm	lb-in.	lb-ft
Water fitting screws (M6 x 20)	10	88.5	–

13. If they were removed, install the drain hoses and T-fitting onto the water supply fittings. Secure the hoses with cable ties.

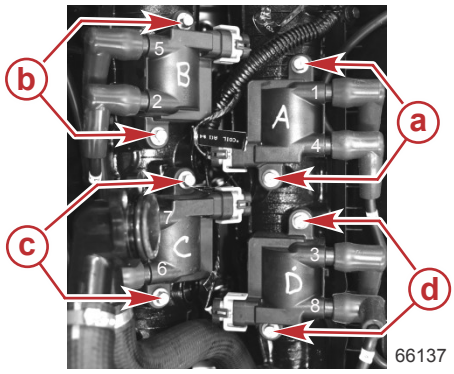


V8 shown—V6 similar

a - Cable ties
b - Starboard cylinder head drain hose
c - Port cylinder head drain hose
d - T-fitting

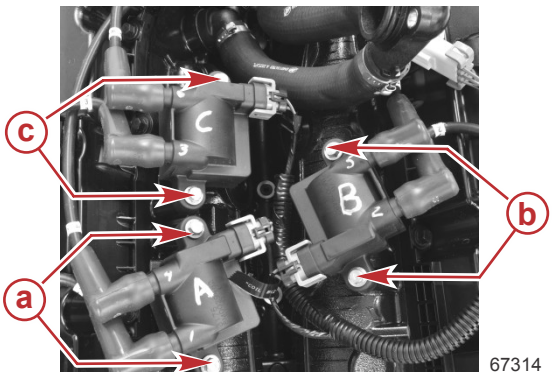
14. Install the ignition coils with the spark plug wires and ignition coil primary harness attached. Install the screws and tighten them to the specified torque.

NOTE: *V8 engines have four ignition coils, V6 engines have three ignition coils. The letters on the ignition coils correspond with the tags on the ignition coil primary harness wires.*



V8

a - Screws securing ignition coil A
b - Screws securing ignition coil B
c - Screws securing ignition coil C
d - Screws securing ignition coil D



V6

a - Screws securing ignition coil A
b - Screws securing ignition coil B
c - Screws securing ignition coil C

Description	Nm	lb-in.	lb-ft
Ignition coil screws (M6 x 30)	10	88.5	–

15. Install the spark plug wires onto the spark plugs.
16. Install the oil pump. Refer to **Oil Pump Installation**. The oil pump must be installed before installing the powerhead.

Oil Pump Installation

1. Prime the oil pump with approximately 88 mL (3 fl oz) 10W-30 4-Stroke Marine Engine Oil.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Oil pump	92-8M0078625

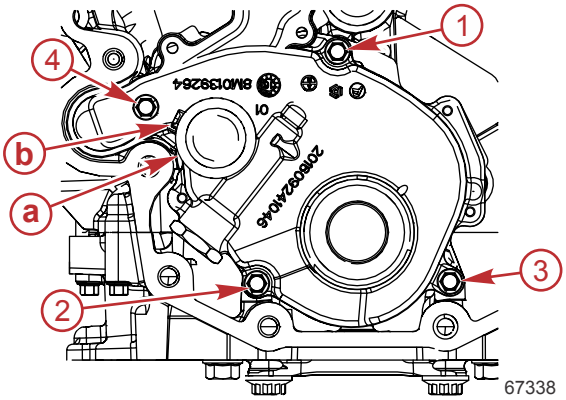
2. Lubricate the oil pump seals and O-rings with Engine Coupler Spline Grease.

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Oil pump seals and O-rings	8M0071842

3. Slide a 39.6 mm Oetiker® clamp onto the oil pickup assembly, and install the assembly onto the oil pump.
4. Position the clamp so that it covers the white mark on the oil pickup hose and the ear is aligned with the screw by the oil output, as shown. Install the oil pump and tighten the four M6 x 48 hex flange screws to the specified torque.

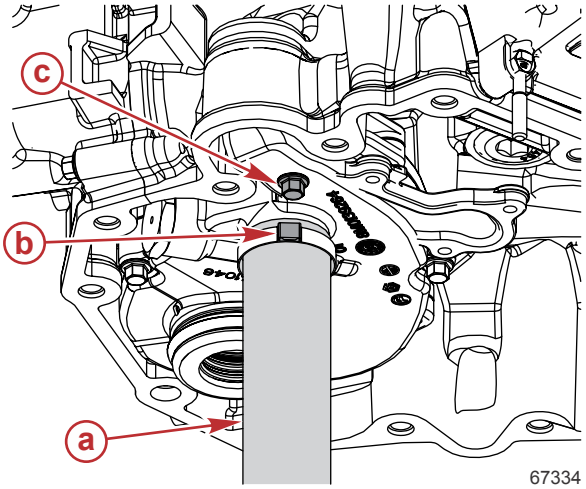
IMPORTANT: The oil pickup hose must be pushed all the way onto the oil pump so the end of the hose contacts the oil pump housing.

The Oetiker clamps must be installed so that the ears of the clamps are positioned as shown. Assembly interference and catastrophic engine damage can occur if the clamps are not installed correctly.



Oil pump fastener torque sequence

a - Oil pickup assembly
b - Ears on Oetiker clamps (aligned with screw 4)



a - Oil pickup assembly
b - Orientation of ear on Oetiker clamp, aligned with item C
c - Fastener on oil pump, at the outlet

Description	Nm	lb-in.	lb-ft
M6 x 48 hex flange screw	10	88.5	–

Powerhead Installation Onto Conventional Midsection (CMS)

⚠ CAUTION

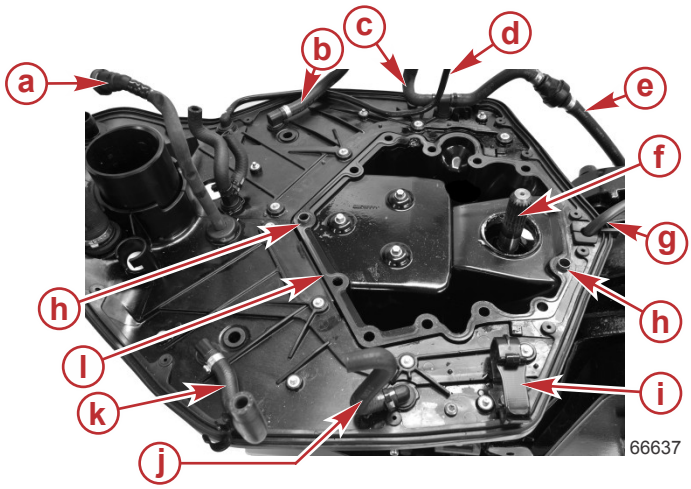
Improper lifting during removal or installation of the engine can cause injury or damage to engine components. Use a hoist, lifting arm, or other approved lifting device. Do not allow the lifting device to hook or compress any engine components.

1. Install a new powerhead gasket onto the midsection. Ensure that both dowel pins are installed.
2. Lubricate the driveshaft splines with Engine Coupler Spline Grease.

   IMPORTANT: Apply Engine Coupler Spline Grease to the driveshaft splines only. Ensure that the top of the driveshaft is clean and has no grease applied.

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Driveshaft splines	8M0071842

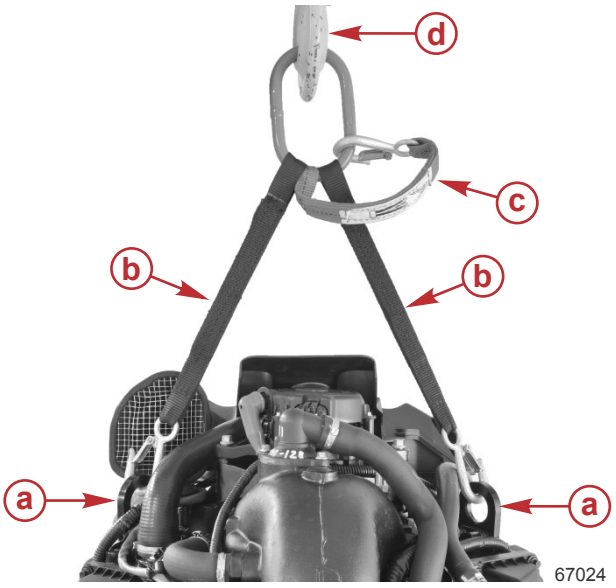
3. Ensure that the components are in place and will not be pinched by the powerhead during installation.



a - Fuel line from fuel supply module (FSM)
b - Fuel line to port fuel rail
c - Port block drain hose
d - FSM reference line
e - Flush hose
f - Driveshaft splines
g - Shift actuator harness
h - Dowel pins (2)
i - Cable keeper
j - Starboard block drain hose
k - Fuel line to starboard fuel rail
l - Powerhead gasket

4. Attach the lifting strap to the lifting eyes. Attach the lifting strap to a hoist with a capacity of at least 450 kg (1000 lb).

IMPORTANT: All engine lifting devices (straps, slings, chains, or hoists) must have a minimum capacity of 450 kg (1000 lb).



a - Lifting eyes on the engine
b - Equal length straps (black)
c - Short strap (red); secured out of the way
d - Overhead hoist

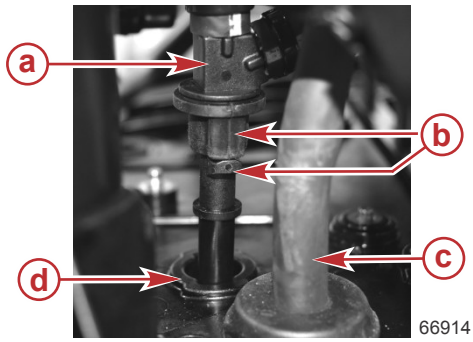
Lifting strap	883705T01

5. If they were removed, install the eight M10 x 1.5 x 185 studs into the cylinder block. Tighten the studs to the specified torque.

Description	Nm	lb-in.	lb-ft
M10 x 1.5 x 185 studs	8	70.8	–

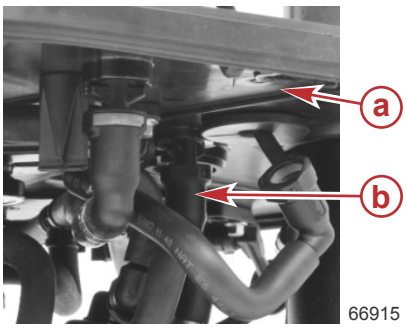
6. Lift the powerhead into position above the midsection, then guide the powerhead onto the midsection. Ensure that the oil pump pickup tube is inserted into the sump.
7. While lowering the powerhead onto the midsection, ensure that the drain fitting is inserted through the chap plate. Ensure that the fuel line is not pinched while lowering the powerhead.

   NOTE: *The grommet must be aligned with the drain fitting tab.*



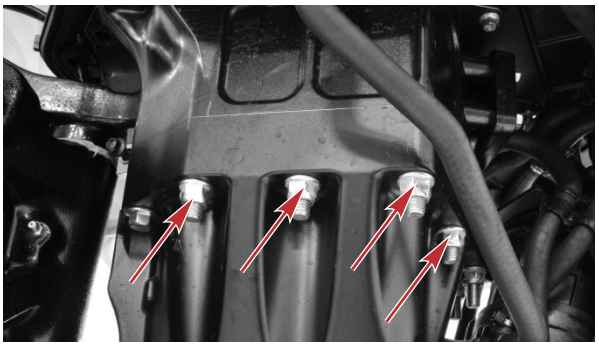
a - Drain fitting
b - Grommet aligned with drain fitting tab
c - Fuel line from FSM
d - Chap plate

8. Connect the quick-connect fitting to the drain fitting under the chap plate.



a - Chap plate
b - Quick-connect fitting

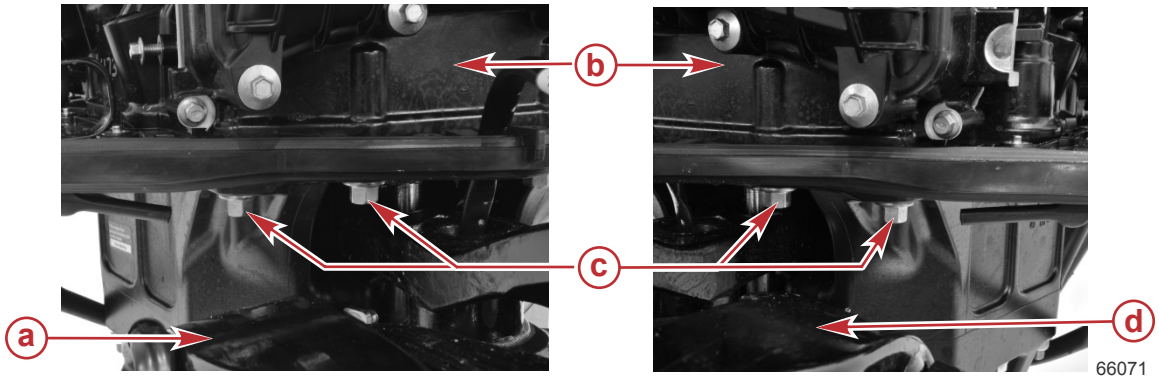
9. Install the four M10 15 mm nylon insert locknuts onto the studs on each side of the outboard. Tighten the nuts to the specified torque.


66080

Port side shown, starboard similar

Description	Nm	lb-in.	lb-ft
M10 15 mm nylon insert locknuts	40.7	–	30

10. Install the four 12 mm screws securing the front of the powerhead to the midsection. Tighten the screws to the specified torque.



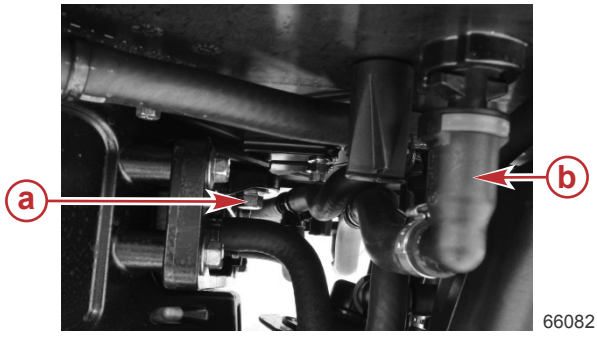
66071

a - Starboard transom bracket
b - Front of powerhead
c - M10 12 mm screws (4)
d - Port transom bracket

Description	Nm	lb-in.	lb-ft
M10 12 mm screws	47.5	–	35

11. Install the remaining M10 screw securing the powerhead at the aft end under the powerhead. Tighten the screw to the specified torque.

IMPORTANT: If the upper mount was replaced, do not tighten the upper mount cover screws until after the powerhead is installed, and the screw that passes up through the hole in the upper mount cover has been tightened to the specified torque. Only then should the upper mount cover screws be tightened to the specified torque. This ensures a tight fit for the seal on the top of the mount cover. Refer to Section 5A - Conventional Midsection (CMS) Assembly for more information.



66082

As seen from port side
a - Screw
b - Fuel line quick-connect fitting to port fuel rail

Description	Nm	lb-in.	lb-ft
M10 screw	47.5	–	35

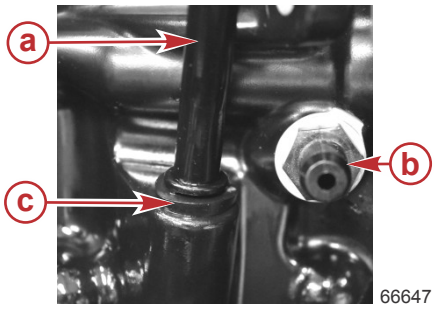
Dipstick Tube and Exhaust Tube Installation

Dipstick Tube

1. Lubricate the dipstick grommet with 10W-30 4-Stroke Marine Engine Oil.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Dipstick grommet	92-8M0078625

2. Install the dipstick grommet into the opening on the port side of the powerhead.
3. Install the dipstick tube into the grommet.

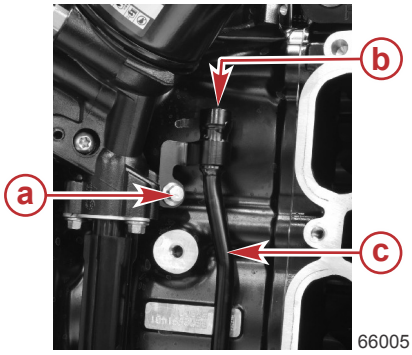


a - Dipstick tube
b - Port water drain fitting
c - Dipstick grommet

4. Lubricate the upper dipstick O-ring with 10W-30 4-Stroke Marine Engine Oil.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Upper dipstick O-ring	92-8M0078625

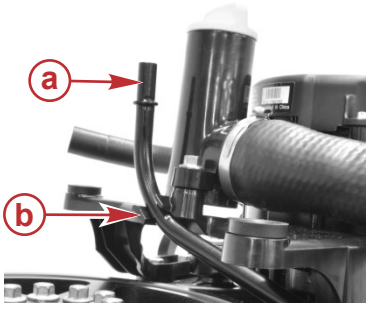
5. Secure the dipstick tube to the cylinder block with an M6 x 12 screw. Tighten the screw to the specified torque.



V8 shown—V6 similar
a - M6 x 12 screw
b - O-ring location
c - Dipstick tube

Description	Nm	lb-in.	lb-ft
M6 x 12 screw	10	88.5	–

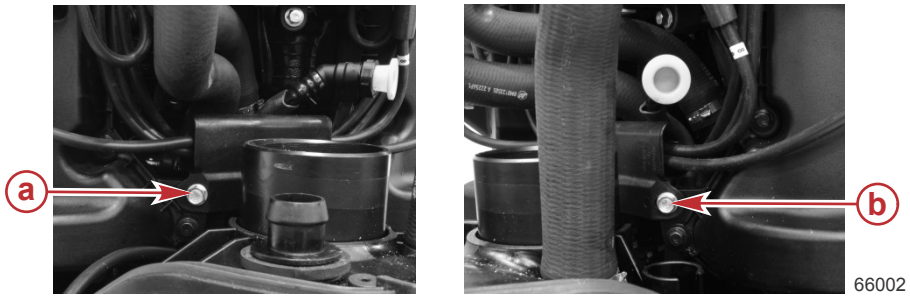
6. Insert the upper dipstick tube into the lower dipstick tube, then clip the dipstick tube into the retainer.



a - Upper dipstick tube
b - Retainer

Exhaust Tube Installation

1. Install the spark plug wire retainer and install the two M6 x 20 screws. Tighten the screws to the specified torque.

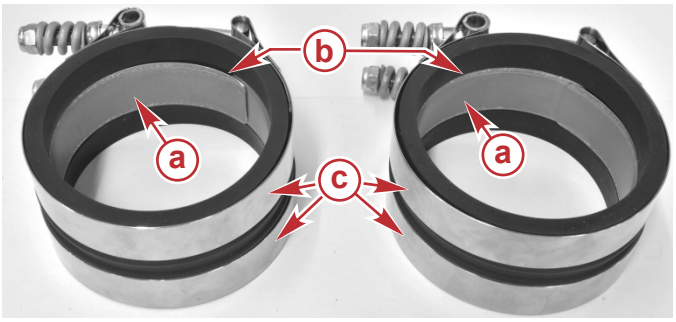


V8 shown—V6 similar

- **a -** Spark plug wire retainer screw on the port side
- **b -** Spark plug wire retainer screw on the starboard side

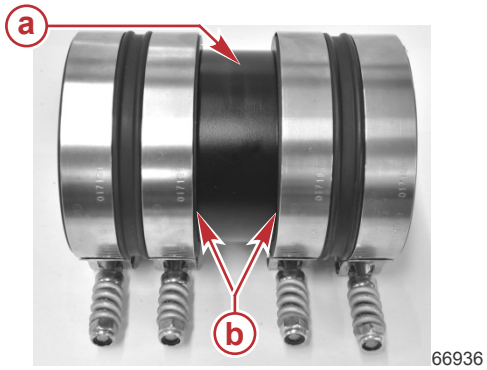
Description	Nm	lb-in.	lb-ft
M6 x 20 screws	7	62	–

2. Assemble the exhaust boots and clamps:
   a. Insert the aluminum collars into the exhaust boots. Align the collars with the ridge inside of the exhaust boots.
   b. Install the exhaust clamps loosely onto the exhaust boots.
   IMPORTANT: V8 models use two exhaust boots. V6 models use one exhaust boot.



- **a -** Aluminum collars
- **b -** Ridge inside of the exhaust boots
- **c -** Exhaust clamps

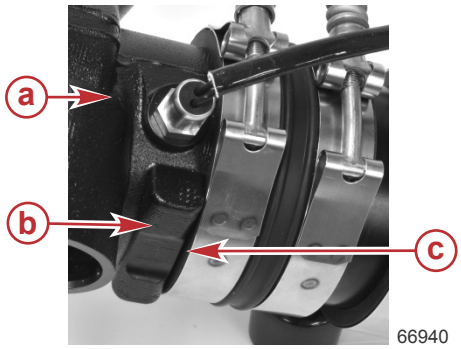
   c. **V8 models—**Align the exhaust boots with the ridges on the outside of the collar.



V8

- **a -** Collar
- **b -** Ridges on the outside of the collar

   d. Slide the exhaust boots and collar onto the exhaust tube until the upper exhaust boot is resting against the stop. Tighten the clamps just enough to keep the boots in place.



V8 shown—V6 similar

- **a -** Exhaust tube
- **b -** Stop
- **c -** Upper exhaust boot resting against the stop

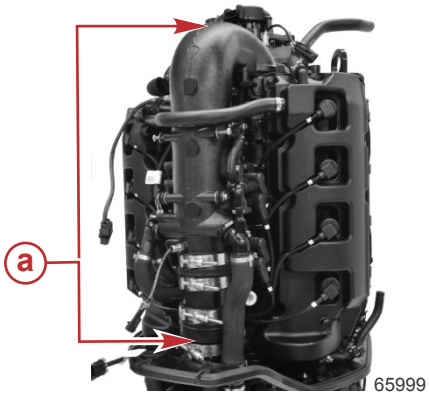
3. Lubricate the exhaust tube O-ring with Parker© Super O-Lube O-ring lubricant.

Tube Ref No.	Description	Where Used	Part No.
	Parker© Super O-Lube	Exhaust tube O-ring	Obtain Locally

4. Install a new exhaust tube gasket onto the starboard exhaust outlet surface.

a - O-ring
b - Starboard exhaust outlet surface

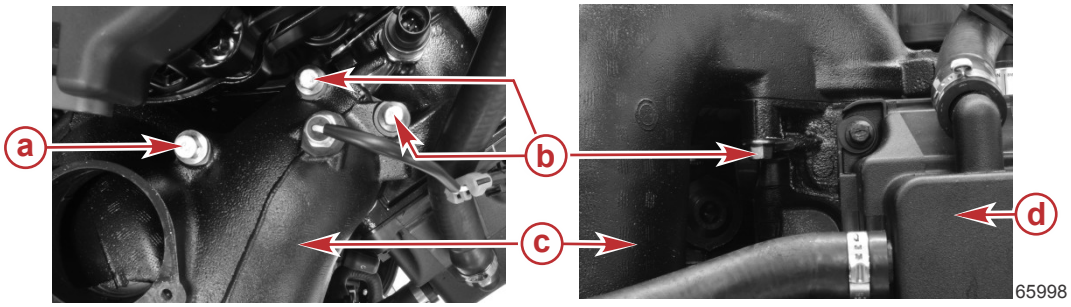
5. Guide the exhaust tube assembly onto the powerhead. Align the bottom of the rubber exhaust boot with the exhaust tube and lower the exhaust tube down onto the exhaust outlets.



V8 shown—V6 similar
a - Exhaust tube assembly

6. Install the four exhaust tube mounting screws securing the exhaust tube assembly to the powerhead. Tighten the screws to the specified torque, then tighten the screws to the specified torque again.

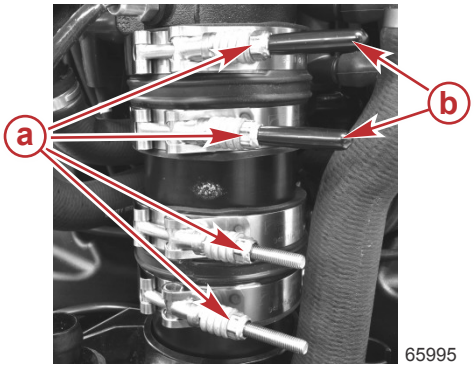
IMPORTANT: Ensure that the exhaust tube is fully seated onto the exhaust outlet surfaces. Do not use the mounting screws to pull the exhaust tube assembly down.



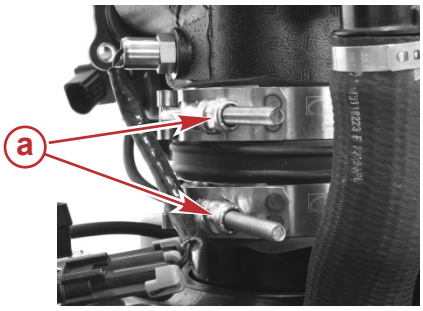
a - M8 x 85 screw
b - M8 x 45 screw (3)
c - Exhaust tube
d - Starboard camshaft cover

Description		Nm	lb-in.	lb-ft
Exhaust tube mounting screws	**First**	28	–	20.7
	Final	28	–	20.7

7. Tighten the exhaust boot clamp nuts to the specified torque. Install the thread protectors onto each exhaust clamp.



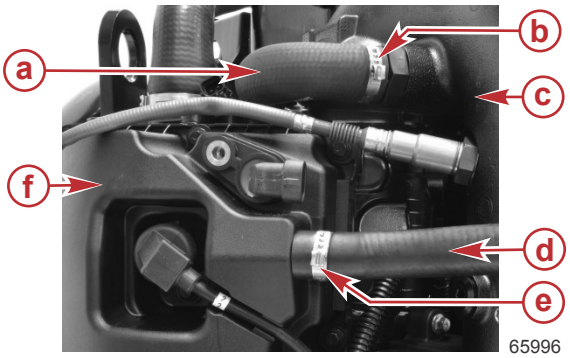
V8
- a - Exhaust boot clamp nuts
- b - Thread protectors



V6—thread protectors not shown
- a - Exhaust boot clamp nuts

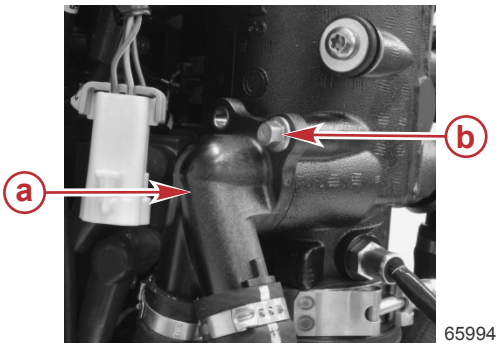
Description	Nm	lb-in.	lb-ft
Exhaust boot clamp nut	6.2	54.9	–

8. Install the breather hose onto the port camshaft cover. Install a 25.6 mm Oetiker clamp to secure the breather hose to the port camshaft cover.
9. Install the water hose onto the fitting. Install a 31.6 mm Oetiker clamp to secure the water hose to the fitting on the exhaust tube.

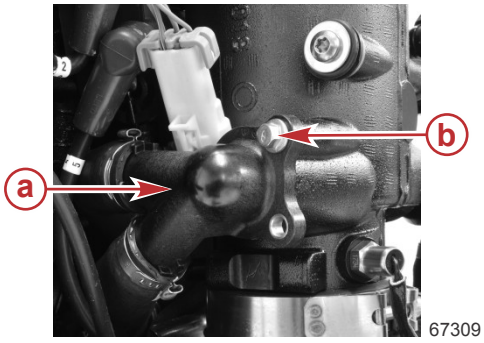


- a - Water hose
- b - 31.6 mm Oetiker clamp
- c - Exhaust tube
- d - Breather hose
- e - 25.6 mm Oetiker clamp
- f - Port camshaft cover

10. Install the water supply fitting onto the port side of the exhaust tube. Tighten the screw to the specified torque.



V8
- a - Water supply fitting
- b - M6 x 16 screw

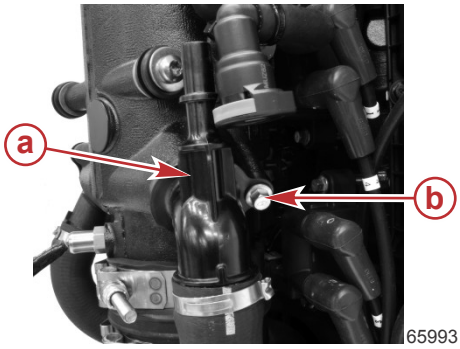


V6

a - Water supply fitting
b - M6 x 16 screw

Description	Nm	lb-in.	lb-ft
Water supply fitting screw (M6 x 16)	10	88.5	–

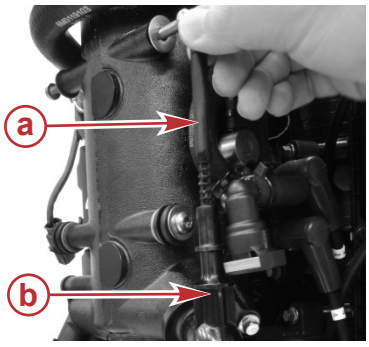
11. Install the water strainer fitting onto the starboard side of the exhaust tube. Tighten the screw to the specified torque.



a - Water strainer fitting
b - M6 x 20 screw

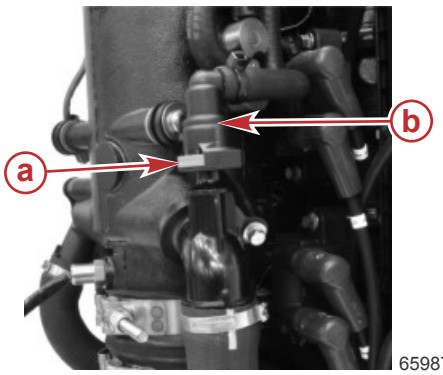
Description	Nm	lb-in.	lb-ft
Water strainer fitting screw (M6 x 20)	10	88.5	–

12. Ensure that the strainer is free of debris or restrictions. Install the strainer into the water strainer fitting.



a - Strainer
b - Water strainer fitting

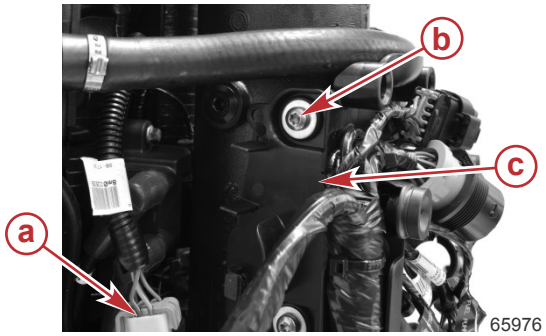
13. Install the water hose connector onto the water strainer fitting. Press the water hose connector down until it clicks into place.



a - Blue tab on the water hose connector
b - Water hose connector

Electrical Harness and Component Installation

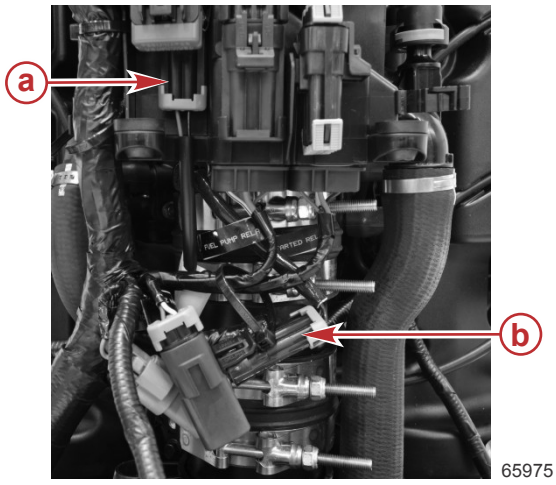
1. Install the electrical plate (together with the harness and PCM) onto the exhaust tube. Tighten the two T30 Torx screws to the specified torque.
2. Install the ignition coil harness connector onto the electrical plate.



V8 shown—V6 similar
- a - Ignition coil primary lead connector
- b - T30 Torx screws and washers (one each per side)
- c - Electrical plate

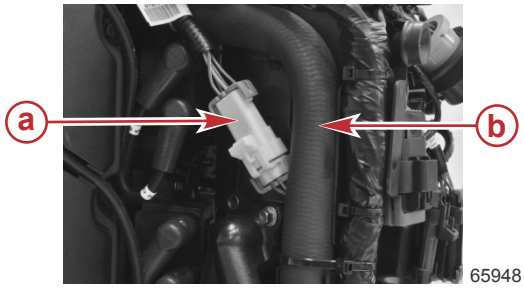
Description	Nm	lb-in.	lb-ft
T30 Torx screws	10	88.5	–

3. Connect the fuel pump connector and exhaust gas temperature (EGT) sensor connectors to the engine harness.



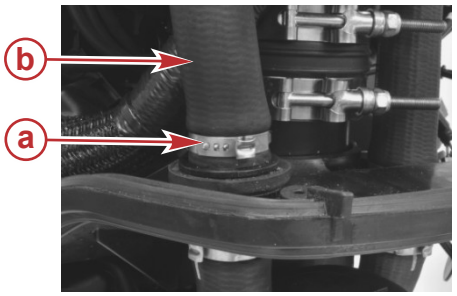
V8 shown—V6 similar
- a - Fuel pump connector
- b - EGT sensor connector

4. Install the thermostat dump hose behind the exhaust tube and route the hose down along the port side of the electrical plate.
5. Connect the ignition coil primary lead connector to the engine harness. Attach the connector to the electrical plate.



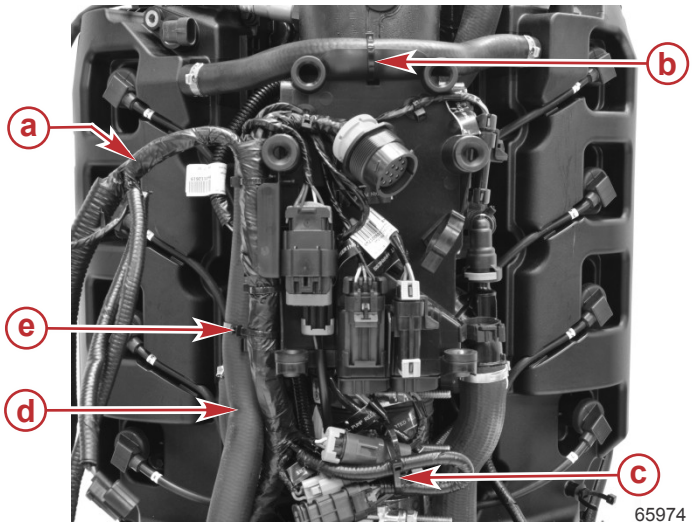
- a - Ignition coil primary lead connector
- b - Thermostat dump hose

6. Install a 31.6 mm Oetiker clamp to secure the thermostat dump hose to the fitting on the adapter plate.



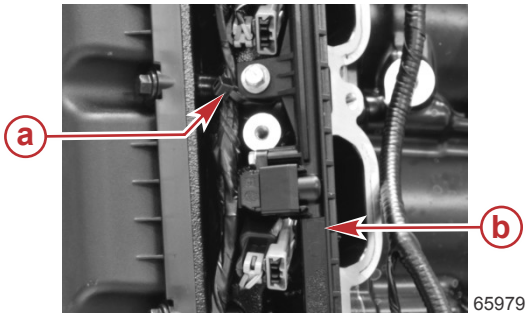
a - 31.6 mm Oetiker clamp
b - Thermostat dump hose

7. Carefully insert the electrical harness under the breather hose, then behind the exhaust tube and push it through to the starboard side.
8. Install a cable tie to secure the aft wiring bundle together.
9. Install a cable tie to secure the thermostat dump hose to the electrical plate.
10. Install a cable tie to secure the breather hose to the electrical plate.



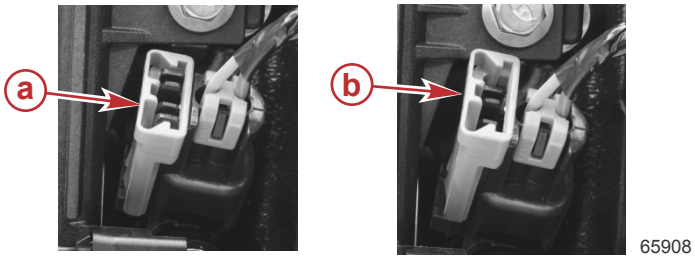
V8 shown—V6 similar
a - Electrical harness to starboard side
b - Cable tie securing the breather hose
c - Cable tie securing the aft wiring bundle
d - Thermostat dump hose
e - Cable tie securing thermostat dump hose

11. Route the starboard side injector harness into position and secure it with a cable tie.



a - Cable tie
b - Starboard fuel rail

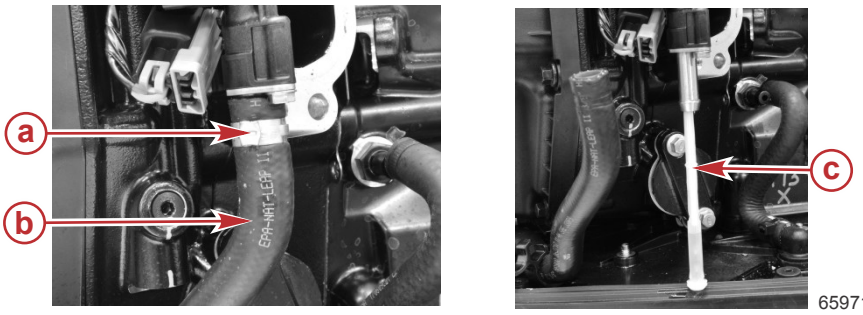
12. Connect the fuel injector connectors to the appropriate fuel injectors:
    a. Push the fuel injector connector onto the fuel injector.
    b. Slide the gray lock tab down to secure the connector.



a - Gray lock tab in the locked position
b - Gray lock tab in the unlocked position

13. Install the fuel line filters into the fuel rails.

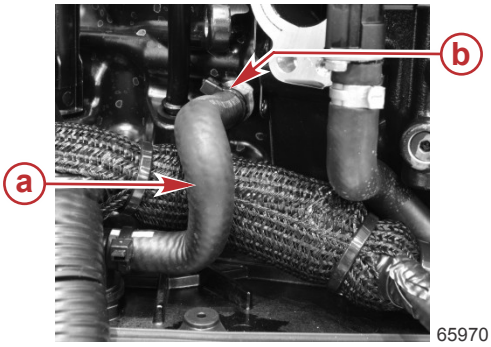
14. Install the fuel hoses onto the fuel rails. Secure the fuel hoses with 16.2 mm Oetiker clamps.



Starboard side shown, port side similar

- **a -** 16.2 mm Oetiker clamps (one per fuel rail)
- **b -** Fuel hose (one per fuel rail)
- **c -** Fuel line filter (one per fuel rail)

15. Place the harness assembly onto the chap plate. Route the harness onto the port side of the chap plate toward the front of the powerhead.
16. Connect the port side drain hose to the fitting and secure the drain hose with a cable tie.

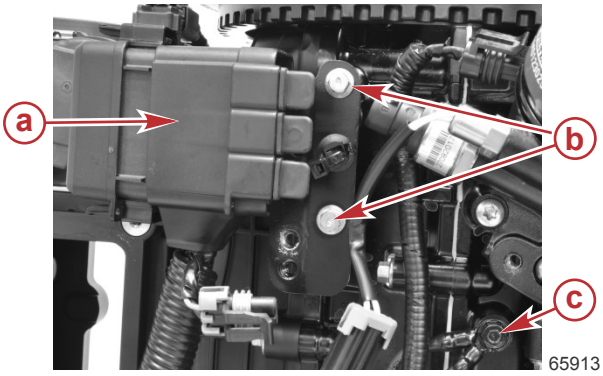


- **a -** Drain hose
- **b -** Cable tie

17. Install the ground wire connections. Tighten the ground screw to the specified torque. Cover the connection with Liquid Neoprene.

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

18. Secure the fuse box with two screws. Tighten the screws to the specified torque.

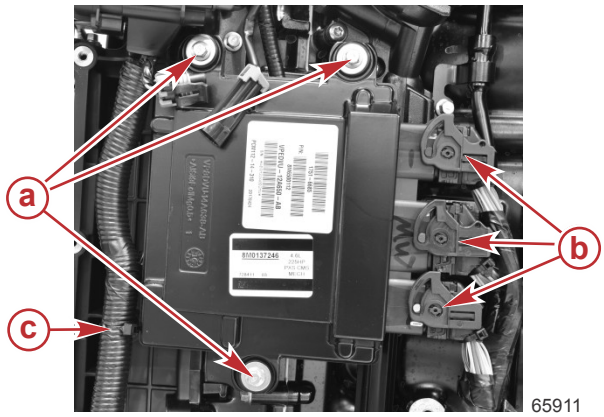


- **a -** Fuse box
- **b -** M6 x 16 screws (2)
- **c -** Ground wire connections

Description	Nm	lb-in.	lb-ft
Fuse box screws (M6 x 16)	10	88.5	–
Ground screw	10	88.5	–

19. Secure the harness next to the PCM with a cable tie.

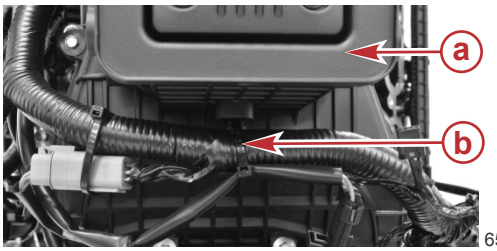
20. Install the PCM and tighten the three M6 x 25 screws to the specified torque.



a - M6 x 25 screws (3)
b - PCM connectors
c - Cable tie

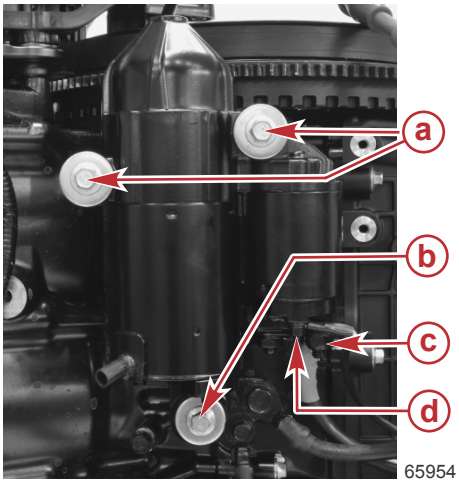
Description	Nm	lb-in.	lb-ft
M6 x 25 screws	10	88.5	–

21. Secure the wiring harness under the intake plenum with a cable tie.



a - Intake plenum
b - Cable tie

22. Install the starter motor. Tighten the three M8 screws to the specified torque.
23. Install the starter solenoid wire (yellow/red) and the positive (+) battery cable to the starter solenoid. Cover the connections with Liquid Neoprene.

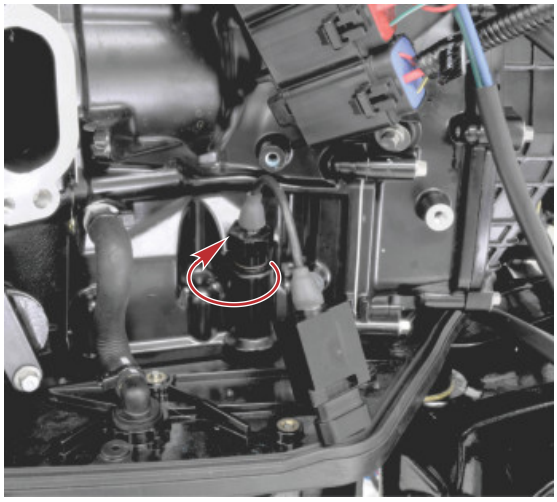


a - M8 x 80 screws and washers
b - M8 x 45 screw and washer
c - Positive (+) battery cable
d - Starter solenoid wire (yellow/red)

Description	Nm	lb-in.	lb-ft
M8 x 80 screws (2)	24	–	17.7
M8 x 45 screw	24	–	17.7

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Starter motor electrical connections	92- 25711 3

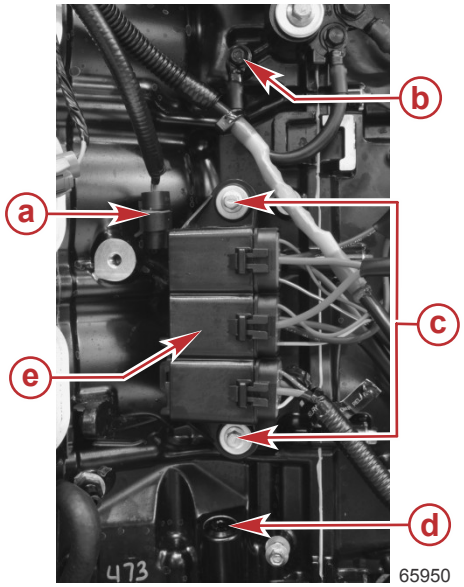
24. **If equipped with a digital oil level sensor—**Install the digital oil level sensor assembly. Tighten the assembly to the specified torque.



66061

Description	Nm	lb-in.	lb-ft
Digital oil level sensor assembly	20	177	–

25. **If not equipped with a digital oil level sensor—**Install the weather cap onto the connector and secure the connector to the relay bracket.
26. Install the relay bracket. Tighten the screws to the specified torque.
27. Install the ground wire connection. Tighten the ground screw to the specified torque and cover the connection with Liquid Neoprene.



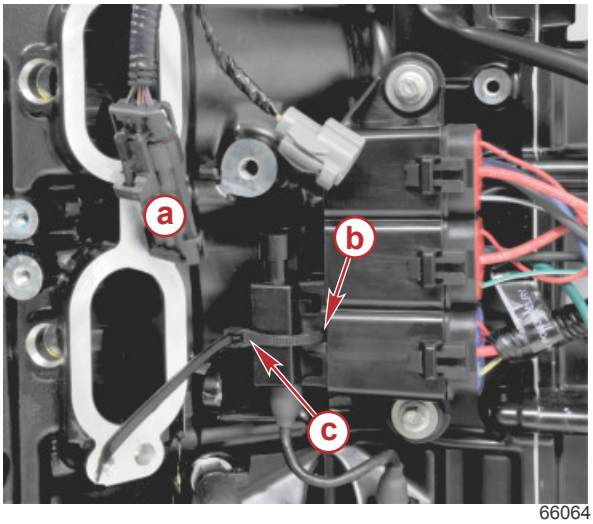
65950

a - Harness connector
b - Ground wire connection
c - Relay bracket screws (M6 x 25)
d - Electronic dipstick location (not equipped in this example)
e - Relay bracket

Description	Nm	lb-in.	lb-ft
Relay bracket screws (M6 x 25)	10	88.5	–
Ground wire screw	10	88.5	–

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Ground wire connection	92- 25711 3

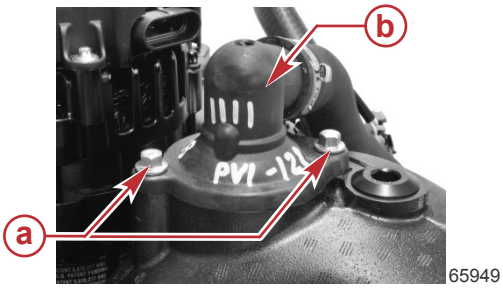
28. **If equipped with a digital oil level sensor—**Secure the signal module to the relay bracket with a cable tie. Remove the dipstick connector weather cap and plug the harness into the signal module.



66064

- **a -** Dipstick connector weather cap
- **b -** Relay bracket housing cable tie slot
- **c -** Cable tie

29. Lubricate the thermostat housing O-ring with Parker© O-Lube. Install the thermostat housing and tighten the two screws to the specified torque.



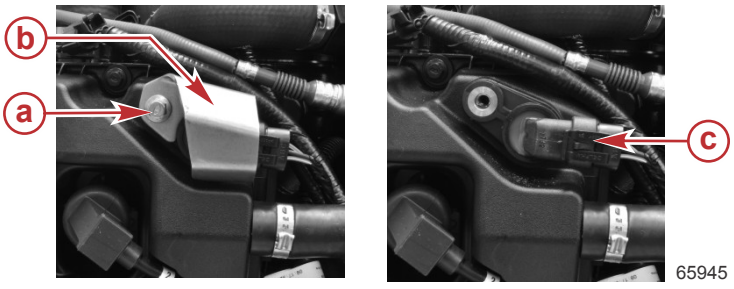
65949

- **a -** M6 x 20 screws
- **b -** Thermostat housing

Description	Nm	lb-in.	lb-ft
Thermostat housing screws (M6 x 20)	10	88.5	–

Tube Ref No.	Description	Where Used	Part No.
	Parker© O-Lube	Thermostat housing O-ring	Obtain Locally

30. Connect the engine harness to the camshaft position sensor connector. Install the sensor guard and tighten the screw to the specified torque.

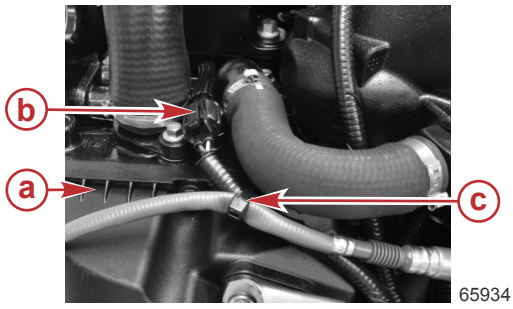


65945

- **a -** M6 x 20 screw
- **b -** Sensor guard
- **c -** Camshaft position sensor connector

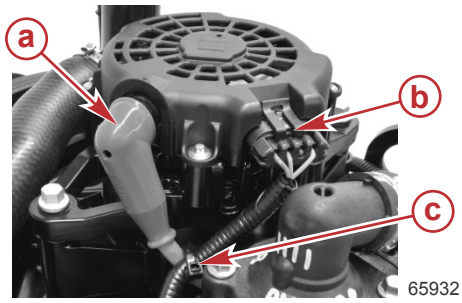
Description	Nm	lb-in.	lb-ft
Camshaft position sensor screw (M6 x 20)	10	88.5	–

31. Connect the crankshaft position sensor connector. Secure the harness with a cable tie as shown.



a - Port camshaft cover
b - Crankshaft position sensor connector
c - Cable tie

32. Install the alternator output lead onto the alternator. Tighten the nut to the specified torque. Apply Liquid Neoprene to protect the connection from corrosion.
33. Plug in the alternator wire connector.
34. Install a cable tie as shown to secure the alternator wiring.

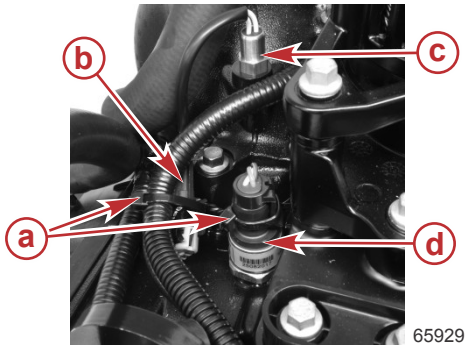


a - Cable boot
b - Alternator wire connector
c - Cable tie

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

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

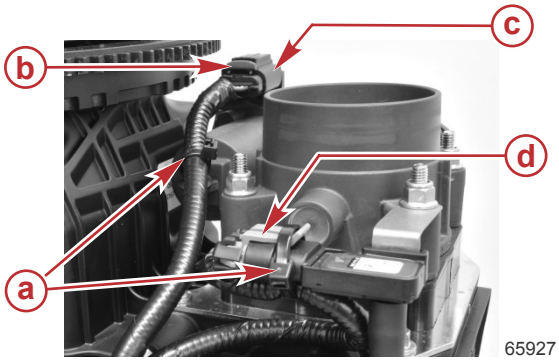
35. Connect the block water pressure sensor connector.
36. Connect the water temperature sensor connector.
37. Secure the harness with cable ties as shown.



a - Cable ties
b - Water temperature sensor connector
c - Water temperature sensor
d - Block water pressure sensor

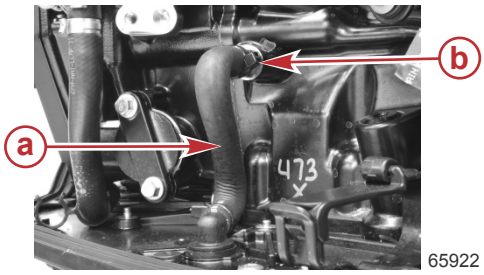
38. Connect the electronic throttle body connector by pushing the connector onto the throttle body, then pushing in the red lock tab.
39. Install a cable tie behind the throttle body to secure the harness.

40. Connect the MAP sensor connector and secure the connector with a cable tie as shown.



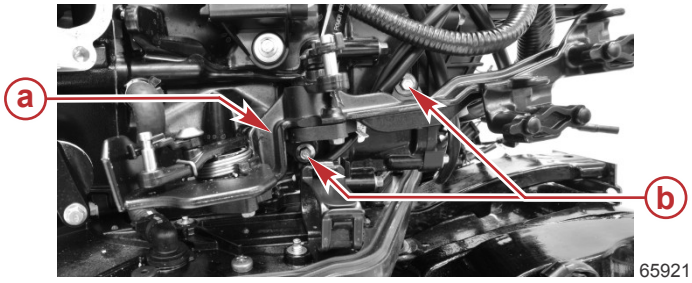
a - Cable ties
b - Red lock tab
c - Electronic throttle body connector
d - MAP sensor connector

41. Install the starboard side drain hose and secure the hose with a cable tie.



a - Drain hose
b - Cable tie

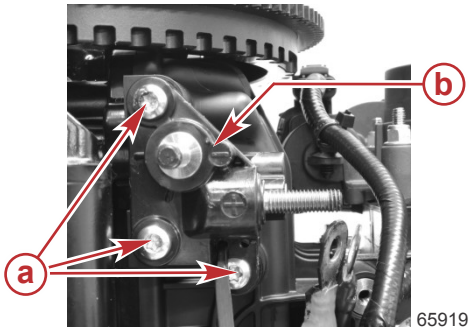
42. **Mechanical throttle and shift models—**Install the cable bracket onto the powerhead and secure it with two screws. Tighten the screws to the specified torque.



a - Cable bracket
b - Screws (2)

Description	Nm	lb-in.	lb-ft
Cable bracket screws	11	97.4	–

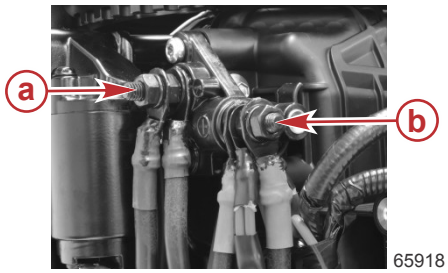
43. Connect the throttle and shift demand connectors to the engine harness.
44. Install the battery cable terminal block onto the powerhead. Tighten the three T30 Torx screws to the specified torque.



a - T30 Torx screws (3)
b - Battery cable terminal block

Description	Nm	lb-in.	lb-ft
T30 Torx screws (M6 x 20)	10	88.5	–

45. Install the battery cables onto the terminals according to the following table. Tighten the nuts to the specified torque. Cover the connections with Liquid Neoprene.



65918

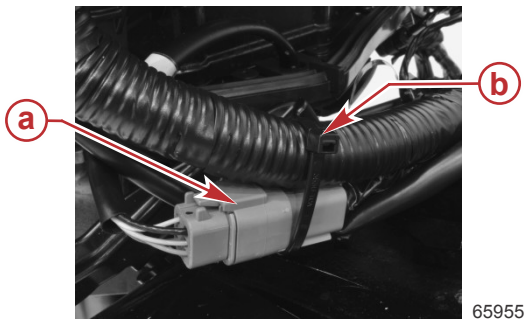
a - Negative (–) battery terminal
b - Positive (+) battery terminal

Installation Order	Positive (+) Battery Terminal Connections	Negative (–) Battery Terminal Connections
1st	Starter positive (+) cable	Starter ground (–)
2nd	Alternator fusible link	Relay ground (–)
3rd	Positive (+) ring terminal to relays	Negative (–) battery cable
4th	Postive (+) battery cable	–

Description	Nm	lb-in.	lb-ft
Battery cable nuts	17	150.5	–

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Battery connections at the engine	92- 25711 3

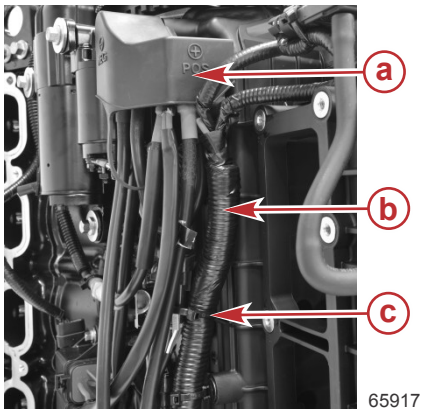
46. Secure the shift actuator connector to the harness with a cable tie under the intake plenum.



65955

a - Shift actuator connector
b - Cable tie

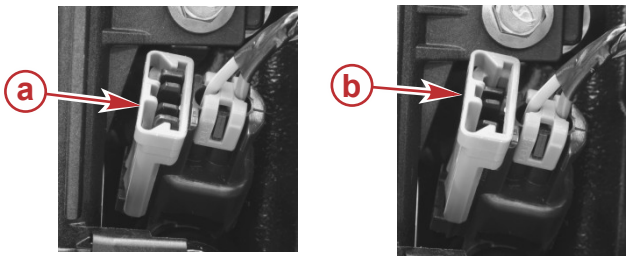
47. Install a cable tie to secure the wiring harness as shown. Install the battery terminal cover.



65917

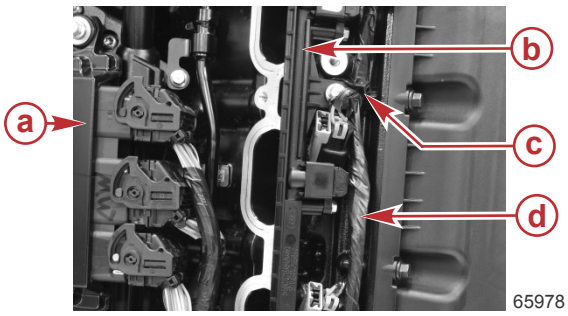
a - Battery terminal cover
b - Wiring harness
c - Cable tie

48. Connect the fuel injector connectors to the fuel injectors on the port fuel rail and press the gray lock tab down to engage.



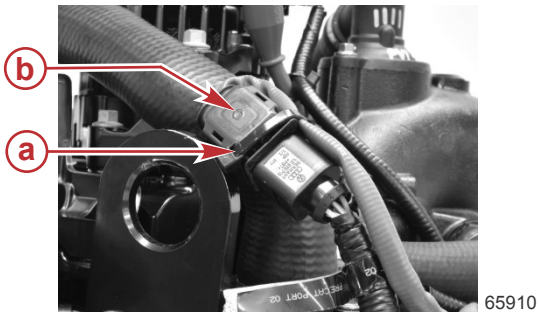
a - Gray lock tab (locked)
b - Gray lock tab (unlocked)

49. Install a cable tie to secure the injector harness to the port fuel rail.



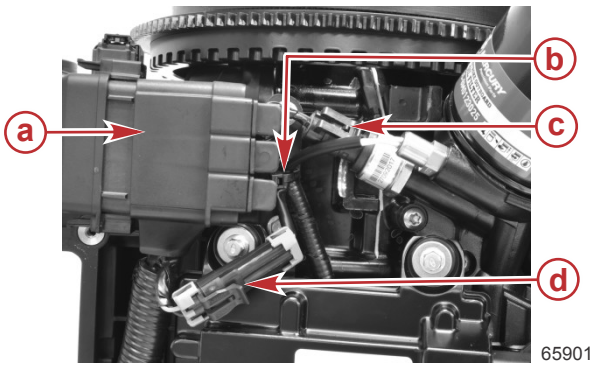
a - PCM
b - Port fuel rail
c - Cable tie
d - Injector harness

50. Connect the oxygen sensor connector to the engine harness and secure it with a cable tie.



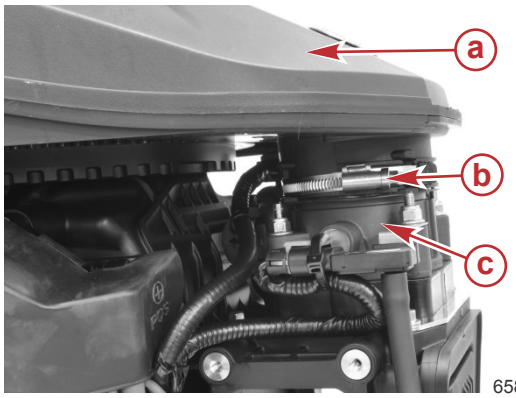
a - Cable tie
b - Oxygen sensor connector

51. Connect the oil pressure and oil temperature sensor connectors.
52. Install a cable tie to secure the wiring harness behind the fuse box.



a - Fuse box
b - Cable tie
c - Oil pressure sensor connector
d - Oil temperature sensor connector

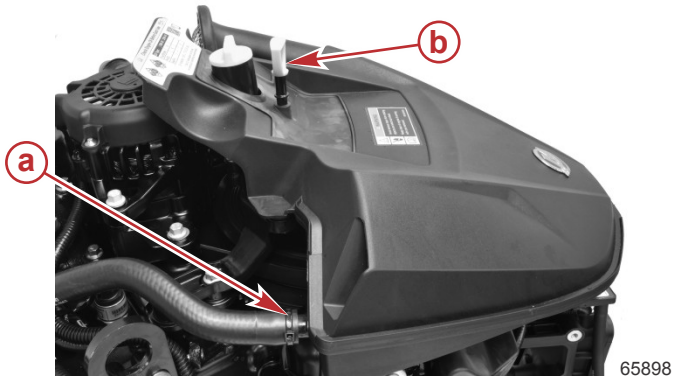
53. Install the flywheel cover onto the throttle body. Tighten the throttle body clamp to the specified torque.



a - Flywheel cover
b - Throttle body clamp
c - Throttle body

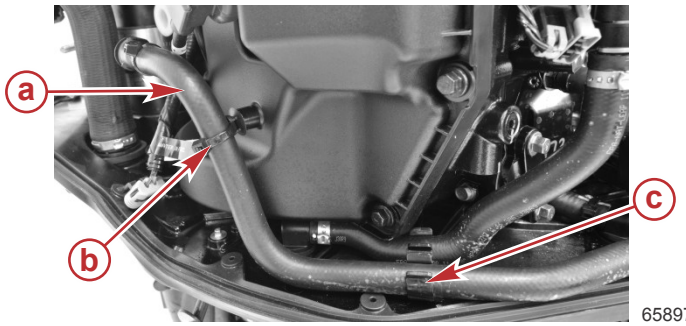
Description	Nm	lb-in.	lb-ft
Throttle body clamp	3	26.6	–

54. Install the engine oil dipstick.
55. Install the breather hose onto the flywheel cover and secure the breather hose with a cable tie.



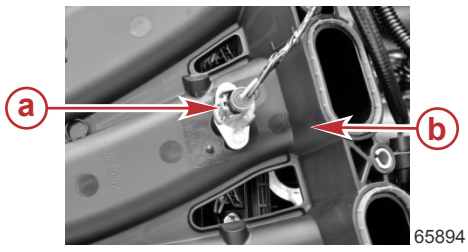
a - Cable tie securing the breather hose
b - Engine oil dipstick

56. Install the fuel hose into the retainer and secure the fuel hose with a cable tie.



a - Fuel hose
b - Cable tie
c - Retainer

57. Plug in the manifold air temperature (MAT) sensor connector. The MAT sensor is located behind the starboard intake runners.

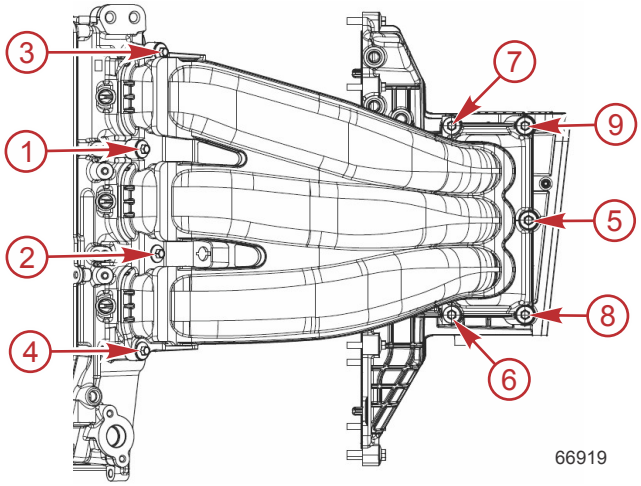


a - MAT sensor
b - Starboard intake runners

58. Install the starboard intake runner. Apply Loctite 242 Threadlocker to the screw threads and tighten the screws to the specified torque in the sequence shown.

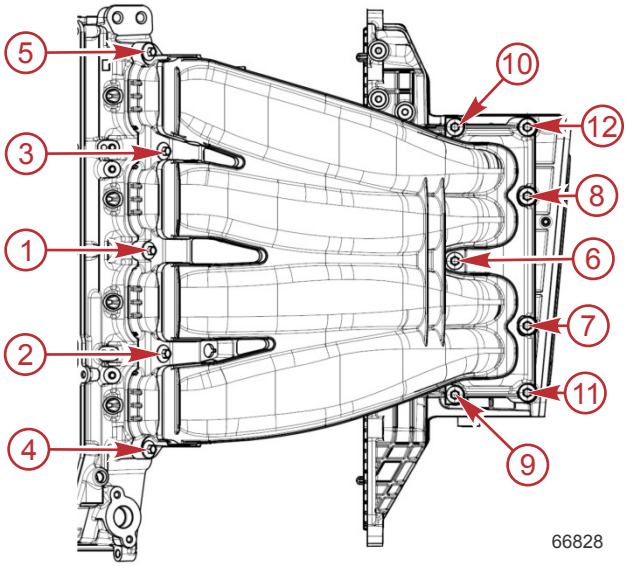
IMPORTANT: Intake runner screws are different lengths. Do not intermix the hardware.

IMPORTANT: Ensure that the intake runner seals are in place and not damaged.



V6 starboard intake runner

Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–4)	10	88.5	–
M6 x 37 screws (7–9)	10	88.5	–



V8 starboard intake runner

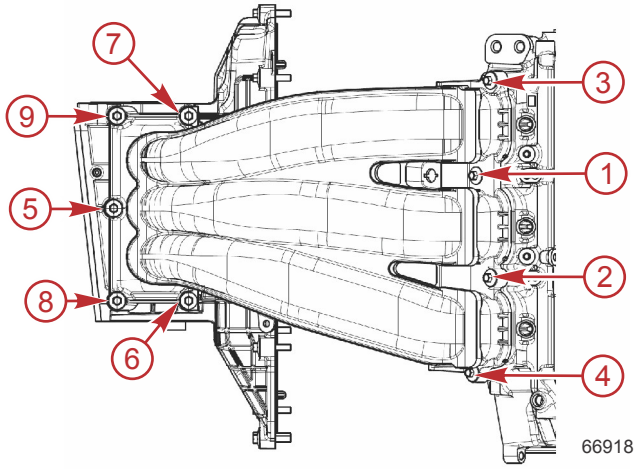
Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–5)	10	88.5	–
M6 x 37 screws (6–12)	10	88.5	–

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Threads of the starboard intake runner screws	92-809821

59. Install the port intake runner. Apply Loctite 242 Threadlocker to the screw threads and tighten the screws to the specified torque in the sequence shown.

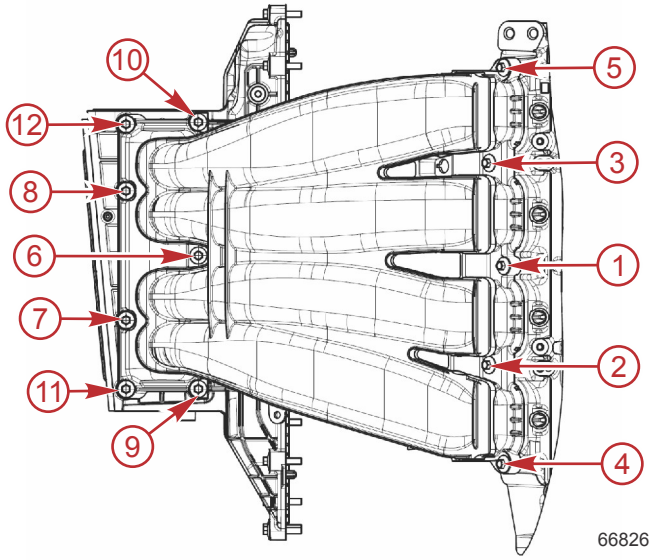
IMPORTANT: Intake runner screws are different lengths. Do not intermix the hardware.

IMPORTANT: Ensure that the intake runner seals are in place and not damaged.



V6 port intake runner

Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–4)	10	88.5	–
M6 x 37 screws (7–9)	10	88.5	–

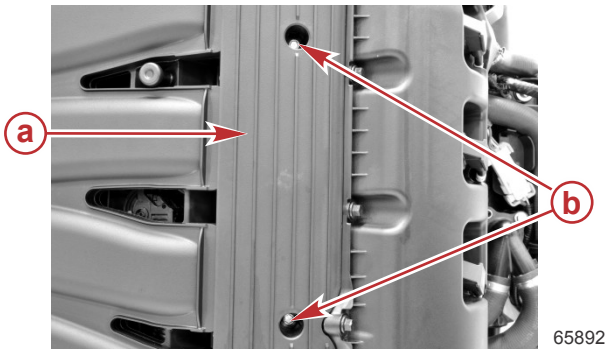


V8 port intake runner

Description	Nm	lb-in.	lb-ft
M6 x 30 screws (1–5)	10	88.5	–
M6 x 37 screws (6–12)	10	88.5	–

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	Threads of the port intake runner screws	92-809821

60. Install the fuel rail covers. Tighten the screws to the specified torque.

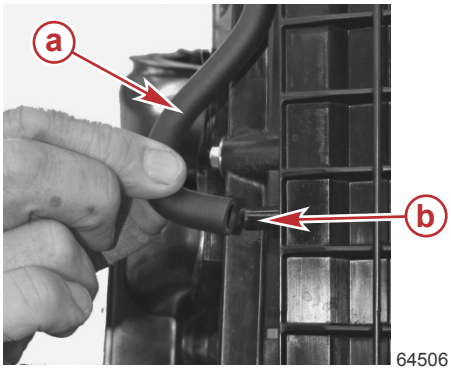


V8 port side shown; starboard and V6 similar

- **a -** Fuel rail cover
- **b -** M6 shoulder screws (2 per side)

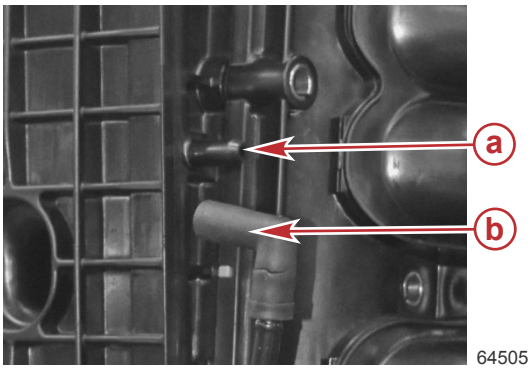
Description	Nm	lb-in.	lb-ft
Fuel rail cover screws (M6 shoulder screws)	10	88.5	–

61. Connect the manifold reference hose onto the fitting near the starboard intake runners.



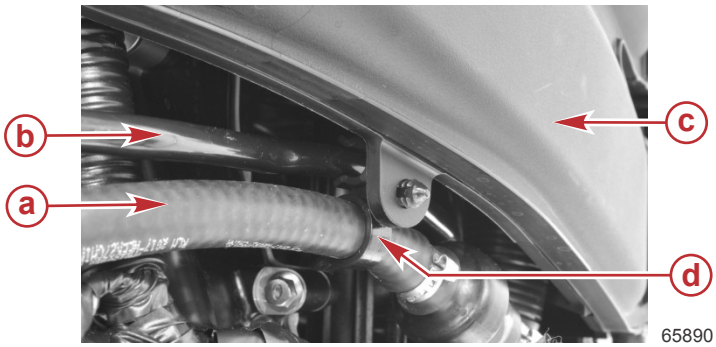
- **a -** Manifold reference hose
- **b -** Fitting

62. Install the FSM reference hose onto the fitting near the port intake runners.



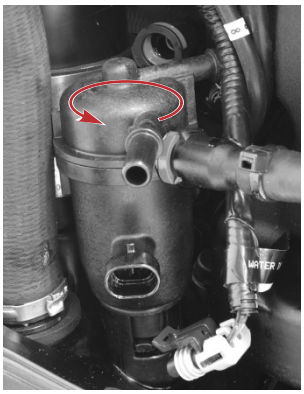
- **a -** Fitting
- **b -** FSM reference hose

63. Install the flush hose and manifold reference hose into the retainer on the port intake runner.

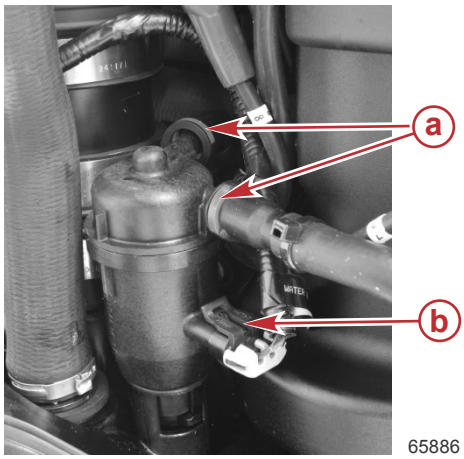


- **a -** Flush hose
- **b -** Manifold reference hose
- **c -** Port intake runner
- **d -** Retainer

64. Install the fuel filter into the chap plate by pressing down and turning 1/4 turn counterclockwise.


66822

65. Connect the fuel hoses to the fuel filter and plug in the WIF sensor connector.



65886

a - Fuel hoses
b - WIF sensor connector

66. Install the upper and lower cowls. Refer to **Section 5C - Upper and Lower Cowls**.
67. Fill the engine with oil. Refer to **Section 1B - Changing Engine Oil and Filter**.

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.

Notes:

Powerhead

Section 4B - Cylinder Head V6

Table of Contents

V6 Cylinder Head Specifications

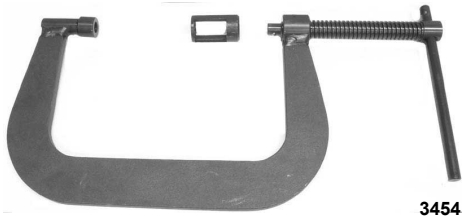
Description	Specification
Head deck maximum warp	0.1 mm (0.0039 in.)
Number of valves	24
Number of valves per cylinder	4
Camshaft bearing inside diameter (cylinder head)	26.000–26.021 mm (1.0236–1.0244 in.)
Camshaft bearing journal	25.96–25.98 mm (1.022–1.023 in.)
Camshaft lobe height	
Intake	43.02 mm (1.694 in.)
Exhaust	44.24 mm (1.742 in.)
Valve lash clearance	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 in.)
Valve seat angles (referenced relative to the valve guide axis)	
Intake	30°, 44° ± 0.25°, 60°
Exhaust	35°, 44° ± 0.25°, 55°
Valve seat width (44°)	
Intake	1.0 ± 0.1 mm (0.039 ± 0.0039 in.)
Exhaust	1.2 ± 0.1 mm (0.047 ± 0.0039 in.)
Valve spring height	
Uncompressed	Reference 46.1 mm (1.815 in.)
Compressed to 33.66 mm (1.3252 in.)	157–173 Nm (35.295–38.892 lb-ft) spring load
Compressed to 24.31 mm (0.9149 in.)	356–390 Nm (80.03–87.67 lb-ft) spring load
Valve outside diameter	
Intake	36.9–37.1 mm (1.4528–1.4606 in.)
Exhaust	30.9–31.1 mm (1.2165–1.2244 in.)
Valve face angle (referenced relative to the end face of the valve)	
Intake	44.75°–45.25°
Exhaust	43.75°–44.25°
Valve margin width	
Intake	0.875 mm (0.034 in.)
Exhaust	1.331 mm (0.052 in.)
Valve stem diameter	
Intake	5.4645–5.4805 mm (0.2151–0.2158 in.)
Exhaust	5.456–5.472 mm (0.2148–0.2154 in.)
Valve stem runout (service limit measured at valve face)	
Intake and exhaust	0.030 mm (0.0012 in.)
Valve height	
Intake	88.49 ± 0.25 mm (3.484 ± 0.0098 in.)
Exhaust	87.667 ± 0.25 mm (3.451 ± 0.0098 in.)
Valve guide bore inside diameter	
Intake and exhaust	5.500–5.512 mm (0.2165–0.217 in.)
Valve stem to valve guide clearance	
Intake	0.0195–0.0475 mm (0.0008–0.0019 in.)
Exhaust	0.028–0.056 mm (0.0011–0.0022 in.)
Valve guide height (dimension from spring seat to end of guide)	
Intake	14.5 mm (0.570 in.)
Exhaust	14.5 mm (0.570 in.)
Valve bucket	

Description	Specification
Intake bucket bore inside diameter	32.000–32.025 mm (1.2589–1.2608 in.)
Exhaust bucket bore inside diameter	32.005–32.025 mm (1.2600–1.2608 in.)
Valve bucket outside diameter	31.964–31.980 mm (1.2584–1.2591 in.)
Bucket to bore clearance	0.020–0.061 mm (0.0008–0.0024 in.)

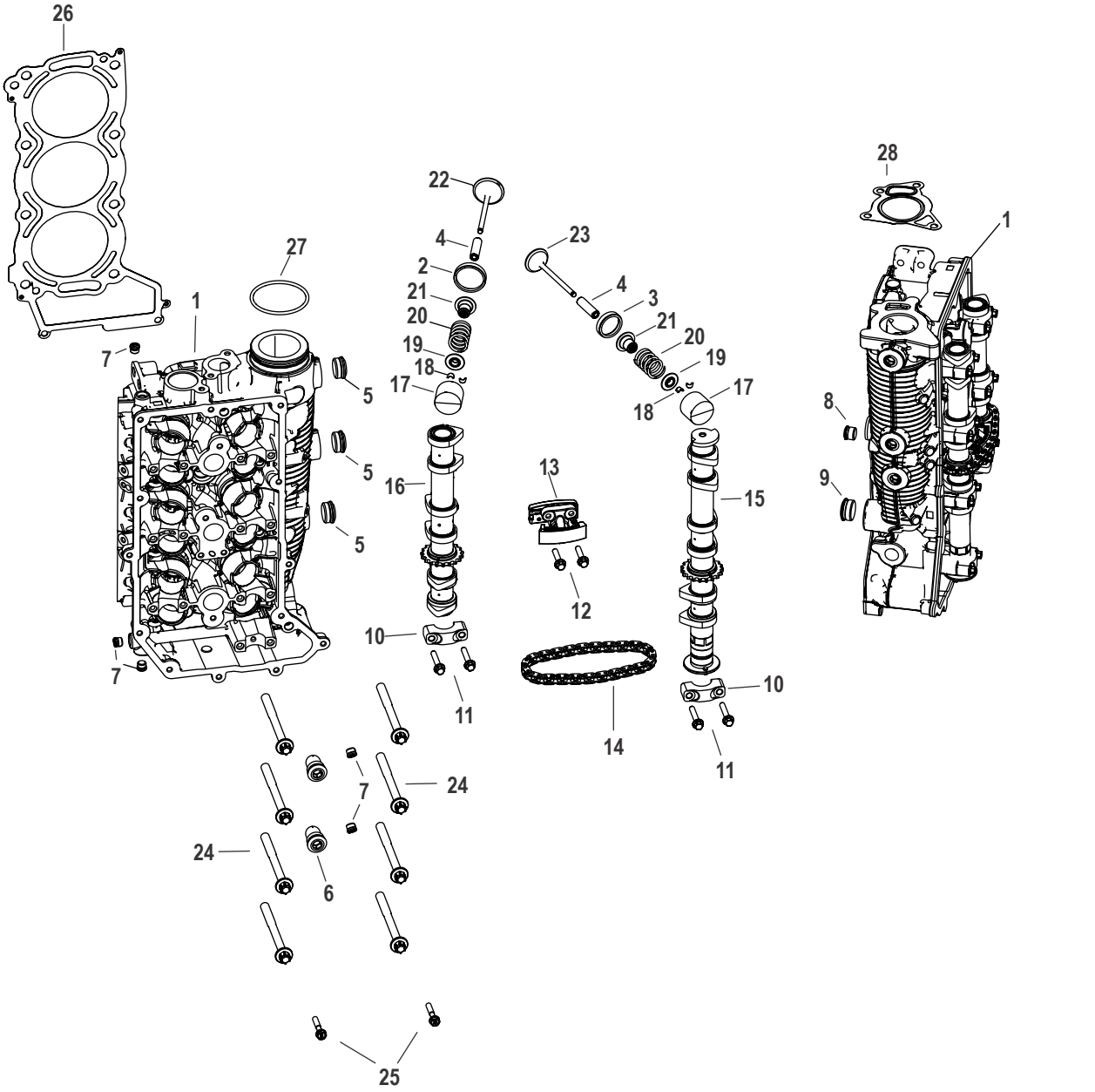
Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Torco® MPZ HP Engine Assembly Lube	Valve guide seals	Obtain Locally
95	2-4-C with PTFE	End of the screwdriver to help install the valve spring retaining key	92-802859A 1
136	Lubriplate SPO 255	Valve bucket tappet outside diameter, valve tip contact pad, or valve tip	Obtain Locally

Special Tools

Valve Spring Compressor	91-809494A1
 3454	Removes and installs valve springs.

Cylinder Head Components



Cylinder Head Components

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	1	Port cylinder head assembly				
	1	Starboard cylinder head assembly				
2	12	Intake valve seat				
3	12	Exhaust valve seat				
4	24	Valve guide				
5	6	24 mm plug		55	–	40.6
6	4	21 mm plug (special)		30	–	22.1
7	9	10 mm plug		7	62	–
8	2	18 mm plug		22	–	16.2
9	2	30 mm plug		55	–	40.6
10	14	Cap				
11	28	M6 x 35 hex flange	**First**	6	53.1	–
			Final	12	106.2	–
12	4	M6 x 30 screw	**First**	6	53.1	–
			Final	12	106.2	–
13	2	Tensioner				
14	2	Cam-to-cam chain				
15	1	Port exhaust camshaft				
	1	Starboard exhaust camshaft				
16	1	Port intake camshaft				
	1	Starboard intake camshaft				
17	24	Valve bucket tappet				
18	48	Valve key				
19	24	Retainer				
20	24	Spring				
21	24	Valve seal				
22	12	Intake valve				
23	12	Exhaust valve				
24	20	E14 Torx flange head bolt	**First**	15	132.8	–
			Second	35	–	25.8
			Final	Tighten an additional 60°		
25	4	M6 x 35 screw		12	106.2	–
26	1	Port cylinder head gasket				
	1	Starboard cylinder head gasket				
27	1	O-ring				
28	1	Exhaust manifold gasket				

Cylinder Head Service Recommendations

All marine engines require periodic inspection and maintenance. Extreme duty cycles and harsh marine enviornements can cause catastrophic engine failure if routine maintenance is not performed at the specified intervals. Failure to follow the engine's **Inspection and Maintenance Schedule** can lead to performance problems, engine failure, and expensive repairs.

Cylinder heads and machined components are manufactured to extremely close tolerances and should only be repaired or replaced by a qualified technician. An automotive machine shop that is capable of performing high quality, close tolerance, machining operations to the manufacture's specifications must be utilized if a cylinder head is damaged. Damage to cylinder heads from improper machining can cause detonation, alter exhaust emissions, and compromise engine performance.

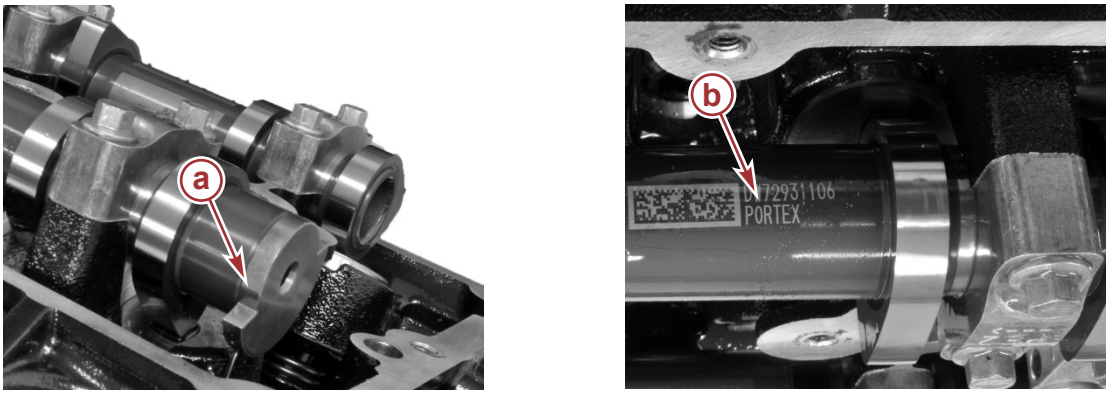
IMPORTANT: Always compare the price of a complete replacement assembly with the cost of cylinder head repair and valve installation when estimating service work.

Machine Shop Information—Lash for Life Cylinder Head Repair

- The cylinder head must be properly installed on the cylinder block using a new head gasket to verify valve lash clearance. Checking valve lash clearance must be completed with the cylinder head mated to the cylinder block and tightened to the specified torque. Failure to properly install the cylinder head before checking valve clearance will result in inaccurate measurements. Refer to **Section 4A - Cylinder Head Installation**.
- If the valve lash clearance is not within the tolerance as listed in the **V6 Cylinder Head Specifications** table then a problem with the camshaft lobes, journals, caps, or cylinder head is indicated.
- The valve tappets have different dimensions. Do not replace an original tappet with a taller or shorter tappet to compensate for a worn or damaged part.
- The valve guide seals must be replaced if the valves are removed from the cylinder head.
- The valve spring coil ratio is the same at both ends of the spring and the springs do not have a top or bottom orientation.
- Bronze sleeved guide bore liners are an acceptable service replacement as an alternative to valve guides.
- The cylinder head must be heated to 176.6 °C (350 °F) before the valve guides are extracted. Remove all plugs before heating.
- Lubricate the valve guides with a light oil before installation.

FourStroke V6 DOHC—Camshaft Identification

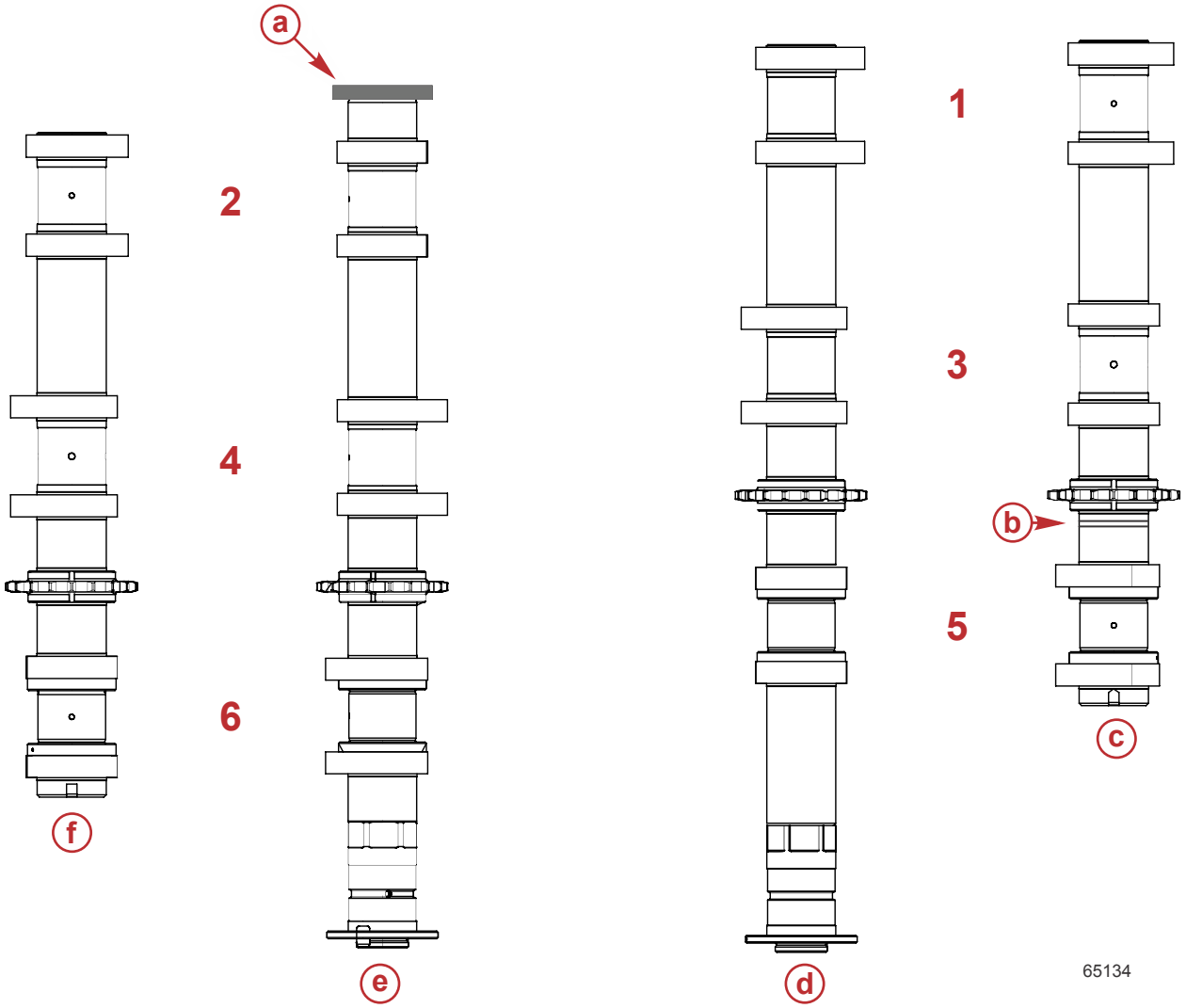
The port exhaust camshaft can be identified by the sensor target at the top of the camshaft. The starboard intake camshaft can be identified by the groove below the chain gear. Each camshaft has an identification mark. Refer to **Section 4A** for camshaft installation procedures.



67354

a - Sensor target—port exhaust camshaft
b - Camshaft identification mark

NOTE: *Observe the camshafts identification marks during powerhead assembly to ensure that each camshaft is installed in the correct location.*



Camshaft identification

- **a -** Sensor target
- **b -** Groove below the chain gear (starboard intake camshaft only)
- **c -** Starboard intake camshaft
- **d -** Starboard exhaust camshaft
- **e -** Port exhaust camshaft
- **f -** Port intake camshaft

Ref.	Description
1	Cylinder number 1
2	Cylinder number 2
3	Cylinder number 3
4	Cylinder number 4
5	Cylinder number 5
6	Cylinder number 6

Cylinder Head Disassembly

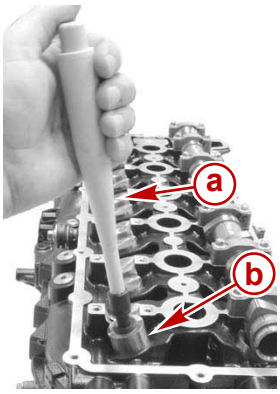
Valve Removal

NOTE: *Refer to* ***Section 4A - Cylinder Block/Crankcase*** *for powerhead, timing chain, camshaft, and cylinder head removal procedures.*

1. Clean the surface of the valve buckets with a solvent to remove any oil residue. With an indelible 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 plunger or suction cup device. 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.



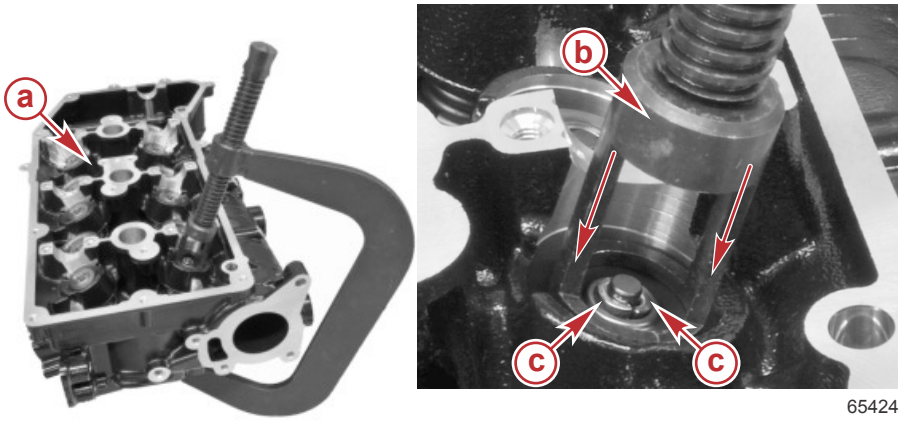
4016

a - Suction cup device
b - Valve bucket tappet

3. Use a valve spring compressor to collapse the valve spring and remove the valve spring retainers and keys.

   NOTE: *Be certain that the cylinder head valve bucket tappet bore is not damaged when using the valve spring compressor.*

   IMPORTANT: Each part must be installed in its original location during reassembly.



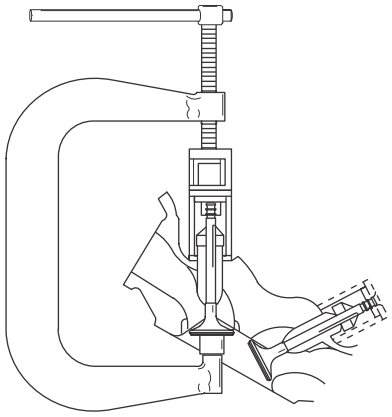
65424

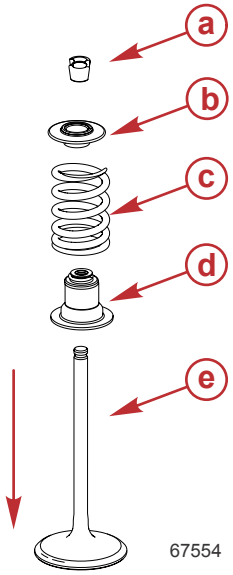
a - Cylinder head
b - Valve spring compressor
c - Retainers (2)

Valve Spring Compressor	91-809494A1

4. Release the valve spring compressor.

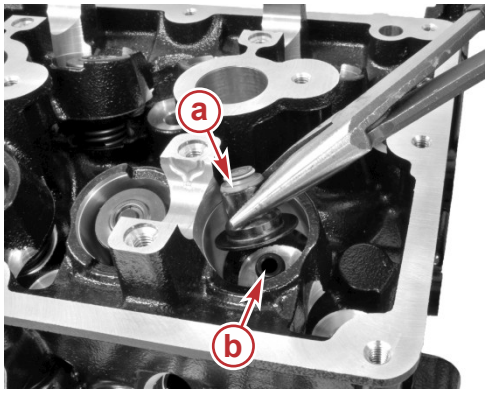
5. Remove the valve from the cylinder head by pulling it through the valve guide and seal.





a - Valve spring retaining key
b - Valve spring retainer
c - Valve spring
d - Valve guide seal
e - Valve

6. Remove the valve spring.
7. Remove the valve guide seal.



a - Valve guide seal
b - Valve guide

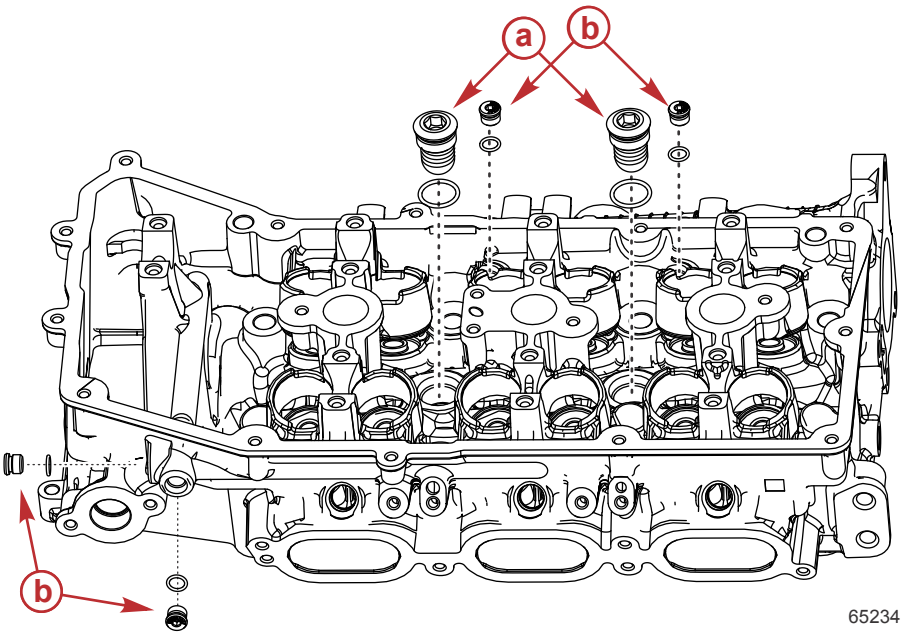
IMPORTANT: Do not reuse valve guide seals after the valve has been removed.

V6 Cylinder Head Plugs—Removal

NOTE: *It may be necessary to lightly tap on the plugs with a brass drift and hammer to break the plug seal.*

1. Remove two 10 mm plugs from the bottom of the oil gallery and discard the O-rings.

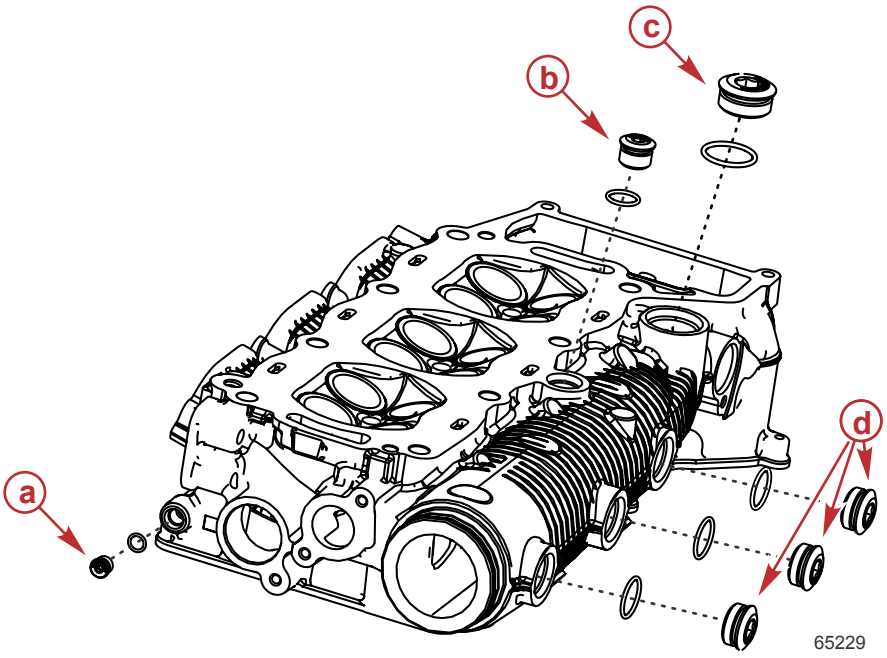
2. Remove two 10 mm plugs and two 21 mm special plugs from the back of the cylinder head. Discard the O-rings.



Starboard head shown

a - 21 mm special plug (2)
b - 10 mm plug (4)

3. Remove the 10 mm plug from the end of the oil gallery and discard the O-ring (port cylinder head only).
4. Remove the three 24 mm plugs from the exhaust water jacket and discard the O-rings.
5. Remove the 18 mm and the 30 mm plug from the front of the cylinder head and discard the O-rings.



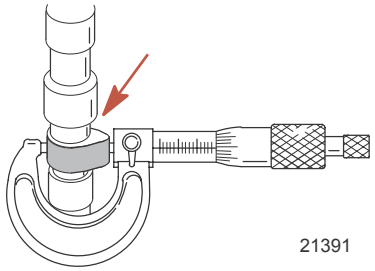
Port head shown

a - 10 mm oil gallery plug (port cylinder head only)
b - 18 mm plug
c - 30 mm plug
d - 24 mm plug (3)

Cleaning/Inspection/Repair

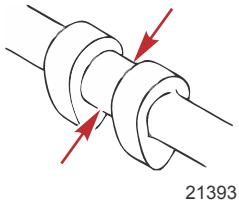
Camshaft

1. Measure the camshaft lobe at its maximum valve lift. Replace the camshaft if the dimensions are out of specification.



Camshaft Lobe Height	
Intake cam	43.02 mm (1.694 in.)
Exhaust cam	44.24 mm (1.742 in.)

2. Measure all of the camshaft bearing journals with a micrometer. Replace the camshaft if the journal dimensions are out of specification.



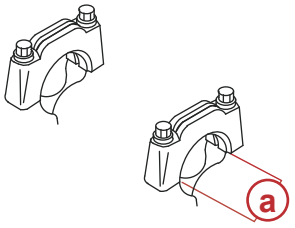
Camshaft Bearing Journal	
Intake and exhaust journal outside diameter	25.96–25.98 mm (1.022–1.023 in.)

IMPORTANT: Torque stages apply to a pair of fasteners for a single camshaft cap, i.e. both fasteners tightened to first stage specified torque, then both fasteners tightened to final stage specified torque.

3. Install the camshaft caps in their correct location and orientation. Tighten the camshaft bearing cap fasteners to the specified torque.

Description		Nm	lb-in.	lb-ft
Camshaft caps	**First**	6	53.1	–
	Final	12	106.2	–

4. Measure the inside diameter of the camshaft bearing surface. Replace the cylinder head if the dimension is out of specification.



a - Camshaft bearing surface inside diameter

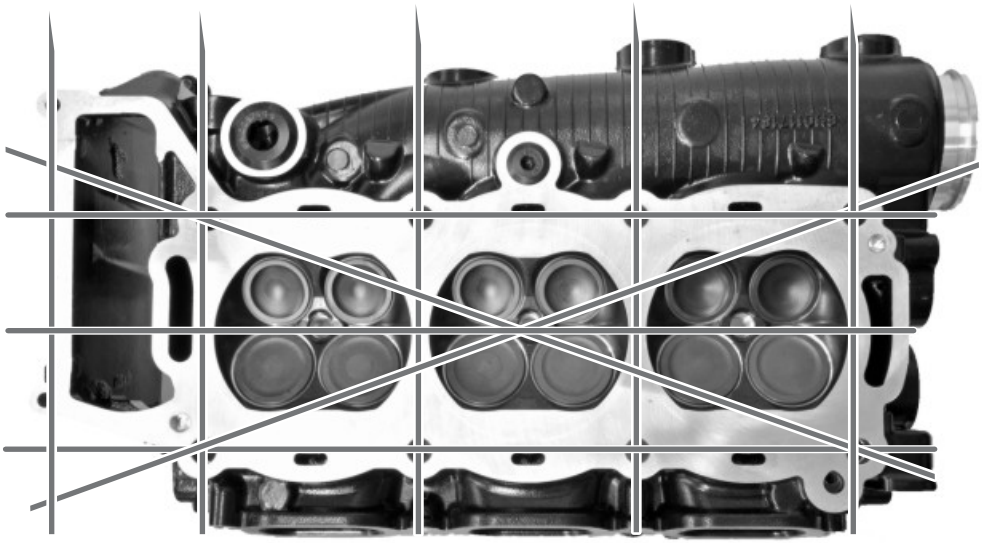
Camshaft Bearing Surface Inside Diameter	
Inside diameter	26.000–26.021 mm (1.0236–1.0244 in.)

V6 Cylinder Head

1. Inspect the cylinder head for mineral deposits and corrosion in the water passageways. Remove deposits and corrosion if found.
2. Pressure test the cylinder head to ensure that there are no leaks or cracks.
3. Inspect the cylinder head for carbon deposits in the combustion chamber. Use a round scraper to clean away deposits. Be careful not to scratch or remove material from the cylinder head.

4. Measure the cylinder head for warpage using a straightedge and a feeler gauge. Maximum warpage must not exceed 0.1 mm (0.0039 in.) in any area of the cylinder head deck. Replace the cylinder head if it is out of specification.

NOTE: *Use a straightedge and a feeler gauge to inspect the cylinder head for warpage.*



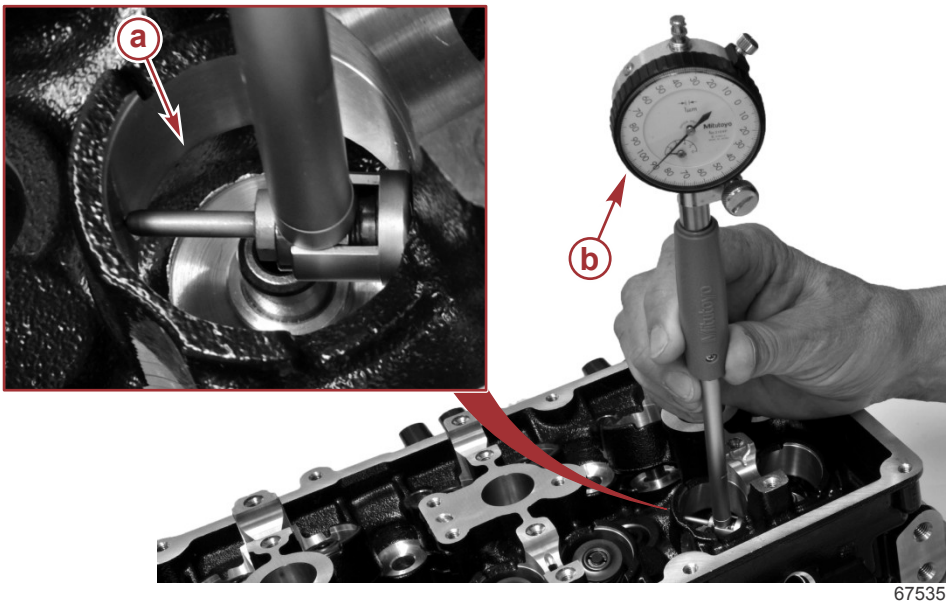
65199

Description	Specification
Head deck maximum warp	0.1 mm (0.0039 in.)

Valve Bucket Tappets

Bore Inside Diameter

Description	Specification
Intake bucket bore inside diameter	32.000–32.025 mm (1.2589–1.2608 in.)
Exhaust bucket bore inside diameter	32.005–32.025 mm (1.2600–1.2608 in.)



67535

Checking bucket bore diameter

a - Bucket bore

b - Bore gauge

Valve Bucket Tappet Outside Diameter

Description	Specification
Valve bucket outside diameter	31.964–31.980 mm (1.2584–1.2591 in.)

67538

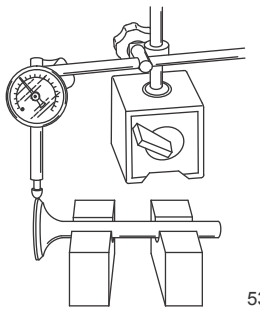
a - Valve bucket tappet
b - Digital micrometer

Bucket Tappet to Bore Clearance

Description	Specification
Bucket to bore clearance	0.020–0.061 mm (0.0008–0.0024 in.)

Valves

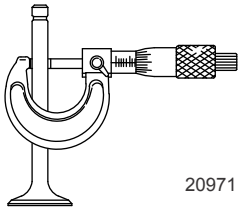
1. Inspect the valves for damage or warpage. Replace the valves if necessary.
2. Measure the valve stem runout. Replace the valves if they are out of specification.



53483

Valve Stem Runout	
Service limit measured at valve face (maximum)	0.030 mm (0.0012 in.)

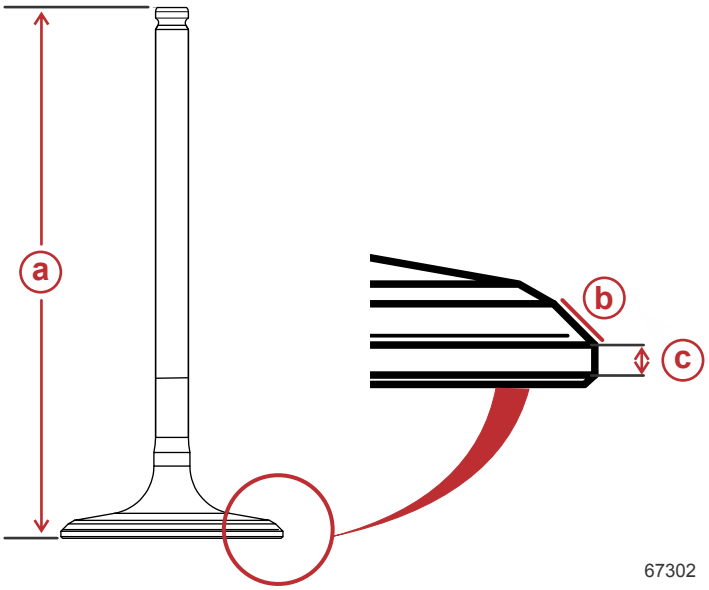
3. Measure the valve stem diameter. Replace the valves if they are out of specification.



20971

Valve Stem Diameter	
Intake	5.4645–5.4805 mm (0.2151–0.2158 in.)
Exhaust	5.456–5.472 mm (0.2148–0.2154 in.)

4. Measure the valve margin width and valve height. Replace the valve if it is out of specification.



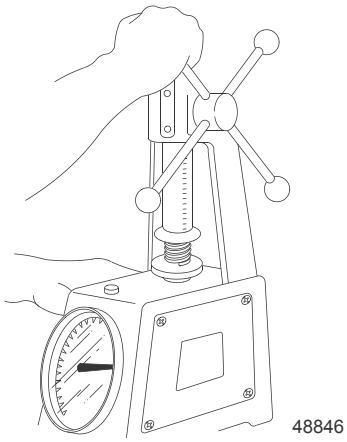
a - Valve height
b - Valve seat contact
c - Valve margin width

Valve Margin Width	
Intake	0.875 mm (0.034 in.)
Exhaust	1.331 mm (0.052 in.)

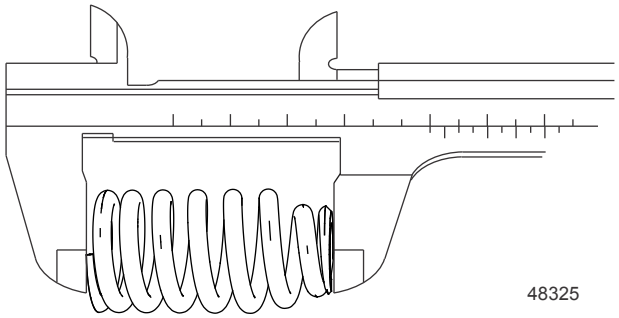
Valve Height	
Intake	88.49 ± 0.25 mm (3.484 ± 0.0098 in.)
Exhaust	87.667 ± 0.25 mm (3.451 ± 0.0098 in.)

Valve Springs

1. Using a valve spring tester, test the valve spring load at the installed height. Refer to the following table for height and load specifications.



Valve Spring Height	Length Specification
Uncompressed	46.1 mm (1.815 in.)

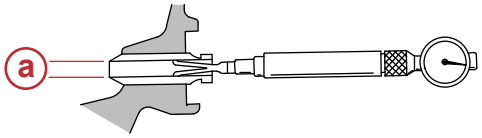


Valve Spring Height	Spring Load Specification
Compressed to 33.66 mm (1.3252 in.)	157–173 Nm (35.295–38.892 lb-ft)
Compressed to 24.31 mm (0.9149 in.)	356–390 Nm (80.03–87.67 lb-ft)

2. Replace the valve springs if they are out of specification.

Valve Guides

Measure the valve guide bore with a valve guide bore gauge. If the valve guide wear is out of specification, replace the valve guide.



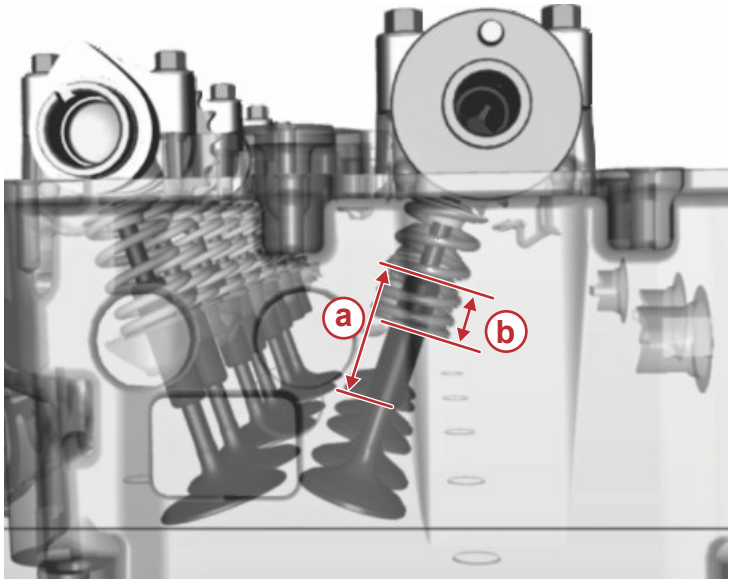
a - Valve guide bore

Valve Guide Bore Inside Diameter	
Intake	5.500–5.512 mm (0.2165–0.2170 in.)
Exhaust	5.500–5.512 mm (0.2165–0.2170 in.)

Valve Guide Replacement

NOTE: *Inexperienced personnel should not attempt to replace the valve guides. Bronze sleeved guide bore liners are an acceptable service replacement as an alternative to valve guides.*

IMPORTANT: Install valve guides using a seat and guide machine with light oil lubrication.



Exhaust shown, intake is same dimension

a - Overall guide length

b - Valve guide height (dimension from spring seat to end of guide)

Valve Guide Height	
Intake (dimension from spring seat to end of guide)	14.5 mm (0.570 in.)
Exhaust (dimension from spring seat to end of guide)	14.5 mm (0.570 in.)

Valve Stem to Valve Guide Clearance	
Intake	0.0195–0.0475 mm (0.0008–0.0019 in.)
Exhaust	0.028–0.056 mm (0.0011–0.0022 in.)

Valve Seat Reconditioning

The cylinder head is machined to extremely close tolerances. The cylinder head and related components should only be repaired by a qualified technician with experience in servicing high-performance engines. A qualified machine shop with special industrial tools that is familiar with automotive engine machining techniques must be utilized if the cylinder head requires reconditioning or clearance correction repair. Damage to the cylinder head combustion area can alter the emissions output of the engine. In some cases it may be necessary to replace the cylinder head assembly if it cannot be repaired, or if repair costs exceed the cost of cylinder head replacement.

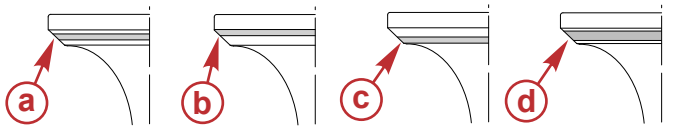
IMPORTANT: Valve seat angle specifications must be carefully observed when cutting valve seats. Modification of the combustion chamber area or flow characteristics of the engine will alter exhaust emissions and can effect the engine's performance.

Valve seat angles are referenced relative to the guide axis, not the face of the valve seat as is commonly used when specifying a service seat cutting tool. This is especially critical for an angle such as the main seat contact surface angle of 44° which would be 46° if referenced to the face of the valve seat.

NOTE: *Follow all special equipment manufacturer's instructions.*

1. Clean the carbon deposits from the combustion chambers and valve seats. Check the valve seats for pitting.
2. Minimal and light pitting should be cleaned up with 600 grit lapping compound.

   IMPORTANT: The exhaust valve and seat should be replaced if the pitting cannot be cleaned with a minimal amount of lapping the valve to the seat. If the valve seat is replaced, the top cut of the valve seat must not go below or alter the factory machining of the combustion chamber.
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.



20969

- **a -** Correct valve seat contact area
- **b -** Valve seat too high
- **c -** Valve seat too low
- **d -** Valve seat contact too wide

Valve Outside Diameter	
Intake	36.9–37.1 mm (1.4528–1.4606 in.)
Exhaust	30.9–31.1 mm (1.2165–1.2244 in.)

Valve Face Angle	
Intake	44.75°–45.25°
Exhaust	43.75°–44.25°

Valve Seat Angles	
Intake	30°, 44° ± 0.25°, 60°
Exhaust	35°, 44° ± 0.25°, 55°

Valve Seat Width (44°)	
Intake	1.0 ± 0.1 mm (0.039 ± 0.0039 in.)
Exhaust	1.2 ± 0.1 mm (0.047 ± 0.0039 in.)

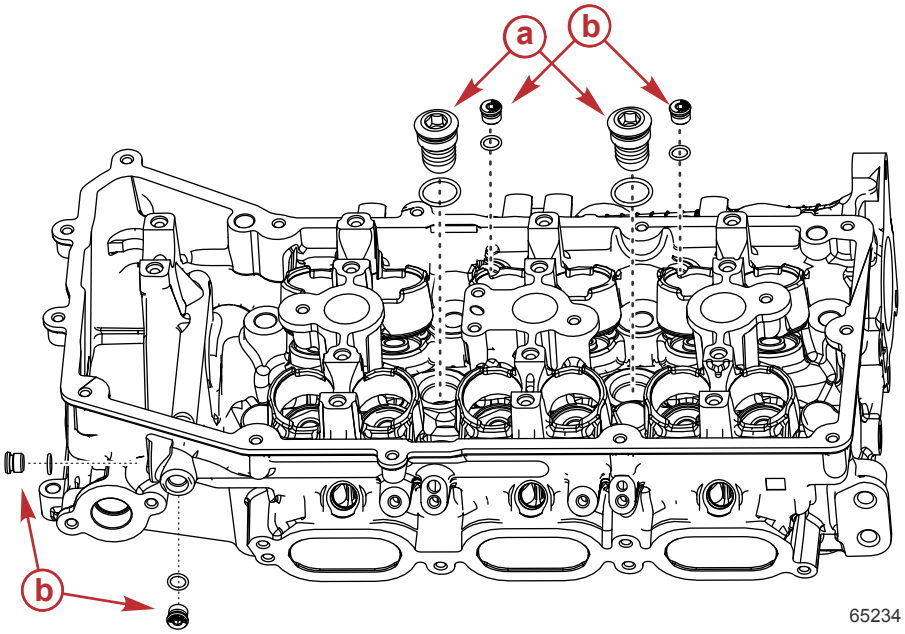
IMPORTANT: After refacing the valve seat, or replacing the valve and valve guide, the valve seat and valve face should be lapped.

IMPORTANT: After reconditioning the valve seat, the valve stem protrusion must be checked.

Cylinder Head Reassembly

V6 Cylinder Head Plugs—Installation

1. Install new O-rings on all plugs, or install new plugs.
2. Install two 10 mm oil plugs on the bottom of the oil gallery.
3. Install two 10 mm plugs and two 21 mm special plugs on the back of the cylinder head.

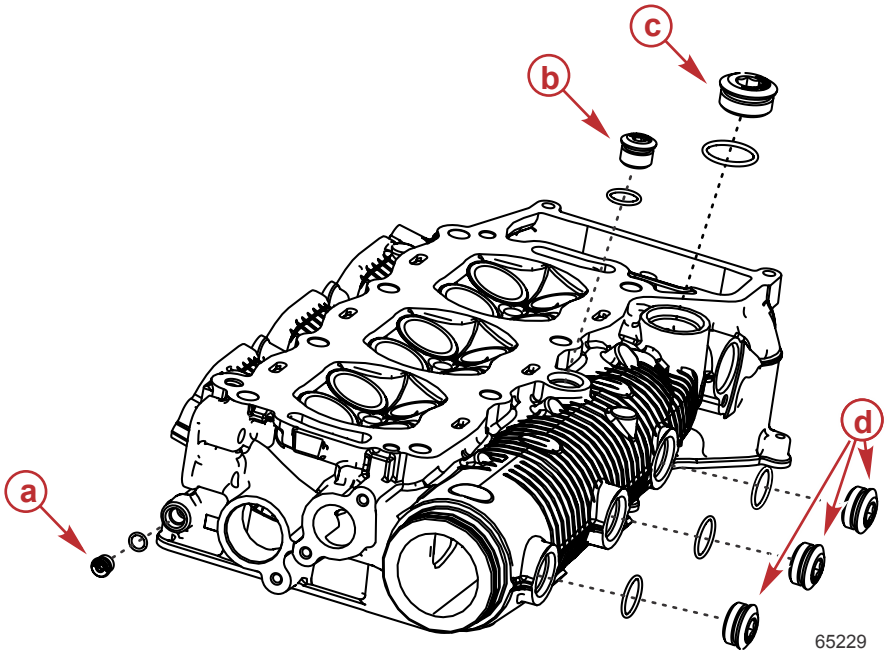


Starboard cylinder head

a - 21 mm special plug (2)

b - 10 mm plug (4)

4. Install one 10 mm plug on the end of the oil gallery (port cylinder head only).



Port cylinder head

a - 10 mm oil gallery plug (port cylinder head only)

b - 18 mm plug

c - 30 mm plug

d - 24 mm plug (3)

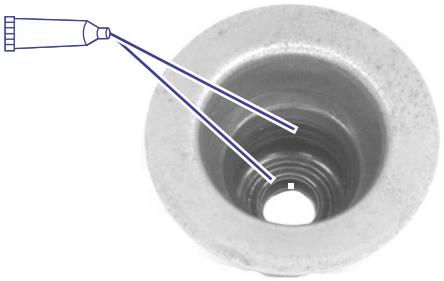
5. Install three 24 mm plugs into the exhaust water jacket.
6. Install the 18 mm and the 30 mm plug from the front of the cylinder head and discard the O-rings.
7. Tighten all plugs to the specified torque.

Description	Nm	lb-in.	lb-ft
10 mm oil gallery plug	7	62	–
18 mm plug	22	–	16.2
21 mm plug	30	–	22.1
24 mm plug	55	–	40.6
30 mm plug	55	–	40.6

Valves

IMPORTANT: The reassembly procedure for the cylinder head must be strictly followed. Failure to follow the assembly procedure may damage the valves, camshaft, or cylinder head.

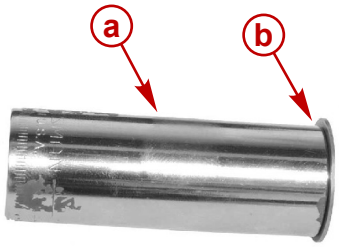
1. Lubricate the valve guide seals with Torco® MPZ HP Engine Assembly Lube.

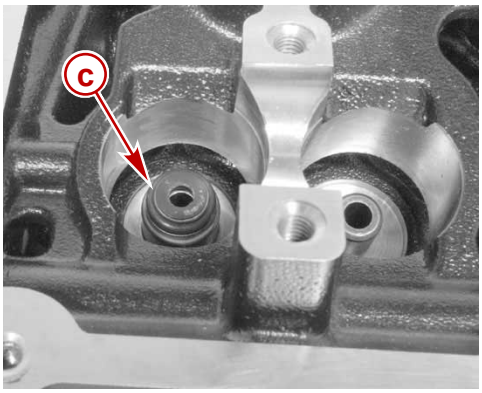


67467

Tube Ref No.	Description	Where Used	Part No.
	Torco® MPZ HP Engine Assembly Lube	Valve guide seals	Obtain Locally

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

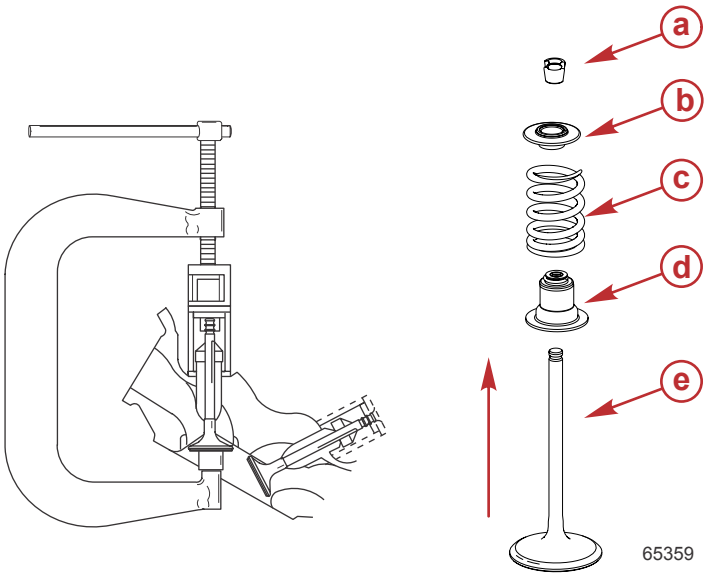
a - 17 mm (11/16 in.) socket
b - Valve guide seal
c - Valve guide seal installed on valve guide

4. Lubricate the valve stem with Torco® MPZ HP Engine Assembly Lube and push the valve through the valve guide seal.

Tube Ref No.	Description	Where Used	Part No.
	Torco® MPZ HP Engine Assembly Lube	Valve stem	Obtain Locally

5. Place the valve spring and valve spring retainer over the valve stem.
6. Compress the valve spring with a valve spring compressor.

IMPORTANT: Use caution when compressing the valve spring. Do not damage the valve, valve spring retainer, or the cylinder head valve bucket tappet bore.

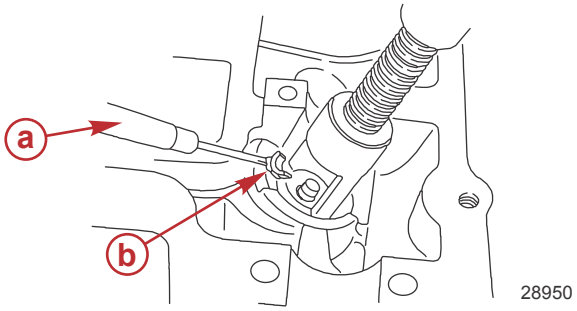


a - Valve spring retaining key
b - Valve spring retainer
c - Valve spring
d - Valve guide seal
e - Valve (intake and exhaust)

Valve Spring Compressor	91-809494A1

7. Place the valve spring retaining key onto the end of a small screwdriver. A small amount of 2-4-C with PTFE applied to the end of the screwdriver will help the valve spring retaining key to adhere to the screwdriver. Install the valve spring retaining keys onto the valve stem.

   IMPORTANT: Two valve spring retaining keys are required per valve.



a - Small screwdriver
b - Valve spring retaining key

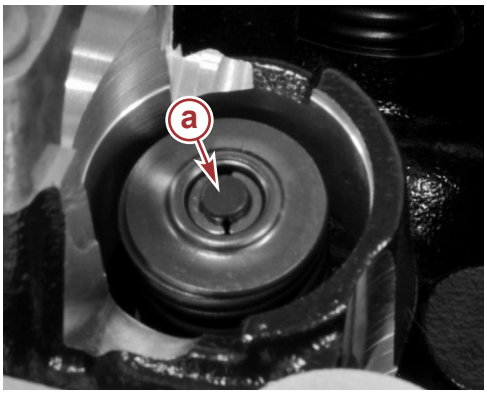
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	End of the screwdriver to help install the valve spring retaining key	92-802859A 1

8. Release the valve spring compressor.
9. Repeat steps 1–8 to install the remaining valves onto the cylinder head.

Valve Bucket Tappets

NOTE: *Refer to* ***Section 4A - Cylinder Block/Crankcase*** *for installation of the cylinder head, camshaft, timing chain, and cylinder block.*

Lubricate the valve bucket tappet outside diameter, valve tip contact pad, or valve tip with Lubriplate SPO 255 and install it in the same location it was removed from during disassembly.



67511

a - Valve tip
b - Valve tip contact pad

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Valve bucket tappet outside diameter, valve tip contact pad, or valve tip	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 3 mm (0.118 in.) valve bucket tappet as a starting point to ensure an accurate valve measurement lash clearance.

Valve Clearance and Adjustments

Valve Clearance Measurement Steps

Valve Lash Clearance	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 in.)

NOTE: *Do not remove the cylinder head from the cylinder block to check the valve lash. Powerhead removal is recommended when checking valve lash. Refer to* ***Section 4A - Removing Powerhead Components and Powerhead Removal****.*

IMPORTANT: Accurate valve clearance measurements must be made on a cold engine at room temperature only after the following assembly procedures are complete.

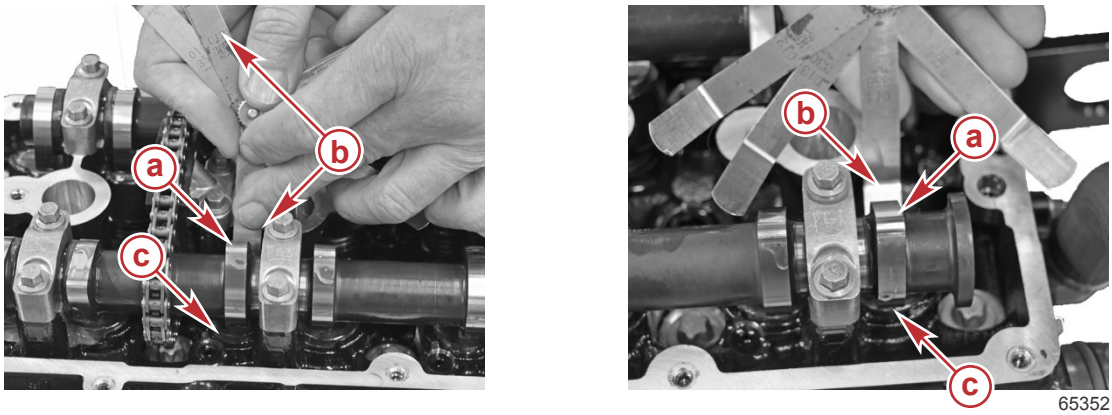
- If removed, the cylinder head must be installed on the cylinder block with head bolts tightened to the specified torque.
- All camshafts (4) must be fully installed with the cam-to-cam chain and cam cap fasteners tightened to the specified torque.

Refer to **Section 4A** for cylinder head, and camshaft installation procedures.

NOTE: *The valve lash measurement must be made with the cam lobe facing 180° from the valve bucket tappet.*

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.

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.



a - Cam lobe (facing 180° from the valve bucket tappet)
b - Feeler gauge
c - Valve bucket tappet

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 **Cylinder Head Disassembly**.

Changing Valve Clearance

IMPORTANT: The following procedure must be completed with the cylinder head mated to the cylinder block with bolts tightened to specification. Failure to have the cylinder head installed with bolts tightened to specification when changing the valve clearance will result in inaccurate measurements.

Refer to **Section 4A - Cylinder Head Installation** for torque specifications and complete cylinder head installation instructions.

Valve Lash Clearance	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 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.

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 calculated in the previous step. This is the required valve bucket tappet height.

EXAMPLE

If the removed valve bucket tappet height is 3 mm (0.118 in.), the feeler gauge valve lash measurement is 0.297 mm (0.011 in.), and the specified valve lash clearance is 0.177 mm (0.007 in.), then the formula will appear as:

Metric measurement: 3 + 0.297 – 0.177 = 3.120 mm. The new valve bucket tappet height is 3.120 mm.

English measurement: 0.118 + 0.011 – 0.007 = 0.122 in. The new valve bucket tappet height is 0.122 in.

NOTE: *Service bucket tappets are available from 3 mm–3.690 mm in 0.015 mm increments, round to the nearest 0.015 mm.*

Measurement Table								
	Intake (cold)				Exhaust (cold)			
Valve	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
Cyl #1 intake								
Cyl #1 intake								
Cyl #1 exhaust								
Cyl #1 exhaust								
Cyl #2 intake								
Cyl #2 intake								
Cyl #2 exhaust								
Cyl #2 exhaust								
Cyl #3 intake								
Cyl #3 intake								
Cyl #3 exhaust								
Cyl #3 exhaust								
Cyl #4 intake								
Cyl #4 intake								
Cyl #4 exhaust								
Cyl #4 exhaust								
Cyl #5 intake								
Cyl #5 intake								
Cyl #5 exhaust								
Cyl #5 exhaust								
Cyl #6 intake								
Cyl #6 intake								
Cyl #6 exhaust								
Cyl #6 exhaust								

Powerhead

Section 4C - Cylinder Head V8

Table of Contents

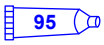
4
C

V8 Cylinder Head Specifications

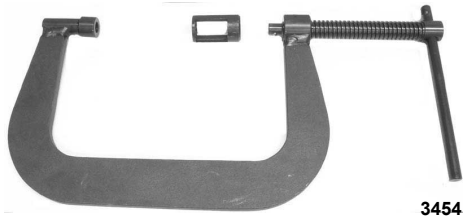
Description	Specification
Head deck maximum warp	0.1 mm (0.0039 in.)
Number of valves	32
Number of valves per cylinder	4
Camshaft bearing inside diameter (cylinder head)	26.000–26.021 mm (1.0236–1.0244 in.)
Camshaft bearing journal	25.96–25.98 mm (1.022–1.023 in.)
Camshaft lobe height	
Intake	43.02 mm (1.694 in.)
Exhaust	44.24 mm (1.742 in.)
Valve lash clearance	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 in.)
Valve seat angles (referenced relative to the valve guide axis)	
Intake	30°, 44° ± 0.25°, 60°
Exhaust	35°, 44° ± 0.25°, 55°
Valve seat width (44°)	
Intake	1.0 ± 0.1 mm (0.039 ± 0.0039 in.)
Exhaust	1.2 ± 0.1 mm (0.047 ± 0.0039 in.)
Valve spring height	
Uncompressed	Reference 46.1 mm (1.815 in.)
Compressed to 33.66 mm (1.3252 in.)	157–173 Nm (35.295–38.892 lb-ft) spring load
Compressed to 24.31 mm (0.9149 in.)	356–390 Nm (80.03–87.67 lb-ft) spring load
Valve outside diameter	
Intake	36.9–37.1 mm (1.4528–1.4606 in.)
Exhaust	30.9–31.1 mm (1.2165–1.2244 in.)
Valve face angle (referenced relative to the end face of the valve)	
Intake	44.75°–45.25°
Exhaust	43.75°–44.25°
Valve margin width	
Intake	0.875 mm (0.034 in.)
Exhaust	1.331 mm (0.052 in.)
Valve stem diameter	
Intake	5.4645–5.4805 mm (0.2151–0.2158 in.)
Exhaust	5.456–5.472 mm (0.2148–0.2154 in.)
Valve stem runout (service limit measured at valve face)	
Intake and exhaust	0.030 mm (0.0012 in.)
Valve height	
Intake	88.49 ± 0.25 mm (3.484 ± 0.0098 in.)
Exhaust	87.667 ± 0.25 mm (3.451 ± 0.0098 in.)
Valve guide bore inside diameter	
Intake and exhaust	5.500–5.512 mm (0.2165–0.217 in.)
Valve stem to valve guide clearance	
Intake	0.0195–0.0475 mm (0.0008–0.0019 in.)
Exhaust	0.028–0.056 mm (0.0011–0.0022 in.)
Valve guide height (dimension from spring seat to end of guide)	
Intake	14.5 mm (0.570 in.)
Exhaust	14.5 mm (0.570 in.)
Valve bucket	

Description	Specification
Intake bucket bore inside diameter	32.000–32.025 mm (1.2589–1.2608 in.)
Exhaust bucket bore inside diameter	32.005–32.025 mm (1.2600–1.2608 in.)
Valve bucket outside diameter	31.964–31.980 mm (1.2584–1.2591 in.)
Bucket to bore clearance	0.020–0.061 mm (0.0008–0.0024 in.)

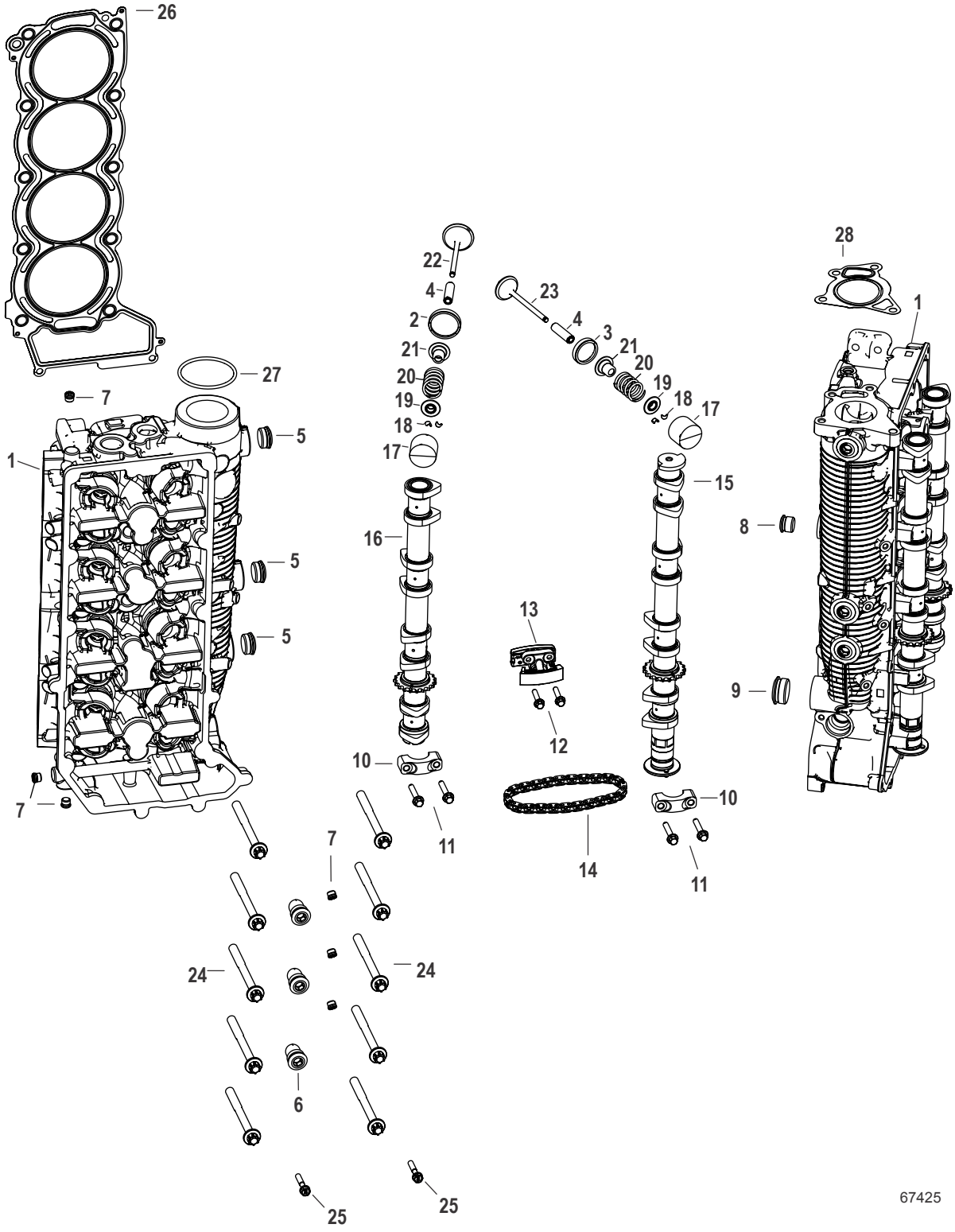
Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Torco® MPZ HP Engine Assembly Lube	Valve guide seals	Obtain Locally
	2-4-C with PTFE	End of the screwdriver to help install the valve spring retaining key	92-802859A 1
	Lubriplate SPO 255	Valve bucket tappet outside diameter, valve tip contact pad, or valve tip	Obtain Locally

Special Tools

Valve Spring Compressor	91-809494A1
	Removes and installs valve springs.

Cylinder Head Components



Cylinder Head Components

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	1	Port cylinder head assembly				
	1	Starboard cylinder head assembly				
2	16	Intake valve seat				
3	16	Exhaust valve seat				
4	32	Valve guide				
5	6	24 mm plug		55	–	40.6
6	6	21 mm plug (special)		30	–	22.1
7	11	10 mm plug		7	62	–
8	2	18 mm plug		22	–	16.2
9	2	30 mm plug		55	–	40.6
10	18	Cap				
11	36	M6 x 35 hex flange	**First**	6	53.1	–
			Final	12	106.2	–
12	4	M6 x 30 screw	**First**	6	53.1	–
			Final	12	106.2	–
13	2	Tensioner				
14	2	Cam-to-cam chain				
15	1	Port exhaust camshaft				
	1	Starboard exhaust camshaft				
16	1	Port intake camshaft				
	1	Starboard intake camshaft				
17	32	Valve bucket tappet				
18	64	Valve key				
19	32	Retainer				
20	32	Spring				
21	32	Valve seal				
22	16	Intake valve				
23	16	Exhaust valve				
24	32	E14 Torx flange head bolt	**First**	15	132.8	–
			Second	35	–	25.8
			Final	Tighten an additional 60°		
25	4	M6 x 35 screw		12	106.2	–
26	1	Port cylinder head gasket				
	1	Starboard cylinder head gasket				
27	1	O-ring				
28	1	Exhaust manifold gasket				

Cylinder Head Service Recommendations

All marine engines require periodic inspection and maintenance. Extreme duty cycles and harsh marine enviornements can cause catastrophic engine failure if routine maintenance is not performed at the specified intervals. Failure to follow the engine's **Inspection and Maintenance Schedule** can lead to performance problems, engine failure, and expensive repairs.

Cylinder heads and machined components are manufactured to extremely close tolerances and should only be repaired or replaced by a qualified technician. An automotive machine shop that is capable of performing high quality, close tolerance, machining operations to the manufacture's specifications must be utilized if a cylinder head is damaged. Damage to cylinder heads from improper machining can cause detonation, alter exhaust emissions, and compromise engine performance.

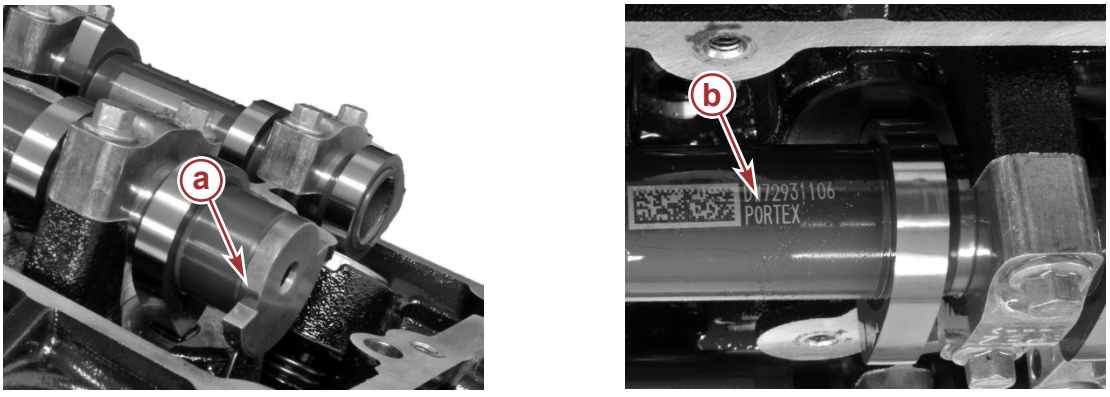
IMPORTANT: Always compare the price of a complete replacement assembly with the cost of cylinder head repair and valve installation when estimating service work.

Machine Shop Information—Lash for Life Cylinder Head Repair

- The cylinder head must be properly installed on the cylinder block using a new head gasket to verify valve lash clearance. Checking valve lash clearance must be completed with the cylinder head mated to the cylinder block and tightened to the specified torque. Failure to properly install the cylinder head before checking valve clearance will result in inaccurate measurements. Refer to **Section 4A - Cylinder Head Installation**.
- If the valve lash clearance is not within the tolerance as listed in the **V8 Cylinder Head Specifications** table then a problem with the camshaft lobes, journals, caps, or cylinder head is indicated.
- The valve tappets have different dimensions. Do not replace an original tappet with a taller or shorter tappet to compensate for a worn or damaged part.
- The valve guide seals must be replaced if the valves are removed from the cylinder head.
- The valve spring coil ratio is the same at both ends of the spring and the springs do not have a top or bottom orientation.
- Bronze sleeved guide bore liners are an acceptable service replacement as an alternative to valve guides.
- The cylinder head must be heated to 176.6 °C (350 °F) before the valve guides are extracted. Remove all plugs before heating.
- Lubricate the valve guides with a light oil before installation.

FourStroke V8 DOHC—Camshaft Identification

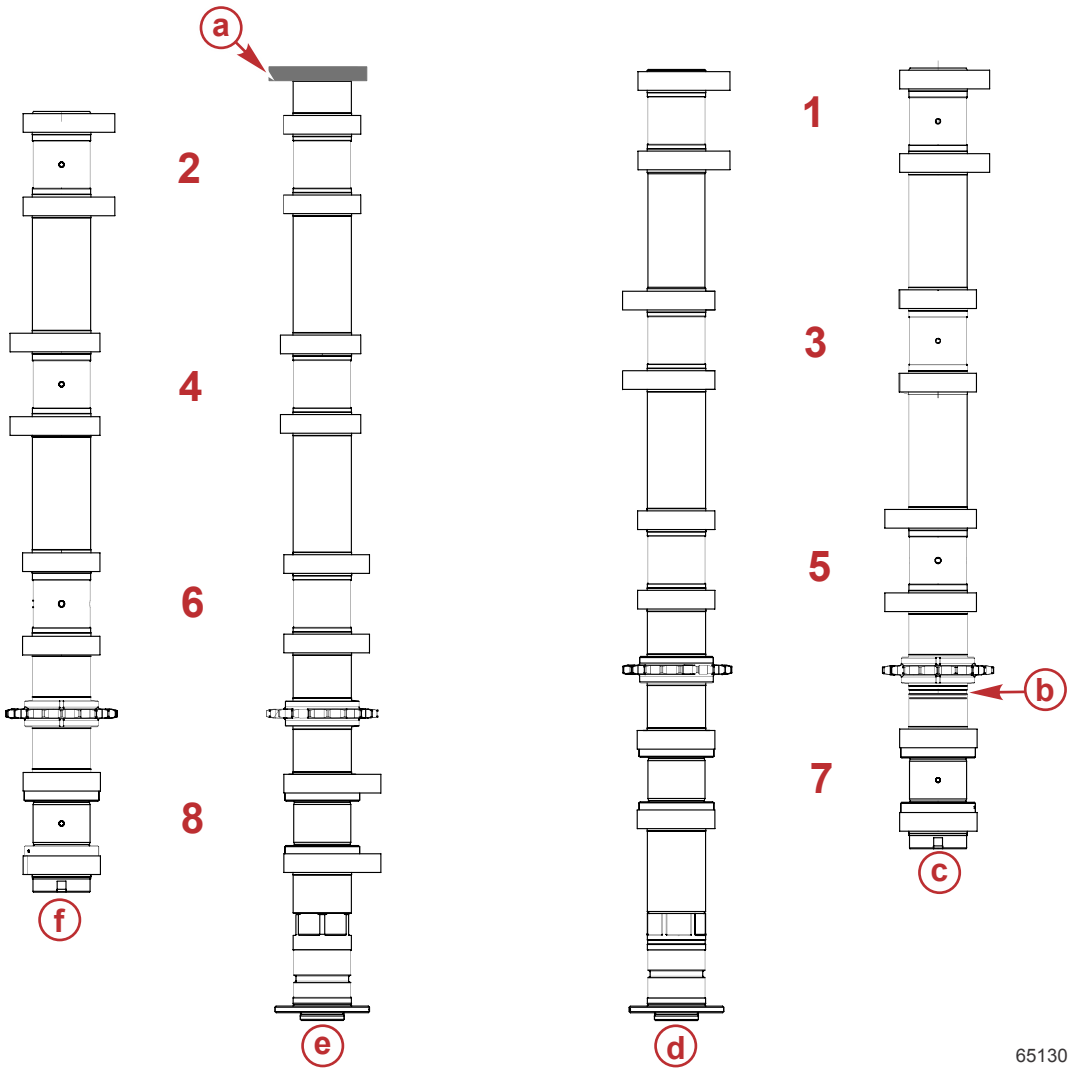
The port exhaust camshaft can be identified by the sensor target at the top of the camshaft. The starboard intake camshaft can be identified by the groove below the chain gear. Each camshaft has an identification mark. Refer to **Section 4A** for camshaft installation procedures.



67354

a - Sensor target—port exhaust camshaft
b - Camshaft identification mark

NOTE: *Observe the camshafts identification marks during powerhead assembly to ensure that each camshaft is installed in the correct location.*



Camshaft identification

- **a -** Sensor target
- **b -** Groove below the chain gear (starboard intake camshaft only)
- **c -** Starboard intake camshaft
- **d -** Starboard exhaust camshaft
- **e -** Port exhaust camshaft
- **f -** Port intake camshaft

Ref.	Description
1	Cylinder number 1
2	Cylinder number 2
3	Cylinder number 3
4	Cylinder number 4
5	Cylinder number 5
6	Cylinder number 6
7	Cylinder number 7
8	Cylinder number 8

Cylinder Head Disassembly

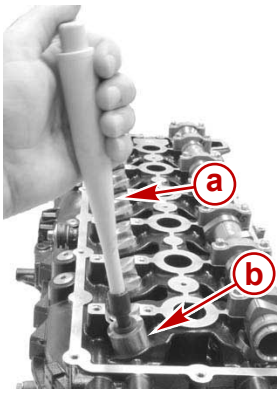
Valve Removal

NOTE: *Refer to* ***Section 4A - Cylinder Block/Crankcase*** *for powerhead, timing chain, camshaft, and cylinder head removal procedures.*

1. Clean the surface of the valve buckets with a solvent to remove any oil residue. With an indelible 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 plunger or suction cup device. 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.



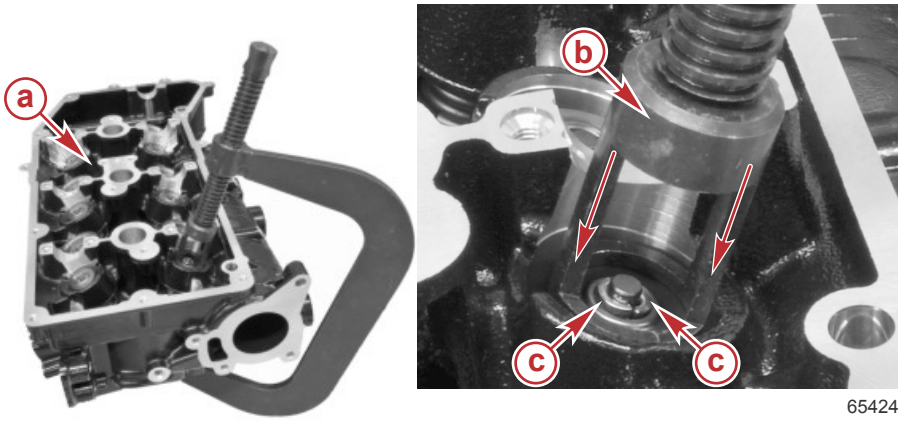
4016

a - Suction cup device
b - Valve bucket tappet

3. Use a valve spring compressor to collapse the valve spring and remove the valve spring retainers and keys.

   NOTE: *Be certain that the cylinder head valve bucket tappet bore is not damaged when using the valve spring compressor.*

   IMPORTANT: Each part must be installed in its original location during reassembly.



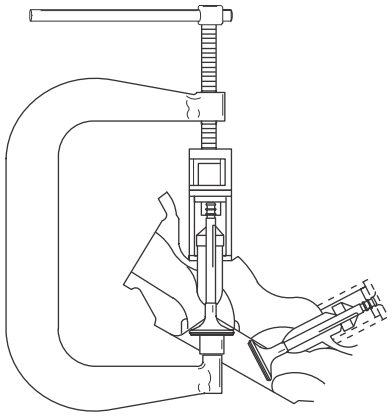
65424

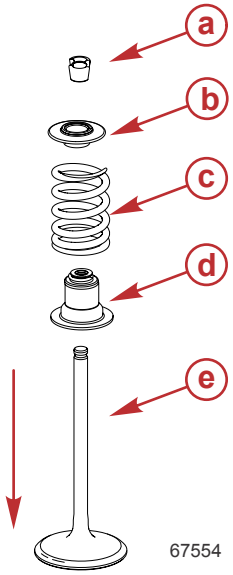
a - Cylinder head
b - Valve spring compressor
c - Retainers (2)

Valve Spring Compressor	91-809494A1

4. Release the valve spring compressor.

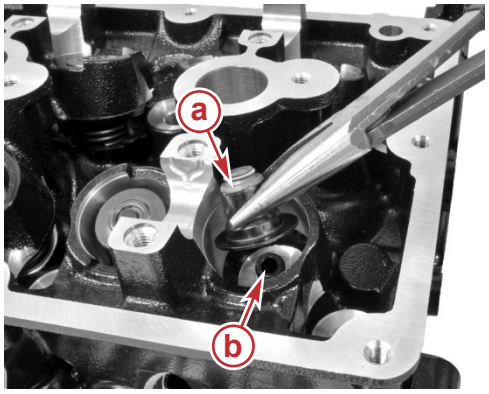
5. Remove the valve from the cylinder head by pulling it through the valve guide and seal.





a - Valve spring retaining key
b - Valve spring retainer
c - Valve spring
d - Valve guide seal
e - Valve

6. Remove the valve spring.
7. Remove the valve guide seal.



a - Valve guide seal
b - Valve guide

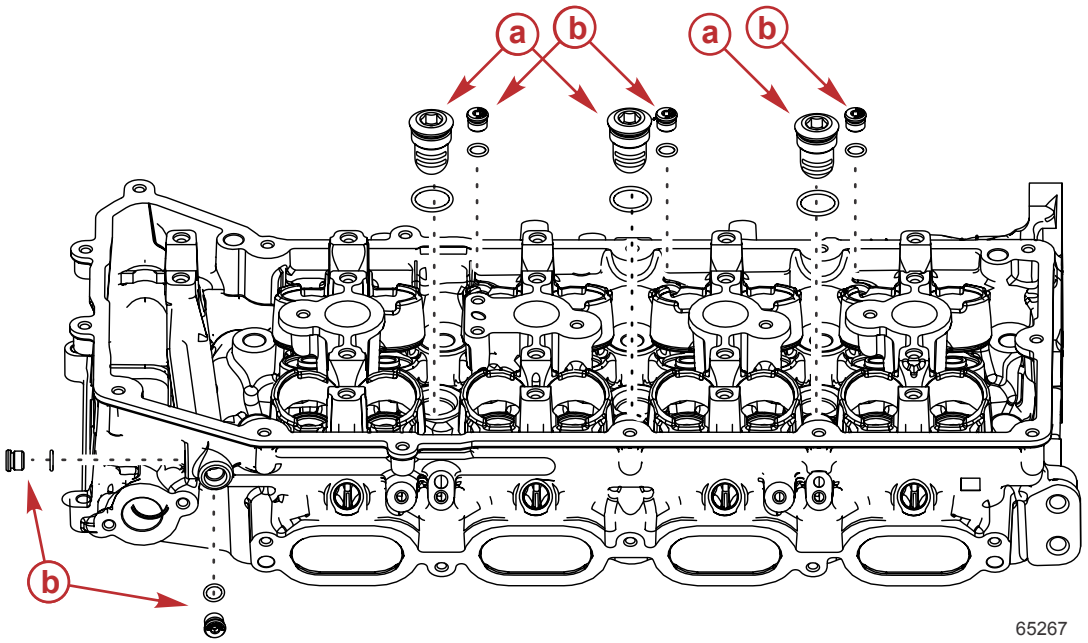
IMPORTANT: Do not reuse valve guide seals after the valve has been removed.

V8 Cylinder Head Plugs—Removal

NOTE: *It may be necessary to lightly tap on the gallery plugs with a brass drift and hammer to break the gallery plug seal.*

1. Remove two 10 mm plugs from the bottom of the oil gallery and discard the O-rings.

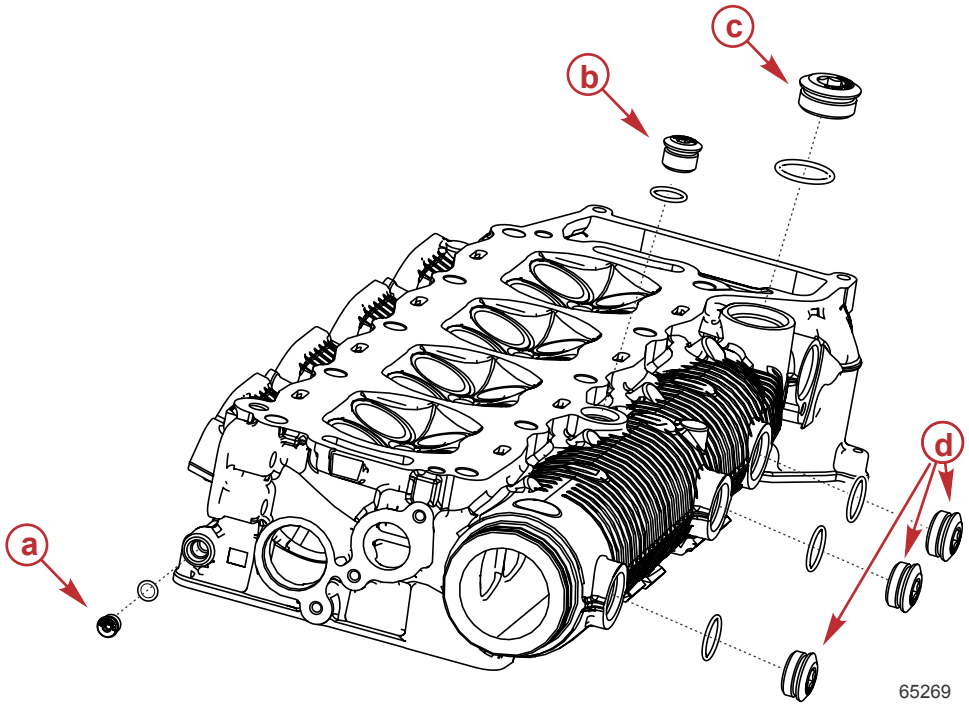
2. Remove three 10 mm plugs and three 21 mm special plugs from the back of the cylinder head. Discard the O-rings.



Starboard head shown

a - 21 mm special plug (3)
b - 10 mm plug (5)

3. Remove the 10 mm plug from the end of the oil gallery and discard the O-ring (port cylinder head only).
4. Remove the three 24 mm plugs from the exhaust water jacket and discard the O-rings.
5. Remove the 18 mm and the 30 mm plug from the front of the cylinder head and discard the O-rings.



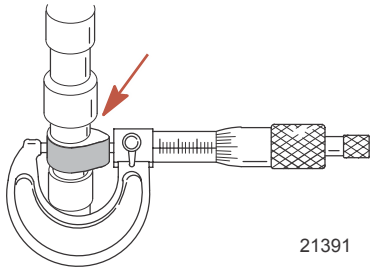
Port head shown

a - 10 mm oil gallery plug (port cylinder head only)
b - 18 mm plug
c - 30 mm plug
d - 24 mm plug (3)

Cleaning/Inspection/Repair

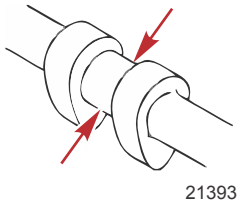
Camshaft

1. Measure the camshaft lobe at its maximum valve lift. Replace the camshaft if the dimensions are out of specification.



Camshaft Lobe Height	
Intake cam	43.02 mm (1.694 in.)
Exhaust cam	44.24 mm (1.742 in.)

2. Measure all of the camshaft bearing journals with a micrometer. Replace the camshaft if the journal dimensions are out of specification.



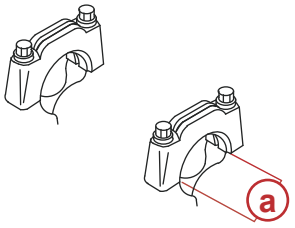
Camshaft Bearing Journal	
Intake and exhaust journal outside diameter	25.96–25.98 mm (1.022–1.023 in.)

IMPORTANT: Torque stages apply to a pair of fasteners for a single camshaft cap, i.e. both fasteners tightened to first stage specified torque, then both fasteners tightened to final stage specified torque.

3. Install the camshaft caps in their correct location and orientation. Tighten the camshaft bearing cap fasteners to the specified torque.

Description		Nm	lb-in.	lb-ft
Camshaft caps	**First**	6	53.1	–
	Final	12	106.2	–

4. Measure the inside diameter of the camshaft bearing surface. Replace the cylinder head if the dimension is out of specification.



a - Camshaft bearing surface inside diameter

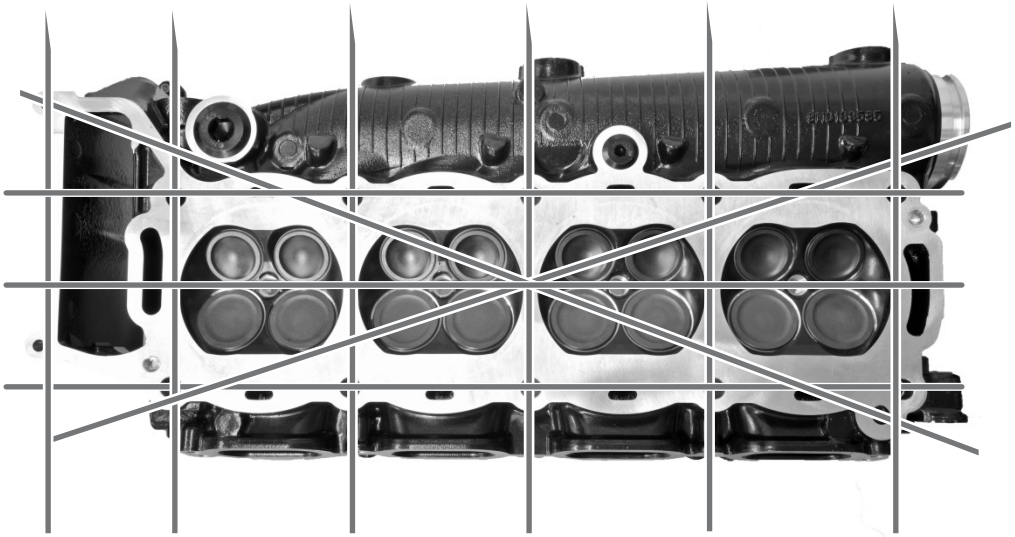
Camshaft Bearing Surface Inside Diameter	
Inside diameter	26.000–26.021 mm (1.0236–1.0244 in.)

V8 Cylinder Head

1. Inspect the cylinder head for mineral deposits and corrosion in the water passageways. Remove deposits and corrosion if found.
2. Pressure test the cylinder head to ensure that there are no leaks or cracks.
3. Inspect the cylinder head for carbon deposits in the combustion chamber. Use a round scraper to clean away deposits. Be careful not to scratch or remove material from the cylinder head.

4. Measure the cylinder head for warpage using a straightedge and a feeler gauge. Maximum warpage must not exceed 0.1 mm (0.0039 in.) in any area of the cylinder head deck. Replace the cylinder head if it is out of specification.

NOTE: *Use a straightedge and a feeler gauge to inspect the cylinder head for warpage.*



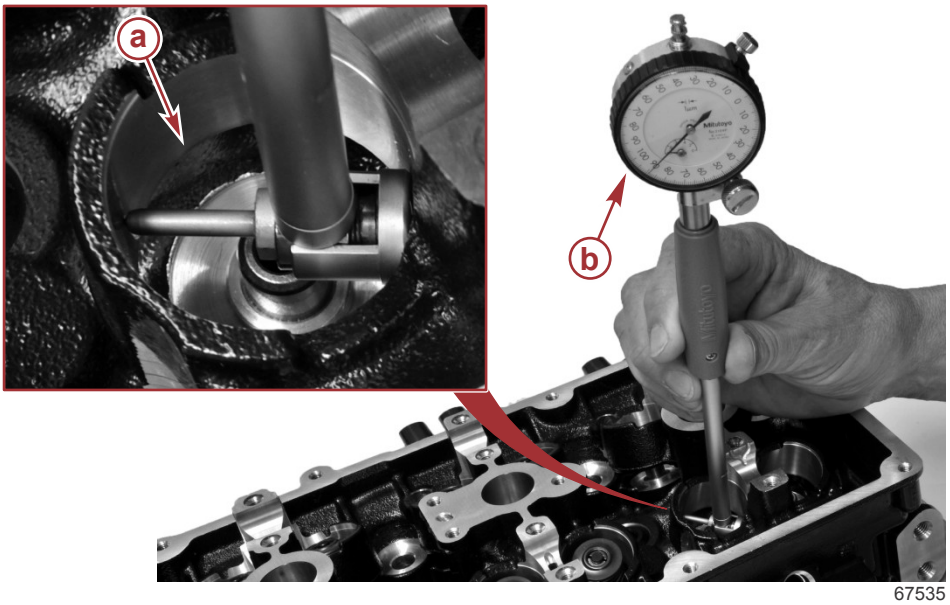
65195

Description	Specification
Head deck maximum warp	0.1 mm (0.0039 in.)

Valve Bucket Tappets

Bore Inside Diameter

Description	Specification
Intake bucket bore inside diameter	32.000–32.025 mm (1.2589–1.2608 in.)
Exhaust bucket bore inside diameter	32.005–32.025 mm (1.2600–1.2608 in.)



67535

Checking bucket bore diameter

a - Bucket bore
b - Bore gauge

Valve Bucket Tappet Outside Diameter

Description	Specification
Valve bucket outside diameter	31.964–31.980 mm (1.2584–1.2591 in.)

67538

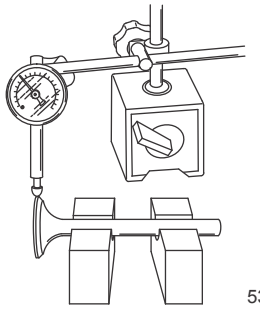
a - Valve bucket tappet
b - Digital micrometer

Bucket Tappet to Bore Clearance

Description	Specification
Bucket to bore clearance	0.020–0.061 mm (0.0008–0.0024 in.)

Valves

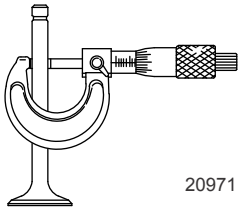
1. Inspect the valves for damage or warpage. Replace the valves if necessary.
2. Measure the valve stem runout. Replace the valves if they are out of specification.



53483

Valve Stem Runout	
Service limit measured at valve face (maximum)	0.030 mm (0.0012 in.)

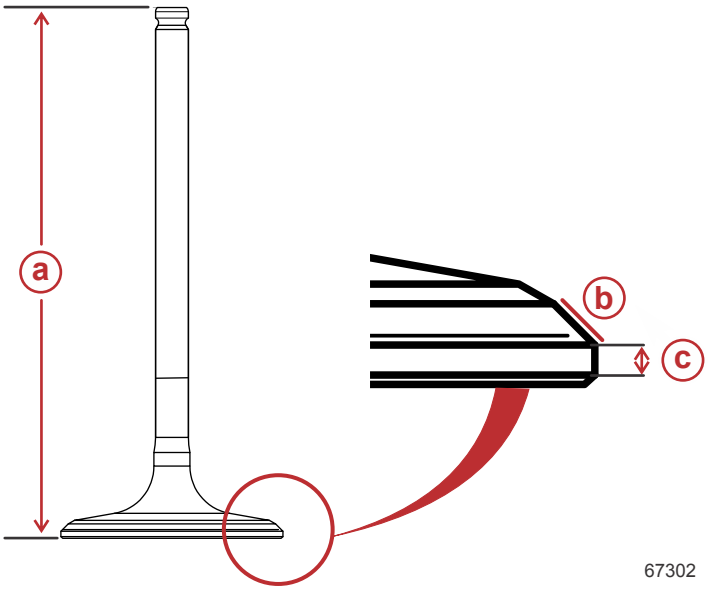
3. Measure the valve stem diameter. Replace the valves if they are out of specification.



20971

Valve Stem Diameter	
Intake	5.4645–5.4805 mm (0.2151–0.2158 in.)
Exhaust	5.456–5.472 mm (0.2148–0.2154 in.)

4. Measure the valve margin width and valve height. Replace the valve if it is out of specification.



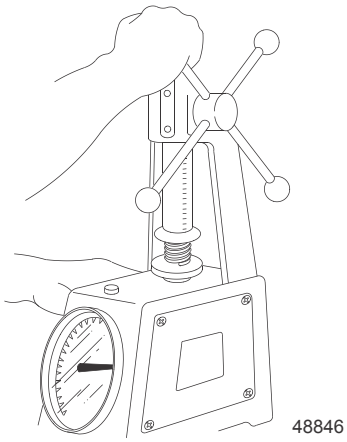
a - Valve height
b - Valve seat contact
c - Valve margin width

Valve Margin Width	
Intake	0.875 mm (0.034 in.)
Exhaust	1.331 mm (0.052 in.)

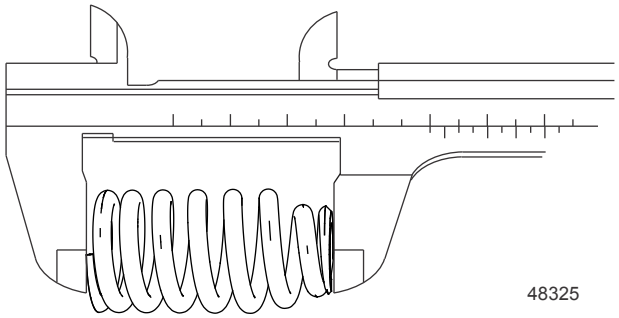
Valve Height	
Intake	88.49 ± 0.25 mm (3.484 ± 0.0098 in.)
Exhaust	87.667 ± 0.25 mm (3.451 ± 0.0098 in.)

Valve Springs

1. Using a valve spring tester, test the valve spring load at the installed height. Refer to the following table for height and load specifications.



Valve Spring Height	Length Specification
Uncompressed	46.1 mm (1.815 in.)

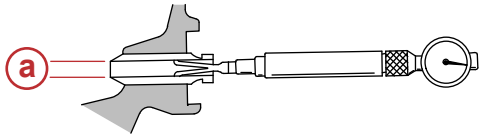


Valve Spring Height	Spring Load Specification
Compressed to 33.66 mm (1.3252 in.)	157–173 Nm (35.295–38.892 lb-ft)
Compressed to 24.31 mm (0.9149 in.)	356–390 Nm (80.03–87.67 lb-ft)

2. Replace the valve springs if they are out of specification.

Valve Guides

Measure the valve guide bore with a valve guide bore gauge. If the valve guide wear is out of specification, replace the valve guide.



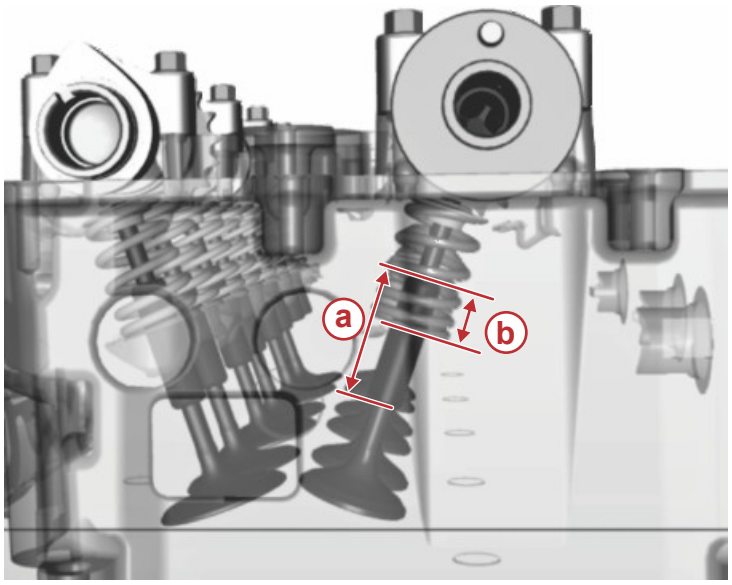
a - Valve guide bore

Valve Guide Bore Inside Diameter	
Intake	5.500–5.512 mm (0.2165–0.2170 in.)
Exhaust	5.500–5.512 mm (0.2165–0.2170 in.)

Valve Guide Replacement

NOTE: *Inexperienced personnel should not attempt to replace the valve guides. Bronze sleeved guide bore liners are an acceptable service replacement as an alternative to valve guides.*

IMPORTANT: Install valve guides using a seat and guide machine with light oil lubrication.



Exhaust shown, intake is same dimension

a - Overall guide length

b - Valve guide height (dimension from spring seat to end of guide)

Valve Guide Height	
Intake (dimension from spring seat to end of guide)	14.5 mm (0.570 in.)
Exhaust (dimension from spring seat to end of guide)	14.5 mm (0.570 in.)

Valve Stem to Valve Guide Clearance	
Intake	0.0195–0.0475 mm (0.0008–0.0019 in.)
Exhaust	0.028–0.056 mm (0.0011–0.0022 in.)

Valve Seat Reconditioning

The cylinder head is machined to extremely close tolerances. The cylinder head and related components should only be repaired by a qualified technician with experience in servicing high-performance engines. A qualified machine shop with special industrial tools that is familiar with automotive engine machining techniques must be utilized if the cylinder head requires reconditioning or clearance correction repair. Damage to the cylinder head combustion area can alter the emissions output of the engine. In some cases it may be necessary to replace the cylinder head assembly if it cannot be repaired, or if repair costs exceed the cost of cylinder head replacement.

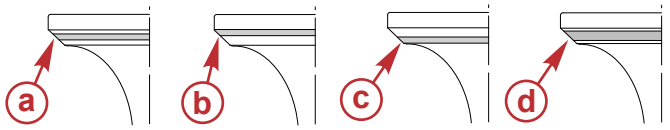
IMPORTANT: Valve seat angle specifications must be carefully observed when cutting valve seats. Modification of the combustion chamber area or flow characteristics of the engine will alter exhaust emissions and can effect the engine's performance.

Valve seat angles are referenced relative to the guide axis, not the face of the valve seat as is commonly used when specifying a service seat cutting tool. This is especially critical for an angle such as the main seat contact surface angle of 44° which would be 46° if referenced to the face of the valve seat.

NOTE: *Follow all special equipment manufacturer's instructions.*

1. Clean the carbon deposits from the combustion chambers and valve seats. Check the valve seats for pitting.
2. Minimal and light pitting should be cleaned up with 600 grit lapping compound.

   IMPORTANT: The exhaust valve and seat should be replaced if the pitting cannot be cleaned with a minimal amount of lapping the valve to the seat. If the valve seat is replaced, the top cut of the valve seat must not go below or alter the factory machining of the combustion chamber.
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.



20969

a - Correct valve seat contact area
b - Valve seat too high
c - Valve seat too low
d - Valve seat contact too wide

Valve Outside Diameter	
Intake	36.9–37.1 mm (1.4528–1.4606 in.)
Exhaust	30.9–31.1 mm (1.2165–1.2244 in.)

Valve Face Angle	
Intake	44.75°–45.25°
Exhaust	43.75°–44.25°

Valve Seat Angles	
Intake	30°, 44° ± 0.25°, 60°
Exhaust	35°, 44° ± 0.25°, 55°

Valve Seat Width (44°)	
Intake	1.0 ± 0.1 mm (0.039 ± 0.0039 in.)
Exhaust	1.2 ± 0.1 mm (0.047 ± 0.0039 in.)

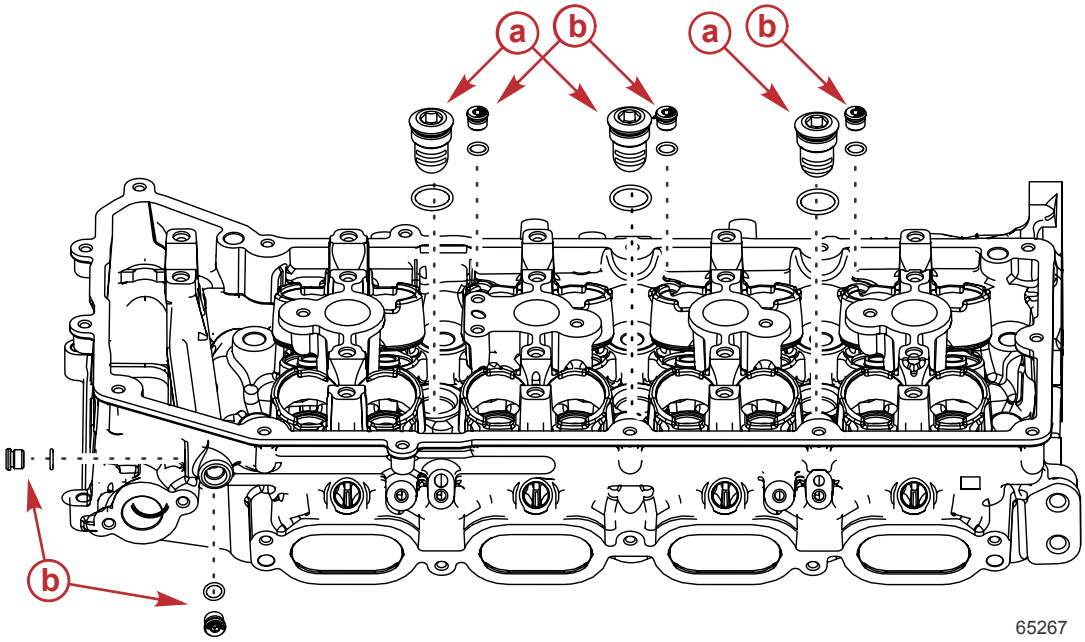
IMPORTANT: After refacing the valve seat, or replacing the valve and valve guide, the valve seat and valve face should be lapped.

IMPORTANT: After reconditioning the valve seat, the valve stem protrusion must be checked.

Cylinder Head Reassembly

V8 Cylinder Head Plugs—Installation

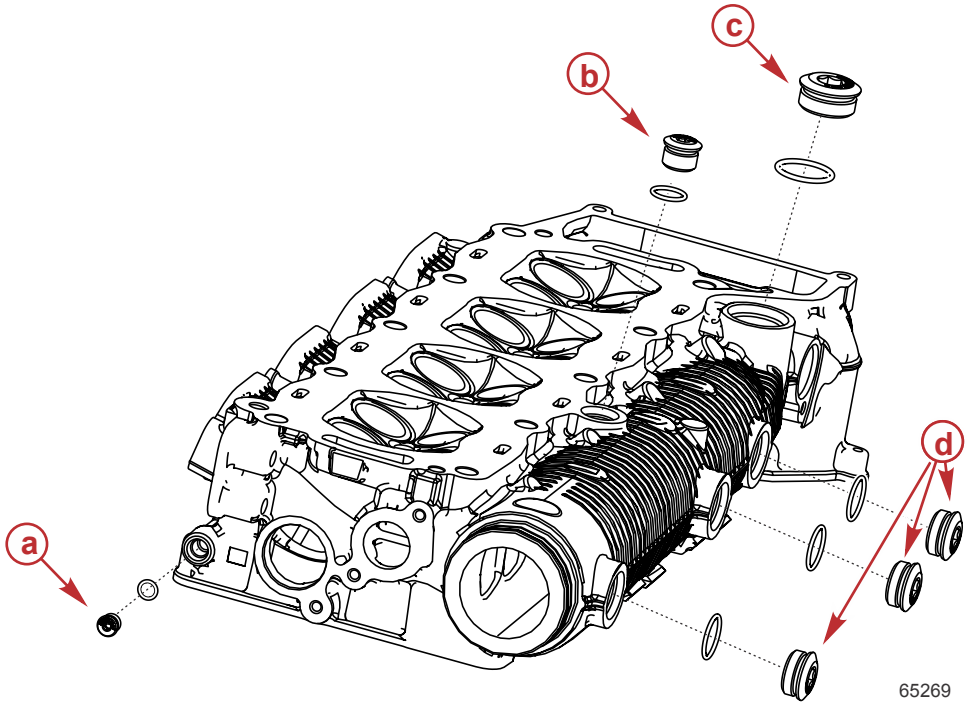
1. Install new O-rings on all plugs, or install new plugs.
2. Install two 10 mm plugs on the bottom of the oil gallery.
3. Install three 10 mm plugs and three 21 mm special plugs on the back of the cylinder head.



Starboard cylinder head

a - 21 mm special plug (3)
b - 10 mm plug (5)

4. Install one 10 mm plug on the end of the oil gallery (port cylinder head only).



Port cylinder head

a - 10 mm oil gallery plug (port cylinder head only)
b - 18 mm plug
c - 30 mm plug
d - 24 mm plug (3)

5. Install three 24 mm plugs into the exhaust water jacket.
6. Install the 18 mm and the 30 mm plug from the front of the cylinder head and discard the O-rings.

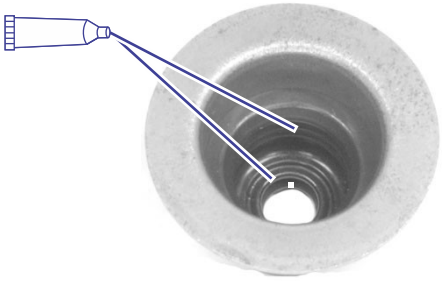
7. Tighten all plugs to the specified torque.

Description	Nm	lb-in.	lb-ft
10 mm oil gallery plug	7	62	–
18 mm plug	22	–	16.2
21 mm plug	30	–	22.1
24 mm plug	55	–	40.6
30 mm plug	55	–	40.6

Valves

IMPORTANT: The reassembly procedure for the cylinder head must be strictly followed. Failure to follow the assembly procedure may damage the valves, camshaft, or cylinder head.

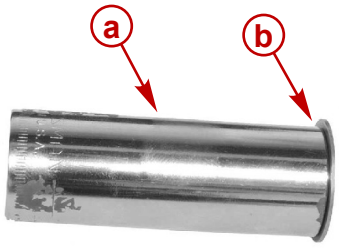
1. Lubricate the valve guide seals with Torco® MPZ HP Engine Assembly Lube.

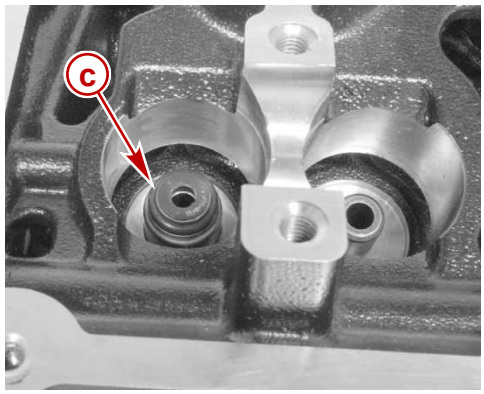


67467

Tube Ref No.	Description	Where Used	Part No.
	Torco® MPZ HP Engine Assembly Lube	Valve guide seals	Obtain Locally

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

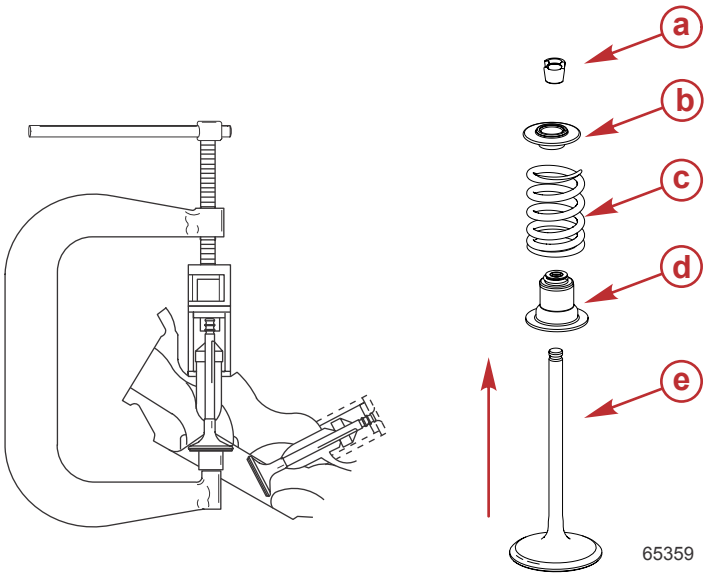
a - 17 mm (11/16 in.) socket
b - Valve guide seal
c - Valve guide seal installed on valve guide

4. Lubricate the valve stem with Torco® MPZ HP Engine Assembly Lube and push the valve through the valve guide seal.

Tube Ref No.	Description	Where Used	Part No.
	Torco® MPZ HP Engine Assembly Lube	Valve stem	Obtain Locally

5. Place the valve spring and valve spring retainer over the valve stem.
6. Compress the valve spring with a valve spring compressor.

IMPORTANT: Use caution when compressing the valve spring. Do not damage the valve, valve spring retainer, or the cylinder head valve bucket tappet bore.

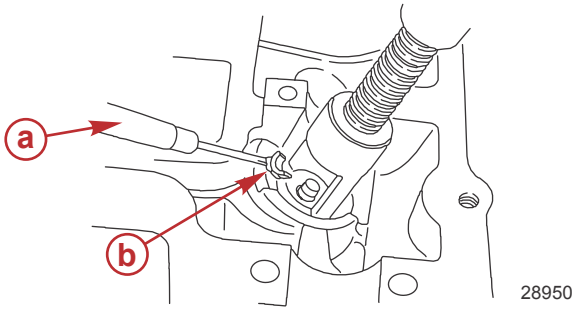


a - Valve spring retaining key
b - Valve spring retainer
c - Valve spring
d - Valve guide seal
e - Valve (intake and exhaust)

Valve Spring Compressor	91-809494A1

7. Place the valve spring retaining key onto the end of a small screwdriver. A small amount of 2-4-C with PTFE applied to the end of the screwdriver will help the valve spring retaining key to adhere to the screwdriver. Install the valve spring retaining keys onto the valve stem.

   IMPORTANT: Two valve spring retaining keys are required per valve.



a - Small screwdriver
b - Valve spring retaining key

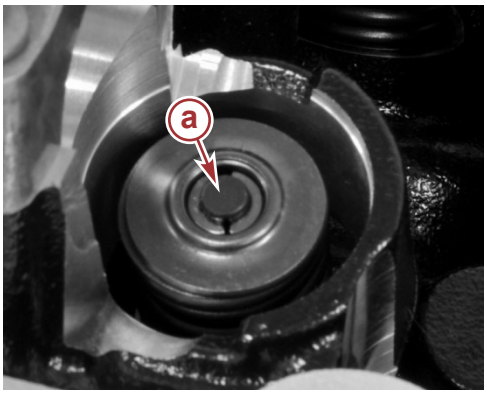
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	End of the screwdriver to help install the valve spring retaining key	92-802859A 1

8. Release the valve spring compressor.
9. Repeat steps 1–8 to install the remaining valves onto the cylinder head.

Valve Bucket Tappets

NOTE: *Refer to* ***Section 4A - Cylinder Block/Crankcase*** *for installation of the cylinder head, camshaft, timing chain, and cylinder block.*

Lubricate the valve bucket tappet outside diameter, valve tip contact pad, or valve tip with Lubriplate SPO 255 and install it in the same location it was removed from during disassembly.



67511

a - Valve tip
b - Valve tip contact pad

Tube Ref No.	Description	Where Used	Part No.
136	Lubriplate SPO 255	Valve bucket tappet outside diameter, valve tip contact pad, or valve tip	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 3 mm (0.118 in.) valve bucket tappet as a starting point to ensure an accurate valve measurement lash clearance.

Valve Clearance and Adjustments

Valve Clearance Measurement Steps

Valve Lash Clearance	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 in.)

NOTE: *Do not remove the cylinder head from the cylinder block to check the valve lash. Powerhead removal is recommended when checking valve lash. Refer to* ***Section 4A - Removing Powerhead Components and Powerhead Removal****.*

IMPORTANT: Accurate valve clearance measurements must be made on a cold engine at room temperature only after the following assembly procedures are complete.

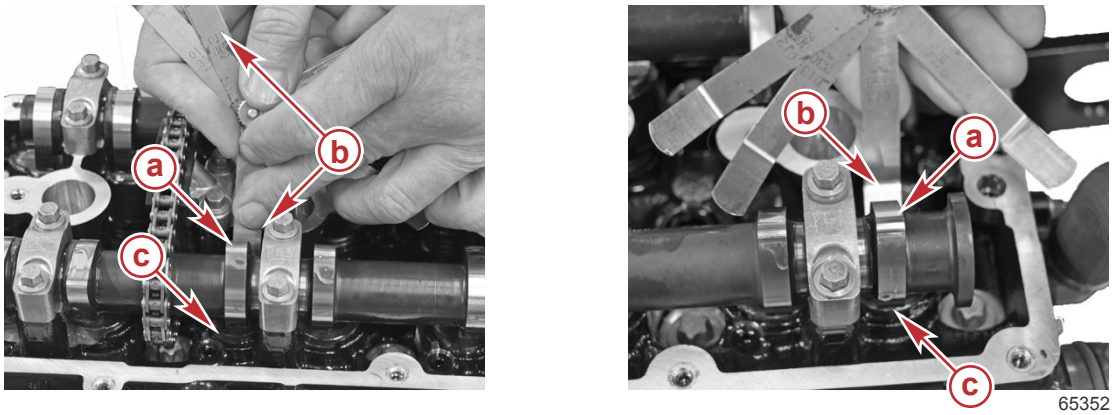
- If removed, the cylinder head must be installed on the cylinder block with head bolts tightened to the specified torque.
- All camshafts (4) must be fully installed with the cam-to-cam chain and cam cap fasteners tightened to the specified torque.

Refer to **Section 4A** for cylinder head, and camshaft installation procedures.

NOTE: *The valve lash measurement must be made with the cam lobe facing 180° from the valve bucket tappet.*

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.

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.



a - Cam lobe (facing 180° from the valve bucket tappet)
b - Feeler gauge
c - Valve bucket tappet

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 **Cylinder Head Disassembly**.

Changing Valve Clearance

IMPORTANT: The following procedure must be completed with the cylinder head mated to the cylinder block with bolts tightened to specification. Failure to have the cylinder head installed with bolts tightened to specification when changing the valve clearance will result in inaccurate measurements.

Refer to **Section 4A - Cylinder Head Installation** for torque specifications and complete cylinder head installation instructions.

Valve Lash Clearance Specification	
Intake	0.125–0.225 mm (0.005–0.009 in.)
Exhaust	0.300–0.400 mm (0.012–0.016 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.

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 calculated in the previous step. This is the required valve bucket tappet height.

EXAMPLE

If the removed valve bucket tappet height is 3 mm (0.118 in.), the feeler gauge valve lash measurement is 0.297 mm (0.011 in.), and the specified valve lash clearance is 0.177 mm (0.007 in.), then the formula will appear as:

Metric measurement: 3 + 0.297 – 0.177 = 3.120 mm. The new valve bucket tappet height is 3.120 mm.

English measurement: 0.118 + 0.011 – 0.007 = 0.122 in. The new valve bucket tappet height is 0.122 in.

NOTE: *Service bucket tappets are available from 3 mm–3.690 mm in 0.015 mm increments, round to the nearest 0.015 mm.*

Measurement Table								
	Intake (cold)				Exhaust (cold)			
Valve	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
Cyl #1 intake								
Cyl #1 intake								
Cyl #1 exhaust								
Cyl #1 exhaust								
Cyl #2 intake								
Cyl #2 intake								
Cyl #2 exhaust								
Cyl #2 exhaust								
Cyl #3 intake								
Cyl #3 intake								
Cyl #3 exhaust								
Cyl #3 exhaust								
Cyl #4 intake								
Cyl #4 intake								
Cyl #4 exhaust								
Cyl #4 exhaust								
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Cyl #5 intake								
Cyl #5 exhaust								
Cyl #5 exhaust								
Cyl #6 intake								
Cyl #6 intake								
Cyl #6 exhaust								
Cyl #6 exhaust								
Cyl #7 intake								
Cyl #7 intake								
Cyl #7 exhaust								
Cyl #7 exhaust								
Cyl #8 intake								
Cyl #8 intake								
Cyl #8 exhaust								
Cyl #8 exhaust								

Powerhead

Section 4D - Lubrication

Table of Contents

4
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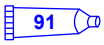
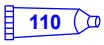
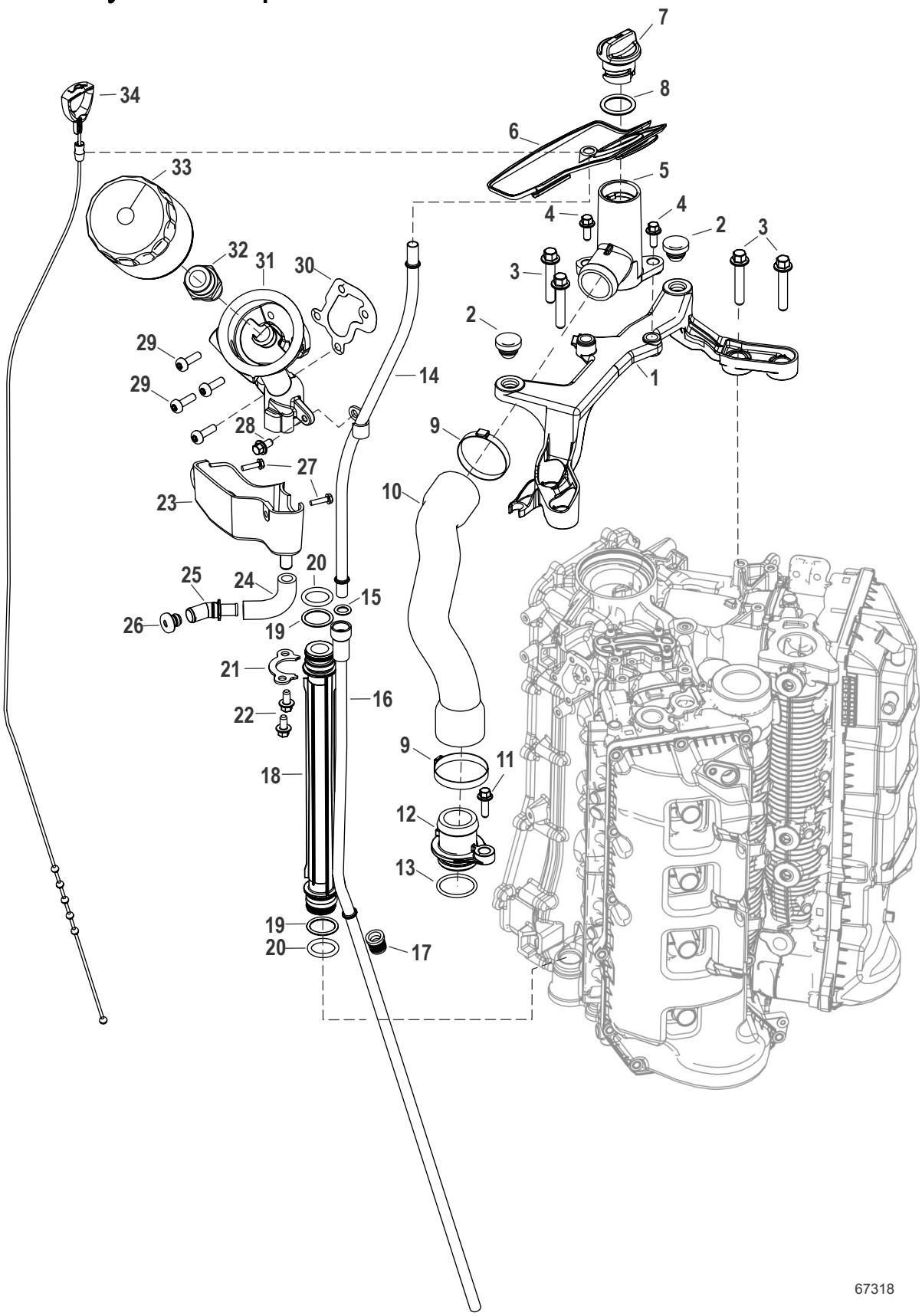
Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Engine Coupler Spline Grease	Oil pump seals and O-rings	8M0071842
	10W-30 4-Stroke Marine Engine Oil	Oil pump outer rotor	92-8M0078625
		Oil pump inner rotor	
		Oil pump	

Notes:

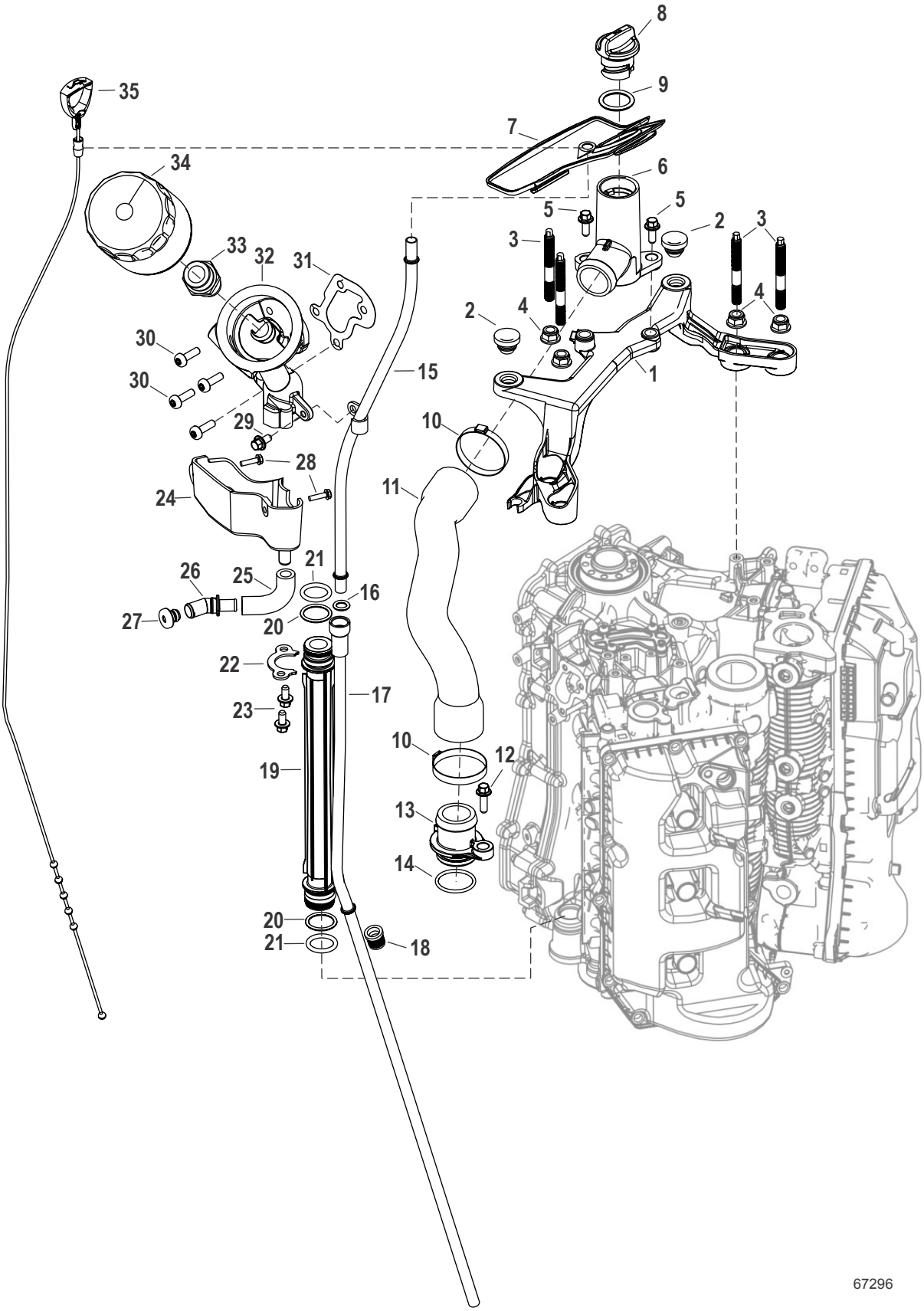
Lubrication System Components - V8



Lubrication System Components - V8

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Bracket			
2	2	Grommet			
3	4	M8 x 45 hex flange head screw	30	–	22.1
4	2	M6 x 16 hex flange head screw	10	88.5	–
5	1	Oil fill neck			
6	1	Oil fill and dipstick grommet			
7	1	Oil fill cap			
8	1	O-ring			
9	2	45.5 mm Oetiker® clamp			
10	1	Oil fill hose			
11	1	M6 x 20 hex flange head screw	10	88.5	–
12	1	Oil fill spigot			
13	1	O-ring			
14	1	Upper dipstick tube			
15	1	O-ring			
16	1	Dipstick tube			
17	1	Grommet			
18	1	Oil filter tube			
19	2	O-ring			
20	2	O-ring			
21	1	Oil tube retention bracket			
22	2	M6 hex flange head screw	10	88.5	–
23	1	Oil drip tray			
24	1	Drip tray hose			
25	1	Drip tray hose fitting			
26	1	Drip tray plug			
27	2	M4 x 1.75 x 16 hex washer head screw	2	17.7	–
28	1	M6 x 12 hex flange head screw	10	88.5	–
29	4	M6 x 20 Torx® pan head screw	10	88.5	–
30	1	Oil filter adapter gasket			
31	1	Oil filter adapter			
32	1	Oil filter fitting	40	–	29.5
33	1	Oil filter			
34	1	Dipstick			

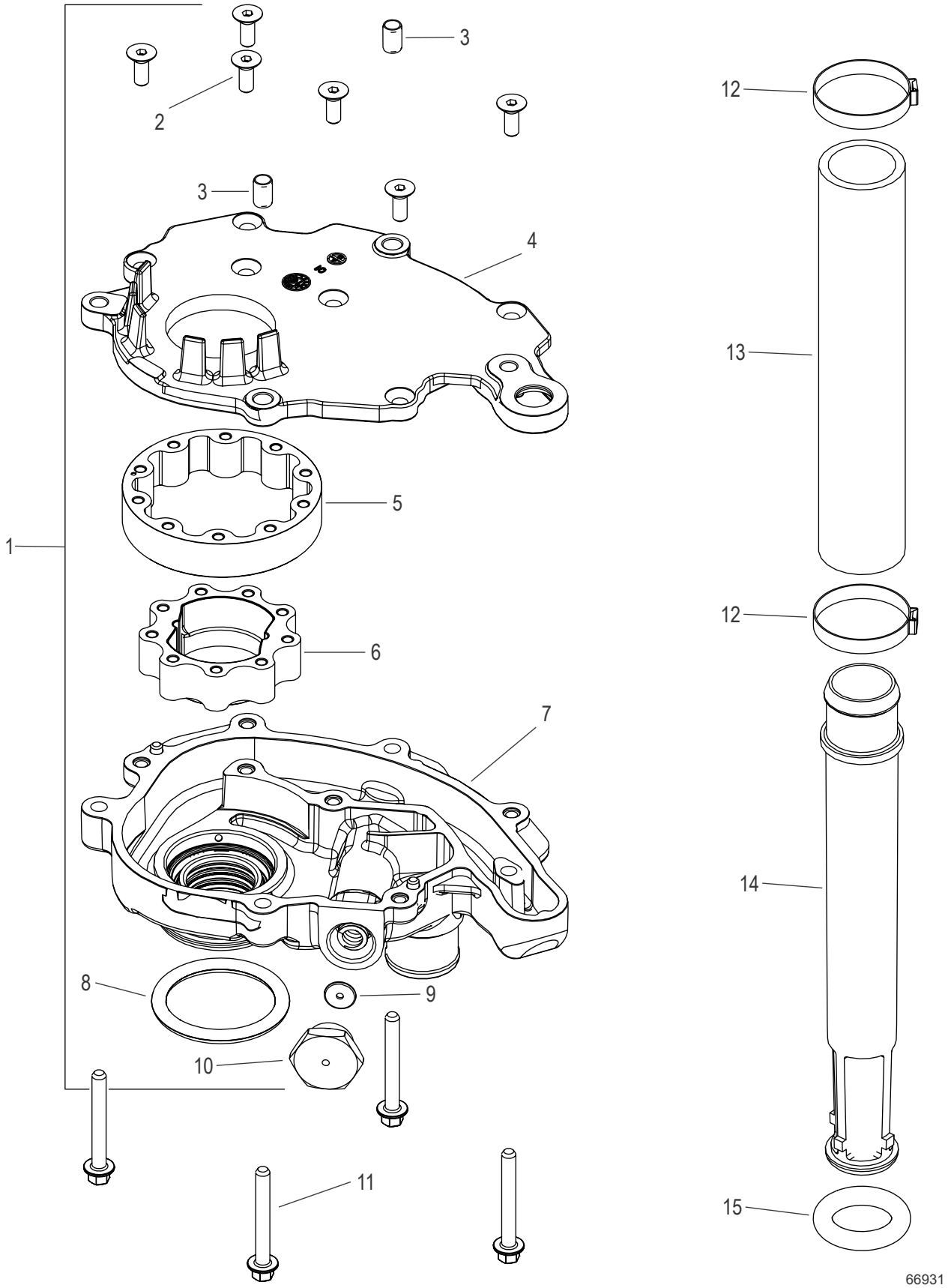
Lubrication System Components - V6



Lubrication System Components - V6

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Bracket			
2	2	Grommet			
3	4	M8 x 1.25 x 71.5 stud	5	44.25	–
4	4	M8 x 1.25 locknut	28	–	20.7
5	2	M6 x 16 hex flange head screw	10	88.5	–
6	1	Oil fill neck			
7	1	Oil fill and dipstick grommet			
8	1	Oil fill cap			
9	1	O-ring			
10	2	45.5 mm Oetiker® clamp			
11	1	Oil fill hose			
12	1	M6 x 20 hex flange head screw	10	88.5	–
13	1	Oil fill spigot			
14	1	O-ring			
15	1	Upper dipstick tube			
16	1	O-ring			
17	1	Dipstick tube			
18	1	Grommet			
19	1	Oil filter tube			
20	2	O-ring			
21	2	O-ring			
22	1	Oil tube retention bracket			
23	2	M6 hex flange head screw	10	88.5	–
24	1	Oil drip tray			
25	1	Drip tray hose			
26	1	Drip tray hose fitting			
27	1	Drip tray plug			
28	2	M4 x 1.75 x 16 hex washer head screw	2	17.7	–
29	1	M6 x 12 hex flange head screw	10	88.5	–
30	4	M6 x 20 Torx® pan head screw	10	88.5	–
31	1	Oil filter adapter gasket			
32	1	Oil filter adapter			
33	1	Oil filter fitting	40	–	29.5
34	1	Oil filter			
35	1	Dipstick			

Oil Pump and Pickup Components



Oil Pump and Pickup Components

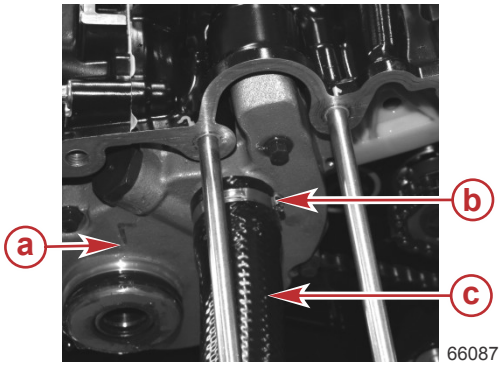
Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Oil pump assembly			
2	6	M6 x 16 hex socket flat head screw	4.5	39.8	–
3	2	Dowel pin			
4	1	Oil pump cover			
5	1	Outer rotor			
6	1	Inner rotor			
7	1	Oil pump housing			
8	1	M6 x 46 O-ring			
9	1	Wear disc			
10	1	Plug			
11	4	M6 x 48 hex flange screw	10	88.5	–
12	2	39.6 mm Oetiker® clamp			
13	1	Oil pickup hose			
14	1	Oil pickup assembly			
15	1	M8 x 25 O-ring			

Oil Pump

Oil Pump Removal

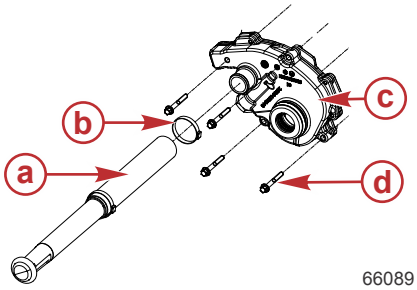
NOTE: *The powerhead must be removed to access the oil pump.*

1. Remove the powerhead. Refer to **Section 4A - Cylinder Block/Crankcase**.
2. Remove the 39.6 mm Oetiker clamp to remove the oil pickup assembly from the oil pump.



a - Oil pump
b - 39.6 mm Oetiker clamp
c - Oil pickup assembly

3. Remove the four screws securing the oil pump to the powerhead. Remove the oil pump.



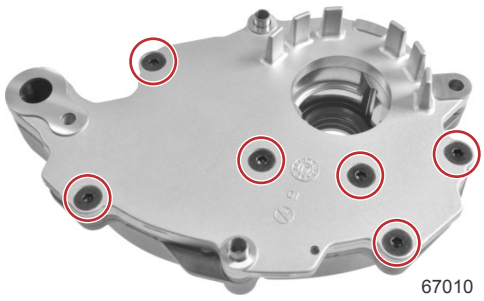
a - Oil pickup assembly
b - 39.6 mm Oetiker clamp
c - Oil pump
d - Screws (4)

Oil Pump Disassembly and Inspection

IMPORTANT: The oil pump assembly is a nonserviceable component. The oil pump assembly should only be disassembled, cleaned, and assembled in a clean environment knowing internal oil pump components are not replaceable or sold individually. When possible, the first choice should always be to replace the oil pump assembly.

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 and discard the six screws securing the oil pump cover to the oil pump housing.



Oil pump cover screws (discard)

2. Remove the oil pump cover.

3. Remove the outer rotor from the oil pump housing.

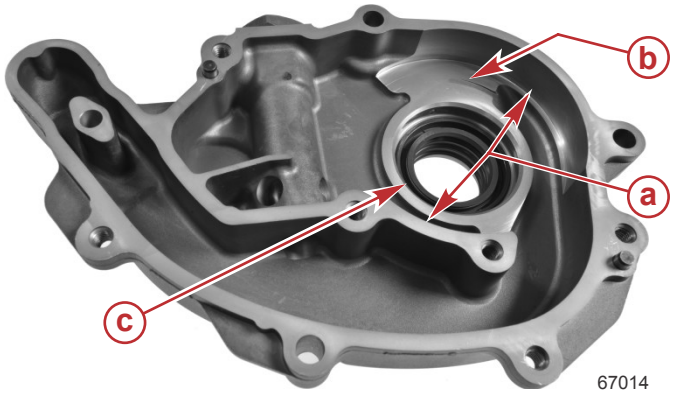
a - Oil pump housing
b - Inner rotor
c - Outer rotor

4. Clean the outer rotor with solvent.
5. 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.

   NOTE: *Minor wear is acceptable. For high hour engines, the entire oil pump should be replaced, regardless of condition.*

6. Inspect the outer rotor housing for scoring or embedded particles.
7. Remove the inner rotor from the oil pump housing.
8. Clean the inner rotor with a solvent.
9. Inspect the inner rotor for damage. If the oil pump inner rotor shows signs of excessive wear or embedded particles, replace the oil pump.

10. Inspect the area between the suction and pressure sides of the oil pump housing.
11. Inspect the three seals around the driveshaft opening.



a - Critical areas where the outer rotor contacts the oil pump housing
b - Critical area between the suction and pressure sides of the housing
c - Water and oil seals

12. Replace the oil pump assembly if damage or embedded particles are found.

Oil Pump Assembly

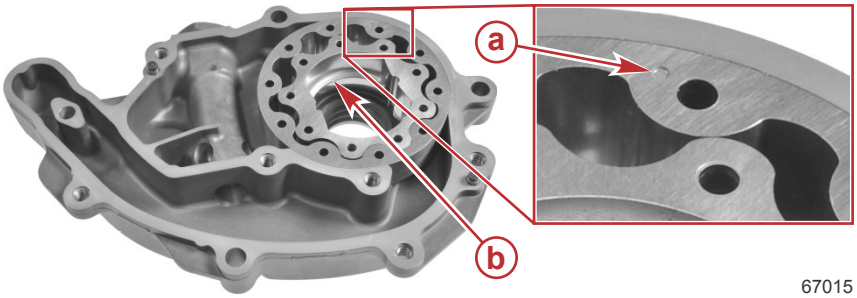
1. Lubricate the oil pump outer rotor with 10W-30 4-Stroke Marine Engine Oil.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Oil pump outer rotor	92-8M0078625

2. Install the outer rotor into the oil pump housing with the orientation mark facing toward the oil pump cover.
3. Lubricate the oil pump inner rotor with 10W-30 4-Stroke Marine Engine Oil.

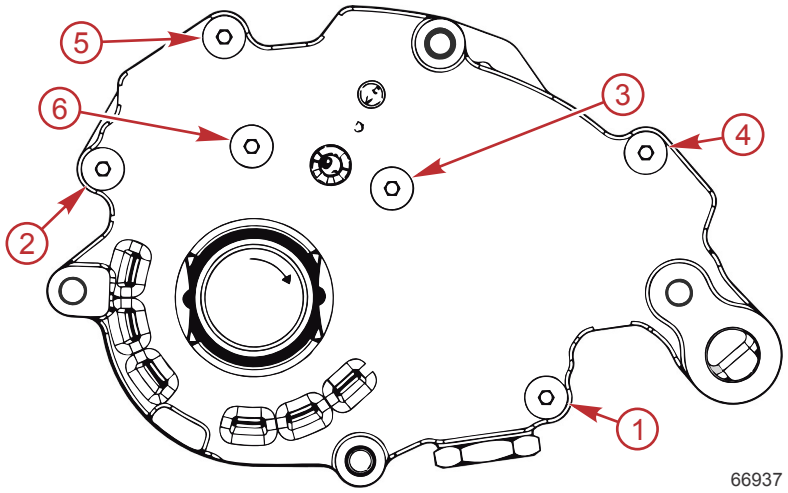
Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Oil pump inner rotor	92-8M0078625

4. Install the inner rotor with the lip facing toward the oil pump cover (larger bore toward the cover).



a - Orientation mark
b - Lip on inner rotor

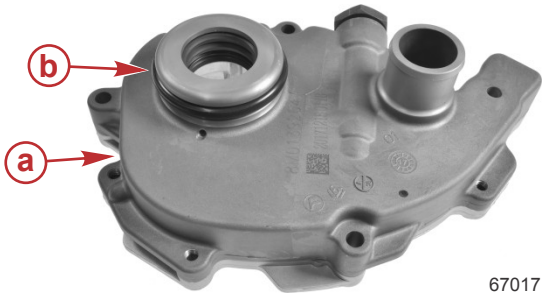
5. Install the oil pump cover assembly onto the oil pump housing.
6. Attach the cover using six new M6 x 16 hex socket flat head screws. Tighten the screws to the specified torque, in the specified sequence.



Oil pump cover screw torque sequence

Description	Nm	lb-in.	lb-ft
M6 x 16 hex socket flat head screw	4.5	39.8	–

7. Install a new O-ring onto the oil pump assembly.



a - Oil pump assembly
b - O-ring

Oil Pump Installation

1. Prime the oil pump with approximately 88 mL (3 fl oz) 10W-30 4-Stroke Marine Engine Oil.

Tube Ref No.	Description	Where Used	Part No.
110	10W-30 4-Stroke Marine Engine Oil	Oil pump	92-8M0078625

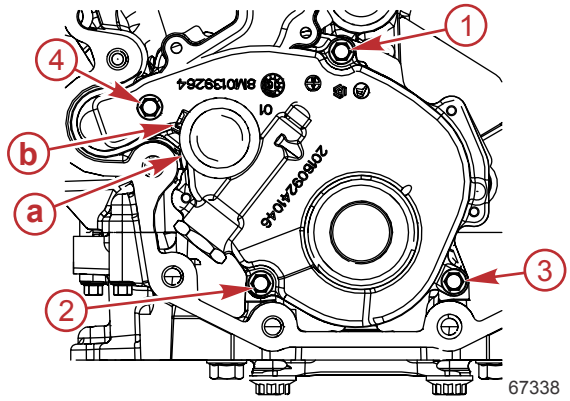
2. Lubricate the oil pump seals and O-rings with Engine Coupler Spline Grease.

Tube Ref No.	Description	Where Used	Part No.
91	Engine Coupler Spline Grease	Oil pump seals and O-rings	8M0071842

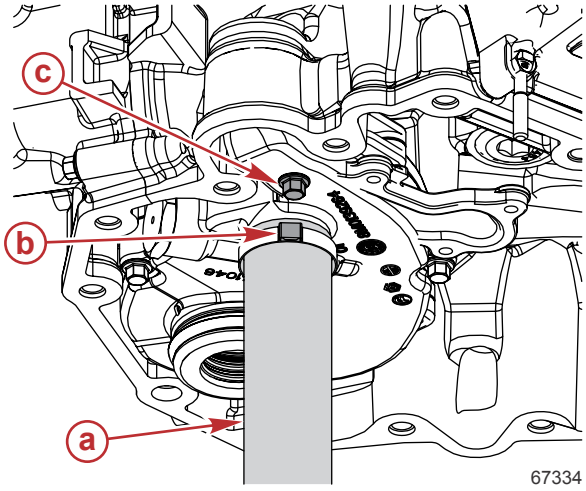
3. Slide a 39.6 mm Oetiker® clamp onto the oil pickup assembly, and install the assembly onto the oil pump.
4. Position the clamp so that it covers the white mark on the oil pickup hose and the ear is aligned with the screw by the oil output, as shown. Install the oil pump and tighten the four M6 x 48 hex flange screws to the specified torque.

IMPORTANT: The oil pickup hose must be pushed all the way onto the oil pump so the end of the hose contacts the oil pump housing.

The Oetiker clamps must be installed so that the ears of the clamps are positioned as shown. Assembly interference and catastrophic engine damage can occur if the clamps are not installed correctly.



Oil pump fastener torque sequence
a - Oil pickup assembly
b - Ears on Oetiker clamps (aligned with screw 4)

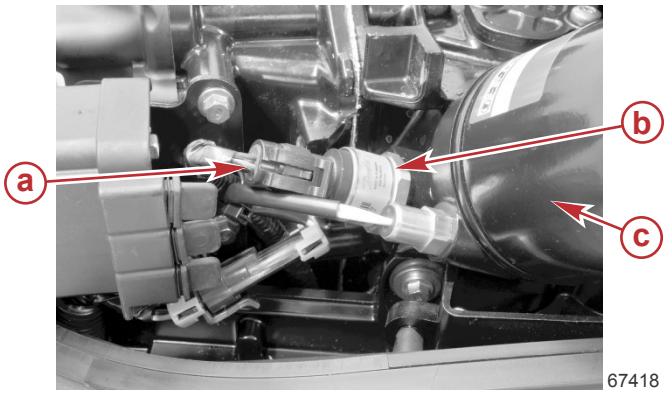


a - Oil pickup assembly
b - Orientation of ear on Oetiker clamp, aligned with item C
c - Fastener on oil pump, at the outlet

Description	Nm	lb-in.	lb-ft
M6 x 48 hex flange screw	10	88.5	–

Oil Pressure Sensor

The oil pressure sensor is located next to the oil filter, near the top of the port side of the engine.



a - Oil pressure sensor connector on the engine harness
b - Oil pressure sensor
c - Oil filter

Sensor Removal

1. Disconnect the engine harness from the sensor.
2. Remove the sensor from the engine.

Sensor Installation

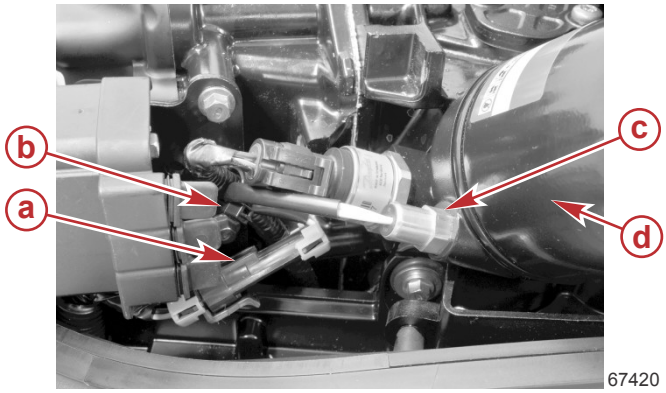
1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the oil pressure sensor into the engine.
3. Tighten the sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
Oil pressure sensor	15	132.8	–

4. Connect the engine harness to the sensor.

Oil Temperature Sensor

The oil temperature sensor is located next to the oil filter, near the top of the port side of the engine.



- **a -** Oil temperature sensor connection to engine harness
- **b -** Cable tie
- **c -** Oil temperature sensor
- **d -** Oil filter

Sensor Removal

1. Cut the cable tie that secures the sensor harness to the engine harness.
2. Disconnect the sensor harness from the engine harness.
3. Remove the sensor from the engine.

Sensor Installation

1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the oil temperature sensor into the engine.
3. Tighten the sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
Oil temperature sensor	15	132.8	–

4. Connect the sensor harness to the engine harness.
5. Secure the sensor harness to the engine harness with a cable tie.

Notes:

Powerhead

Section 4E - Cooling

Table of Contents

Cooling System Specifications

Description		Specification
Cooling system		Water cooled, thermostat control
Water pressure	At 600 RPM (idle)	10–20 kPa (1.5–2.9 psi)
	At 6000 RPM (WOT)	60–260 kPa (8.7–37.7 psi)
Thermostat	Valve stroke (minimum) at full open temperature	10.0 mm (0.39 in.)
	Start to open temperature	57–61 °C (134.6–141.8 °F)
	Full open temperature	77 °C (170.6 °F)

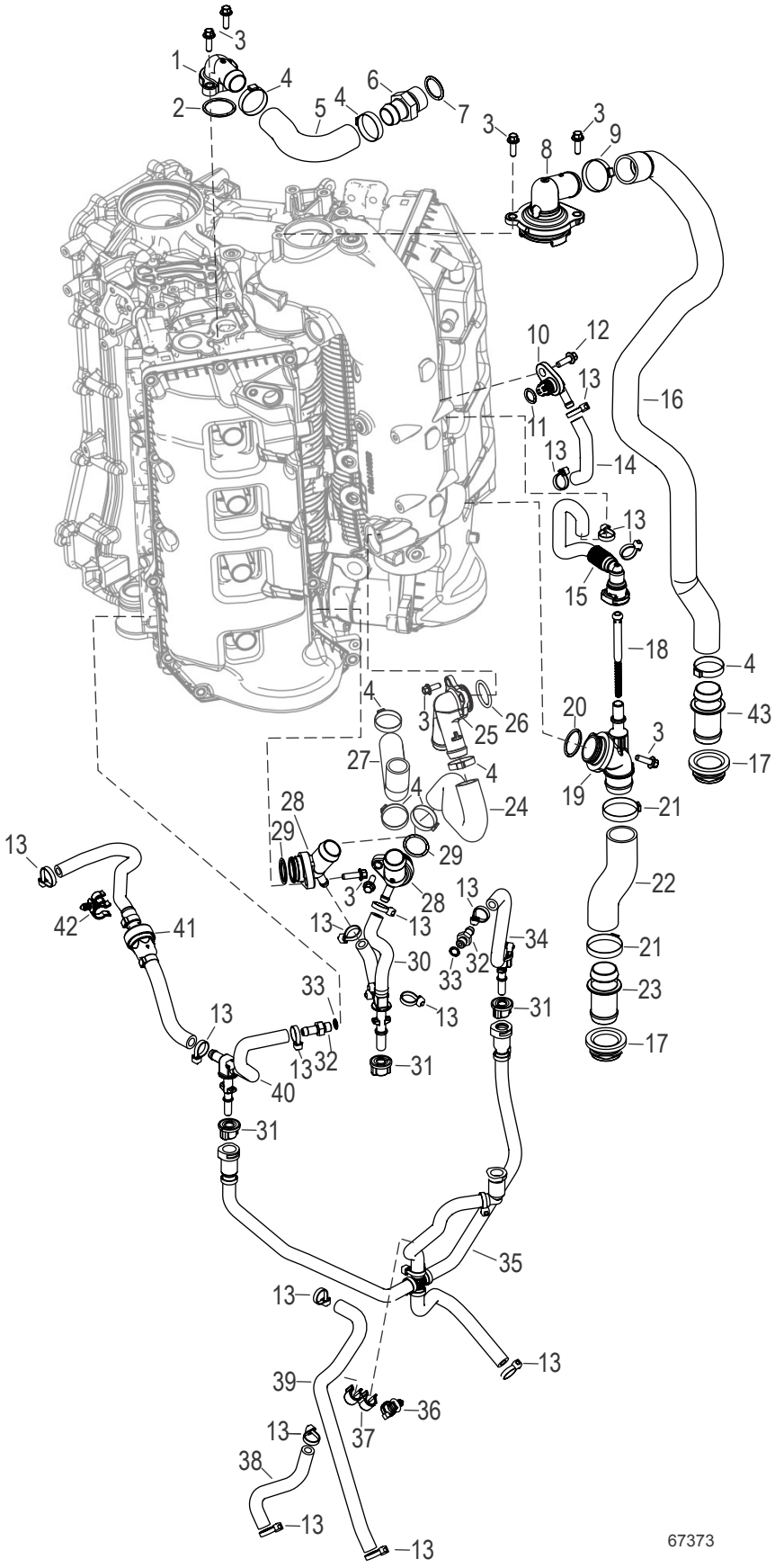
Additional Cooling System Information

This section covers the replacement of cooling components located on the powerhead. Additional cooling system information can be found in other sections of this manual.

- For exhaust water strainer inspection details, refer to **Section 1B - Maintenance**.
- For information on the cooling components located in the midsection, such as the sprayer assembly, refer to **Section 5A - Clamp/Swivel Brackets and Driveshaft Housing**.
- For cooling system flow diagrams, refer to **Section 8A - Color Diagrams**.

Notes:

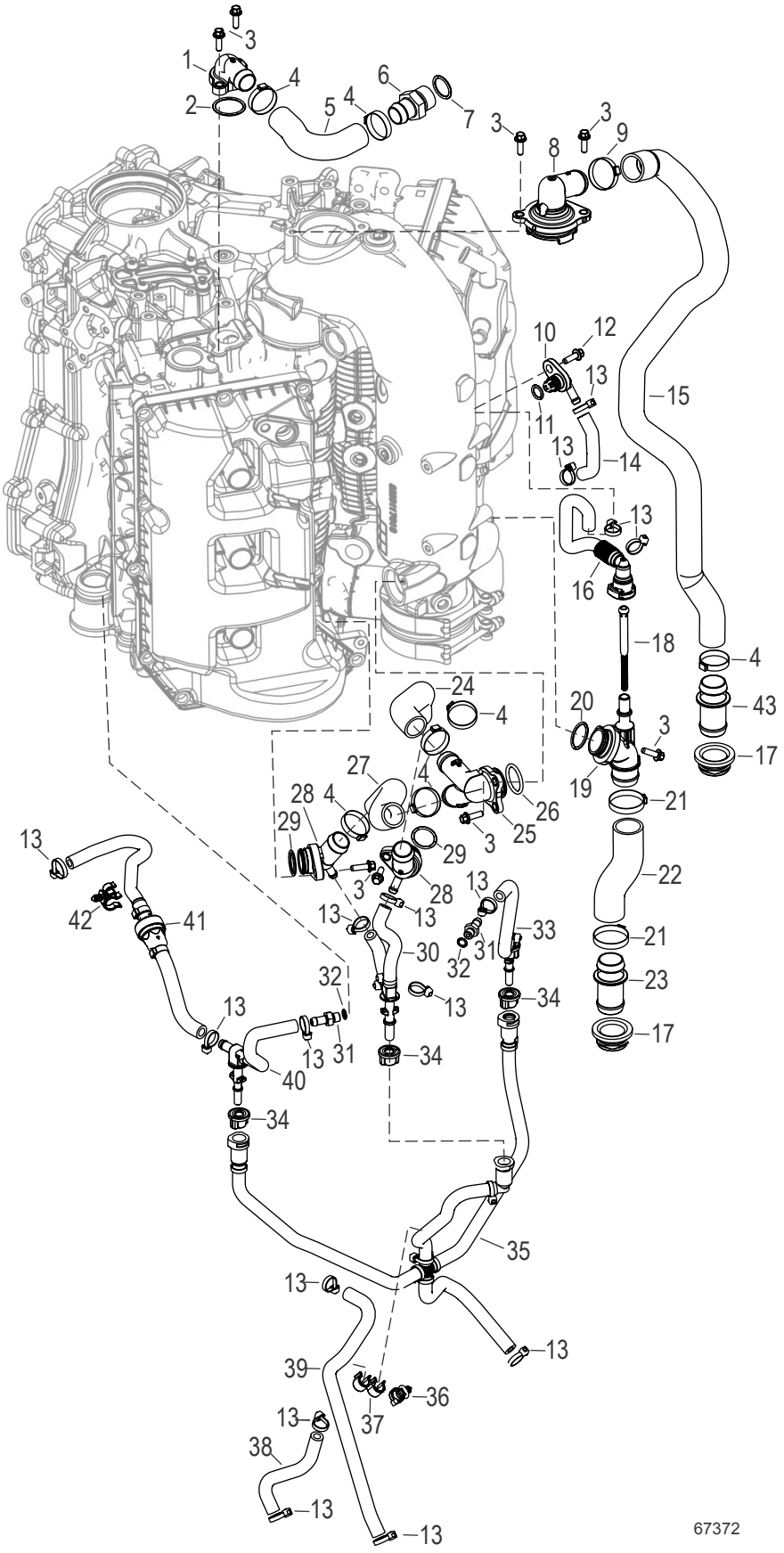
Cooling System Components - V8



Cooling System Components - V8

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Fitting			
2	1	O-ring			
3	8	M6 x 20 screw	10	88.5	–
4	6	Clamp			
5	1	Hose			
6	1	Barbed fitting			
7	1	O-ring			
8	1	Thermostat			
9	1	34.6 mm clamp			
10	1	Strainer fitting			
11	1	O-ring			
12	1	M6 x 16 screw	10	88.5	–
13	16	Cable tie			
14	1	Hose			
15	1	Hose			
16	1	Thermostat outlet hose			
17	2	Grommet			
18	1	Water strainer			
19	1	Fitting			
20	1	O-ring			
21	2	38.1 mm clamp			
22	1	Hose			
23	1	Fitting			
24	1	Hose			
25	1	Fitting			
26	1	O-ring			
27	1	Hose			
28	2	Fitting			
29	2	O-ring			
30	1	Hose assembly			
31	3	Grommet			
32	2	Barbed fitting			
33	2	O-ring			
34	1	Starboard water outlet hose assembly			
35	1	Hose assembly			
36	1	Cable tie clip			
37	1	Clip			
38	1	Hose			
39	1	Hose			
40	1	Port water outlet hose assembly			
41	1	Hose assembly			
42	1	Clip			
43	1	Fitting			

Cooling System Components - V6



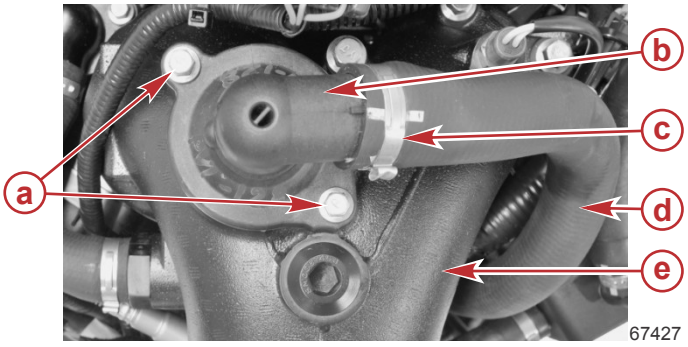
Cooling System Components - V6

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Fitting			
2	1	O-ring			
3	8	M6 x 20 screw	10	88.5	–
4	6	Clamp			
5	1	Hose			
6	1	Barbed fitting			
7	1	O-ring			
8	1	Thermostat			
9	1	34.6 mm clamp			
10	1	Strainer fitting			
11	1	O-ring			
12	1	M6 x 16 screw	10	88.5	–
13	16	Cable tie			
14	1	Hose			
15	1	Thermostat outlet hose			
16	1	Hose			
17	2	Grommet			
18	1	Water strainer			
19	1	Fitting			
20	1	O-ring			
21	2	38.1 mm clamp			
22	1	Hose			
23	1	Fitting			
24	1	Hose			
25	1	Fitting			
26	1	O-ring			
27	1	Hose			
28	2	Fitting			
29	2	O-ring			
30	1	Hose assembly			
31	2	Barbed fitting			
32	2	O-ring			
33	1	Starboard water outlet hose assembly			
34	3	Grommet			
35	1	Hose assembly			
36	1	Cable tie clip			
37	1	Clip			
38	1	Hose			
39	1	Hose			
40	1	Port water outlet hose assembly			
41	1	Hose assembly			
42	1	Clip			
43	1	Fitting			

Thermostat Assembly

Thermostat Assembly Removal

1. Remove the two M6 x 20 screws securing the thermostat assembly to the top of the exhaust tube.
2. If the thermostat assembly is being replaced, remove the Oetiker® clamp to disconnect the thermostat outlet hose from the thermostat assembly.
3. Remove the thermostat assembly from the exhaust tube.



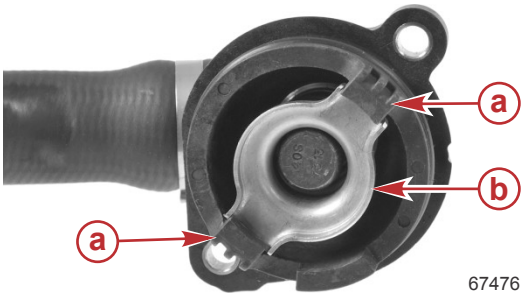
a - M6 x 20 screws (2)
b - Thermostat assembly
c - Oetiker clamp
d - Thermostat outlet hose
e - Exhaust tube

4. Inspect the O-ring. If the O-ring is in poor condition, replace the thermostat assembly.
5. Clean any sealant or debris from the sealing surfaces on the thermostat assembly and the exhaust tube.

Thermostat Cleaning and Inspection

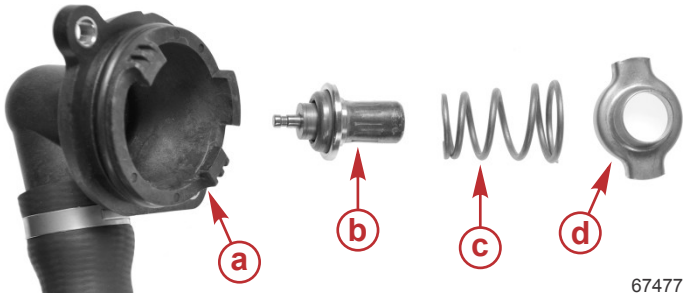
IMPORTANT: The thermostat assembly may require cleaning if debris has entered the cooling system.

1. Push down on the thermostat retainer to disengage the thermostat retainer.
2. Turn the thermostat retainer to unlock it from the thermostat housing.



a - Thermostat retainer locks (2)
b - Thermostat retainer

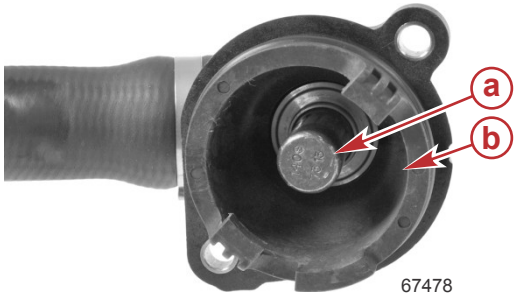
3. Remove the thermostat, thermostat spring, and thermostat retainer from the thermostat housing.



a - Thermostat housing
b - Thermostat
c - Thermostat spring
d - Thermostat retainer

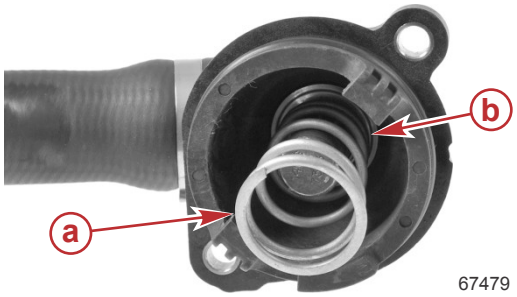
4. Inspect the thermostat for damage or corrosion, and test the thermostat if it is being reinstalled. If any components are damaged or if the thermostat fails testing, replace the entire assembly.

5. Install the thermostat into the thermostat housing.



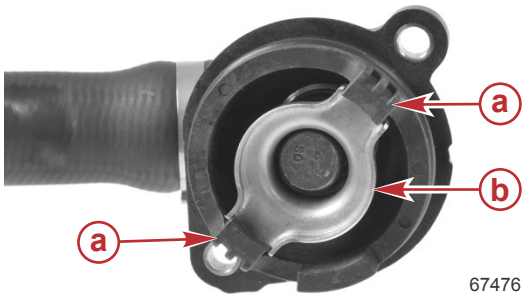
a - Thermostat
b - Thermostat housing

6. Insert the smaller end of the spring into the thermostat housing, and install the thermostat spring onto the thermostat.



a - Thermostat spring
b - Smaller end of the spring

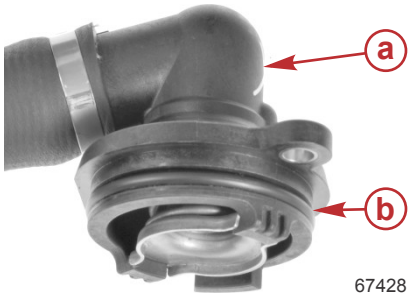
7. Install the thermostat retainer onto the thermostat spring.
8. Push down on the thermostat retainer, and turn it to lock it into the thermostat housing.



a - Thermostat retainer locks (2)
b - Thermostat retainer

Thermostat Assembly Installation

1. Ensure that the O-ring is in good condition and is in place on the thermostat assembly.

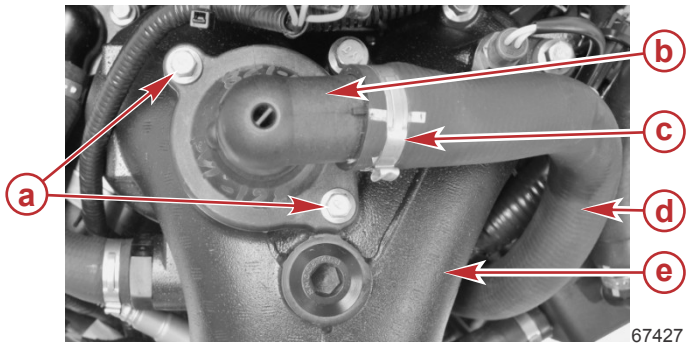


Shown with outlet hose attached
a - Thermostat assembly
b - O-ring

2. Install the thermostat assembly onto the exhaust tube. Tighten the two M6 x 20 screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M6 x 20 screw	10	88.5	–

3. If previously removed, secure the thermostat outlet hose to the thermostat assembly, using a 34.6 mm Oetiker® clamp.



a - M6 x 20 screws (2)
b - Thermostat assembly
c - 34.6 mm Oetiker clamp
d - Thermostat outlet hose
e - Exhaust tube

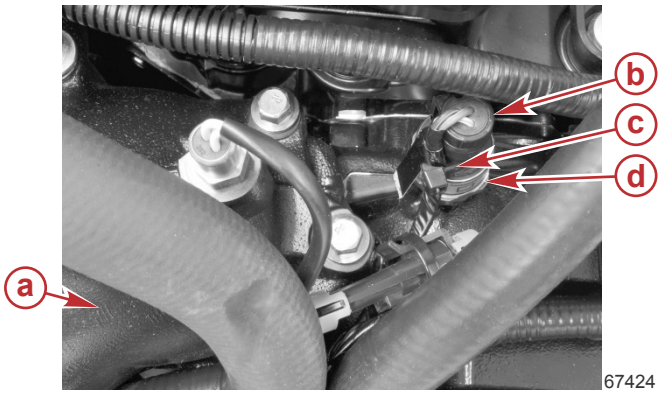
Block Water Pressure Sensor

NOTE: *Not all models are equipped with a block water pressure sensor. Some models have a Legris fitting installed in its place, for use with an analog pressure gauge.*

The block water pressure sensor, if equipped, is located at the rear of the engine, near the top of the exhaust tube.

Sensor Removal

1. Cut the cable tie from the sensor's engine harness connector.
2. Disconnect the engine harness from the sensor.
3. Remove the sensor from the engine block.



a - Top of the exhaust tube
b - Engine harness connector
c - Cable tie
d - Block water pressure sensor

Sensor Installation

1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the block water pressure sensor into the engine block.
3. Tighten the sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
Block water pressure sensor	15	132.8	–

4. Connect the engine harness to the sensor.
5. Secure the connection with a cable tie.

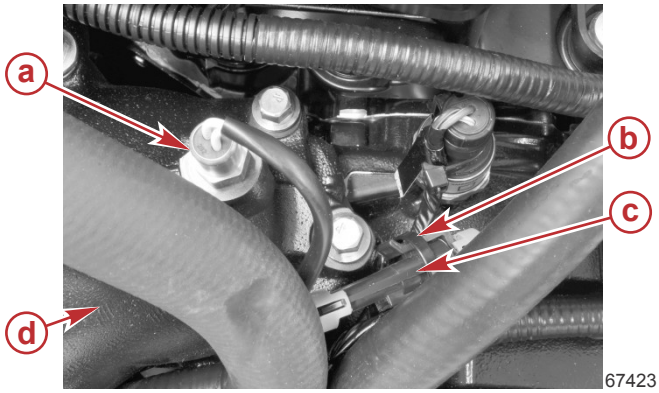
Engine Coolant Temperature Sensor

The engine coolant temperature sensor is located in the top of the exhaust tube, at the rear of the engine.

Sensor Removal

1. Cut the cable tie that secures the sensor harness connector to the engine harness.
2. Disconnect the sensor harness from the engine harness.

3. Remove the sensor from the exhaust tube.



a - Engine coolant temperature sensor
b - Cable tie
c - Sensor harness connector
d - Top of the exhaust tube

Sensor Installation

1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the engine coolant temperature sensor into the exhaust tube.
3. Tighten the sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
Engine coolant temperature sensor	15	132.8	–

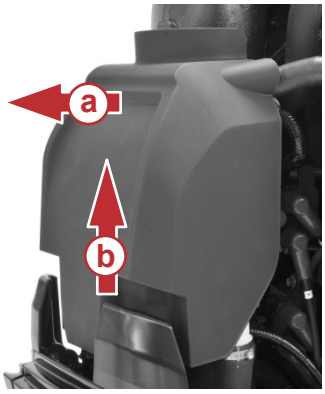
4. Connect the sensor harness to the engine harness.
5. Secure the sensor harness connector to the engine harness with a cable tie.

Exhaust Gas Temperature (EGT) Sensor

The exhaust gas temperature (EGT) sensor is located in the exhaust tube, just below the electrical panel, as shown in the following procedures.

Sensor Removal

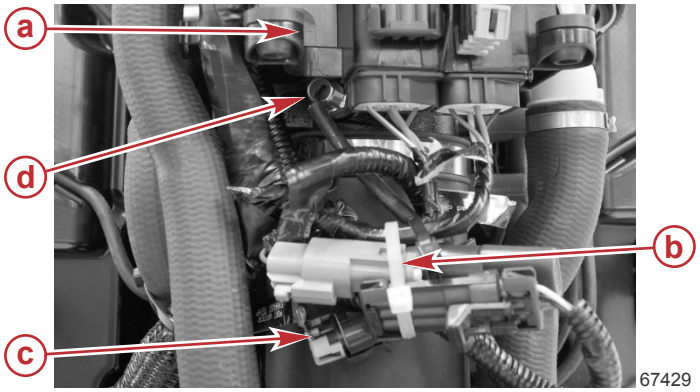
1. Remove the engine cowls. Refer to **Section 5C - Upper and Lower Cowls**.
2. Remove the electrical panel cover.
   - On V8 models, pull the top aft until the pins are clear of the grommets, and then lift up.



V8 models
a - Pull aft
b - Lift up

   - On V6 models, pull the panel aft.

3. Cut the cable tie that secures the electrical connector bundle below the electrical plate, locate the EGT sensor harness, and disconnect it from the engine harness.



a - Electrical panel
b - Cable tie
c - EGT sensor connector (location varies)
d - EGT sensor

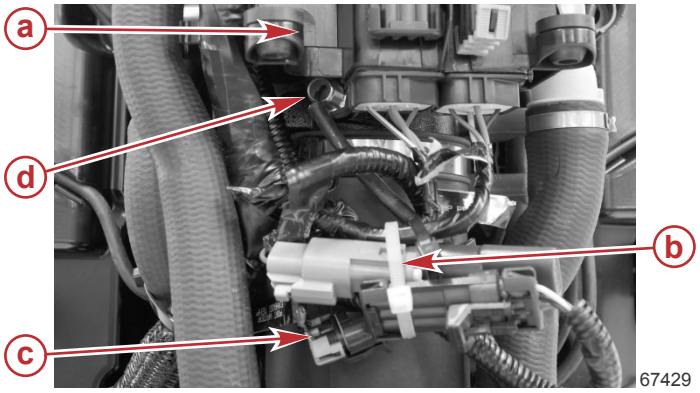
4. Remove the top two T30 Torx screws and washers securing the electrical plate to the exhaust tube.
5. Slide the electrical plate upward to gain additional access to the EGT sensor.
6. Remove the EGT sensor from the exhaust tube.

Sensor Installation

1. Ensure that the O-ring is in good condition and is present on the sensor.
2. Install the EGT sensor into the exhaust tube.
3. Tighten the sensor to the specified torque.

Description	Nm	lb-in.	lb-ft
EGT sensor	15	132.8	–

4. Connect the sensor harness to the engine harness.
5. Secure the electrical connector bundle with a cable tie.



a - Electrical panel
b - Cable tie to secure electrical connector bundle
c - EGT sensor connector (location varies)
d - EGT sensor

6. Slide the electrical panel into position, and secure it to the exhaust tube with two T30 Torx screws and washers. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
T30 Torx screws	10	88.5	–

Midsection

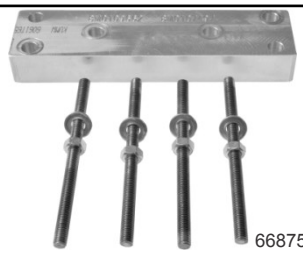
Section 5A - Clamp/Swivel Brackets and Driveshaft Housing

Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange head screws	92-809821
		M6 x 25 hex flange head screw	
		M10 x 1.5 x 60 hex flange head screws	
		M8 x 35 hex flange head screws	
		M6 x 20 Torx socket head screws	
		M14 x 2.0 x 100 hex flange head screws	
		M8 x 30 hex flange head screws	
		M6 x 55 hex flange head screws	
		M6 x 20 hex flange head screw	
		M6 x 20 hex flange head screws	
95	2-4-C with PTFE	Swivel tube, swivel tube splines	92-802859A 1
		Swivel tube assembly	

Special Tools

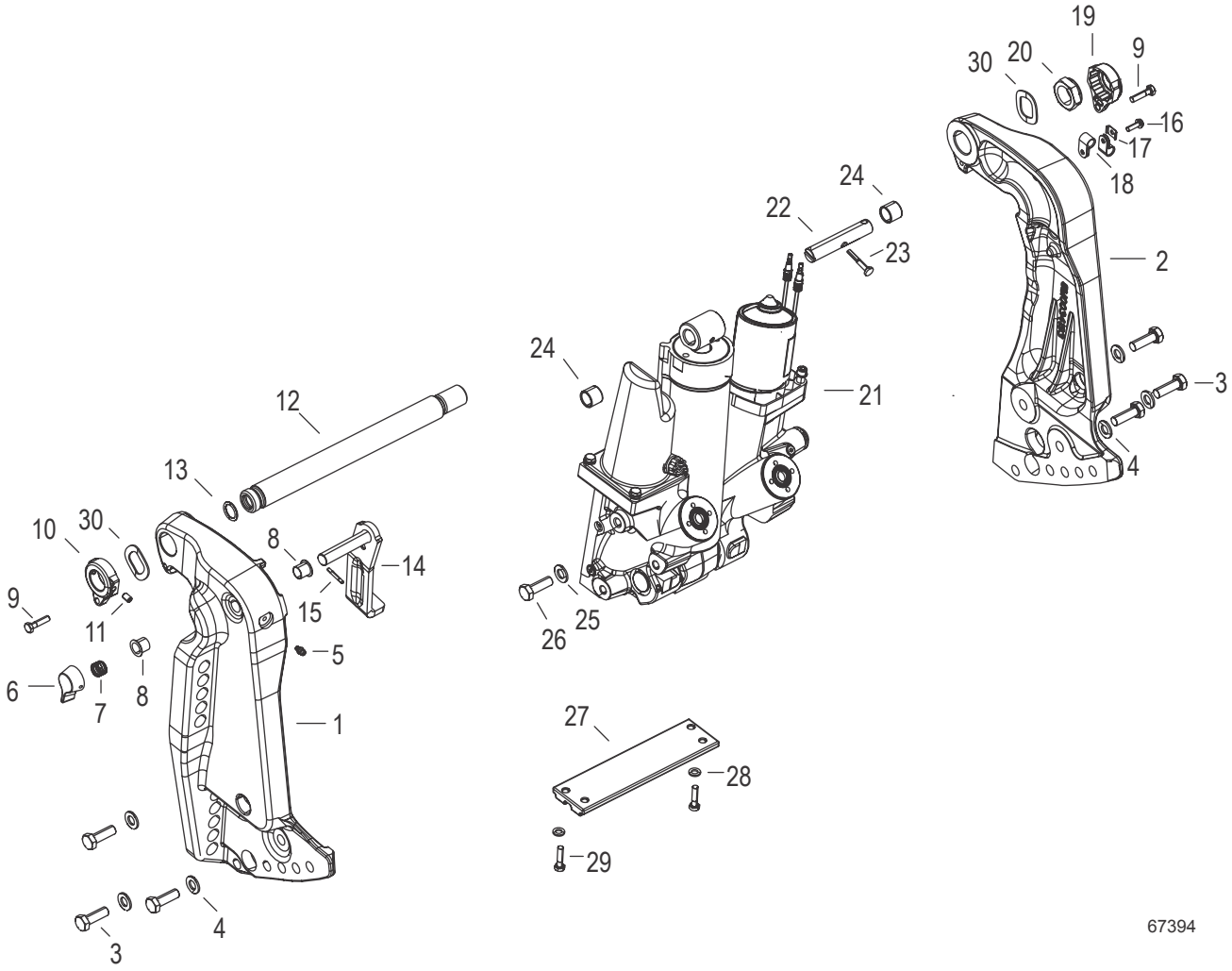
Upper Mount Installation/Removal Tool	8M0148872
 66875	Facilitates the installation and removal of the upper engine mount on V6/V8 fourstroke outboard engines. Tool ID number 8M0109662

Swivel Bracket and Driveshaft Housing Specifications—CMS

Description		Specification
Recommended transom height	Long shaft	508 mm (20 in.)
	XL shaft	635 mm (25 in.)
	XXL shaft	762 mm (30 in.)
Steering pivot range		60°
Full tilt up angle		71°
Trim angle (on 14° boat transom)		– 6° to + 14°
Allowable transom thickness	Minimum	44.5 mm (1.75 in.)
	Maximum	70 mm (2.75 in.)

Notes:

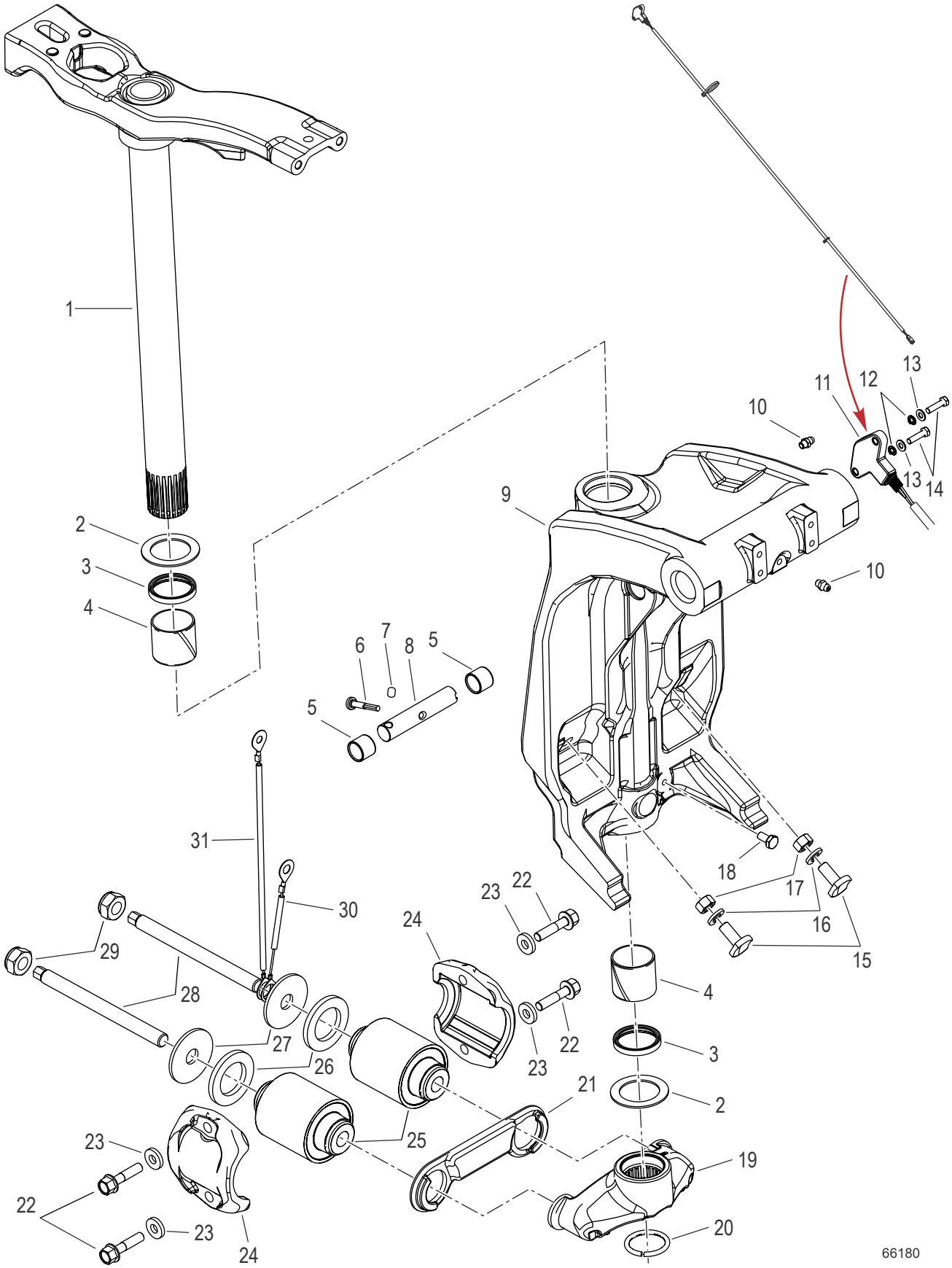
Transom Bracket Components



Transom Bracket Components

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	1	Port transom bracket				
2	1	Starboard transom bracket				
3	6	M10 x 30 screw		62	–	45.7
4	6	Washer				
5	1	Grease fitting		8.5	75	–
6	1	Knob				
7	1	Compression spring				
8	2	Nyliner				
9	2	M6 x 25 screw		9	79.7	–
10	1	Tilt tube locknut		62	–	45.7
11	1	Screw		9	79.7	–
12	1	Tilt tube				
13	1	O-ring				
14	1	Tilt lever lock assembly				
15	1	Groove pin				
16	1	Screw		6	53.1	–
17	1	C-washer				
18	2	Clip				
19	1	Tilt tube bracket				
20	1	Nut	**First**	68	–	50.2
			Final	Back nut off 1/4 turn		
21	1	Power trim assembly				
22	1	Pin				
23	1	Trilobe pin				
24	2	Bushing				
25	1	Washer				
26	1	M10 x 30 screw				
27	1	Anode Kit				
28	2	Washer				
29	2	M6 x 25 screw		8	70.8	–

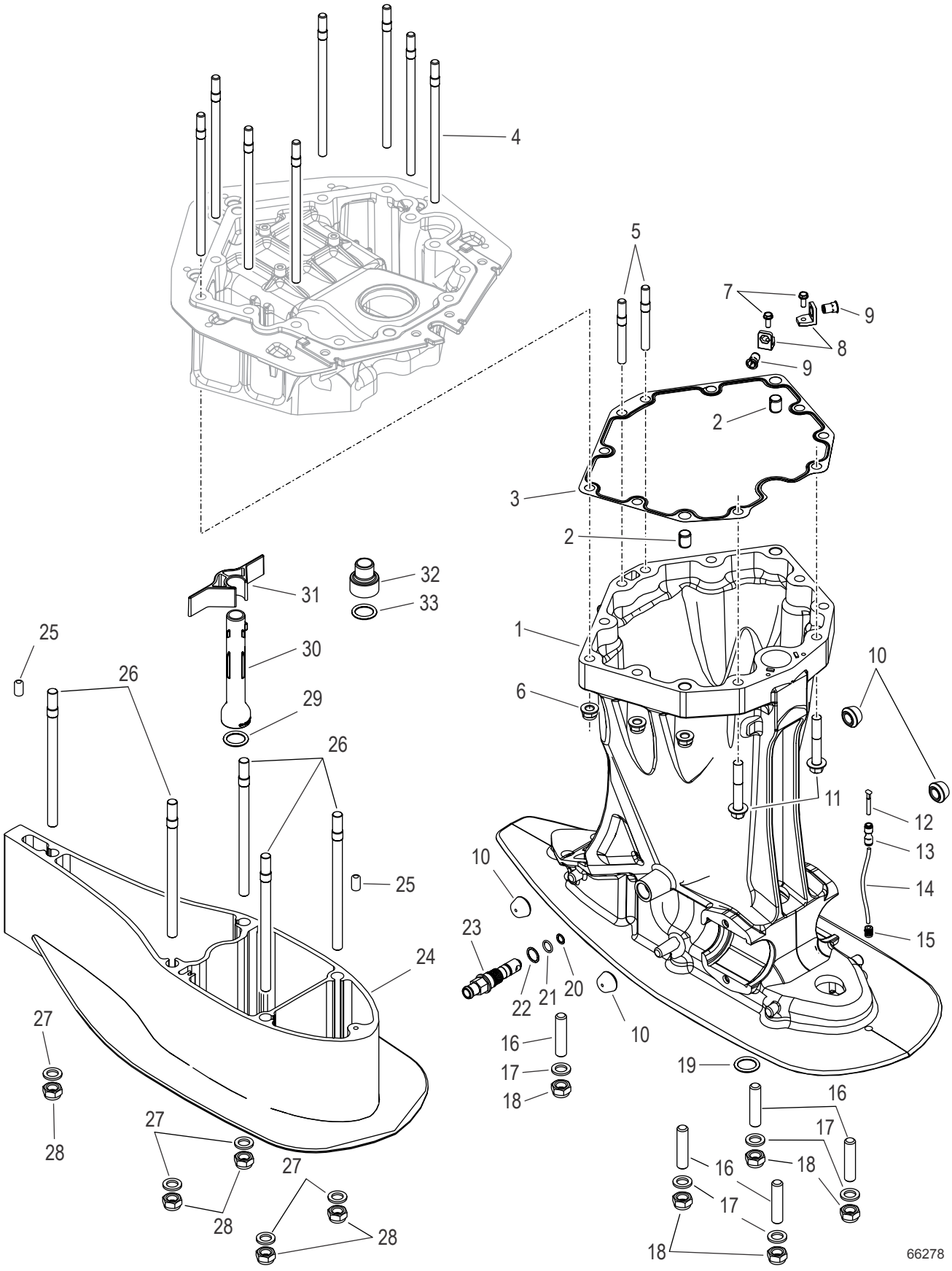
Swivel Bracket and Steering Arm Components



Swivel Bracket and Steering Arm Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Steering arm assembly			
2	2	Thrust bearing washer			
3	2	Swivel tube seal			
4	2	Swivel tube pivot bushing			
5	2	Journal bearing			
6	1	Trilobe pin			
7	1	Magnet			
8	1	Rod eye pin			
9	1	Swivel bracket			
10	2	Grease fitting			
11	1	Trim position sensor assembly			
12	2	Washer			
13	2	Split lockwasher			
14	2	Hex head tin plate screw	1.7	15.0	–
15	2	Trim shaft striker plate			
16	2	Split lockwasher			
17	2	Nut	32	–	23.6
18	1	0.250-20 x 0.50 hex head cap screw	10	88.5	–
19	1	Lower yoke			
20	1	Closed type retaining ring			
21	1	Lower mount snubber			
22	4	M8 x 35 hex flange head screw	27.1	–	20.0
23	4	Washer			
24	2	Lower mount cover			
25	2	Tubular lower mount			
26	2	Washer			
27	2	Special washer			
28	2	M14 x 2 x 146 stud	32	–	23.6
29	2	M14 locknut	90	–	66.4
30	1	101.6 mm (4 in.) cable			
31	1	254 mm (10 in.) cable			

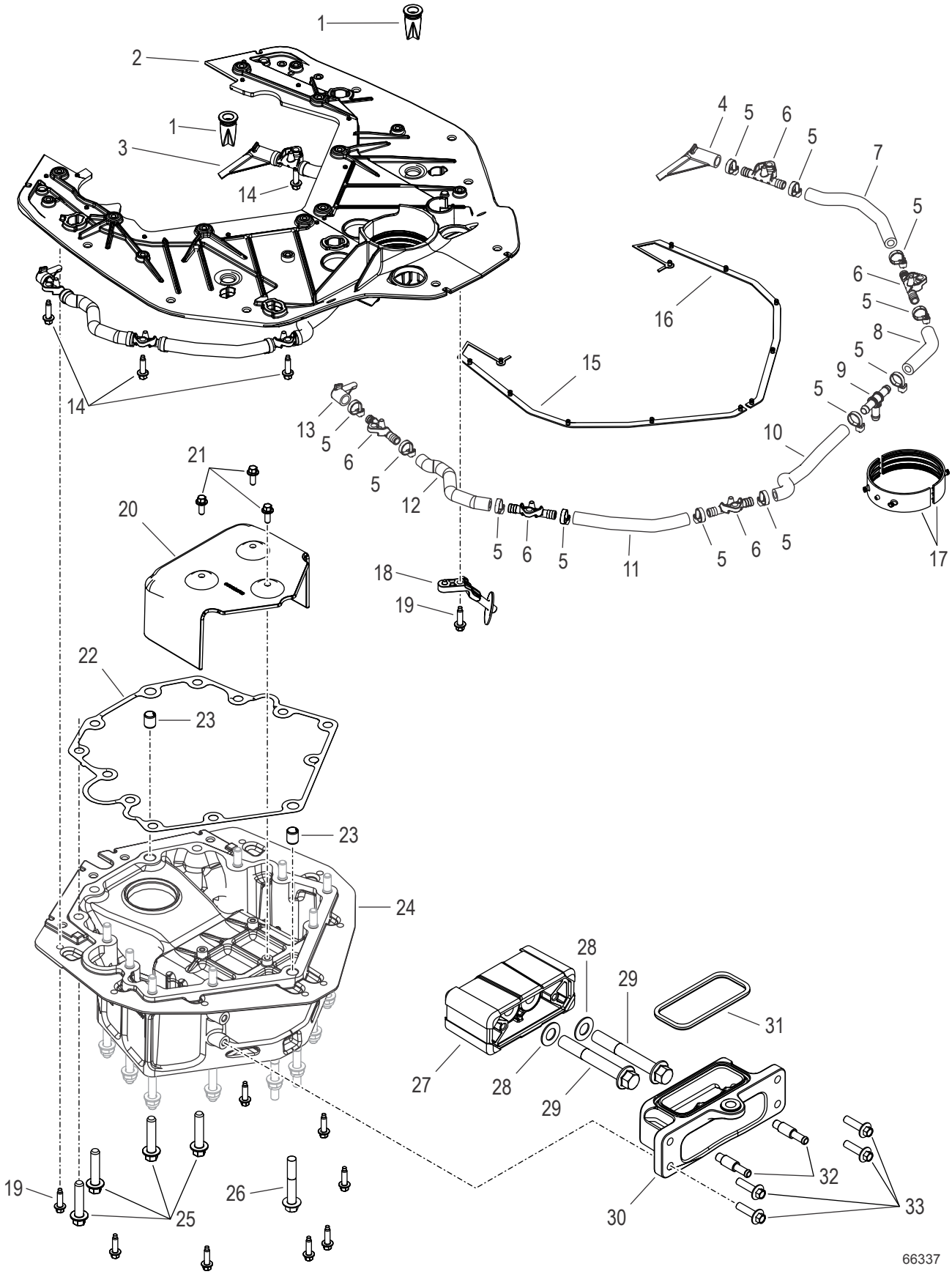
Driveshaft Housing Components



Driveshaft Housing Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Driveshaft housing			
2	2	Dowel pin			
3	1	Adapter plate to driveshaft housing gasket			
4	8	M10 x 1.5 x 185 double ended stud	22	–	16.2
5	2	M10 x 1.5 x 81.5 double ended stud	22	–	16.2
6	10	M10 x 1.5 locknut	30	–	22.1
7	2	M5 x 13 hex washer head screw			
8	2	Bib mounting bracket			
9	2	M6 x 1 open ended threaded insert			
10	4	Chap support cap			
11	2	M10 x 1.5 x 60 hex flange head screw	47.5	–	35
12	1	Plug fitting			
13	1	4 mm coupler fitting (plastic)			
14	1	44.00 lg tubing			
15	1	4 mm legris fitting			
16	5	M12 x 1.75 x 52 double ended stud	30	–	22.1
17	5	Washer			
18	5	M12 hex locknut	60	–	44.2
19	1	O-ring			
20	1	O-ring			
21	1	O-ring			
22	1	O-ring			
23	1	Oil plug	15	132.8	–
24	1	Driveshaft housing spacer			
25	2	Dowel pin			
26	5	M12 x 1.75 x 179 double ended stud	30	–	22.1
27	5	Washer			
28	5	M12 hex locknut	60	–	44.2
29	1	O-ring			
30	1	Water tube extension			
31	1	Water tube guide			
32	1	Water tube coupler			
33	1	O-ring			

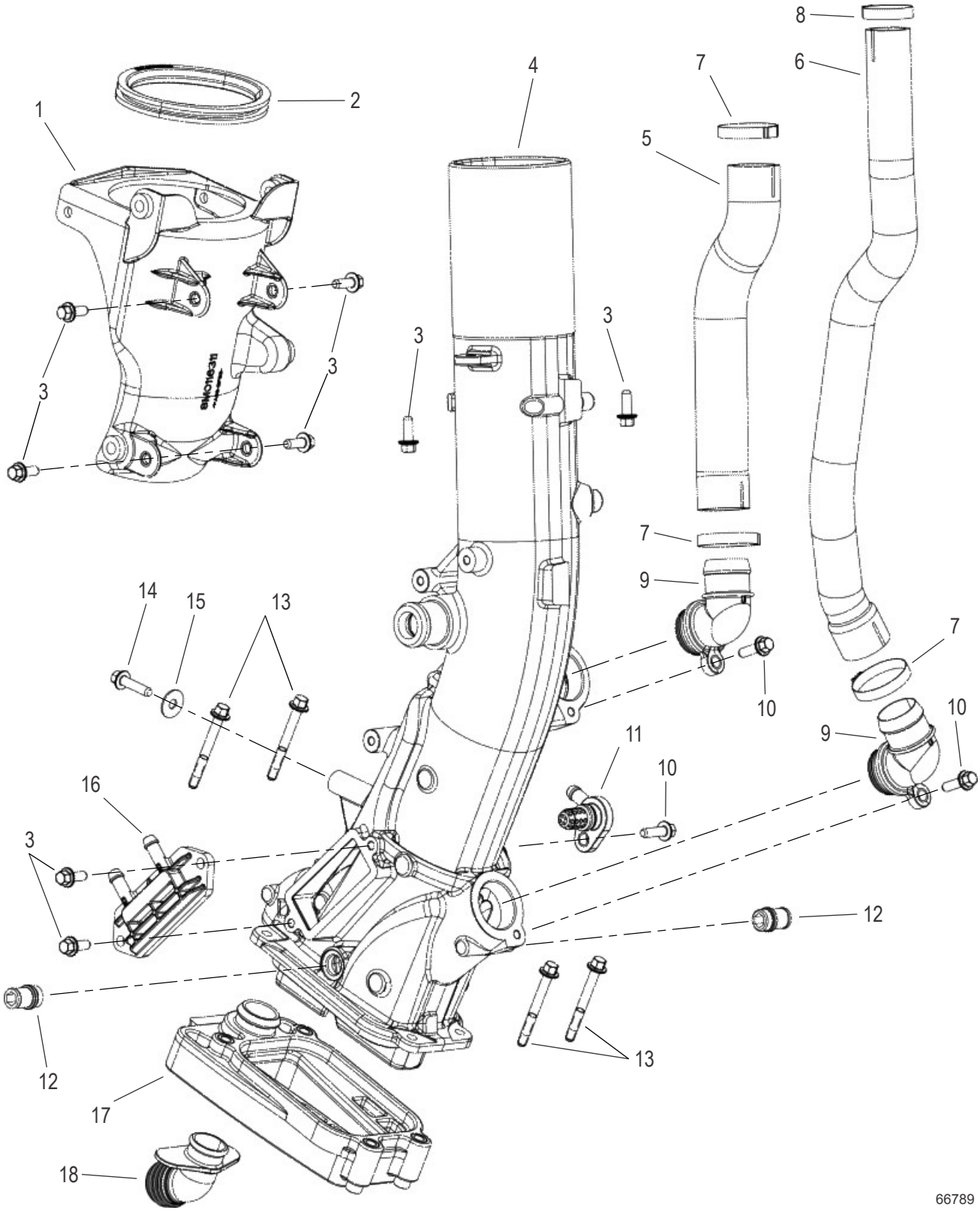
Adapter Plate Components



Adapter Plate Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Cowl drain			
2	1	Chap plate assembly			
3	1	Sprayer hose assembly			
4	1	Starboard end sprayer			
5	12	Cable tie			
6	5	Multiple nozzle sprayer			
7	1	Water hose			
8	1	Water hose			
9	1	5/16 barb T-fitting			
10	1	Water hose			
11	1	Water hose			
12	1	Water hose			
13	1	Port end sprayer			
14	5	M6 hex flange dog point screw (4 visible, 5th obscured in view)	6.0	53.1	–
15	1	Port chap plate seal			
16	1	Starboard chap plate seal			
17	2	Exhaust channel chap plate seal			
18	1	Water pump indicator fitting			
19	9	M6 hex flange dog point screw	10	88.5	–
20	1	Mount oil deflector shield			
21	3	M6 x 16 hex flange head screw	8.0	70.8	–
22	1	Adapter plate to block gasket			
23	2	Dowel pin			
24	1	Adapter plate			
25	4	M10 x 45 hex flange screw	47.5	–	35
26	1	M10 x 1.5 x 60 hex flange head screw	47.5	–	35
27	1	Upper mount			
28	2	Washer			
29	2	M14 x 2.0 x 100 hex flange head screw	160	–	118
30	1	Mount retainer bracket			
31	1	Upper mount bracket seal			
32	2	Straight fitting			
33	4	M8 x 30 hex flange head screw	27.1	–	20

Exhaust Tube Components



Exhaust Tube Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Fuel supply module (FSM) bracket			
2	1	FSM retainer grommet			
3	8	M6 x 16 hex flange head screw	10	88.5	–
4	1	Exhaust tube			
5	1	Water inlet hose			
6	1	Water outlet hose			
7	3	38.1 mm Oetiker® clamp			
8	1	31.6 mm Oetiker® clamp			
9	2	Elbow fitting			
10	3	M6 x 20 hex flange head screw	10	88.5	–
11	1	Strainer			
12	1 or 2	Muffler drain fitting	2.0	17.7	–
13	4	M6 x 55 hex flange head screw	15	132.8	–
14	1	M6 x 25 hex flange head screw	10	88.5	–
15	1	Washer			
16	1	Strainer assembly			
17	1	Exhaust grommet			
18	1	Elbow fitting			

Lower Mounts

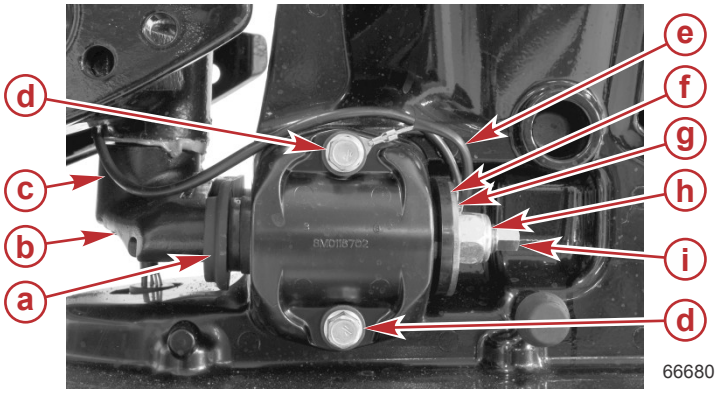
The lower mounts can be replaced without removing the powerhead or gearcase and without dismantling the midsection. Replace the mounts one at a time. Although the following lists replacing the port mount first, the sequence does not matter.

Preparation

1. Disconnect the starting battery from the engine.
2. Remove the propeller.
3. Remove the top cowl.
4. Remove the lower cowls. Refer to **Section 5C - Conventional Midsection (CMS) Lower Cowl Removal**.

Lower Port Mount Removal

1. Remove the M14 locknut that secures the lower port mount.
2. Remove the two ground cables, special washer, and rubber washer.
3. Remove the M14 x 2 x 146 stud from the lower yoke.
4. Remove the upper M8 x 35 hex flange head screw, washer, and short ground cable.
5. Remove the lower M8 x 35 hex flange head screw, washer, lower mount cover, and lower mount.



a - Snubber
b - Lower yoke
c - Long ground cable
d - M8 x 35 hex flange head screws and washers (2 each)
e - Short ground cable
f - Rubber washer
g - Special washer
h - M14 locknut
i - M14 x 2 x 146 stud

Lower Port Mount Installation

1. Place the lower mount in position.
2. Ensure that the snubber is in position on the lower yoke.
3. Pass the M14 x 2 x 146 stud through the lower mount and snubber, and hand-start it into the lower yoke.
4. Place the lower mount cover over the lower mount, with the cast-in part number right-side up. Attach the cover and short ground cable with two M8 x 35 hex flange head screws and two washers, ensuring that the short ground cable ring terminal is between the upper washer and the mount cover.
5. Tighten the screws to the specified torque.

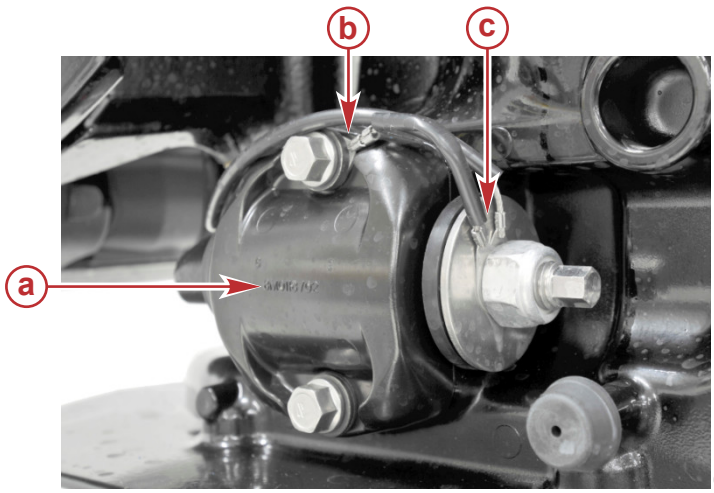
Description	Nm	lb-in.	lb-ft
M8 x 35 hex flange head screw	27.1	–	20.0

6. Tighten the M14 x 2 x 146 stud to the specified torque.

Description	Nm	lb-in.	lb-ft
M14 x 2 x 146 stud	32	–	23.6

7. Position the rubber washer and special washer over the stud and against the lower mount.

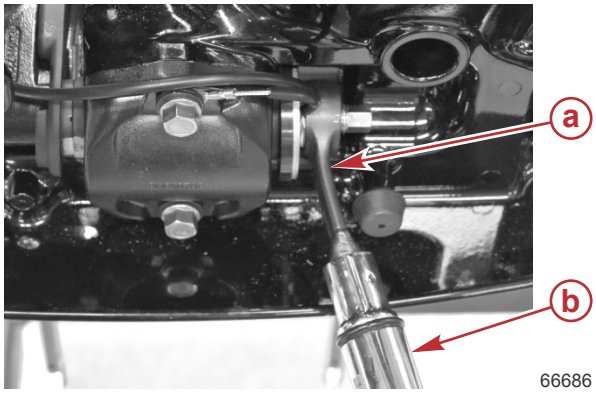
8. Place the ring terminals of both ground cables over the stud, against the special washer. Ensure that the ring terminals are slightly offset.



Lower port mount installation

- **a -** Part number on cover right-side up
- **b -** Ring terminal behind washer
- **c -** Ring terminals slightly offset

9. Secure the lower mount assembly on the stud with an M14 locknut. Use an interchangeable head torque wrench with a 22 mm box end torque head (obtain locally) to tighten the locknut to the specified torque.

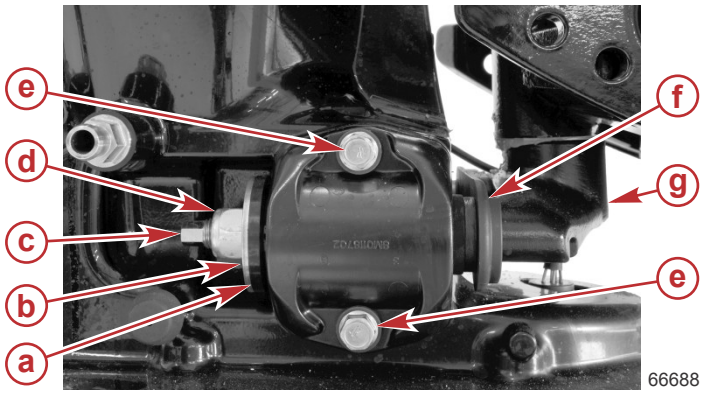


- **a -** 22 mm box end torque head
- **b -** Interchangeable head torque wrench

Description	Nm	lb-in.	lb-ft
M14 locknut	90	–	66.4

Lower Starboard Mount Removal

1. Remove the M14 locknut that secures the lower starboard mount.
2. Remove the special washer and the rubber washer.
3. Remove the M14 x 2 x 146 stud from the lower yoke.
4. Remove the two M8 x 35 hex flange head screws and two washers.
5. Remove the lower mount cover and lower mount.



- **a -** Rubber washer
- **b -** Special washer
- **c -** M14 x 2 x 146 stud
- **d -** M14 locknut
- **e -** M8 x 35 hex flange head screws and washers (2 each)
- **f -** Snubber
- **g -** Lower yoke

Lower Starboard Mount Installation

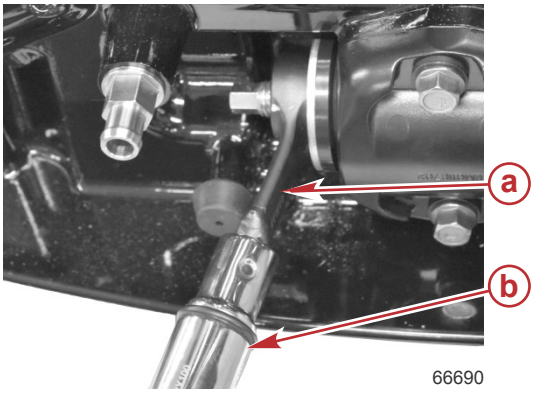
1. Place the lower mount in position, with the paint mark toward the lower yoke.
2. Ensure that the snubber is in position on the lower yoke.
3. Pass the M14 x 2 x 146 stud through the lower mount and snubber, and hand-start it into the lower yoke.
4. Place the lower mount cover over the lower mount, with the cast-in part number upside down. Attach the cover with two M8 x 35 hex flange head screws and two washers.
5. Tighten the screws to the specified torque.

Description	Nm	lb-in.	lb-ft
M8 x 35 hex flange head screw	27.1	–	20.0

6. Tighten the M14 x 2 x 146 stud to the specified torque.

Description	Nm	lb-in.	lb-ft
M14 x 2 x 146 stud	32	–	23.6

7. Position the rubber washer and special washer over the stud and against the lower mount.
8. Secure the lower mount assembly on the stud with a M14 locknut. Use an interchangeable head torque wrench with a 22 mm box end torque head (obtain locally) to tighten the locknut to the specified torque.



a - 22 mm box end torque head
b - Interchangeable head torque wrench

Description	Nm	lb-in.	lb-ft
M14 locknut	90	–	66.4

Return to Service

1. Install the lower cowls. Refer to **Section 5C - Conventional Midsection (CMS) Lower Cowl Installation**.
2. Install the top cowl.
3. Install the propeller.
4. Connect the starting battery to the engine.

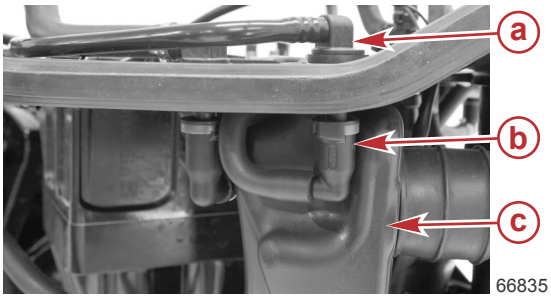
Idle Relief Muffler

Pro XS Muffler (Single)

IMPORTANT: This procedure assumes the engine has been removed from service and all cowls have been removed.

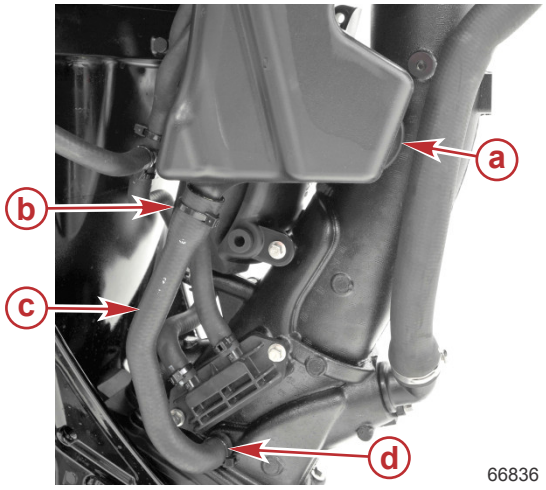
Removal

1. Disconnect the reference hose from the underside of the chap plate.



Shown with powerhead removed
a - Reference hose fitting (through chap plate)
b - Reference hose quick-connect
c - Muffler

2. If the powerhead has been removed, remove the reference hose and fitting from the topside of the chap plate.
3. Cut the cable tie that secures the muffler drain hose, and remove the hose from the fitting in the exhaust tube.



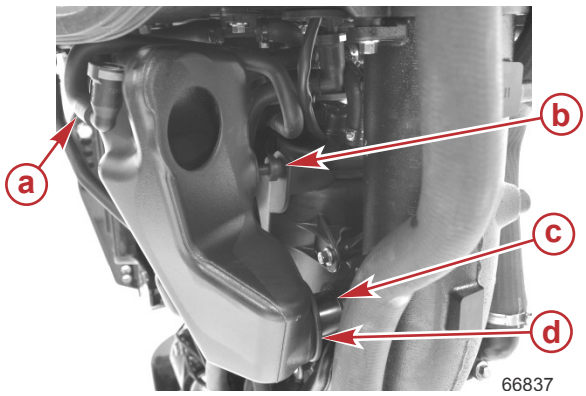
a - Muffler exhaust inlet
b - Cable tie securing drain hose to muffler (remove as required)
c - Muffler drain hose
d - Cable tie securing drain hose to fitting in the exhaust tube

4. Carefully pull the muffler away from the exhaust tube and fuel supply module (FSM) bracket.
   NOTE: *If the reference hose fitting was not removed (step 2), exercise care to not damage the fitting.*

Installation

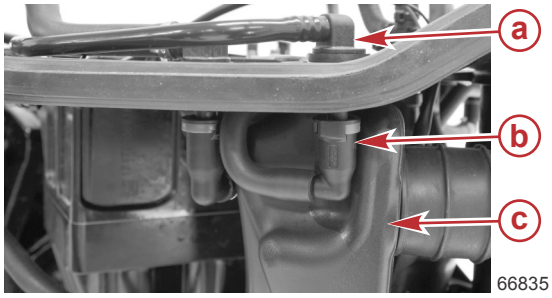
NOTE: *To ease installation of components, use soapy water as a lubricant.*

1. Ensure that the grommet is in the muffler inlet opening, and press the muffler onto the exhaust tube and into the upper grommet in the FSM bracket.
   NOTE: *If the reference hose fitting was not removed from the chap plate, carefully maneuver the muffler around the fitting.*



Shown with reference hose fitting removed
a - Reference hose; use care, if the fitting has not been removed
b - Upper grommet in FSM bracket
c - Muffler inlet (exhaust tube outlet)
d - Grommet in muffler

2. Attach the drain hose to the bottom of the muffler and to the fitting on the exhaust tube. Secure each connection with a cable tie.
3. Install the reference hose and fitting into the topside of the chap plate, if it was removed.
4. Attach the reference hose quick-connect to the fitting on the underside of the chap plate.



Shown with powerhead removed
a - Reference hose fitting (through chap plate)
b - Reference hose quick-connect
c - Muffler

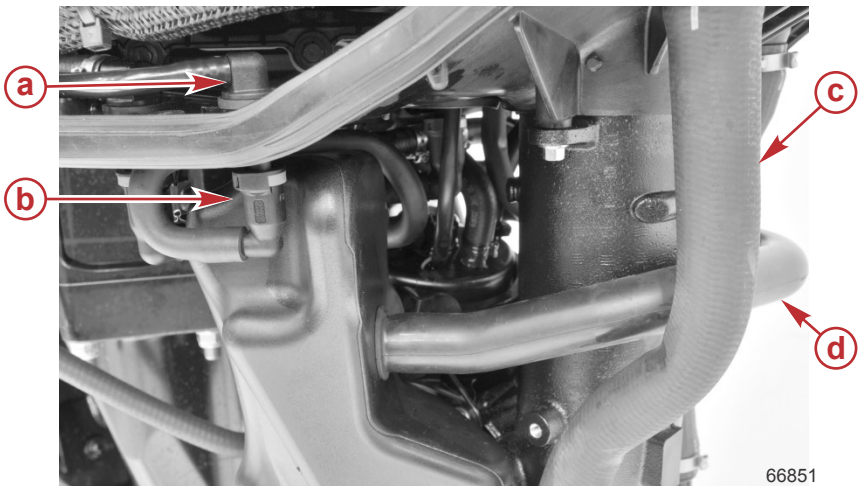
Standard Muffler Assembly (Dual)

IMPORTANT: This procedure assumes the engine has been removed from service and all cowls have been removed.

The idle relief muffler grommet and exhaust outlet hose are a single assembly and should be removed and installed with the lower cowls.

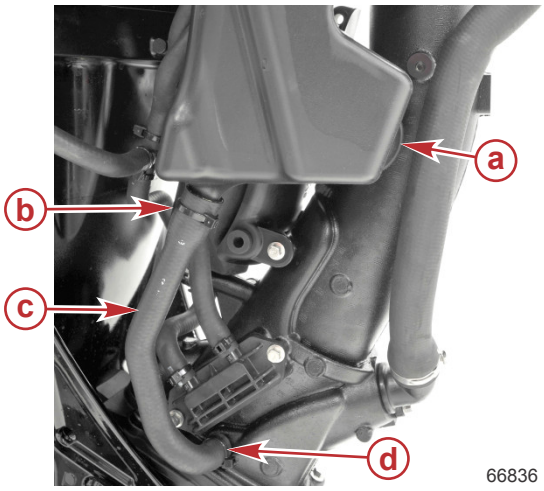
Removal

1. Disconnect the reference hose from the underside of the chap plate.
2. If the powerhead has been removed, remove the reference hose and fitting from the topside of the chap plate.
3. Remove the crossover hose from the port muffler.



a - Reference hose fitting
b - Reference hose quick-connect
c - Water supply hose
d - Exhaust crossover hose

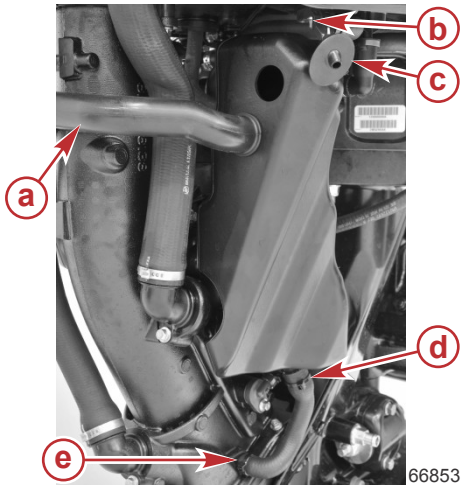
4. Cut the cable tie that secures the port muffler drain hose, and remove the hose from the fitting in the exhaust tube.



a - Port muffler exhaust inlet
b - Cable tie securing drain hose to muffler (remove as required)
c - Port muffler drain hose
d - Cable tie securing drain hose to fitting in the exhaust tube

5. Carefully pull the port muffler away from the exhaust tube and fuel supply module (FSM) bracket.
   NOTE: *If the reference hose fitting was not removed (step 2), exercise care to not damage the fitting.*
6. Remove one M6 hex flange dog point screw to remove the water pump indicator fitting from the chap plate.

7. Cut the cable tie that secures the starboard muffler drain hose, and remove the hose from the fitting in the exhaust tube.



a - Crossover hose
b - M6 hex flange dog point screw
c - Water pump indicator fitting
d - Cable tie securing drain hose to muffler (remove as required)
e - Cable tie securing drain hose to fitting in the exhaust tube

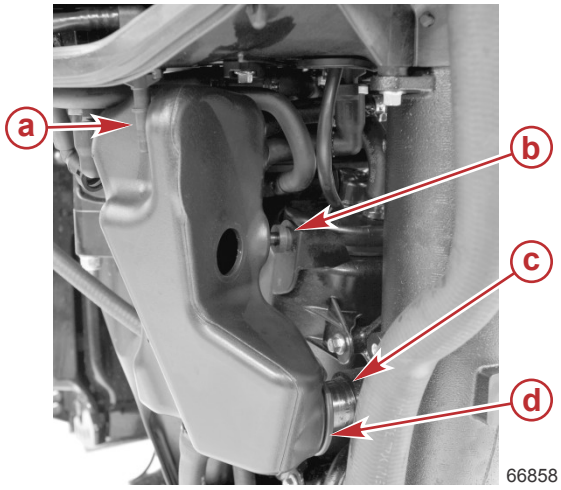
8. Pull the starboard muffler away from the FSM bracket.

Installation

NOTE: *To ease installation of components, use soapy water as a lubricant.*

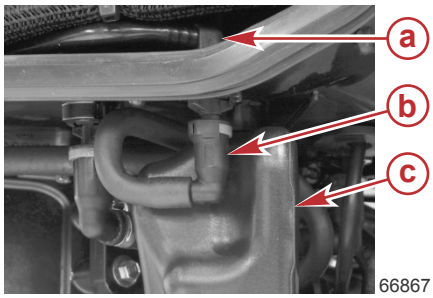
1. Ensure that the grommet is in the port muffler inlet opening, and press the muffler onto the exhaust tube and into the upper grommet on the FSM bracket.

   NOTE: *If the reference hose fitting was not removed from the chap plate, carefully maneuver the muffler around the fitting.*



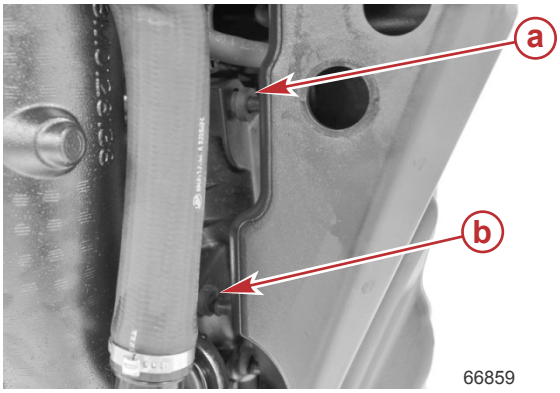
a - Reference hose fitting; use care to avoid damage to the fitting
b - Upper grommet in FSM bracket
c - Port muffler inlet (exhaust tube outlet)
d - Grommet in port muffler

2. Attach the drain hose to the bottom of the port muffler and to the fitting on the exhaust tube. Secure each connection with a cable tie.
3. Install the reference hose and fitting into the topside of the chap plate, if it was removed.
4. Attach the reference hose quick-connect to the fitting on the underside of the chap plate.



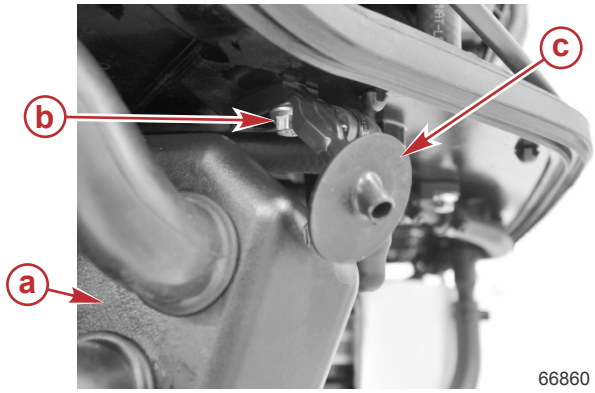
a - Reference hose fitting
b - Reference hose quick-connect
c - Port muffler

5. Press the pins on the starboard muffler into the grommets in the FSM bracket.



a - Upper grommet in FSM bracket
b - Lower grommet in FSM bracket

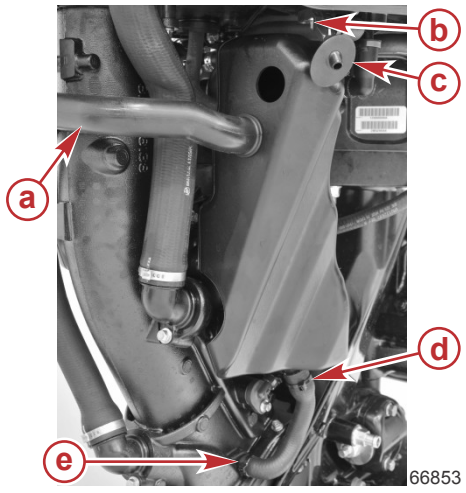
6. Use one M6 hex flange dog point screw to attach the water pump indicator fitting (and attached hose) to the underside of the chap plate. Tighten the screw to the specified torque.



a - Starboard muffler
b - M6 hex flange dog point screw
c - Water pump indicator fitting

Description	Nm	lb-in.	lb-ft
M6 hex flange dog point screw	10	88.5	–

7. Attach the drain hose to the bottom of the starboard muffler and to the fitting on the exhaust tube. Secure each connection with a cable tie.
8. Route the crossover hose behind the water supply hose, and insert it into both the port and starboard mufflers.



a - Crossover hose
b - M6 hex flange dog point screw
c - Water pump indicator fitting
d - Cable tie securing drain hose to muffler
e - Cable tie securing drain hose to fitting in the exhaust tube

Fuel Supply Module (FSM)

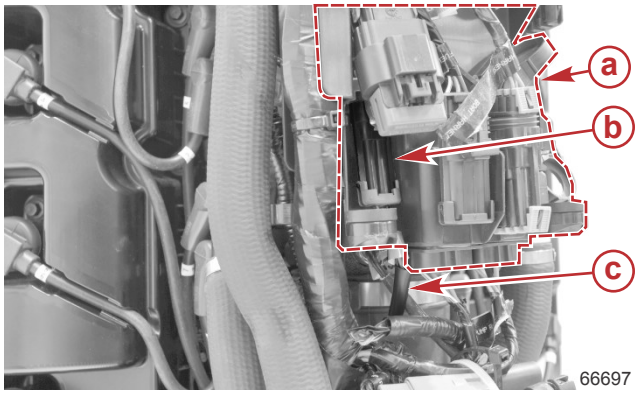
Fuel Supply Module (FSM) Removal

⚠ 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.

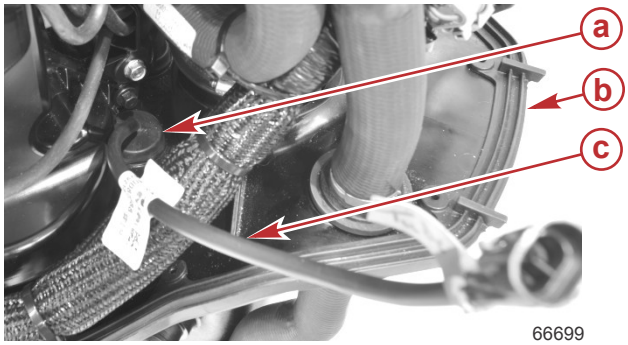
Use this procedure to remove the FSM from the midsection for servicing, without removing the powerhead.

1. Remove all engine cowls. Refer to **Section 5C - Upper and Lower Cowls**.
2. Use a fuel pressure gauge or other suitable method to relieve the pressure from both fuel rails. Collect and dispose of fuel according to all applicable regulations.
3. Remove the idle relief mufflers. Refer to **Idle Relief Muffler**.
4. Disconnect the FSM from the engine harness, and remove the connector from the electrical bracket.



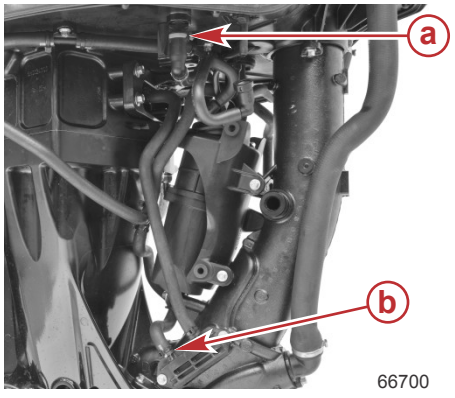
a - Electrical bracket
b - FSM harness connector
c - FSM harness

5. Carefully push the grommet down through the chap plate, bringing the FSM harness down with it.



a - Grommet
b - Chap plate
c - FSM harness

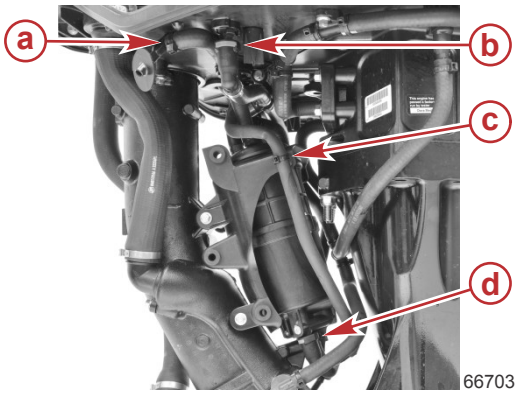
6. Cut the cable tie and remove the water supply hose from the water strainer.
7. Disconnect the port fuel rail supply hose from the quick-connect fitting in the chap plate. Be certain to capture and dispose of fuel according to all applicable regulations.



a - Quick-connect for port fuel rail supply hose
b - Cable tie on water supply hose

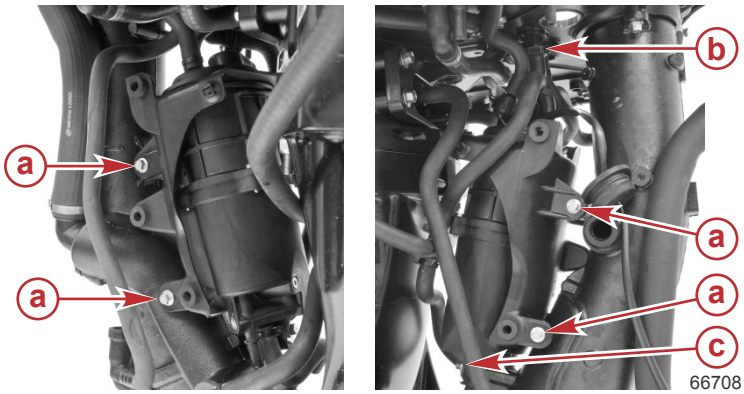
8. Cut the cable tie and remove the hose from the water pump indicator fitting.

9. Cut the cable tie securing the fuel hose to the FSM bracket.
10. Disconnect the fuel supply hose from the quick-connect fitting at the bottom of the FSM. Be certain to capture and dispose of fuel according to all applicable regulations.
11. Disconnect the starboard fuel rail supply hose from the quick-connect fitting in the chap plate. Be certain to capture and dispose of fuel according to all applicable regulations.



a - Cable tie on hose at the water pump indicator fitting
b - Quick-connect for starboard fuel rail supply hose
c - Cable tie securing fuel hose to FSM bracket
d - Quick-connect for FSM supply hose

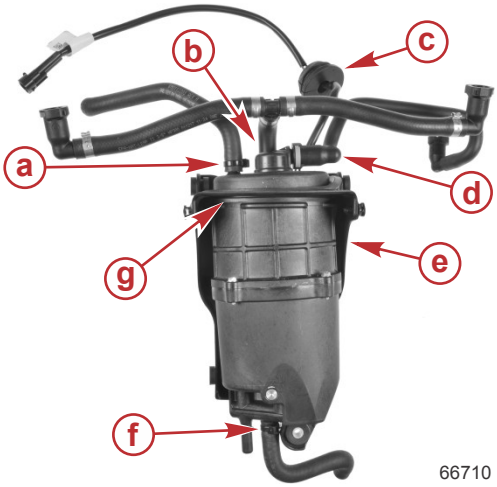
12. To aid in the removal of the FSM, disconnect the cylinder head drain hose quick-connect.
13. Remove the M6 x 25 hex flange head screw and washer that secures the bottom of the FSM to the exhaust tube.
14. Remove the four M6 x 16 hex flange head screws that secure the FSM bracket to the exhaust tube.



a - M6 x 16 hex flange head screws (4 total, 2 each side)
b - Cylinder head drain hose quick-connect fitting
c - M6 x 25 hex flange head screw and washer

15. Carefully remove the FSM assembly (including bracket and hoses) from the midsection.

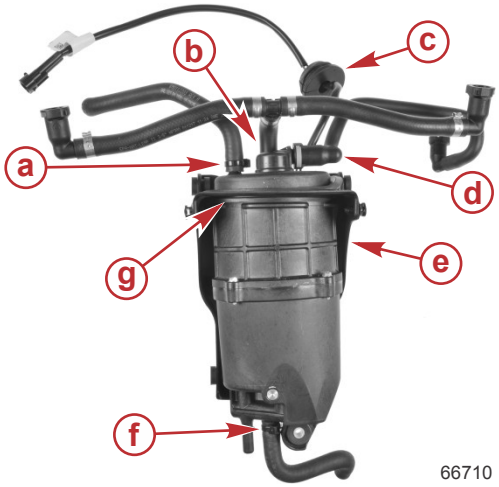
    NOTE: *Lift the assembly up until the bracket clears the bosses on the exhaust tube. Some shifting of hoses may be required.*
16. Remove the bracket and hoses as necessary to service the FSM. For FSM service instructions, refer to **Section 3B - Fuel Supply Module (FSM)**.



a - Cut cable tie to remove water outlet hose (to water pump indicator fitting)
b - Remove Oetiker® clamp (not shown) to remove fuel rail supply hoses
c - FSM harness grommet
d - Disconnect quick-connect fitting to remove reference hose
e - Slide FSM bracket upward to remove
f - Cut cable tie to remove water inlet hose (from strainer)
g - FSM bracket grommet

Fuel Supply Module (FSM) Installation

1. Ensure that the bracket and hoses are attached to the FSM.



a - Cable tie used to secure the water outlet hose (to water pump indicator fitting)
b - 16.2 mm Oetiker® clamp (not shown) used to secure the fuel rail supply hoses
c - Grommet installed on the FSM harness
d - Reference hose connected to quick-connect fitting
e - FSM bracket (with grommet) installed by sliding down over FSM

NOTE: *Use soapy water as a lubricant, to ease installation.*

f - Cable tie used to secure the water inlet hose (from strainer)
g - FSM bracket grommet securely in position

2. Carefully position the FSM assembly (including bracket and hoses) into the midsection.

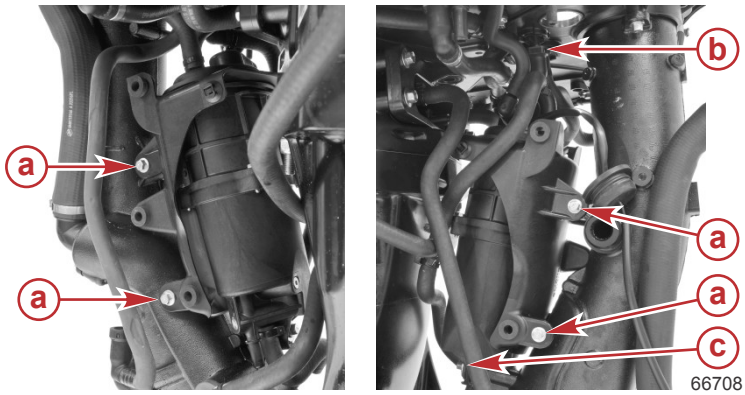
   NOTE: *Position the assembly so that the holes in the bracket are above the bosses on the exhaust tube. Then slide the assembly down into position. Some shifting of hoses may be required.*

3. Apply Loctite® 242 Threadlocker to four M6 x 16 hex flange head screws and one M6 x 25 hex flange head screw. Use the four short screws to secure the FSM bracket to the exhaust tube and the single long screw and washer to secure the FSM to the exhaust tube. Tighten all five screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange head screws	92-809821
66	Loctite 242 Threadlocker	M6 x 25 hex flange head screw	92-809821

Description	Nm	lb-in.	lb-ft
M6 x 16 hex flange head screw	10	88.5	–
M6 x 25 hex flange head screw	10	88.5	–

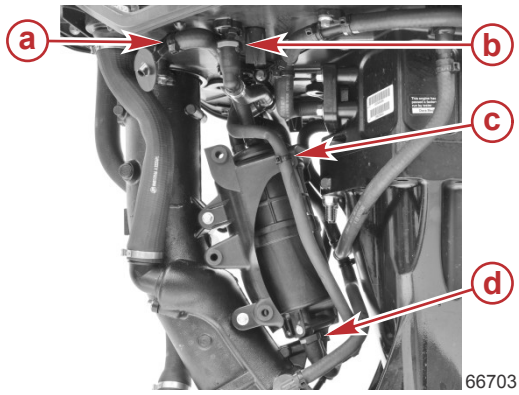
4. Connect the cylinder head drain hose to the quick-connect fitting in the chap plate.



a - M6 x 16 hex flange head screws (4 total, 2 each side)
b - Cylinder head drain hose quick-connect fitting
c - M6 x 25 hex flange head screw and washer

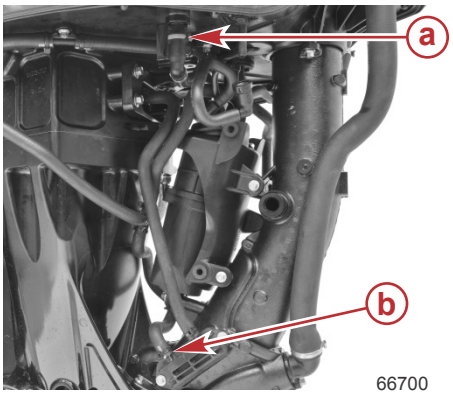
5. Connect the fuel supply hose to the quick-connect fitting at the bottom of the FSM.
6. Secure the fuel hose to the fuel pump bracket with a cable tie through the anchor.
7. Connect the starboard fuel rail supply hose to the quick-connect fitting in the chap plate.

8. Connect the hose to the water pump indicator fitting and secure it with a cable tie.



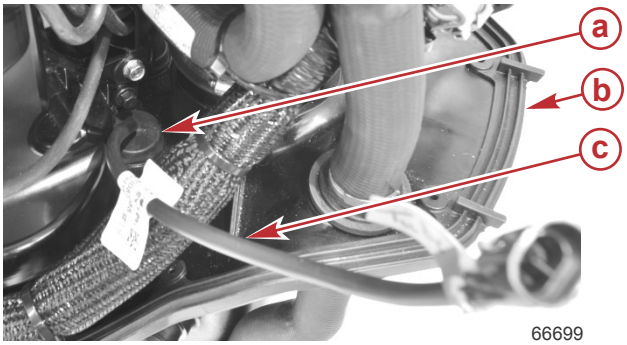
a - Cable tie on hose at the water pump indicator fitting
b - Quick-connect for starboard fuel rail supply hose
c - Cable tie securing fuel hose to FSM bracket
d - Quick-connect for FSM fuel supply hose

9. Connect the FSM water supply hose to the strainer, and secure it with a cable tie.
10. Connect the port fuel rail supply hose to the quick-connect fitting in the chap plate.



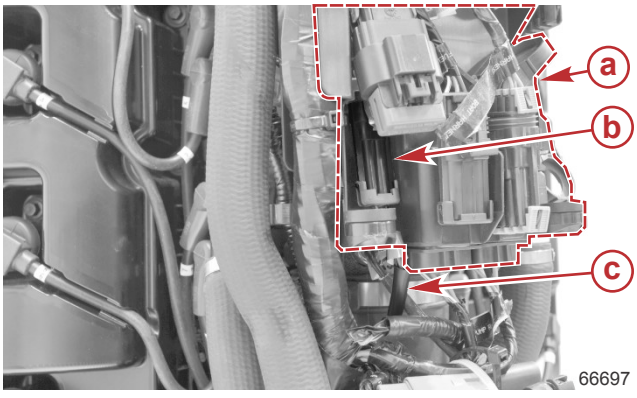
a - Quick-connect for port fuel rail supply hose
b - Cable tie on the FSM water supply hose

11. Feed the FSM harness up through the chap plate, and carefully press the grommet up into place. Use soapy water as a lubricant, to ease installation.



a - Grommet
b - Chap plate
c - FSM harness

12. Attach the FSM harness connector to its anchor on the electrical bracket, and connect the FSM harness to the engine harness.



a - Electrical bracket
b - FSM harness connector
c - FSM harness

13. Install the idle relief mufflers. Refer to **Idle Relief Muffler**.

14. Install the engine cowls. Refer to **Section 5C - Upper and Lower Cowls**.

Conventional Midsection (CMS) Disassembly

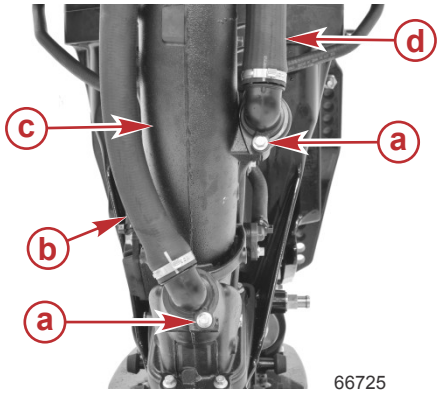
Preparation for CMS Disassembly

1. Remove the lower cowls. Refer to **Section 5C - Upper and Lower Cowls**.
2. Remove the powerhead. Refer to **Section 4A - Powerhead Removal from Conventional Midsection (CMS)**.
3. Remove the gearcase. Refer to **Section 6A - Gear Housing Removal**, **Section 6B - Gear Housing Removal**, or **Section 6C - Gear Housing Removal**.

   IMPORTANT: The water pump indicator fitting is fragile. Remove the water pump indicator fitting before removing the starboard idle relief muffler.
4. Remove the idle relief components. Refer to **Idle Relief Muffler**.

Remove the Chap Plate

1. Remove two screws to disconnect the water supply and return hoses (with elbows) from the exhaust tube.



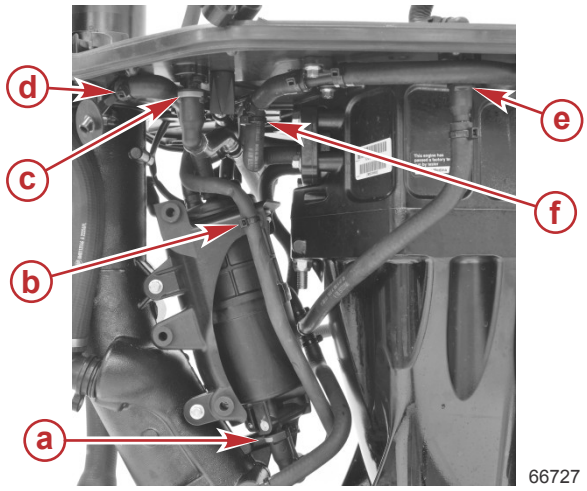
a - Screws (2)
b - Water return hose
c - Exhaust tube
d - Water supply hose

2. Disconnect the quick-connects for the water and fuel hoses on the port side of the chap plate. Be certain to capture and dispose of fuel according to applicable regulations.

a - Port block drain hose quick-connect
b - Port fuel rail supply hose quick-connect
c - Cylinder head drain hose quick-connect
d - Reference hose quick-connect (disconnected during idle relief muffler removal)

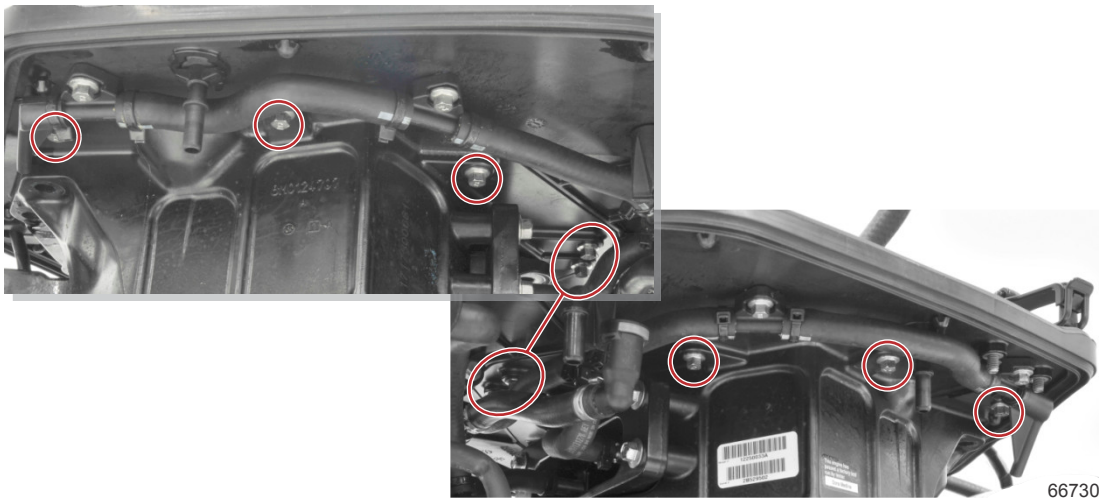
3. Disconnect the water and fuel hoses on the starboard side of the chap plate:
   - Cut the cable tie that secures the hose to the water pump indicator fitting, and remove the hose from the fitting.
   - Remove the cable tie that secures the water hose to the T-fitting of the sprayer assembly, and remove the hose from the fitting.
   - Disconnect the quick-connect fitting for the starboard block drain hose.
   - Remove the cable tie that secures the fuel supply module (FSM) fuel supply hose to the FSM bracket.

- Disconnect the quick-connect fittings for the FSM fuel supply hose and the starboard fuel rail supply hose. Be certain to capture and dispose of fuel according to applicable regulations.



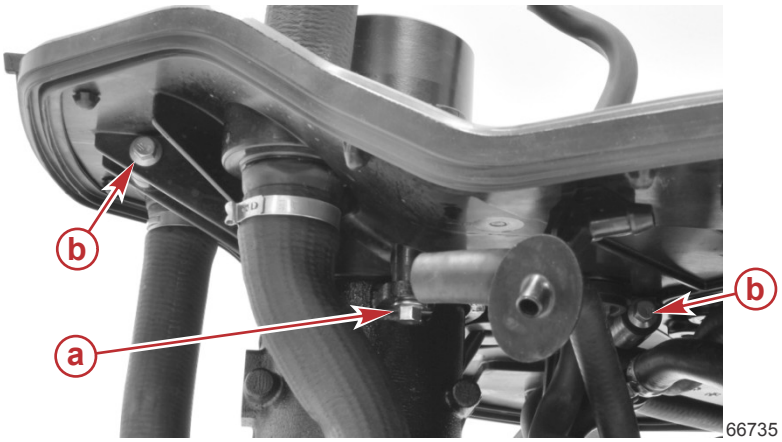
a - FSM fuel supply hose quick-connect
b - Cable tie and anchor securing FSM fuel supply hose to FSM bracket
c - Starboard fuel rail supply hose quick-connect
d - Cable tie on the water pump indicator hose
e - Starboard block drain hose quick-connect
f - Cable tie on the T-fitting for the sprayer assembly

4. Remove eight M6 hex flange dog point screws (four per half) that secure the chap plate to the adapter plate.



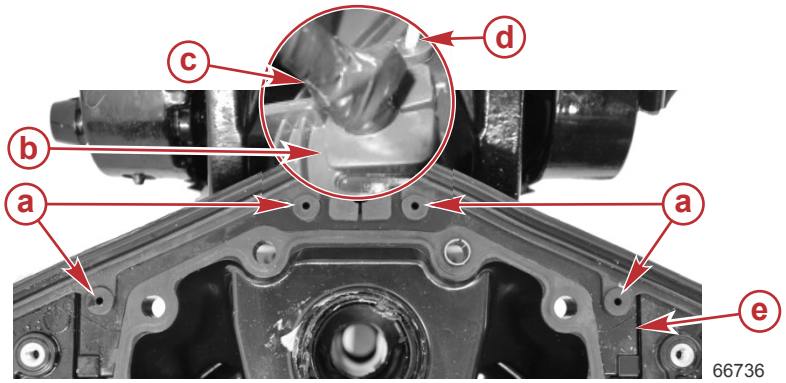
M6 hex flange dog point screws (chap plate screws, 8 total)

5. Remove the two M6 x 16 hex flange head screws securing the chap plate to the exhaust tube.
6. Loosen, but do not remove the two screws holding the chap plate halves together.



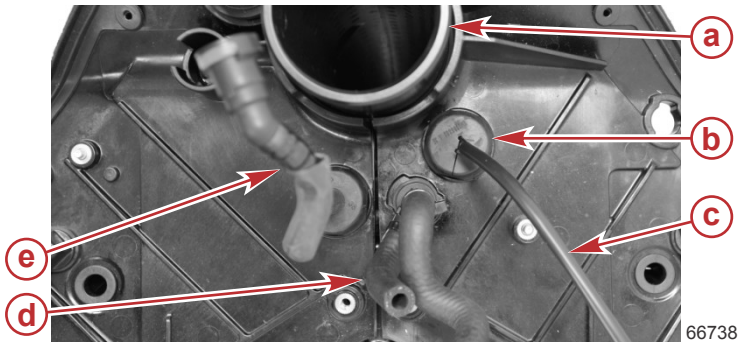
a - Screws securing the chap plate to the exhaust tube (2 total, 1 each side)
b - Screws holding the chap plate halves together (2) - do not remove

7. Remove the front portion of the chap plate seal from the adapter plate by releasing the four locating pins. Remove the shift actuator harness from the grommet hole in the seal.



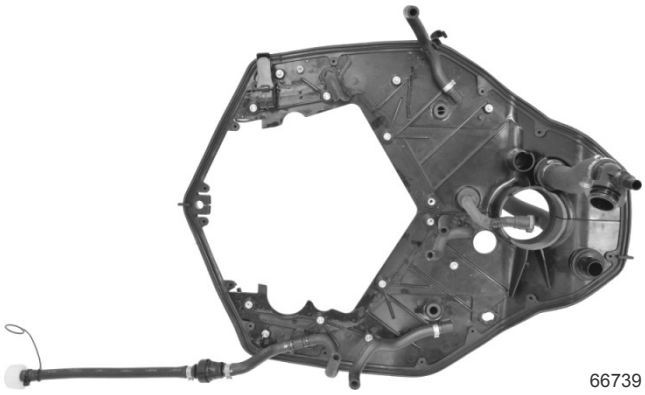
- **a -** Chap plate seal locating pins
- **b -** Grommet in chap plate seal
- **c -** Shift actuator harness
- **d -** Pitot water tube (mechanical engines)
- **e -** Adapter plate

8. Push the fuel supply module (FSM) harness and grommet down through the chap plate.



- **a -** Exhaust tube
- **b -** FSM harness grommet
- **c -** FSM harness
- **d -** Cylinder head drain hoses and fitting
- **e -** FSM supply hose

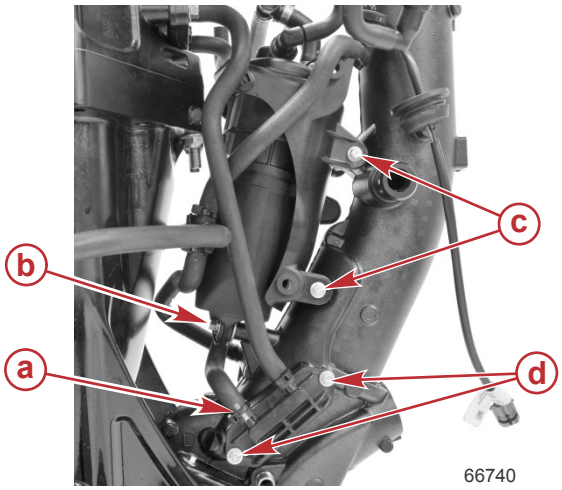
9. Lift the chap plate off the adapter plate and exhaust tube.



Remove the FSM and the Exhaust Tube

1. Cut the cable tie that secures the FSM water supply hose to the port side strainer.
2. Remove the one screw and washer at the bottom of the FSM assembly and the four screws securing the FSM bracket to the exhaust tube.

3. Remove two screws to remove the strainer from the exhaust tube.

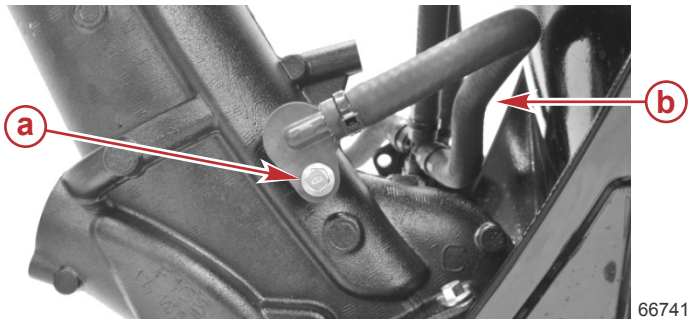


- **a -** Cable tie on FSM water supply hose
- **b -** FSM screw and washer
- **c -** FSM bracket screws (4 total, 2 each side)
- **d -** Strainer screws

4. Remove the FSM assembly. Remove the bracket and hoses as necessary to service the FSM. For FSM service instructions, refer to **Section 3B - Fuel Supply Module (FSM)**.

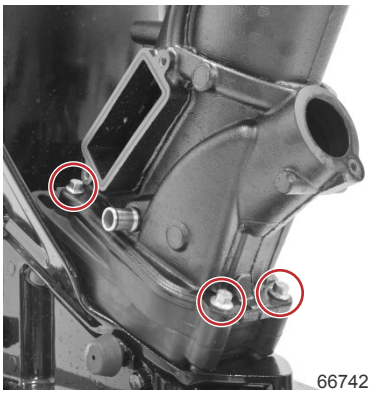
- **a -** Cut cable tie to remove water outlet hose (to water pump indicator fitting)
- **b -** Remove Oetiker® clamp (not shown) to remove fuel rail supply hoses
- **c -** FSM harness grommet
- **d -** Disconnect quick-connect fitting to remove reference hose
- **e -** Slide FSM bracket upward to remove
- **f -** Cut cable tie to remove water inlet hose (from strainer)
- **g -** FSM bracket grommet

5. Remove one screw to remove the starboard strainer (with attached drain hose assembly) from the exhaust tube.



- **a -** Strainer screw
- **b -** Drain hose assembly

6. Remove the four exhaust tube mounting screws (two each side), and remove the exhaust tube from the midsection.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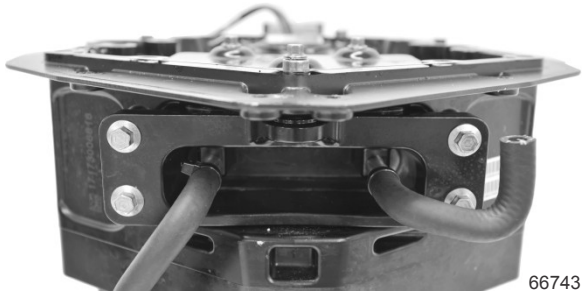
Remove the Upper Mount

1. Remove the four M8 x 30 hex flange head screws from the mount cover. Remove the mount cover.

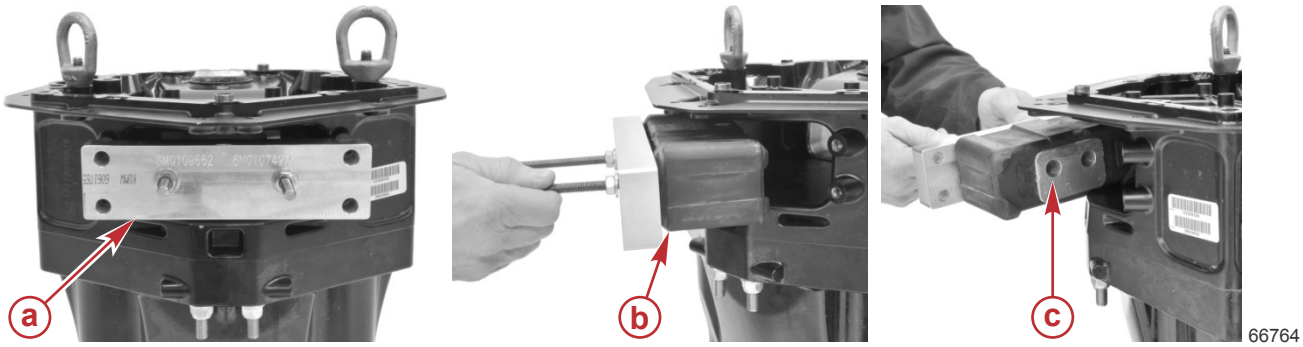

66743

2. Use a 6-point socket to remove the two M14 x 2.0 x 100 hex flange head screws from the upper mount. Retain the special hardened washers.


66745

3. Use the upper mount installation/removal tool to remove the mount.
   a. Hold the bar from the upper mount installation/removal tool in place, and install two threaded rods a minimum of 20 mm into the threaded holes next to the M14 screw holes.
   b. Install two washers and two nuts onto the threaded rods, and finger-tighten.
   c. Tighten the nuts evenly until the upper mount is loose enough to pull out by hand.

d. Remove the threaded rods from the mount.

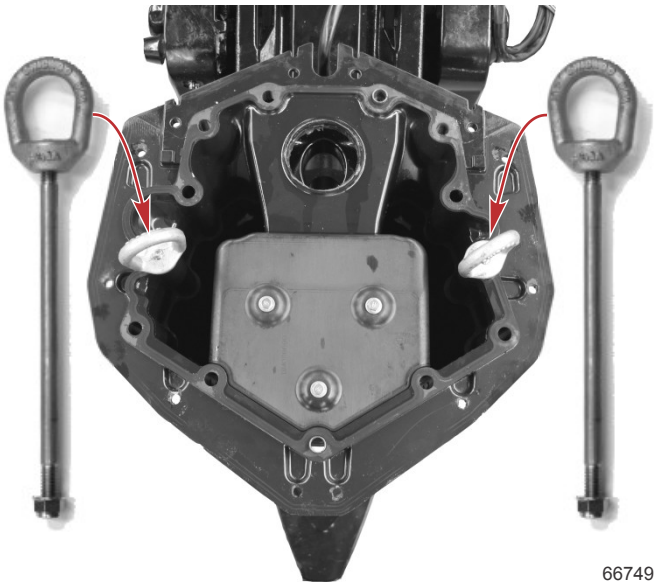


a - Upper mount installation/removal tool
b - Upper mount
c - Note orientation: holes closer to the top of the mount

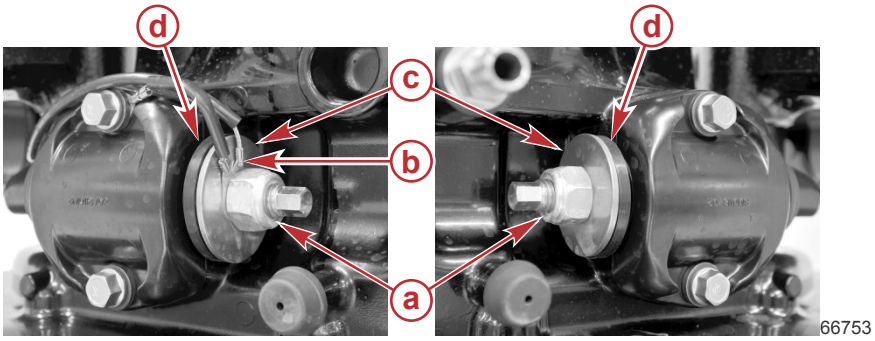
Upper Mount Installation/Removal Tool	8M0148872

Separate the Transom/Swivel Bracket

1. Support the midsection with a hoist, using lift hooks and threaded studs.

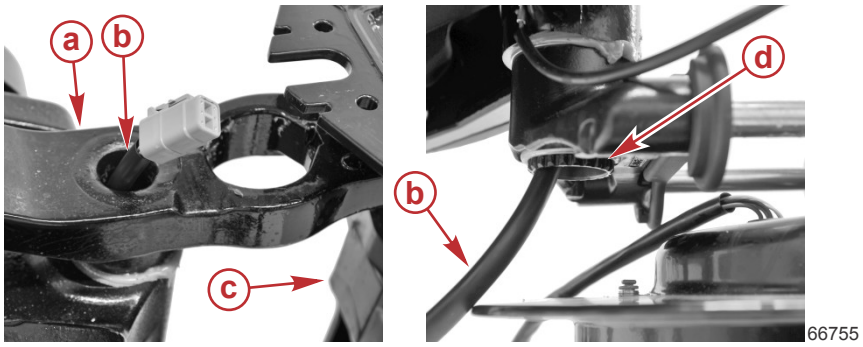


2. Remove the lower mount nuts, ground cables, special washers, and rubber washers.



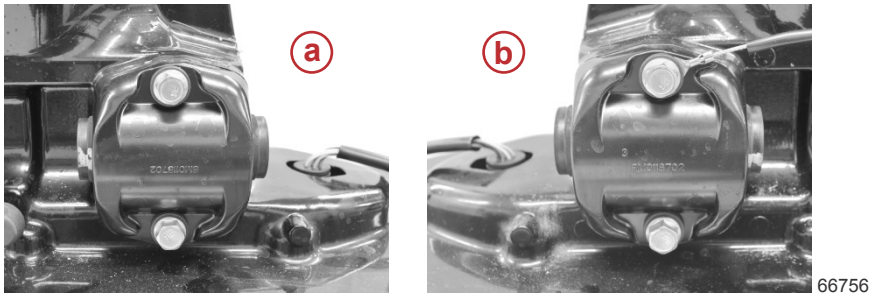
a - Lower mount nuts
b - Ground cables (2, port side only)
c - Special washers
d - Rubber washers (snubbers)

3. Feed the shift actuator harness down through the swivel tube, while removing the driveshaft housing.



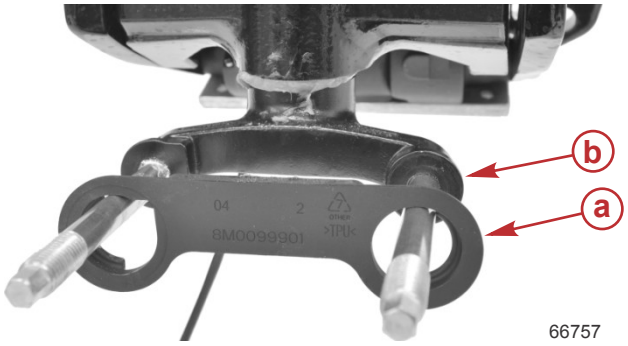
a - Steering arm
b - Shift actuator harness
c - Driveshaft housing
d - Swivel tube

4. Remove the lower mount cover screws.
5. Remove the lower mount covers and the lower mounts.



a - Lower mount with cover, starboard side
b - Lower mount with cover, port side

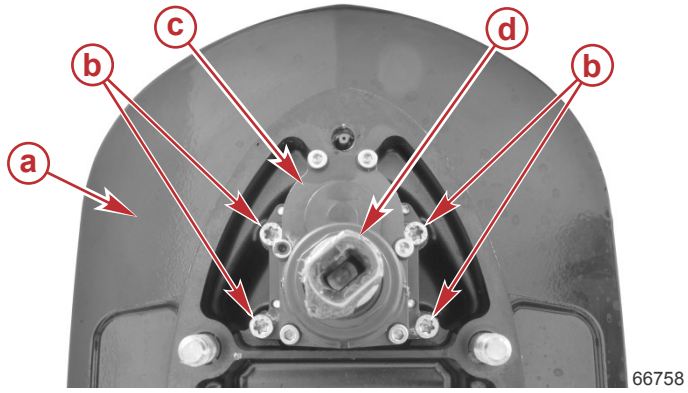
6. Remove the lower mount snubber.



a - Lower mount snubber
b - Lower yoke

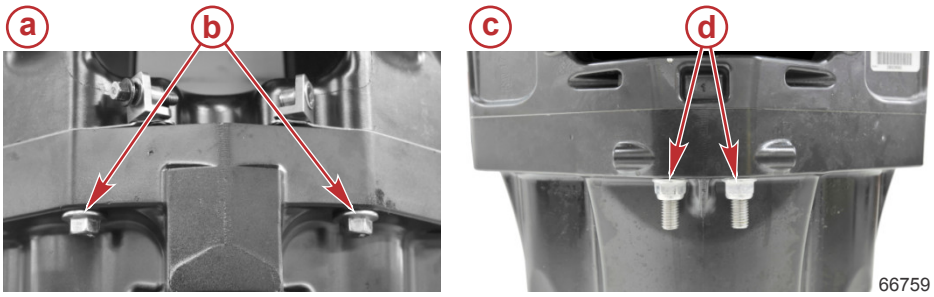
Driveshaft Housing Disassembly

1. Remove the four M6 x 20 Torx® socket head screws, and remove the shift actuator.



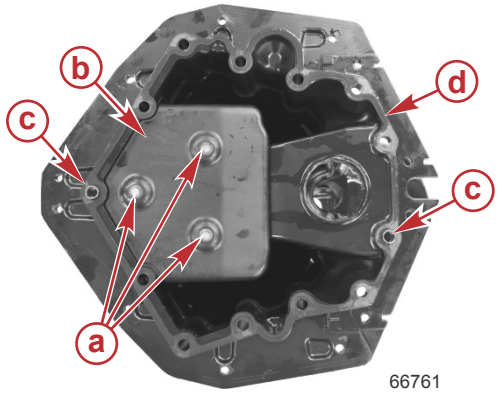
a - Underside of driveshaft housing
b - M6 x 20 Torx socket head screws (4)
c - Shift actuator
d - Shift shaft coupler

2. Remove two M10 x 1.5 x 60 hex flange head screws from the front of the driveshaft housing and two M10 x 1.5 locknuts from the rear, to separate the adapter plate from the driveshaft housing.



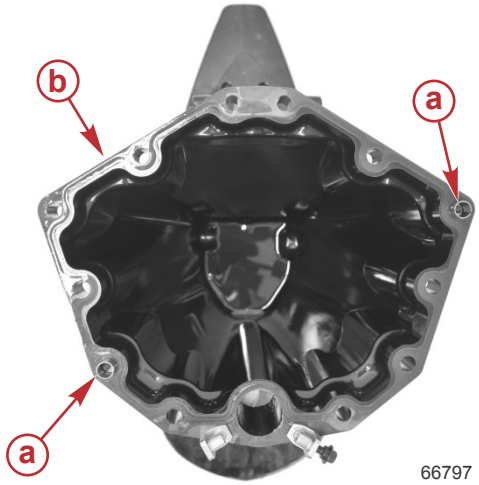
a - Front of driveshaft housing
b - M10 x 1.5 x 60 hex flange head screws (2)
c - Rear of driveshaft housing
d - M10 x 1.5 locknuts (2)

3. Remove the three M6 x 16 hex flange head screws from the mount oil deflector shield, and remove the shield.
4. Remove the gasket from the top of the adapter plate.



a - M6 x 16 hex flange head screws (3)
b - Mount oil deflector shield
c - Dowel pins (2)
d - Adapter plate to block gasket

5. Remove the gasket from the top of the driveshaft housing.



a - Dowel pins (2)
b - Adapter plate to driveshaft housing gasket

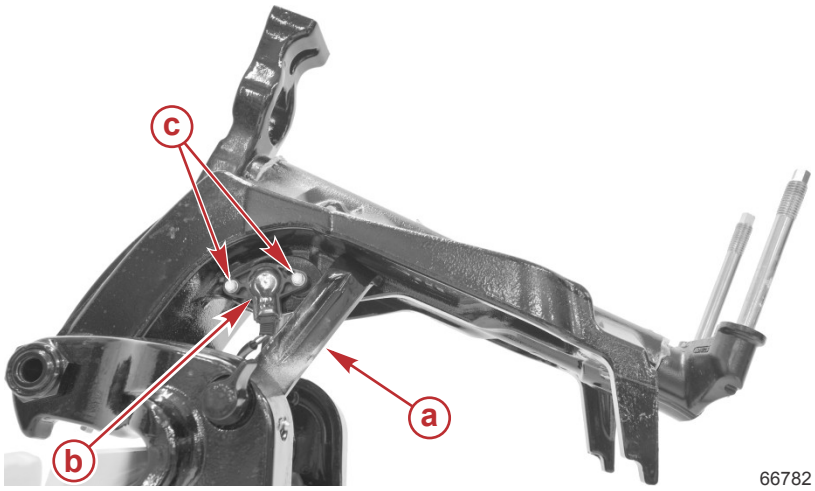
Transom/Swivel Bracket

Transom/Swivel Bracket Disassembly

NOTE: *This procedure leaves the power trim assembly and transom brackets intact. To completely disassemble the transom/swivel bracket assembly, the power trim assembly must be removed: 1) refer to* ***Section 5B - Power Trim Assembly Removal****, and 2) return to step 5 of this procedure.*

1. Remove the steering cylinder assembly. Refer to **Section 7 - Steering**.
2. Trim the assembly to the full-up position. Engage the tilt lock lever.

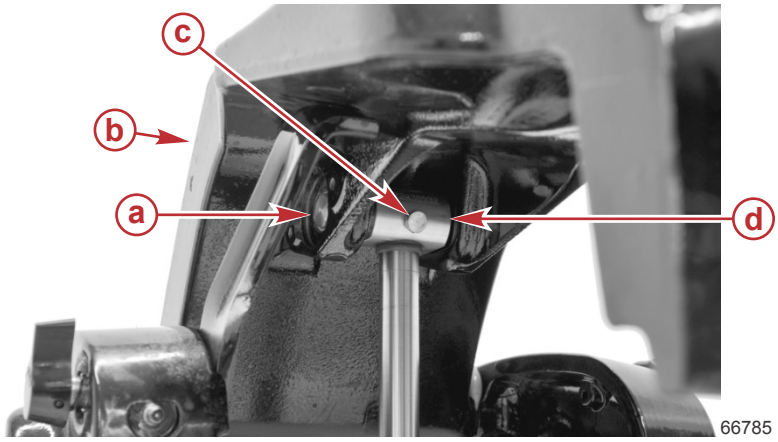
3. Remove the two hex head screws securing the trim position sensor to the port transom bracket, and remove the trim position sensor.



- **a -** Tilt lock
- **b -** Trim position sensor
- **c -** Hex head screws (2)

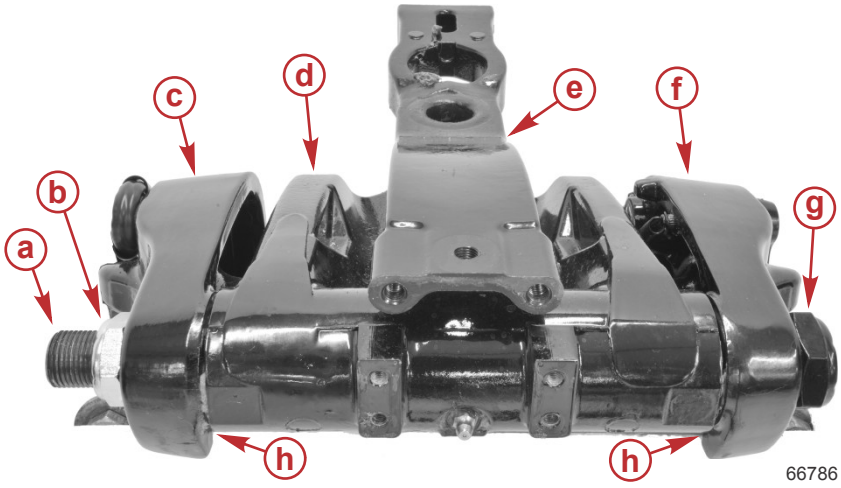
4. Remove the trilobe pin, and push out the rod eye pin. Be careful to retain the magnet located in the trim position sensor end of the rod eye pin.

IMPORTANT: Do not reuse the trilobe pin.



- **a -** Rod eye pin
- **b -** Swivel bracket
- **c -** Trilobe pin
- **d -** Tilt cylinder rod end

5. Remove the 1-1/4 in. locknut from the tilt tube.
6. Support the swivel bracket, and remove the tilt tube from the transom/swivel bracket assembly. The swivel bracket and two wave washers will come loose.

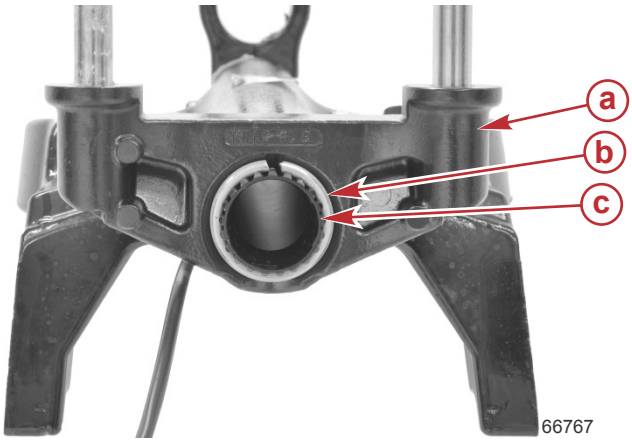


- **a -** Tilt tube
- **b -** 1-1/4 in. locknut
- **c -** Starboard transom bracket
- **d -** Swivel bracket
- **e -** Swivel tube/steering arm assembly
- **f -** Port transom bracket
- **g -** 1-3/8 in. locknut (do not remove)
- **h -** Wave washers (2)

7. Remove the swivel bracket, and retain the wave washers.

Swivel Tube/Steering Arm Removal

1. Remove the retaining ring from the bottom of the swivel tube.

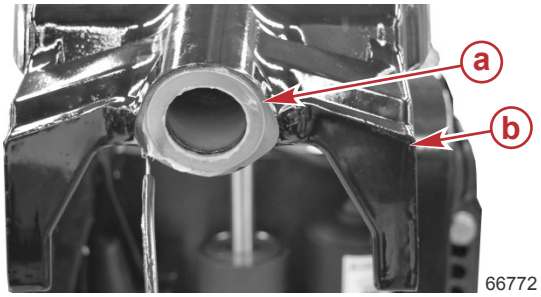


a - Lower yoke
b - Retaining ring
c - Swivel tube

2. Remove the lower yoke.

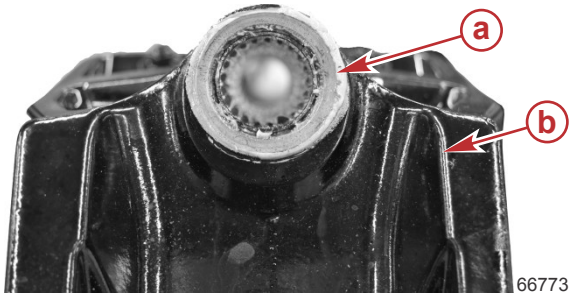
3. Remove the swivel tube/steering arm assembly.

4. Remove the thrust washers at the top and bottom of the swivel bracket.



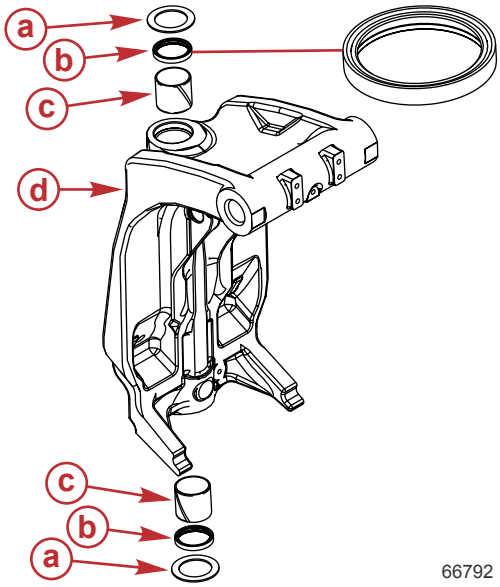
a - Thrust washer (1 each, top and bottom of swivel bracket)
b - Bottom of swivel bracket

5. Remove the seals at the top and bottom of the swivel bracket.



a - Seal (1 each, top and bottom of swivel bracket)
b - Top of swivel bracket

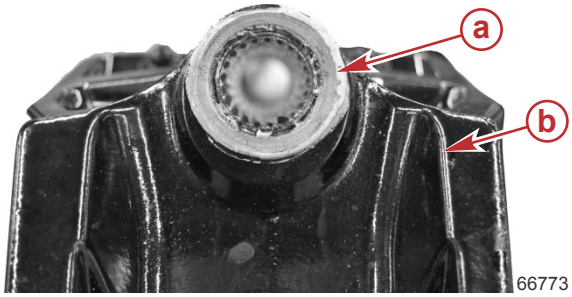
6. Remove the old grease from the swivel bracket bore and clean the bore.
7. Inspect the bushings in each end of the swivel bracket. Replace, if required.



a - Thrust washer (2)
b - Seal (2) - spring side out
c - Bushing (2)
d - Swivel bracket

Swivel Tube/Steering Arm Installation

1. Ensure that the bushings are inserted into each end of the swivel bracket.
2. Install new seals (spring side out) in the top and bottom of the swivel bracket.



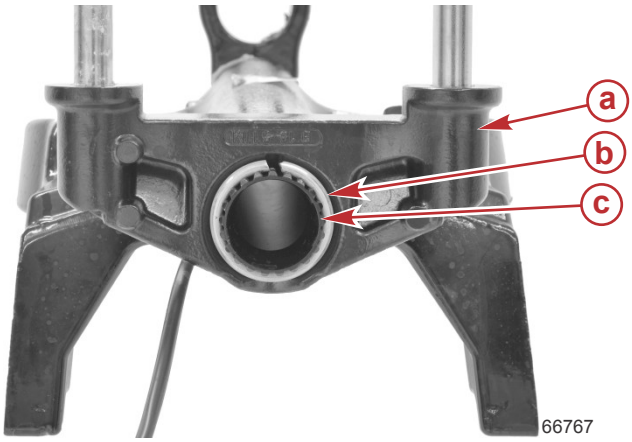
a - Seal (1 each, top and bottom of swivel bracket)
b - Top of swivel bracket

3. Install a thrust washer onto the swivel tube, and slide the swivel tube into the swivel bracket. Ensure that the bottom seal remains in place.
4. Lubricate the swivel tube with 2-4-C with PTFE through the grease fitting in the swivel bracket. Apply the grease until it emerges from both ends of the swivel bracket.
5. Apply 2-4-C with PTFE directly to the swivel tube splines.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Swivel tube, swivel tube splines	92-802859A 1

6. Slide a thrust washer onto the end of the swivel tube.
7. Align the lower yoke with the steering arm, and slide the lower yoke onto the swivel tube.

8. Using a suitable mandrel, instal the retaining ring into the groove on the swivel tube. Ensure that the retaining ring is free to rotate in the groove. If it does not rotate, it is not properly installed.

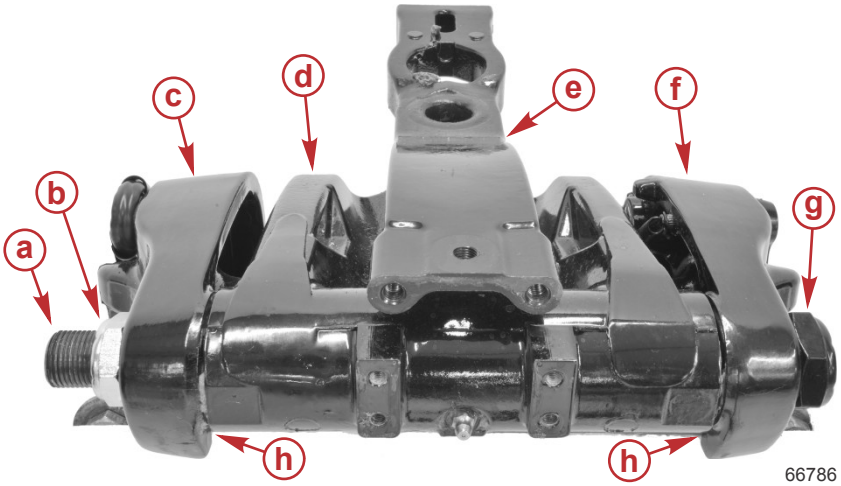


a - Lower yoke
b - Retaining ring
c - Swivel tube

Transom/Swivel Bracket Assembly

NOTE: *This procedure assumes that the power trim assembly and transom brackets were left intact. If any parts were removed from the transom brackets, use the torque values listed in the table in* ***Transom Bracket Components****, to assemble. If the power trim assembly was removed: 1) complete steps 1, 2, and 3 of this procedure, and 2) refer to* ***Section 5B - Power Trim Assembly Installation****.*

1. Assemble the swivel bracket/swivel pin assembly and wave washers between the transom brackets.
2. Insert the tilt tube through the transom brackets, swivel bracket, and wave washers.
3. Install and tighten the tilt tube locknuts in sequence:
   a. Thread the 1-3/8 in. (large) locknut onto the starboard end of the tilt tube until it bottoms on the shoulder.
   b. Tighten the 1-3/8 in. locknut to the specified torque.
   c. Thread the 1-1/4 in. (small) locknut onto the port end of the tilt tube.
   d. Tighten the 1-1/4 in. locknut to the specified torque. Then back the nut off 1/4 turn.



a - Tilt tube
b - 1-1/4 in. locknut
c - Starboard transom bracket
d - Swivel bracket
e - Swivel tube/steering arm assembly
f - Port transom bracket
g - 1-3/8 in. locknut
h - Wave washers (2)

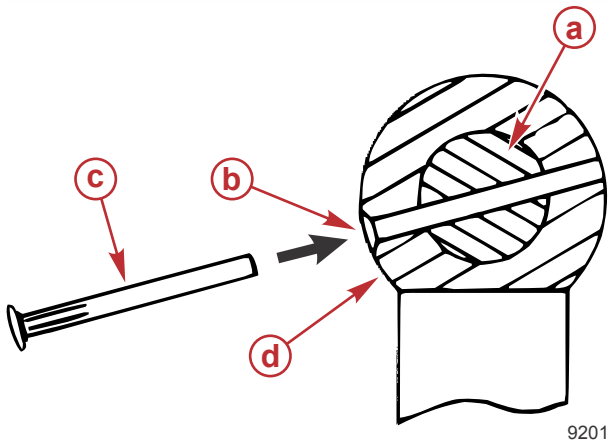
Description		Nm	lb-in.	lb-ft
1-3/8 in. locknut		62	–	45.7
1-1/4 in. locknut	**First**	68	–	50.2
	Final	Back nut off 1/4 turn		

4. Align the tilt cylinder rod end and the swivel bracket cross holes.

   NOTE: *The chamfered hole in the tilt cylinder rod end faces aft.*

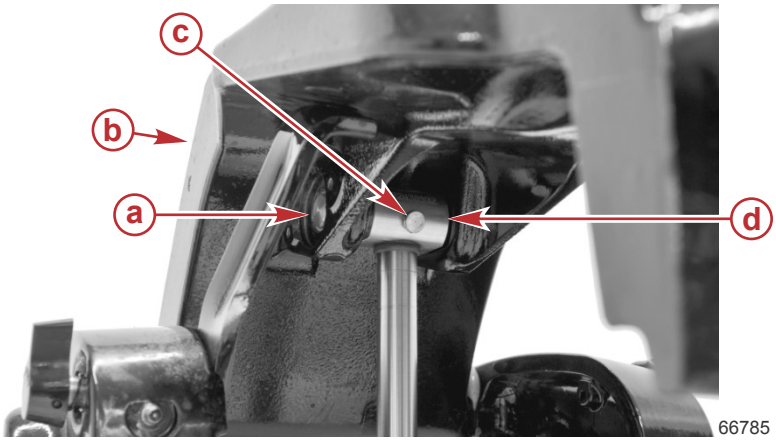
5. Ensure that the magnet is in the rod eye pin, and insert the rod eye pin through the swivel bracket and tilt cylinder rod end. The end of the rod eye pin with the magnet faces the trim position sensor.

6. Insert a punch into the hole in the tilt cylinder rod end to align the cross hole in the rod eye pin.



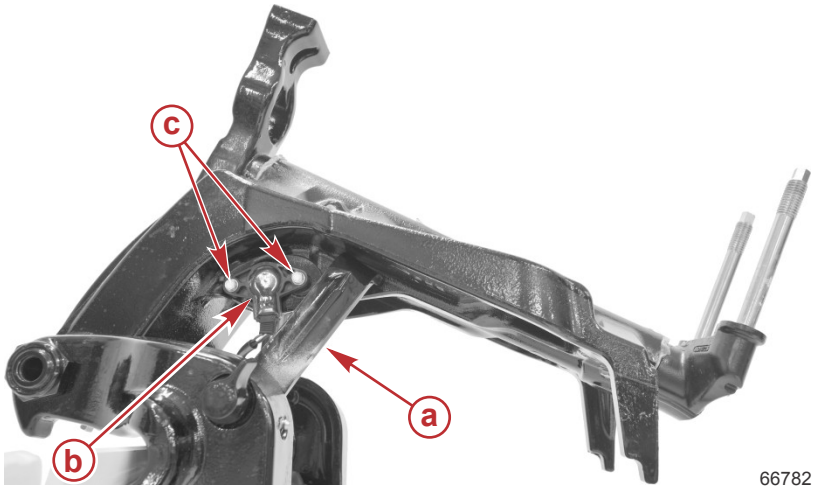
a - Rod eye pin
b - Chamfered end of hole (faces away from transom)
c - Trilobe pin
d - Tilt cylinder rod end

7. Install a new trilobe pin in the upper pivot pin and tilt cylinder rod end. Tap the new trilobe pin in until flush.



a - Rod eye pin (magnet at this end)
b - Swivel bracket
c - Trilobe pin
d - Tilt cylinder rod end

8. Install the trim position sensor and secure it with two hex head screws. Tighten the screws to the specified torque.



a - Tilt lock
b - Trim position sensor
c - Hex head screws (2)

Description	Nm	lb-in.	lb-ft
Hex head screws	1.7	15	–

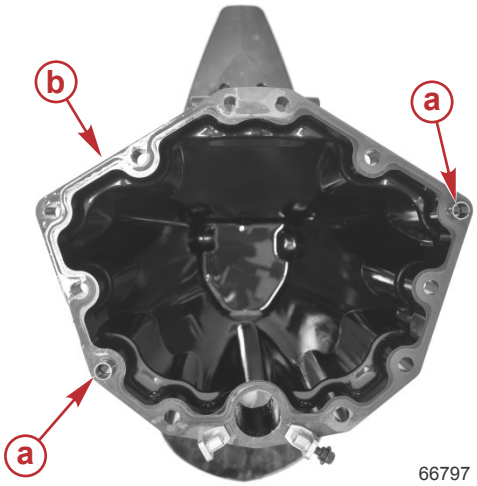
9. Lubricate the swivel tube assembly through the grease fitting in the swivel bracket with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Swivel tube assembly	92-802859A 1

Conventional Midsection (CMS) Assembly

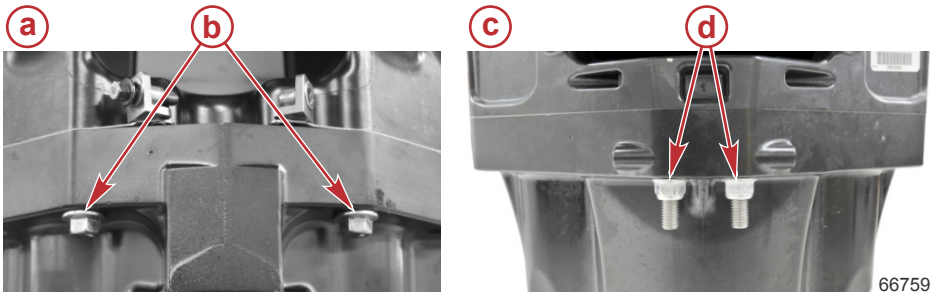
Driveshaft Housing (DSH) Assembly

1. Ensure that the two dowel pins are installed in the driveshaft housing, as shown.
2. Install a new multilayer steel (MLS) gasket onto the driveshaft housing.



a - Dowel pins (2)
b - New multilayer steel gasket (adapter plate to driveshaft housing gasket)

3. Apply Loctite® 242 Threadlocker to two M10 x 1.5 x 60 hex flange head screws. Attach the adapter plate to the driveshaft housing, using the two screws and two M10 x 1.5 locknuts. Tighten the fasteners to the specified torque.



a - Front of driveshaft housing
b - M10 x 1.5 x 60 hex flange head screws (2)
c - Rear of driveshaft housing
d - M10 x 1.5 locknuts (2)

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M10 x 1.5 x 60 hex flange head screws	92-809821

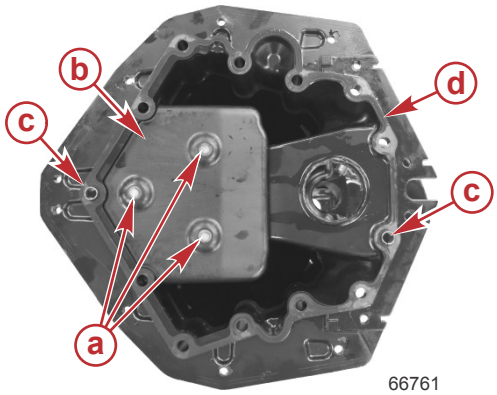
Description	Nm	lb-in.	lb-ft
M10 x 1.5 x 60 hex flange head screw	47.5	–	35
M10 x 1.5 locknut	30	–	22.1

4. Install the mount oil deflector shield into the adapter plate. Apply Loctite® 242 Threadlocker to three M6 x 16 hex flange head screws, and use the screws to secure the shield. Tighten the screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange head screws	92-809821

Description	Nm	lb-in.	lb-ft
M6 x 16 hex flange head screw	8.0	70.8	–

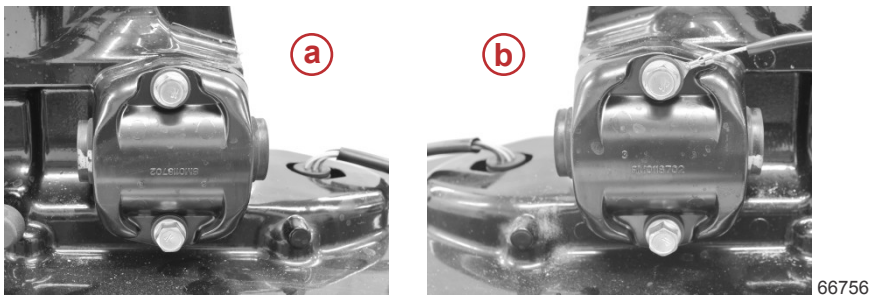
5. Ensure that two dowel pins are installed into the top of the adapter plate, as shown.



66761

a - M6 x 16 hex flange head screws (3)
b - Mount oil deflector shield
c - Dowel pins (2)
d - New adapter plate to block gasket

6. Place the lower mounts into the driveshaft housing.
7. Apply Loctite® 242 Threadlocker to four M8 x 35 hex flange head screws. Install the lower mount covers using two screws and two washers, each.
   - Note the orientation: the part number on the starboard cover is upside down, while the part number on the port cover is right-side up. The covers will only fit one way.
   - Ensure that the ring terminal of the short ground cable is between the washer and the port side mount cover.



66756

a - Starboard lower mount cover, part number upside down
b - Port lower mount cover, part number right-side up and short ground cable attached to upper screw

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M8 x 35 hex flange head screws	92-809821

8. Tighten the screws to the specified torque.

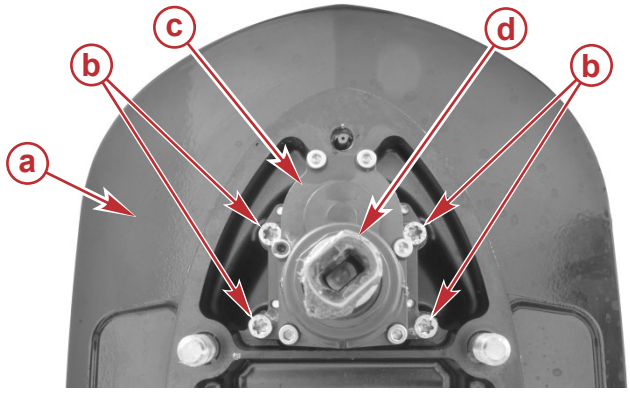
Description	Nm	lb-in.	lb-ft
M8 x 35 hex flange head screw	27.1	–	20

9. Install the shift actuator:
   a. Inspect the seal on the top of the shift actuator. Replace, if necessary.
   b. Apply Loctite® 242 Threadlocker to four M6 x 20 Torx® socket head screws.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 20 Torx socket head screws	92-809821

   c. Feed the shift actuator harness through the opening in the top of the anti-ventilation plate, and position the shift actuator on the underside of the driveshaft housing.

d. Use a T30 wrench to install the shift actuator. Tighten the four screws to the specified torque.



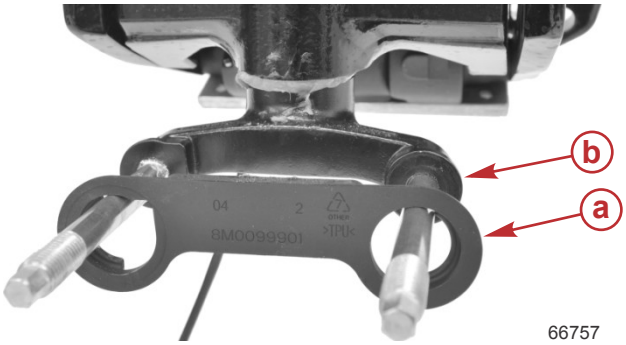
66758

- **a -** Underside of driveshaft housing
- **b -** M6 x 20 Torx socket head screws (4)
- **c -** Shift actuator
- **d -** Shift shaft coupler

Description	Nm	lb-in.	lb-ft
M6 x 20 Torx socket head screw	11	97.4	–

Attach the DSH to the Transom/Swivel Bracket

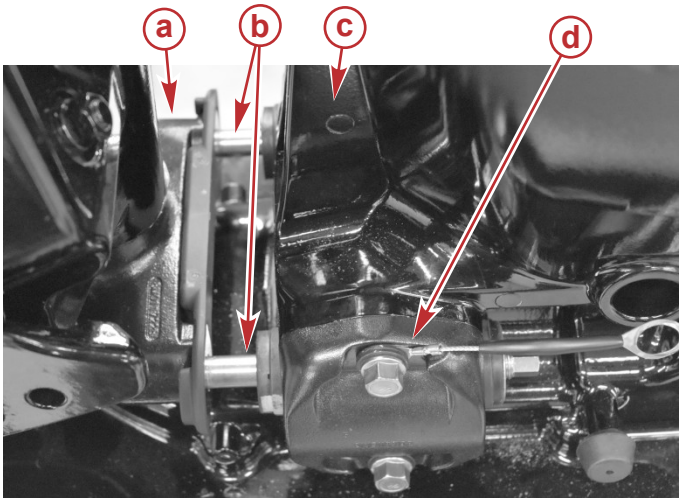
1. Install the snubber onto the lower yoke.



66757

- **a -** Lower mount snubber
- **b -** Lower yoke

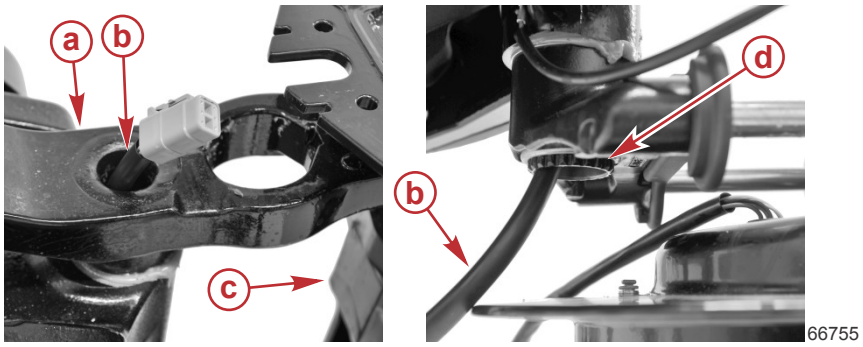
2. Hoist the driveshaft housing (DSH) into position, and carefully maneuver it until the threaded studs pass through the lower mounts.



66800

- **a -** Lower yoke
- **b -** Threaded studs
- **c -** Driveshaft housing
- **d -** Short ground cable on port lower mount

3. Route the shift actuator harness through the swivel tube.

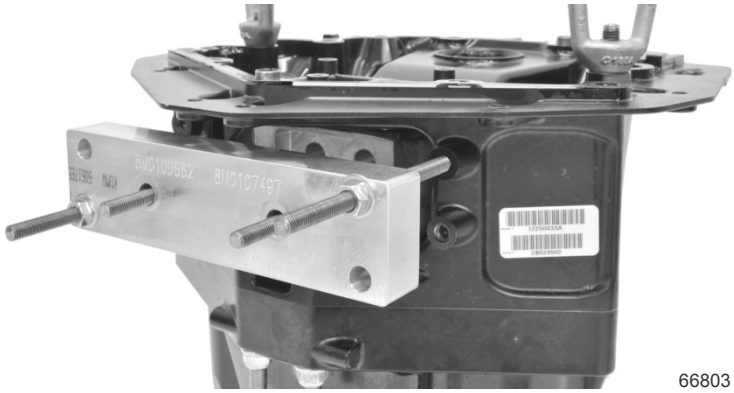


a - Steering arm
b - Shift actuator harness
c - Driveshaft housing
d - Swivel tube

4. Attach the upper mount installation/removal tool to the upper mount:
   a. Install two M8 threaded rods 20 mm into the upper mount threaded holes next to the M14 screw holes.
   b. Add two nuts to the threaded rods. Position the nut face 62 mm from the mount inner metal, and place one washer over each nut.
   c. Slide the bar over the threaded rods to rest on the washers.

Upper Mount Installation/Removal Tool	8M0148872

5. Lubricate the upper mount with soapy water. Ensure that the mount is properly oriented (holes closer to the top). Use the upper mount installation tool to install the upper mount into the adapter plate:
   a. Install two more threaded rods through diagonally opposite corners of the installation/removal bar. Turn the rods a minimum of 20 mm into the adapter plate.
   b. Install two washers and two nuts onto the threaded rods, and finger-tighten.
   c. Alternately tighten the two corner nuts until the mount is pressed firmly into position.
   d. Remove the upper mount installation/removal tool.



6. Apply Loctite® 242 Threadlocker to two M14 x 2.0 x 100 hex flange head screws.

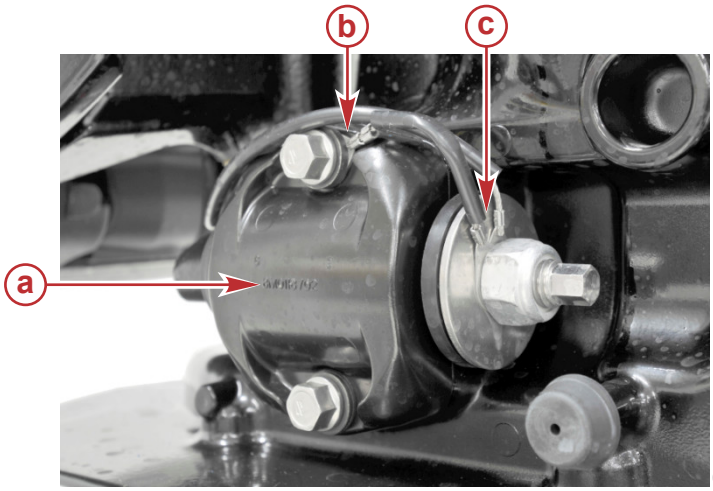
Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M14 x 2.0 x 100 hex flange head screws	92-809821

7. Secure the upper mount with the screws and special hardened washers. Use a torque wrench with a six-point 18 mm socket to tighten the screws to the specified torque.


66745

Description	Nm	lb-in.	lb-ft
M14 x 2.0 x 100 hex flange head screw	160	–	118

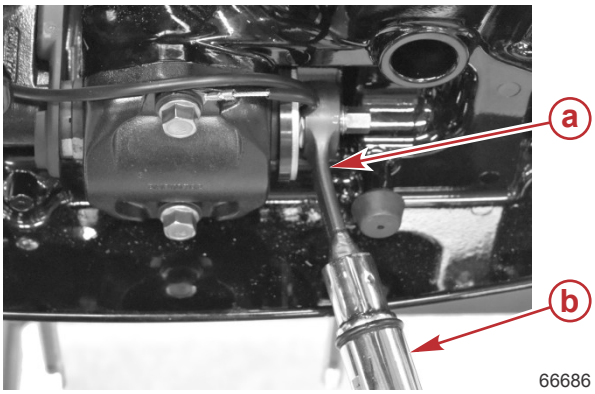
8. Install the rubber washers (snubbers) and special washers onto the lower mount studs.
9. Place the ring terminals of both ground cables over the port lower mount stud, against the special washer. Ensure that the ring terminals are slightly offset. Place M14 locknuts on the port and starboard lower mount studs.



66775

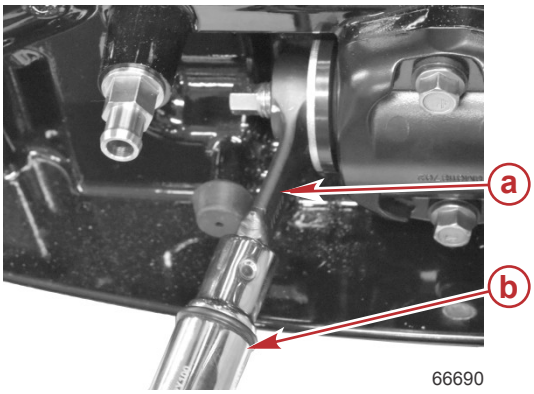
a - Port lower mount cover (part number right-side up)
b - Ring terminal behind washer
c - Ring terminals slightly offset

10. Using an interchangeable head torque wrench with a 22 mm box end torque head (obtain locally), tighten the M14 locknuts to the specified torque.



66686

Port lower mount



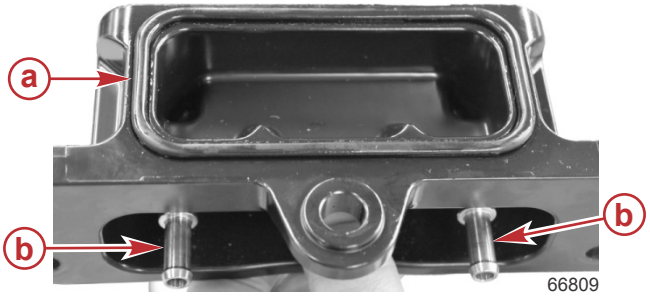
66690

Starboard lower mount

a - 22 mm box end torque head
b - Interchangeable head torque wrench

Description	Nm	lb-in.	lb-ft
M14 locknut	90	–	66.4

11. Ensure that the upper mount cover seal is in place on the top of the upper mount cover and the straight fittings are installed.



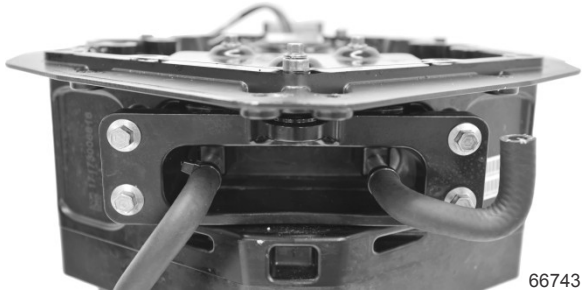
a - Upper mount cover seal
b - Straight fittings

IMPORTANT: Do not tighten the upper mount cover screws until after the powerhead is installed and the rear powerhead screw (M10 x 1.5 x 60 hex flange screw) has been tightened to the specified torque. Only then should the upper mount cover screws be tightened to the specified torque.

12. Apply Loctite® 242 Threadlocker to four M8 x 30 hex flange head screws.

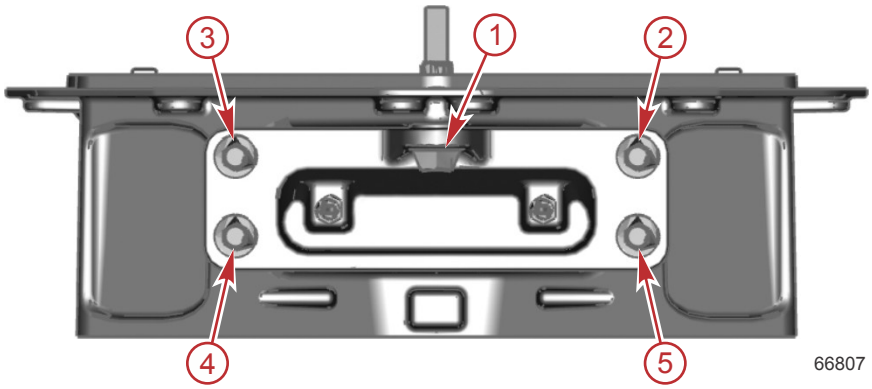
Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M8 x 30 hex flange head screws	92-809821

13. Install the upper mount cover, using the four screws. Use a 10 mm socket to run the screws down, but do not tighten.



Upper mount cover, shown with cooling fittings and hoses installed

14. After the M10 x 1.5 x 60 hex flange head screw (rear powerhead screw) that passes through the mount cover has been tightened to specification, tighten the four M8 x 30 hex flange screws (upper mount cover screws) to the specified torque, in the specified sequence.

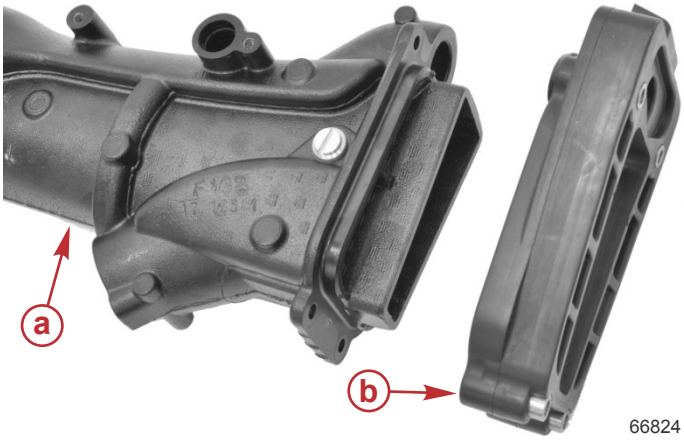


Torque sequence for upper mount cover fasteners

Description	Nm	lb-in.	lb-ft
M10 x 1.5 x 60 hex flange head screw (rear powerhead screw)	47.5	–	35
M8 x 30 hex flange screw (upper mount cover screw)	27.1	–	20

Install the FSM and the Exhaust Tube

1. Install the exhaust grommet onto the exhaust tube. Use soapy water as lubricant, if necessary.



a - Exhaust tube
b - Exhaust grommet

IMPORTANT: Ensure that the exhaust grommet doesn't pinch during assembly.

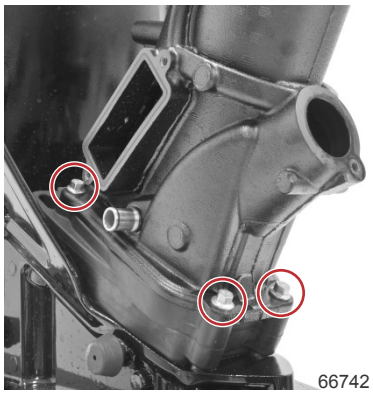
2. Install the water intake elbow fitting into the exhaust grommet. Use soapy water for lubrication.

a - Exhaust tube
b - Exhaust grommet
c - Water intake elbow

3. Apply Loctite® 242 Threadlocker to four M6 x 55 hex flange head screws.

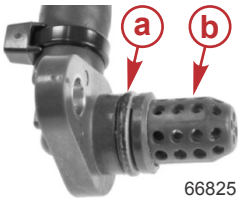
Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 55 hex flange head screws	92-809821

4. Install the exhaust tube onto the driveshaft housing. Use soapy water as lubricant, to help guide the water intake elbow into the hole in the driveshaft housing.
5. Use an 8 mm socket to tighten the four screws to the specified torque in a crossing pattern. Repeat the torque sequence a second time.



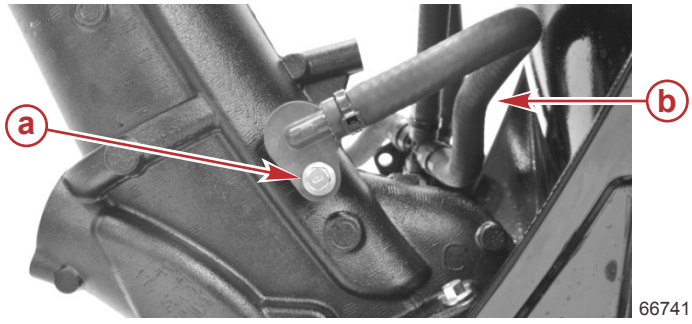
Description		Nm	lb-in.	lb-ft
M6 x 55 hex flange head screw (tighten in a crossing pattern)	**First**	15	132.8	–
	Final	15	132.8	–

6. Ensure that the O-ring is in place on the starboard strainer, and install the strainer into the exhaust tube.



a - O-ring
b - Starboard strainer

7. Apply Loctite® 242 Threadlocker to an M6 x 20 hex flange head screw, secure the starboard strainer with the screw, and tighten the screw to the specified torque.



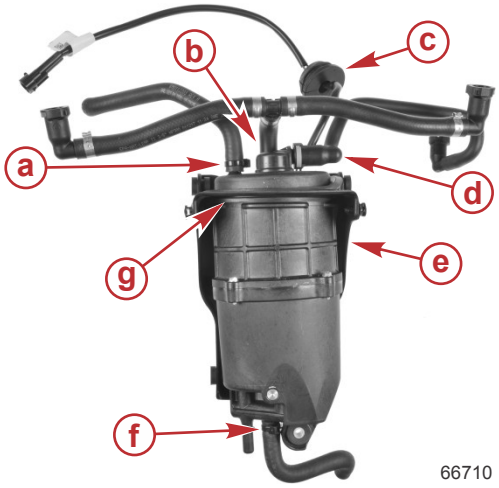
Starboard strainer, shown with drain hose assembly attached

a - M6 x 20 hex flange head screw
b - Drain hose assembly

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 20 hex flange head screw	92-809821

Description	Nm	lb-in.	lb-ft
M6 x 20 hex flange head screw	10	88.5	–

8. Ensure that the bracket and hoses are attached to the FSM.



FSM assembly, shown with bracket and hoses attached

a - Cable tie used to secure the water outlet hose (to water pump indicator fitting)
b - 16.2 mm Oetiker® clamp (not shown) used to secure the fuel rail supply hoses
c - Grommet installed on the FSM harness
d - Reference hose connected to quick-connect fitting
e - FSM bracket (with grommet) installed by sliding down over FSM
f - Cable tie used to secure the water inlet hose (from strainer)
g - FSM bracket grommet securely in position

9. Install the FSM assembly onto the exhaust tube, aligning the holes in the FSM bracket with the bosses on the exhaust tube.
10. Apply Loctite® 242 Threadlocker to four M6 x 16 hex flange head screws and one M6 x 25 hex flange head screw. Use the four short screws to secure the FSM bracket to the exhaust tube and the single long screw and washer to secure the FSM to the exhaust tube. Tighten all five screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange head screws	92-809821
66	Loctite 242 Threadlocker	M6 x 25 hex flange head screw	92-809821

Description	Nm	lb-in.	lb-ft
M6 x 16 hex flange head screw	10	88.5	–
M6 x 25 hex flange head screw	10	88.5	–

11. Ensure that the O-ring is in the groove on the strainer assembly. Install the strainer into the port side of the exhaust tube.

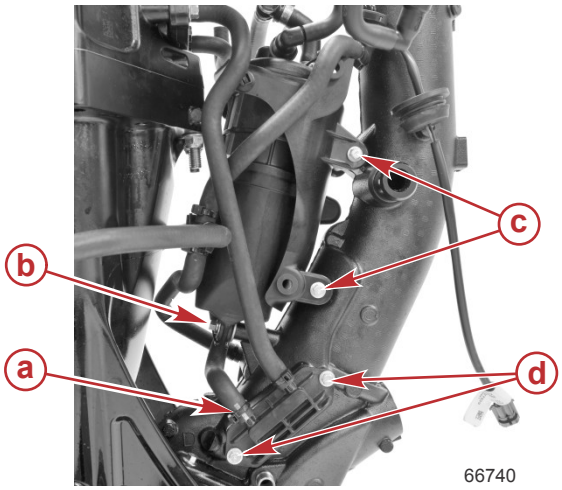
a - O-ring
b - Strainer

12. Apply Loctite® 242 Threadlocker to two M6 x 16 hex flange head screws. Use the screws to secure the strainer to the exhaust tube, and tighten the screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange head screws	92-809821

Description	Nm	lb-in.	lb-ft
M6 x 16 hex flange head screw	10	88.5	–

13. Attach the FSM water hose to the strainer. Secure the connection with a cable tie.

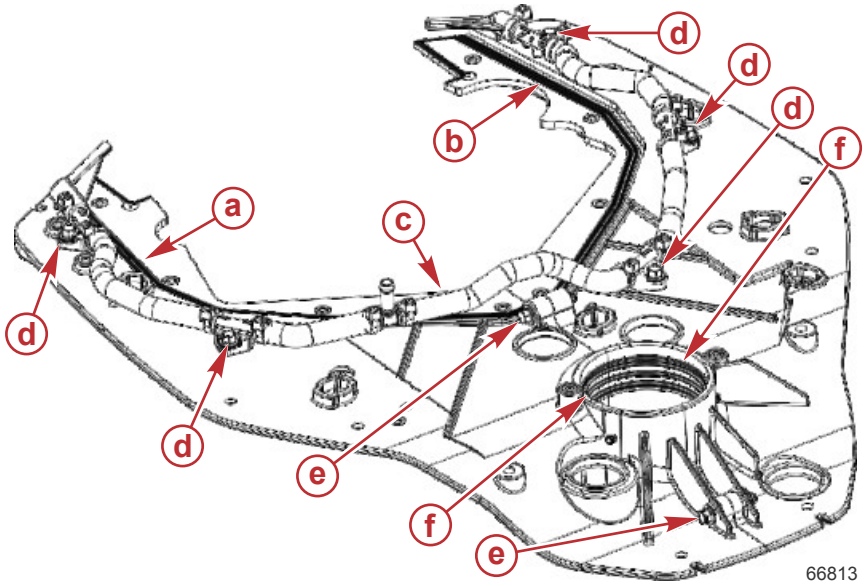


a - Cable tie on FSM water hose
b - M6 x 25 hex flange head screw and washer
c - M6 x 16 hex flange head screws (4 total, 2 each side)
d - M6 x 16 hex flange head screws

14. Attach the water hose between the strainer and the upper mount cover fitting. Secure both connections with cable ties.

Install the Chap Plate

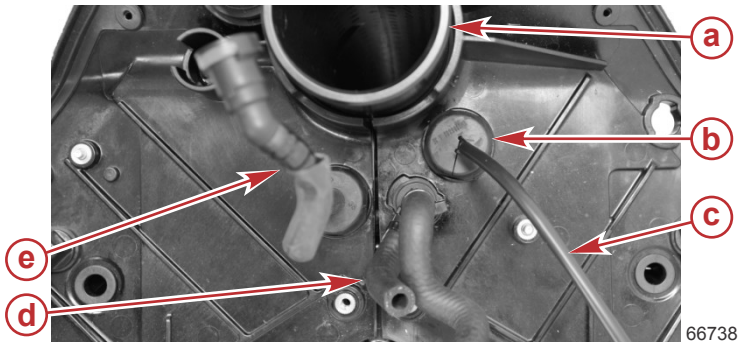
1. Ensure that the chap plate seals are in the underside of the chap plate, the sprayer assembly is installed on the underside of the chap plate, and the exhaust channel chap plate seals are in the exhaust tube opening.



Underside of chap plate

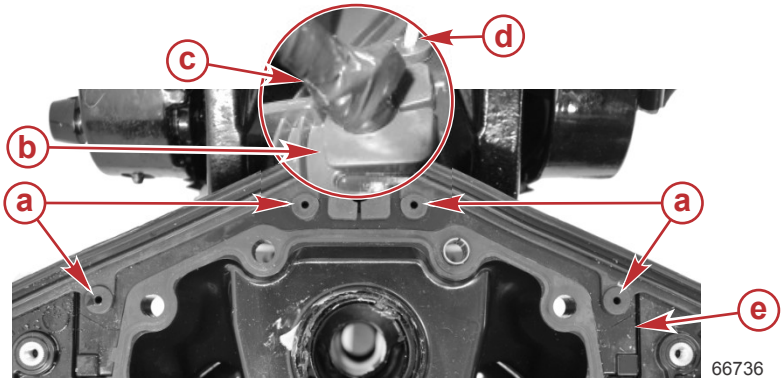
- **a -** Starboard chap plate seal
- **b -** Port chap plate seal
- **c -** Sprayer hose assembly
- **d -** M6 hex flange dog point screws (5)
- **e -** M6 hex flange head screws (2)
- **f -** Exhaust channel chap plate seals (2)

2. Install the chap plate over the exhaust tube and onto the adapter plate. Use soapy water to lubricate the exhaust channel chap plate seals, as necessary.
3. Route the FSM harness through the chap plate, and press the grommet into place. To ease installation, use soapy water to lubricate the grommet.
4. If the cylinder head drain hoses and fitting are not present, install the assembly into the chap plate.
5. If the FSM supply hose is not present, route it through the chap plate.



- **a -** Exhaust tube
- **b -** FSM harness grommet
- **c -** FSM harness
- **d -** Cylinder head drain hoses and fitting
- **e -** FSM supply hose

6. Route the shift actuator harness through the chap plate, and secure the chap plate seal to the adapter plate by pressing the four pins into the adapter plate. Lubricate the pins with soapy water, to ease installation.



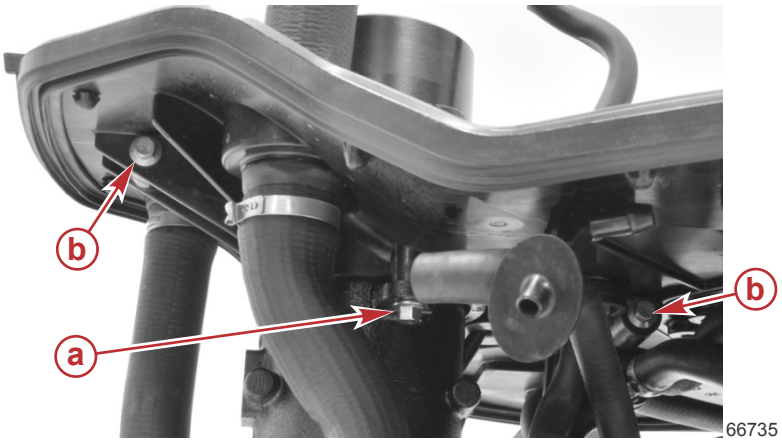
- **a -** Chap plate seal locating pins
- **b -** Grommet in chap plate seal
- **c -** Shift actuator harness
- **d -** Pitot water tube (mechanical engines)
- **e -** Adapter plate

7. Apply Loctite® 242 Threadlocker to two M6 x 16 hex flange head screws, and use the screws to secure the chap plate to the exhaust tube. Tighten the screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 16 hex flange head screws	92-809821

Description	Nm	lb-in.	lb-ft
M6 x 16 hex flange head screw	10	88.5	–

8. Tighten the two M6 hex flange head screws that hold the two chap plate halves together to the specified torque.

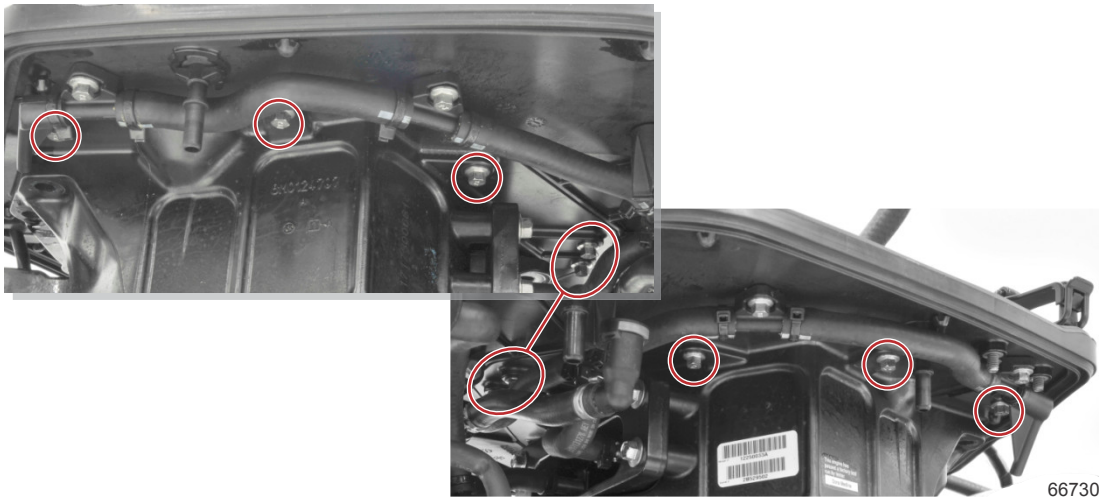


a - M6 x 16 hex flange head screws securing the chap plate to the exhaust tube (2 total, 1 each side)

b - M6 hex flange head screws securing chap plate halves together (2)

Description	Nm	lb-in.	lb-ft
M6 hex flange head screw	6.0	53.1	–

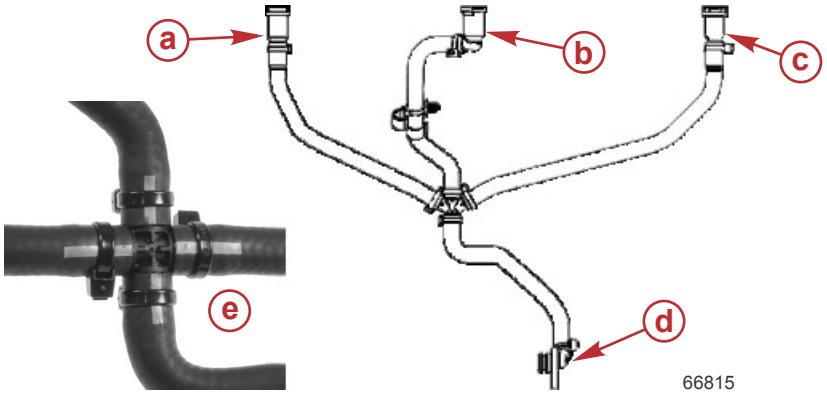
9. Apply Loctite® 242 Threadlocker to eight M6 hex flange dog point screws. Use the screws to secure the chap plate to the adapter plate. Tighten the screws to the specified torque.



Chap plate screws (M6 hex flange dog point screws, 8 total)

Description	Nm	lb-in.	lb-ft
M6 hex flange dog point screw	10	88.5	–

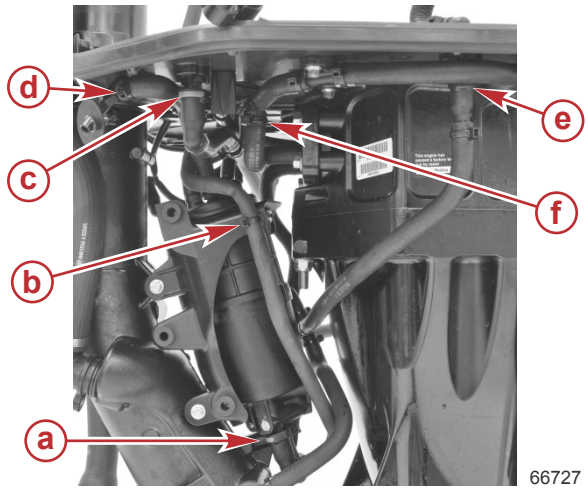
10. Ensure that the drain hose assembly is complete and is connected to the starboard strainer. Assemble and secure with cable ties, as required.



a - Port block drain quick-connect
b - Cylinder head drain quick-connect
c - Starboard block drain quick-connect
d - Starboard strainer
e - Alignment marks

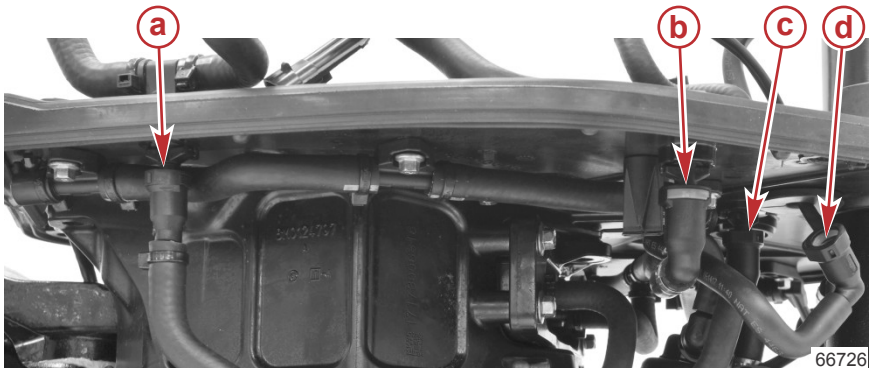
11. Connect the water and fuel hoses on the starboard side of the chap plate:
    - Connect the water hose from the FSM to the water pump indicator fitting. Secure the connection with a cable tie.
    - Connect the water hose to the sprayer assembly T-fitting. Secure the connection with a cable tie.

      NOTE: *If the water hose from the T-fitting was disconnected from the upper mount straight fitting, attach it to the straight fitting, and secure the connection with a cable tie.*
    - Connect the quick-connect fitting for the starboard block drain hose.
    - Connect the quick-connect fittings for the FSM fuel supply hose and the starboard fuel rail supply hose.
    - Secure the FSM fuel supply hose to the FSM bracket anchor with a cable tie.



a - FSM fuel supply hose quick-connect
b - Cable tie and anchor
c - Starboard fuel rail supply hose quick-connect
d - Cable tie on the water pump indicator hose
e - Starboard block drain hose quick-connect
f - Cable tie on the T-fitting for the sprayer assembly

12. Connect the water and fuel hoses on the port side of the chap plate:
    - Connect the quick-connect fitting for the port block drain hose.
    - Connect the quick-connect fitting for the cylinder head drain hose.
    - Connect the quick-connect fitting for the port fuel rail supply hose.



a - Port block drain hose quick-connect
b - Port fuel rail supply hose quick-connect
c - Cylinder head drain hose quick-connect
d - Reference hose quick-connect (reconnect after idle relief muffler installation)

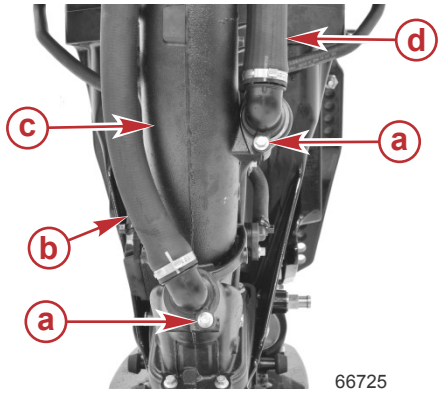
13. Ensure that the O-rings are present on the water supply and water return elbow fittings, and insert the fittings into the exhaust tube. Lubricate the fittings with soapy water as required, to ease installation.

14. Apply Loctite® 242 Threadlocker to two M6 x 20 hex flange head screws. Secure the elbow fittings with the screws, and tighten the screws to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
66	Loctite 242 Threadlocker	M6 x 20 hex flange head screws	92-809821

Description	Nm	lb-in.	lb-ft
M6 x 20 hex flange head screw	10	88.5	–

15. Ensure that the water supply and return hoses are connected to the through-chap plate fittings and the elbow fittings. Connections at both top and bottom must be secured with three 38.1 mm and one 31.6 mm Oetiker® clamps.



a - M6 x 20 hex flange head screws (2)
b - Water return hose, secured with one 31.6 mm Oetiker clamp (top) and one 38.1 mm Oetiker clamp (bottom)
c - Exhaust tube
d - Water supply hose, secured with two 38.1 mm Oetiker clamps

16. Ensure that all hose connections not secured by clamps (or quick-connects) are secured by cable ties.

CMS Final Assembly

1. Install the idle relief components. Refer to **Idle Relief Muffler**.

   NOTE: *After muffler installation:*

- *Be certain to connect the reference hose quick-connect to the fitting in the chap plate.*
- *Be certain that the water pump indicator fitting is securely installed into the chap plate and is connected to the hose from the FSM.*

2. Install the gearcase. Refer to **Section 6A - Gear Housing Installation**, **Section 6B - Gear Housing Installation**, or **Section 6C - Gear Housing Installation**.

   IMPORTANT: Ensure that a new gasket is in place on the top of the adapter plate, for powerhead installation.

3. Install the powerhead. Refer to **Section 4A - Powerhead Installation onto Conventional Midsection (CMS)**.

   IMPORTANT: If the lower mount cover was removed, be certain to tighten the four screws to the specified torque, after the rear powerhead screw has been fully tightened.

4. Install the lower cowls. Refer to **Section 5C - Upper and Lower Cowls**.

Midsection

Section 5B - Conventional Midsection (CMS) Power Trim

Table of Contents

Conventional Midsection (CMS) Power Trim Specifications

Power Trim Specifications	
Trim up relief valve—tilt extended relief pressure	17237 kPa (2500 psi) minimum
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

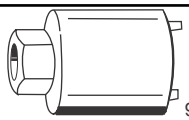
Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Trim cylinder rod end rollers	8M0071842
114	Power Trim and Steering Fluid	Power trim system	92-858074K01
		O-rings and seals	
		Tilt cylinder O-rings and seals	
		Tilt cylinder	
		O-rings	
		Tilt ram alignment tool and shaft	
		O-ring	
		Fill 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

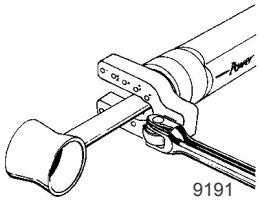
Special Tools

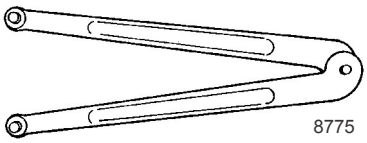
Pressure Adapter Fitting - Up	8M0061797
 48707	Install in place of the manual release valve to measure the up pressure in the power trim system.

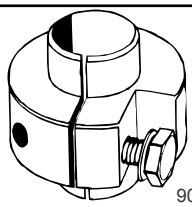
Power Trim Test Gauge Kit	91-52915A6
 3753	Tests circuit pressures for various trim pumps.

Pressure Adapter Fitting - Down	8M0054662
 48708	Install in place of the manual release valve to measure the down pressure in the power trim system.

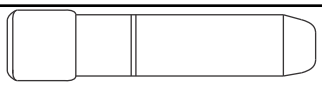
Trim Rod Guide Removal Tool	91-44487T 1
 9086	Aids in the removal of the trim rod from the trim cylinders.

Trim Cylinder End Cap Tool	91-821709T
 9191	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).

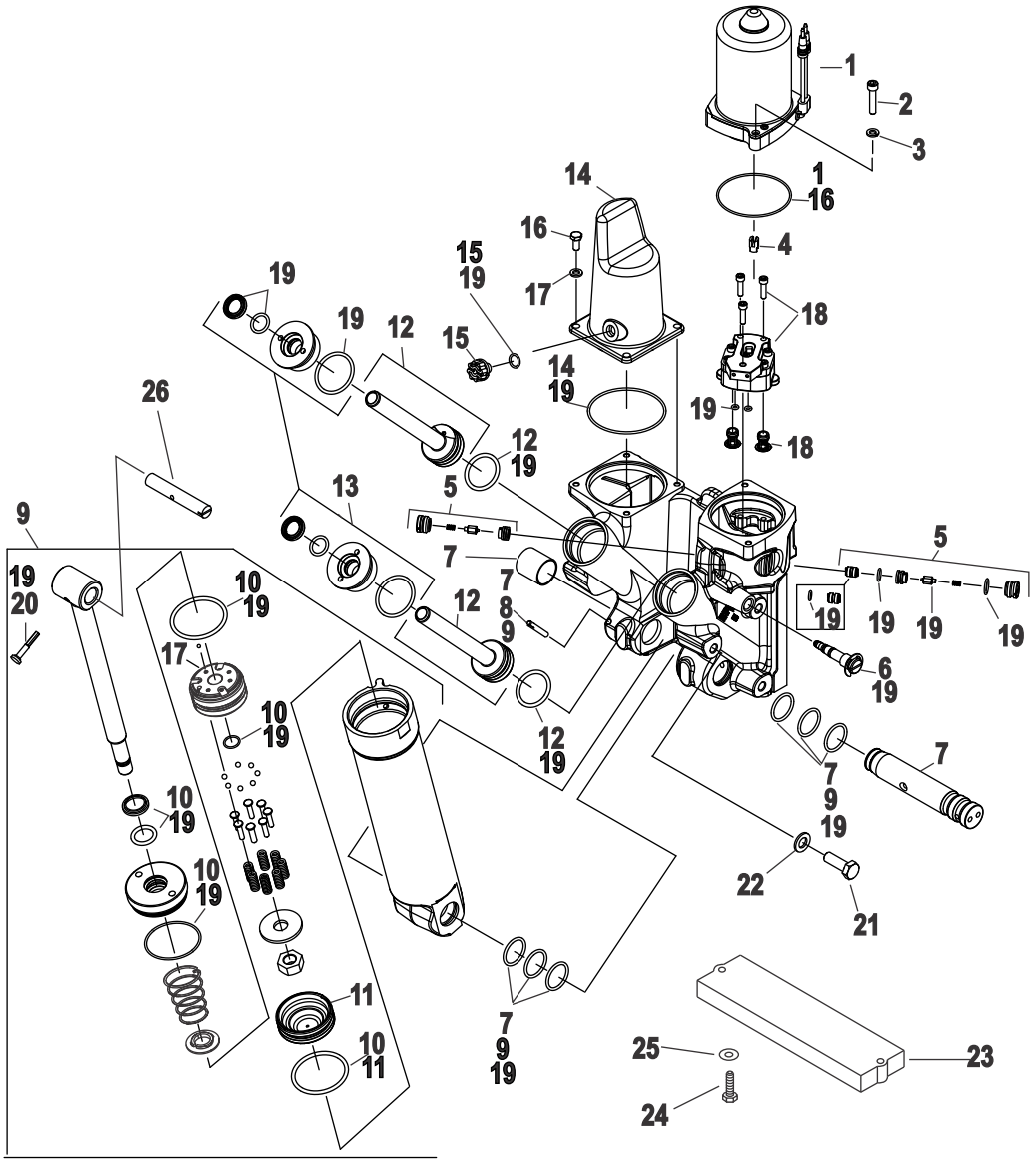
Spanner Wrench	91-74951
 8775	Removes and installs trim cylinder end caps.

Trim Rod Removal Tool	91-44486A 1
 9089	Aids in the removal of the trim rod from the trim cylinders.

Lockring Pliers	Snap-On SRP-4
 4799	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.

CMS Power Trim Components



CMS Power Trim Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Trim motor			
2	2	M6 x 30 screw	9.04	80	–
3	2	M6 lockwasher			
4	1	Drive coupling			
5	1	Check valve kit			
6	1	Manual release valve kit			
7	1	Tilt shaft kit			
8	1	Pin			
9	1	Tilt cylinder assembly			
10	1	Tilt cylinder O-ring kit			
11	1	Memory piston kit			
12	1	Piston assembly			
13	1	End cap assembly	122	–	90
14	1	Reservoir kit			
15	1	Plug assembly			
16	4	M6 x 14 screw	9.04	80	–
17	4	6.60 x 12.5 x 1.5 mm stainless steel washer			
18	1	Pump kit			
19	1	Power trim repair kit			
20	1	Trilobe pin			
21	6	M10 x 30 screw	61	–	45
22	6	Washer			
23	1	Anode kit			
24	2	M6 x 25 screw	8	70.8	–
25	2	0.281 x 0.500 x 0.060 stainless steel washer			
26	1	Pin			

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 the engine is under power or when the 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 the 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 the up circuit will actuate the up relay located under the 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 the 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 the down circuit will actuate the down relay located under engine cowl and close the electric motor circuit. The motor will run in the 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.

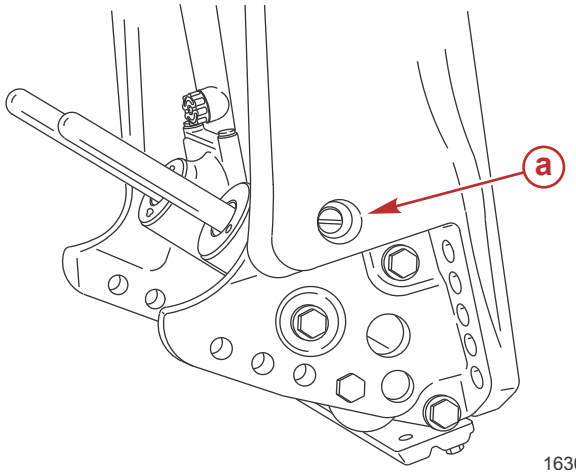
If the outboard must be tilted for clearance between skeg and pavement, a device such as a transom saver should be installed. This prevents stress to the boat transom from the weight of the outboard while the boat/engine are transported.

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 the outboard at the desired tilt position.



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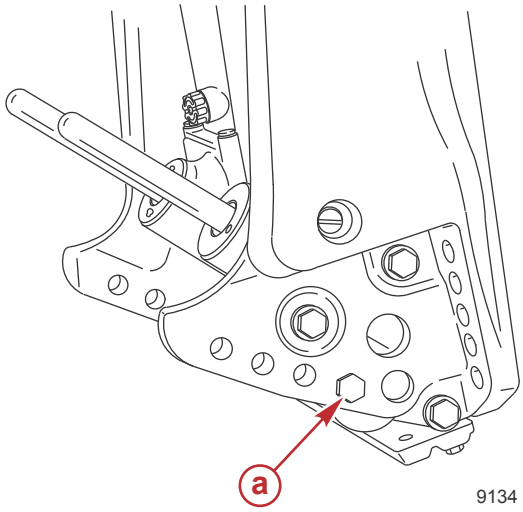
a - Manual release valve

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.

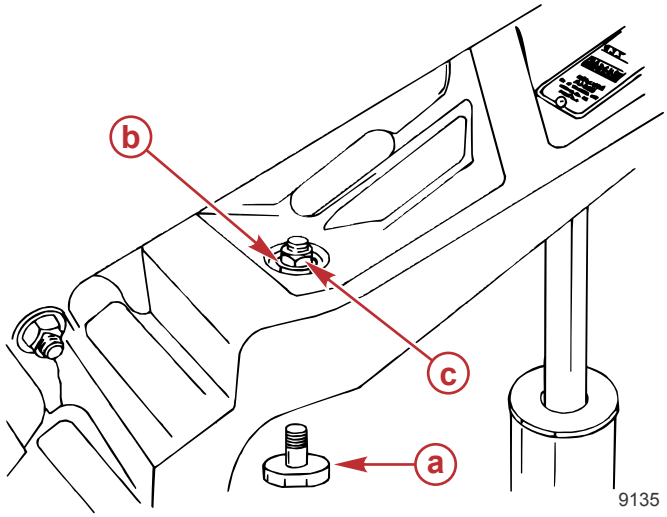
IMPORTANT: Some boat/engine combinations may not exhibit undesirable or unsafe handling at planing speed when the trim angle adjustment bolt is not used, and the outboard is set to the full trim-in angle. Not using the trim angle adjustment bolt may be advantageous to acceleration and planing in these cases. A water test is required to determine if these characteristics apply to a particular boat/engine combination.



a - Trim angle adjustment bolt

Striker Plate Replacement

Visually inspect the striker plates and replace if worn excessively.



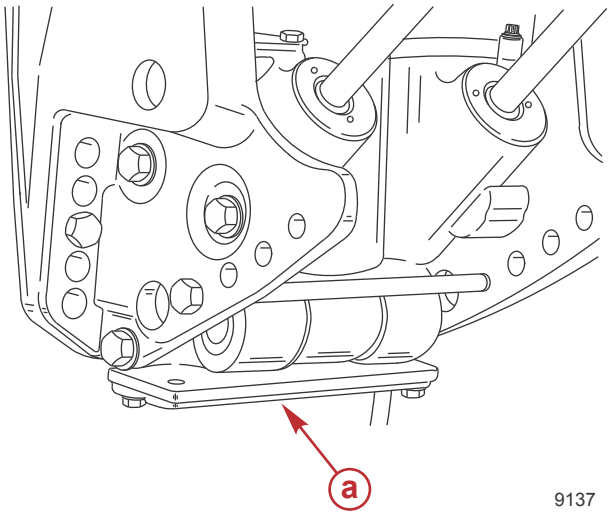
a - Striker plate (2)
b - Lockwasher
c - Locknut

Description	Nm	lb-in.	lb-ft
Locknut	32	–	23.6

Anode Plate

The 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 the anode plate when it is 50% consumed.

IMPORTANT: Do not paint or place protective coating on the 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).

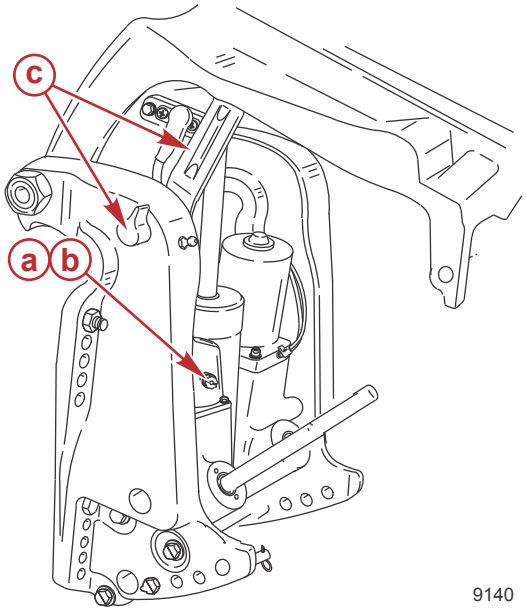
Check, Fill, and Purge

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. Check the fluid level. The system is full when the fluid level is present at the filler hole.
5. Tighten the fill plug to the specified torque.



a - Fill plug and O-ring
b - Fill system with Power Trim and Steering Fluid
c - Tilt lock lever

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.
	Power Trim and Steering Fluid	Power trim system	92-858074K01

Description	Nm	lb-in.	lb-ft
Power trim fill plug	2.5	22.1	–

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. Remove the fill plug and O-ring.
3. Check the fluid level. Add fluid if necessary. The system is full when the oil level is present at the fill hole.
4. Tighten the fill plug before tilting the outboard down or retracting the trim/tilt rams.
5. Tighten the fill plug securely.

Description	Nm	lb-in.	lb-ft
Power trim fill plug	2.5	22.1	–

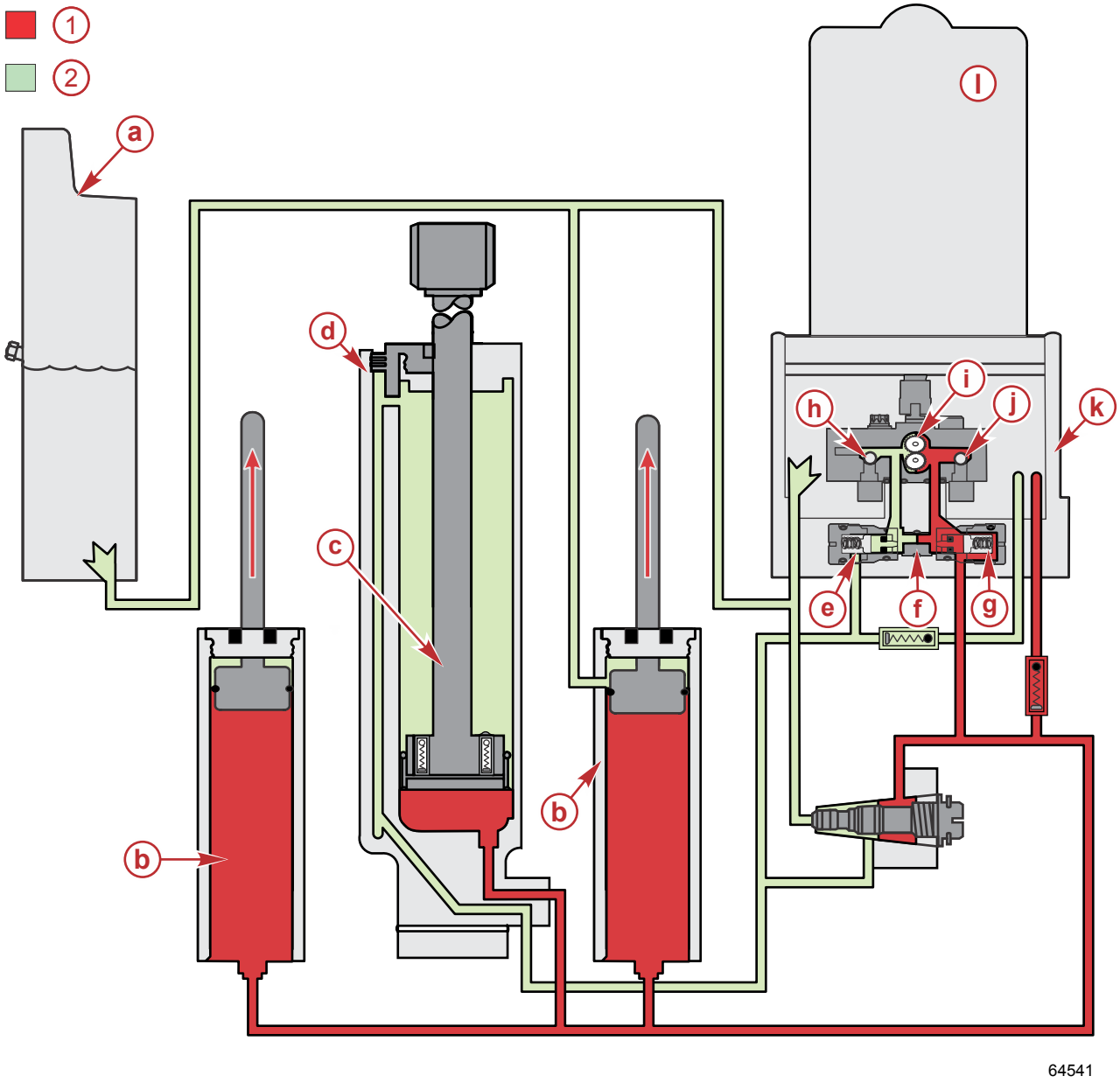
To Purge:

IMPORTANT: The fill plug and O-ring must be tightened securely before purging the system.

1. Run the trim system in short intervals until the pump is primed and the trim system moves.
   IMPORTANT: Pump driveshaft failure can occur if the trim motor is run without priming the pump.
2. Cycle the outboard through the entire trim/tilt range four times.
3. Check the fluid level after purging the system.
4. Push down on the outboard when the trim rams are slightly extended. If the rams retract more than 3.2 mm (0.125 in.), air is present in the system.
5. Cycle the system again and check the fluid level.

Power Trim Flow Diagrams

Trim Up Circuit



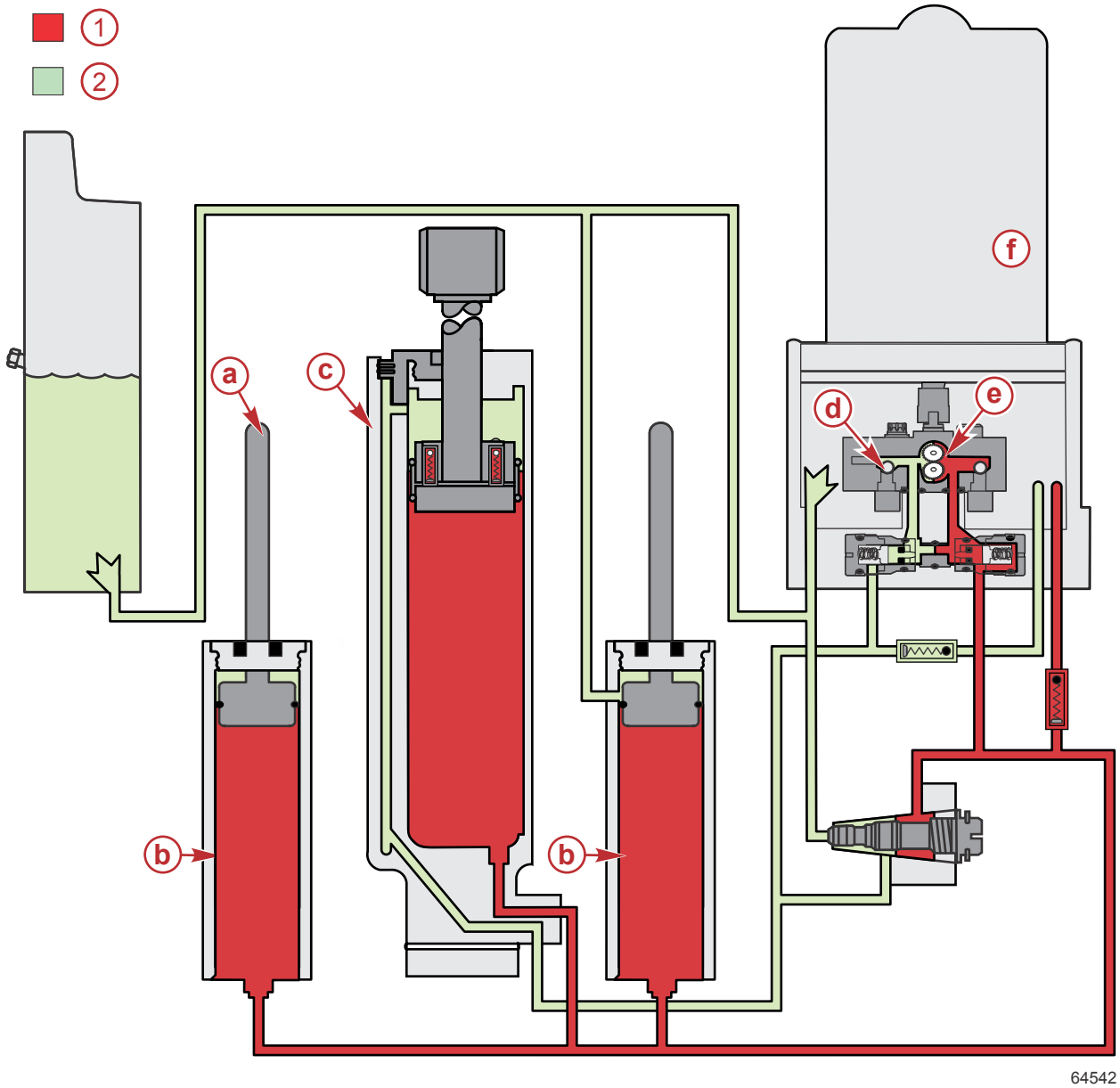
1 - High pressure

2 - Low pressure

- a - Reservoir
- b - Trim cylinders
- c - Tilt cylinder ram/piston
- d - Tilt cylinder
- e - Down circuit pressure-operated valve
- f - Shuttle spool
- g - Up circuit pressure-operated valve
- h - Up circuit suction check valve
- i - Oil pump
- j - Down circuit suction check valve
- k - Reservoir
- l - Trim motor

When the trim up button is pressed, the electric motor will rotate the oil pump gears. As the oil pump gears 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 to 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 to the pump from the 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

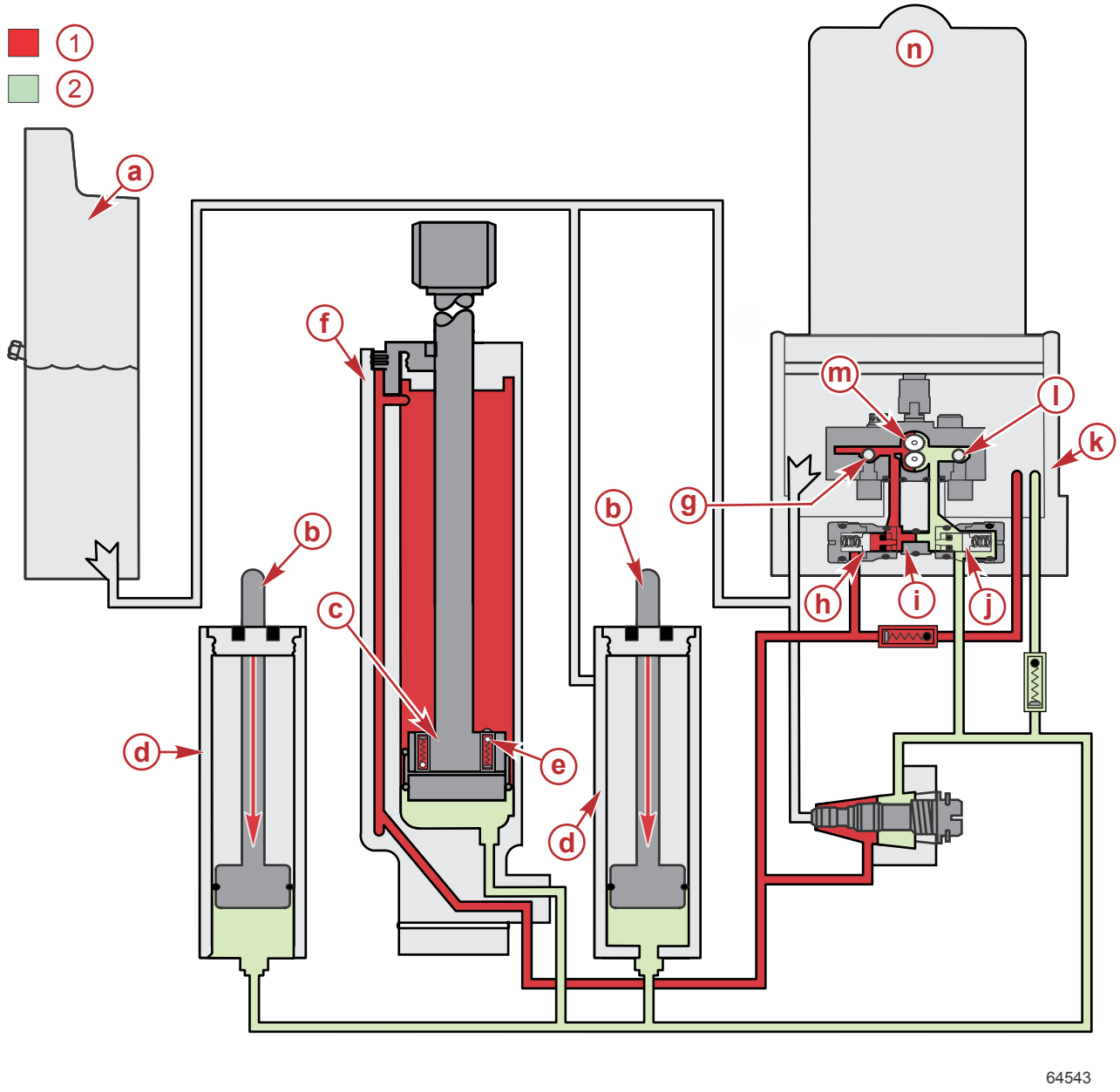


1 - High pressure **2 - Low pressure**

a - Port trim ram
b - Trim cylinders
c - Tilt cylinder
d - Up circuit suction check valve
e - Oil pump
f - Trim motor

When the up circuit is activated, the electric motor rotates the hydraulic pump gears. As the pump gears rotate, fluid is drawn through a check valve and into the inlet passages of the pump. The flow then passes through the up pressure-operated valve in the manifold and into the bottom of the trim cylinder. The pressurized oil also opens the down pressure-operated valve, allowing oil to return to the pump inlet and reservoir. The fluid pushes the pistons out, trimming the engine up. Oil, from the top side of the cylinder, returns into the manifold to the inlet side of the pump. When the engine is not running, the outboard may be tilted to the full up position by activating the cowl trim switch. In this mode, as the trim cylinder extends to its limit, up pressure increases and opens the up pressure relief valve, bypassing oil to the reservoir. When the engine is running above 2000 RPM, trim angle is limited to 20 degrees by the trim angle sensor and the PCM.

Trim Down Circuit

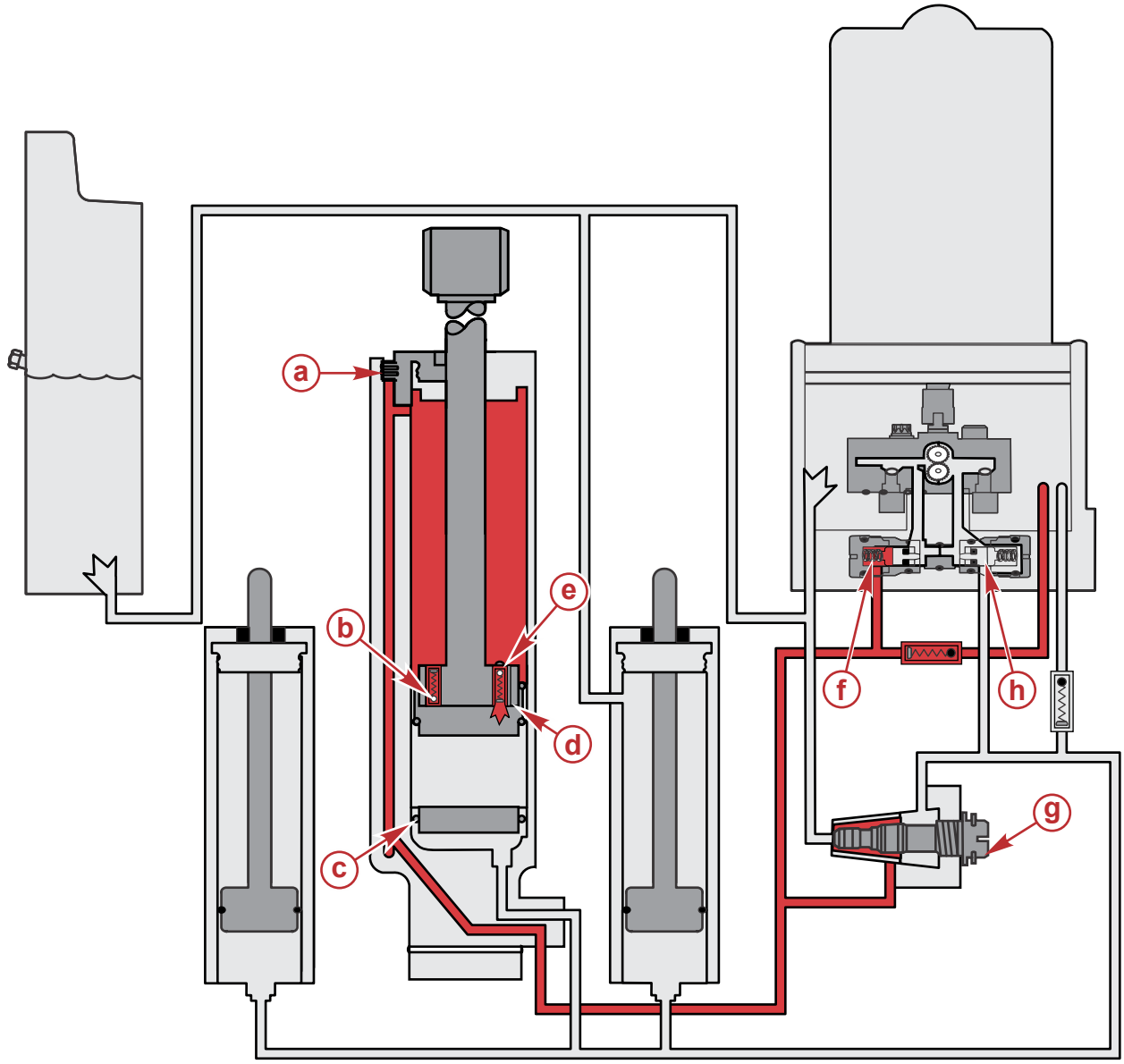


1 - High pressure
2 - Low pressure

- **a -** Reservoir
- **b -** Trim rams
- **c -** Shock piston
- **d -** Trim cylinders
- **e -** Impact relief and trail over valves
- **f -** Tilt cylinder
- **g -** Up circuit suction check valve
- **h -** Down circuit pressure-operated valve
- **i -** Shuttle spool
- **j -** Up circuit pressure-operated valve
- **k -** Reservoir
- **l -** Down circuit suction check valve
- **m -** Oil pump
- **n -** Trim motor

When the trim down button is pressed, the electric motor will rotate the oil pump gears in the opposite direction of trimming up. As the oil pump gears 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 to 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 the 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 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



- **a -** Tilt cylinder
- **b -** Return valve
- **c -** Memory piston
- **d -** Tilt cylinder piston
- **e -** Impact relief and trail over valves
- **f -** Down circuit pressure-operated valve
- **g -** Manual release valve
- **h -** Up circuit pressure-operated valve

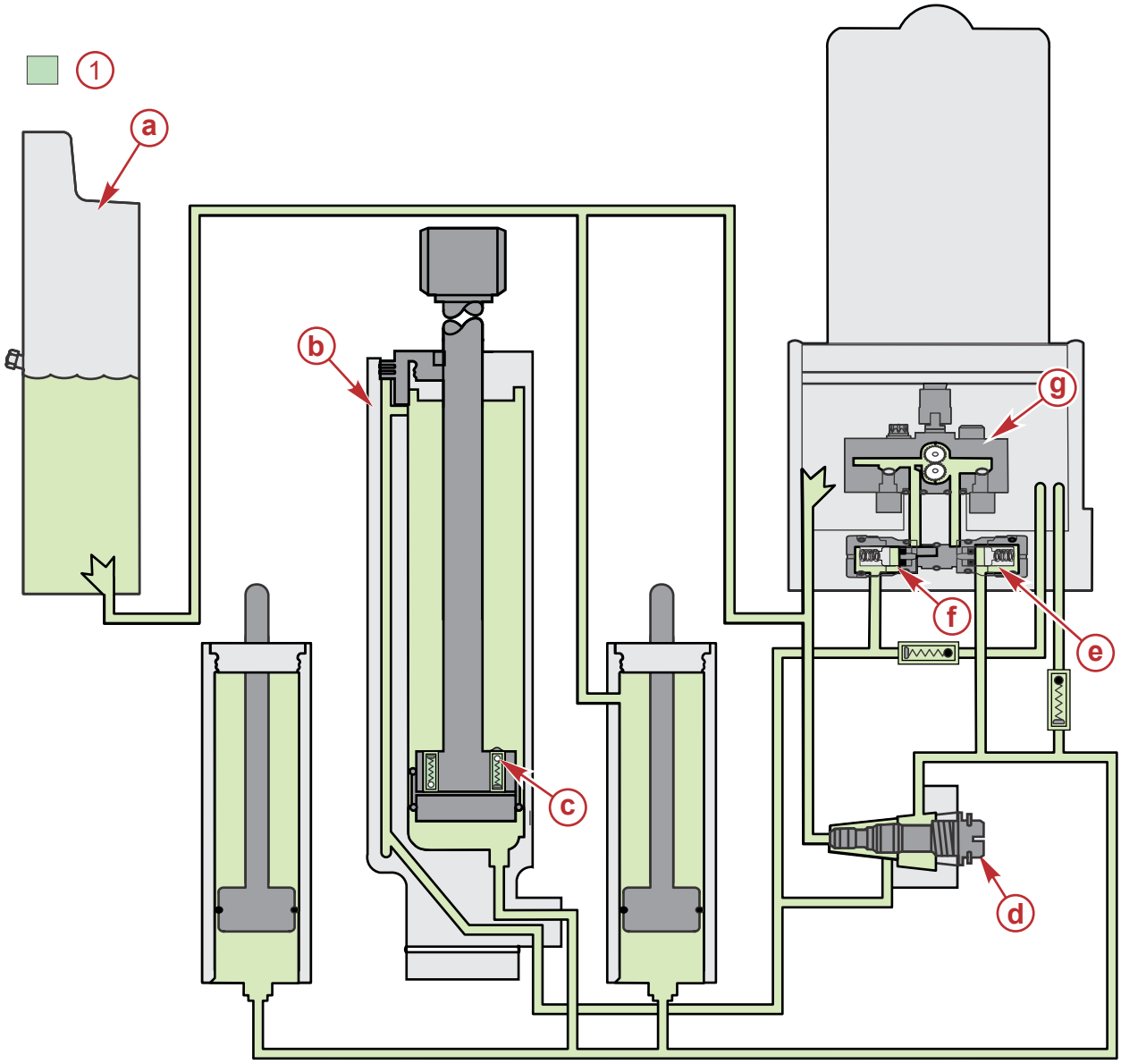
Trail Over System

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 release 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 release 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 -** Reservoir
- **b -** Tilt cylinder
- **c -** Impact relief and trail over valves
- **d -** Manual release valve
- **e -** Up circuit pressure-operated valve
- **f -** Down circuit pressure-operated valve
- **g -** Oil pump

Manual Tilt System

To manually raise or lower the outboard, turn the manual release 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 up or down 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 raising up or trailing out when shifted into reverse or throttling back rapidly, oil in the trim system must be locked in a static position. This is accomplished by closing the:

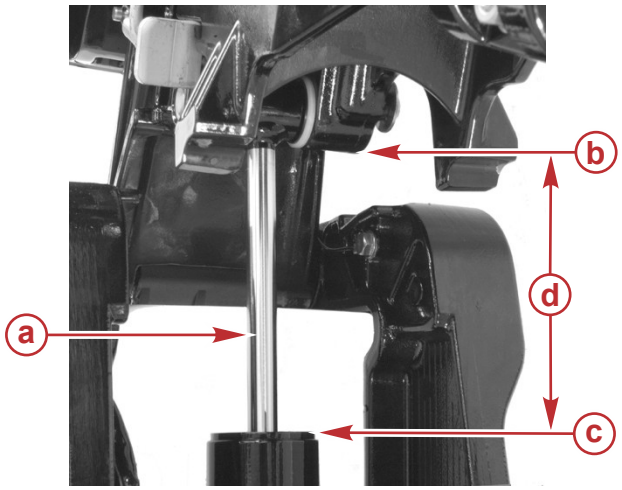
- Up circuit pressure-operated valve
- Down circuit pressure-operated valve
- Trim relief check valve
- Trail over valve
- Impact relief valves
- Manual release valve

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.



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.)

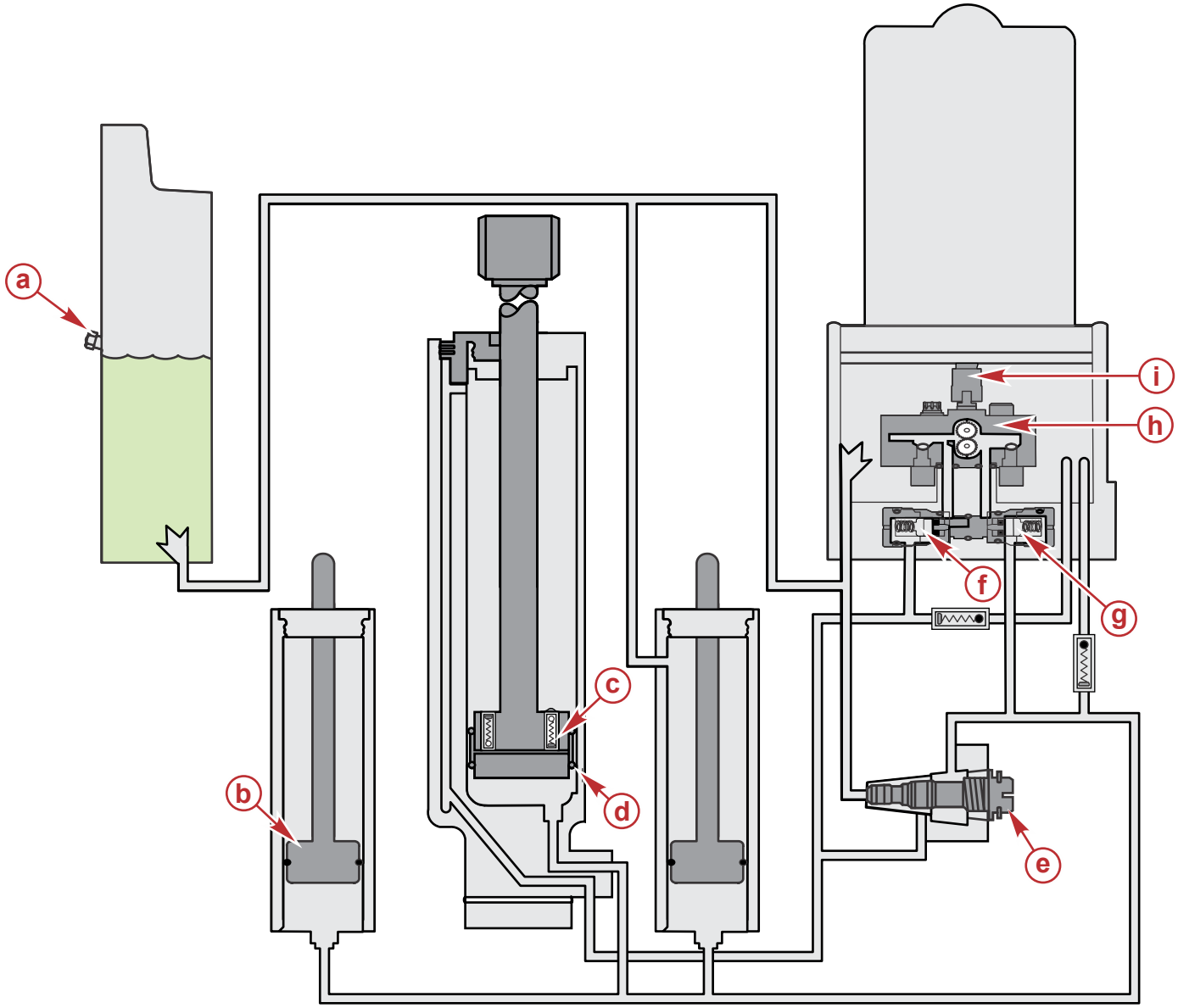
Method 2

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



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- **a -** Reservoir oil level
- **b -** Trim ram piston
- **c -** Tilt piston ball (impact relief and trail over ball)
- **d -** Tilt ram O-ring
- **e -** Manual release valve
- **f -** Down circuit pressure-operated valve
- **g -** Up circuit pressure-operated valve
- **h -** Oil pump
- **i -** Pump driveshaft

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 solenoid.	
		Service/replace components as necessary.	
Wiring	Wiring reversed in the remote control	Inspect and correct as necessary.	**Diagnostic Manual**
	Wiring harness is corroded	Inspect and service/replace components as necessary.	
	Open circuit in the trim wiring	Inspect the wiring in the trim system for disconnected or damaged wires.	
Trim motor	Trim motor brushes need replacement	Test the trim motor.	**Motor and Electrical Tests/Repair**
	Armature is inoperable	The trim motor is not serviceable. Replace the trim motor if it does not function.	
	Motor commutator is dirty or worn		
Trim switch	Trim switch failure	Determine which switch is faulty (engine or helm).	**Diagnostic Manual**
		Troubleshoot the up or down circuit (whichever applies).	
		Compare results with **Troubleshooting the Up Circuit or Down Circuit** in the **Diagnostic Manual** .	
Trim relays	Trim relay is inoperative	Perform a power trim relay test to determine failure.	**Diagnostic Manual**

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.	**Diagnostic Manual**

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	Inspect the wiring in the trim system for disconnected or damaged wires.	**Diagnostic Manual**
	Wiring harness is corroded	Inspect and service/replace components as necessary.	
Trim switch	Trim switch failure	Determine which switch is faulty (engine or helm).	**Diagnostic Manual**
		Troubleshoot the up or down circuit (whichever applies).	
		Compare results with **Troubleshooting the Up Circuit or Down Circuit** in the **Diagnostic Manual**.	

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.	
Manual release valve	Leaking valve	Pressure check both circuits.	
		Inspect the O-ring condition.	
Pump assembly	Pump assembly is faulty	Inspect the trim pump motor for fault. Service/replace components as necessary.	
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 Test** in the **Diagnostic Manual**.
		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 Test** in the **Diagnostic Manual**.
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 valve 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.	

Outboard Does Not Trim Up 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.	
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:
Manual release valve	Leaking valve	Verify that the manual release valve is closed.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures**
		Inspect the O-ring condition.	
Pump assembly	Pump assembly is faulty	Inspect the trim pump motor 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**
Trim motor	Trim motor brushes need replacement	Inspect and replace as necessary.	
	Armature is inoperable	Test the trim motor.	
	Motor commutator is dirty or worn		
	Loose connection	The trim motor is not serviceable. Replace the trim motor if it does not function.	
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 Down 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

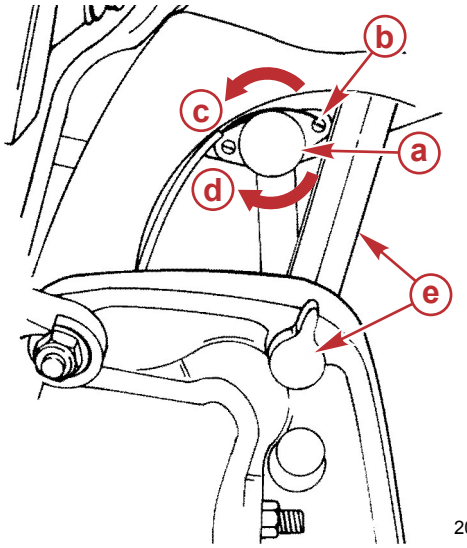
Component or Problem	Possible Causes	Corrective Action	Refer To:
Tilt ram piston	Piston ball not seated	Inspect the ball for wear, dirt, or displacement.	The appropriate procedure within **Power Trim Assembly Removal and Installation Procedures**
		Service/replace components as necessary.	
	Worn O-ring	Inspect the O-ring for nicks, cuts, or abrasions.	

Trim Position Sensor

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 the battery is fully charged before performing these tests.

⚠ CAUTION

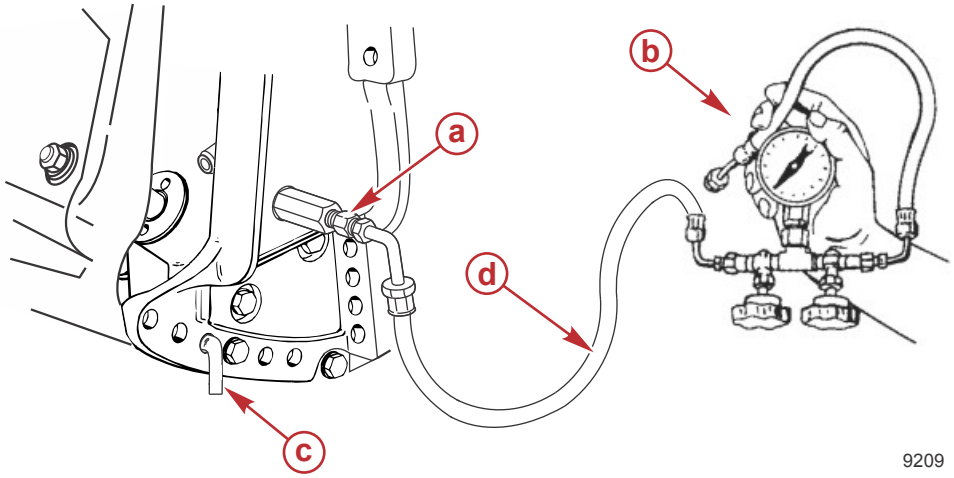
Contamination can damage the hydraulic system or cause the system to malfunction. Failure of power trim or steering components can result in injury or product damage. Ensure that the work area, shop tools and all components are clean and lint free during reassembly.

1. Tilt the outboard to the full up position and engage the tilt lock lever.
2. Slowly remove the fill plug to bleed pressure from the reservoir.
3. Remove the circlip securing the manual release valve and unscrew the release valve from the trim assembly.

   NOTE: *A small amount of trim fluid may drip from the manual release valve hole. Place a suitable container under the trim assembly to collect any leakage.*
4. Install the pressure adapter fitting into the manual release valve hole.

Pressure Adapter Fitting - Up	8M0061797

5. Thread the hose from the test gauge kit into the brass fitting on the adapter.

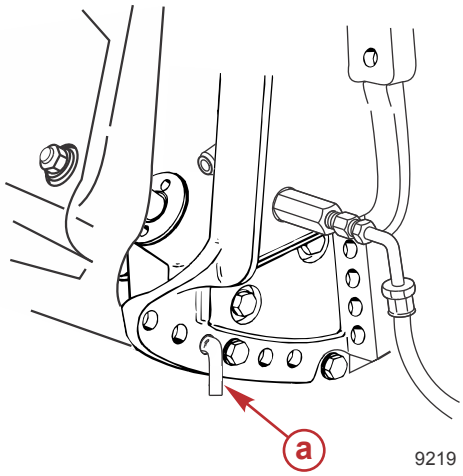


a - Brass fitting
b - Test gauge assembly
c - Tilt pin
d - Hose

Power Trim Test Gauge Kit	91-52915A6

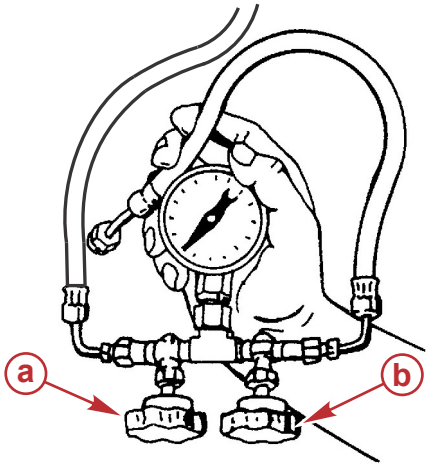
6. Install the fill plug.
7. Run the trim up and disengage the tilt lock lever.

   IMPORTANT: Install the tilt pin correctly to prevent transom failure and personal injury.
8. Move the outboard in until the hole in the swivel bracket ear aligns with the third tilt hole in the transom bracket. Lock the engine in trim range by installing a 10 mm (0.375 in.) diameter tilt pin or two 10 mm (0.375 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 the trim up. Ensure that the trim up pressure meets specification.

Trim Up Relief Valve Pressure (Tilt cylinder extended)	
Pressure	17237 kPa (2500 psi) minimum

IMPORTANT: If pressure is less than 17237 kPa (2500 psi), troubleshoot the system per the preceding instructions in this section.

11. Run the trim down to release pressure and remove the spare tilt pin or bolts and nuts.
12. Tilt the outboard full up and engage the tilt lock lever.
13. Slowly remove the fill plug to bleed pressure.
14. Remove the test gauge hose and adapter.
15. Install the manual release valve and secure the valve with the circlip.
16. Tighten the fill plug.

Down Pressure Check

IMPORTANT: Ensure the battery is fully charged before performing these tests.

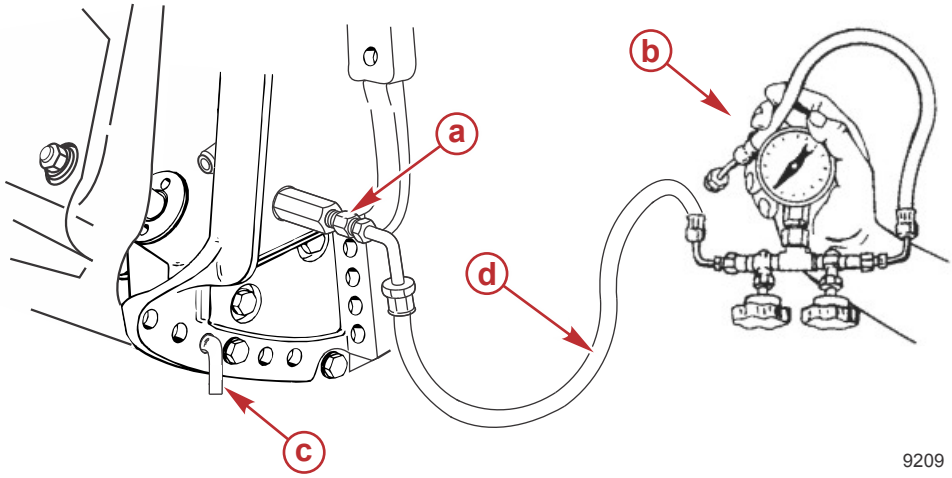
1. Tilt the outboard to the full up position and engage the tilt lock lever.
2. Slowly remove the fill plug to bleed pressure from the reservoir.
3. Remove the circlip securing the manual release valve and unscrew the release valve from the trim assembly.

   NOTE: *A small amount of trim fluid may drip from the manual release valve hole. Place a suitable container under the trim assembly to collect any leakage.*

Pressure Adapter Fitting - Down	8M0054662

4. Install the pressure adapter fitting into the manual release valve hole.

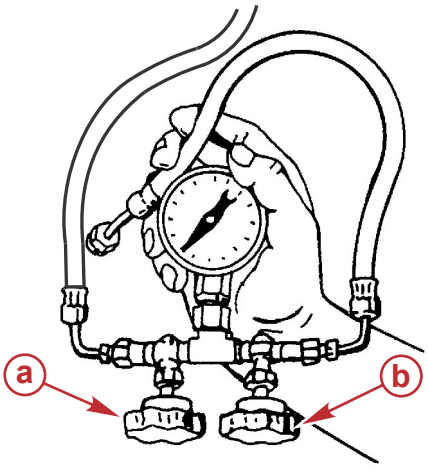
5. Thread the hose from the test gauge kit into the brass fitting on the adapter.



a - Brass fitting
b - Test gauge assembly
c - Tilt pin
d - Hose

Power Trim Test Gauge Kit	91-52915A6

6. Install the fill plug.
7. Run the trim up.
8. Disengage the tilt lock lever.
9. Open valve A and close valve B.



a - Valve A
b - Valve B

10. Run the trim down. Minimum pressure should be 4400 kPa (640 psi).

Power Trim Down Relief Valve	
Pressure	4400–7300 kPa (640–1060 psi)

IMPORTANT: If pressure is less than 4400 kPa (640 psi), troubleshoot the system per the preceding instructions in this section.

11. Tilt the outboard full up and engage the tilt lock lever.
12. Slowly remove the fill plug to bleed pressure.
13. Remove the test gauge hose and adapter.
14. Install the manual release valve and secure the valve with the circlip.
15. Tighten the fill plug.

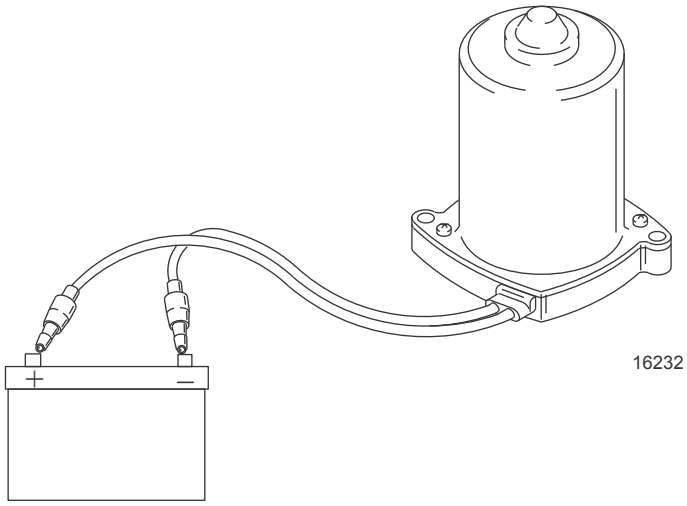
Motor and Electrical Tests/Repair

Trim Pump Motor Testing and Repair

⚠ WARNING

A spark may occur when making connections which could result in fire or explosion. Do not perform this test near flammables or explosives.

1. Connect a 12-volt power supply to the trim pump motor wires. Connect one trim pump motor wire to the positive (+) battery terminal and the other trim pump motor wire to the negative (–) battery terminal. The motor should run.
2. Reverse the trim pump motor leads between battery terminals. The motor should run in the opposite direction.



3. Replace the trim pump motor if it does not run. The trim pump motor is not serviceable. Refer to **Trim Motor Removal** to remove the trim motor from the pump.

   NOTE: *The power trim system does not have to be removed from the outboard to replace the trim pump motor.*

Power Trim Assembly Removal and Installation Procedures

Power Trim Assembly Removal

1. Remove the screw securing the clamp to the transom bracket to free the power trim wiring.

⚠ CAUTION

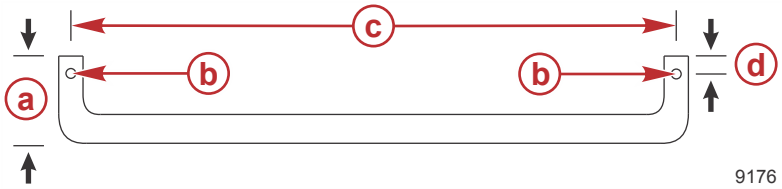
Failure to support the outboard can result in serious injury. Always support the outboard with the tilt-lock lever and support tool when servicing the outboard.

2. Raise the outboard to the full up position and engage the tilt lock lever.
3. Remove the trim position sensor screws. Remove the trim position sensor.

IMPORTANT: Support the outboard as shown below to prevent the engine from tipping when the power trim retaining pin is removed.

a - Screw
b - Screws (2)
c - Trim position sensor
d - Tilt lock lever

4. Create an appropriate support tool using a 9.5 mm (0.375 in.) diameter metal rod with the following dimensions:
   NOTE: *A used shift shaft works well to create this support tool.*

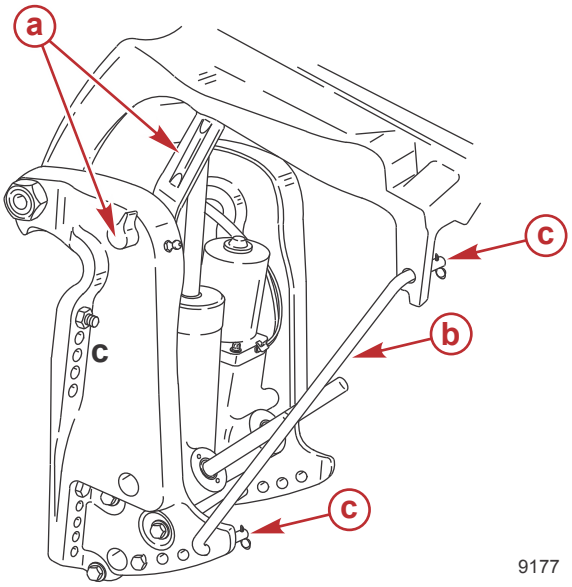


a - 50.8 mm (2.0 in.)
b - Drill holes for retaining clip
c - 35.56 cm (14.0 in.)
d - 6.35 mm (0.25 in.)

⚠ 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.

5. Support the outboard, as shown, using the support tool.



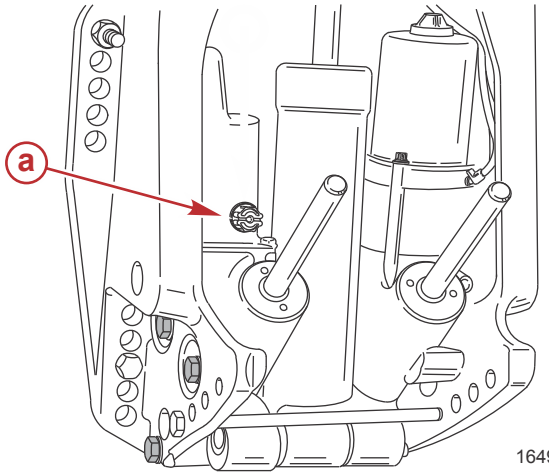
a - Tilt lock lever
b - Support tool
c - Retaining clips

6. Disconnect the blue and the green bullet connector harness.

⚠ WARNING

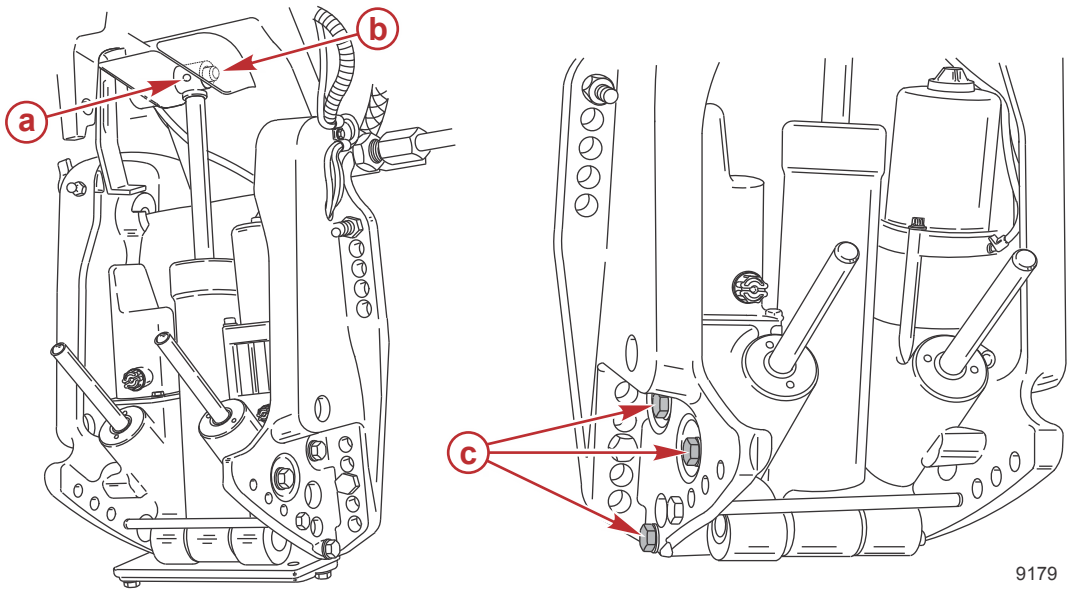
Performing service or maintenance without first disconnecting the battery can cause product damage, personal injury, or death due to fire, explosion, electrical shock, or unexpected engine starting. Always disconnect the battery cables from the battery before maintaining, servicing, installing, or removing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

7. Open the filler cap and release any remaining pressure in the system.



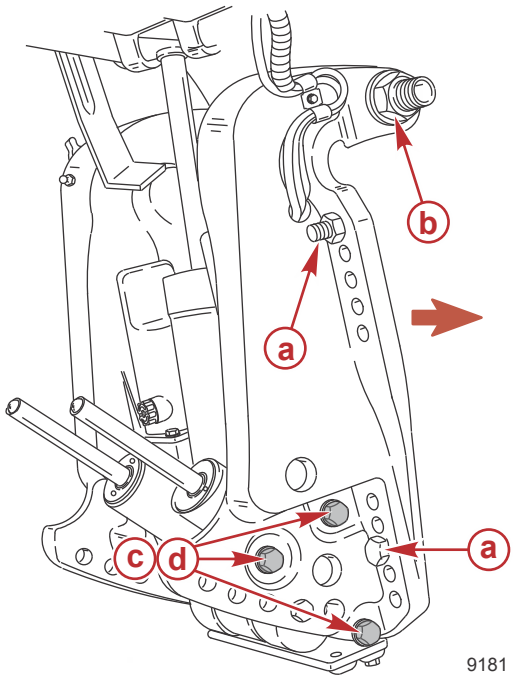
a - Filler cap

8. Remove the trilobe pin, push out the upper swivel pin, and remove the three screws and washers in the port clamp bracket.
   IMPORTANT: Do not reuse the trilobe pin.
   NOTE: *The six trim mounting screws should not be reused. Replace with new patch lock screws.*



a - Trilobe pin
b - Upper swivel pin
c - Port transom bracket screws and washers (3)

9. Remove the three screws and washers in the starboard transom bracket.



a - Transom mount bolts
b - Tilt tube nut (flush with end of thread)
c - Screws (3)
d - Washers (3)

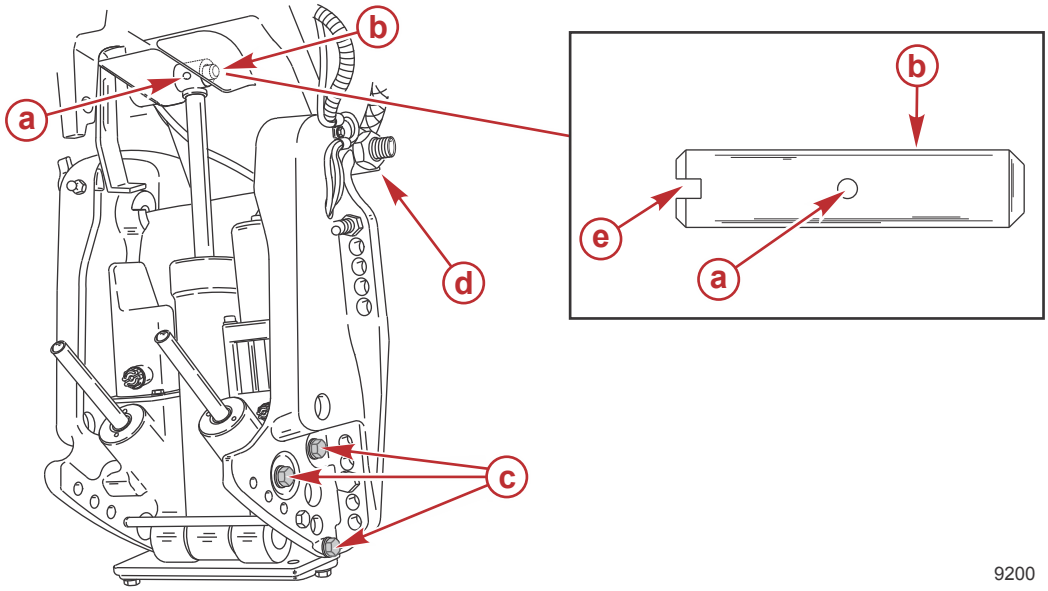
10. Remove the outboard transom mounting bolts and loosen the tilt tube nut until it is flush with the end of the tilt tube thread.
11. Remove the system from the outboard.

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 strikers 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.

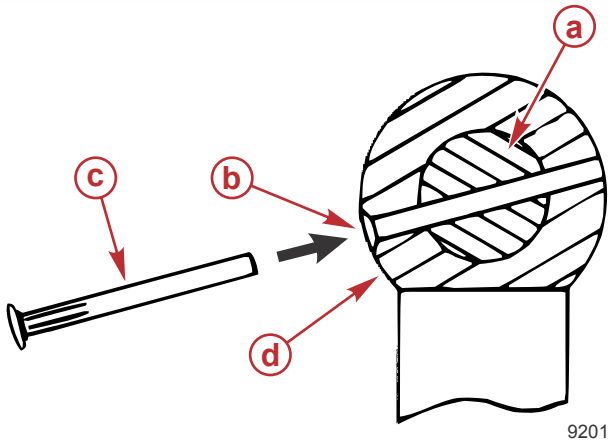
IMPORTANT: Do not reuse the trilobe pin.



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.

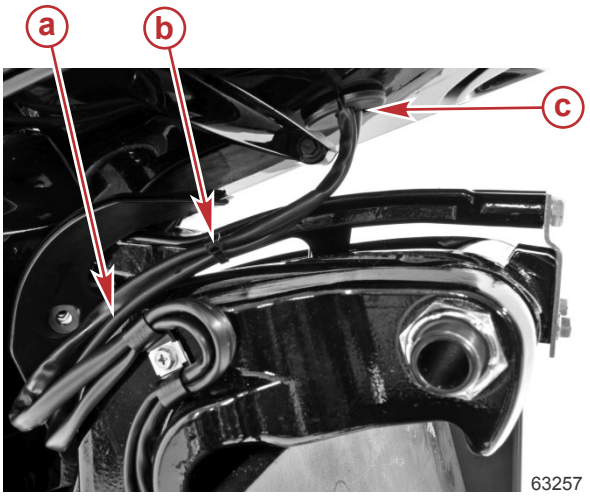


a - Upper pivot pin (slot is in line with cross hole)
b - Chamfered end of hole (faces away from transom)
c - Trilobe pin
d - Tilt ram end

10. Connect the blue and the green bullet connector harness.
11. Route the trim wires as shown. Secure them together with a cable tie in the location shown.

⚠ 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.



a - Trim wires
b - Cable tie
c - Grommet

12. Secure the trim wires with the wire clamp. Install the trim position sensor.

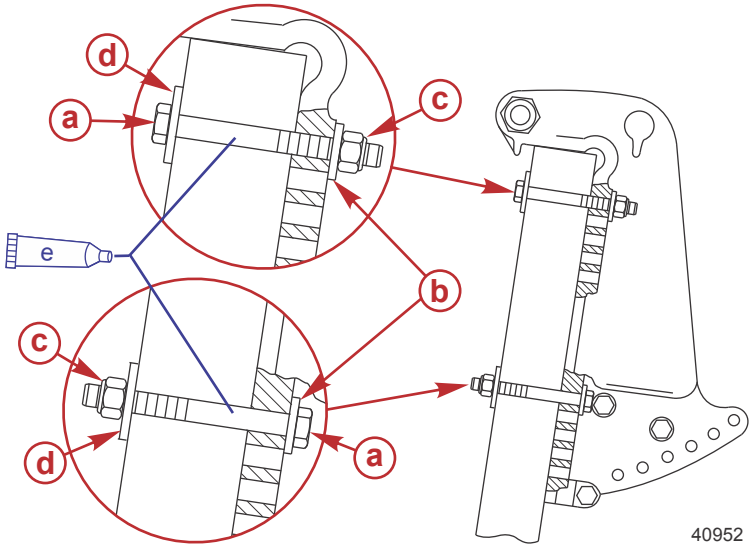
a - Screw
b - Screws (2)
c - Trim position sensor
d - Tilt lock lever

13. Apply marine-grade silicone sealer to the shanks, not the threads, of the mount bolts and install the transom mount bolts. Secure with flat washers and locknuts. Ensure that 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 wrench to tighten the transom mount bolts.

14. Tighten the locknuts to the specified torque.



- **a -** Outboard mounting bolts (4)
- **b -** Special hardened steel flat washer (7/8 in. diameter) - place against outboard transom bracket (4), do not replace with standard metal flat washers
- **c -** Nylon insert locknuts (4)
- **d -** Flat washer (1-1/2 in. diameter) - place inside against transom surface (4)
- **e -** Marine sealer - apply to shank of bolts, not threads

Description	Nm	lb-in.	lb-ft
Outboard mounting locknuts and bolts - standard boat transom	75	–	55.3
Outboard mounting locknuts and bolts - metal lift plates and setback brackets	122	–	90

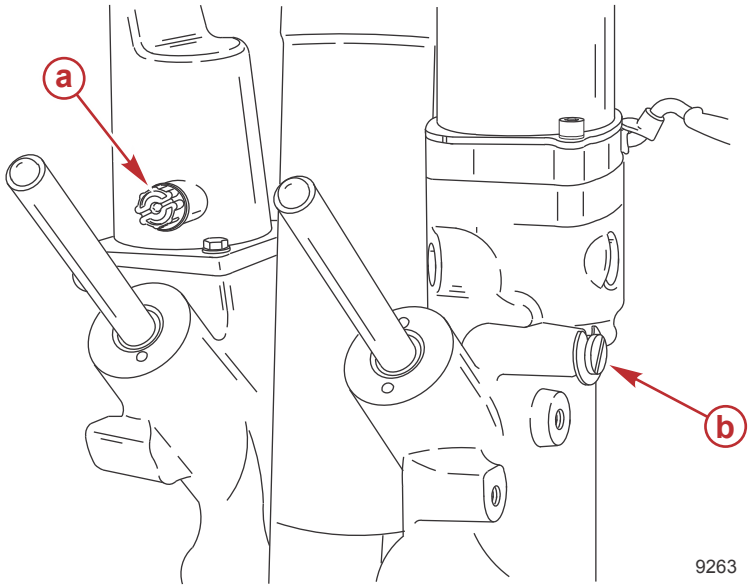
15. Tighten the tilt tube nut securely.

Power Trim Disassembly

Power Trim Removal

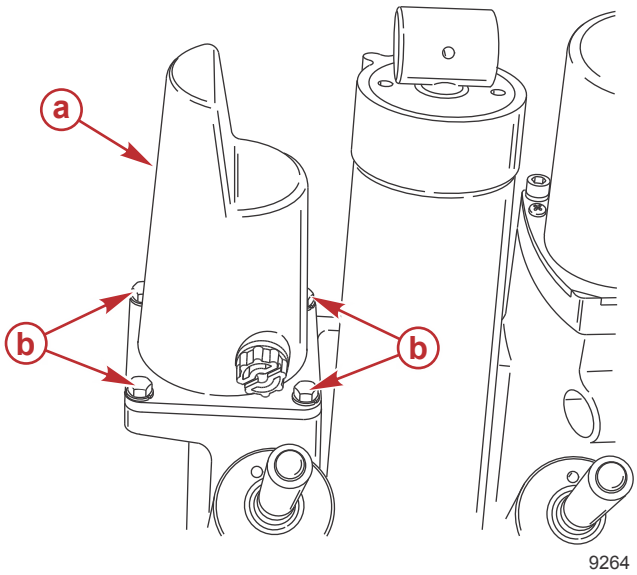
IMPORTANT: The power trim system is pressurized. The trim rams must be in the full up position (fully extended) prior to removal of the fill/drain plug or manual release valve.

1. Remove the reservoir cap to drain the oil.
2. Remove the manual release valve to drain any remaining oil.



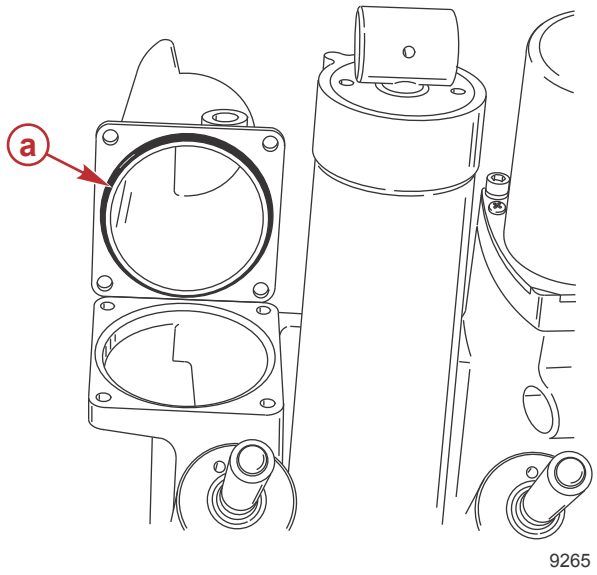
- **a -** Reservoir cap
- **b -** Manual release valve

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

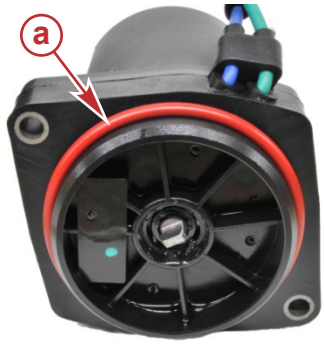
1. Secure the power trim assembly in a soft jaw vise.

2. Remove the two screws and washers securing the trim motor to the power trim assembly.

63373

a - Screws and washers (2)

3. Remove the trim motor.
4. Inspect the trim motor O-ring for cuts and abrasions. Replace as necessary.



63376

a - O-ring

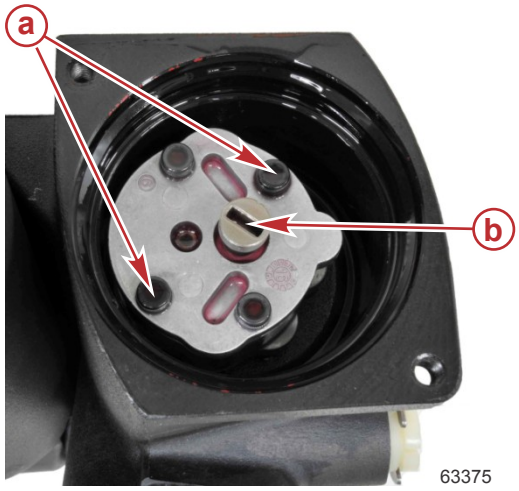
Pump and Component Removal

⚠ 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 driveshaft from the pump.
2. Remove the two screws securing the pump. Remove the pump and drain any remaining fluid from the pump housing.

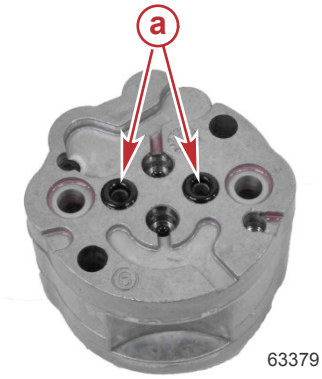
   IMPORTANT: There are no serviceable parts within the oil pump. Failure of, or damage to, internal components of the pump requires pump assembly replacement.



63375

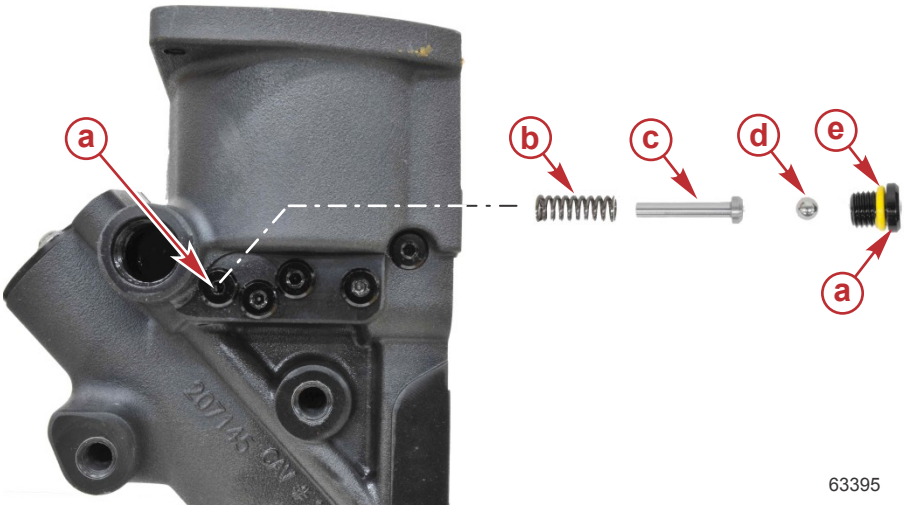
a - Screws (2)
b - Driveshaft

3. Inspect the O-rings on the bottom of the oil pump. Replace the O-rings as necessary.



a - O-rings (2)

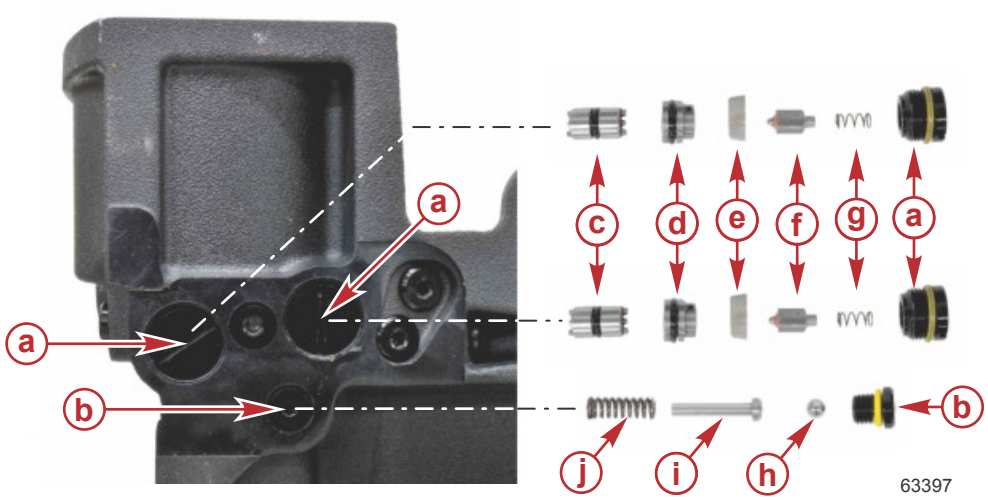
4. Remove the plug as shown. Remove the spring, seat, and check ball from the housing.
IMPORTANT: Inspect all components and O-rings for damage.



a - Plug
b - Spring
c - Seat
d - Check ball
e - O-ring

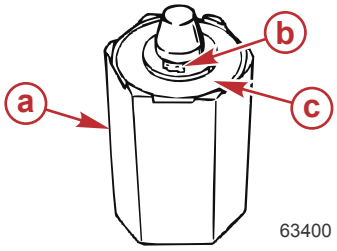
5. Remove the small plug and two large plugs from the housing. Remove the components as shown.
IMPORTANT: Inspect the seats, O-rings, and all other components for damage.

IMPORTANT: Check the screen for debris and clean the screen if necessary.



- **a -** Large plug (2)
- **b -** Small plug
- **c -** Spool (2)
- **d -** Seat (2)
- **e -** Screen (2)
- **f -** Poppet (2)
- **g -** Spring (2)
- **h -** Check ball
- **i -** Seat
- **j -** Spring

6. Inspect the poppet assembly for debris, nicks, cuts, or damage in the area shown. If debris or damage is found on the poppet, replace the poppet. Inspect the O-rings on the plugs, seats, and spools for cuts or abrasions. Replace as necessary.



- **a -** Poppet
- **b -** Debris on seat
- **c -** Rubber seat

Trim Cylinder

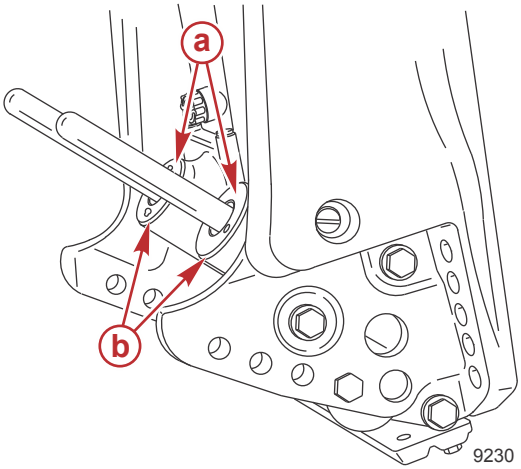
Trim Rod Removal

NOTE: *Power trim does not have to be removed from the outboard to remove the trim rods.*

NOTE: *If this procedure is being performed as part of a complete teardown, remove the fluid reservoir and trim motor first.*

1. Tilt the outboard to the 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 by turning them counterclockwise.

NOTE: *Place a drain 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.

Clean the trim rod with a parts cleaner and dry with compressed air.

Trim Rod Installation

IMPORTANT: Components must be clean and free of dirt and lint. Any debris in the system can cause a malfunction.

NOTE: For service replacement trim units*—install the trim rod with the check valve into the port cylinder.*

1. Apply ATF Dexron III or Power Trim and Steering Fluid on all O-rings and seals before installation.

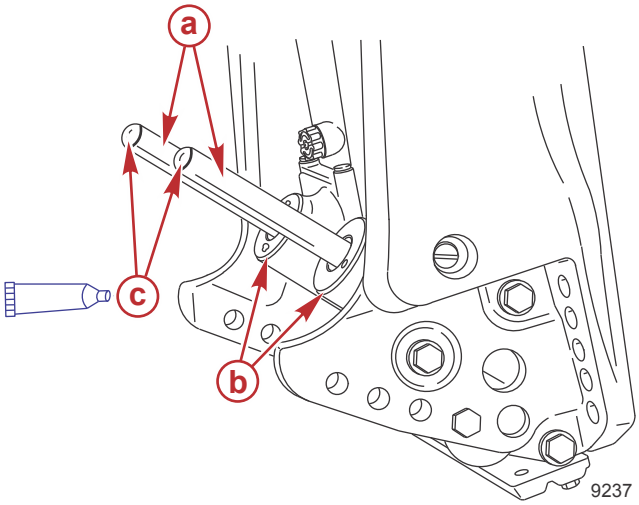
Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	O-rings and seals	92-858074K01

2. Install the trim rods and caps. Use the trim rod guide removal tool or trim cylinder end cap tool to tighten the caps to the specified torque.

Trim Rod Guide Removal Tool	91-44487T 1
Trim Cylinder End Cap Tool	91-821709T

Description	Nm	lb-in.	lb-ft
Trim cylinder end caps	122	–	90

3. Lubricate the trim cylinder rod end rollers with Extreme Grease.



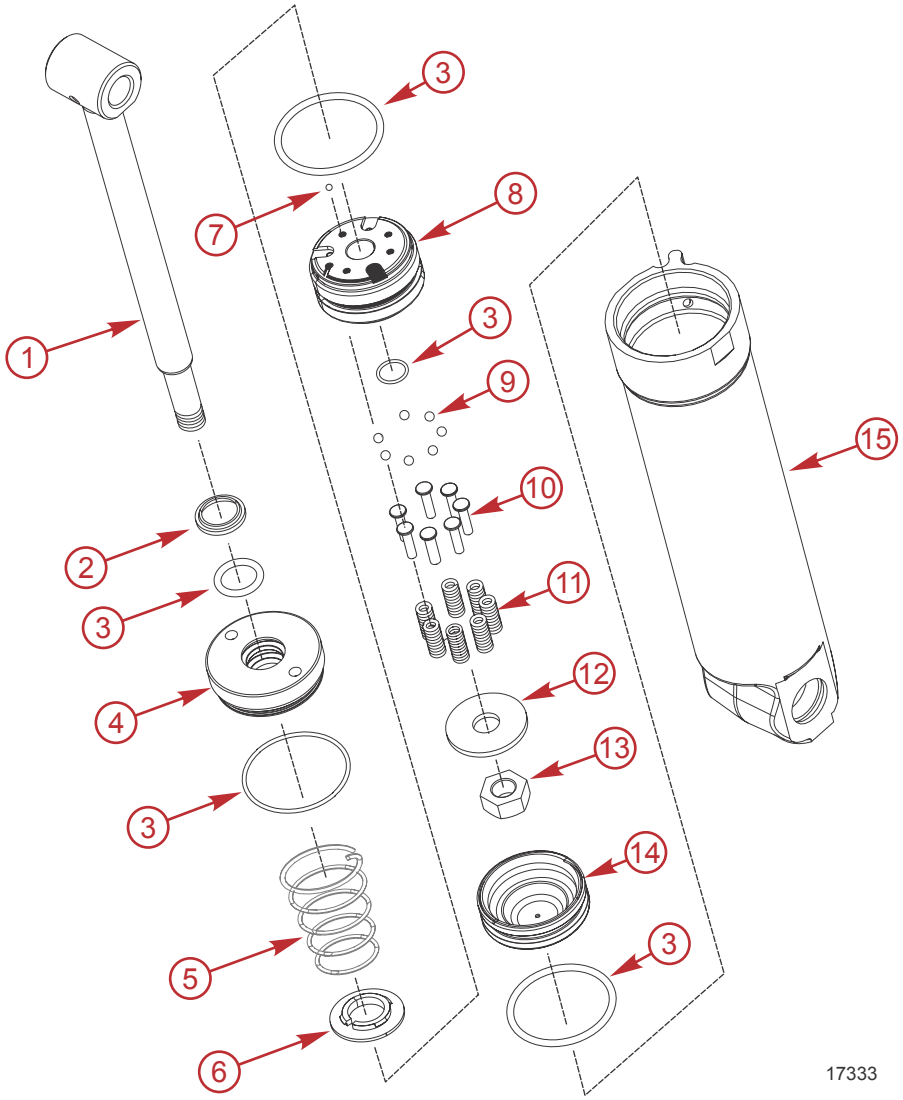
a - Trim rods
b - Cylinder end caps
c - Rod end rollers

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Trim cylinder rod end rollers	8M0071842

Tilt Cylinder

Tilt Cylinder Components

NOTE: *Tilt cylinder rod components are not available as individual replacement parts. The tilt cylinder rod must be replaced as an assembly.*



1 - Tilt cylinder rod
2 - Scraper seal
3 - O-ring
4 - Cylinder cap (blue anodized)
5 - Damper spring
6 - Damper plate
7 - Return ball
8 - Shock piston
9 - Shock balls
10 - Spring keepers
11 - Shock springs
12 - Washer
13 - Nut
14 - Memory piston
15 - Housing

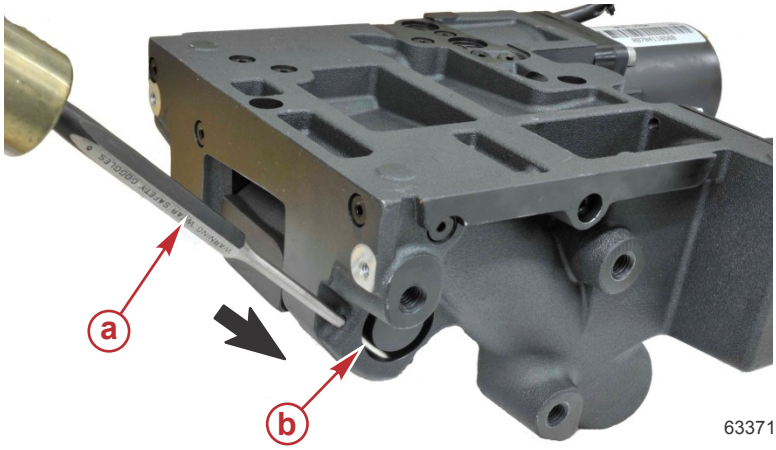
Tilt Ram Removal

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.

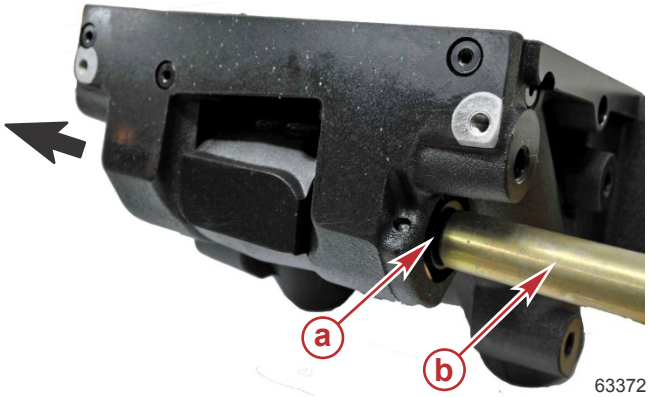
1. Remove the cross pin using a hammer and a punch in the direction shown. Discard the cross pin after removal.



a - Punch
b - Cross pin

2. Remove the lower swivel pin using a hammer and a brass or plastic drift in the direction shown.

IMPORTANT: Use only a brass or plastic drift to remove the swivel pin. A steel drift can damage the finish of the swivel pin.



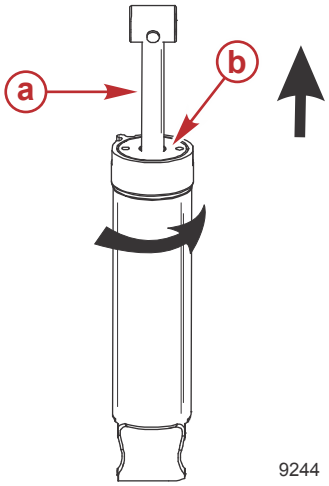
a - Lower swivel pin
b - Brass drift

3. Remove the tilt ram from the power trim unit.

Disassembly

IMPORTANT: The tilt cylinder rod is not serviceable. It can only be replaced as an assembly.

Secure the tilt ram in a soft jawed vise. Remove the end cap and tilt cylinder rod.

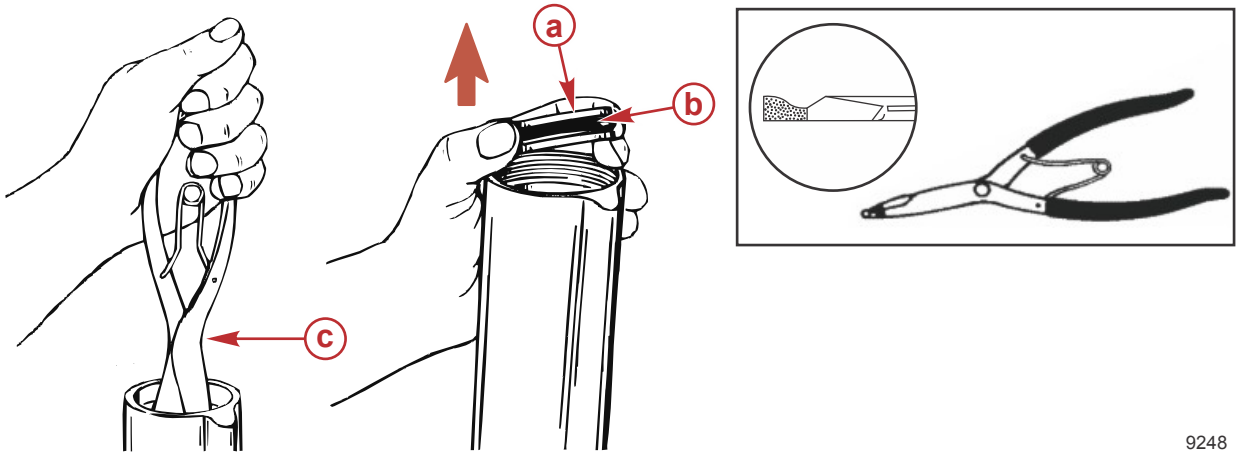


a - Tilt cylinder rod
b - End cap

Trim Cylinder End Cap Tool	91-821709T
Spanner Wrench	91-74951

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 end cap assembly if the tilt rod is scratched or worn.
3. Clean the 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

Tilt Cylinder Assembly

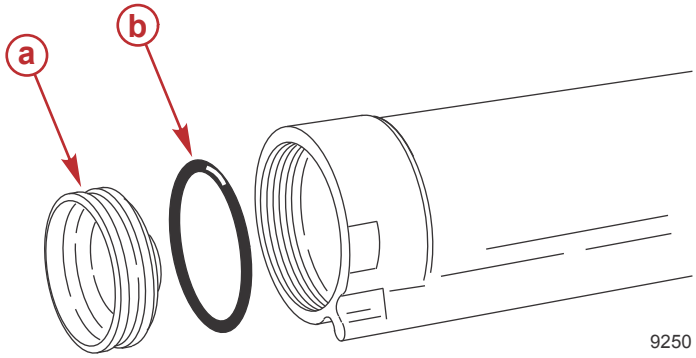
IMPORTANT: The tilt cylinder rod is not serviceable. It can only be replaced as an assembly.

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 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

2. Install a new O-ring onto the memory piston and install into the cylinder.

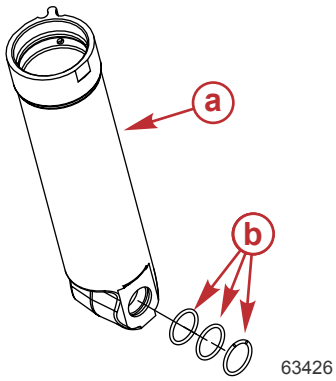


a - Memory piston
b - O-ring

3. Add Power Trim and Steering Fluid to the tilt cylinder. This will reduce the time necessary to bleed air from the cylinder before operation.

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

4. Replace the three O-rings in the bottom of the tilt cylinder. Lubricate the O-rings prior to installation.

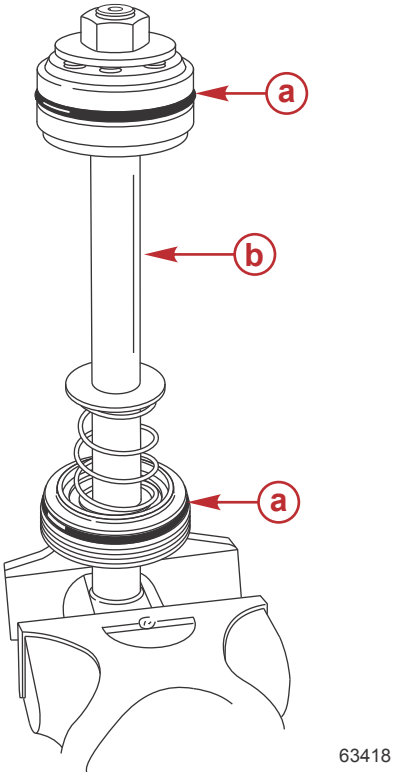


a - Tilt cylinder
b - O-rings (3)

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

5. Replace the O-rings on the tilt cylinder rod. Lubricate the O-rings before installation.

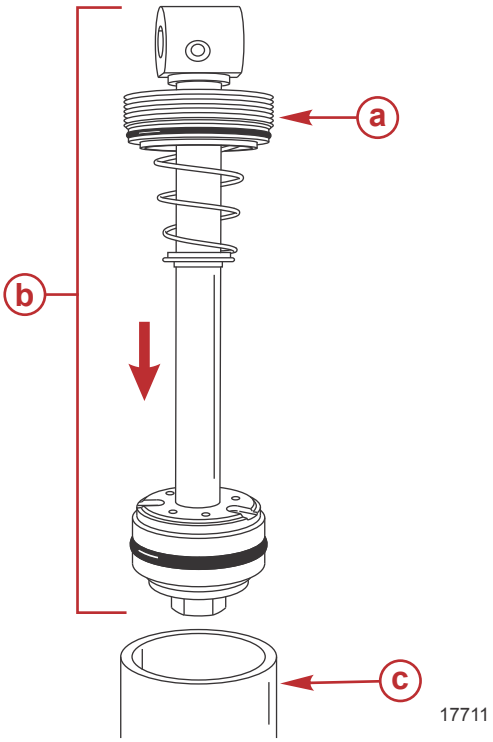
IMPORTANT: The tilt cylinder rod is not serviceable. It can only be replaced as an assembly.



a - O-rings (2)
b - Tilt cylinder rod

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

6. Clamp the tilt cylinder in a soft jawed vise and install the tilt rod assembly. Tighten the end cap to the specified torque.



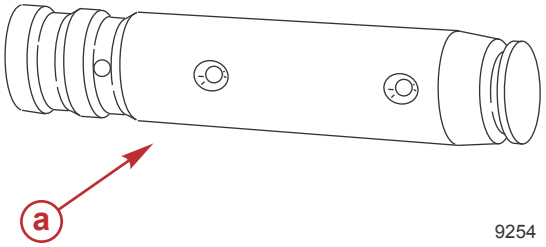
a - End cap
b - Tilt rod assembly
c - Tilt cylinder

Trim Cylinder End Cap Tool	91-821709T

Description	Nm	lb-in.	lb-ft
Tilt cylinder end cap	135.6	–	100

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).

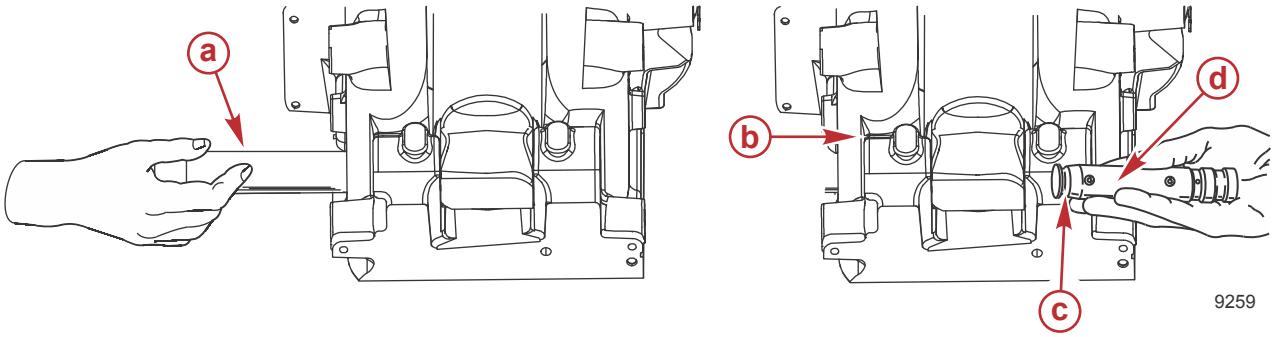


a - Shaft

Alignment Tool	91-11230--1

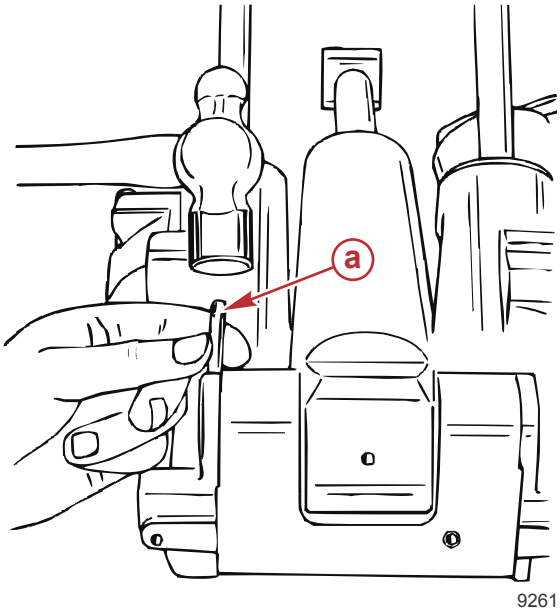
Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	Tilt ram alignment tool and shaft	92-858074K01

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.



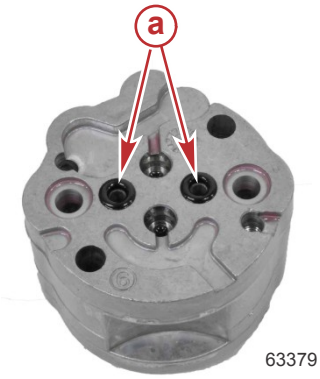
a - Pin

Pump, Motor, and Component Assembly

⚠ 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. Lubricate the O-rings before installation. Install new O-rings onto the pump.



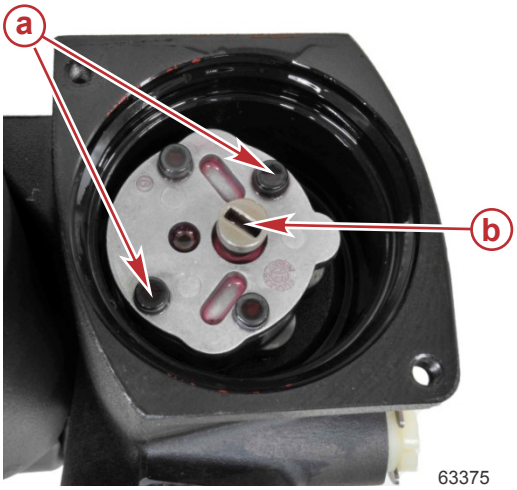
a - O-rings (2)

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

2. Install the pump onto the power trim manifold.
3. Install the driveshaft onto the pump.

IMPORTANT: The driveshaft is a loose part and may fall out of position during assembly.

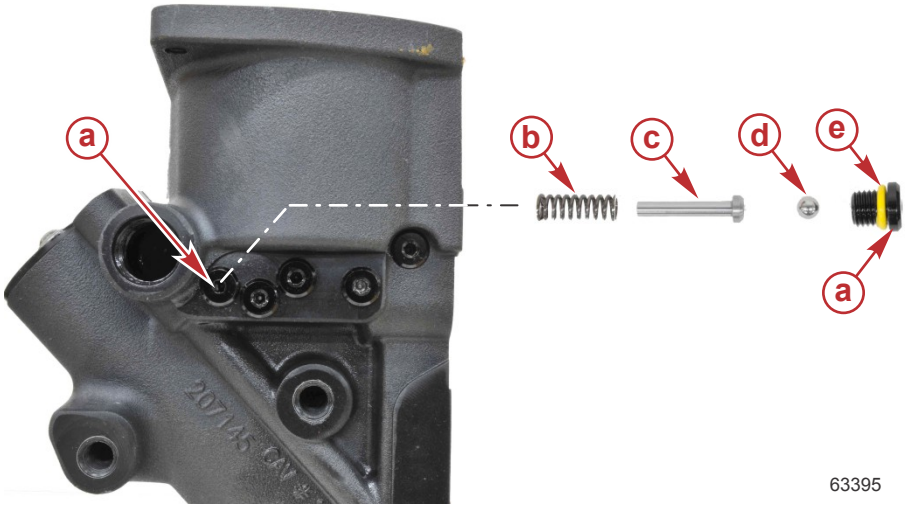
4. Secure the pump with two screws. Tighten the screws to the specified torque.



a - Screws (2)
b - Driveshaft

Description	Nm	lb-in.	lb-ft
Pump retaining screws (2)	7	62	–

5. Lubricate and install a new O-ring onto the plug as shown.
6. Install the components as shown. Tighten the plug to the specified torque.



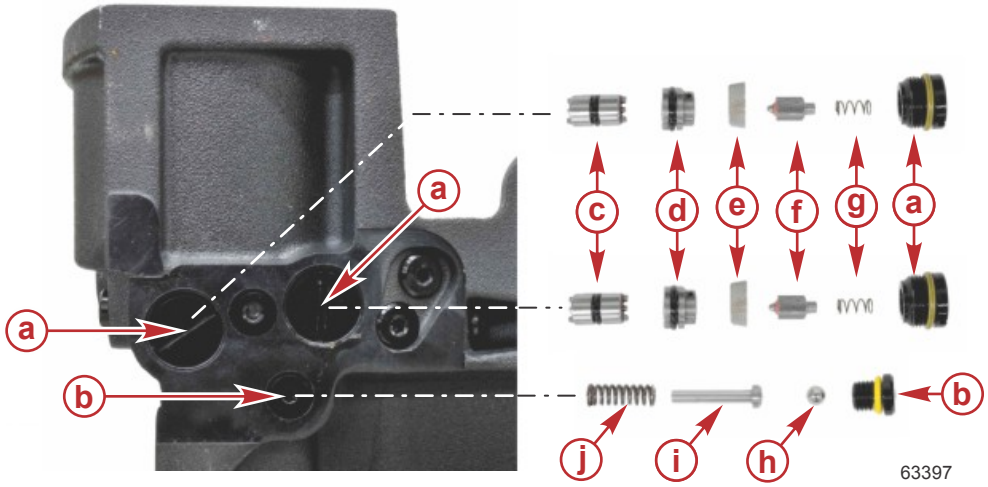
a - Plug
b - Spring
c - Seat
d - Check ball
e - O-ring

Description	Nm	lb-in.	lb-ft
Plug	3.95	35	–

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

7. Lubricate and install the O-rings onto the plugs as shown. Replace the O-rings if they are damaged.

8. Install the components as shown. Tighten the plugs to the specified torque.



a - Large plug (2)
b - Small plug
c - Spool (2)
d - Seat (2)
e - Screen (2)
f - Poppet (2)
g - Spring (2)
h - Check ball
i - Seat
j - Spring

Description	Nm	lb-in.	lb-ft
Small plug	3.95	35	–
Large plug (2)	3.95	35	–

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

9. 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

10. Lubricate and install the O-ring onto the motor housing. Replace the O-ring if it is damaged.

a - O-ring

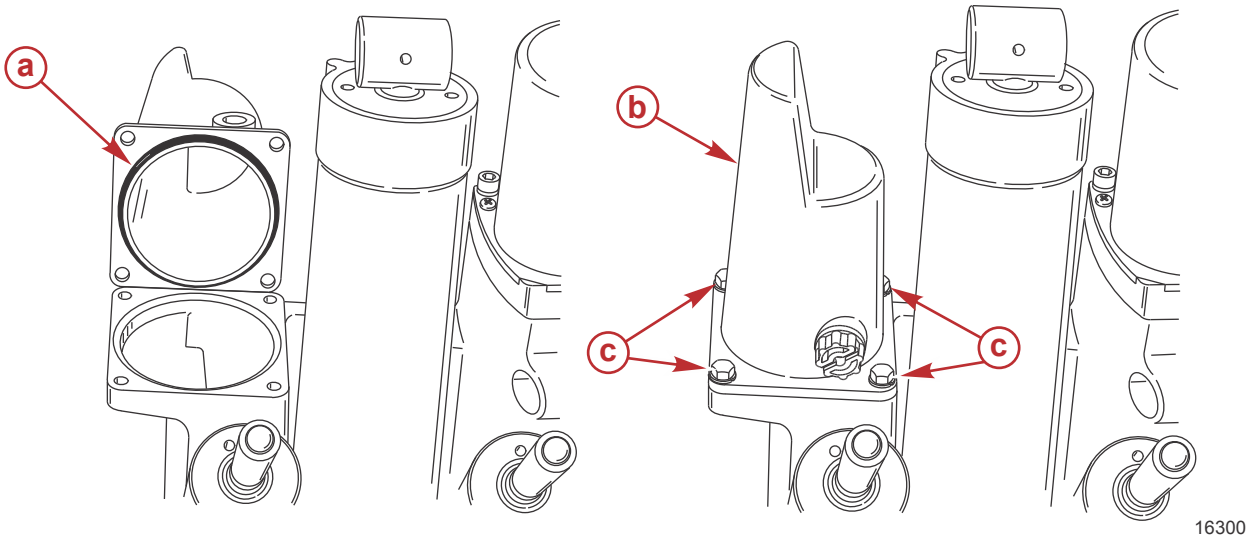
Tube Ref No.	Description	Where Used	Part No.
114	Power Trim and Steering Fluid	O-ring	92-858074K01

11. Align the motor shaft with the pump driveshaft.
12. Install the motor and secure with two screws. Tighten the screws to the specified torque.

a - Screws (2)

Description	Nm	lb-in.	lb-ft
Screw (2)	9.04	80	–

13. Inspect the reservoir cover O-ring and replace it if damage is found. Lubricate and install the O-ring onto the reservoir cover.
14. Install the reservoir cover.
15. Secure the cover with four screws. Tighten the 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)	9.04	80	–

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

16. Install the power trim system as outlined in **Power Trim Assembly Installation**.

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.
	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 intervals until the pump motor primes and the trim system moves. If the trim motor is run without priming the pump, driveshaft failure could result.

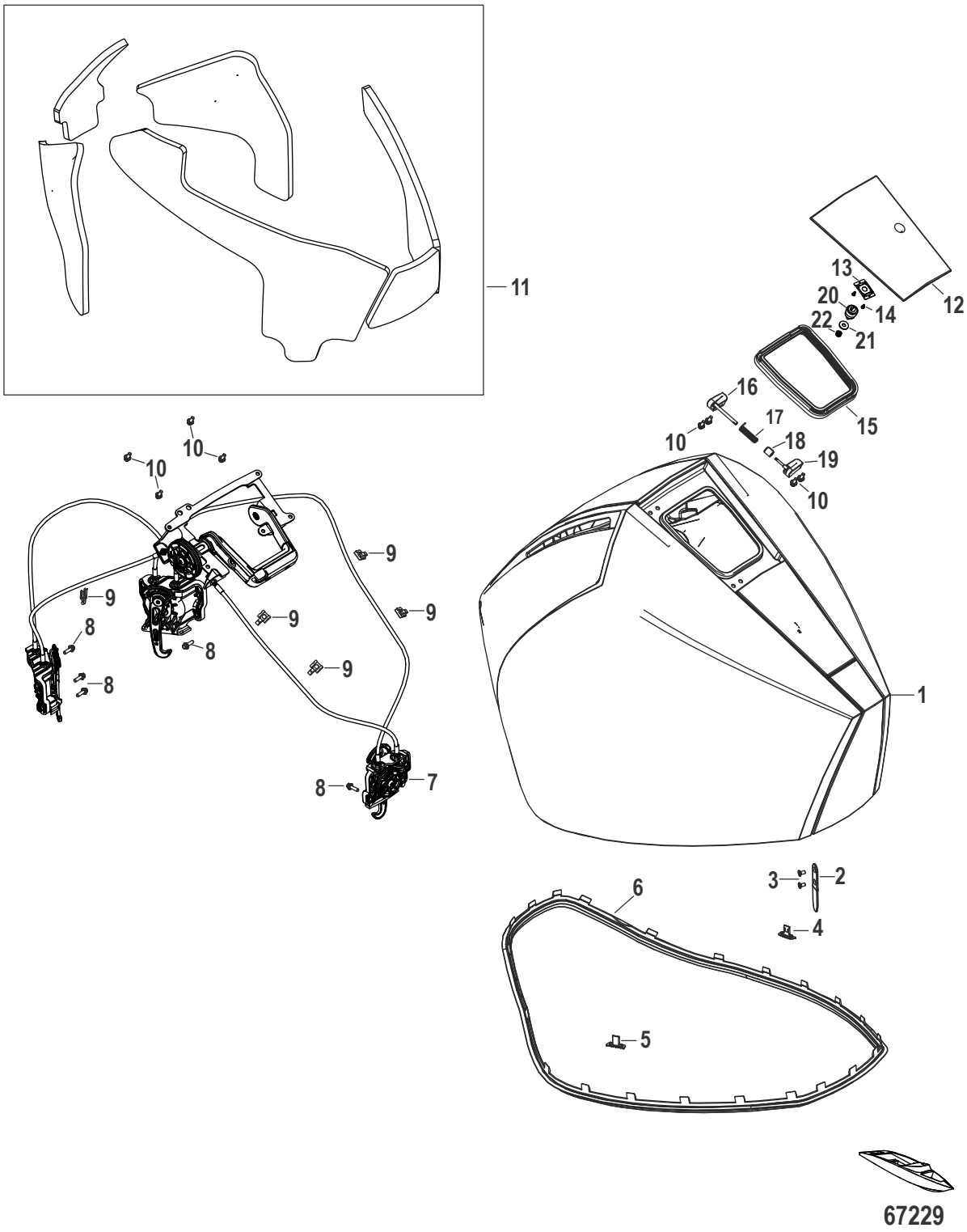
Midsection

Section 5C - Upper and Lower Cowls

Table of Contents

5
C

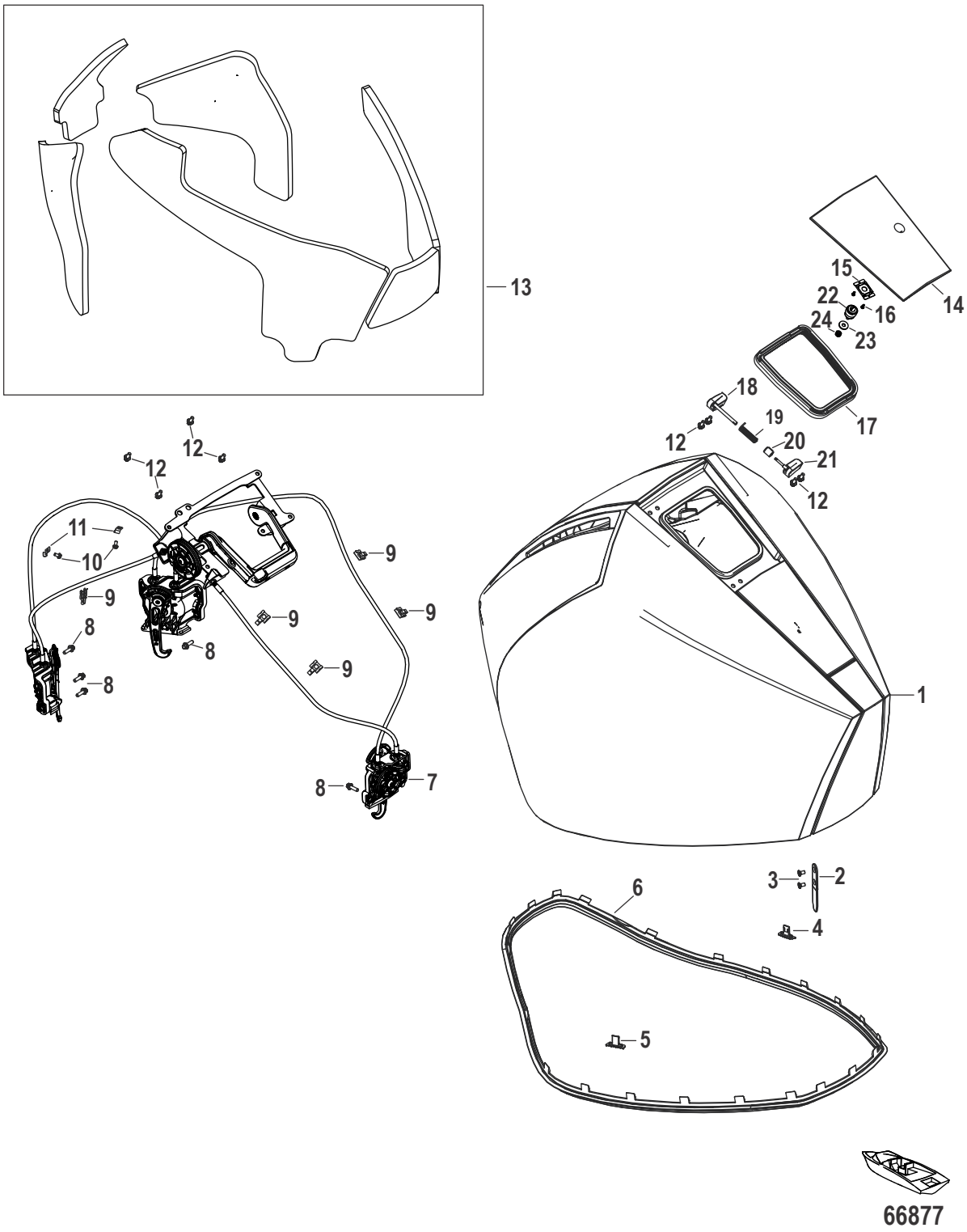
V6 Top Cowl Components



V6 Top Cowl Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Top cowl assembly			
2	4	Alignment leg			
3	8	Screw	10	88.5	–
4	1	Port bumper			
5	1	Starboard bumper			
6	1	Top cowl seal			
7	1	Cowl latch assembly			
8	10	M6 x 20 stainless steel screw	10	88.5	–
9	7	Clip			
10	8	M6 x 14 stainless steel screw	5.6	49.6	–
11	1	Sound blanket kit			
12	1	Door assembly			
13	1	Keeper assembly			
14	2	Screw	1	8.8	–
15	1	Door seal			
16	1	Hinge			
17	1	Spring			
18	1	Damper assembly			
19	1	Hinge			
20	1	Push lock			
21	1	Latch shim			
22	1	M6 stainless steel nut	5.6	49.6	–

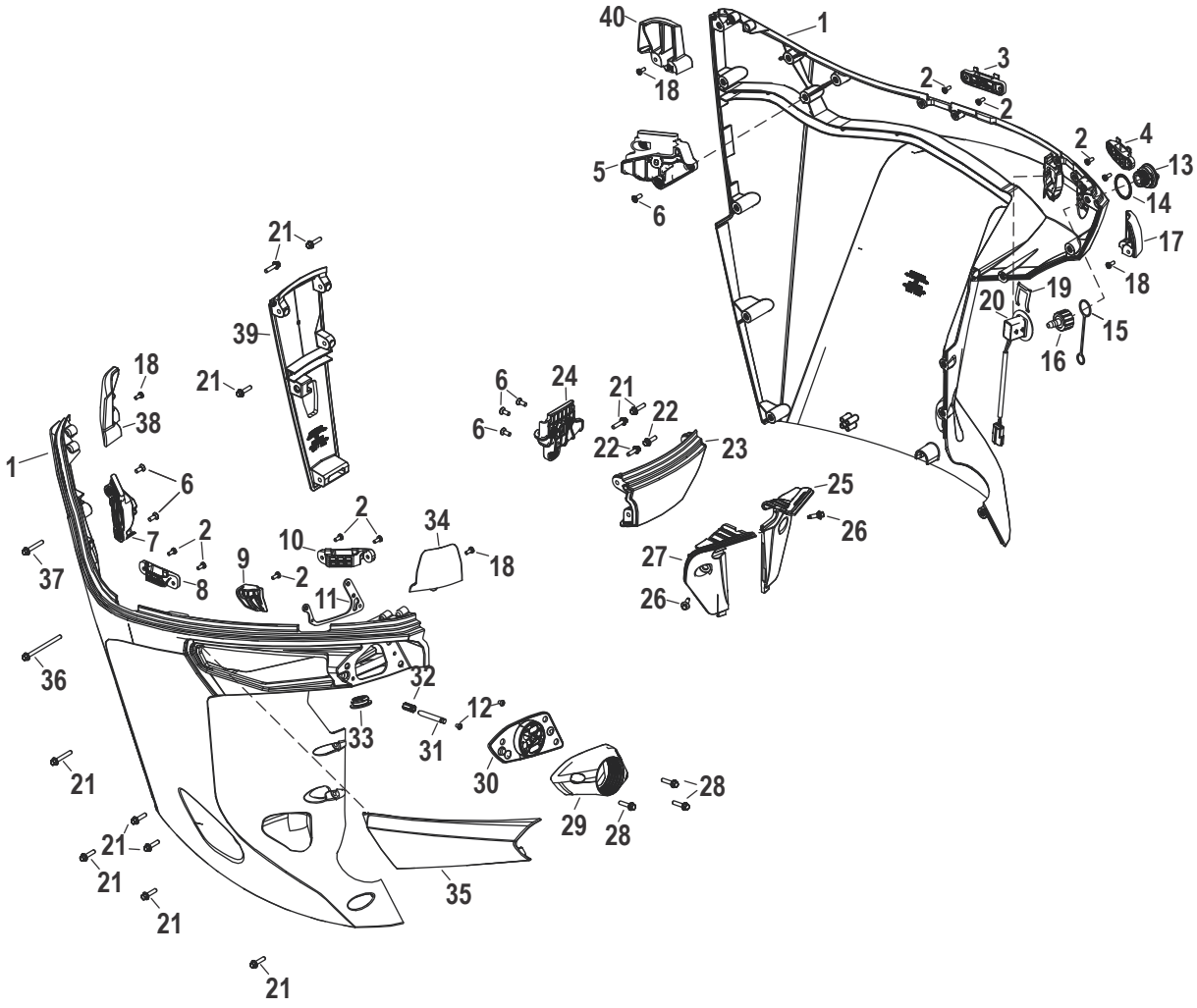
V8 Top Cowl Components



V8 Top Cowl Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Top cowl assembly			
2	4	Alignment leg			
3	8	Screw	10	88.5	–
4	1	Port bumper			
5	1	Starboard bumper			
6	1	Top cowl seal			
7	1	Cowl latch assembly			
8	10	M6 x 20 stainless steel screw	10	88.5	–
9	8	Clip			
10	2	Screw	5.6	49.6	–
11	2	Clip			
12	8	M6 x 14 stainless steel screw	10	88.5	–
13	1	Sound blanket kit			
14	1	Door assembly			
15	1	Keeper assembly			
16	2	Screw	1	8.8	–
17	1	Door seal			
18	1	Hinge			
19	1	Spring			
20	1	Damper assembly			
21	1	Hinge			
22	1	Push lock			
23	1	Latch shim			
24	1	M6 stainless steel nut	5.6	49.6	–

CMS Lower Cowl Components



CMS Lower Cowl Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Port and starboard lower cowl assembly			
2	9	Screw	5.6	49.6	–
3	1	Port rear retainer			
4	1	Port front retainer			
5	1	Port striker assembly			
6	9	Screw	10	88.5	–
7	1	Starboard striker assembly			
8	1	Starboard rear retainer			
9	1	Block			
10	1	Starboard front retainer			
11	1	Plate			
12	2	M5 x 8 screw	5.6	49.6	–
13	1	Plug			
14	1	Seal			
15	1	Tether			
16	1	Flush fitting assembly			
17	1	Port front guide			
18	4	Screw	5.6	49.6	–
19	1	Switch retainer			
20	1	Trim switch			
21	11	M6 x 25 screw	6	53.1	–
22	2	M6 x 20 hex flange screw	6	53.1	–
23	1	Front lower cowl assembly			
24	1	Front striker assembly			
25	1	Port cover			
26	2	M6 shoulder screw	6	53.1	–
27	1	Starboard cover			
28	3	M6 x 30 hex flange screw	6	53.1	
29	1	Adapter			
30	1	Grommet			
31	1	Rigging door pin			
32	1	Bushing			
33	1	Trim sensor grommet			
34	1	Starboard front guide			
35	1	Rigging door			
36	1	M6 x 85 hex flange screw	6	53.1	–
37	1	Screw	6	53.1	
38	1	Starboard rear guide			
39	1	Lower rear cowl panel			
40	1	Port rear guide			

Top Cowl Removal and Installation

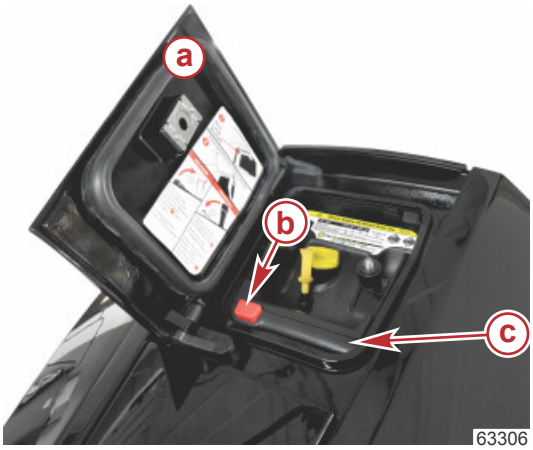
NOTE: *It is recommended to remove and install the cowl while standing inside the boat.*

Removal

1. Tilt the outboard up so the top of the cowl is facing you.
2. Push down on the port side of the service access door to unlock and open the door.

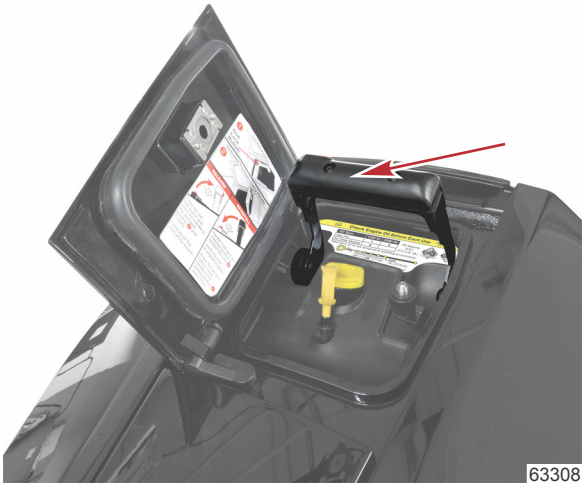
Push here to unlock

3. Press on the red lock button and lift the handle.



a - Service access door
b - Red lock button
c - Handle

4. Push the handle towards the aft to lock the handle into the cowl lift position.



Handle locked in the lift position

5. With a firm grip on the handle, carefully lift the cowl off the engine.

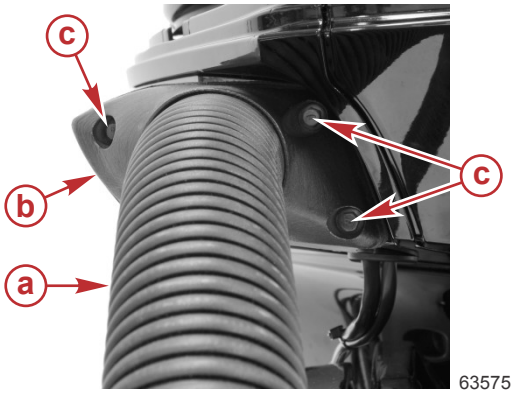
Installation

1. With a firm grip on the handle, carefully lower the top cowl over the engine.
2. Verify the cowl is correctly aligned by checking the cowl alignment guides on the port and starboard side of the cowl. If there is misalignment, one side of the cowl will have a gap that is larger than the other side.

   NOTE: *It may be necessary to slightly lift the larger gap side of the cowl to correctly position the alignment guides.*
3. Gently push down on the cowl.
4. Push the red lock button and pull the handle. Continue to push the handle down into the locked position.
5. Close the service access door.

Conventional Midsection (CMS) Lower Cowl Removal

1. Remove the top cowl. Refer to **Top Cowl Removal and Installation**.
2. Remove the rigging adapter, rigging grommet, and rigging tube (if equipped).



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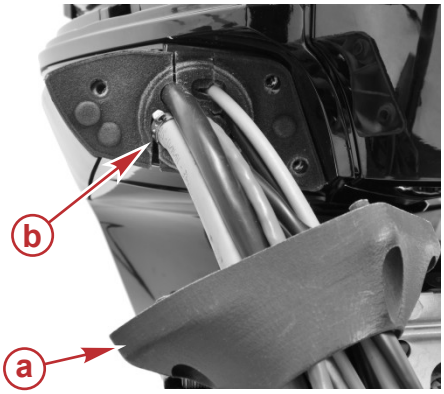
a - Rigging tube (optional)
b - Rigging adapter
c - Screws (3)



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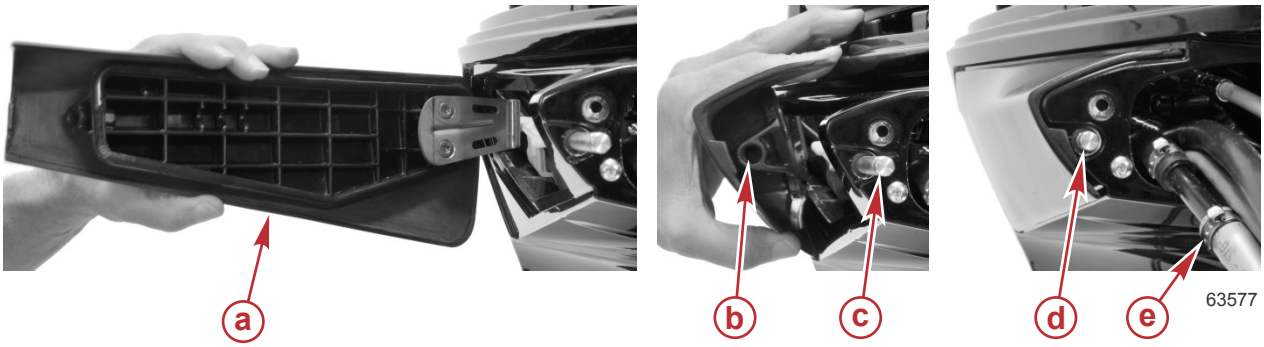
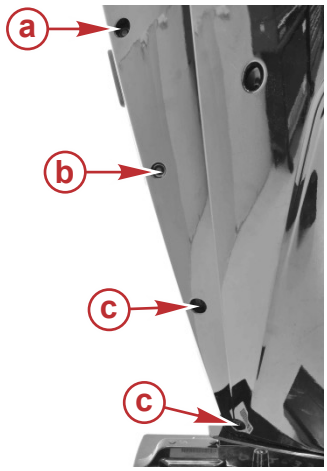
a - Rigging adapter
b - Clamp on fuel line, outside of rigging grommet

3. Remove the rigging access panel by pulling out the retaining pin and opening the panel.



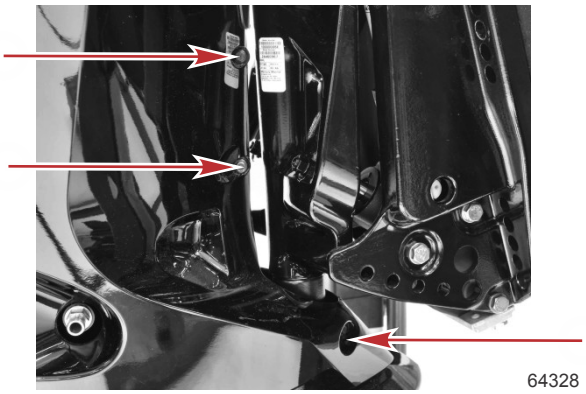
a - Rigging access panel
b - Socket in rigging access panel for retaining pin
c - Retaining pin
d - Retaining pin fully seated
e - Hose clamp on remote fuel line

4. Remove the rigging from the outboard. Refer to **Section 1D - Outboard Installation**.
5. Remove the four screws from the aft end of the starboard lower cowl.

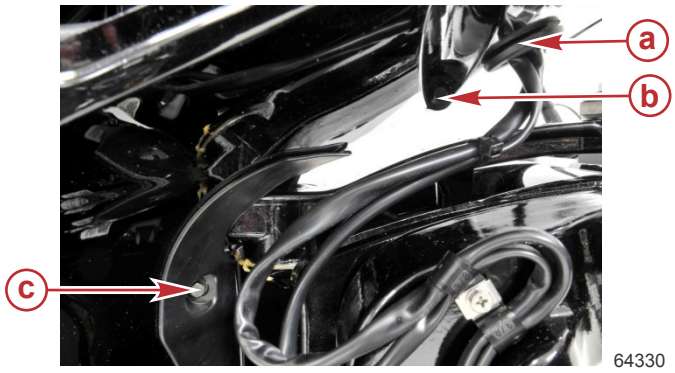


a - M6 x 40 screw
b - M6 x 85 screw
c - M6 x 25 screw (2)

6. Remove the three M6 x 25 screws from the starboard lower cowl near the transom bracket.

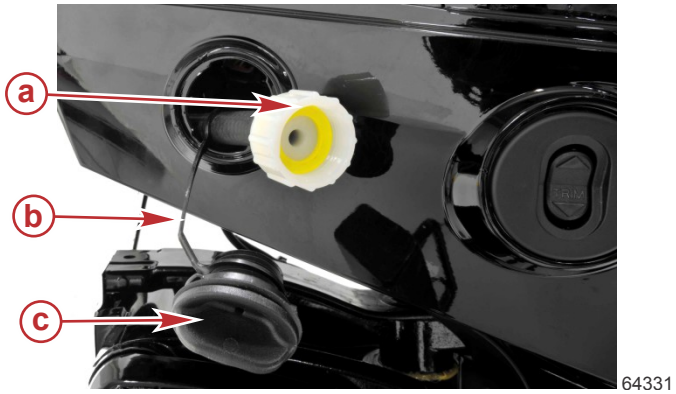


7. Remove the two remaining screws from the starboard lower cowl. Remove the remaining M6 shoulder screw from the port lower cowl.



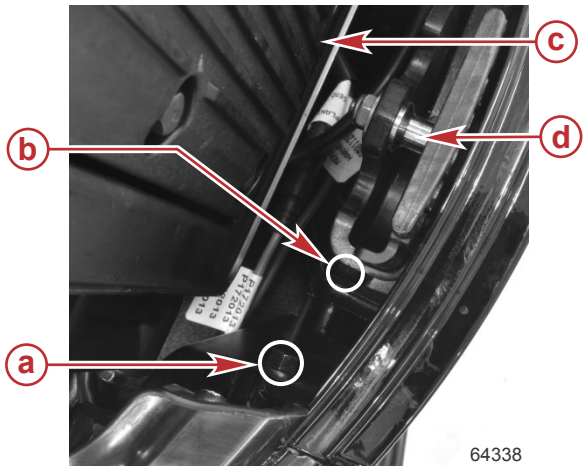
a - Grommet
b - M6 x 25 screw
c - M6 shoulder screw (one per side)

8. Remove the flush hose connector from the port lower cowl. Unscrew the cap from the tether.



a - Flush hose connector
b - Tether
c - Cap

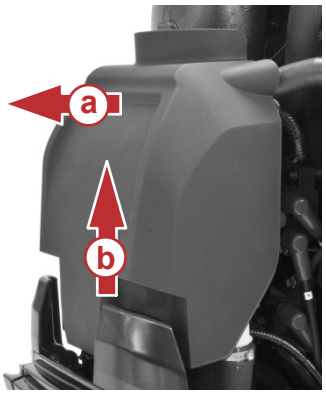
9. Push the flush hose connector into the port lower cowl.
10. Remove the two screws from the starboard lower cowl, inside the cowl near the front cowl latch. Use a socket, swivel, and long extension through the flush hose connector opening in the lower cowl to remove the screws.



a - M6 x 25 screw
b - M6 x 20 screw
c - Intake plenum
d - Front cowl latch

11. Remove the electrical panel cover.

- On V8 models, pull the top rearward until the pins are clear of the grommets, and then lift up.

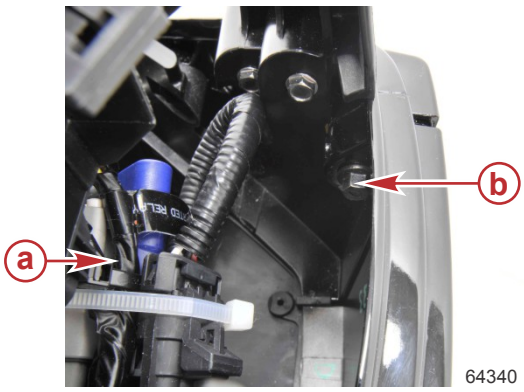


63580

V8 models
a - Pull rearward
b - Lift up

- On V6 models, pull the panel aft.

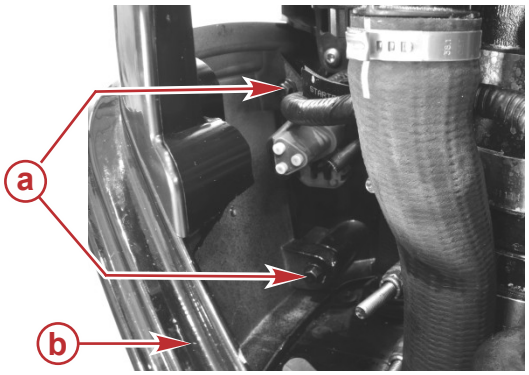
12. Remove the screw from the starboard inside aft end of the lower cowl below the electrical plate.



64340

a - Electrical plate
b - M6 x 25 screw

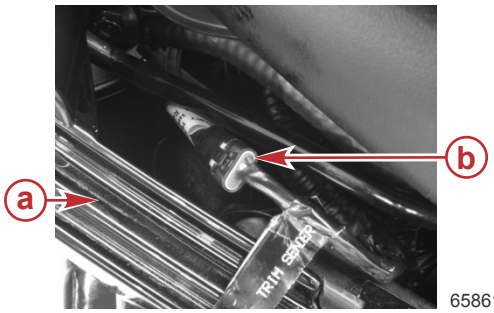
13. Remove the two M6 x 25 screws that secure the lower rear cowl panel to the port lower cowl.



67094

a - M6 x 25 screws
b - Port lower cowl

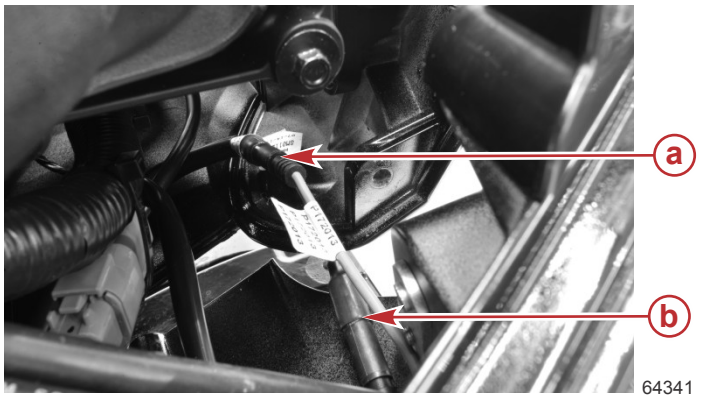
14. Disconnect the trim position sensor connector.



65861

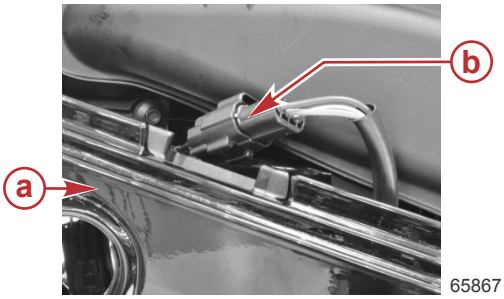
a - Port lower cowl
b - Trim position sensor connector

15. Starting from the aft end, pull the starboard lower cowl away from the outboard enough to access the power trim connectors at the front of the outboard. Disconnect the power trim connectors.



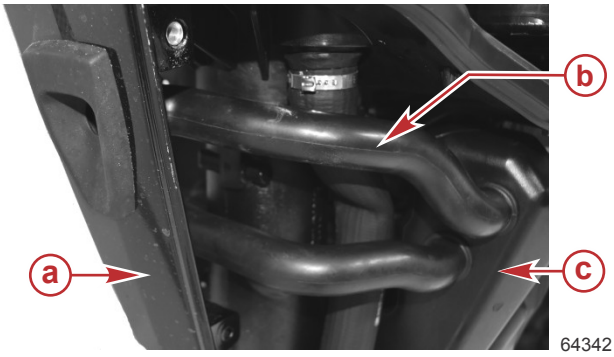
a - Trim down connector (green wire)
b - Trim up connector (blue wire)

16. Remove the starboard lower cowl from the outboard.
17. Remove the power trim grommet from the starboard lower cowl to free the power trim wires.
18. Disconnect the cowl trim switch connector from the harness.

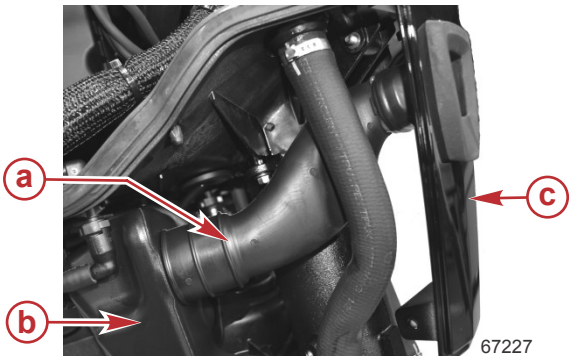


a - Port lower cowl
b - Cowl trim switch connector

19. Remove the port lower cowl.
20. If necessary, remove the lower rear cowl panel:
    a. Remove the idle exhaust hose from the idle exhaust muffler.
    b. Remove the lower rear cowl panel and idle exhaust hose as an assembly.



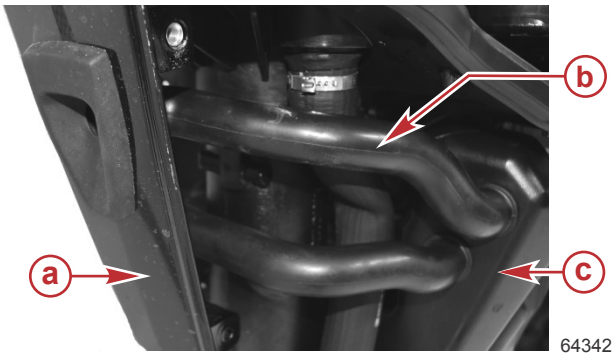
Standard models
a - Lower rear cowl panel
b - Idle exhaust hose
c - Idle exhaust muffler



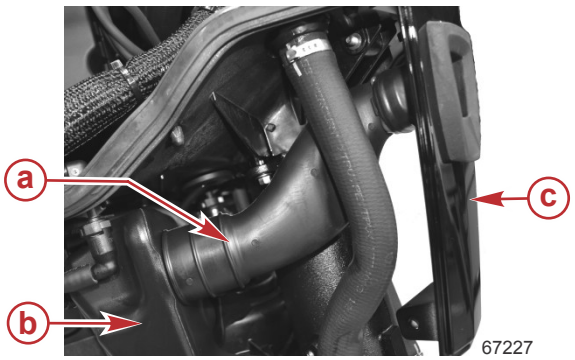
Pro XS models
a - Idle exhaust hose
b - Idle exhaust muffler
c - Lower rear cowl panel

Conventional Midsection (CMS) Lower Cowl Installation

1. Lubricate the lower cowl seal with soapy water.
2. If the lower rear cowl panel was removed:
   a. Install the lower rear cowl panel onto the chap plate seal.
   b. Connect the idle exhaust hose to the idle exhaust muffler.

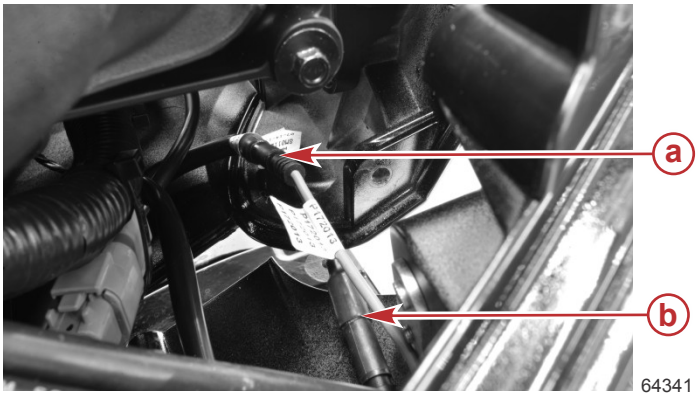


Standard models
- **a -** Lower rear cowl panel
- **b -** Idle exhaust hose
- **c -** Idle exhaust muffler



Pro XS models
- **a -** Idle exhaust hose
- **b -** Idle exhaust muffler
- **c -** Lower rear cowl panel

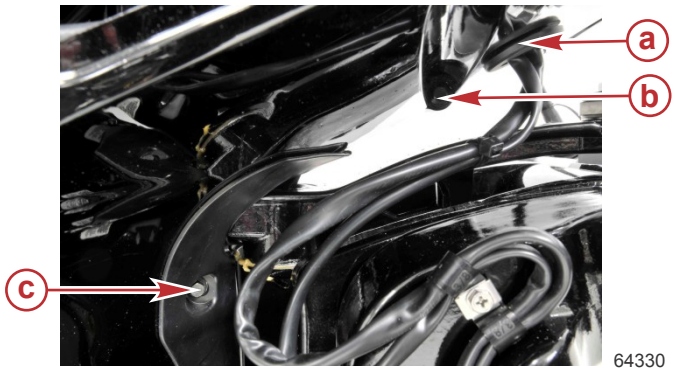
3. Install the port lower cowl onto the outboard.
4. Partially install the starboard lower cowl onto the outboard.
5. Install the power trim wiring and grommet into the starboard lower cowl.
6. Connect the power trim connectors (blue and green wires).



- **a -** Trim down connector (green wire)
- **b -** Trim up connector (blue wire)

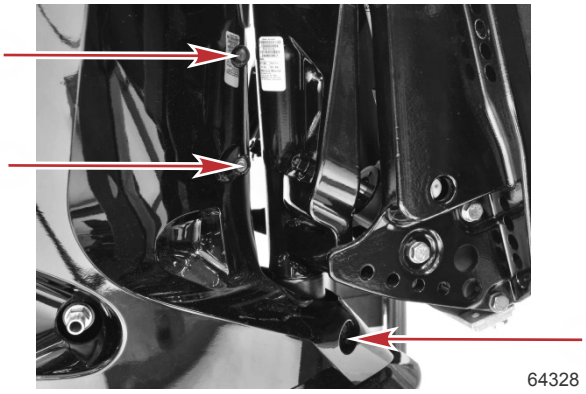
7. Push the starboard lower cowl into position.

8. Install the M6 x 25 screw in the location shown. Install one M6 shoulder screw per side in the location shown. Do not fully tighten the screws at this time.

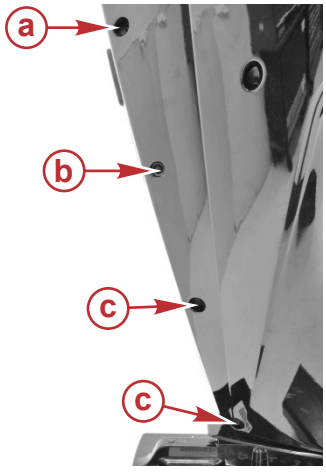


a - Grommet
b - M6 x 25 screw
c - M6 special screw (one per side)

9. Install the three M6 x 25 screws into the starboard cowl near the transom bracket. Do not fully tighten the screws at this time.



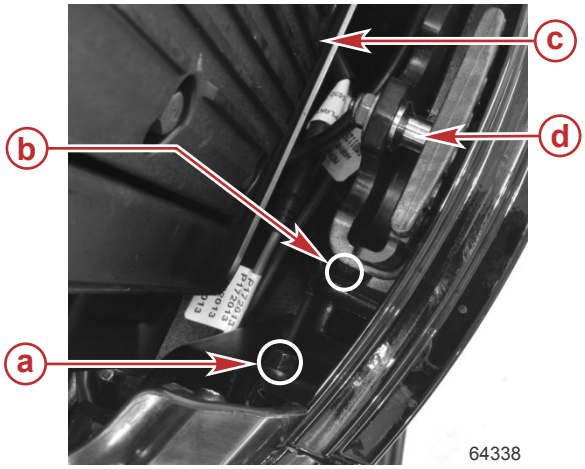
10. Install the four screws into the aft end of the starboard lower cowl. Tighten the screws to the specified torque, then tighten the screws installed in steps 8 and 9 to the specified torque.



a - M6 x 40 screw
b - M6 x 85 screw
c - M6 x 25 screw (2)

Description	Nm	lb-in.	lb-ft
M6 screws	6	53.1	–
M6 shoulder screw	6	53.1	–

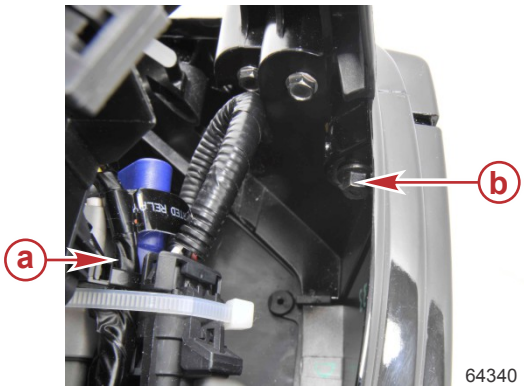
11. Install the two screws into the starboard lower cowl, inside the cowl near the front cowl latch. Use a socket, swivel, and long extension through the flush hose connector opening in the lower cowl to install the screws. Tighten the screws to the specified torque.



a - M6 x 25 screw
b - M6 x 20 screw
c - Intake plenum
d - Front cowl latch

Description	Nm	lb-in.	lb-ft
M6 screws	6	53.1	–

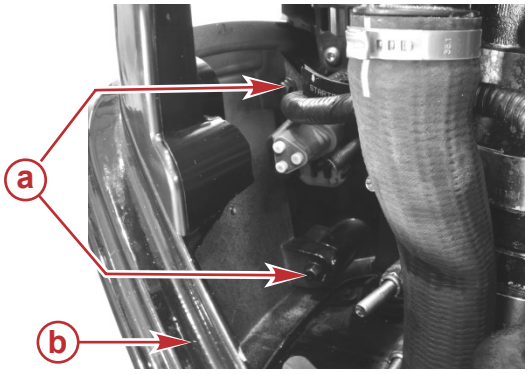
12. Install the screw into the starboard inside aft end of the lower cowl. Tighten the screw to the specified torque.



a - Electrical plate
b - M6 x 25 screw

Description	Nm	lb-in.	lb-ft
M6 x 25 screw	6	53.1	–

13. Install the two M6 x 25 screws that secure the lower rear cowl panel to the port lower cowl. Tighten the screws to the specified torque.

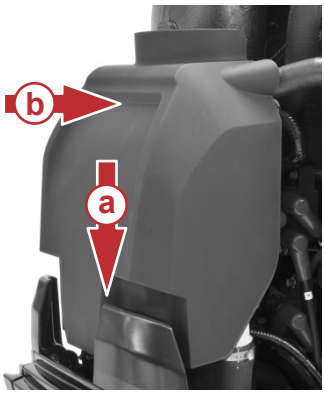


a - M6 x 25 screws
b - Port lower cowl

Description	Nm	lb-in.	lb-ft
M6 x 25 screws	6	53.1	–

14. Install the electrical panel cover.

- On V8 models, push the cover down then forward until the pins are seated in the grommets.

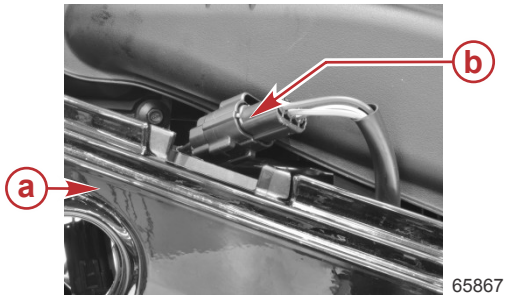


67068

a - Push down
b - Push forward

- On V6 models, push the cover forward until the pins are seated in the grommets.

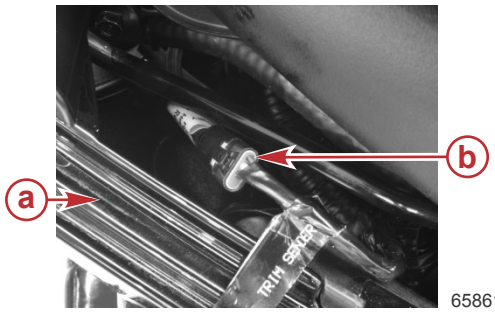
15. Connect the cowl trim switch connector to the harness. Tuck the connector and harness into the lower cowl.



65867

a - Port lower cowl
b - Cowl trim switch connector

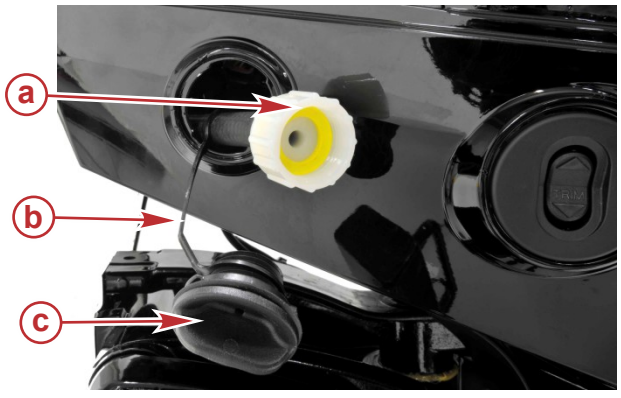
16. Connect the trim position sensor connector. Tuck the connector and harness into the lower cowl.



65861

a - Port lower cowl
b - Trim position sensor connector

17. Pull the flush hose connector through the opening in the port lower cowl. Screw the cap back onto the tether and secure the flush hose connector to the lower cowl.

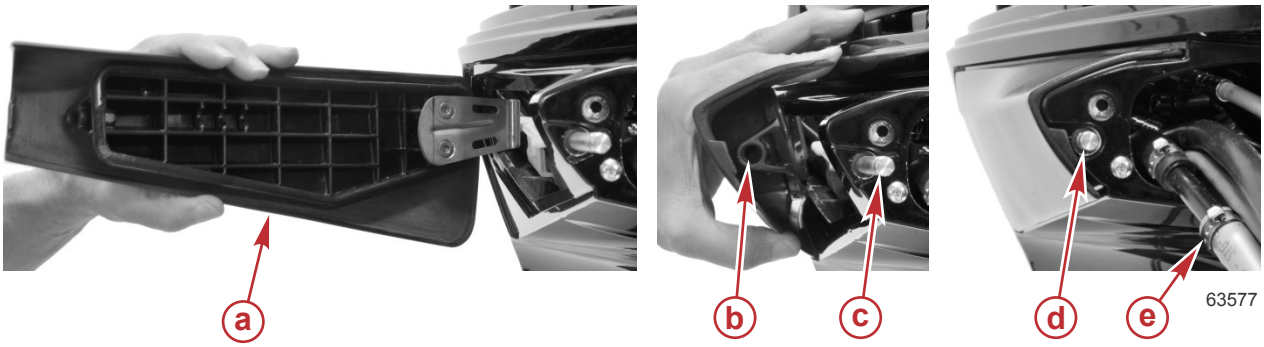


64331

a - Flush hose connector
b - Tether
c - Cap

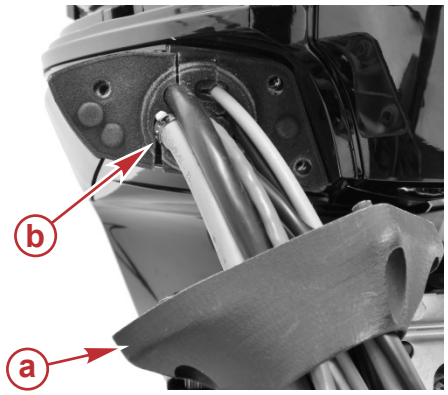
18. Install the rigging onto the outboard. Refer to **Section 1D - Outboard Installation**.

19. Close the rigging access panel and push in the retaining pin to secure the panel.



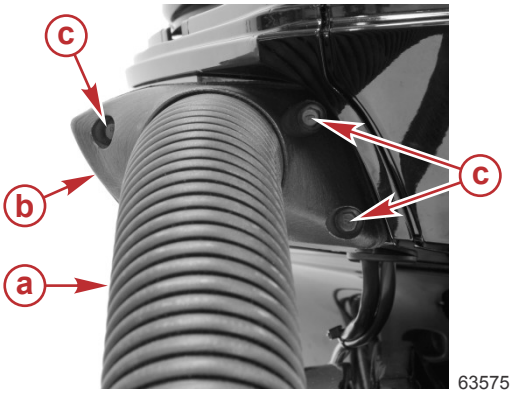
a - Rigging access panel
b - Socket in rigging access panel for retaining pin
c - Retaining pin
d - Retaining pin fully seated
e - Hose clamp on remote fuel line

20. Install the rigging grommet. Ensure that the fuel line clamp is outside of the rigging grommet.



a - Rigging adapter
b - Clamp on fuel line, outside of rigging grommet

21. Install the rigging adapter and rigging tube. Secure the rigging adapter with three M6 screws. Tighten the screws to the specified torque.



a - Rigging tube (optional)
b - Rigging adapter
c - Screws (3)

Description	Nm	lb-in.	lb-ft
M6 screws	8	70.1	–

22. If a rigging tube is not used, secure the wiring, hoses, and cables together with a cable tie.


63574

Notes:

Gear Housing

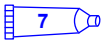
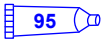
Section 6A - Right-Hand and Left-Hand Rotation (4.8 in. Diameter)

Table of Contents

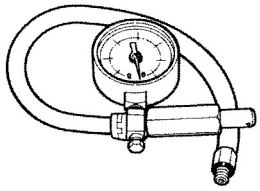
Gear Housing Specifications (4.8 in. Diameter)

Description	Specification
Gear ratio	1.85:1 (13/24 teeth)
Gearcase capacity—right-hand rotation	710 ml (24 fl oz)
Gearcase capacity—left-hand rotation	810 ml (27.4 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Pinion height	0.635 mm (0.025 in.)
Front gear backlash—right-hand rotation (forward gear)	0.482–0.660 mm (0.019–0.026 in.)
Front gear backlash—left-hand rotation (reverse gear)	1.27–1.47 mm (0.050–0.058 in.)
Rear gear backlash—right-hand rotation (reverse gear)	1.27–1.47 mm (0.050–0.058 in.)
Rear gear backlash—left-hand rotation (forward gear)	0.482–0.660 mm (0.019–0.026 in.)
Gear housing pressure (without gear lubricant, 5 minutes without leakage)	103.4 kPa (15 psi)
Propeller shaft runout	0.23 mm (0.009 in.)

Lubricants, Sealants, Adhesives

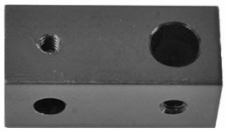
Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Shift shaft splines and driveshaft splines	8M0071842
	Loctite 271 Threadlocker	Pinion gear nut threads	92-809819
		Threads of pinion nut	
		Water pump screws	
	Bellows Adhesive	Driveshaft pinion gear washer	92-86166Q1
	High Performance Gear Lubricant	Tapered bearing cup bore	92-858064K01
		Bore that roller bearing race is pressed into	
		Bearing bore in carrier	
		Inside diameter of the driveshaft tapered bearings	
		Inside diameter of front gear	
		Front gear bearing cup bore	
		Pinion bearing bore	
		Gear housing	
	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1
		O-ring	
		Bore that roller bearing is pressed into	
		Bearing carrier O-ring	
		Shift shaft bushing threads, O-ring, and oil seal lip	
		Retainer threads	
		Bearing carrier retainer nut threads	
		Bearing carrier O-ring, forward and aft outer diameters of bearing carrier, gear housing area where carrier will seat, space between propeller shaft seals	
		Bearing carrier retainer nut threads and corresponding gear housing threads	
		Oil seal carrier oil seal lips, space between the seals, and the O-ring	
		Flat surface of impeller key	
		Inside of the water pump cover	
		Water seal coupler O-ring	

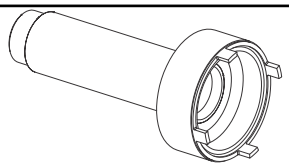
Special Tools

Leakage Tester Kit	FT8950
 29497	Used for pressure testing of closed systems (gearcase, fuel lines, cooling).

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.

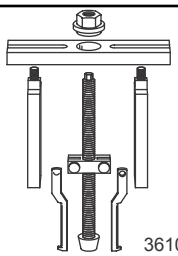
Bearing Carrier Retainer Nut Wrench	8M0057002
 46139	Installs and removes the bearing carrier retainer nut

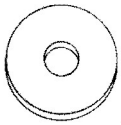
Puller Jaws Assembly	91-46086A1
 9514	Removes bearing carrier and bearing races; use with Puller Bolt (91-85716)

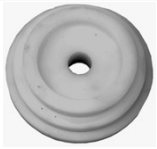
Slide Hammer	91-34569A 1
 6761	Aids in the removal of various engine components. Use with puller jaws.

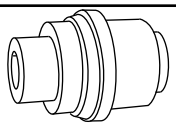
Universal Puller Plate	91-37241
 8505	Removes bearings from gears and the driveshaft

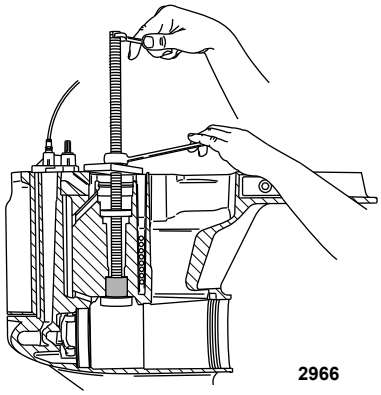
Torch Lamp	91- 63209
 8776	Heats surfaces to aid in the removal and installation of interference fit engine components.

Bearing Puller Assembly	91- 83165T
 3610	Removes bearings, races and bearing carriers

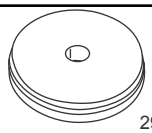
Pilot Washer	91-36571T
 29490	Used in pinion gear and pinion bearing installation

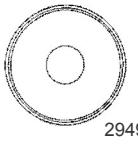
Bearing Carrier Guide Plate	91-8M0053084
 46141	Aids in the installation of bearing carrier seals and propeller shaft tapered bearing race

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
 **6229**	Installs bearing carrier cup and seals.

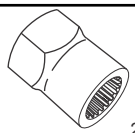
Bearing Removal and Installation Kit	91- 31229A 7
 2966	Installs and removes the bearings in all gearcases 91- 31229A 7 tool assembly includes the following components: 11- 24156 Hex Nut 12- 34961 Washer 91- 15755T Bearing Carrier 91- 29310 Plate 91- 30366T 1 Mandrel 91- 31229 Puller Shaft 91- 32325T 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- 37312T Driver Head 91- 37323 Driver Head Rod 91- 37324T Pilot Washer 91- 37350T Pilot Mandrel 91- 38628T Puller/Driver Head 91-52393T Driver Needle Bearing 91-52394 Head Pull Rod

Needle Bearing Removal Tool	91-816245
 10793	Removes the needle bearings from the back adapter of a counter rotating gearcase.

Seal Driver Guide	91-889845
 29590	Aids in the installation of bearing carrier seals.

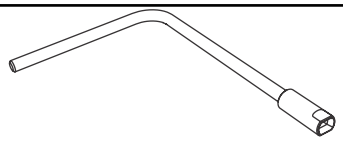
Bearing Cup Driver	91-885592T
 29492	Installs reverse gear bearing cup

Driveshaft Bearing Retainer Wrench	91-43506T
 9520	Removes and installs the threaded bearing retainer

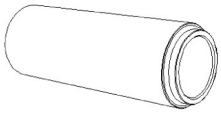
Driveshaft Holding Tool	91-889958T
 28677	Holds driveshaft during pinion nut removal on the Verado models

Propeller Shaft Holder	8M0075944
 39510	Stabilizes propeller shaft

Pinion Nut Wrench	91- 61067T03
 29501	Holds the pinion nut when removing the pinion gear and driveshaft.

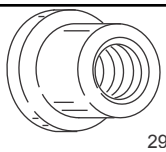
Shift Shaft Handle Tool	8M0142973
 63932	Used to rotate gear housing shift shaft. Tool ID number 8M0127025.

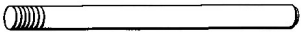
Propeller Shaft/Driveshaft Adapter	91-61077T
 10805	Provides a hex surface to turn the propeller shaft

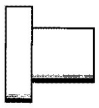
Driveshaft Bearing Installation Tool	91-8M0052590
 47416	Install upper and lower driveshaft bearings

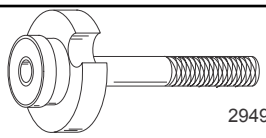
Guide Plate	91-816243
 4481	Centers the rod used to drive in the forward gear bearing on a standard rotation gearcase, and the reverse gear bearing on a counterrotation gearcase.

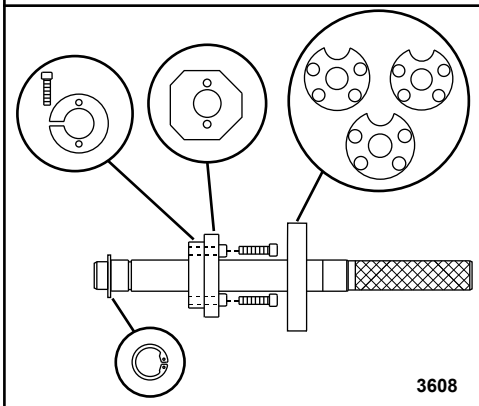
Shift Shaft Tool	8M0142969
 63663	Aids in removal or installation of the shift shaft. Tool ID number 8M0120169.

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

Puller/Driver Head	91- 38628T
 29491	Used in pinion gear and pinion bearing installation.

Pinion Gear Locating Tool	91- 56048001
 29493	Measures pinion gear height.

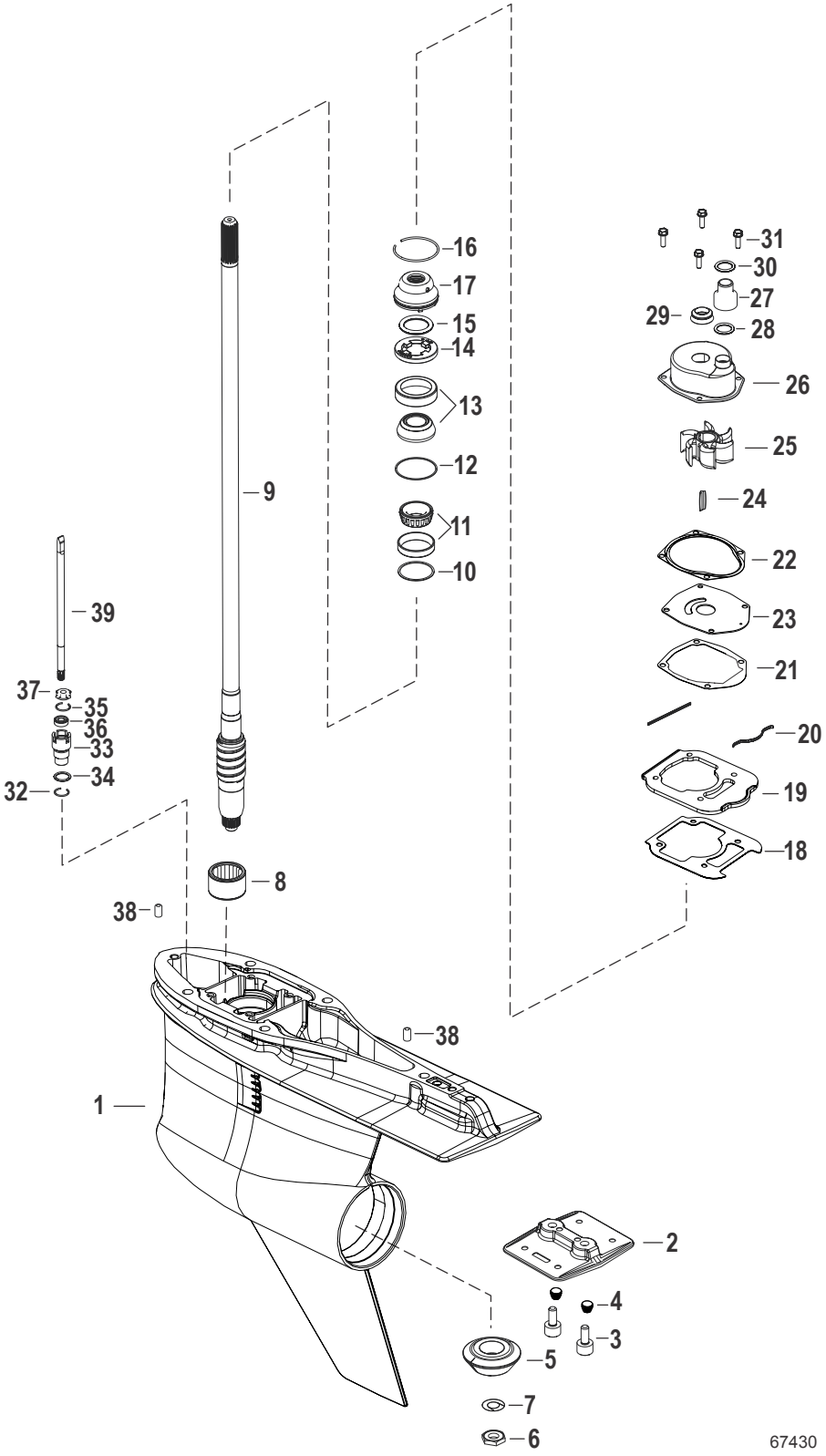
Pinion Gear Locating Tool	91- 12349A05
 3608	Measures pinion gear height.

Backlash Indicator Rod	91-8M0053505
 46158	Aids in checking gear backlash.

Driveshaft Seal Installation Tool	91-818769
 47536	Sets driveshaft seal height

Gear Housing Components

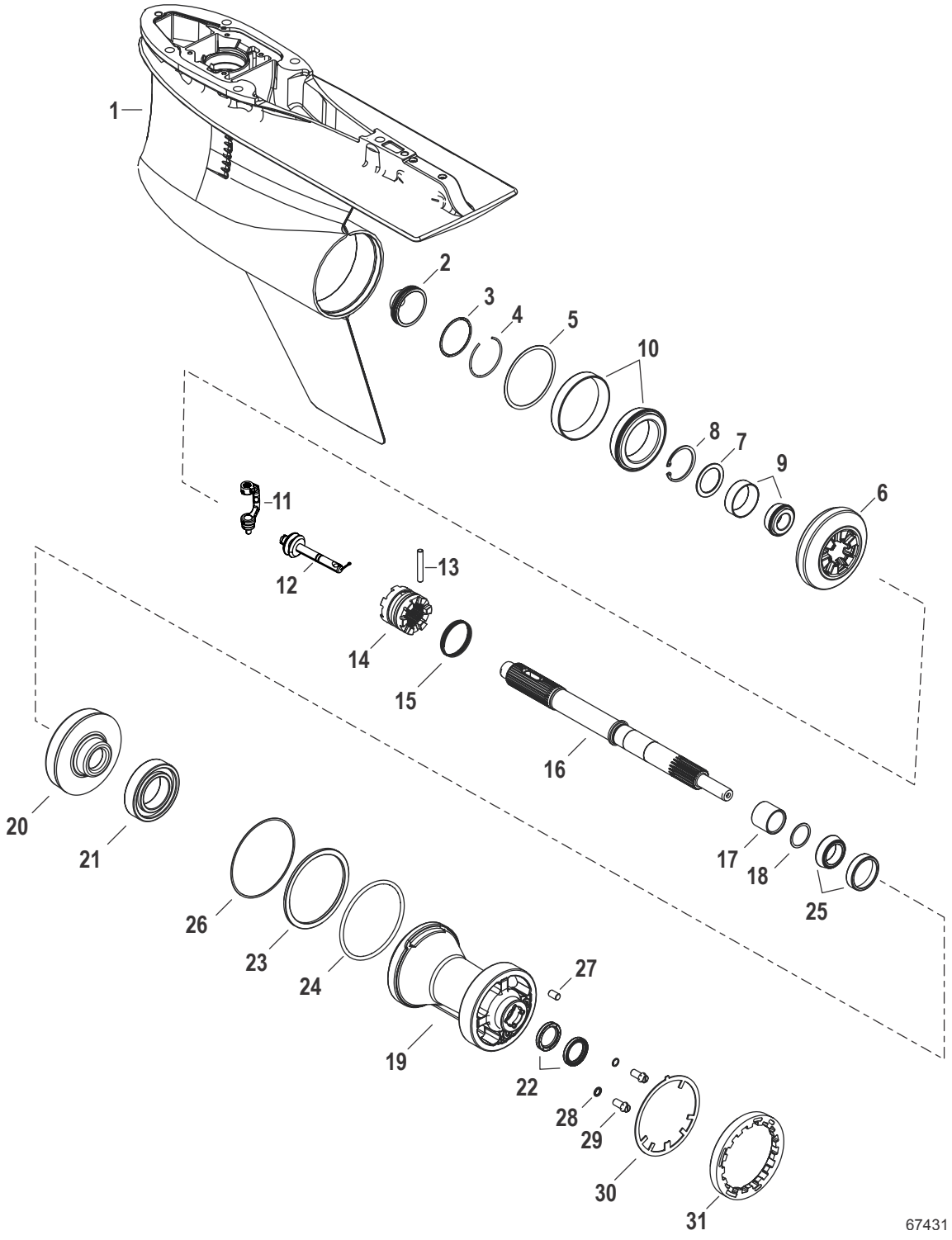
Gear Housing (4.8 in. Diameter)—Driveshaft



Gear Housing (4.8 in. Diameter)—Driveshaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing assembly			
2	1	Anode			
3	2	Screw	54.23	–	40
4	2	Plug			
5	1	Pinion gear			
6	1	Pinion nut	101.7	–	75
7	1	Pinion washer			
8	1	Bearing assembly			
9	1	Driveshaft			
10	1	Shim			
11	1	Bearing assembly			
12	1	Shim			
13	1	Bearing assembly			
14	1	Retainer	135.5	–	100
15	1	O-ring			
16	1	Retaining ring			
17	1	Oil seal assembly			
18	1	Gasket			
19	1	Top cover			
20	2	Seal			
21	1	Rubber-coated stainless steel gasket			
22	1	Beaded gasket			
23	1	Faceplate			
24	1	Key			
25	1	Impeller			
26	1	Water pump housing			
27	1	Water pump coupler			
28	1	O-ring			
29	1	Face seal			
30	1	O-ring			
31	4	Screw	6.8	60	–
32	1	Retaining ring			
33	1	Shift shaft bushing	54.2	–	40
34	1	O-ring			
35	1	Retaining ring			
36	1	Oil seal			
37	1	Rubber grommet			
38	2	Dowel pin			
39	1	Shift shaft—XL shown			

Gear Housing (4.8 in. Diameter, Right-Hand Rotation)—Propeller Shaft

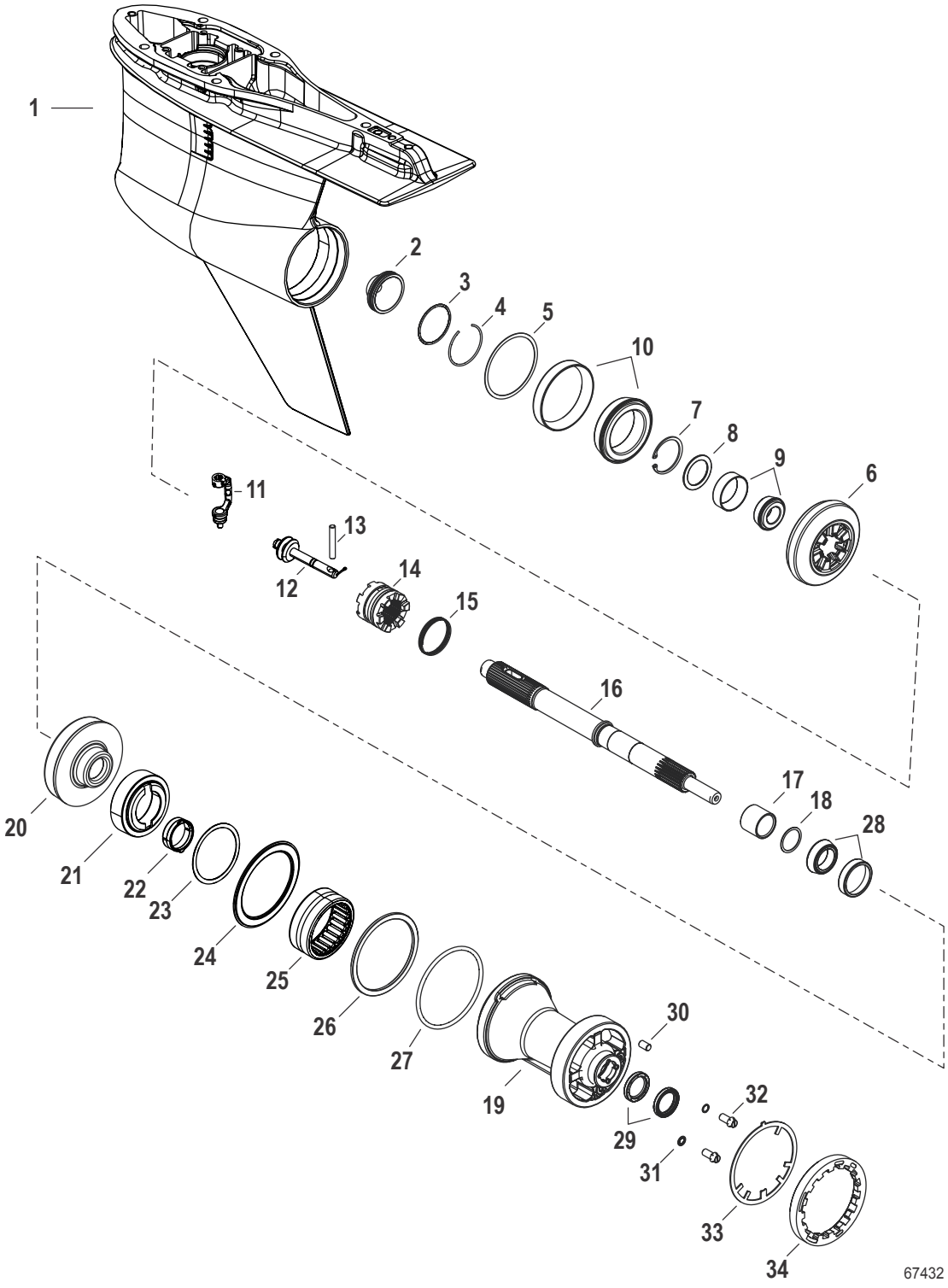


Gear Housing (4.8 in. Diameter, Right-Hand Rotation)—Propeller Shaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing assembly			
2	1	Torpedo plug			
3	1	O-ring			
4	1	Retaining ring			
5	1	Shim			
6	1	Front (forward) gear			
7	1	Thrust washer			
8	1	Retaining ring			
9	1	Tapered roller bearing			
10	1	Tapered roller bearing			
11	1	Shift crank			
12	1	Spool			
13	1	Pin			
14	1	Clutch			
15	1	Spring			
16	1	Propeller shaft			
17	1	Spacer			
18	1	Washer			
19	1	Bearing carrier			
20	1	Rear (reverse) gear			
21	1	Bearing			
22	2	Oil seal			
23	1	Thrust ring			
24	1	O-ring			
25	1	Bearing assembly			
26	1	Shim			
27	1	Pin			
28	2	Seal			
29	2	Fill and vent plugs	11.3	100	–
30	1	Tab washer			
31	1	Bearing carrier 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).

Gear Housing (4.8 in. Diameter, Left-Hand Rotation)—Propeller Shaft



Gear Housing (4.8 in. Diameter, Left-Hand Rotation)—Propeller Shaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing assembly			
2	1	Torpedo plug			
3	1	O-ring			
4	1	Retaining ring			
5	1	Shim			
6	1	Front (reverse) gear			
7	1	Retaining ring			
8	1	Thrust washer			
9	1	Tapered roller bearing assembly			
10	1	Tapered roller bearing assembly			
11	1	Shift crank			
12	1	Spool			
13	1	Pin			
14	1	Clutch			
15	1	Spring			
16	1	Propeller shaft			
17	1	Spacer			
18	1	Washer			
19	1	Bearing carrier			
20	1	Rear (forward) gear			
21	1	Forward gear bearing adapter			
22	1	Gear adapter			
23	1	Shim			
24	1	Thrust bearing			
25	1	Needle bearing assembly			
26	1	Thrust ring			
27	1	O-ring			
28	1	Bearing assembly			
29	2	Oil seal			
30	1	Pin			
31	2	Seal			
32	2	Fill and vent plugs	11.3	100	–
33	1	Tab washer			
34	1	Bearing carrier 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).

General Service Recommendations

There may be more than one way to disassemble or reassemble a particular part. It is recommended that the entire procedure be read prior to repair.

IMPORTANT: Read the following before attempting any repairs.

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 that the sequence be followed without deviation to assure proper repairs. When performing partial repairs, follow the instructions to the point where the desired component can be replaced, then proceed to reassembly and installation of that component in the reassembly part of this section. Use the **Table of Contents** to find the correct page number.

Threaded parts are right-hand (RH), unless otherwise indicated.

When holding, pressing, or driving is required, use soft metal vise jaw protectors or wood for protection of parts. Use a suitable mandrel 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 the bearings with solvent and dry with compressed air. Air should be directed at the bearing so that it passes through the bearing. Do not spin the bearing with compressed air, as this may cause the bearing to score from lack of lubrication. After cleaning, lubricate the bearings with High Performance Gear Lubricant. Do not lubricate the tapered roller bearing cups until after inspection.

Inspect all bearings for roughness, catches, and bearing race side wear. Work the inner bearing race in and out, while holding the outer race, to check for side wear.

When inspecting the tapered roller bearings, determine the condition of the rollers and the inner bearing race by inspecting the bearing cup for pits, scoring, grooves, uneven wear, imbedded particles, and/or discoloration from overheating. Always replace the tapered roller bearing cone and cup as a set.

Inspect the gear housing for bearing races that have spun in their respective bores. If the race has spun, the gear housing must be replaced.

Roller bearing condition is determined by inspecting the bearing surface of the shaft that the roller bearing supports. Check the shaft surface for pits, scoring, grooves, embedded particles, uneven wear, and/or discoloration from overheating. The shaft and bearing must be replaced if the conditions described are found.

Shims

Keep a record of all shim amounts and their location during disassembly to aid in reassembly. Be sure to follow the shimming instructions during reassembly, as gears must be installed to the correct depth and have the correct amount of backlash to avoid noisy operation and premature gear failure.

Seals

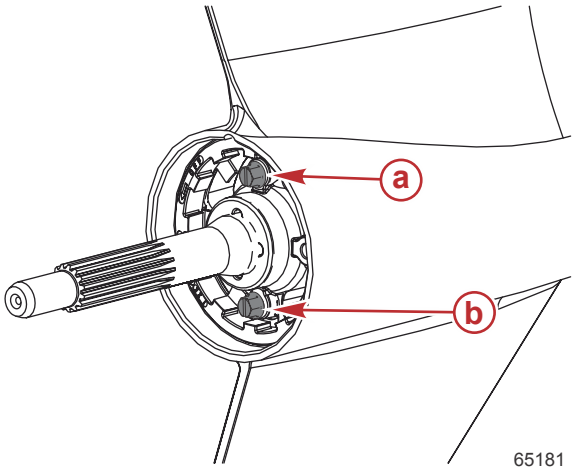
As a normal procedure, all O-rings and oil seals should be replaced without regard to appearance. To prevent leakage around oil seals, apply Loctite 271 Threadlocker to the outer diameter of all metal case oil seals. When using Loctite on seals or threads, the surfaces must be clean and dry. To ease installation, apply 2-4-C with PTFE on all O-rings. To prevent wear, apply 2-4-C with PTFE on the I.D. of oil seals.

Gearcase Serviceability Inspection

Draining and Inspecting Gear Housing Lubricant

1. Place the gear housing in a suitable holding fixture or vise with the driveshaft in a vertical position.

2. Position a clean drain pan under the gear housing and remove the plugs from the gear housing with a 10 mm socket or slot screwdriver.

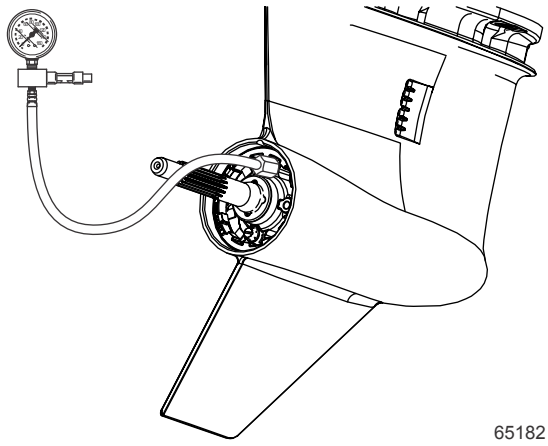


a - Vent plug
b - Fill/drain plug

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

Gear Housing Pressure Test

1. Tilt the engine up approximately 20° to prevent residual oil from coming out of the vent hole.
2. Remove the vent plug and install the pressure test gauge.



3. Pressurize the housing and observe the gauge for 15 minutes.
4. Rotate the driveshaft, propeller shaft, and shift shaft while the housing is pressurized to check for leaks.
5. If pressure drop is noted, immerse the housing in water.
6. Repressurize and check for air bubbles.
7. Replace the leaking seals, as necessary. Retest the housing after seal replacement.

Gear Housing Test Pressure	
Applied air pressure	103.4 kPa (15 psi)
Length of time	15 minutes

Leakage Tester Kit	FT8950

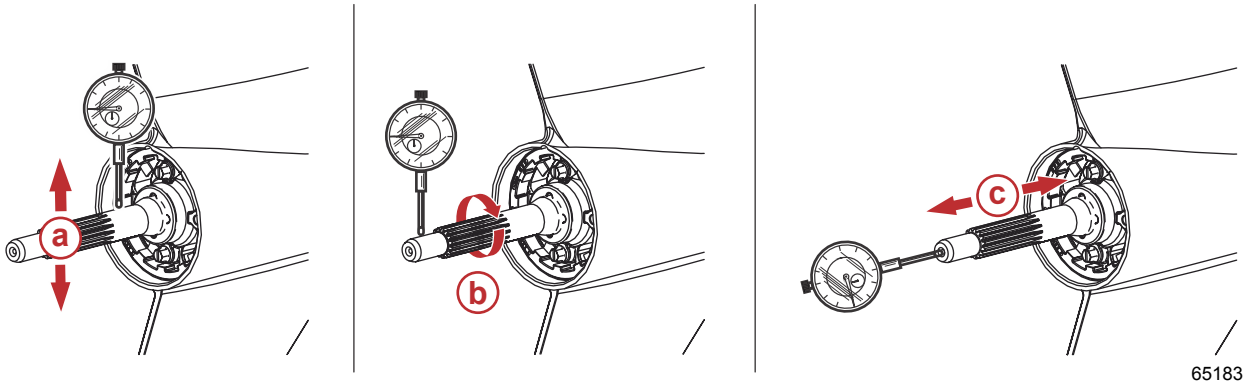
8. If air bubbles are noticed from the water inlet holes at the front of the torpedo, the gear housing must be replaced.
9. Remove the tester from the housing and install the vent plug and sealing washer.

Propeller Shaft Inspection

1. Inspect the propeller shaft for up and down movement, as follows:
   a. Position the dial indicator on the propeller shaft, just forward of the splines, as shown in the following illustration.
   b. Push the propeller shaft down and zero the dial indicator.
   c. Move the propeller shaft up while observing the dial indicator.
   d. A shaft deflection of more than 0.08 mm (0.003 in.) indicates a worn propeller shaft bearing.

Dial Indicator	91- 58222A 1
Dial Indicator Adapter	91-83155
Dial Indicator Holding Tool	91- 89897

2. Check for a bent propeller shaft as follows:
   a. Reposition the dial indicator to the threaded end of the propeller shaft. Rotate the propeller shaft while observing the dial indicator.
   b. If the deflection is more than 0.23 mm (0.009 in.), the propeller shaft is bent and should be replaced.
3. 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 - Check propeller shaft deflection
b - Check for bent propeller shaft
c - Check propeller shaft end play

Gear Housing Removal

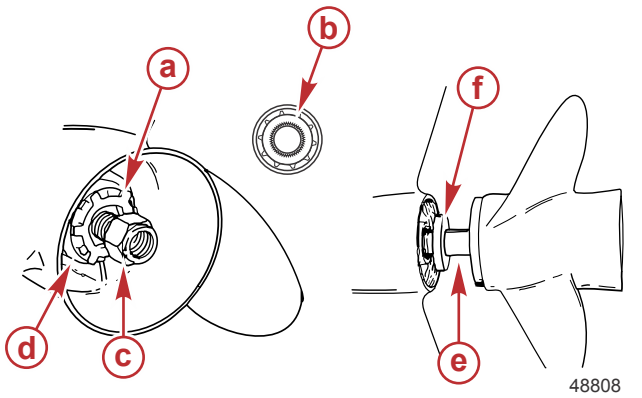
⚠ WARNING

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.

NOTE: *It is not necessary to drain the oil sump when removing the gearcase.*

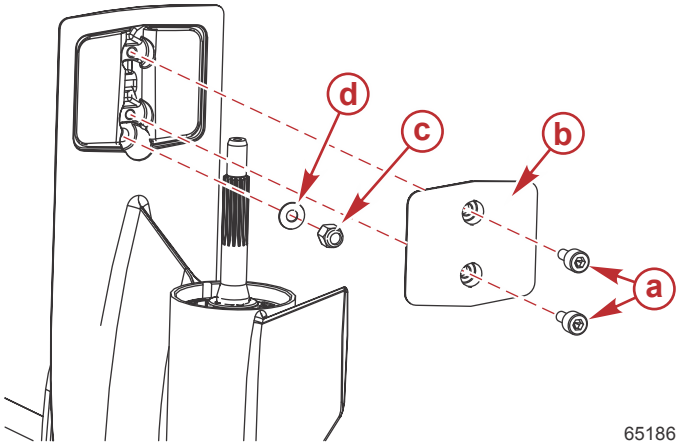
1. Tilt the outboard to the trailer full up position and engage the tilt lock lever.

2. Bend the tabs of the propeller tab washer away from the rear thrust hub. Remove the propeller locknut, tab washer, rear thrust hub, propeller, and forward thrust washer from the propeller shaft.



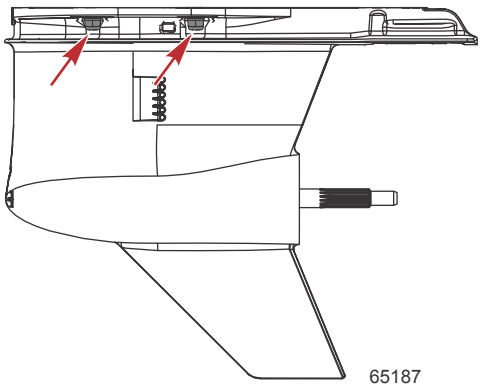
a - Tab washer
b - Continuity washer (if equipped)
c - Propeller locknut
d - Rear thrust hub
e - Propeller shaft
f - Forward thrust washer

3. Using a 10 mm hex, remove the screws securing the anode plate to the gear housing, and remove the anode plate. After the anode plate is removed, remove the nut and washer from inside the cavity.



a - Anode plate screws
b - Anode plate
c - Nut
d - Washer

4. Loosen the side mounting locknuts; two on each side. Do not attempt to remove one locknut before the opposite side is loosened sufficiently or the gear housing could be damaged.



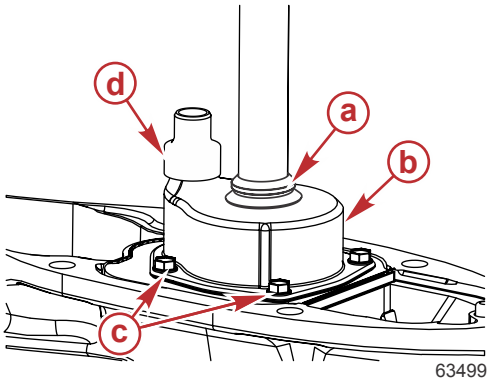
IMPORTANT: The long shaft model is shown. The XL and XXL models use a driveshaft spacer which will come off with the gear housing. Be careful not to drop or lose the driveshaft spacer on these models.

5. Pull the gear housing away from the driveshaft housing as far as the loosened locknuts will allow, then remove the loosened lcoknuts. Do not allow the gear housing to fall, as it is now free.
6. Pull the gear housing from the driveshaft housing.

Water Pump

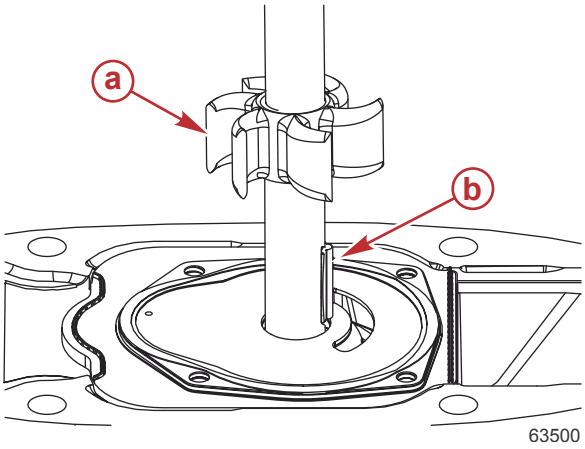
Removal and Disassembly

1. Remove the driveshaft seal, water pump screws, and the water seal coupler.



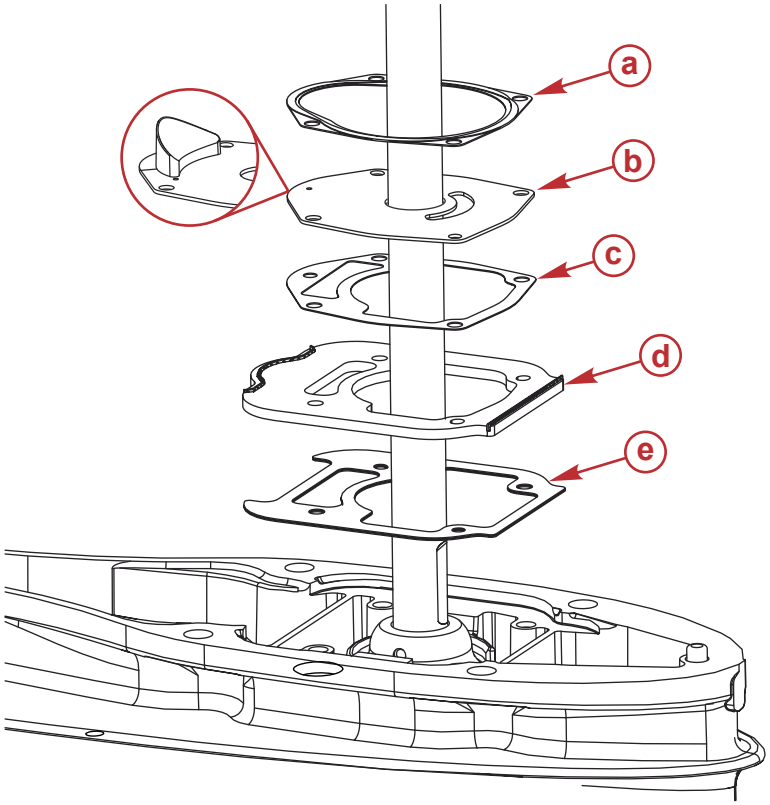
a - Driveshaft seal
b - Water pump cover
c - Screws (two each side)
d - Water seal coupler

2. Lift the water pump cover straight up and off the driveshaft.
3. Remove the impeller and impeller key.



a - Impeller
b - Impeller key

4. Remove the top beaded gasket, faceplate, rubber-coated stainless steel gasket, top cover, and the lower gasket by lifting straight up and off of the driveshaft.



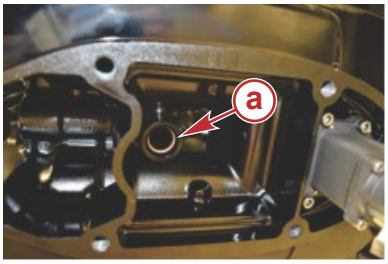
a - Beaded gasket
b - Faceplate

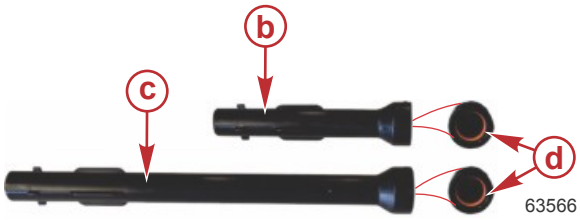
NOTE: *Early models were equipped with a faceplate deflector. The deflector is no longer required.*

c - Rubber-coated stainless steel gasket
d - Top cover
e - Gasket

Cleaning and Inspection

1. With the gear housing removed, inspect the water tube O-ring inside the driveshaft housing for wear or damage. On XL and XXL gearcases, be sure to check the O-ring in the water tube extension. Replace worn or damaged components.





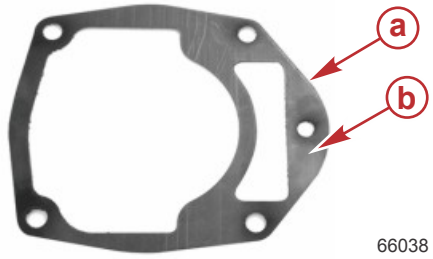
a - Water tube
b - XL water tube extension
c - XXL water tube extension
d - O-ring inside extensions

2. Inspect the water seal coupler and O-ring for wear or damage. Replace worn or damaged parts.

a - Water seal coupler
b - O-ring

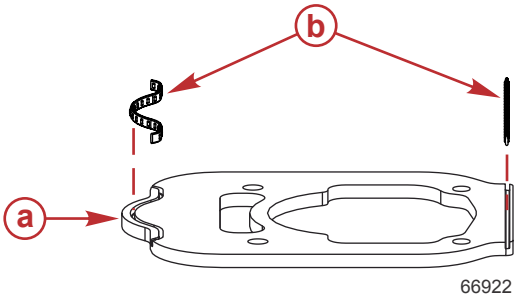
3. Inspect the faceplate and water pump liner for grooves or rough surfaces.
IMPORTANT: The circular groove on the faceplate, formed by the impeller, will not affect water pump output.

4. Inspect all gaskets for damage and replace as required. Inspect the coated surface on the stainless steel gasket for scratches or damage. If the coating is scratched or damaged, replace the stainless steel gasket.



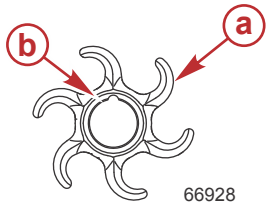
a - Stainless steel gasket
b - Coating

5. Inspect the top cover seals. Replace worn, damaged, or missing seals.



a - Top cover
b - Top cover seals (2)

6. Inspect the impeller seal surfaces and ends of the impeller blades for cracks, tears, and wear. Replace the impeller if any of these conditions are found.
7. Inspect the impeller hub for cracks, and ensure that the impeller is bonded to the hub.



a - Impeller
b - Hub

8. Inspect the impeller for a glazed or melted appearance, caused by operation without sufficient water supply. Replace the impeller if any of these conditions exist.

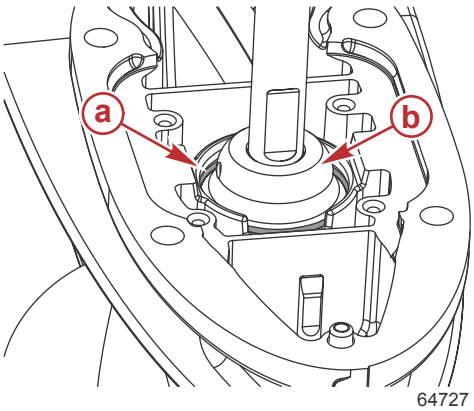
   IMPORTANT: When completing gear housing repairs that require removal of the water pump impeller, it is recommended the impeller be replaced. However, if the impeller must be used, do not install in reverse to original rotation; premature impeller failure will occur.

Oil Seal Carrier

Removal

NOTE: *Push down on the oil seal carrier to aid in the removal of the retaining ring above the oil seal carrier.*

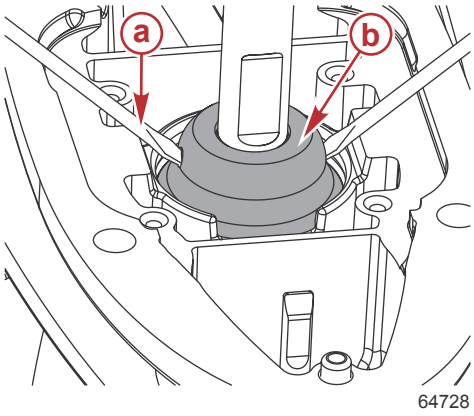
1. While pushing down on the oil seal carrier, use a flat tip screwdriver to aid in the removal of the retaining ring above the oil seal carrier.



a - Retaining ring
b - Oil 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.

   NOTE: *When prying the oil seal carrier up, avoid contact with the painted surface of the gear housing, or protect the painted surface where the tools may contact the gear housing. This will prevent paint damage that could result in future corrosion.*



a - Screwdrivers
b - Oil seal carrier

Disassembly

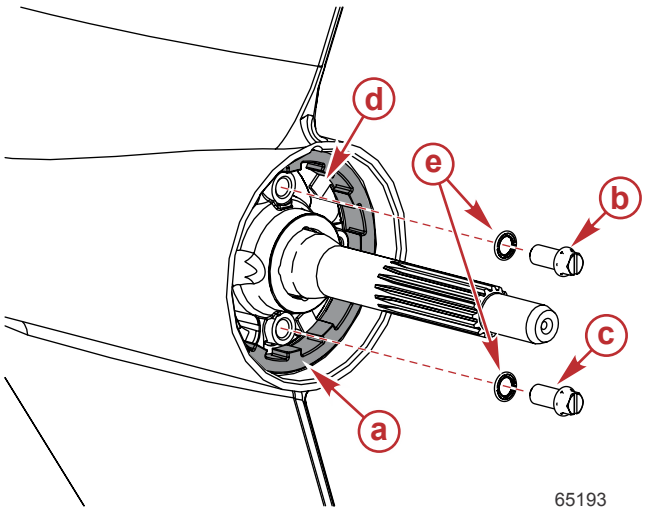
NOTE: *The oil seals within the oil seal carrier are not individually replaceable. If the oil seals require replacement, the oil seal carrier must be replaced as an assembly.*

Bearing Carrier

Bearing Carrier Removal

1. Straighten the tab on the tab washer that is bent into the bearing carrier retainer.

   NOTE: *The vent and fill/drain plugs in the bearing carrier may have to be removed before using the bearing carrier retainer nut wrench to remove the bearing carrier retainer.*

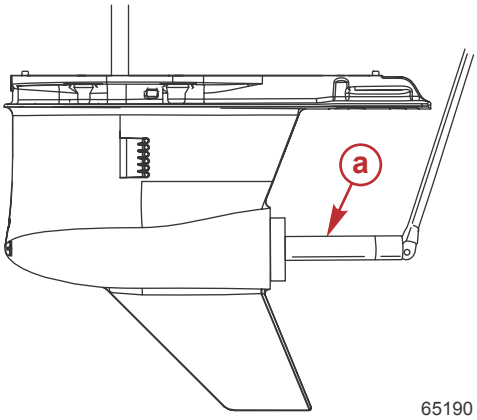


a - Bearing carrier retainer
b - Vent plug
c - Fill/drain plug
d - Lock tab on tab washer
e - Fill/drain and vent plug seals

2. Remove the bearing carrier retainer following step "a" or "b," as follows:

   IMPORTANT: Drilling into the bearing carrier retainer can potentially damage the gear housing. Ensure that you do not drill into the gear housing when removing a seized retainer.

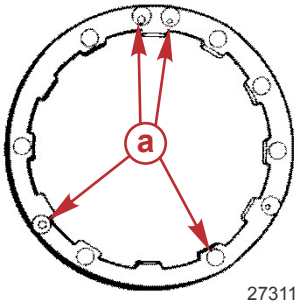
a. Remove the bearing carrier retainer by turning the retainer counterclockwise using a bearing carrier retainer nut wrench.



a - Bearing carrier retainer nut wrench

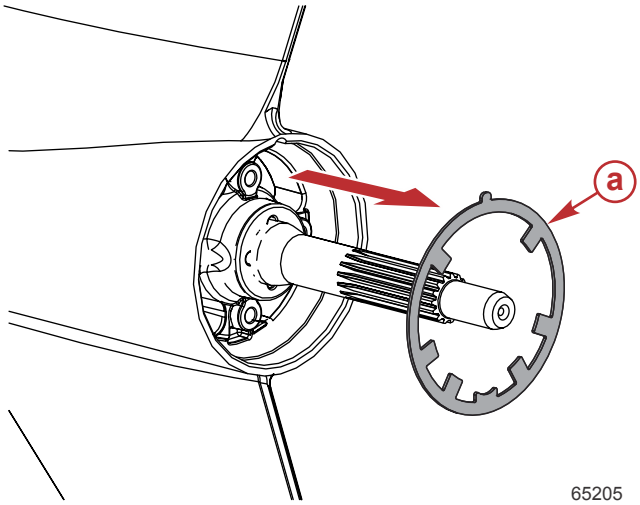
Bearing Carrier Retainer Nut Wrench	8M0057002

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

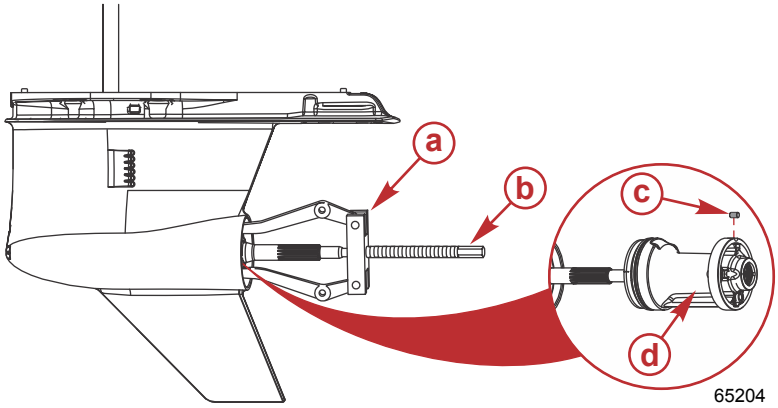
3. Remove the tab washer.



a - Tab washer

4. Pull the bearing carrier from the gear housing by pulling on the outer ring of the bearing carrier. Position the puller jaws close to the bosses in the carrier. The locating pin will likely come out with the bearing carrier. Be careful not to lose the locating pin.

NOTE: *If the bearing carrier is seized in the gear housing, it may be necessary to use heat to loosen the carrier.*

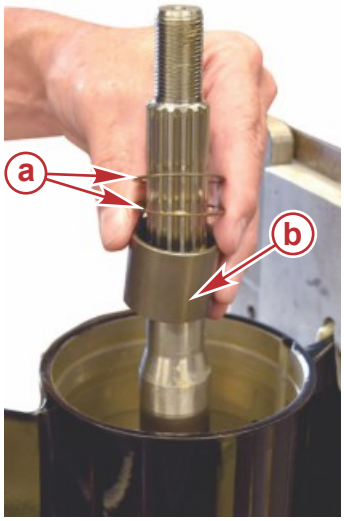


- **a -** Puller jaws assembly
- **b -** Puller bolt
- **c -** Locating pin
- **d -** Bearing carrier

Puller Jaws Assembly	91-46086A1

5. Remove the propeller shaft spacer and shims.

NOTE: *The shims may stick to the bearing carrier when pulling it out. Check the bearing carrier if no shims are found on the propeller shaft.*



- **a -** Propeller shaft shims
- **b -** Propeller shaft spacer

Right-Hand Rotation Bearing Carrier—Inspection, Disassembly, Assembly

Inspection

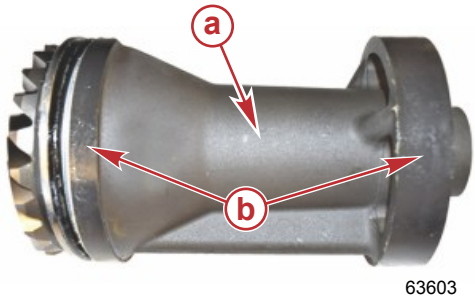
IMPORTANT: All seals and O-rings should be replaced to assure effective repair.

⚠ 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.

1. Clean the bearing carrier with solvent and dry 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.

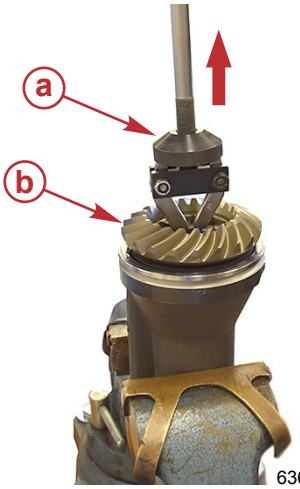


63603

a - Bearing carrier
b - Inspect for corrosion

3. Secure the bearing carrier assembly in a vise and use a slide hammer with puller jaws to remove the rear gear.

NOTE: *The rear gear ball bearing may come out while removing the rear gear. Do not separate the gear from the bearing at this time.*



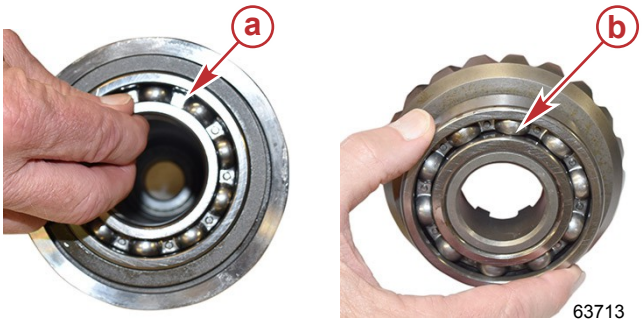
63615

a - Slide hammer with puller jaws
b - Rear gear

Slide Hammer	91-34569A 1

4. Inspect the remaining bearing carrier components as follows.
   a. Inspect the rear gear ball bearing. Rotate the bearing while checking for rough spots or catches. Push in and pull out on the rear gear to check for bearing side wear. Replace the bearing if any of these conditions exist.

   NOTE: *The ball bearing may have come out with the rear gear when removed in the previous step.*



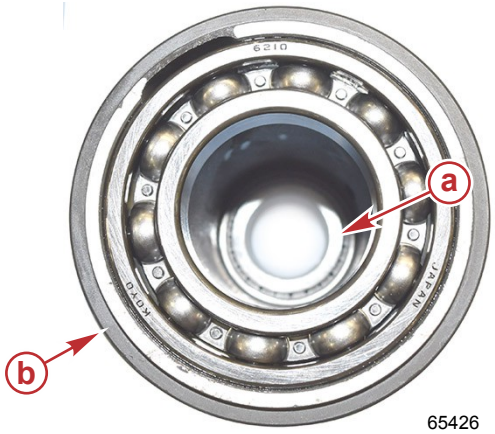
63713

a - Rear gear ball bearing—shown in bearing carrier
b - Rear gear ball bearing—shown on rear gear

   b. Inspect the aft propeller shaft tapered bearing cone and cup for pits, scoring, discoloration, or excessive looseness.

   NOTE: *The tapered bearing cone can be removed from the bearing carrier for inspection. Refer to* ***Disassembly*** *for removal of the bearing cup.*

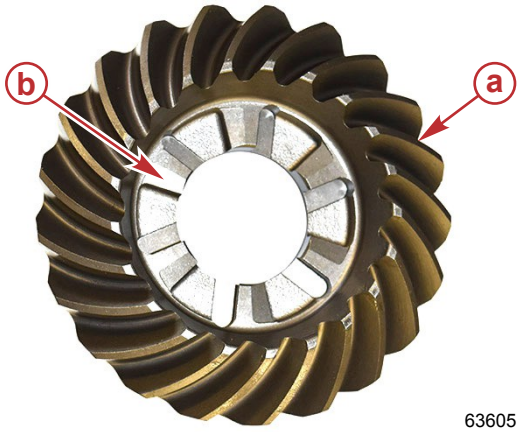
c. Inspect the bearing carrier oil seals.



65426

a - Tapered roller bearing cone (cup hidden under bearing)
b - Bearing carrier (rear gear removed)

5. Inspect the rear gear to pinion gear wear pattern. It should be even and smooth. If not, replace the rear gear, pinion gear, and front gear.
6. Inspect the rear gear for hairline fractures. Replace the rear gear and the pinion gear if any fractures are found. If extensive damage is observed, such as chips, spalling, or broken teeth, replace all gears.
7. Check the clutch jaws on the rear gear for damage. Replace the rear gear if damage is found on the clutch jaws.



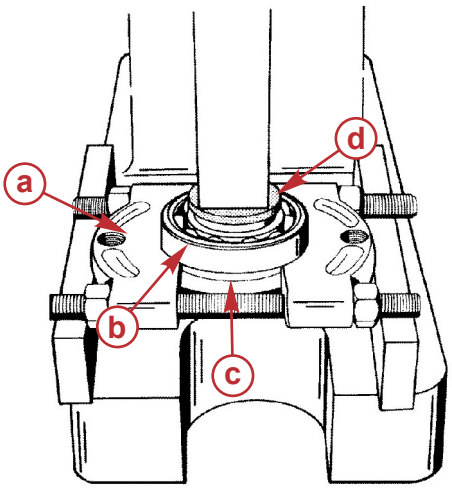
63605

a - Rear gear
b - Clutch jaws

8. Do not proceed with disassembly unless the inspected parts require replacement.

Disassembly

1. If the rear gear ball bearing is still attached to the rear gear, use a suitable mandrel and universal puller plate to support the bearing, then press the bearing from the rear gear as shown.



28472

a - Universal puller plate
b - Bearing
c - Gear
d - Mandrel

Universal Puller Plate	91-37241

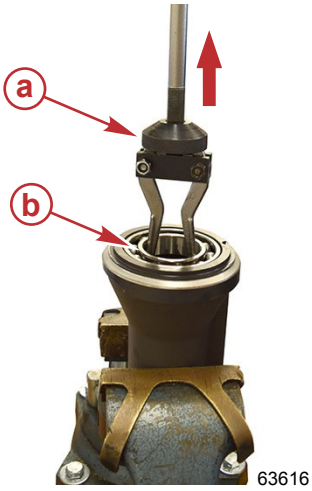
2. Remove the thrust ring. Remove and discard the O-ring.

a - Bearing carrier
b - O-ring
c - Thrust ring

NOTE: *If the rear gear ball bearing is already removed from the bearing carrier, proceed to step 5.*

3. Use the slide hammer with puller jaws to remove the ball bearing from the bearing carrier.

NOTE: *It may be necessary to use a torch lamp to heat the bearing carrier area surrounding the ball bearing.*



a - Slide hammer with puller jaws
b - Ball bearing

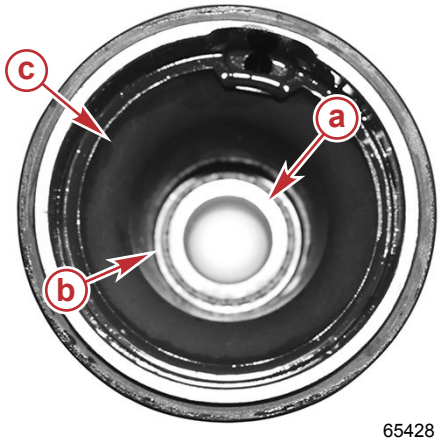
Torch Lamp	91- 63209
Slide Hammer	91-34569A 1

4. Inspect the ball bearing after removal from the bearing carrier.
5. Remove the oil blocker plate from inside the bearing carrier, if equipped.

NOTE: *Some early models are equipped with the oil blocker plate; it is not required on later models.*

a - Bearing carrier
b - Oil blocker plate

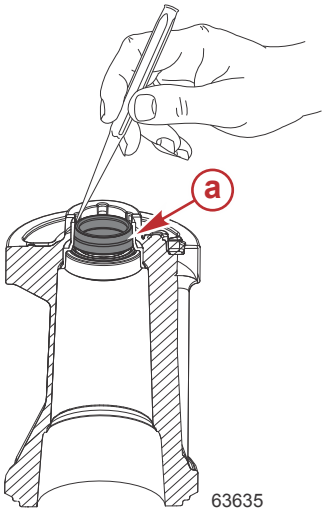
6. Replace the tapered bearing cone and bearing cup inside of the bearing carrier, if required.



65428

a - Tapered bearing cone
b - Bearing cup
c - Bearing carrier

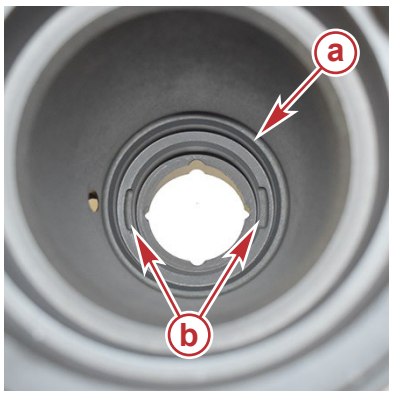
7. If damaged, replace the tapered bearing cup and bearing carrier seals as follows.
   a. **If replacing the seals only:** Remove the oil seals with a suitable punch, being careful not to damage the bore of the bearing carrier. Discard the seals.



63635

a - Seals

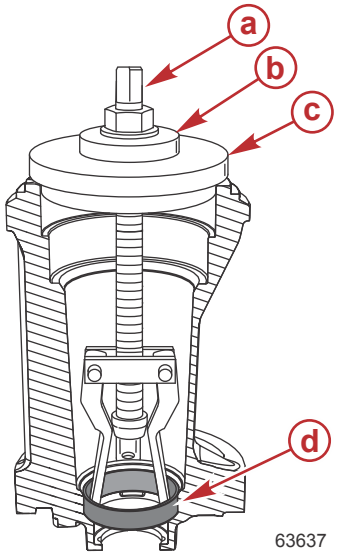
   b. **If replacing the tapered roller bearing cup and seals:** Remove the seals with a punch as noted in the previous step. There are slots cast into the bearing carrier to aid in the removal of the bearing cup with puller jaws.



63725

a - Bearing carrier—bearing cup removed for clarity
b - Slots

c. Remove the tapered bearing cup from the carrier using a bearing puller assembly, pilot washer, and bearing carrier guide plate. Discard the bearing, cup, and seals.



a - Bearing puller assembly
b - Pilot washer
c - Bearing carrier guide plate
d - Bearing cup

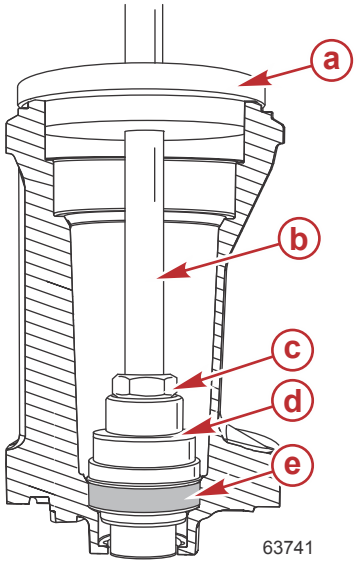
Bearing Puller Assembly	91- 83165T
Pilot Washer	91-36571T
Bearing Carrier Guide Plate	91-8M0053084

Assembly

1. Clean the components with a suitable solvent and dry the parts with compressed air.
2. Lubricate the tapered bearing cup bore with High Performance Gear Lubricant.

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Tapered bearing cup bore	92-858064K01

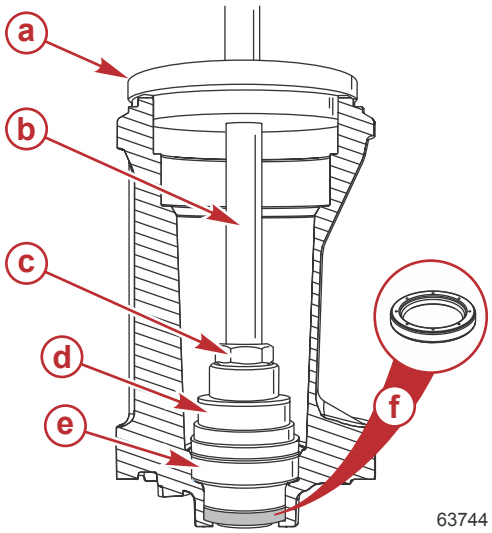
3. Assemble the bearing cup onto the driver.
4. Press the bearing cup into the bearing carrier until the cup bottoms out in the bearing carrier.



a - Bearing carrier guide plate
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Tapered bearing cup

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Carrier Guide Plate	91-8M0053084
Bearing Removal and Installation Kit	91- 31229A 7

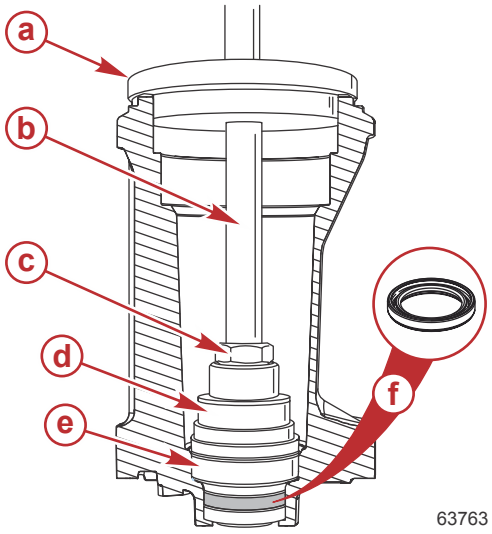
5. Thoroughly clean the bore in which the first seal is to be pressed.
6. Assemble the first seal, with the lips of the seal facing away from the driver shoulder, onto the long end of the oil seal driver.
7. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



- **a -** Bearing carrier guide plate
- **b -** Driver rod
- **c -** Hex nut
- **d -** Bearing cup driver/oil seal installer
- **e -** Bearing cup
- **f -** Oil seal (first)

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Carrier Guide Plate	91-8M0053084
Bearing Removal and Installation Kit	91- 31229A 7

8. Assemble the second seal, with the lips of the seal facing the driver shoulder, onto the short end of the oil seal driver.
9. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



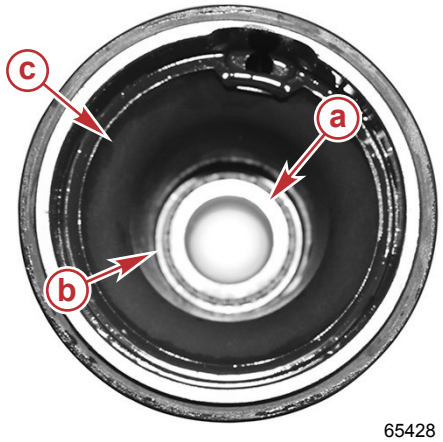
- **a -** Bearing carrier guide plate
- **b -** Driver rod
- **c -** Hex nut
- **d -** Bearing cup driver/oil seal installer
- **e -** Bearing cup
- **f -** Oil seal (second)

Bearing Carrier Guide Plate	91-8M0053084
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Removal and Installation Kit	91- 31229A 7

10. Lubricate the seal lips and fill the area between the seals with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1

11. Install the propeller shaft tapered bearing cone into the bearing carrier.



65428

a - Tapered bearing cone
b - Bearing cup
c - Bearing carrier

12. Install the oil blocker plate into the bearing carrier, if equipped.

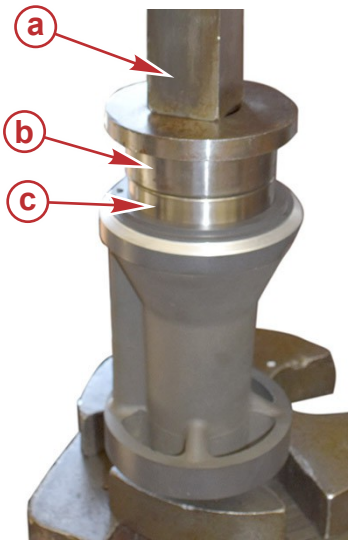
NOTE: *Some early models are equipped with the oil blocker plate. Install the oil blocker plate if it was removed during disassembly.*

65209

a - Bearing carrier
b - Oil blocker plate

13. Press the new ball bearing into the bearing carrier using a suitable mandrel. Make sure to press on the outer race of the bearing.

NOTE: *If the ball bearing is still attached to the rear gear, skip this step.*



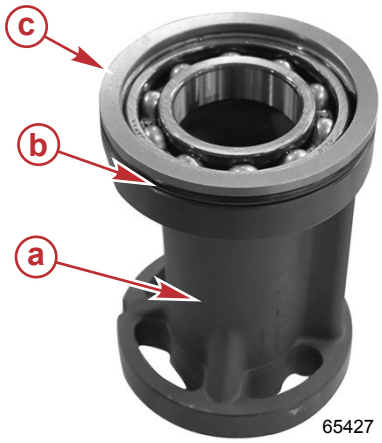
63640

a - Press
b - Mandrel, aligned with outer bearing race
c - New ball bearing

14. Lubricate the O-ring with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	O-ring	92-802859A 1

15. Install the O-ring and thrust ring onto the bearing carrier.

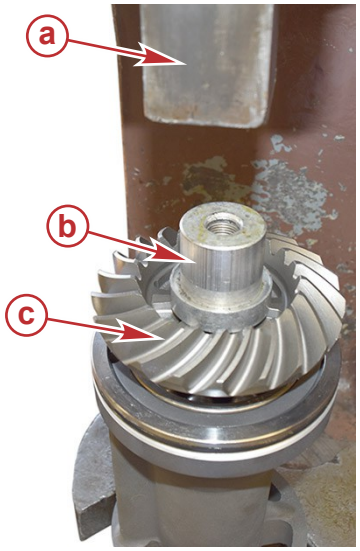


65427

a - Bearing carrier
b - O-ring
c - Thrust ring

16. Using a suitable mandrel that presses on the clutch teeth, press the rear gear into the new ball bearing in the bearing carrier.

NOTE: *If the ball bearing is still attached to the rear gear, press the gear and bearing into the bearing carrier as an assembly.*



63641

a - Press
b - Mandrel
c - Rear gear

Left-Hand Rotation Bearing Carrier—Inspection, Disassembly, Assembly

Inspection

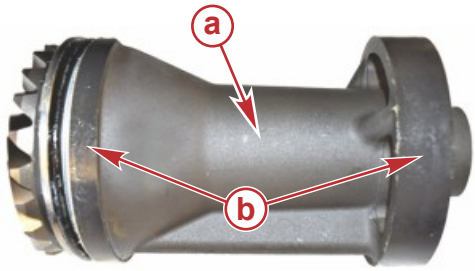
IMPORTANT: It is recommended that all seals and O-rings be replaced, as a normal repair procedure, to assure effective repair.

1. Clean the 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.

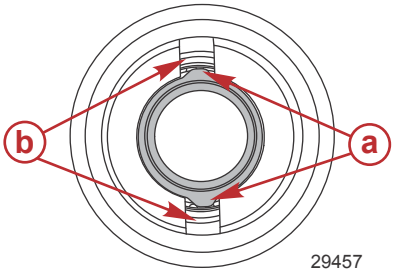
2. Inspect the bearing carrier for signs of excessive corrosion, especially in the area where the bearing carrier touches the gear housing. If excessive corrosion is evident, replace the carrier.



63603

a - Bearing carrier
b - Inspect for corrosion

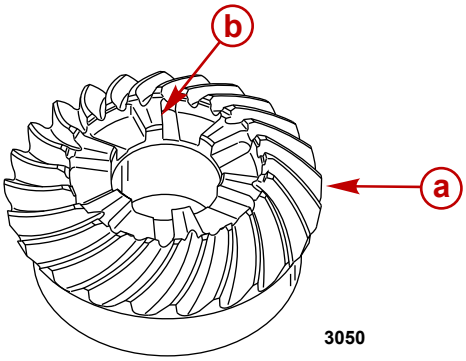
3. The propeller shaft utilizes a tapered roller bearing and cup for shaft support just forward of the bearing carrier seals. The forward (rear) gear and bearing adapter assembly must be removed from the bearing carrier to gain access to the propeller shaft tapered bearing for inspection.
4. The forward (rear) gear can be removed from the adapter/bearing carrier assembly by rotating the gear until the forward (rear) gear adapter tabs align with the slots in the bearing adapter. The forward (rear) gear can then be removed from the adapter/bearing carrier assembly.



29457

a - Forward (rear) gear sleeve tabs
b - Bearing adapter slots

5. Inspect the forward (rear) gear to pinion gear wear pattern. It should be even and smooth. If not, replace the rear gear, pinion gear, and front gear.
6. Inspect the forward (rear) gear for hairline fractures. Replace the forward (rear) gear and the pinion gear if any fractures are found. If extensive damage is observed, such as chips, spalling, or broken teeth, replace all gears.
7. Check the clutch jaws on the forward (rear) gear for damage. Replace the forward (rear) gear if damage is found on the clutch jaws.



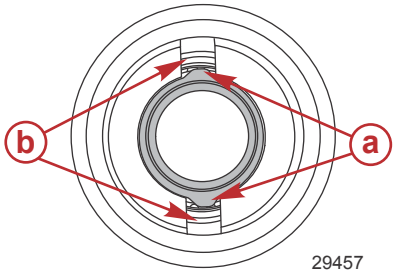
3050

a - Forward (rear) gear
b - Clutch jaws

Disassembly

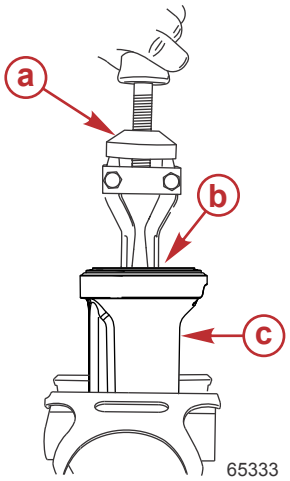
1. Remove and discard the O-ring between the bearing carrier and the thrust washer.

2. Remove the forward (rear) gear assembly by rotating the forward gear adapter tabs to align with the bearing adapter slots. Remove the gear.



a - Forward gear adapter tabs
b - Bearing adapter slots

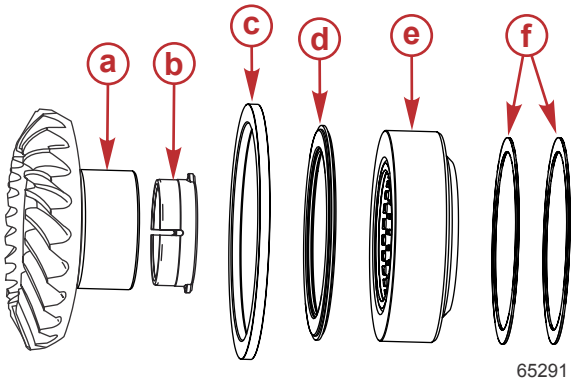
3. Remove the thrust washer and thrust bearing from the bearing carrier.
4. Remove the forward (rear) gear bearing and adapter as follows:
   a. Place the bearing carrier in a vise.
   b. Remove the bearing adapter as an assembly using a slide hammer puller.



a - Slide hammer puller
b - Bearing adapter
c - Bearing carrier

Slide Hammer	91-34569A 1

5. Clean the forward (rear) gear bearing assembly with a suitable solvent and dry using compressed air.

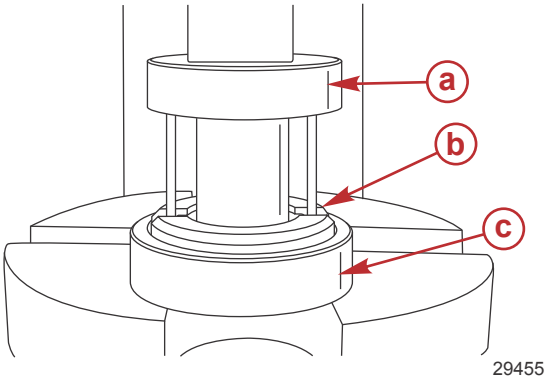


a - Forward (rear) gear
b - Gear adapter
c - Thrust washer
d - Thrust bearing
e - Roller bearing and bearing adapter assembly
f - Shims

NOTE: *The condition of the bearing surfaces on the forward (rear) gear in the areas that the bearings of the bearing adapter and the thrust bearing rides, is an indication of the condition of the 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. The bearing should not be used after it has been removed from the bearing adapter.

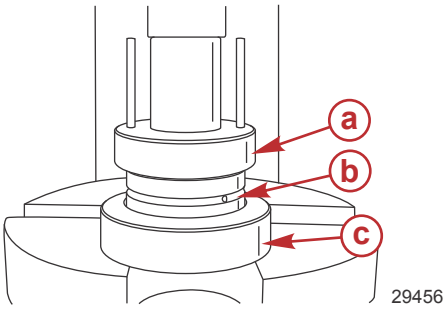
6. If the roller bearing in the bearing adapter must be replaced, remove the bearing from the adapter using a bearing removal tool. Align the pins of the tool with the slots of the adapter and apply force to the center of the tool so the pressure is equal on both of the pins. Discard the bearing after 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 that the roller bearing is pressed into with 2-4-C with PTFE.
   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 a bearing removal tool until the tool contacts the adapter.

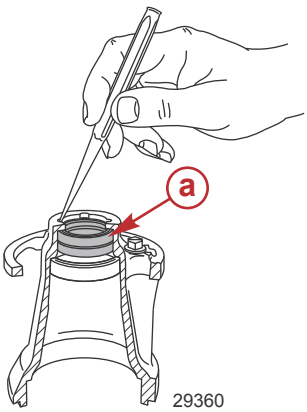


a - Bearing removal tool
b - Roller bearing (numbers/letters face driver)
c - Bearing adapter

Needle Bearing Removal Tool	91-816245

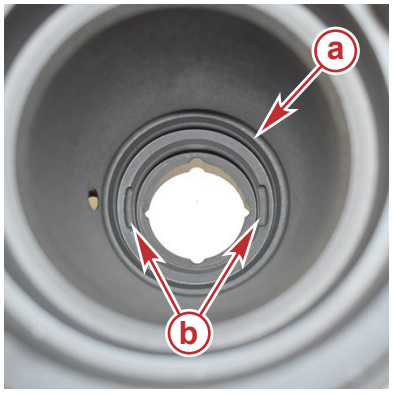
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bore that roller bearing is pressed into	92-802859A 1

8. Replace the tapered bearing cup and seals if damaged. 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

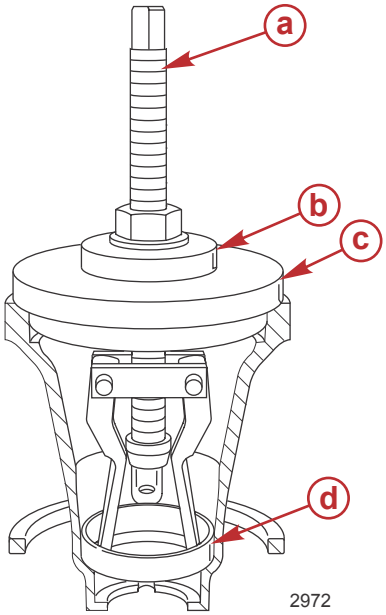
b. **If replacing the tapered roller bearing and seals:** Remove the seals with a punch as noted above. There are slots cast into the carrier to aid in the removal of the bearing cup with puller jaws.



63725

a - Bearing carrier—bearing cup removed for clarity
b - Slots

c. Remove the tapered bearing cup from the carrier using a bearing puller assembly, pilot washer, and seal driver guide. Discard the bearing, cup, and both seals.



2972

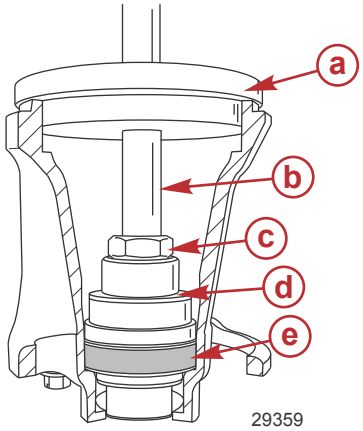
a - Bearing puller assembly
b - Pilot washer
c - Seal driver guide
d - Cup

Bearing Puller Assembly	91- 83165T
Pilot Washer	91-36571T
Seal Driver Guide	91-889845

Assembly

1. Clean all of the components with a suitable solvent and dry the parts thoroughly using compressed air.
2. Lubricate the bore that the roller bearing race is pressed into with High Performance Gear Lubricant.
3. Assemble the bearing cup onto the driver.

4. Press the bearing cup into the bearing carrier until the cup bottoms out in the bearing carrier.

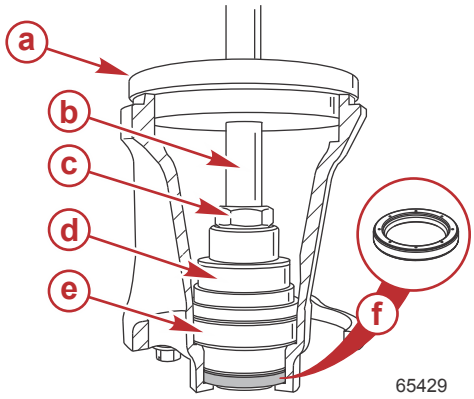


a - Seal driver guide
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Tapered bearing cup

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91- 31229A 7
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Bore that roller bearing race is pressed into	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. Press on the oil seal driver until the driver bottoms out on the bearing cup.

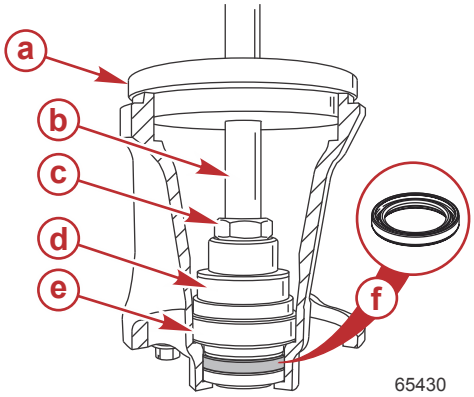


a - Seal driver guide
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Bearing cup
f - Oil seal (first)

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91- 31229A 7
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01

8. Assemble the second seal, with the lips of the seal facing the driver shoulder, onto the short end of the driver.

9. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



- **a -** Seal driver guide
- **b -** Driver rod
- **c -** Hex nut
- **d -** Bearing cup driver/oil seal installer
- **e -** Bearing cup
- **f -** Oil seal (second)

Seal Driver Guide	91-889845
Bearing Removal and Installation Kit	91- 31229A 7
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01

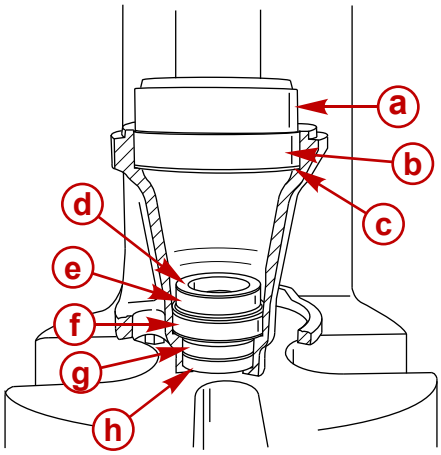
10. Lubricate the seal lips and fill the area between the seals with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1

11. Install the propeller shaft tapered roller bearing into the carrier bearing cup.
12. Lubricate the bore that 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

13. Install the bearing adapter shims into the bearing carrier.
14. Press the bearing adapter into the bearing carrier until the adapter bottoms out in the bearing carrier.



- **a -** Bearing cup driver
- **b -** Bearing adapter
- **c -** Bearing adapter shim
- **d -** Shims
- **e -** Spacer
- **f -** Tapered bearing
- **g -** Seal
- **h -** Seal

Bearing Cup Driver	91-885592T

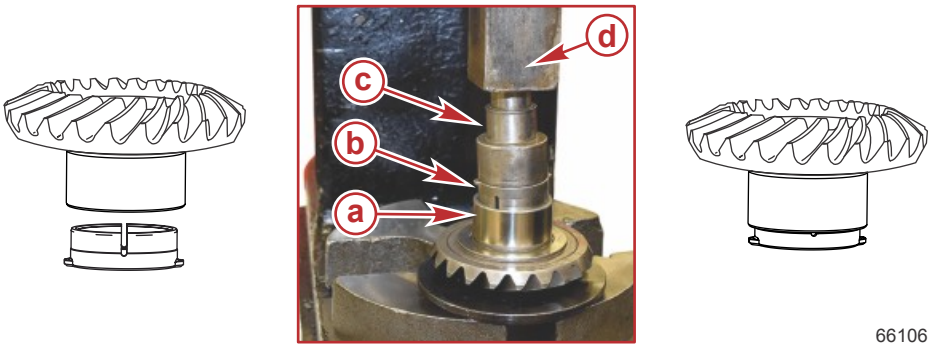
NOTE: *The shims and spacer above the tapered bearing may be installed before the propeller shaft, or placed on the propeller shaft, and installed into the carrier with the propeller shaft. However, without the propeller shaft installed in the bearing carrier, the shims, spacer, and tapered bearing may fall out of alignment.*

15. Install the O-ring and thrust ring onto the bearing carrier.

65431

a - O-ring
b - Thrust ring
c - Thrust bearing

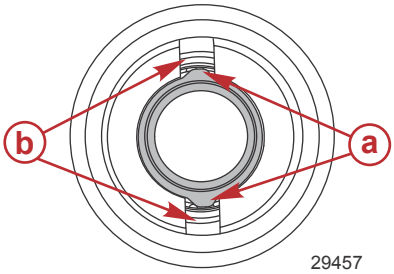
16. Install the thrust bearing onto the bearing adapter.
17. Ensure that the gear adapter is installed into the forward (rear) gear. If it was removed, press the gear adapter into the forward (rear) gear using a suitable mandrel, as shown.



66106

a - Forward (rear) gear
b - Gear adapter
c - Mandrel
d - Press

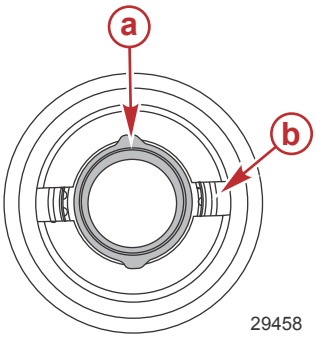
18. Install the forward (rear) gear into the bearing adapter by aligning the forward gear adapter sleeve tabs with the slots in the bearing adapter.



29457

a - Forward gear sleeve tabs
b - Bearing adapter slots

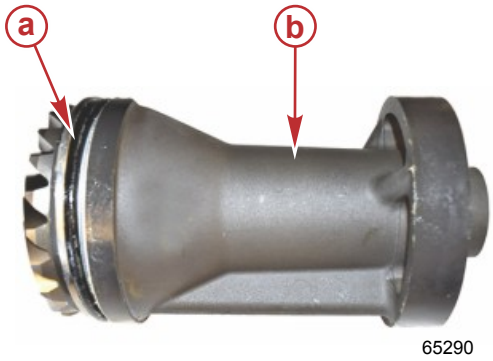
19. Rotate the forward (rear) gear 90 degrees after installing the gear into the bearing adapter.



29458

a - Forward gear sleeve tabs—gear not shown for clarity
b - Bearing adapter slots

20. Lubricate the O-ring with 2-4-C with PTFE.



65290

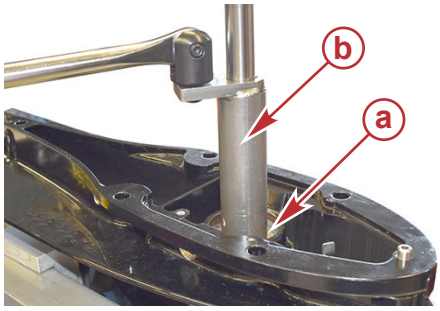
a - O-ring
b - Bearing carrier

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier O-ring	92-802859A 1

Driveshaft Removal, Inspection, Disassembly, and Assembly

Driveshaft Removal

1. Remove the driveshaft bearing retainer with the driveshaft bearing retainer wrench.

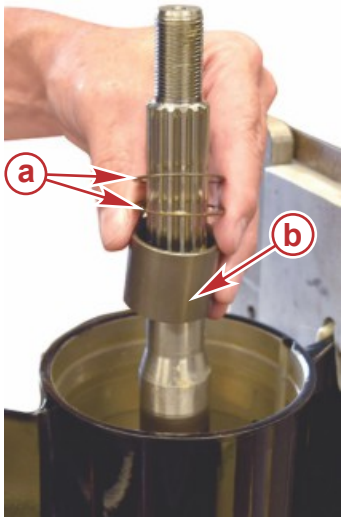


63643

a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

2. Remove the shims and spacer from the propeller shaft, if not already removed.

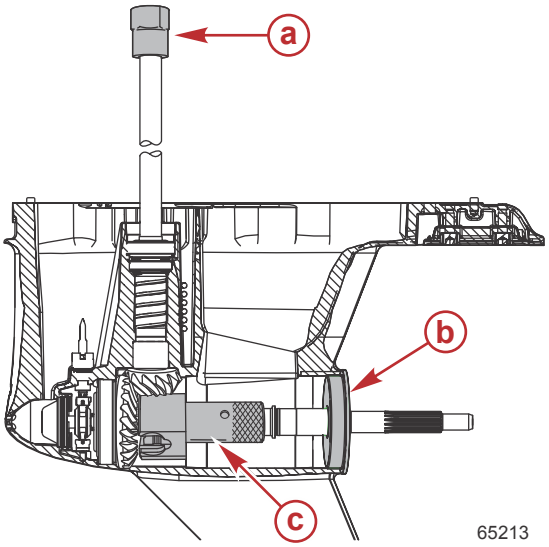


65206

a - Shims
b - Spacer

3. Insert the pinion nut wrench into the gear housing with the MR slot facing the pinion gear. It may be necessary to lift and rotate the driveshaft to align the pinion gear nut into the pinion nut wrench.
4. Install the propeller shaft holder over the propeller shaft and into the gear housing to maintain the pinion nut wrench alignment.

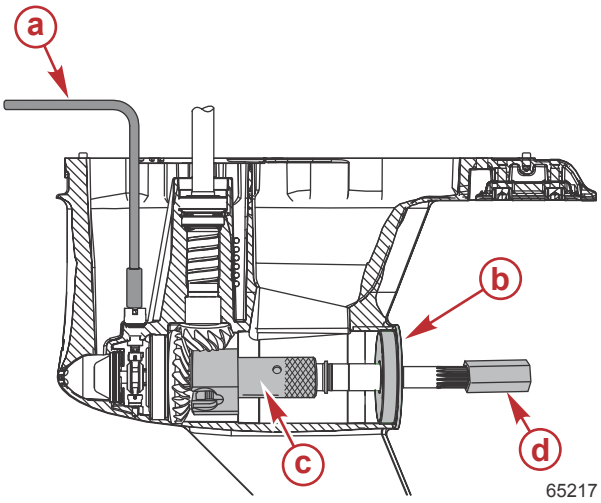
5. Install the driveshaft holding tool onto the driveshaft.
6. Use the driveshaft holding tool to loosen the pinion nut.



a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut wrench

Driveshaft Holding Tool	91-889958T
Propeller Shaft Holder	8M0075944
Pinion Nut Wrench	91- 61067T03

7. If the driveshaft is broken, place the propeller shaft adapter onto the propeller shaft splines. Use the shift shaft handle tool to hold the shift shaft against the rear gear, and loosen the pinion nut by rotating the propeller shaft counterclockwise.

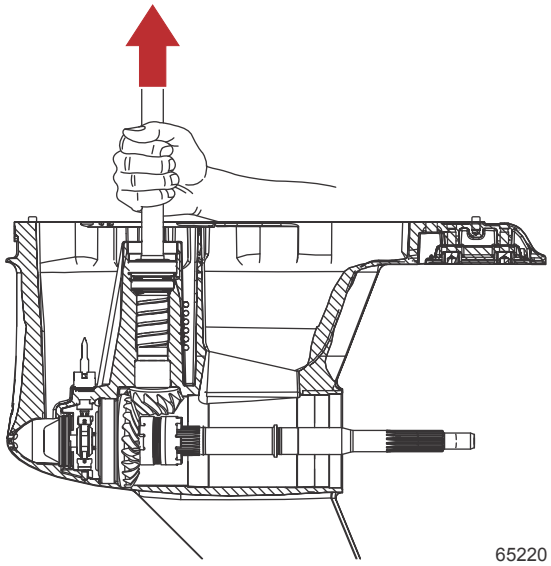


a - Shift shaft handle tool
b - Propeller shaft holder
c - Pinion nut wrench
d - Propeller shaft adapter

Shift Shaft Handle Tool	8M0142973
Propeller Shaft Holder	8M0075944
Pinion Nut Wrench	91- 61067T03
Propeller Shaft/Driveshaft Adapter	91-61077T

8. Remove all of the tools.

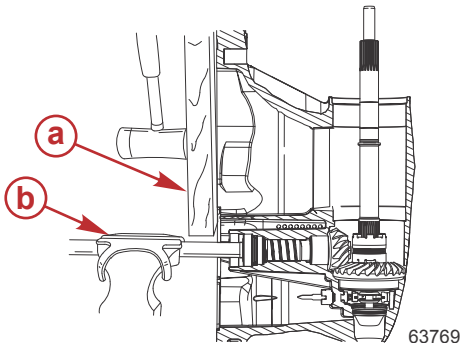
9. Remove the driveshaft by pulling the driveshaft straight out of the gear housing.



10. If the pinion gear is seized onto the driveshaft, clamp the driveshaft in a soft jaw vise. Place a block of wood on the gear housing mating surface. Use a mallet and carefully tap the gear housing away from the driveshaft.

IMPORTANT: Striking a gear housing directly with a mallet can distort the gear housing causing gear housing failure.

IMPORTANT: The pinion bearing rollers can fall out of the pinion bearing race after the driveshaft is removed. Do not lose the 18 rollers.

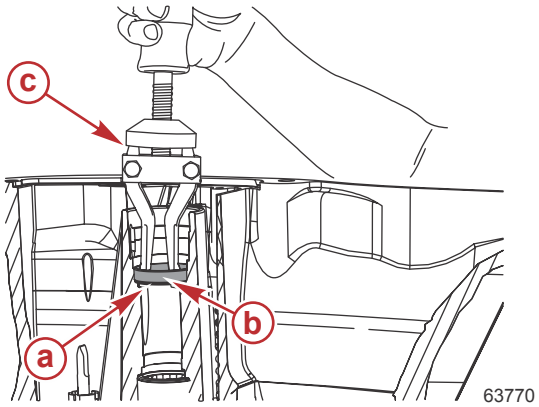


a - Wood block
b - Driveshaft in soft jaw vise

11. Move the propeller shaft downward to retrieve the pinion gear and nut from inside the gear housing.

NOTE: *The washer will likely come out with the pinion gear. Do not lose the washer.*

12. Remove the driveshaft bearing cup and shims with a slide hammer. Retain the shims for installation.



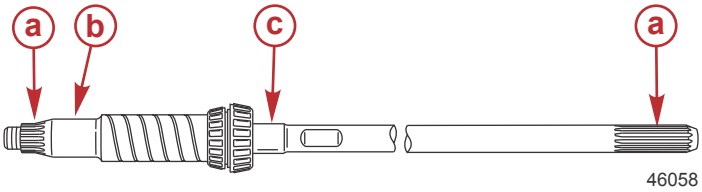
a - Shims
b - Bearing cup
c - Slide hammer puller

Slide Hammer	91-34569A 1

Driveshaft Inspection

1. Clean all parts with a suitable solvent and dry the parts thoroughly using compressed air. Do not 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 needles 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 the driveshaft for grooves where the water pump base oil seals contact the shaft. Replace the driveshaft if grooves are found.



a - Splines
b - Pinion bearing surface
c - Seal surface

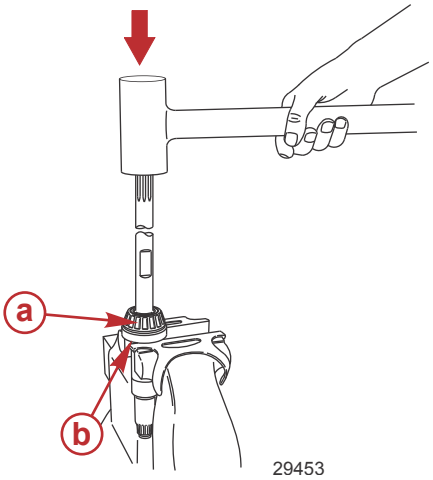
6. Inspect the pinion gear for pits, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the pinion gear and the front gear as a set if any defects are found.

Driveshaft Disassembly

NOTE: *Do not remove the upper and lower tapered roller bearings from the driveshaft unless replacement is indicated. Bearings cannot be reused after removal from the driveshaft.*

NOTE: *If one driveshaft tapered roller bearing is damaged, both tapered bearings and spacer must be replaced as a set.*

1. Both the upper and lower tapered roller bearings can be removed from the driveshaft in one operation. Using the bottom bearing cup removed from the gear housing, 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.

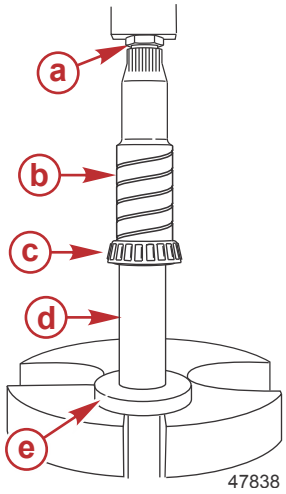


a - Driveshaft with both upper and lower bearings
b - Lower bearing cup removed from gearcase

Driveshaft Assembly

1. Apply High Performance Gear Lubricant on the inside diameter of the driveshaft tapered bearings.
2. Install the lower tapered roller bearing to the driveshaft, with the small outside diameter of the bearing facing towards the pinion gear end of the driveshaft.
3. Thread a used pinion nut onto the end of the driveshaft. Leave approximately 2 mm (1/16 in.) of nut threads exposed. The driveshaft threads must not extend beyond the nut or thread damage will result when pressing the bearing on.

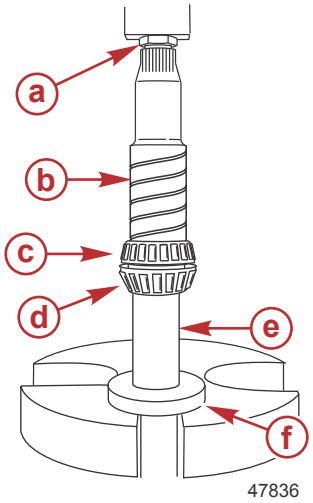
4. Press the lower bearing onto the driveshaft with the driveshaft bearing installation tool.



- **a -** Pinion nut
- **b -** Driveshaft
- **c -** Lower driveshaft tapered bearing
- **d -** Driveshaft bearing installation tool
- **e -** Flat washer (obtain locally)

Driveshaft Bearing Installation Tool	91-8M0052590

5. Install the upper bearing onto the driveshaft, with the large outside diameter of the bearing facing the pinion gear end of the driveshaft.
6. Press the upper bearing onto the driveshaft with the driveshaft bearing installation tool.



- **a -** Pinion nut
- **b -** Driveshaft
- **c -** Lower driveshaft tapered bearing
- **d -** Upper driveshaft tapered bearing
- **e -** Driveshaft bearing installation tool
- **f -** Flat washer (obtain locally)

Driveshaft Bearing Installation Tool	91-8M0052590

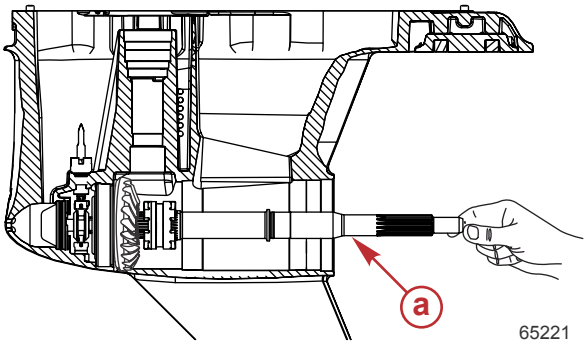
Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of the driveshaft tapered bearings	92-858064K01

Propeller Shaft Assembly and Front Gear Bearing Cup

Removal

NOTE: *The front gear and propeller shaft assembly can only be removed from the gear housing after the driveshaft and pinion gear have been removed.*

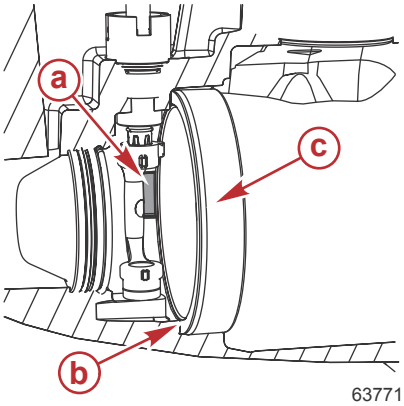
1. On right-hand rotation gear housings, tilt the propeller shaft to the starboard side of the gear housing and remove the shaft. On left-hand rotation gear housings, tilt the propeller shaft to the port side of the gear housing and remove the shaft.



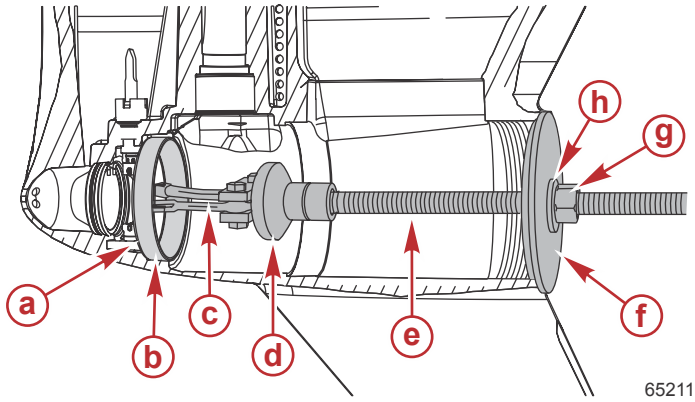
a - Propeller shaft

2. Remove the front gear bearing cup and shims. Measure and make note of the shim thickness. If the shims are not damaged, they may be reused.

NOTE: *Two notches are provided in the gear housing, just forward of the front gear bearing cup, to position the puller jaws for easier removal of the bearing cup and shims.*



a - Notches
b - Shims
c - Front gear bearing cup



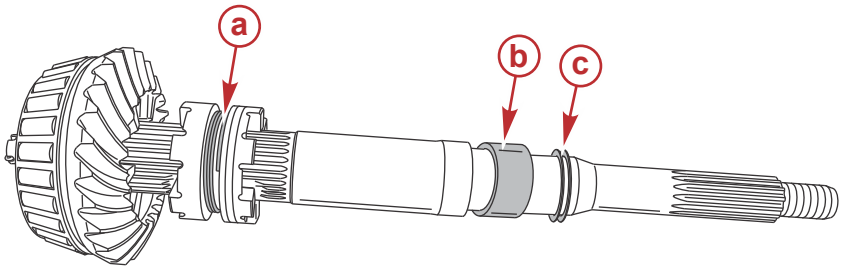
a - Shims
b - Bearing cup
c - Jaws (from slide hammer puller kit)
d - Puller head (from slide hammer puller kit)
e - Puller shaft
f - Guide plate
g - Nut
h - Washer

Slide Hammer	91-34569A 1
Bearing Removal and Installation Kit	91- 31229A 7
Guide Plate	91-816243

Component Disassembly

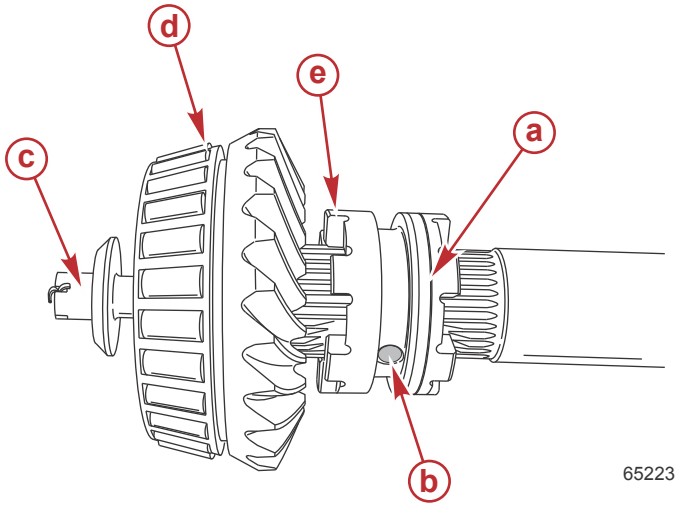
NOTE: *When performing the next step, all of the parts are free to come apart. Work closely over a workbench to avoid dropping or damaging the parts and to avoid personal injury.*

1. Ensure the propeller shaft thrust spacer and shims are removed.



a - Spring
b - Thrust spacer
c - Shims

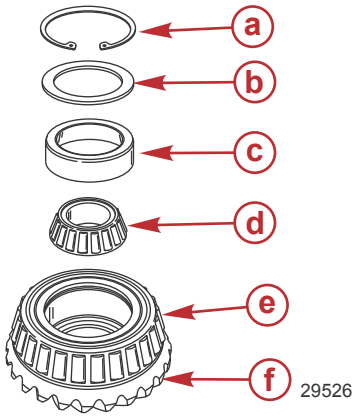
2. Remove the spring around the clutch, being careful not to overstretch it during removal. If the spring does not coil back to its normal position after it has been removed, it must be replaced.
3. Remove the cross pin that goes through the clutch.
4. Remove the remainder of the components.



a - Clutch band (faces toward rear gear)
b - Cross pin
c - Shift spool and actuating shaft assembly
d - Front gear assembly
e - Clutch

Inspection

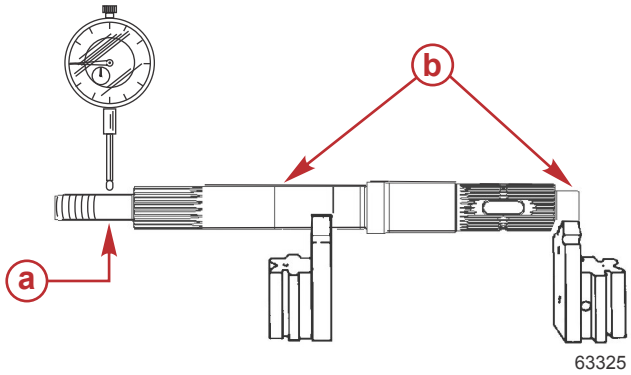
1. Clean all the parts with a suitable solvent and dry the parts thoroughly with compressed air. Be careful not to spin the bearings.
2. Inspect the sliding clutch jaws for damage. Replace the clutch if the jaws are chipped or rounded off.
3. The propeller shaft uses two tapered roller bearing and cup assemblies for propeller shaft support.
   a. One tapered bearing is just forward of the bearing carrier seals. Refer to the **Bearing Carrier Disassembly** section for information on accessing this bearing for inspection.
   b. The other tapered bearing is located inside of the front gear assembly. Remove the front gear assembly from the propeller shaft. Remove the snap ring retainer and flat washer from the front gear assembly to remove the tapered bearing for inspection.



a - Snap ring
b - Flat washer
c - Inner tapered bearing cup
d - Inner tapered bearing cone
e - Outer front gear bearing cone
f - Front gear

NOTE: *The outer front gear bearing should not be removed from the front gear unless replacement is necessary. The bearing is not reusable if it 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 the V-blocks.
   b. Adjust the height of the V-blocks to level the propeller shaft.
   c. Position the dial indicator tip forward of the propeller shaft threads.
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

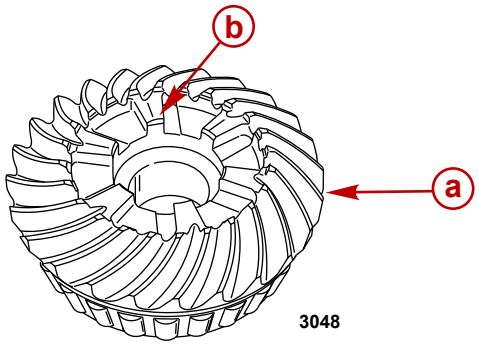
Propeller Shaft	
Runout	0.23 mm (0.009 in.)

Dial Indicator	91- 58222A 1

Front Gear Assembly

Component Inspection

1. Clean the front gear assembly and the front gear bearing cup with a suitable solvent and dry with compressed air. Be careful not to spin the bearings.
2. Inspect the gear for pits, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the front 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 front gear and pinion gear as a set if any of these conditions exist.



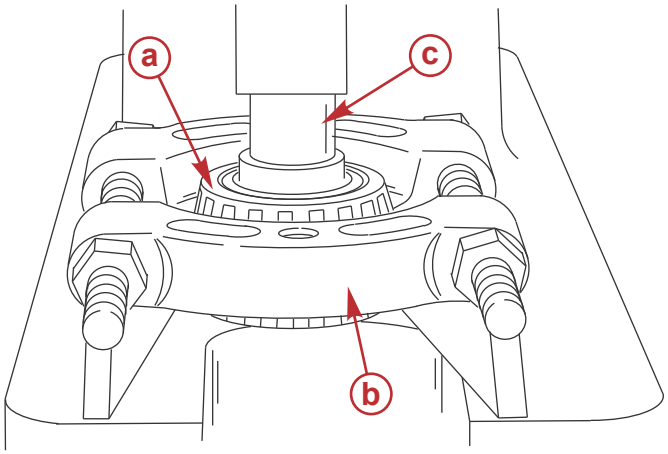
a - Front gear teeth
b - Clutch jaws

4. Inspect the propeller shaft tapered roller bearing on the inside of the front 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.
5. Inspect the tapered roller bearing pressed onto the front gear and the bearing surface on the front gear bearing cup. If either the roller bearing or the bearing surface of the front gear bearing cup is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles, replace the front gear bearing cup and remove and replace the tapered roller bearing.

Disassembly

IMPORTANT: Do not remove the pressed on tapered roller bearing from the front gear unless replacement of the bearing is required. The bearing cannot be reused after it has been removed.

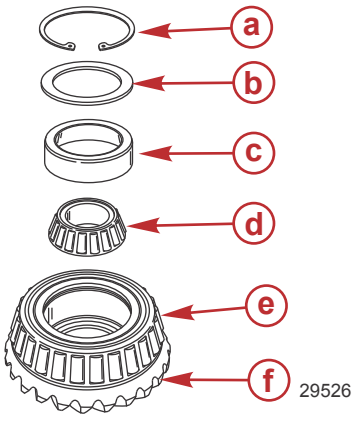
1. If inspection determines that replacement of the front gear tapered bearing is required, separate the gear from the bearing as follows:
   a. Install the universal puller plate between the front gear and the tapered bearing.
   b. Place the assembly on a press and press the gear out of the bearing with a suitable mandrel.
   NOTE: *The tapered bearing cup and cone must be replaced as a set.*



a - Front gear bearing
b - Universal puller plate
c - Mandrel

Universal Puller Plate	91-37241

2. If inspection determines that replacement of the propeller shaft tapered roller bearing is required, remove the bearing as follows:
   IMPORTANT: Use suitable eye protection when removing or installing the snap ring.
   a. Use snap ring pliers to remove the snap ring. Remove the tapered roller bearing assembly out of the inside of the front gear.

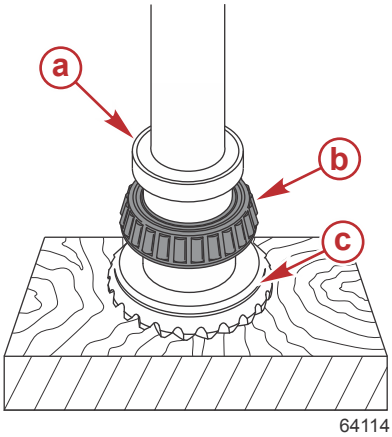


a - Snap ring
b - Flat washer
c - Tapered bearing cup
d - Tapered bearing cone
e - Front gear bearing cone
f - Front gear

Assembly

1. Use a suitable mandrel to press the tapered roller bearing onto the front gear. Press on the inner bearing race until the bearing contacts the gear.

IMPORTANT: Use a block of wood under the gear as shown to prevent damage to the gear while installing the bearing.

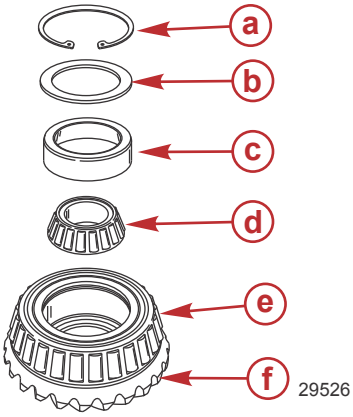


- **a -** Mandrel
- **b -** Tapered roller bearing
- **c -** Front gear

2. Apply High Performance Gear Lubricant to the I.D. of the front gear. Install a new tapered roller bearing cone, race, and flat washer into the front gear until the bearing seats.

   IMPORTANT: Use suitable eye protection when removing or installing the snap ring.

3. Install the snap ring into the groove of the front gear to secure the tapered roller bearing assembly.



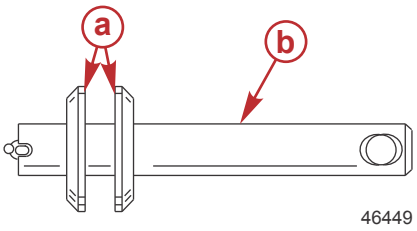
- **a -** Snap ring
- **b -** Flat washer
- **c -** Tapered bearing cup
- **d -** Tapered bearing cone
- **e -** Front gear bearing cone
- **f -** Front gear

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of front gear	92-858064K01

Shift Spool Assembly

Inspection

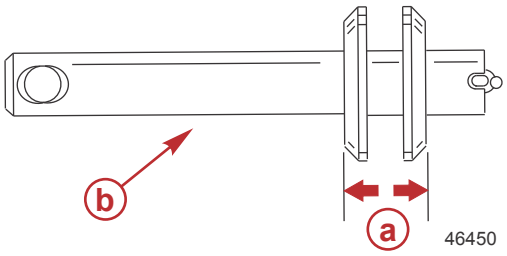
1. Clean the assembly with solvent and dry all parts using compressed air.
2. Inspect the shift spool assembly for damage. Small nicks and burrs may be smoothed. If any parts are damaged or worn excessively, replace the complete shift spool assembly.
3. Inspect the shift spool for wear in the area where the shift crank comes into contact.



- **a -** Contact area
- **b -** Nonratcheting shift spool

4. Verify the spool spins freely.

5. Verify the spool has end play. The 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

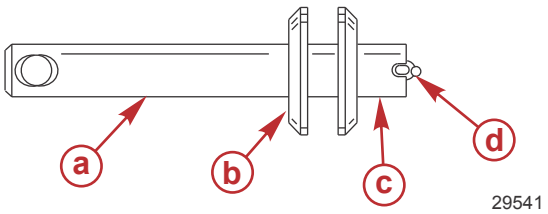
NOTE: *If the spool spins freely and has the proper clearance, it will not be necessary to disassemble and reassemble the spool. If the spool does not function properly, proceed with the following disassembly procedures.*

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, replace the 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

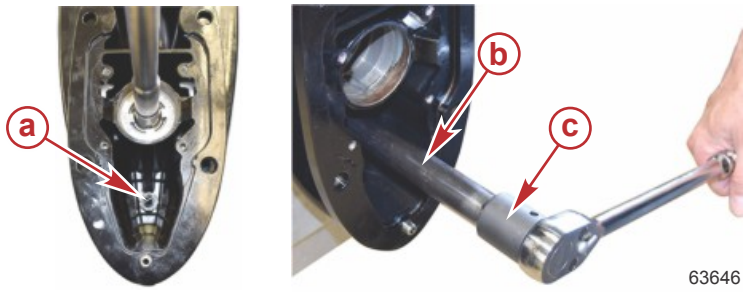
Shift Spool	
End play	0.05–0.25 mm (0.002–0.010 in.)

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, replace the shift spool assembly.

Shift Shaft Removal and Assembly

Removal

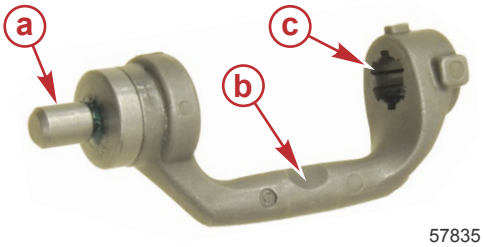
1. Remove the shift shaft assembly from the gear housing using the shift shaft tool and 1 in. socket.



a - Shift shaft
b - Shift shaft tool
c - 1 in. socket

Shift Shaft Tool	8M0142969

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 for wear in the areas that contact the shift spool and inspect the splines and the pivot pin for damage or wear.



a - Pivot pin
b - Contact area
c - Splines

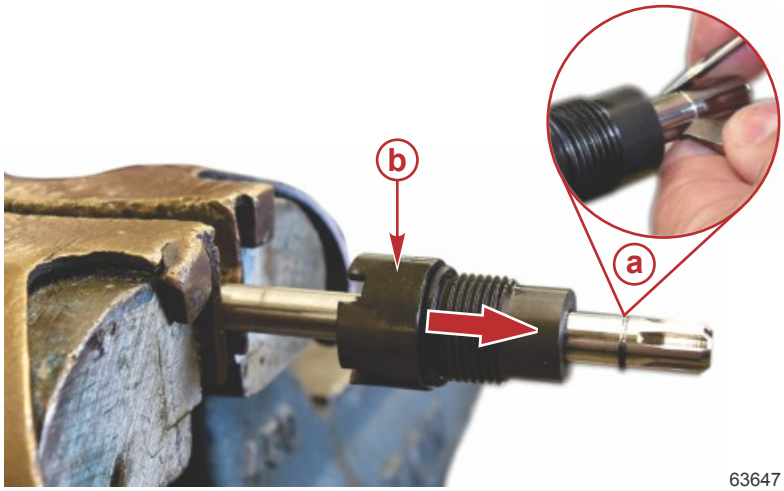
Disassembly and Inspection

1. Secure the shift shaft assembly in a vise as shown.

⚠ CAUTION

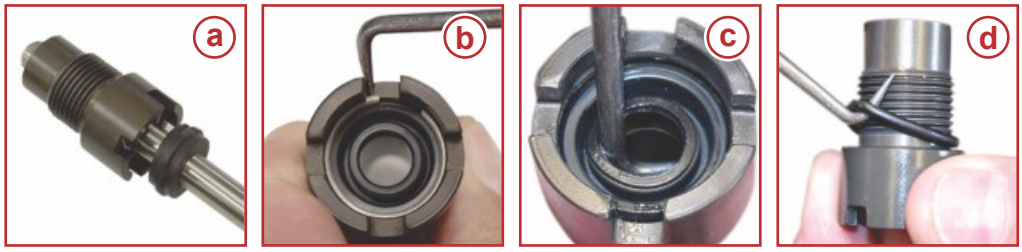
Wear eye protection when performing the following procedure. Failure to do so may cause personal injury.

a. Remove the snap ring from the end of the shift shaft.
b. Remove the bushing from the shift shaft.



a - Snap ring
b - Bushing

2. Remove the rubber grommet, snap ring, seal, and O-ring from the shift shaft bushing.



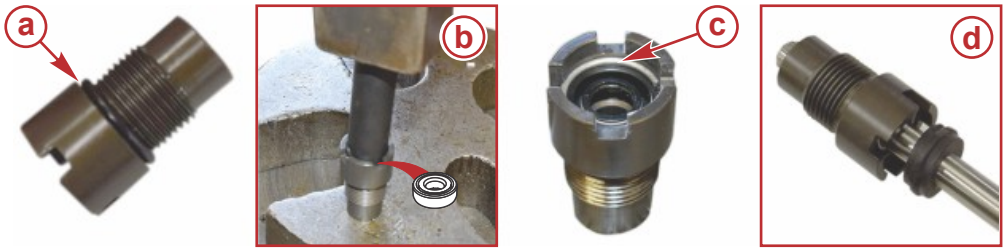
63648

a - Rubber grommet
b - Snap ring
c - Seal
d - O-ring

3. Clean all components with a suitable solvent and dry with compressed air.
4. Inspect all of the components.
   a. Inspect the shift shaft bushing for damage or leaks.
   b. Inspect the O-ring and rubber grommet for damage or excessive wear.
5. Inspect the shift shaft splines and oil seal surface for corrosion or excessive wear. Replace the shift shaft if either of these conditions are found.

Assembly

1. Lubricate the O-ring with 2-4-C with PTFE and install onto the shift shaft bushing.
2. Using a suitable mandrel, press the oil seal into the shift shaft bushing with the lips of the seal facing out.
3. Lubricate the oil seal lips with 2-4-C with PTFE.
4. Install the snap ring to secure the seal.

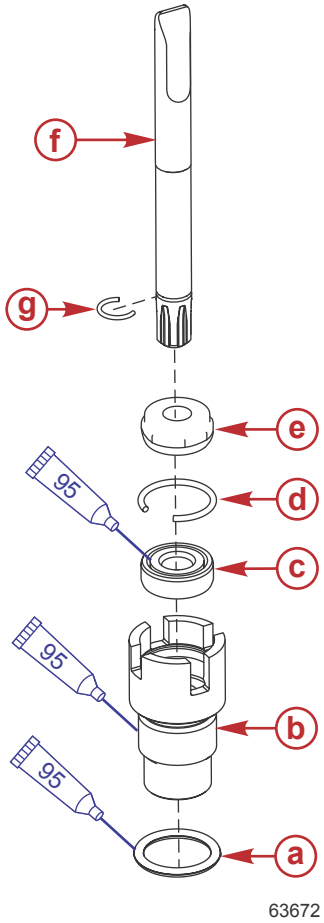


63745

a - O-ring
b - Press seal into bushing
c - Snap ring
d - Rubber grommet

5. Install the rubber grommet onto the shift shaft.
6. Install the shift shaft bushing onto the shift shaft.
7. Install the snap ring on the end of the shift shaft.

8. Lubricate the threads of the shift shaft bushing with 2-4-C with PTFE.



63672

- **a -** O-ring
- **b -** Shift shaft bushing
- **c -** Shift shaft seal
- **d -** Snap ring—secures seal in bushing
- **e -** Rubber grommet
- **f -** Shift shaft—L shown, XL and XXL available
- **g -** Snap ring—shift shaft

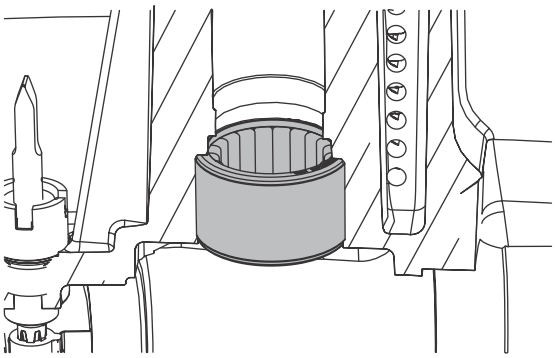
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift shaft bushing threads, O-ring, and oil seal lip	92-802859A 1

Pinion Bearing Removal

NOTE: *Inspect the pinion bearing surface on the driveshaft. The condition of the driveshaft at this location gives an indication of the condition of the roller bearing. Replace the 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.

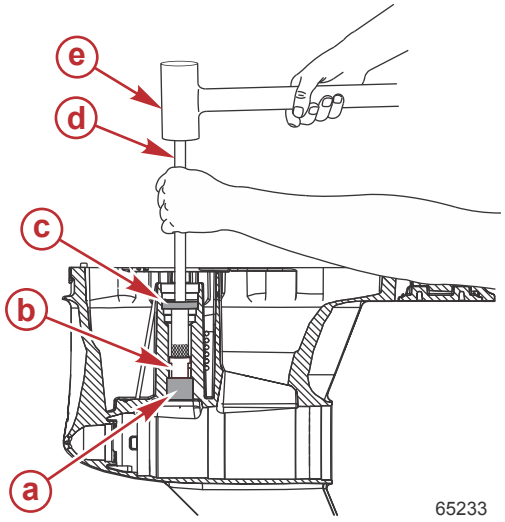
IMPORTANT: Do not use the bearing race or rollers after they have been removed.



63774

Pinion bearing

Remove and discard the pinion bearing race and rollers using the tools as shown.



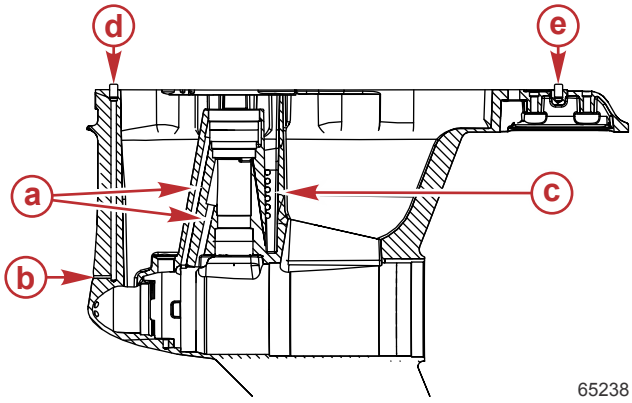
- **a -** Pinion bearing
- **b -** Driver head
- **c -** Pilot washer
- **d -** Driver rod
- **e -** Dead blow hammer

Driver Head	91- 36569T
Pilot Washer	91-36571T
Driver Rod	91- 37323

Gear Housing Inspection

1. Clean the gear housing with a suitable solvent and a hard bristle (not wire) brush. Dry the gear housing with compressed air. Ensure that all sealants, locking agents, and debris are removed.
2. Verify the two oil circulation holes in the driveshaft bore are clear and free of debris.
3. Inspect the gear housing for excessive corrosion, impact, or any other damage. Excessive damage or corrosion requires replacement of the gear housing.
4. Inspect the bearing carrier retainer threads in the gear housing for corrosion or stripped threads. Damage or corrosion to the threads requires replacement of the gear housing.

   NOTE: *The driveshaft bearing cups are 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 the bearing cone and cup contact area with the gearcase bearing bore for evidence of the bearing cup spinning. Check that the bearing cups are not loose in the bearing bores. A press fit type bearing bore in which the cup is loose will require replacement of the gear housing.
6. Inspect for blockage in the water inlet holes and the speedometer hole and 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
- **d -** Hollow locating pin for speedometer passage
- **e -** Locating pin

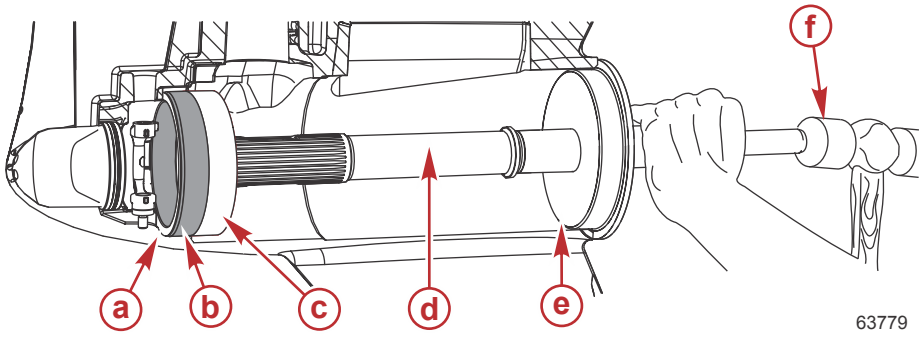
7. Verify the locating pins are in place in the gear housing and the corresponding holes in the driveshaft housing are not elongated. The driveshaft may break if the housings are not aligned properly due to missing locating pins or elongated holes.

Front Gear Bearing Cup Installation

NOTE: *If the front gear, front gear bearing and cup, or gear housing were not replaced, install the same measurement of shims that were removed. If the front gear, front gear bearing and cup, or gear housing were replaced, install 0.762 mm (0.030 in.) shims.*

1. Lubricate the front gear bearing cup bore with High Performance Gear Lubricant.
2. Install the shims into the front gear bearing cup bore.

   IMPORTANT: Verify the bearing cup is positioned as straight as possible to avoid damaging the bore while pressing the bearing cup in.



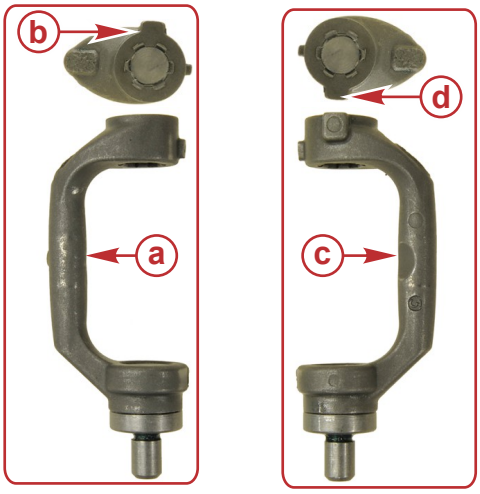
- **a -** Shims
- **b -** Front gear bearing cup
- **c -** Bearing cup driver
- **d -** Propeller shaft (old nonserviceable)
- **e -** Propeller shaft holder
- **f -** Mallet

Bearing Cup Driver	91-885592T
Propeller Shaft Holder	8M0075944

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Front gear bearing cup bore	92-858064K01

Shift Shaft Installation

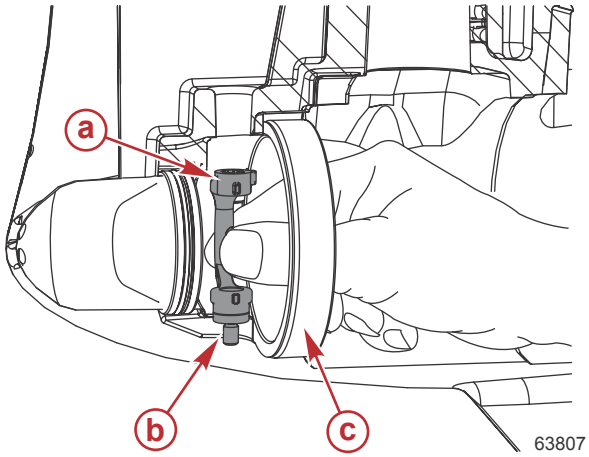
IMPORTANT: The shift crank has a tab on it. The tab faces aft in right-hand rotation gear housings. The tab faces forward in left-hand rotation gear housings.



Shift crank

- **a -** Left-hand rotation aft view—shift crank toward port
- **b -** Left-hand rotation top view—tab facing forward
- **c -** Right-hand rotation aft view—shift crank toward starboard
- **d -** Right-hand rotation top view—tab facing aft

1. Place the shift crank into the pivot pin hole in the forward section of the gear housing. Ensure that the shift crank faces towards the starboard side of the gear housing for right-hand rotation gear housings. Ensure that the shift crank faces toward the port side of the gear housing for left-hand rotation gear housings.



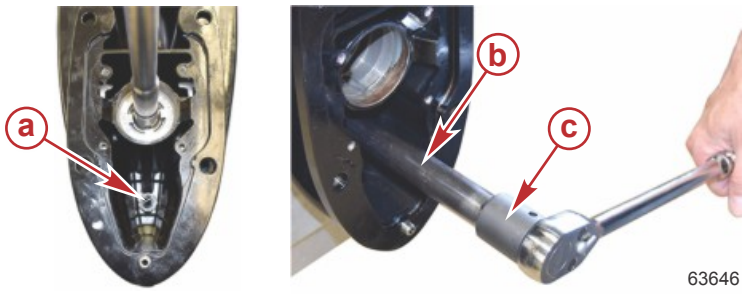
Right-hand rotation shown
- **a -** Shift crank
- **b -** Pivot pin
- **c -** Front gear bearing cup

2. Install the shift shaft assembly into the gear housing. Engage the splined end of the shift shaft with the shift crank. Ensure that the flat at the tip of the shift shaft is parallel with the direction of the shift crank.

NOTE: *The shift crank is shown outside of the gear housing for clarity.*

XL shift shaft shown
- **a -** Left-hand rotation shift shaft and crank orientation
- **b -** Right-hand rotation shift shaft and crank orientation
- **c -** Incorrect shift shaft orientation

3. Tighten the shift shaft bushing to the specified torque using the shift shaft tool and a 1 in. socket.

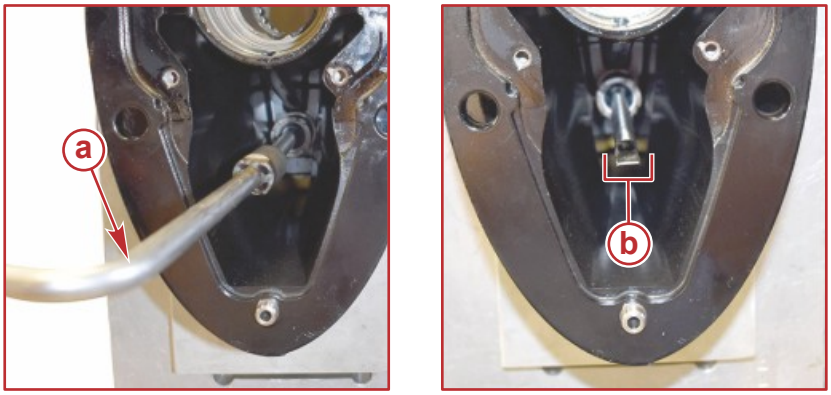


- **a -** Shift shaft
- **b -** Shift shaft tool
- **c -** 1 in. socket

Shift Shaft Tool	8M0142969

Description	Nm	lb-in.	lb-ft
Shift shaft bushing	54.2	–	40

4. Operate the shift shaft with the shift shaft handle tool to ensure it has engaged into the shift crank. The proper neutral position can be identified below.



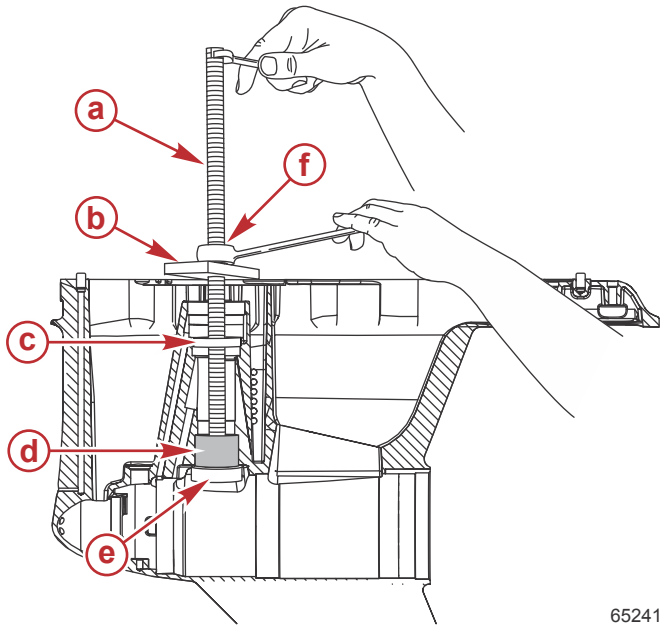
XL shift shaft shown
- **a -** Shift shaft handle tool
- **b -** Neutral position

Shift Shaft Handle Tool	8M0142973

Pinion Bearing Installation

IMPORTANT: Install only a new pinion bearing. Do not install 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, as shown.
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 washer
- **d -** Pinion bearing
- **e -** Driver head
- **f -** Hex nut

Puller/Driver Head	91- 38628T
Bearing Removal and Installation Kit	91- 31229A 7

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Pinion bearing bore	92-858064K01

Driveshaft Bearing Rolling Torque and Pinion Gear Height

IMPORTANT: The sequence of setting up the driveshaft bearing rolling torque and pinion height must be completed before checking the front and rear gear backlash. Failure to set the driveshaft bearing rolling torque and pinion height prior to checking the front and rear gear backlash may cause errors in determining the correct lash, and will increase assembly time of the gear housing to factory specifications.

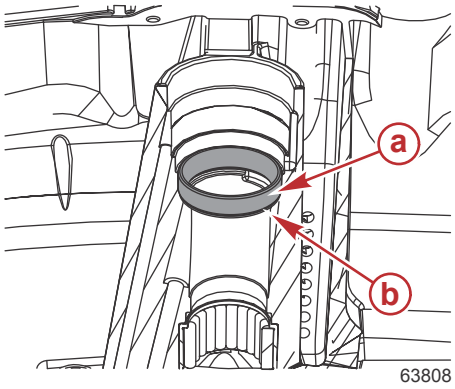
Driveshaft and Pinion Gear Installation

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 by installing a 0.508 mm (0.020 in.) shim for the lower tapered roller bearing.*

NOTE: *If the original shims were retained or the measurement is known, and none of the above listed parts were replaced, install the same shims or same amount of shims.*

IMPORTANT: Do not apply Loctite 271 Threadlocker to the threads of the pinion gear nut until after the pinion height, pinion bearing rolling torque, and front gear backlash have been confirmed.

1. Place the lower tapered bearing shims into the driveshaft housing bore.
2. Install the lower tapered bearing cup into the driveshaft housing bore.



a - Tapered bearing cup
b - Shims

3. Install the front gear assembly.

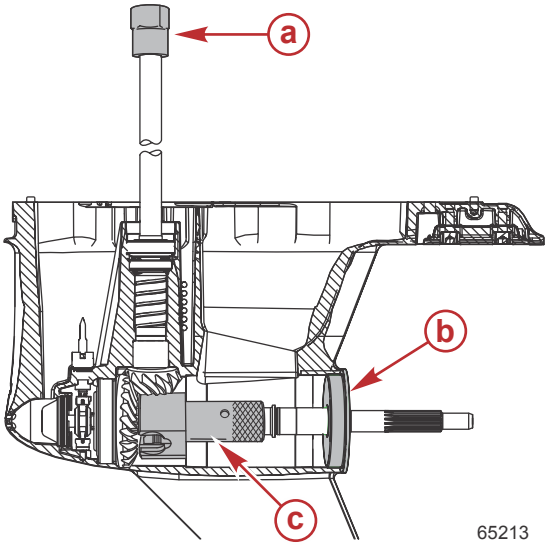
   IMPORTANT: The front gear must be installed to support the pinion nut holding tool.
4. Install the pinion gear and driveshaft.
5. Secure the pinion gear with the pinion nut and washer.

   NOTE: *Install the pinion gear nut with the flat side of the nut away from the pinion gear.*
6. Install the upper driveshaft tapered roller bearing shim.
7. Install the upper driveshaft tapered roller bearing cup. Apply 2-4-C with PTFE to the retainer threads and install the retainer.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Retainer threads	92-802859A 1

8. Install the driveshaft holding tool.
9. Install the propeller shaft into the front gear.
10. Install the pinion nut wrench over the propeller shaft and secure the pinion nut with the pinion nut wrench.
11. Install the propeller shaft holder.

12. Use the driveshaft holding tool to tighten the pinion nut to the specified torque.



a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut wrench

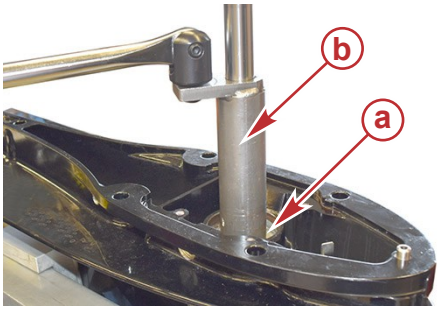
Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03
Propeller Shaft Holder	8M0075944

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	101.7	–	75

13. Remove the driveshaft holding tool, propeller shaft holder, pinion nut wrench, propeller shaft, and front gear.

Driveshaft Bearing Rolling Torque

1. Use the driveshaft bearing retainer wrench to tighten the upper driveshaft bearing retainer to the specified torque.



a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

2. Install the driveshaft holding tool.

Driveshaft Holding Tool	91-889958T

3. Use the driveshaft holding tool to check the driveshaft bearing rolling torque. Units correctly assembled to this point would be within the specified rolling torque range. If the rolling torque is not within specification, the shim under the upper tapered roller bearing cup will need to be changed and the rolling torque rechecked. If the rolling torque is too high, add shims under the upper bearing cup. If the rolling torque is too low, remove shims from under the upper bearing cup.

Description	Nm	lb-in.	lb-ft
Driveshaft bearing rolling torque	0.45–1.13	4–10	–

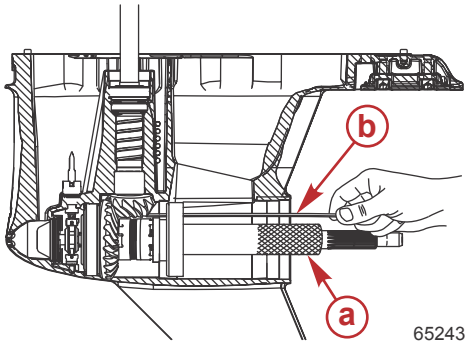
Checking and Adjusting Pinon Gear Height with Pinion Gear Locating Tool 91-56048001

NOTE: *The propeller shaft and front gear can be installed when checking pinion height if this pinion gear locating tool is used.*

1. Place the pinion gear locating tool into the gear housing, aligning the window in the tool with the 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 shimming tool. Record the measurement.



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 (height). Record the measurement.
4. Repeat this process until three measurements have been recorded.
5. Add the three measurements together and divide the sum by three to get the average pinion gear height. Make note of this average measurement.

Pinion Gear	
Height	0.635 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 the removed components and tighten the retainer to the specified torque.

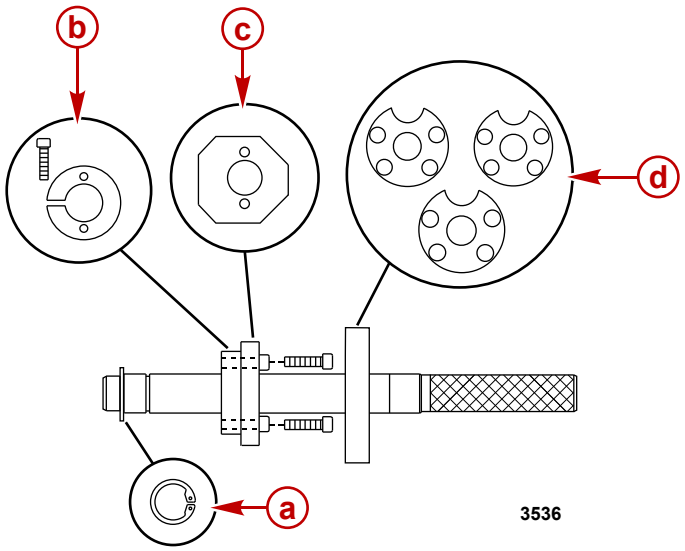
Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

8. Rotate the driveshaft at least three full turns in a clockwise direction. Check the pinion gear height. If the pinion gear clearance is not within specification, adjust the shim thickness and repeat this process until the average pinion gear height is within specification.
9. Verify the driveshaft bearing rolling torque is within specification.

Description	Nm	lb-in.	lb-ft
Driveshaft bearing rolling torque	0.45–1.13	4–10	–

10. Remove the pinion gear locating tool, driveshaft, pinion gear, and front gear.

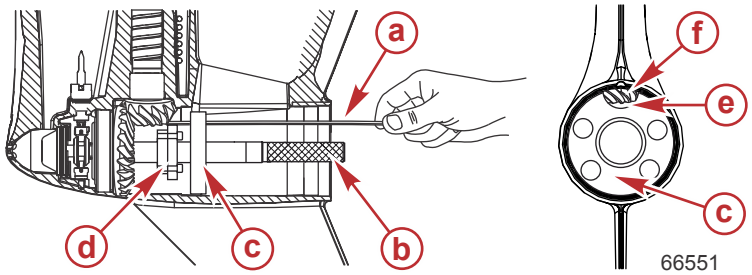
Checking and Adjusting Pinion Gear Height with Pinion Gear Locating Tool 91-12349A05



a - Retaining ring - relocate to first groove
b - Split collar
c - Gauging block - use flat #4
d - Locating disc - use disc #2

NOTE: *The front gear assembly must be installed when using pinion gear locating tool 91-12349A05.*

1. Install the retaining ring on the pinion height tool into the first groove of the arbor.
2. Using 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

NOTE: *Take the following measurements at three locations, rotating the driveshaft 120° 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 the high point of the shimming tool. Record the measurement.
4. Rotate the driveshaft 120° in a clockwise direction and take another measurement.
5. Repeat this process until three measurements have been recorded.
6. Add the three measurements together and divide the sum by three to get the average pinion gear height. Make note of this average measurement.

Pinion Gear	
Height	0.635 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 all removed components and tighten the retainer to the specified torque.

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

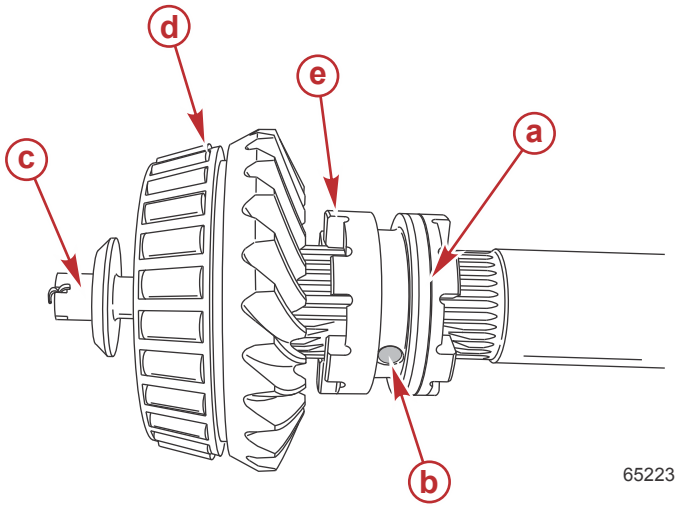
9. Rotate the driveshaft a minimum of three full turns in a clockwise direction. Check the pinion gear height. If the pinion gear clearance is not within specification, adjust the shim thickness and repeat this process until the average pinion gear height is within specification.
10. Verify the driveshaft bearing rolling torque is within specification.

Description	Nm	lb-in.	lb-ft
Driveshaft bearing rolling torque	0.45–1.13	4–10	–

11. Remove the pinion gear locating tool, driveshaft, pinion gear, and front gear.

Propeller Shaft Assembly

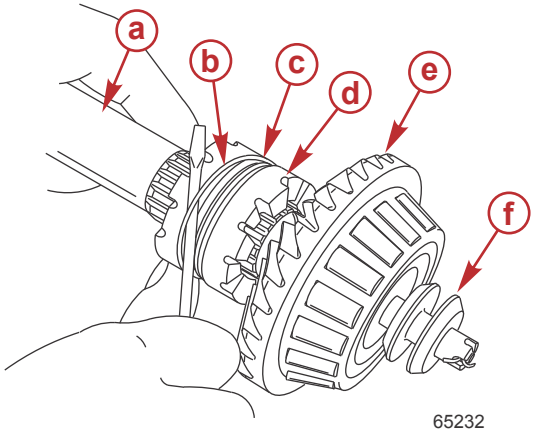
1. Install the sliding clutch onto the propeller shaft so the band on the clutch is facing aft. Align the cross pin holes in the clutch with the slot in the propeller shaft.
2. Assemble the front gear assembly to the propeller shaft.
3. Assemble the shift spool assembly to the propeller shaft, making 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.



- **a -** Clutch band (faces toward rear gear)
- **b -** Cross pin
- **c -** Shift spool and actuating shaft assembly
- **d -** Front gear assembly
- **e -** Clutch

5. 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.

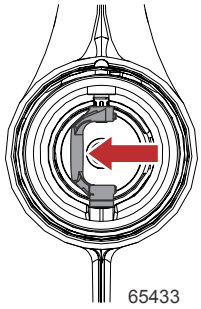
   IMPORTANT: Verify the spring is wound on so that it does not cross over on itself and that it lies flat against the clutch once it is assembled. If it does not lie flat against the clutch, a new spring must be installed.



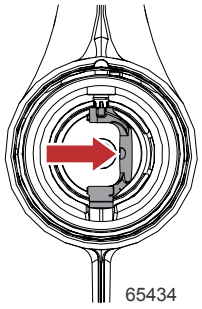
- **a -** Propeller shaft
- **b -** Cross pin retaining spring
- **c -** Cross pin (hidden)
- **d -** Sliding clutch
- **e -** Front gear assembly
- **f -** Shift spool and actuating shaft assembly

Propeller Shaft Installation

1. Verify the shift crank is positioned properly before installing the propeller shaft. The shift crank should face toward the starboard side of the gear housing for right-hand rotation gear housings, and should face toward the port side of the gear housing for left-hand rotation gear housings.



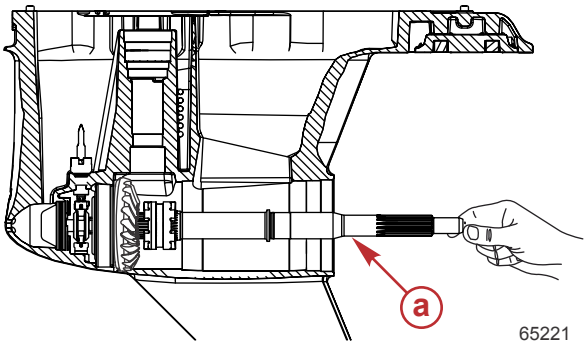
Shift crank position—left-hand rotation



Shift crank position—right-hand rotation

NOTE: *The shift/clutch assembly should be in the neutral position when installing the propeller shaft.*

2. To allow for the engagement of the shift spool with the shift crank, tilt the propeller end of the propeller shaft assembly to the starboard side of the gear housing for right-hand rotation gear housings and to the port side of the gear housing for left-hand rotation gear housings. Hold the shift shaft in neutral while installing the propeller shaft.



a - Propeller shaft

3. Operate the shift shaft to ensure it has been properly installed. On right-hand rotation gear housings, the sliding clutch should move forward when the shift shaft is turned counterclockwise. The sliding clutch should move aft when the shift shaft is turned clockwise. On left-hand rotation gear housings, the sliding clutch should move forward when the shift shaft is turned clockwise. The sliding clutch should move aft when the shift shaft is turned counterclockwise. Hold the shift shaft handle tool in the neutral position, and ensure that the propeller shaft rotates freely in either direction.

Shift Shaft Handle Tool	8M0142973

Driveshaft and Pinion Gear Final Installation

1. Apply Loctite 271 Threadlocker to the threads of the pinion gear nut and place the pinion gear nut into the MR slot of the pinion nut wrench.

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.*

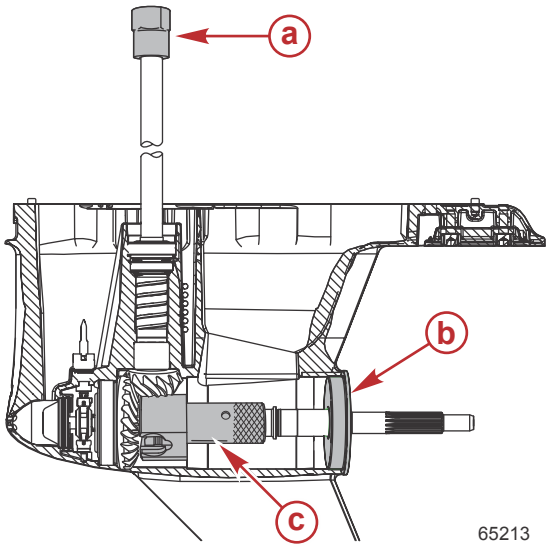
NOTE: *For ease of installation, glue the washer to the pinion gear using 3M Adhesive, Bellows Adhesive, or equivalent.*

Tube Ref No.	Description	Where Used	Part No.
27	Bellows Adhesive	Driveshaft pinion gear washer	92-86166Q1

NOTE: *Do not apply Loctite 271 Threadlocker to the pinion nut until the front gear backlash setting is finalized. Do not reuse the old pinion nut. Install a new pinion nut after backlash is finalized.*

2. Place the pinion gear into the gear housing.
3. With the propeller shaft horizontal, insert the pinion nut wrench with the nut into the gear housing.
4. 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.
5. Start the pinion nut onto the driveshaft threads by rotating the driveshaft until the nut is snug.
6. Install the propeller shaft holder into the gear housing to hold the propeller shaft and the pinion nut wrench in position.

7. Tighten the pinion nut to the specified torque by turning the driveshaft using the driveshaft holding tool and torque wrench.

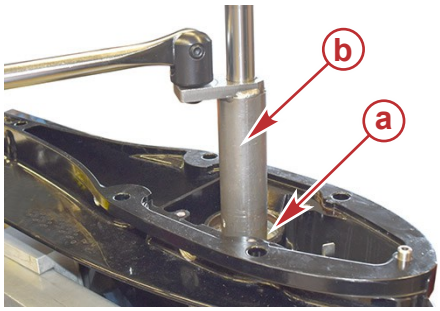


a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut wrench

Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03
Propeller Shaft Holder	8M0075944

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	101.7	–	75

8. Apply 2-4-C with PTFE to the retainer threads and install the retainer. Tighten the retainer to the specified torque.



a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

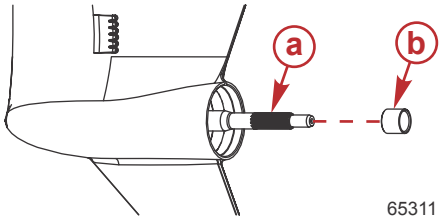
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Retainer threads	92-802859A 1

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

9. Remove the propeller shaft holder, pinion nut wrench, and driveshaft bearing retainer wrench.

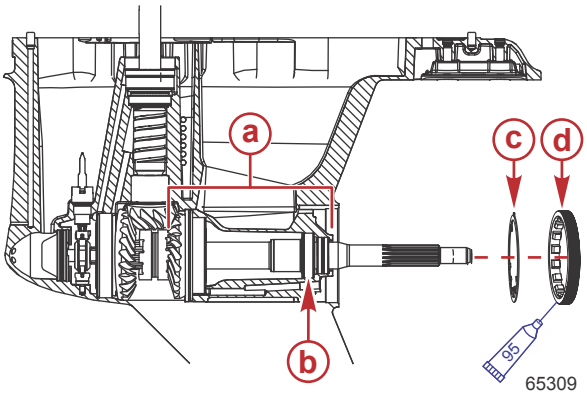
Front Gear Backlash

1. Install the propeller shaft thrust spacer onto the propeller shaft. Do not install the propeller shaft shims at this time.



a - Propeller shaft
b - Thrust spacer

2. Place the bearing carrier assembly into the gear housing. Carefully align the rear propeller shaft tapered bearing with the propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion and rear gears.
3. Lubricate the bearing carrier retainer nut threads with 2-4-C with PTFE. Install the locking tab washer and bearing carrier retainer into the gear housing. Use the bearing carrier retainer nut wrench to thread the retainer on hand-tight.

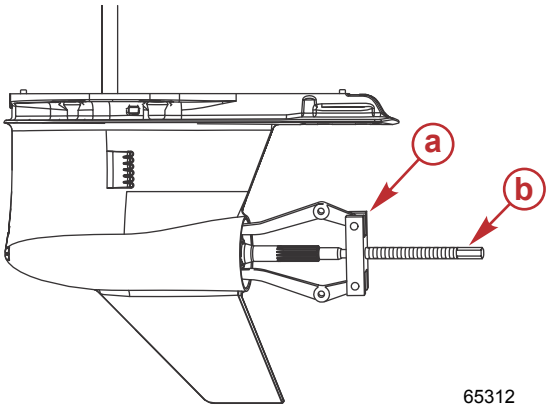


a - Bearing carrier assembly
b - Propeller shaft tapered bearing
c - Locking tab washer
d - Bearing carrier retainer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier retainer nut threads	92-802859A 1

Bearing Carrier Retainer Nut Wrench	8M0057002

4. Apply forward pressure to the propeller shaft as follows:
   a. Install the puller jaws assembly onto the bearing carrier bosses and propeller shaft.
   b. Tighten the puller bolt to the specified torque. Rotate the driveshaft three full turns clockwise and check the puller bolt torque.

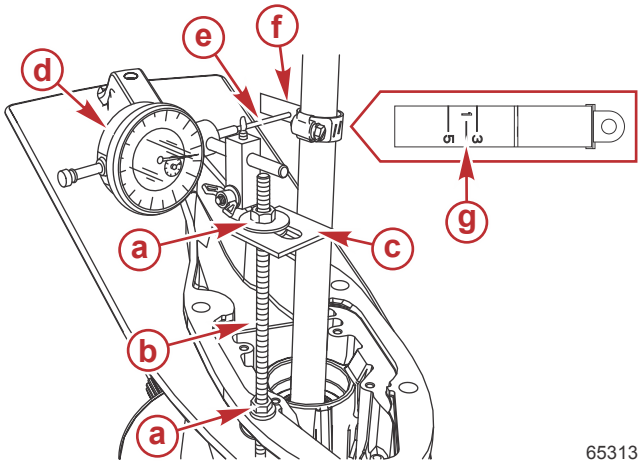


a - Puller jaws assembly
b - Puller bolt

Puller Jaws Assembly	91-46086A1

Description	Nm	lb-in.	lb-ft
Puller bolt	5.6	50	–

5. Install a dial indicator and align the dial indicator pointer so that it is perpendicular to and touching the "1" mark on the dial indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so that the needle in the dial makes 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 tool
- **g -** Backlash indicator tool—1 mark

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Rod	91-8M0053505

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° in a clockwise direction.
   c. Repeat step **b** 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.

   IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "1" mark and are only valid if the pinion height is within specification.

Front Gear Backlash Specification	
Right-hand rotation—forward	0.482–0.660 mm (0.019–0.026 in.)
Left-hand rotation—reverse	1.27–1.47 mm (0.050–0.058 in.)

8. If the backlash is less than the specification, remove shims in front of the front gear bearing cup to obtain the correct backlash.

Example (backlash is too low—right-hand rotation)	
Front gear backlash average specification:	0.56 mm (0.022 in.)
Subtract the front gear backlash measurement:	0.25 mm (0.010 in.)
Remove this quantity of shims:	0.31 mm (0.012 in.)
Provides backlash of:	0.56 mm (0.022 in.)

9. If the backlash is more than the specification, add shims in front of the front gear bearing cup to obtain the correct backlash.

Example (backlash is too high—right-hand rotation)	
Front gear backlash measurement:	1.02 mm (0.040 in.)
Subtract the front gear backlash average specification:	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.)

NOTE: *By adding or subtracting 0.025 mm (0.001 in.) shim, the backlash will change approximately 0.025 mm (0.001 in.).*

10. Remove the puller jaw assembly and puller bolt.
11. When the backlash is within specification, apply Loctite 271 Threadlocker to the threads of a new pinion nut and tighten to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Threads of pinion nut	92-809819

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	101.7	–	75

Rear Gear Backlash

Although reverse gear backlash is not adjustable, it may be checked as follows:

IMPORTANT: Backlash values are only valid if the pinion height is within specification.

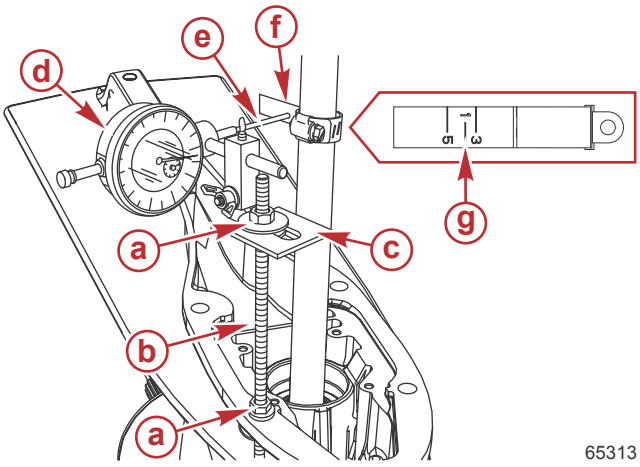
NOTE: *The propeller shaft shims must be removed from the propeller shaft to check the rear gear backlash.*

1. Tighten the bearing carrier retainer nut to the specified torque.

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5	–	100
	Second	285	–	210

NOTE: *Tighten the retainer to 135.5 Nm (100 lb-ft), then check rolling torque on the propeller shaft. If the torque is within specification, tighten the retainer to 285 Nm (210 lb-ft).*

2. Apply backward pressure on the propeller shaft by holding the shift crank against the rear gear.
3. Install a dial indicator and align the dial indicator pointer so that it is perpendicular to and touching the "1" mark on the dial indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so that the needle in the dial makes 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 tool
- **g -** Backlash indicator tool—1 mark

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Rod	91-8M0053505

4. Lightly turn the driveshaft back and forth. This is the amount of backlash. No movement should be noticed at the propeller shaft. Record the amount of backlash.
5. Loosen the indicator tool and rotate the driveshaft 120° clockwise.
6. Align the dial indicator pointer so that it is perpendicular to and touching the "1" mark on the dial indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so that the needle in the dial makes one full revolution and comes to "0" on the dial indicator scale.
7. Lightly turn the driveshaft back and forth. No movement should be noticed at the propeller shaft. Record the amount of backlash. Repeat this for a total of three backlash measurements.
8. Add the three measurements together and divide the sum by three. This is the average rear gear backlash. If rear gear backlash is not within specification, the gear housing is not properly assembled or the parts are excessively worn and must be replaced.

   IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "1" mark and are only valid if the pinion height is within specification.

Rear Gear Backlash Specification	
Right-hand rotation—reverse	1.27–1.47 mm (0.050–0.058 in.)
Left-hand rotation—forward	0.482–0.660 mm (0.019–0.026 in.)

9. Remove the backlash indicator tool. Remove the dial indicator and all of its mounting components.

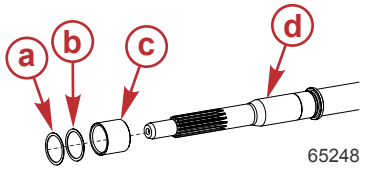
Propeller Shaft Bearing Preload

NOTE: *All gear housing components must be installed and correctly shimmed before checking propeller shaft bearing preload. The propeller shaft tapered roller bearing must be properly seated in the race during installation. The driveshaft retainer should be tightened to the specified torque.*

Description	Nm	lb-in.	lb-ft
Driveshaft retainer	135.5	–	100

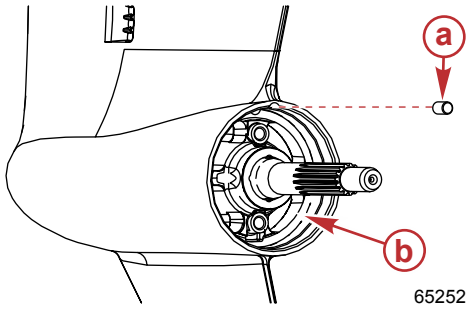
IMPORTANT: Install a maximum of two shims on the propeller shaft to obtain the specified propeller shaft rolling torque. To obtain the specified rolling torque, shims of different thicknesses may have to be interchanged. Do not use a shim thinner than 0.51 mm (0.020 in.).

1. Remove the bearing carrier.
2. Install the new thrust spacer onto the new propeller shaft.
3. Install a shim onto the propeller shaft. Do not use a shim smaller than 0.51 mm (0.020 in.) shim thickness. A maximum of two shims may be installed on the shaft to obtain the specified rolling torque. If two shims are required, install the thinner shim last.



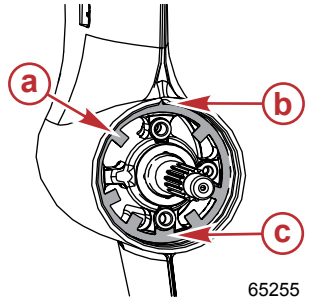
a - Thin shim if required (install onto propeller shaft last)
b - Shim
c - Thrust spacer
d - Propeller shaft

4. Install the bearing carrier, aligning the rear propeller shaft bearing with the propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion gear with the rear gear.
5. Install the locating pin.



a - Locating pin
b - Bearing carrier assembly installed

6. Insert the small rectangular tab of the new 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/drain hole in the bearing carrier.

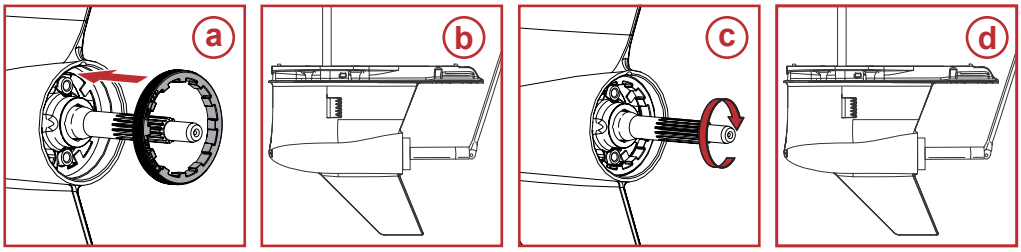


a - Tab washer
b - Rectangular tab
c - U-shaped tab

7. With the gear housing in neutral, install the bearing carrier retainer nut.

   IMPORTANT: Before tightening the bearing carrier retainer nut to the specified torque, the gear housing must be bolted to the driveshaft housing or securely fastened in a gear housing holding fixture to avoid possible damage to the gear housing.
8. Use the bearing carrier retainer nut wrench to tighten the retainer nut to the first specified torque.

9. Rotate the propeller shaft several times to seat the propeller shaft tapered roller bearings in their races.
10. Use the bearing carrier retainer nut wrench to tighten the retainer nut to the final specified torque.



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a - Install bearing carrier retainer nut
b - Tighten to first specified torque
c - Rotate propeller shaft
d - Tighten to final specified torque

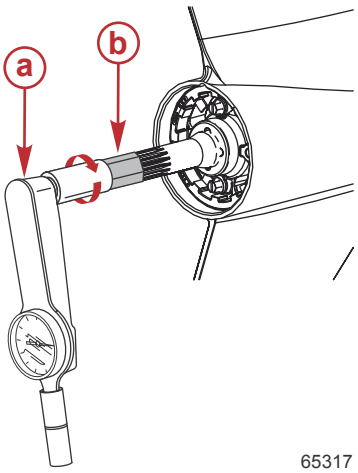
Bearing Carrier Retainer Nut Wrench	8M0057002

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5	–	100
	Final	285	–	210

11. Remove the bearing carrier retainer nut wrench from the propeller shaft.
12. Use the shift shaft handle tool to hold the clutch in the neutral position.

Shift Shaft Handle Tool	8M0142973

13. Install the propeller shaft adapter. Using a torque wrench, rotate the propeller shaft in the direction of normal rotation with a slow steady motion.



65317

a - Torque wrench
b - Propeller shaft adapter

14. Verify the rolling torque is within specification for new or used bearings.

Description	Nm	lb-in.	lb-ft
Bearing rolling torque (new bearings)	1.1–2.0	10–18	–
Bearing rolling torque (used bearings)	0.45–1.1	4–10	–

NOTE: *Bearing preload will change approximately 0.056 Nm (0.5 lb-in.) of rolling torque per 0.025 mm (0.001 in.) of shim change.*

15. If the rolling torque is too high, install a thinner shim on the propeller shaft aft of the thrust spacer. If the torque is too low, install a thicker shim. Be certain the shims are installed aft of the thrust spacer.

IMPORTANT: Install a maximum of two shims on the propeller shaft to obtain the specified propeller shaft rolling torque. To obtain the specified rolling torque, shims of different thicknesses may have to be interchanged. Do not use a shim thinner than 0.51 mm (0.020 in.).

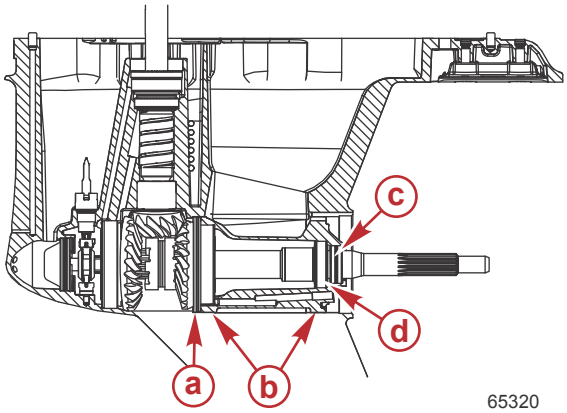
Propeller Shaft/Driveshaft Adapter	91-61077T

NOTE: *If the shims are changed, tighten the bearing carrier retainer nut to the first specified torque. Rotate the propeller shaft several times to seat the propeller shaft tapered bearing. Tighten the retainer nut to the final specified torque. Use the torque wrench to check the rolling torque. Repeat this procedure each time the shims are changed.*

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5	–	100
	Final	285	–	210

Bearing Carrier Final Installation

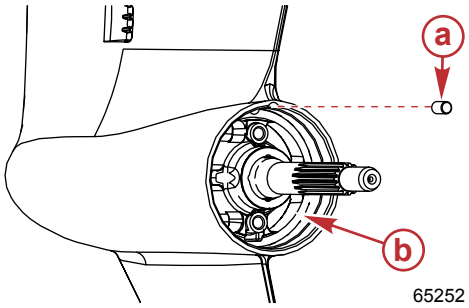
1. Remove the bearing carrier and lubricate the following as specified:
   a. Lubricate the bearing carrier O-ring with 2-4-C with PTFE.
   b. Lubricate both the forward and aft outer diameters of the bearing carrier and gear housing area where the carrier will seat with 2-4-C with PTFE.
   c. Fill the space between the propeller shaft seals with 2-4-C with PTFE.



a - O-ring
b - Forward and aft outer diameters of bearing carrier
c - Propeller shaft seals
d - Propeller shaft bearing

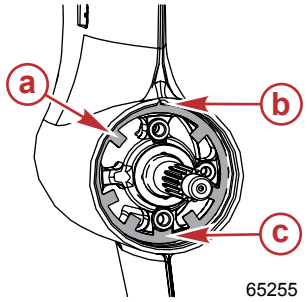
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier O-ring, forward and aft outer diameters of bearing carrier, gear housing area where carrier will seat, space between propeller shaft seals	92-802859A 1

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 gear and the rear gear.
3. Install the bearing carrier locating pin.



a - Locating pin
b - Bearing carrier assembly installed

4. Insert the small rectangular tab of the tab washer into its corresponding slot in the gear housing 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/drain hole in the bearing carrier.



a - Tab washer
b - Rectangular tab
c - U-shaped tab

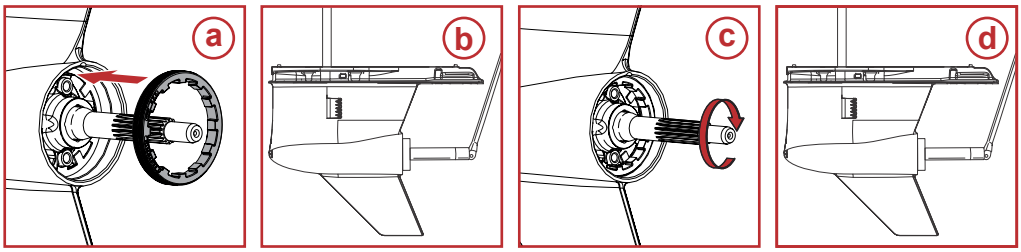
5. Apply 2-4-C with PTFE to the bearing carrier retainer nut threads and the corresponding gear housing threads. Install the retainer into the gear housing hand-tight.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier retainer nut threads and corresponding gear housing threads	92-802859A 1

IMPORTANT: Before tightening the bearing carrier retainer nut to the specified torque, the gear housing must be bolted to the driveshaft housing or securely fastened in a gear housing holding fixture to avoid possible damage to the gear housing.

NOTE: *Tighten the retainer nut to the first specified torque. Rotate the propeller shaft several times to seat the tapered roller bearings. The retainer nut can then be tightened to the final specified torque.*

6. Use the bearing carrier retainer nut wrench to tighten the bearing carrier retainer nut to the specified torque. If one tab does not align between two of the notches, continue to tighten the retainer until alignment is achieved. Do not loosen the retainer to achieve alignment.



a - Install bearing carrier retainer nut hand-tight
b - Tighten to first specified torque
c - Rotate propeller shaft
d - Tighten to final specified torque

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5	–	100
	Final	285	–	210

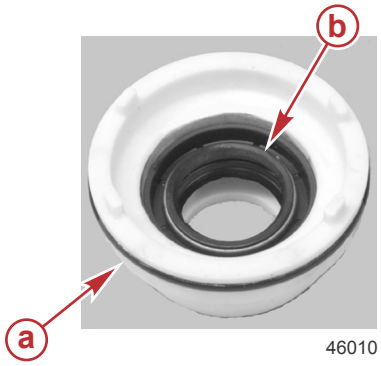
Bearing Carrier Retainer Nut Wrench	8M0057002

7. Remove the bearing carrier retainer nut wrench from the propeller shaft.
8. Bend one tab of the tab washer aft (outward) into a space between two of the notches of the retainer. Bend all the remaining tabs forward (inward).

Oil Seal Carrier Installation

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 PTFE.



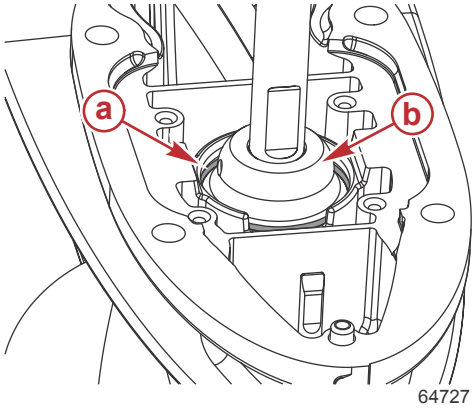
a - O-ring
b - Oil seal lips

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal carrier oil seal lips, space between the seals, and the O-ring	92-802859A 1

2. Install the oil seal carrier over the driveshaft and into the gearcase.

   NOTE: *The oil seal carrier may be lightly tapped into position by sliding the driveshaft bearing retainer wrench over the driveshaft.*

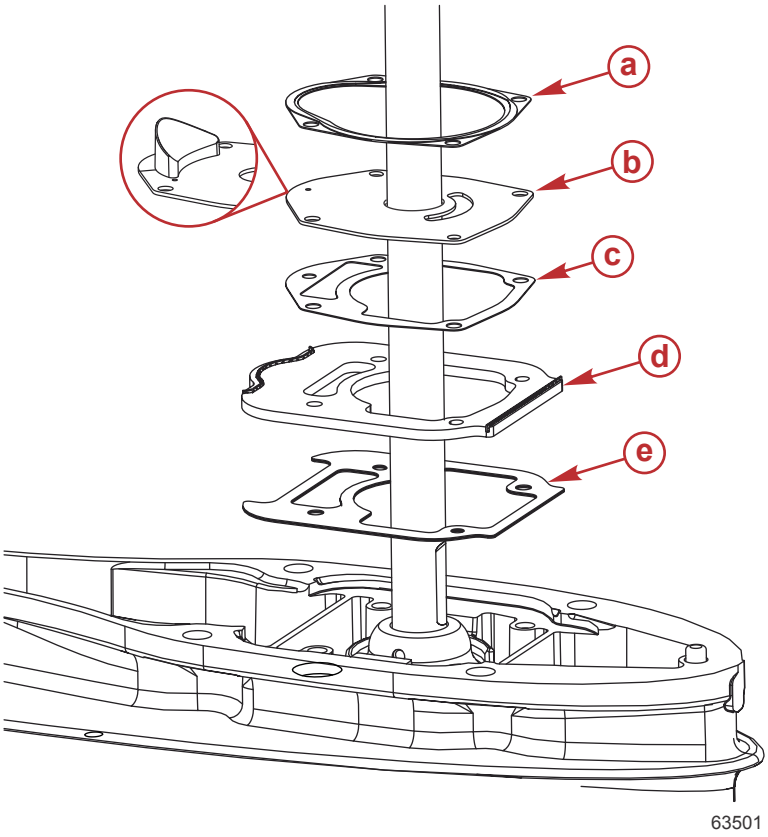
3. Install the retaining ring above the oil seal carrier.



a - Retaining ring
b - Oil seal carrier

Water Pump Installation

1. Install the lower gasket, top cover, rubber-coated stainless steel gasket, faceplate, and top beaded gasket.



a - Beaded gasket
b - Faceplate

NOTE: *Early models were equipped with a faceplate deflector. The deflector is no longer required.*

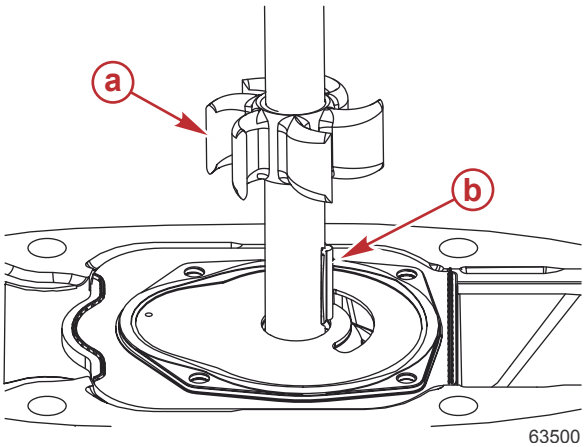
c - Rubber-coated stainless steel gasket
d - Top cover
e - Gasket

2. Apply a small amount of 2-4-C with PTFE onto the flat surface of the impeller key and install the key onto the driveshaft keyway.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Flat surface of impeller key	92-802859A 1

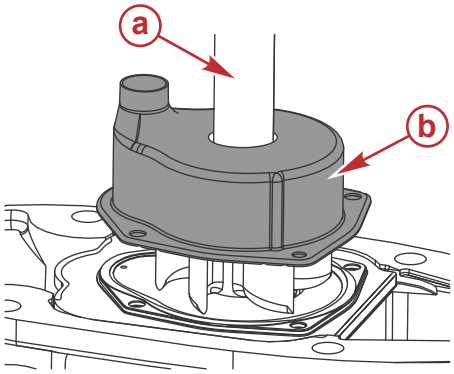
3. Install the water pump impeller onto the driveshaft and over the impeller key.

IMPORTANT: Do not install a used impeller with the blades oriented in a reversed direction from the original rotation. Premature impeller failure will occur.



a - Impeller
b - Impeller key

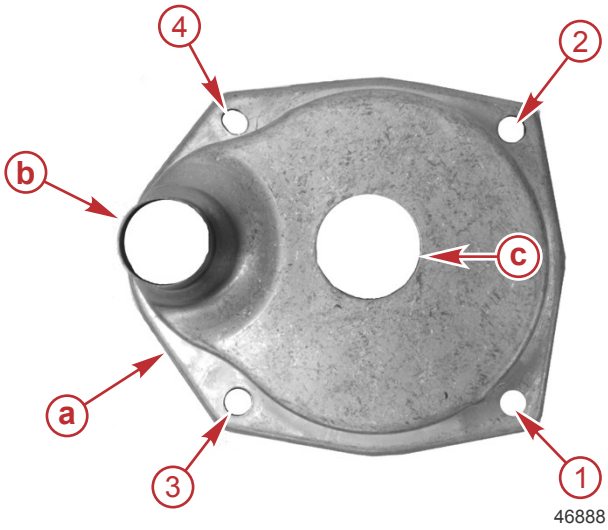
4. Apply 2-4-C with PTFE to the inside of the water pump cover. Position the water pump cover over the driveshaft. Rotate the driveshaft in a clockwise direction while pushing down on the water pump cover.



a - Rotate driveshaft clockwise
b - Water pump cover

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Inside of the water pump cover	92-802859A 1

5. Apply Loctite 271 Threadlocker to each water pump screw, and install the four screws into the water pump housing. Tighten the screws in the sequence shown to the specified torque.



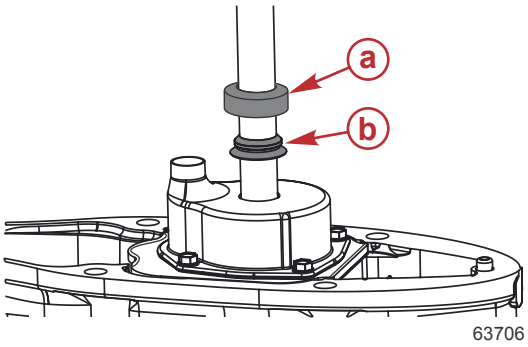
a - Water pump cover
b - Water outlet
c - Driveshaft access hole

Description	Nm	lb-in.	lb-ft
Water pump screws	6.8	60	–

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Water pump screws	92-809819

6. Install the driveshaft seal and use the tool provided in the seal kit or the water pump kit to press the seal down.

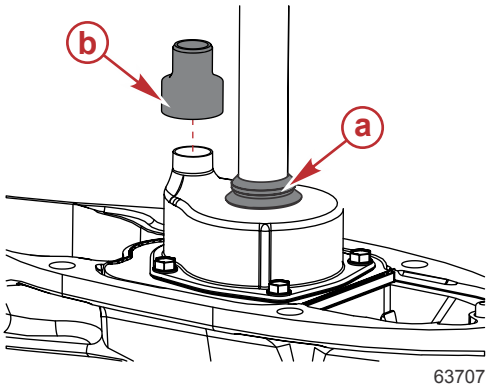
IMPORTANT: If the driveshaft seal is not installed at the proper height, air will be drawn into the water pump, causing the engine to overheat.



a - Driveshaft seal installation tool
b - Driveshaft seal

Driveshaft Seal Installation Tool	91-818769

7. If the tool is not available, press the seal against the water pump housing until the height of the seal is 11.1 ± 0.3 mm (0.437 ± 0.012 in.).



a - Driveshaft seal
b - Water seal coupler

IMPORTANT: After the water pump is installed, do not rotate the driveshaft counterclockwise.

8. Apply 2-4-C with PTFE to the O-ring in the water seal coupler. Install the water seal coupler onto the water pump cover.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Water seal coupler O-ring	92-802859A 1

Checking Gear Housing Operation

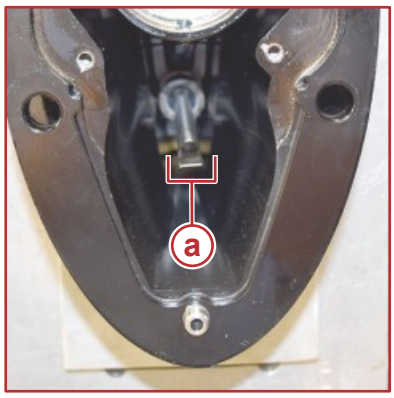
Prior to filling the gear housing with lubricant, check the gear housing for proper shift operation, as follows:

NOTE: *Rotate the driveshaft in a clockwise direction while performing these tests.*

Right-Hand Rotation

1. Rotate the shift shaft counterclockwise to the forward motion position. The propeller shaft should rotate clockwise and then lock.
2. Rotate the shift shaft clockwise to the reverse motion position. The propeller shaft should rotate counterclockwise and then lock.

3. Rotate the shift shaft to a point halfway between the forward and reverse motion position. This should be the neutral position. The propeller shaft should rotate freely both clockwise and counterclockwise.



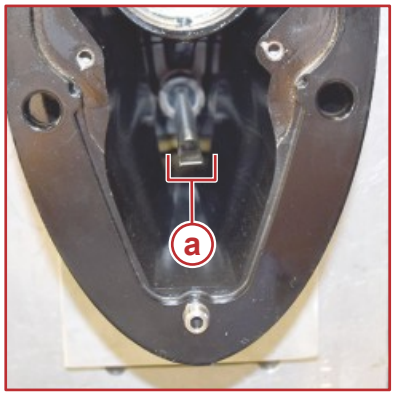
65169

a - Shift shaft in neutral position

IMPORTANT: If the shifting operation is not as described, the gear housing must be disassembled and the shift crank reversed. Refer to Shift Shaft Installation.

Left-Hand Rotation

1. Rotate the shift shaft counterclockwise to the forward motion position. The propeller shaft should rotate counterclockwise and then lock.
2. Rotate the shift shaft clockwise to the reverse motion position. The propeller shaft should rotate clockwise and then lock.
3. Rotate the shift shaft to a point halfway between the forward and reverse motion position. This should be the neutral position. The propeller shaft should rotate freely both clockwise and counterclockwise.



65169

a - Shift shaft in neutral position

IMPORTANT: If the shifting operation is not as described, the gear housing must be disassembled and the shift crank reversed. Refer to Shift Shaft Installation.

NOTE: *Before installing the gear housing to the driveshaft housing, check for any leaks. Refer to* ***Gear Housing Pressure Test*** *for instructions.*

Gear Housing Installation

⚠ WARNING

Accidental starting can cause serious injury. Before removing or installing the gear housing, disconnect and isolate the spark plug leads. Disable the ignition system by removing the keys from the ignition (if equipped) and engaging the lanyard stop switch to prevent the engine from starting.

1. Lubricate the splines of the driveshaft with Extreme Grease. Do not allow lubricant on top of the shift shaft or driveshaft.

NOTICE

Installing the gear housing to the powerhead without adequately cleaning the top of the driveshaft can result in severe product damage. Any lubricant trapped in the space between the driveshaft and the crankshaft prevent the two from properly engaging. Always clean the top of the driveshaft before installing the gear housing.

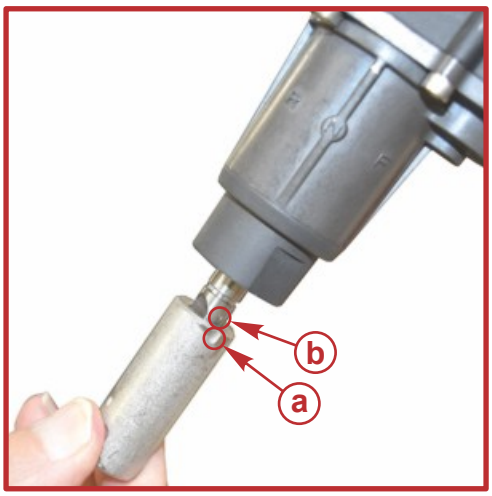
Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Shift shaft splines and driveshaft splines	8M0071842

2. On right-hand rotation gearcases, use the shift shaft tool to rotate the shift shaft counterclockwise into the front (forward) gear. For left-hand rotation gearcases, use the shift shaft tool to rotate the shift shaft clockwise into the front (reverse) gear.

   NOTE: *It may be necessary to rotate the propeller shaft to ensure that the clutch is engaged.*

Shift Shaft Handle Tool	8M0142973

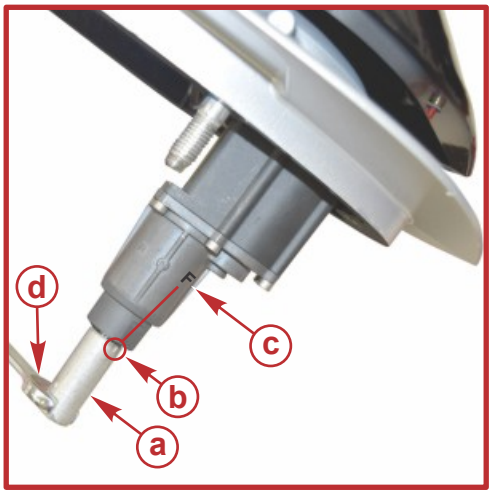
3. Ensure that the notch on the shift shaft coupler aligns with the notch on the shift actuator output shaft.



65132

a - Notch on shift actuator coupler
b - Notch on shift actuator output shaft

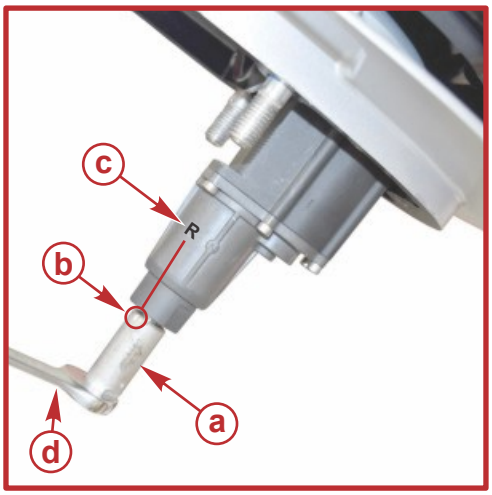
4. On right-hand rotation gearcases, use a 15 mm wrench to rotate the shift actuator coupler so the notch on the coupler is aligned with the "F" marking on the shift actuator. For left-hand rotation gearcases, use a 15 mm wrench to rotate the shift actuator coupler so the notch on the coupler is aligned with the "R" marking on the shift actuator.



65127

Right-hand rotation models

a - Shift actuator coupler
b - Tab on shift actuator coupler
c - "F" marking on shift actuator
d - Wrench



65128

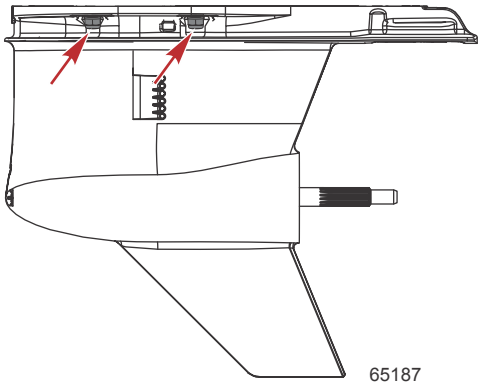
Left-hand rotation models

a - Shift actuator coupler
b - Tab on shift actuator coupler
c - "R" marking on shift actuator
d - Wrench

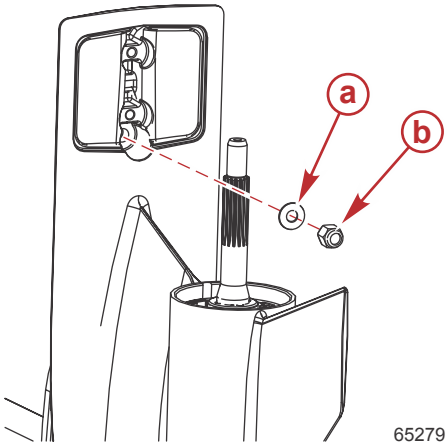
5. Position the gear housing so the driveshaft is protruding into the driveshaft housing.
6. Move the gear housing up toward the driveshaft housing while aligning the water pump coupler to the water tube and the shift shaft into the shift shaft actuator coupler.

   NOTE: *If the driveshaft splines will not align with the crankshaft splines, rotate the propeller shaft slightly to reposition the splines.*

7. Secure the gear housing assembly to the driveshaft housing with four side mounting locknuts and washers; two on each side. Do not fully tighten the nuts at this time.



8. Install the nut and washer on the underside of the anti-ventilation plate, inside of the anode plate recess. Do not fully tighten the nut at this time.

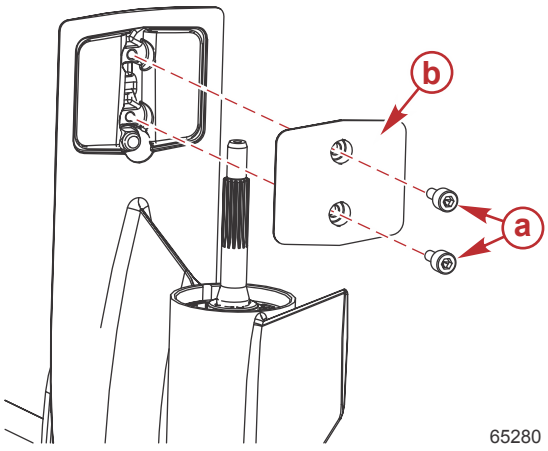


a - Washer
b - Nut

9. Check the shift shaft spline engagement and correct if necessary.
10. Evenly tighten the four side mounting locknuts, and the nut on the underside of the anti-ventilation plate to the specified torque.

Description	Nm	lb-in.	lb-ft
Side mounting locknuts (4), and nut on underside of anti-ventilation plate (1)	60	–	44

11. Install the anode plate on the underside of the anti-ventilation plate. Using a 10 mm hex, tighten the two screws to the specified torque.



a - Anode plate screws
b - Anode plate

Description	Nm	lb-in.	lb-ft
Anode plate screws	54.23	–	40

Gear Lubricant Filling Instructions

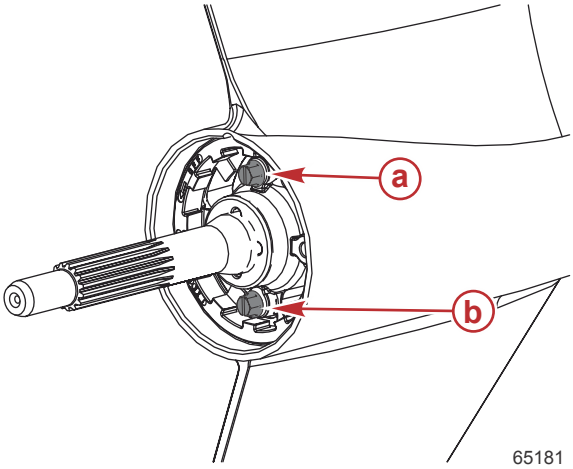
NOTE: *After the gear housing has been serviced, perform a pressure test prior to filling with lubricant. Refer to* ***Gear Housing Pressure Test*** *for instructions.*

1. Remove the vent plug from the gear housing.
2. Remove the fill plug from the gear housing.
3. Inspect the fill and vent plug sealing washers for cuts or abrasions. Replace the washers if necessary.

   IMPORTANT: Never add lubricant to the gear housing without removing the vent plug. The gear housing cannot be filled if the vent plug is not removed because of trapped air. Fill the gear housing only when the housing is in a vertical position.
4. Slowly fill the housing through the fill hole with High Performance Gear Lubricant until the lubricant flows out of the vent hole and no air bubbles are visible.
5. Install the vent plug into the vent hole.

   IMPORTANT: Do not lose more than 15 cc (0.5 fl oz) of gear lubricant while installing the fill plug.
6. Remove the fill tube or hose from the fill hole and quickly install the fill plug into the fill hole. Tighten the fill and vent plugs to the specified torque.

   NOTE: *Some early model right-hand 4.8 in. bearing carriers may have the vent located at the three o'clock position. These models will require a slightly lower volume of gear lubricant.*



a - Vent plug
b - Fill plug

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 plugs	11.3	100	–

Gear Housing

Section 6B - Right-Hand and Left-Hand Rotation (5.44 in. Diameter)

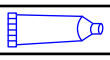
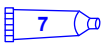
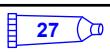
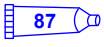
Table of Contents

Gear Housing Specifications (5.44 in. Diameter)

Description	Specification
Propeller shaft	31.75 mm (1.25 in.) diameter, 19-spline
Propeller hub	
Option 1	Flo-Torq II HD solid hub kit
Option 2	Flo-Torq SSR HD hub kit
Gear ratio	
Standard	1.75:1
Optional	1.85:1
Gear teeth count pinion/forward	
1.75:1	12/21
1.85:1	13/24
Gear housing lubricant capacity	
Right-hand	720 ml (24.4 fl oz)
Left-hand	680 ml (23.0 fl oz)
Right-hand—SeaPro	980 ml (33.1 fl oz)
Left-hand—SeaPro	980 ml (33.1 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Propeller shaft lubricant	2-4-C with PTFE
Propeller shaft runout limit (bent)	0.23 mm (0.009 in.)
Propeller shaft end play	No end play
Pinion height tool (optional)	91-8M0046443
Pinion height	0.635 mm (0.025 in.)
Backlash indicator tool	8M0053505
Align dial indicator pin with mark	5
Front gear backlash—right-hand rotation (forward gear)	0.508–0.609 mm (0.020–0.024 in.)
Front gear backlash—left-hand rotation (reverse gear)	0.787–0.965 mm (0.031–0.038 in.)
Rear gear backlash—right-hand rotation 1.75:1 (reverse gear)	0.787–0.940 mm (0.031–0.037 in.)
Rear gear backlash—right-hand rotation 1.85:1 (reverse gear)	1.067–1.219 mm (0.042–0.048 in.)
Rear gear backlash—left-hand rotation (forward gear)	0.457–0.584 mm (0.018–0.023 in.)
Water pressure	
At 600 RPM (idle)	10–20 kPa (1.5–2.9 psi)
At 6000 RPM (WOT)	60–260 kPa (8.7–37.7 psi)
Gear housing leak test pressure (without gear lubricant, 5 minutes without leakage)	103.4 kPa (15 psi)

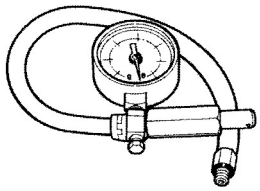
IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "5" mark and are only valid if the pinion height is within specification.

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Shift shaft splines and driveshaft splines	8M0071842
	Loctite 271 Threadlocker	Pinion gear nut threads	92-809819
		Threads of pinion nut	
		Water pump screws	
	Bellows Adhesive	Driveshaft pinion gear washer	92-86166Q1
	High Performance Gear Lubricant	Tapered bearing cup bore	92-858064K01
		Inside diameter of the driveshaft tapered bearings	
		Inside diameter of front gear	
		Front gear bearing cup bore	
		Gearcase pinion bearing bore	
		Gear housing	

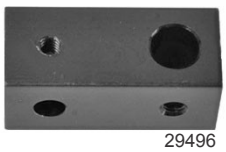
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1
		O-ring	
		O-ring and bearing carrier bores	
		Shift shaft bushing threads, O-ring, and oil seal lip	
		Retainer threads	
		Bearing carrier retainer nut threads	
		Bearing carrier O-ring, forward and aft outer diameters of bearing carrier, gearcase area where bearing carrier will seat, space between propeller shaft oil seals	
		Bearing carrier retainer nut threads and corresponding gear housing threads	
		Torpedo ring threads	
		Oil seal carrier oil seal lips, space between the seals, and the O-ring	
		Flat surface of impeller key	
		Inside of the water pump cover	
		Water seal coupler O-ring	

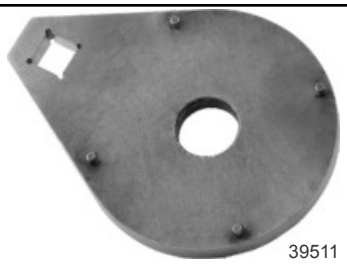
Special Tools

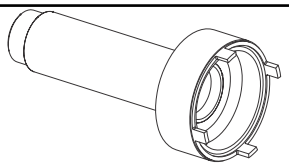
Leakage Tester Kit	FT8950
 29497	Used for pressure testing of closed systems (gearcase, fuel lines, cooling).

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.

Torpedo Ring Installation Tool	91-8M0039309
 39511	Installs torpedo ring

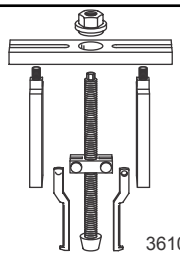
Bearing Carrier Retainer Nut Tool	91-8M0046632
 46139	Aids in the removal and installation of the bearing carrier retainer

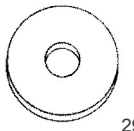
Puller Jaws Assembly	91-46086A1
 9514	Removes bearing carrier and bearing races; use with Puller Bolt (91-85716)

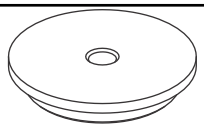
Slide Hammer	91-34569A 1
 6761	Aids in the removal of various engine components. Use with puller jaws.

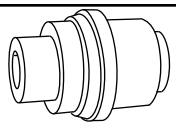
Universal Puller Plate	91-37241
 8505	Removes bearings from gears and the driveshaft

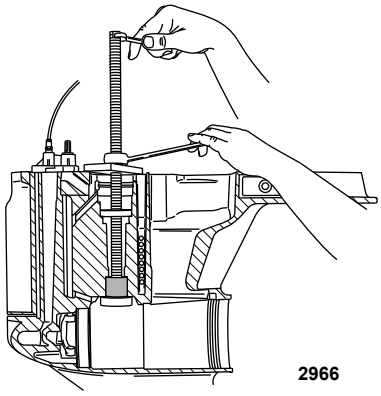
Torch Lamp	91- 63209
 8776	Heats surfaces to aid in the removal and installation of interference fit engine components.

Bearing Puller Assembly	91- 83165T
 3610	Removes bearings, races and bearing carriers

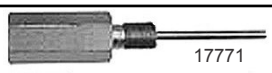
Pilot Washer	91-36571T
 29490	Used in pinion gear and pinion bearing installation

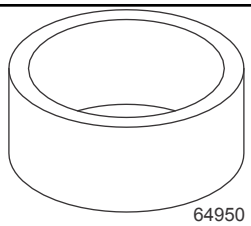
Bearing Carrier Guide Plate	8M0142624
 64953	Aids in the installation of bearing carrier seals and propeller shaft tapered bearing race. Tool ID number 8M0138782.

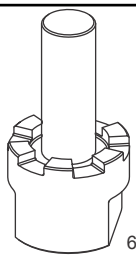
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
 6229	Installs bearing carrier cup and seals.

Bearing Removal and Installation Kit	91- 31229A 7
 2966	Installs and removes the bearings in all gearcases 91- 31229A 7 tool assembly includes the following components: 11- 24156 Hex Nut 12- 34961 Washer 91- 15755T Bearing Carrier 91- 29310 Plate 91- 30366T 1 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- 37312T Driver Head 91- 37323 Driver Head Rod 91- 37324T Pilot Washer 91- 37350T Pilot Mandrel 91- 38628T Puller/Driver Head 91-52393T Driver Needle Bearing 91-52394 Head Pull Rod

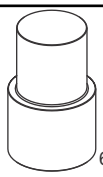
Collet	Snap-On CG-45-7
 64360	Used to remove bearings or gears. Use with Snap-On Expanding Rod (CG-45-4).

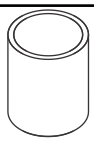
Expanding Rod	Snap-On CG45-4
 17771	Aids in the removal of the bearings or gears. Use with Snap-On Collet.

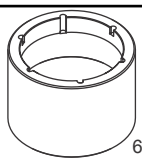
Press Spacer Mandrel	8M0142615
 64950	Used to hold bearing carrier and universal puller plate on a press. Tool ID number 8M0138781.

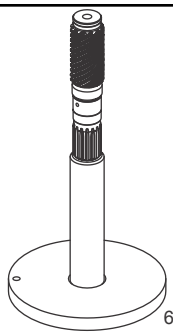
Gear Assembly Holding Fixture	8M0142559
 64364	Insert into vise to hold forward (rear) gear. Tool ID number 8M0133013.

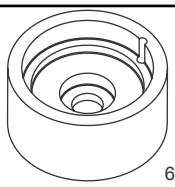
Retaining Nut Wrench	91-8M0070085
 55843	Install locknut onto forward gear hub

Bearing Mandrel	8M0142636
 64981	Used to press gear out of bearings and cone. Tool ID number 8M0139065.

Rear Gear Bearing Cone Mandrel	8M0142413
 64952	Used to press in the rear gear bearing cones. Tool ID number 8M0138783.

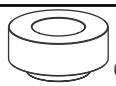
Preload Driver Alignment Tool	8M0142970
 64372	Aligns bearings and spacers during press and torque actions. Tool ID number 8M0125728.

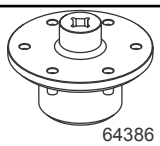
Threaded Shaft Tool	8M0142983
 64384	Holds bearing carrier upright and aids in turning rear gear bearing assembly when pressing into the bearing carrier. Tool ID number 8M0132747.

Press Fixture Base Tool	8M0142976
 64383	Holds threaded shaft tool and secures bearing carrier to prevent movement when pressing rear gear bearing assembly into the bearing carrier. Tool ID number 8M0132742.

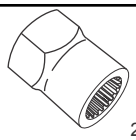
Threaded Clutch Assembly Tool	8M0145393
 64381	Engages with clutch jaws to rotate the gear as it is being pressed into the bearing carrier. Tool ID number 8M0132921.

Bearing Tool	31-861792
 64385	Allows the press fixture retainer tool to spin while pressing the gear into the bearing carrier.

Press Fixture Retainer Tool	8M0142974
 64382	Presses into bearing tool surface to aid in spinning while the gear is pressed into the bearing carrier. Tool ID number 8M0132707.

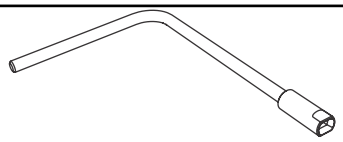
Gear Assembly Driver Tool	8M0142414
 64386	Used to check bearing carrier rolling torque. Tool ID number 8M0138814.

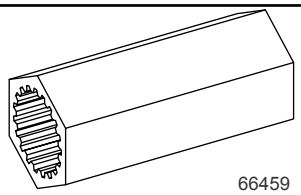
Driveshaft Bearing Retainer Wrench	91-43506T
 9520	Removes and installs the threaded bearing retainer

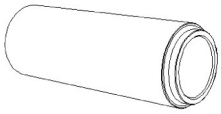
Driveshaft Holding Tool	91-889958T
 28677	Holds driveshaft during pinion nut removal on the Verado models

Pinion Nut Holder	91-8M0036288
 39509	For torquing pinion nut.

Propeller Shaft Holder	91-8M0035594
 39510	Stabilizes propshaft

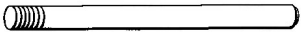
Shift Shaft Handle Tool	8M0142973
 63932	Used to rotate gear housing shift shaft. Tool ID number 8M0127025.

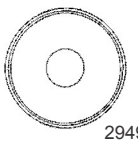
Propeller Shaft Adapter	8M0147118
 66459	Provides a hex surface to turn the propeller shaft. Tool ID number 8M0145218.

Driveshaft Bearing Installation Tool	91-8M0052590
 47416	Install upper and lower driveshaft bearings

Shift Shaft Tool	8M0142969
 63663	Aids in removal or installation of the shift shaft. Tool ID number 8M0120169.

Pinion Bearing Removal Tool	91-8M0046348
 46152	Removes pinion bearing

Driver Rod	91- 37323
 25431	Aids in the removal and installation of various bearings and bearing races

Bearing Cup Driver	91-885592T
 29492	Installs front gear bearing cup

Pinion Bearing Installation Tool	91-8M0046360
 46153	Installs pinion bearing

Pinion Gear Locating Tool	91-8M0046443
 46157	Sets pinion location

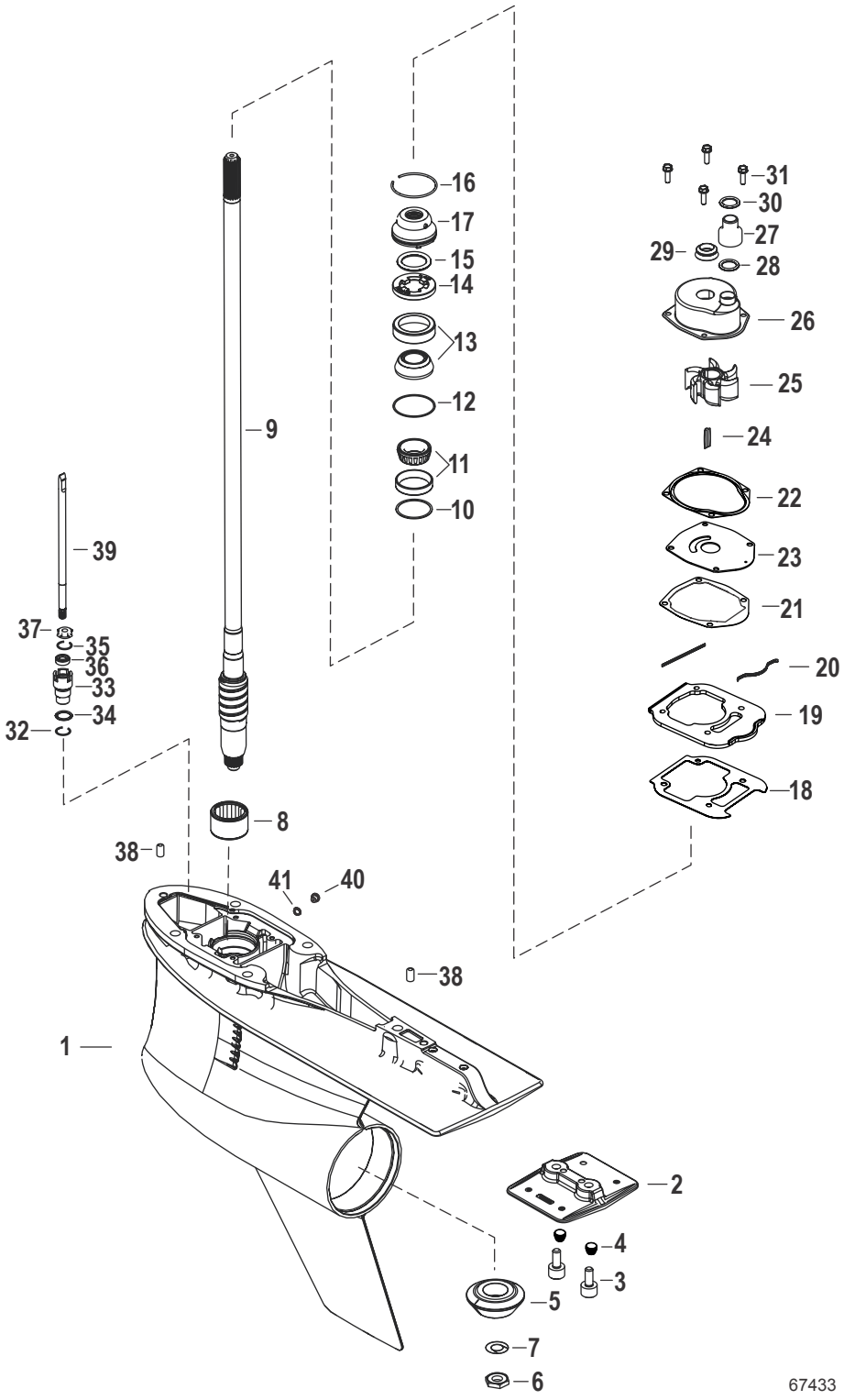
Bearing Carrier Installation Tool	91-8M0059911
 9518	Protects the seals when installing the bearing carrier on 19 spline (1-1/4 inch) propeller shaft. (Part of assembly 91-840393A1)

Backlash Indicator Tool	91-8M0053505
 46158	Aids in checking gear backlash

Driveshaft Seal Installation Tool	91-818769
 47536	Sets driveshaft seal height

Gear Housing Components

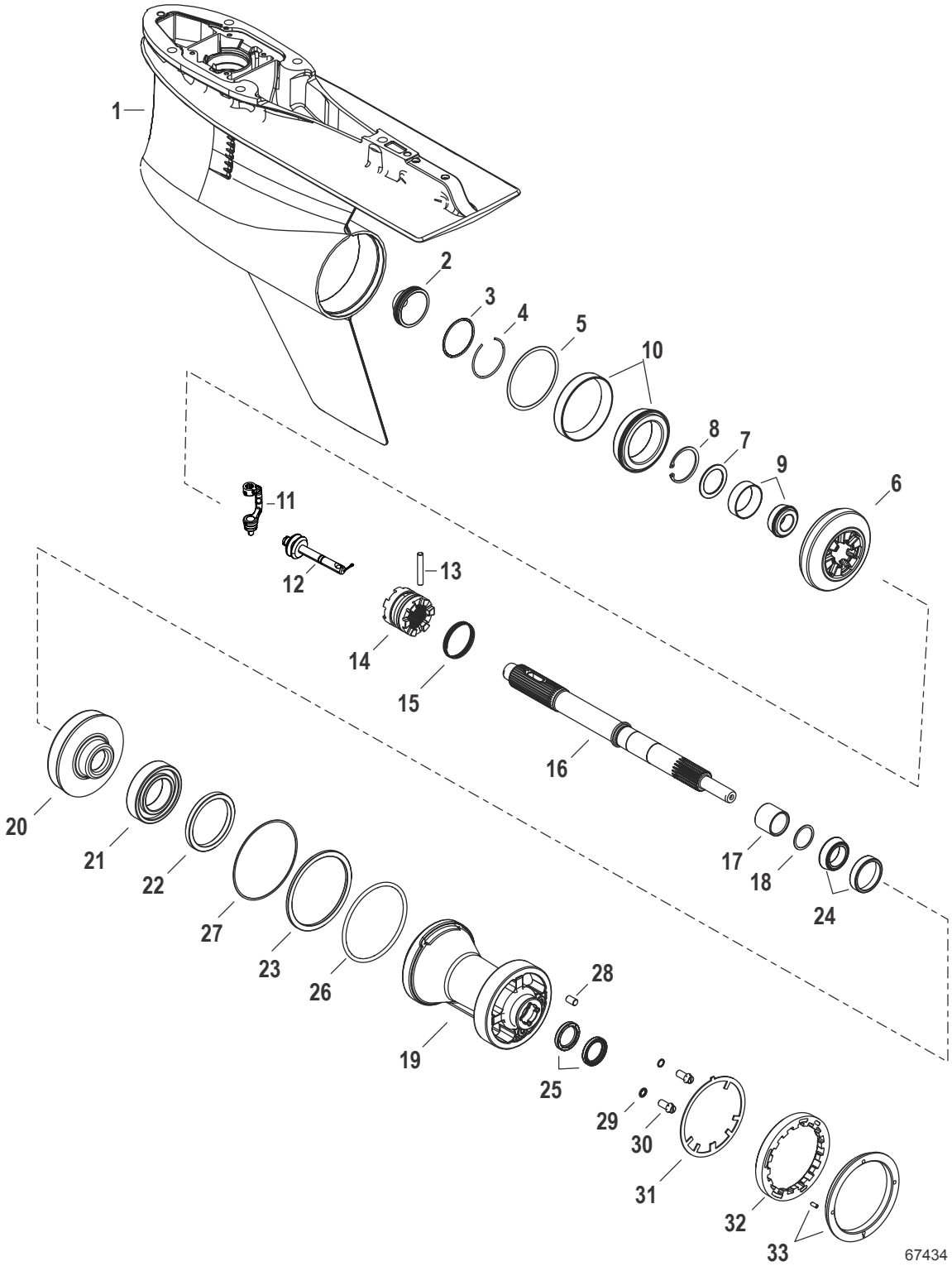
Gear Housing (5.44 in. Diameter)—Driveshaft



Gear Housing (5.44 in. Diameter)—Driveshaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing assembly			
2	1	Anode			
3	2	Screw	54.2	–	40
4	2	Plug			
5	1	Pinion gear			
6	1	Pinion nut	169.5	–	125
7	1	Pinion washer			
8	1	Bearing assembly			
9	1	Driveshaft			
10	1	Shim			
11	1	Bearing assembly			
12	1	Shim			
13	1	Bearing assembly			
14	1	Retainer	135.5	–	100
15	1	O-ring			
16	1	Retaining ring			
17	1	Oil seal assembly			
18	1	Gasket			
19	1	Top cover			
20	2	Seal			
21	1	Rubber-coated stainless steel gasket			
22	1	Beaded gasket			
23	1	Faceplate			
24	1	Key			
25	1	Impeller			
26	1	Water pump housing			
27	1	Water pump coupler			
28	1	O-ring			
29	1	Face seal			
30	1	O-ring			
31	4	Screw	6.8	60	–
32	1	Retaining ring			
33	1	Shift shaft bushing	54.2	–	40
34	1	O-ring			
35	1	Retaining ring			
36	1	Oil seal			
37	1	Rubber grommet			
38	2	Dowel pin			
39	1	Shift shaft—XL shown			
40	2	Plug	11.3	100	–
41	2	Seal			

Gear Housing (5.44 in. Diameter, Right-Hand Rotation)—Propeller Shaft

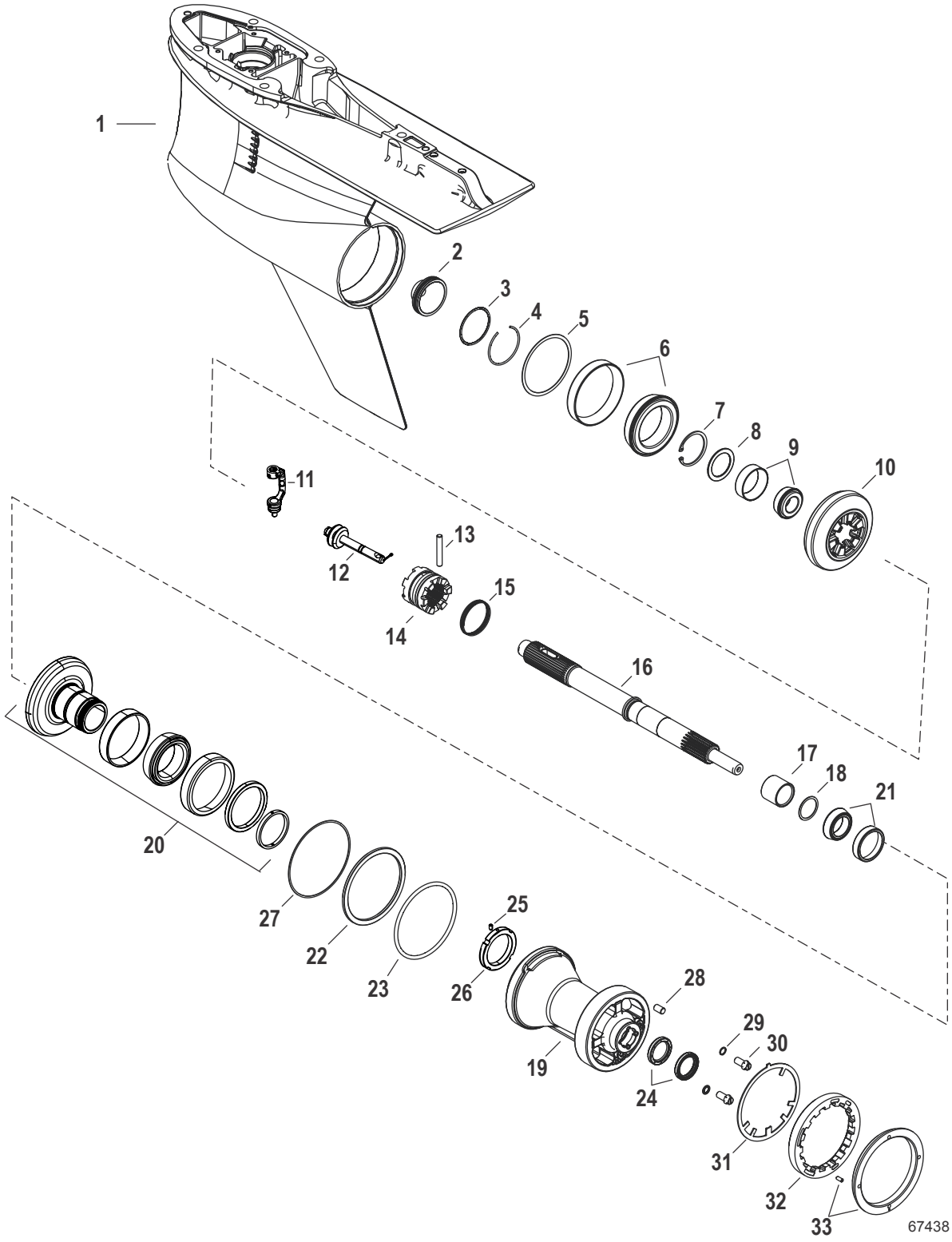


Gear Housing (5.44 in. Diameter, Right-Hand Rotation)—Propeller Shaft

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	1	Gear housing assembly				
2	1	Torpedo plug				
3	1	O-ring				
4	1	Retaining ring				
5	1	Shim				
6	1	Front (forward) gear				
7	1	Thrust washer				
8	1	Retaining ring				
9	1	Tapered roller bearing				
10	1	Tapered roller bearing				
11	1	Shift crank				
12	1	Spool				
13	1	Pin				
14	1	Clutch				
15	1	Spring				
16	1	Propeller shaft				
17	1	Spacer				
18	1	Washer				
19	1	Bearing carrier				
20	1	Rear (reverse) gear				
21	1	Bearing				
22	1	Spacer				
23	1	Thrust ring				
24	1	Bearing assembly				
25	2	Oil seal				
26	1	O-ring				
27	1	Shim				
28	1	Pin				
29	2	Seal				
30	2	Fill and vent plugs		11.3	100	–
31	1	Tab washer				
32	1	Bearing carrier retainer		285[1.]	–	210[1.]
33	1	Cover kit	Torpedo ring	68	–	50
			Set screw	2.8	25	–

1. Tighten retainer to 135.5 Nm (100 lb-ft), then check rolling torque on propeller shaft. If torque is within specification, tighten retainer to 285 Nm (210 lb-ft). Rotate the retainer an additional 3.8 cm (1.5 in.) per the instructions in the **Bearing Carrier Final Installation** procedure.

Gear Housing (544 in. Diameter, Left-Hand Rotation)—Propeller Shaft



Gear Housing (544 in. Diameter, Left-Hand Rotation)—Propeller Shaft

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	1	Gear housing assembly				
2	1	Torpedo plug				
3	1	O-ring				
4	1	Retaining ring				
5	1	Shim				
6	1	Tapered roller bearing assembly				
7	1	Retaining ring				
8	1	Thrust washer				
9	1	Tapered roller bearing assembly				
10	1	Front (reverse) gear				
11	1	Shift crank				
12	1	Spool				
13	1	Pin				
14	1	Clutch				
15	1	Spring				
16	1	Propeller shaft				
17	1	Spacer				
18	1	Washer				
19	1	Bearing carrier				
20	1	Rear (forward) gear				
21	1	Bearing assembly				
22	1	Thrust ring				
23	1	O-ring				
24	2	Oil seal				
25	1	Screw				
26	1	Locknut				
27	1	Shim				
28	1	Pin				
29	2	Seal				
30	2	Fill and vent plugs		11.3	100	–
31	1	Tab washer				
32	1	Bearing carrier retainer		285[1.]	–	210[1.]
33	1	Cover kit	Torpedo ring	68	–	50
			Set screw	2.8	25	–

1. Tighten retainer to 135.5 Nm (100 lb-ft), then check rolling torque on propeller shaft. If torque is within specification, tighten retainer to 285 Nm (210 lb-ft). Rotate the retainer an additional 3.8 cm (1.5 in.) per the instructions in the **Bearing Carrier Final Installation** procedure.

General Service Recommendations

There may be more than one way to disassemble or reassemble a particular part. It is recommended that the entire procedure be read prior to repair.

IMPORTANT: Read the following before attempting any repairs.

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 that the sequence be followed without deviation to assure proper repairs. When performing partial repairs, follow the instructions to the point where the desired component can be replaced, then proceed to reassembly and installation of that component in the reassembly part of this section. Use the **Table of Contents** to find the correct page number.

Threaded parts are right-hand (RH), unless otherwise indicated.

When holding, pressing, or driving is required, use soft metal vise jaw protectors or wood for protection of parts. Use a suitable mandrel 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 the bearings with solvent and dry with compressed air. Air should be directed at the bearing so that it passes through the bearing. Do not spin the bearing with compressed air, as this may cause the bearing to score from lack of lubrication. After cleaning, lubricate the bearings with High Performance Gear Lubricant. Do not lubricate the tapered roller bearing cups until after inspection.

Inspect all bearings for roughness, catches, and bearing race side wear. Work the inner bearing race in and out, while holding the outer race, to check for side wear.

When inspecting the tapered roller bearings, determine the condition of the rollers and the inner bearing race by inspecting the bearing cup for pits, scoring, grooves, uneven wear, imbedded particles, and/or discoloration from overheating. Always replace the tapered roller bearing cone and cup as a set.

Inspect the gear housing for bearing races that have spun in their respective bores. If the race has spun, the gear housing must be replaced.

Roller bearing condition is determined by inspecting the bearing surface of the shaft that the roller bearing supports. Check the shaft surface for pits, scoring, grooves, embedded particles, uneven wear, and/or discoloration from overheating. The shaft and bearing must be replaced if the conditions described are found.

Shims

Keep a record of all shim amounts and their location during disassembly to aid in reassembly. Be sure to follow the shimming instructions during reassembly, as gears must be installed to the correct depth and have the correct amount of backlash to avoid noisy operation and premature gear failure.

Seals

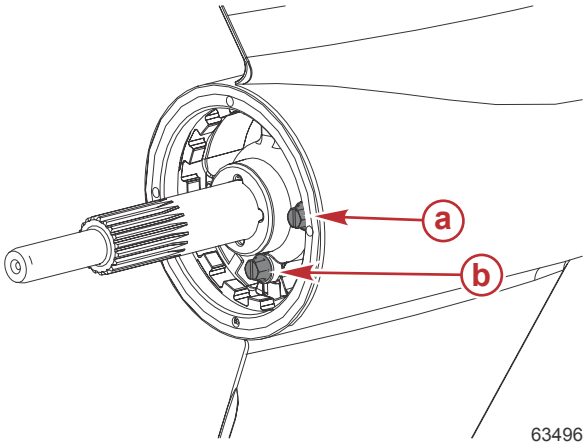
As a normal procedure, all O-rings and oil seals should be replaced without regard to appearance. To prevent leakage around oil seals, apply Loctite 271 Threadlocker to the outer diameter of all metal case oil seals. When using Loctite on seals or threads, the surfaces must be clean and dry. To ease installation, apply 2-4-C with PTFE on all O-rings. To prevent wear, apply 2-4-C with PTFE on the I.D. of oil seals.

Gearcase Serviceability Inspection

Draining and Inspecting Gear Housing Lubricant—Non-SeaPro Models

1. Place the gear housing in a suitable holding fixture or vise with the driveshaft in a vertical position.

2. Position a clean drain pan under the gear housing and remove the plugs from the gear housing with a 10 mm socket or slot screwdriver.



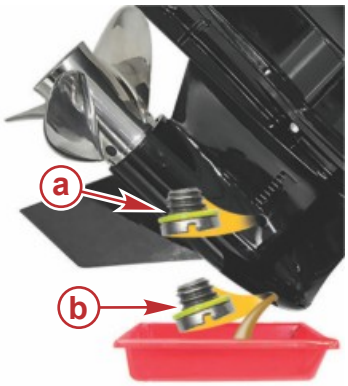
a - Vent plug
b - Fill/drain plug

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

Draining and Inspecting Gear Housing Lubricant—SeaPro Models

All SeaPro FourStroke Outboards include a gearcase lubricant drain located at the front of the torpedo. Gearcase lubricant changes can be completed while the outboard is tilted up.

1. Place the outboard in the tilted up position.
2. Remove the upper vent plug.
3. Position a clean drain pan under the gear housing.
4. Remove the front drain/fill plug from the torpedo and drain the lubricant.



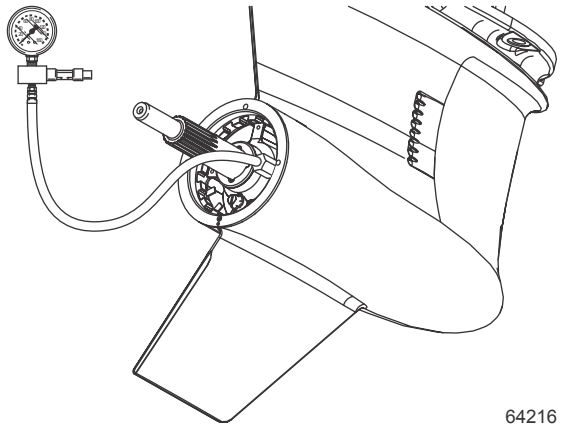
a - Upper vent plug
b - Front drain/fill plug

5. Inspect the gear lubricant for metal particles. Presence of a small amount of fine metal particles resembling powder indicates normal wear. Presence of larger particles, or a large quantity of fine particles, indicates the gear housing should be disassembled and inspected.
6. Note the color of the gear lubricant. White or cream color indicates the presence of water in the lubricant. Check the drain pan for water separation from the lubricant. Presence of water in the gear lubricant indicates the gear housing should be disassembled and inspected.

Gear Housing Pressure Test

1. Tilt the engine up approximately 20° to prevent residual oil from coming out of the vent hole.

2. Remove the vent plug and install the pressure test gauge.



3. Pressurize the housing and observe the gauge for 15 minutes.
4. Rotate the driveshaft, propeller shaft, and shift shaft while the housing is pressurized to check for leaks.
5. If pressure drop is noted, immerse the housing in water.
6. Repressurize and check for air bubbles.
7. Replace the leaking seals, as necessary. Retest the housing after seal replacement.

Gear Housing Test Pressure	
Applied air pressure	103.4 kPa (15 psi)
Length of time	15 minutes

Leakage Tester Kit	FT8950

8. If air bubbles are noticed from the water inlet holes at the front of the torpedo, the gear housing must be replaced.
9. Remove the tester from the housing and install the vent plug and sealing washer.

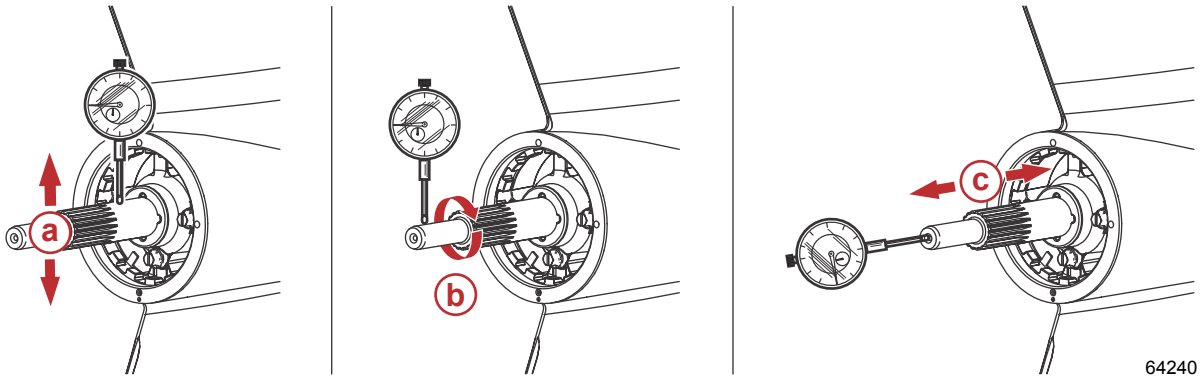
Propeller Shaft Inspection

1. Inspect the propeller shaft for up and down movement, as follows:
   a. Position the dial indicator on the propeller shaft, just forward of the splines, as shown in the following illustration.
   b. Push the propeller shaft down and zero the dial indicator.
   c. Move the propeller shaft up while observing the dial indicator.
   d. A shaft deflection of more than 0.08 mm (0.003 in.) indicates a worn propeller shaft bearing.

Dial Indicator	91- 58222A 1
Dial Indicator Adapter	91-83155
Dial Indicator Holding Tool	91- 89897

2. Check for a bent propeller shaft as follows:
   a. Reposition the dial indicator to the threaded end of the propeller shaft. Rotate the propeller shaft while observing the dial indicator.
   b. If the deflection is more than 0.23 mm (0.009 in.), the propeller shaft is bent and should be replaced.

3. 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 - Check propeller shaft deflection
b - Check for bent propeller shaft
c - Check propeller shaft end play

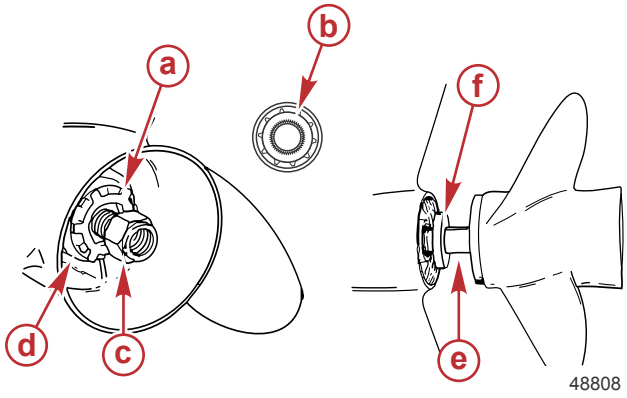
Gear Housing Removal

⚠ 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.

NOTE: *It is not necessary to drain the oil sump when removing the gear housing.*

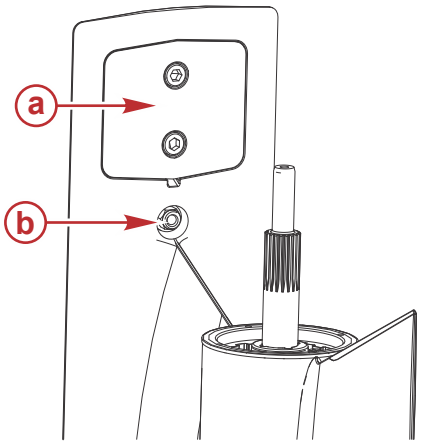
1. Tilt the outboard to the trailer full up position and engage the tilt lock lever.
2. Bend the tabs of the propeller tab washer away from the rear thrust hub. Remove the propeller locknut, tab washer, rear thrust hub, propeller, and forward thrust washer from the propeller shaft.



a - Tab washer
b - Continuity washer (if equipped)
c - Propeller locknut
d - Rear thrust hub
e - Propeller shaft
f - Forward thrust washer

3. Remove the nut and washer from the underside of the anti-ventilation plate, just forward of the anode plate.

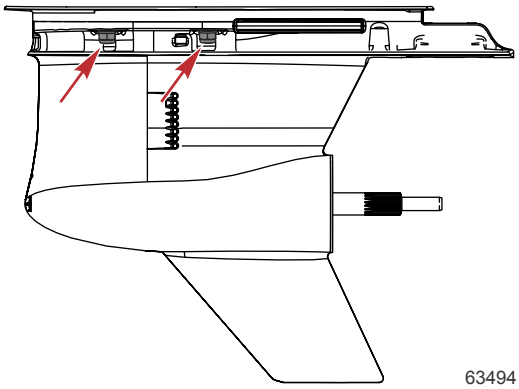
NOTE: *It is not necessary to remove the anode plate on these gearcases.*



63498

a - Anode plate
b - Remove nut and washer

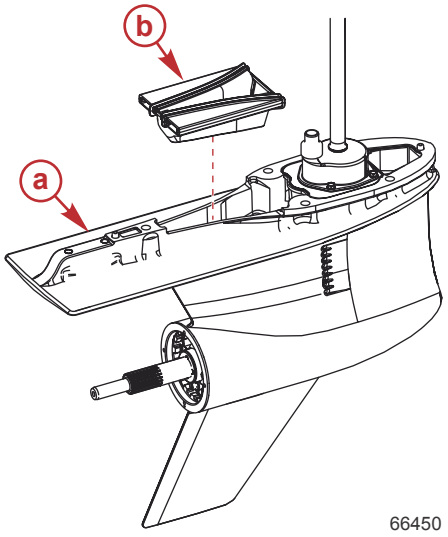
4. Loosen the side mounting locknuts; two on each side. Do not attempt to remove one locknut before the opposite side is loosened sufficiently or the gear housing could be damaged.



63494

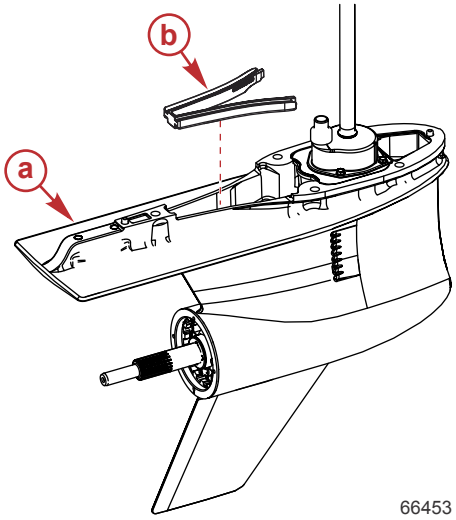
IMPORTANT: The long shaft model is shown. The XL and XXL models use a driveshaft spacer which will come off with the gear housing. Be careful not to drop or lose the driveshaft spacer on these models.

5. Pull the gear housing away from the driveshaft housing as far as the loosened lcoknuts will allow, then remove the loosened locknuts. Do not allow the gear housing to fall, as it is now free.
6. Pull the gear housing from the driveshaft housing.
7. On AMS models, remove, clean, and inspect the lower exhaust relief muffler. Replace the muffler if it is deteriorated or damaged. On CMS models, remove, clean, and inspect the lower relief muffler plug. Replace the plug if it is deteriorated or damaged.



AMS models

a - Gear housing
b - Lower exhaust relief muffler



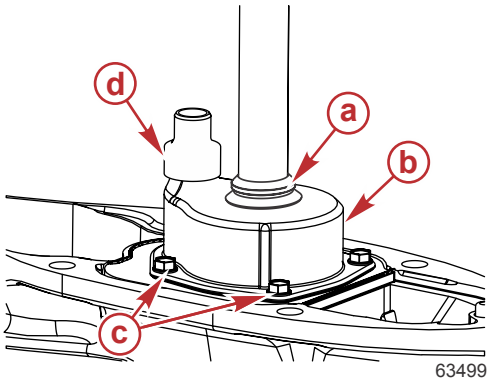
CMS models

a - Gear housing
b - Lower relief muffler plug

Water Pump

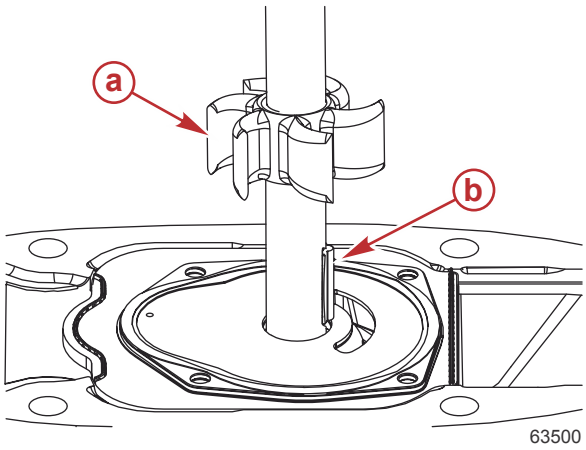
Removal and Disassembly

1. Remove the driveshaft seal, water pump screws, and the water seal coupler.



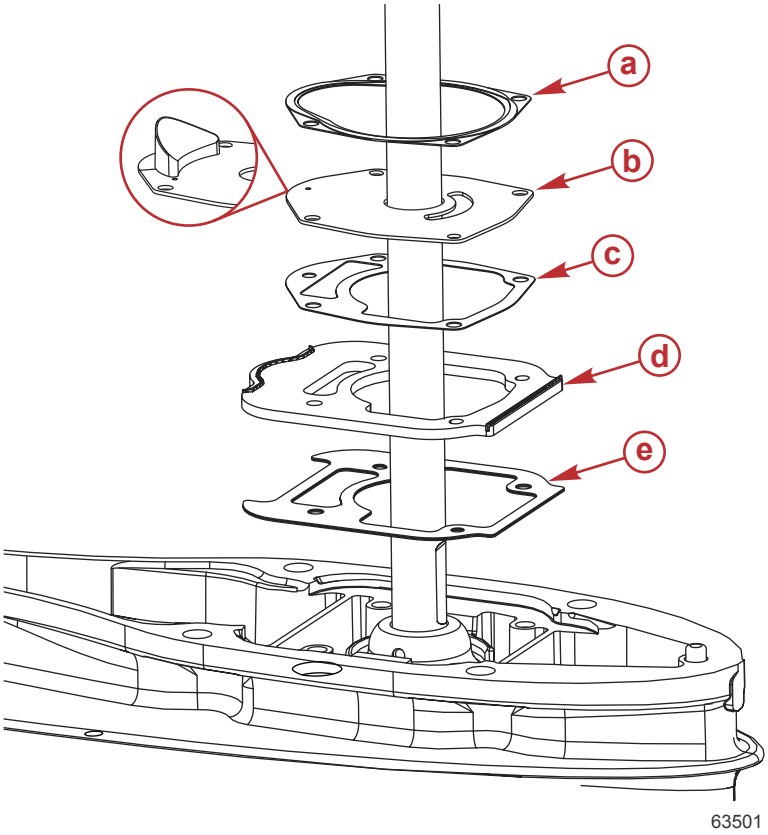
a - Driveshaft seal
b - Water pump cover
c - Screws (two each side)
d - Water seal coupler

2. Lift the water pump cover straight up and off the driveshaft.
3. Remove the impeller and impeller key.



a - Impeller
b - Impeller key

4. Remove the top beaded gasket, faceplate, rubber-coated stainless steel gasket, top cover, and the lower gasket by lifting straight up and off of the driveshaft.



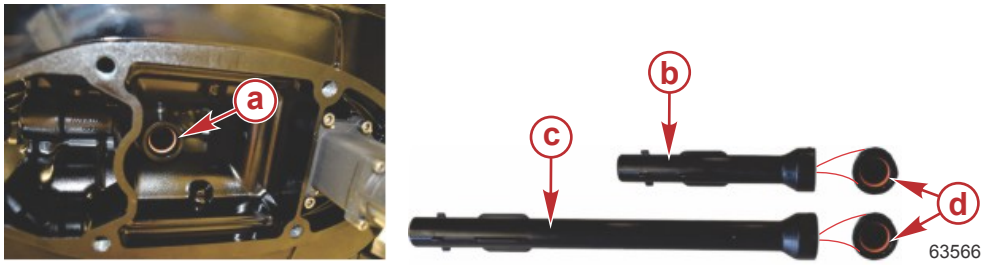
a - Beaded gasket
b - Faceplate

NOTE: *Early models were equipped with a faceplate deflector. The deflector is no longer required.*

c - Rubber-coated stainless steel gasket
d - Top cover
e - Gasket

Cleaning and Inspection

1. With the gear housing removed, inspect the water tube O-ring inside the driveshaft housing for wear or damage. On XL and XXL gearcases, be sure to check the O-ring in the water tube extension. Replace worn or damaged components.



a - Water tube
b - XL water tube extension
c - XXL water tube extension
d - O-ring inside extensions

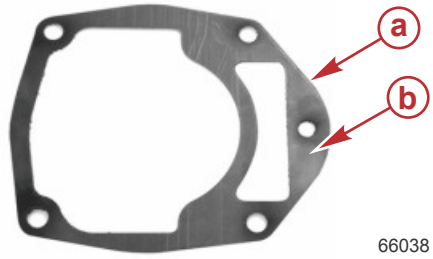
2. Inspect the water seal coupler and O-ring for wear or damage. Replace worn or damaged parts.

a - Water seal coupler
b - O-ring

3. Inspect the faceplate and water pump liner for grooves or rough surfaces.

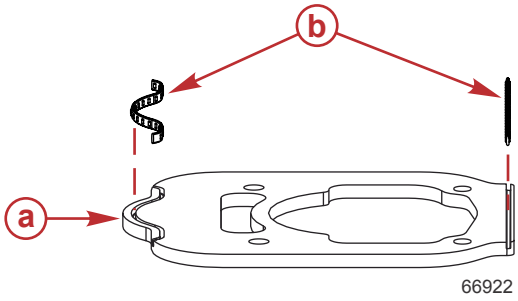
IMPORTANT: The circular groove on the faceplate, formed by the impeller, will not affect water pump output.

4. Inspect all gaskets for damage and replace as required. Inspect the coated surface on the stainless steel gasket for scratches or damage. If the coating is scratched or damaged, replace the stainless steel gasket.



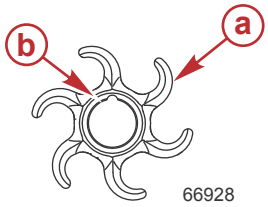
a - Stainless steel gasket
b - Coating

5. Inspect the top cover seals. Replace worn, damaged, or missing seals.



a - Top cover
b - Top cover seals (2)

6. Inspect the impeller seal surfaces and ends of the impeller blades for cracks, tears, and wear. Replace the impeller if any of these conditions are found.
7. Inspect the impeller hub for cracks, and ensure that the impeller is bonded to the hub.



a - Impeller
b - Hub

8. Inspect the impeller for a glazed or melted appearance, caused by operation without sufficient water supply. Replace the impeller if any of these conditions exist.

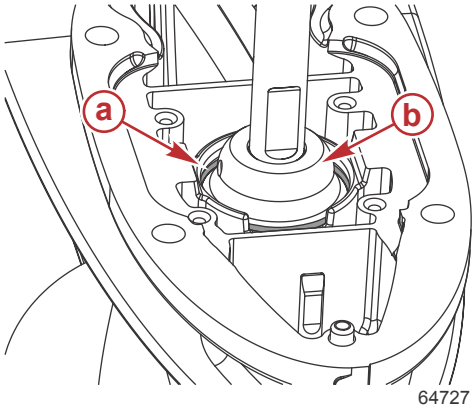
   IMPORTANT: When completing gear housing repairs that require removal of the water pump impeller, it is recommended the impeller be replaced. However, if the impeller must be used, do not install in reverse to original rotation; premature impeller failure will occur.

Oil Seal Carrier

Removal

NOTE: *Push down on the oil seal carrier to aid in the removal of the retaining ring above the oil seal carrier.*

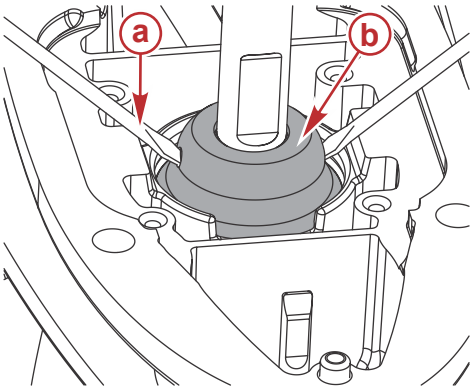
1. While pushing down on the oil seal carrier, use a flat tip screwdriver to aid in the removal of the retaining ring above the oil seal carrier.



a - Retaining ring
b - Oil 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.

   NOTE: *When prying the oil seal carrier up, avoid contact with the painted surface of the gear housing, or protect the painted surface where the tools may contact the gear housing. This will prevent paint damage that could result in future corrosion.*



64728

a - Screwdrivers
b - Oil seal carrier

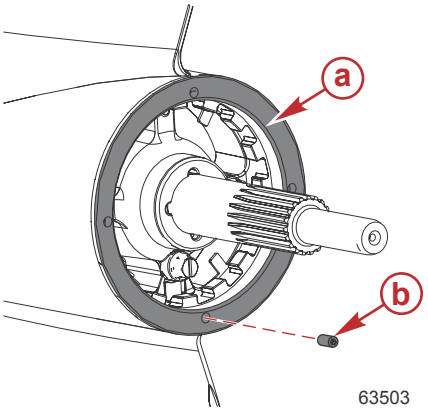
Disassembly

NOTE: *The oil seals within the oil seal carrier are not individually replaceable. If the oil seals require replacement, the oil seal carrier must be replaced as an assembly.*

Bearing Carrier

Bearing Carrier Removal

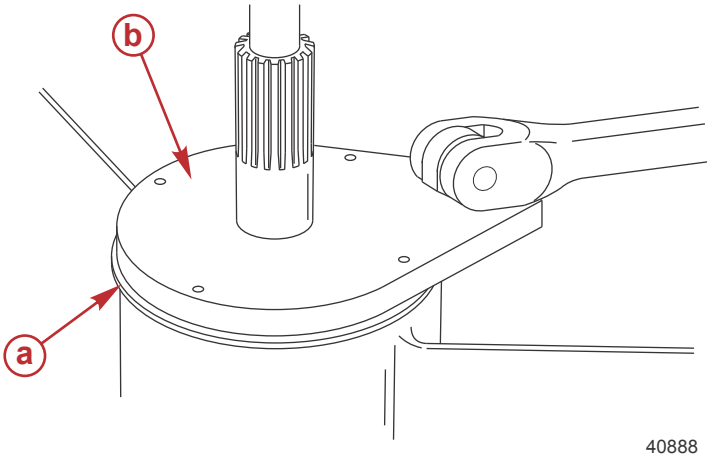
1. Remove the set screw from the torpedo ring using a 3/32 in. Allen wrench.



63503

a - Torpedo ring
b - Set screw

2. Remove the torpedo ring using a torpedo ring installation tool.



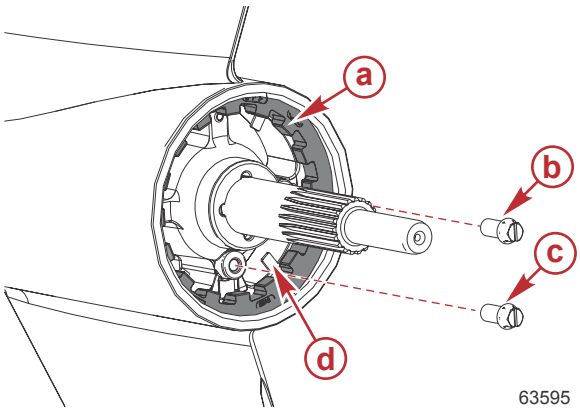
40888

a - Torpedo ring
b - Torpedo ring installation tool

Torpedo Ring Installation Tool	91-8M0039309

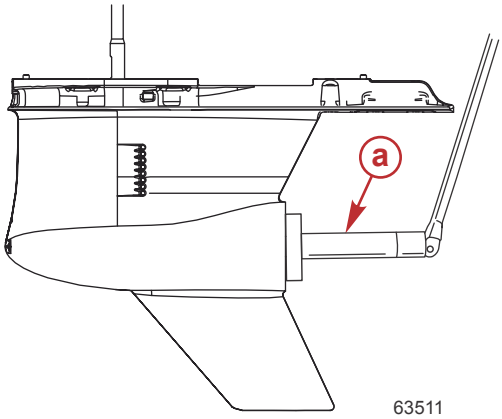
3. Straighten the tab on the tab washer that is bent into the bearing carrier retainer.

   NOTE: *The vent and fill/drain plugs in the bearing carrier may have to be removed before using the bearing carrier retainer nut tool to remove the bearing carrier retainer.*



a - Bearing carrier retainer
b - Vent plug
c - Fill/drain plug
d - Lock tab on tab washer

4. Remove the bearing carrier retainer following step "a" or "b," as follows:
   a. Use a bearing carrier retainer nut tool to remove the bearing carrier retainer by turning the retainer counterclockwise.

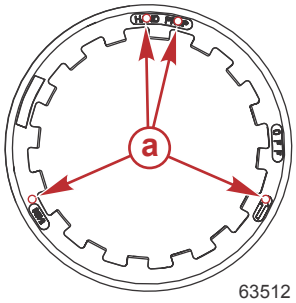


a - Bearing carrier retainer nut tool

Bearing Carrier Retainer Nut Tool	91-8M0046632

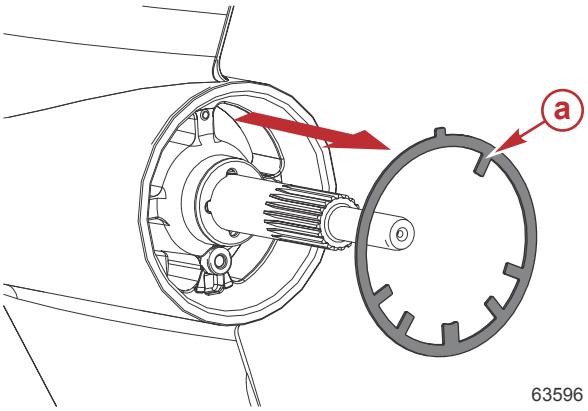
IMPORTANT: Drilling into the bearing carrier retainer can potentially damage the gearcase. Ensure that you do not drill into the gearcase when removing a seized retainer.

   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 - Recommended drilling areas

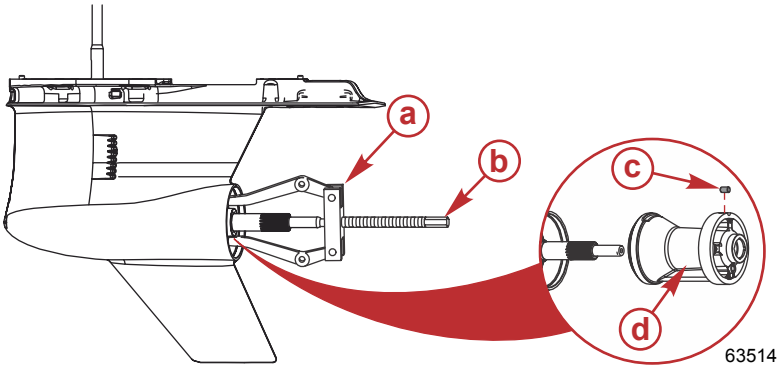
5. Remove the tab washer.



a - Tab washer

6. Pull the bearing carrier from the gear housing by pulling on the outer ring of the bearing carrier. Position the puller jaws close to the bosses in the carrier. The locating pin will likely come out with the bearing carrier. Be careful not to lose the locating pin.

NOTE: *If the bearing carrier is seized in the gear housing, it may be necessary to use heat to loosen the carrier.*

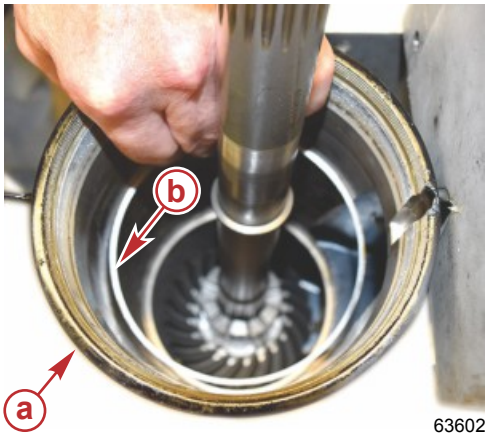


a - Puller jaws assembly
b - Puller bolt
c - Locating pin
d - Bearing carrier

Puller Jaws Assembly	91-46086A1

7. Remove the bearing carrier shims from the gear housing.

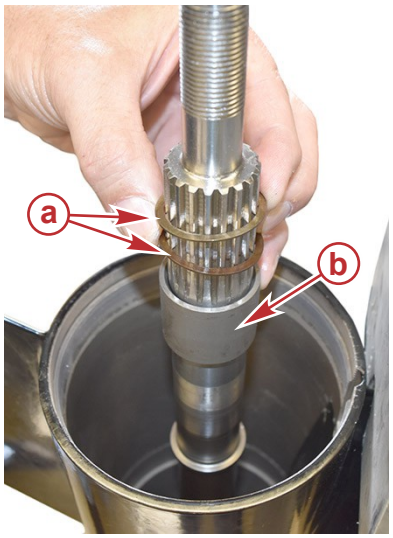
NOTE: *The shims may stick to the thrust ring when pulling out the bearing carrier. Check the bearing carrier if no shims are found in the gear housing.*



a - Gear housing
b - Bearing carrier shims

8. Remove the propeller shaft spacer and shims.

NOTE: *The shims may stick to the bearing carrier when pulling it out. Check the bearing carrier if no shims are found on the propeller shaft.*



63655

a - Propeller shaft shims
b - Propeller shaft spacer

Right-Hand Rotation Bearing Carrier—Inspection, Disassembly, Assembly

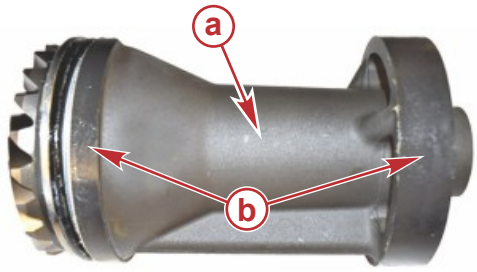
Inspection

IMPORTANT: All seals and O-rings should be replaced to assure effective repair.

⚠ 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.

1. Clean the bearing carrier with solvent and dry 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.

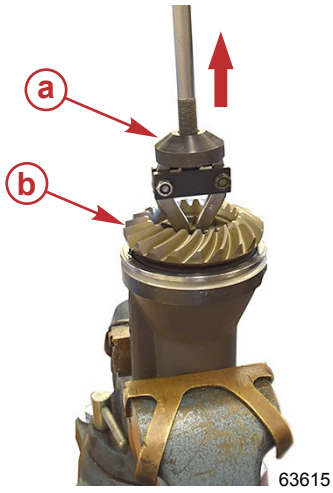


63603

a - Bearing carrier
b - Inspect for corrosion

3. Secure the bearing carrier assembly in a vise and use a slide hammer with puller jaws to remove the rear gear.

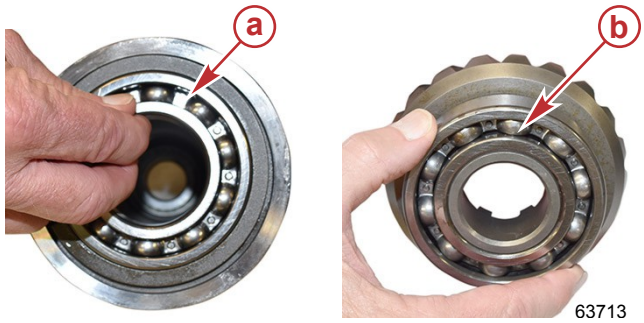
NOTE: *The rear gear ball bearing may come out while removing the rear gear. Do not separate the gear from the bearing at this time.*



a - Slide hammer with puller jaws
b - Rear gear

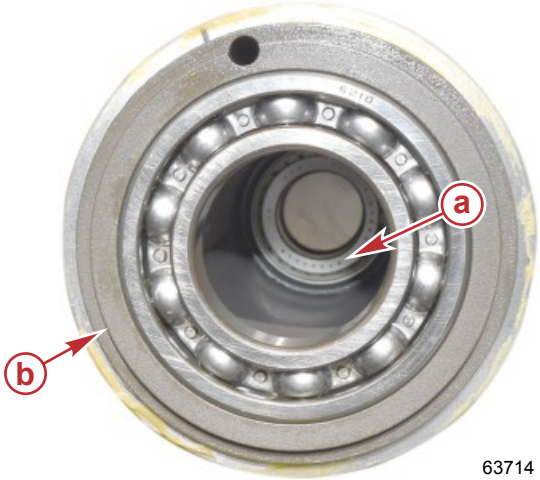
Slide Hammer	91-34569A 1

4. Inspect the remaining bearing carrier components as follows.
   a. Inspect the rear gear ball bearing. Rotate the bearing while checking for rough spots or catches. Push in and pull out on the rear gear to check for bearing side wear. Replace the bearing if any of these conditions exist.
   NOTE: *The ball bearing may have come out with the rear gear when removed in the previous step.*



a - Rear gear ball bearing—shown in bearing carrier
b - Rear gear ball bearing—shown on rear gear

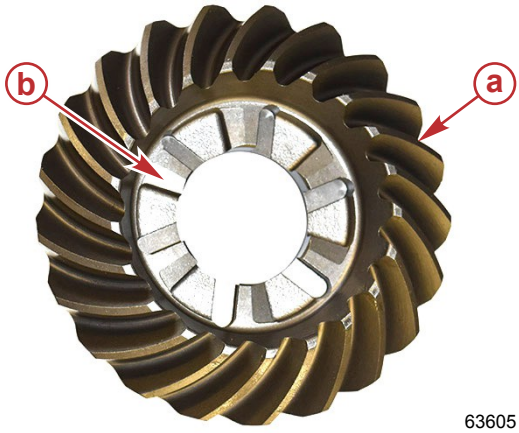
   b. Inspect the aft propeller shaft tapered bearing cone and cup for pits, scoring, discoloration, or excessive looseness.
   NOTE: *The tapered bearing cone can be removed from the bearing carrier for inspection. Refer to* ***Disassembly*** *for removal of the bearing cup.*



a - Tapered roller bearing cone (cup hidden under bearing)
b - Bearing carrier (rear gear removed)

   c. Inspect the bearing carrier oil seals.
5. Inspect the rear gear to pinion gear wear pattern. It should be even and smooth. If not, replace the rear gear, pinion gear, and front gear.

6. Inspect the rear gear for hairline fractures. Replace the rear gear and the pinion gear if any fractures are found. If extensive damage is observed, such as chips, spalling, or broken teeth, replace all gears.
7. Check the clutch jaws on the rear gear for damage. Replace the rear gear if damage is found on the clutch jaws.



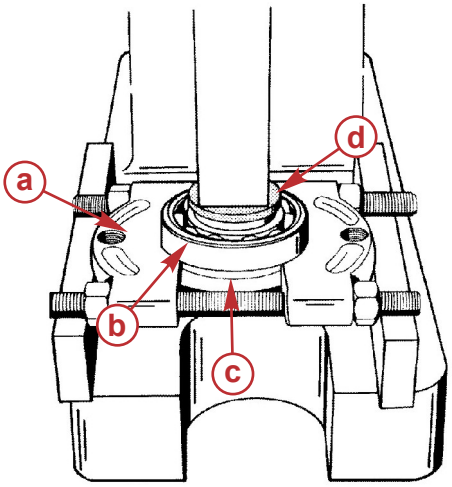
63605

a - Rear gear
b - Clutch jaws

8. Do not proceed with disassembly unless the inspected parts require replacement.

Disassembly

1. If the rear gear ball bearing is still attached to the rear gear, use a suitable mandrel and universal puller plate to support the bearing, then press the bearing from the rear gear as shown.

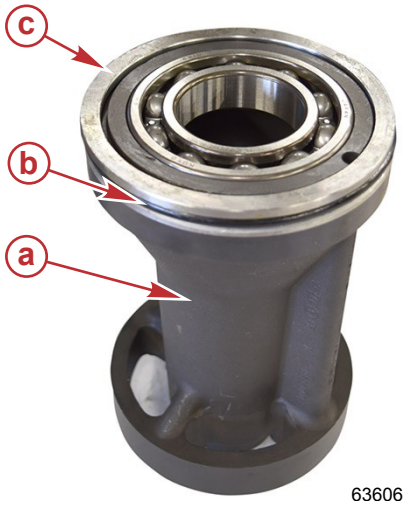


28472

a - Universal puller plate
b - Bearing
c - Gear
d - Mandrel

Universal Puller Plate	91-37241

2. Remove the thrust ring. Remove and discard the O-ring.



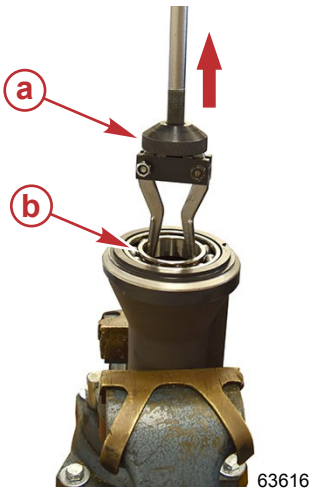
63606

a - Bearing carrier
b - O-ring
c - Thrust ring

NOTE: *If the rear gear ball bearing is already removed from the bearing carrier, proceed to step 5.*

3. Use the slide hammer with puller jaws to remove the ball bearing from the bearing carrier.

   NOTE: *It may be necessary to use a torch lamp to heat the bearing carrier area surrounding the ball bearing.*



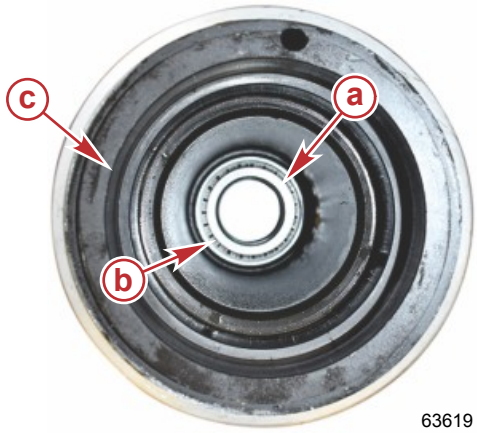
a - Slide hammer with puller jaws
b - Ball bearing

Torch Lamp	91- 63209
Slide Hammer	91-34569A 1

4. Inspect the ball bearing after removal from the bearing carrier.
5. Remove the spacer from the bearing carrier.

a - Bearing carrier
b - Spacer

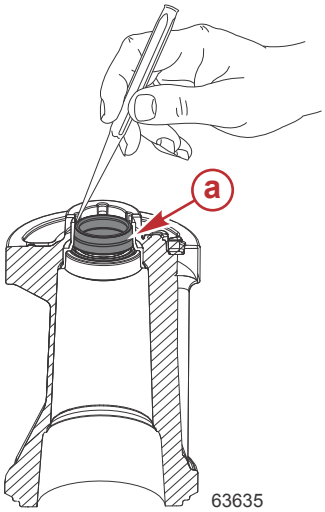
6. Replace the tapered bearing cone and bearing cup inside of the bearing carrier, if required.



a - Tapered bearing cone
b - Bearing cup
c - Bearing carrier

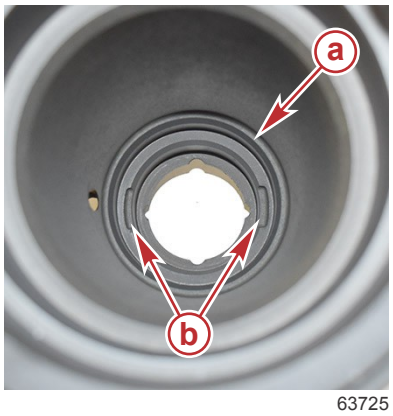
7. If damaged, replace the tapered bearing cup and seals as follows:

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 the seals.



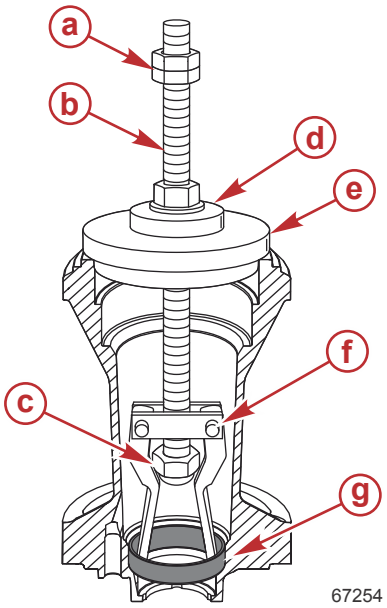
a - Seals

b. **If replacing the tapered roller bearing cup and seals:** Remove the seals with a punch as noted above. There are slots cast into the bearing carrier to aid in the removal of the bearing cup with puller jaws.



a - Bearing carrier—bearing cup removed for clarity
b - Slots

c. Remove the tapered bearing cup from the carrier using a bearing puller assembly, pilot washer, and bearing carrier guide plate. Fabricate an M14-1.5 x 25.4 cm (10 in.) threaded rod to use with the puller jaws. Also obtain two M14-1.50 hex nuts, and one M14-1.50 acorn nut. Remove the 17.8 cm (7 in.) rod supplied with the bearing puller assembly and substitute it with the 25.4 cm (10 in.) rod, acorn nut, and two hex nuts, as shown. Remove the bearing cup. Discard the bearing, cup, and seals.



a - M14-1.50 hex nuts (2), locked against each other and secured to threaded rod
b - 25.4 cm (10 in.) threaded rod
c - M14-1.50 acorn nut
d - Pilot washer
e - Bearing carrier guide plate
f - Bearing puller assembly
g - Tapered bearing cup

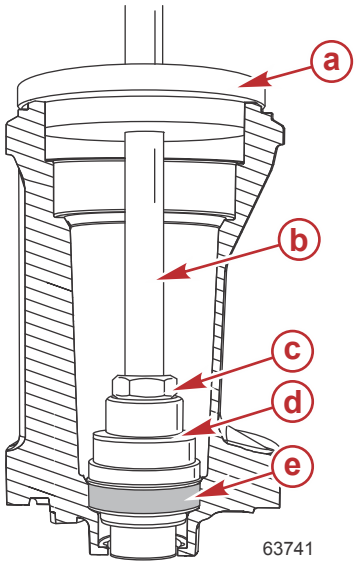
Bearing Puller Assembly	91- 83165T
Pilot Washer	91-36571T
Bearing Carrier Guide Plate	8M0142624

Assembly

1. Clean the components with a suitable solvent and dry the parts with compressed air.
2. Lubricate the tapered bearing cup bore with High Performance Gear Lubricant.

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Tapered bearing cup bore	92-858064K01

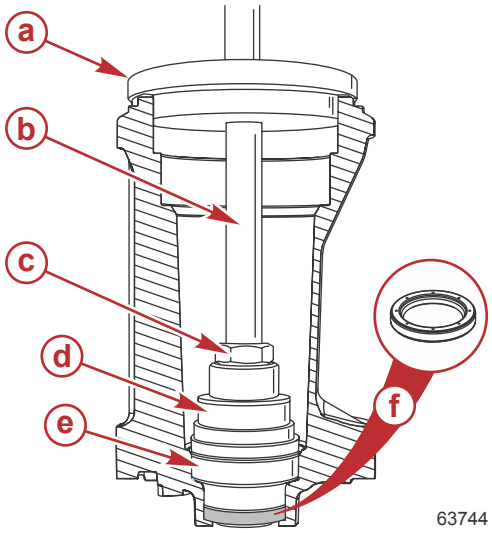
3. Assemble the bearing cup onto the driver.
4. Press the bearing cup into the bearing carrier until the cup bottoms out in the bearing carrier.



a - Bearing carrier guide plate
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Tapered bearing cup

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Carrier Guide Plate	8M0142624
Bearing Removal and Installation Kit	91- 31229A 7

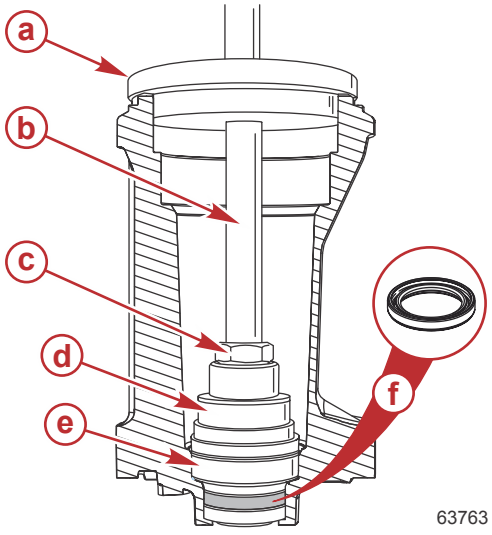
5. Thoroughly clean the bore in which the first seal is to be pressed.
6. Assemble the first seal, with the lips of the seal facing away from the driver shoulder, onto the long end of the oil seal driver.
7. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



- **a -** Bearing carrier guide plate
- **b -** Driver rod
- **c -** Hex nut
- **d -** Bearing cup driver/oil seal installer
- **e -** Bearing cup
- **f -** Oil seal (first)

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Carrier Guide Plate	8M0142624
Bearing Removal and Installation Kit	91- 31229A 7

8. Assemble the second seal, with the lips of the seal facing the driver shoulder, onto the short end of the oil seal driver.
9. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



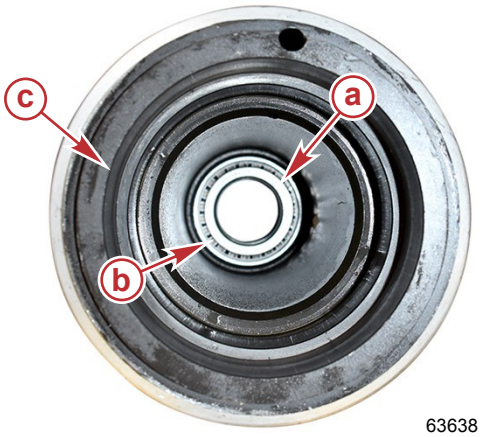
- **a -** Bearing carrier guide plate
- **b -** Driver rod
- **c -** Hex nut
- **d -** Bearing cup driver/oil seal installer
- **e -** Bearing cup
- **f -** Oil seal (second)

Bearing Carrier Guide Plate	8M0142624
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Removal and Installation Kit	91- 31229A 7

10. Lubricate the seal lips and fill the area between the seals with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1

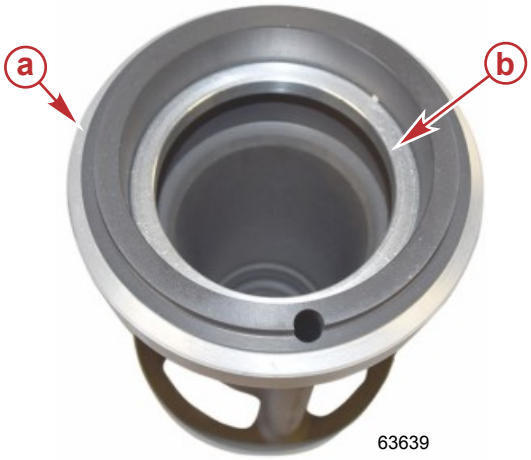
11. Install the propeller shaft tapered bearing cone into the bearing carrier.



63638

a - Tapered bearing cone
b - Bearing cup
c - Bearing carrier

12. Install the spacer into the bearing carrier.

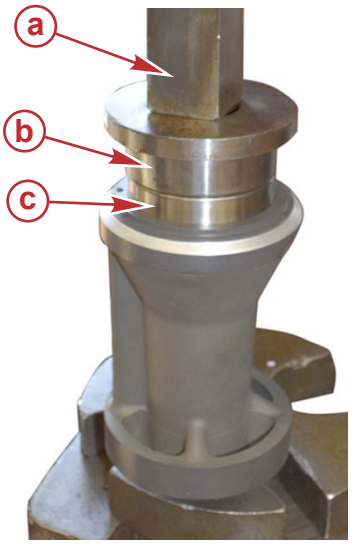


63639

a - Bearing carrier
b - Spacer

13. Press the new ball bearing into the bearing carrier using a suitable mandrel. Make sure to press on the outer race of the bearing.

NOTE: *If the ball bearing is still attached to the rear gear, skip this step.*



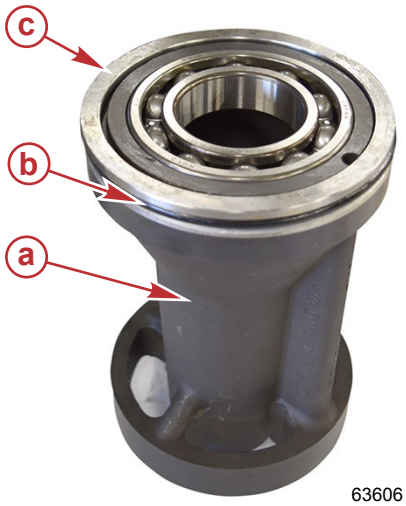
63640

a - Press
b - Mandrel, aligned with outer bearing race
c - New ball bearing

14. Lubricate the O-ring with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	O-ring	92-802859A 1

15. Install the O-ring and thrust ring onto the bearing carrier.

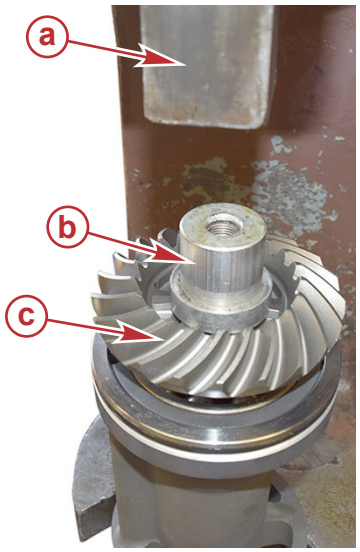


63606

a - Bearing carrier
b - O-ring
c - Bearing carrier thrust ring

16. Using a suitable mandrel that presses on the clutch teeth, press the rear gear into the new ball bearing in the bearing carrier.

NOTE: *If the ball bearing is still attached to the rear gear, press the gear and bearing into the bearing carrier as an assembly.*



63641

a - Press
b - Mandrel
c - Rear gear

Left-Hand Rotation Bearing Carrier—Inspection, Disassembly, Assembly

Inspection and Disassembly

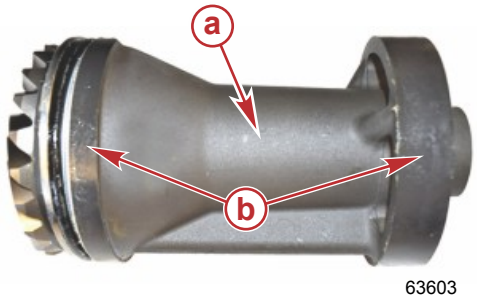
IMPORTANT: All seals and O-rings should be replaced to assure effective repair.

⚠ 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.

1. Clean the bearing carrier with solvent and dry with compressed air.

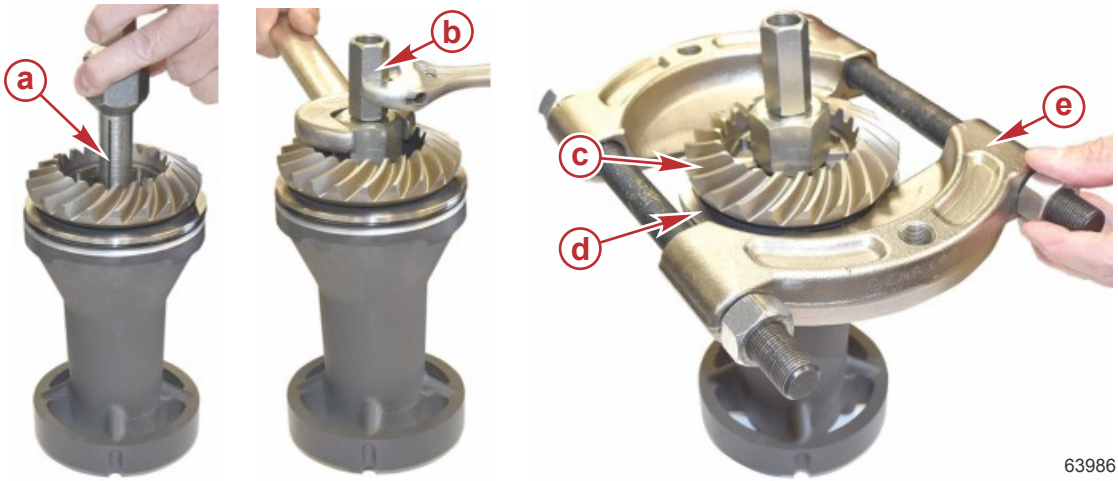
2. Inspect the bearing carrier for signs of excessive corrosion, especially in the area where the bearing carrier touches the gear housing. If excessive corrosion is evident, replace the carrier.



63603

a - Bearing carrier
b - Inspect for corrosion

3. Remove the rear gear bearing assembly as follows.
   a. Install bearing puller collet and expanding rod, and tighten until it locks into the inside diameter of the gear bearing.
   b. Install a universal puller plate on top of the thrust ring.



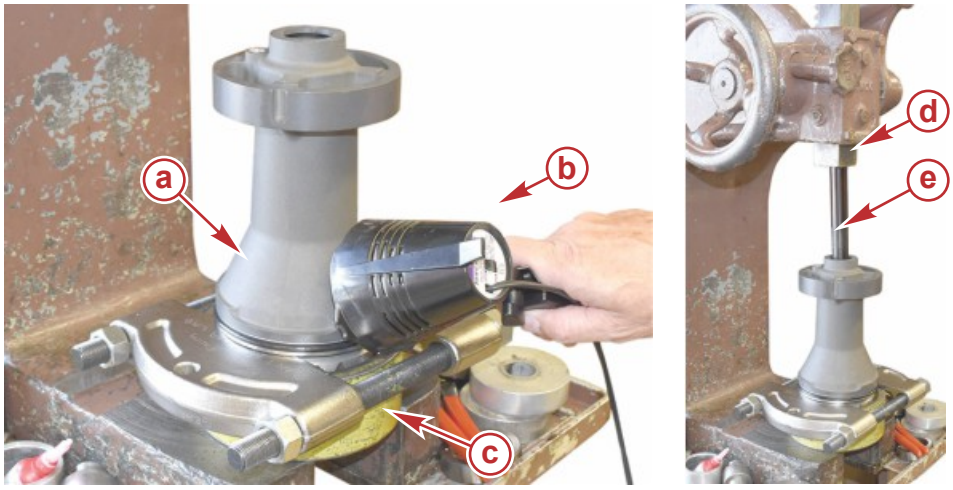
63986

a - Collet
b - Expanding rod
c - Rear gear
d - Thrust ring
e - Universal puller plate

Collet	Snap-On CG-45-7
Expanding Rod	Snap-On CG45-4
Universal Puller Plate	91-37241

4. Press out the rear gear bearing assembly as follows.
   a. Place the bearing carrier and universal puller plate assembly on a press upside down, resting on top of the press spacer mandrel.
   b. Insert an appropriate rod.
   c. Press out the gear assembly.

NOTE: *It may be necessary to use a torch lamp to apply heat to loosen the rear gear bearing.*

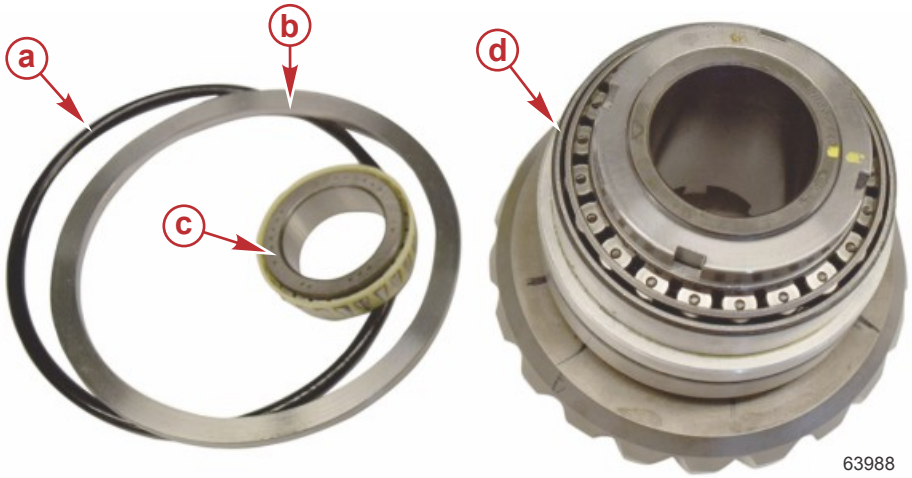


63987

- **a -** Bearing carrier and vise assembly
- **b -** Torch lamp
- **c -** Press spacer mandrel
- **d -** Press
- **e -** Rod

Torch Lamp	91- 63209
Press Spacer Mandrel	8M0142615

5. Remove the bearing carrier, gear assembly, bearing, and thrust ring from the press. Remove the O-ring from the bearing carrier.
6. Remove the expanding rod, collet tool, and universal puller plate.
7. Inspect the bearing carrier components as follows.
   a. Inspect the rear gear roller bearing. Rotate the bearing while checking for rough spots or catches. Push in and pull out on the rear gear to check for bearing side wear. Replace the bearing if any of these conditions exist.
   b. Inspect the aft propeller shaft tapered bearing cone and cup for pits, scoring, discoloration, or excessive looseness. Replace the bearing if any of these conditions exist.
   c. Inspect the O-ring and thrust ring for cracks or damage.

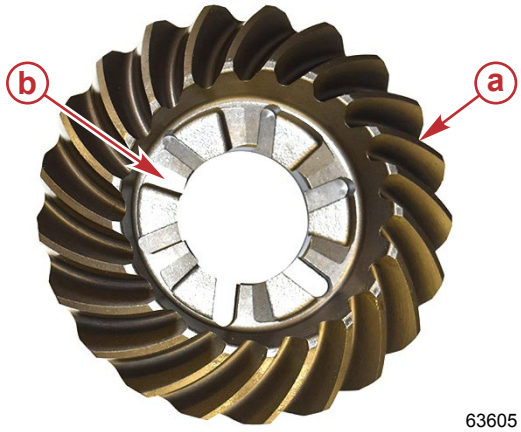


63988

- **a -** O-ring
- **b -** Thrust ring
- **c -** Tapered bearing cone
- **d -** Gear assembly

8. Inspect the rear gear to pinion gear wear pattern. It should be even and smooth. If not, replace the rear gear, pinion gear, and front gear.
9. Inspect the rear gear for hairline fractures. Replace the rear gear and the pinion gear if any fractures are found. If extensive damage is observed, such as chips, spalling, or broken teeth, replace all gears.

10. Check the clutch jaws on the rear gear for damage. Replace the rear gear if damage is found on the clutch jaws.



63605

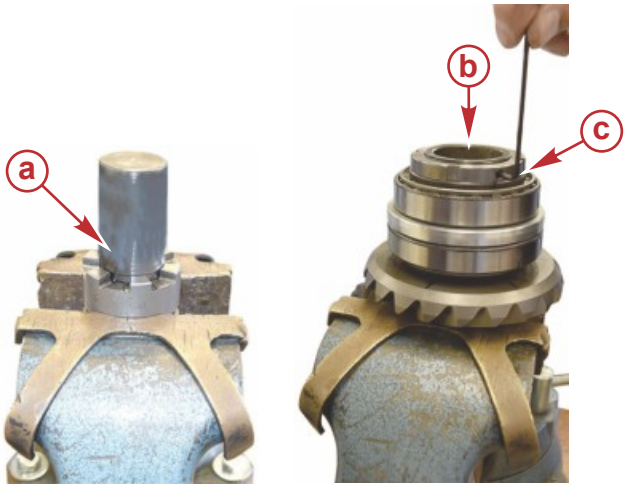
a - Rear gear
b - Clutch jaws

11. Do not proceed with disassembly unless the inspected parts require replacement.

IMPORTANT: All bearings must be replaced if disassembled.

12. To disassemble the rear gear assembly, secure the gear assembly holding fixture in a vise and set the gear assembly onto the holding fixture. Use a 3/32 inch Allen wrench to remove the set screw from the retaining nut.

IMPORTANT: Dispose of the set screw once removed. It cannot be reused.

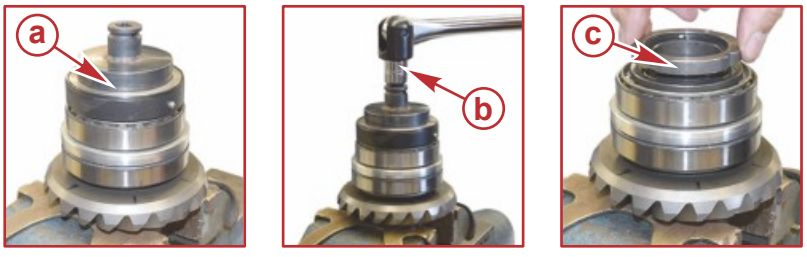


63989

a - Gear assembly holding fixture
b - Gear assembly
c - Remove set screw from retaining nut

Gear Assembly Holding Fixture	8M0142559

13. Remove the retaining nut from the gear assembly as follows.
    a. Install the retaining nut wrench.
    b. Loosen the retaining nut with the wrench.
    c. Remove the retaining nut from the gear assembly.



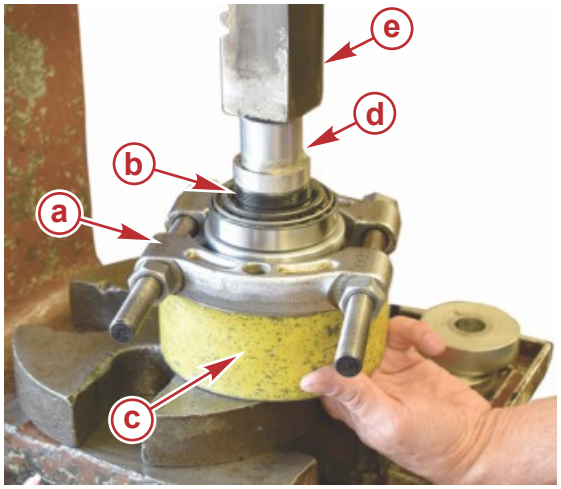
63990

a - Retaining nut wrench
b - Loosen
c - Locknut

Retaining Nut Wrench	91-8M0070085

14. Remove the tapered roller bearings and spacer from the gear assembly as follows.
    a. Install a universal puller plate between the gear and the large tapered bearing cup.

b. Place the gear assembly on the press, resting on top of the press spacer mandrel.
c. Use a bearing mandrel to press the gear out of the bearings.
d. The small tapered roller bearing and cup, outer spacer, inner spacer, and large bearing cup are now free to remove.

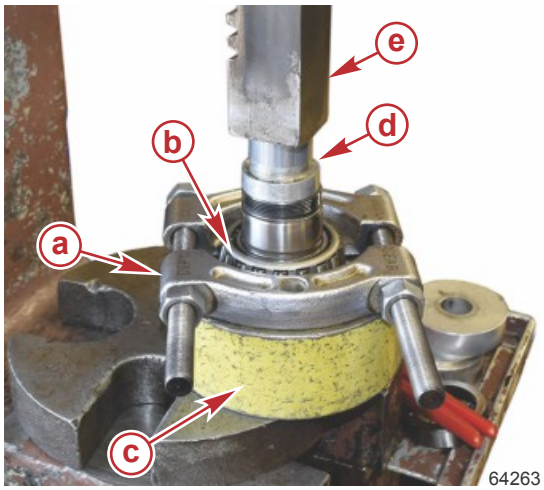


64262

a - Universal puller plate
b - Gear assembly
c - Press spacer mandrel
d - Bearing mandrel
e - Press

Universal Puller Plate	91-37241
Press Spacer Mandrel	8M0142615
Bearing Mandrel	8M0142636

15. Remove the large tapered roller bearing cone from the gear as follows.
a. Install a universal puller plate between the large tapered roller bearing cone and the gear.
b. Place the gear assembly on the press, resting on top of the press spacer mandrel.
c. Use a bearing mandrel to press the gear out of the tapered roller bearing cone.

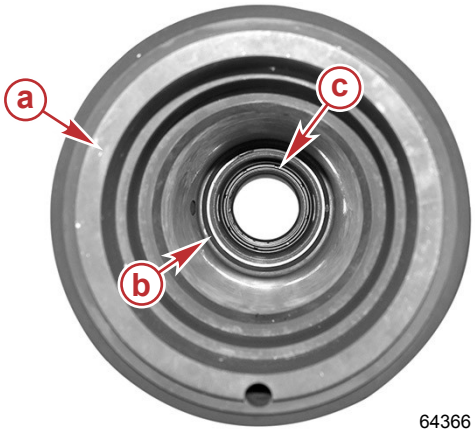


64263

a - Universal puller plate
b - Large tapered roller bearing cone
c - Press spacer mandrel
d - Bearing mandrel
e - Press

Universal Puller Plate	91-37241
Bearing Mandrel	8M0142636

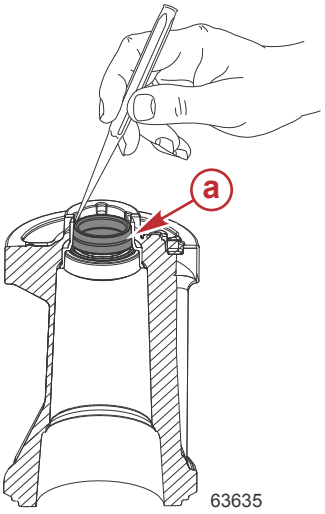
16. Inspect the bearing cup and seals inside the bearing carrier.



64366

a - Bearing carrier
b - Bearing cup
c - Seals

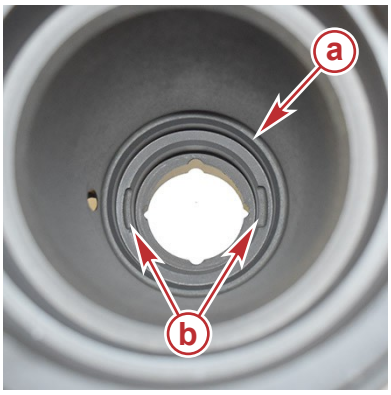
17. If damaged, replace the tapered bearing cup and seals as follows:
    a. **If replacing the seals only:** Remove the oil seals with a suitable punch, being careful not to damage the bore of the bearing carrier. Discard the seals.



63635

a - Seals

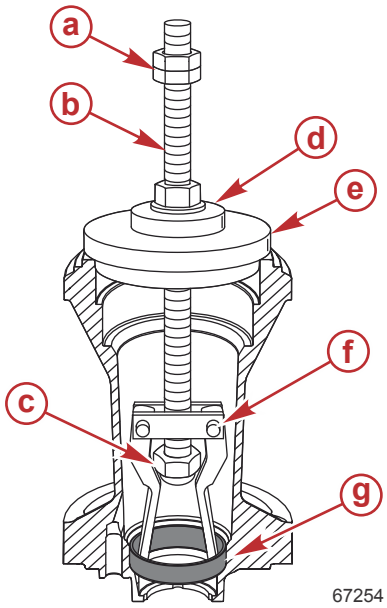
    b. **If replacing the tapered roller bearing cup and seals:** Remove the seals with a punch as noted above. Discard the seals. There are slots cast into the bearing carrier to aid in the removal of the bearing cup with puller jaws.



63725

a - Bearing carrier—bearing cup removed for clarity
b - Slots

c. Remove the tapered bearing cup from the carrier using a bearing puller assembly, pilot washer, and bearing carrier guide plate. Fabricate an M14-1.5 x 25.4 cm (10 in.) threaded rod to use with the puller jaws. Also obtain two M14-1.50 hex nuts, and one M14-1.50 acorn nut. Remove the 17.8 cm (7 in.) rod supplied with the bearing puller assembly and substitute it with the 25.4 cm (10 in.) rod, acorn nut, and two hex nuts, as shown. Remove the bearing cup. Discard the bearing, cup, and seals.



a - M14-1.50 hex nuts (2), locked against each other and secured to threaded rod
b - 25.4 cm (10 in.) threaded rod
c - M14-1.50 acorn nut
d - Pilot washer
e - Bearing carrier guide plate
f - Bearing puller assembly
g - Tapered bearing cup

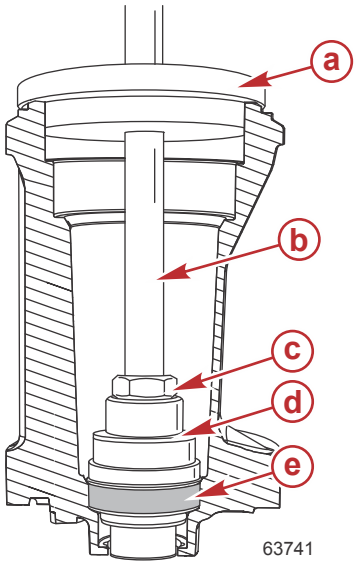
Bearing Puller Assembly	91- 83165T
Pilot Washer	91-36571T
Bearing Carrier Guide Plate	8M0142624

Assembly

1. Clean the components with a suitable solvent and dry the parts thoroughly using compressed air.
2. Lubricate the tapered bearing cup bore with High Performance Gear Lubricant.

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Tapered bearing cup bore	92-858064K01

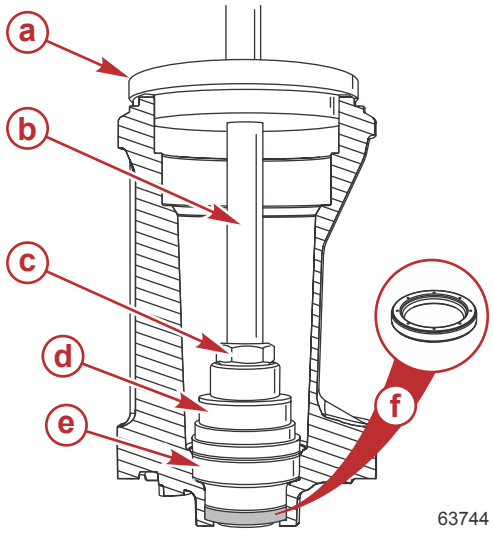
3. Assemble the bearing cup onto the driver.
4. Press the bearing cup into the bearing carrier until the cup bottoms out in the bearing carrier.



a - Bearing carrier guide plate
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Tapered bearing cup

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Carrier Guide Plate	8M0142624
Bearing Removal and Installation Kit	91- 31229A 7

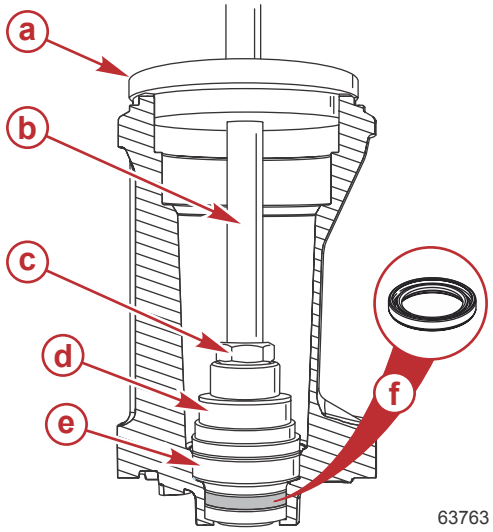
5. Thoroughly clean the bore in which the first seal is to be pressed.
6. Assemble the first seal, with the lips of the seal facing away from the driver shoulder, onto the long end of the oil seal driver.
7. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



- **a -** Bearing carrier guide plate
- **b -** Driver rod
- **c -** Hex nut
- **d -** Bearing cup driver/oil seal installer
- **e -** Bearing cup
- **f -** Oil seal (first)

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Carrier Guide Plate	8M0142624
Bearing Removal and Installation Kit	91- 31229A 7

8. Assemble the second seal, with the lips of the seal facing the driver shoulder, onto the short end of the oil seal driver.
9. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



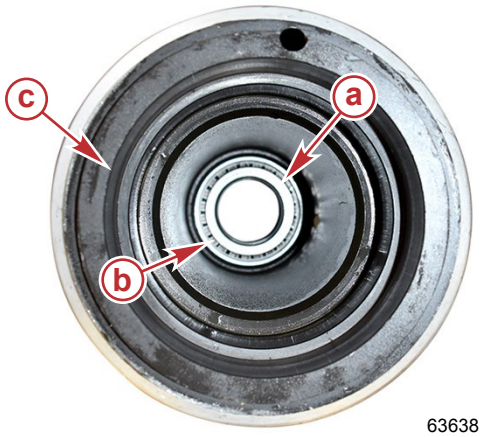
- **a -** Bearing carrier guide plate
- **b -** Driver rod
- **c -** Hex nut
- **d -** Bearing cup driver/oil seal installer
- **e -** Bearing cup
- **f -** Oil seal (second)

Bearing Carrier Guide Plate	8M0142624
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Removal and Installation Kit	91- 31229A 7

10. Lubricate the seal lips and fill the area between the seals with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1

11. Install the propeller shaft tapered bearing cone into the bearing carrier.



63638

a - Tapered bearing cone
b - Bearing cup
c - Bearing carrier

12. Lubricate the bearing carrier bores and the O-ring with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	O-ring and bearing carrier bores	92-802859A 1

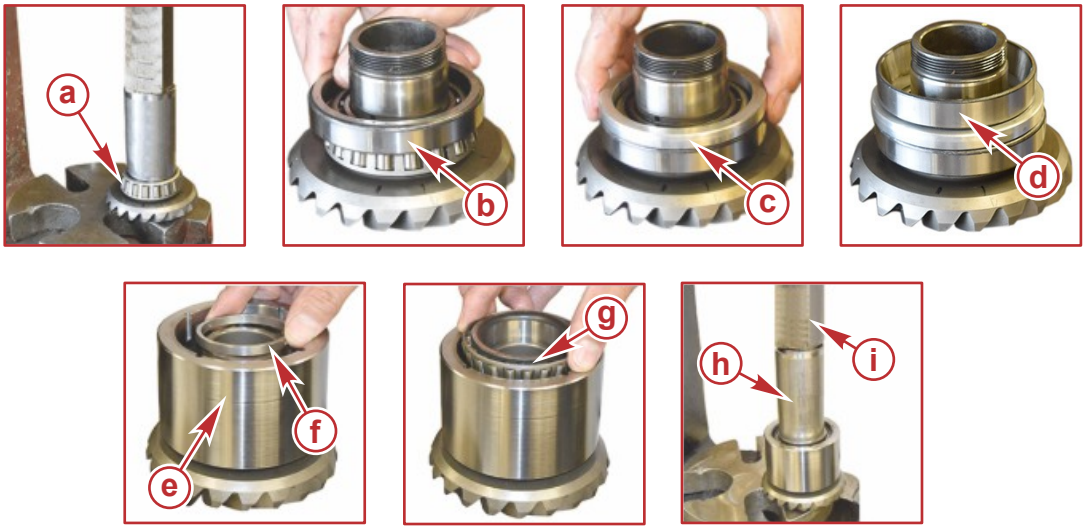
13. Install the O-ring and thrust ring onto the bearing carrier.

63997

a - Bearing carrier bores
b - O-ring
c - Thrust ring

14. If the rear gear bearing assembly is intact, proceed to step 16. If the rear gear bearing assembly was disassembled, reassemble as follows.
    a. Press the large tapered roller bearing cone onto the gear with the rear gear bearing cone mandrel.
    b. Install the large tapered roller bearing cup over the cone.
    c. Install the outer spacer.
    d. Install the small tapered roller bearing cup.
    e. Install the preload driver alignment tool over the rear gear bearings.
    f. Install the internal spacer.

g. Install the small tapered roller bearing cone and press in using the rear gear bearing cone mandrel.



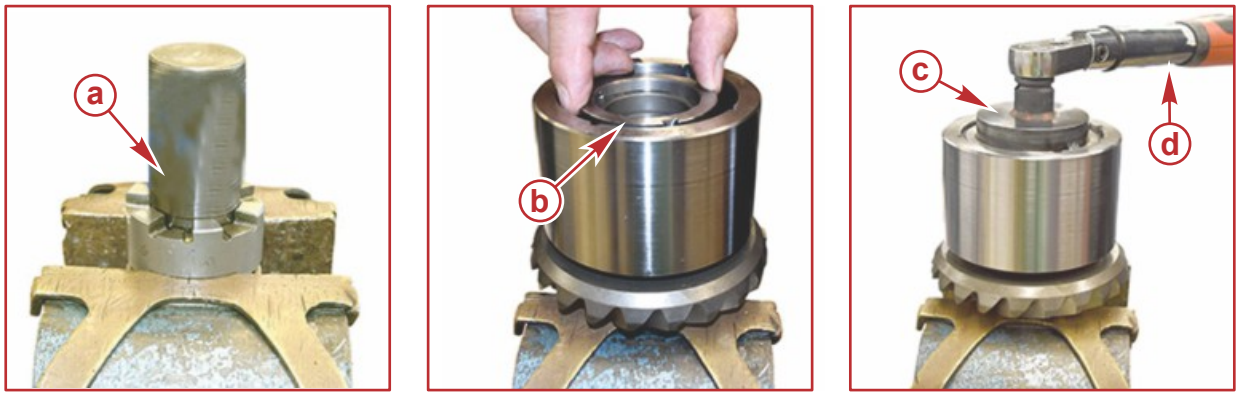
63993

a - Large tapered roller bearing cone
b - Large tapered roller bearing cup
c - Outer spacer
d - Small tapered roller bearing cup
e - Preload driver alignment tool
f - Internal spacer
g - Small tapered roller bearing cone
h - Rear gear bearing cone mandrel
i - Press

Rear Gear Bearing Cone Mandrel	8M0142413
Preload Driver Alignment Tool	8M0142970

15. Install the retaining nut as follows.
    a. Secure the gear assembly holding fixture in a vise and set the gear assembly with the preload driver alignment tool onto the holding fixture.
    b. Install the retaining nut.
    c. Install the retaining nut wrench into the deep set of slots on the preload driver alignment tool. Tighten the retaining nut to the specified torque. Remove the retaining nut wrench.

Description	Nm	lb-in.	lb-ft
Retaining nut	135.6	–	100



63996

a - Gear assembly holding fixture
b - Retaining nut
c - Retaining nut wrench
d - Torque wrench

Gear Assembly Holding Fixture	8M0142559
Retaining Nut Wrench	91-8M0070085

16. Check the rolling torque as follows.
    a. Insert the retaining nut wrench into the shallow set of slots on the preload driver alignment tool and measure the rolling torque.

Description	Nm	lb-in.	lb-ft
Rolling torque	0–4.07	0–36	–

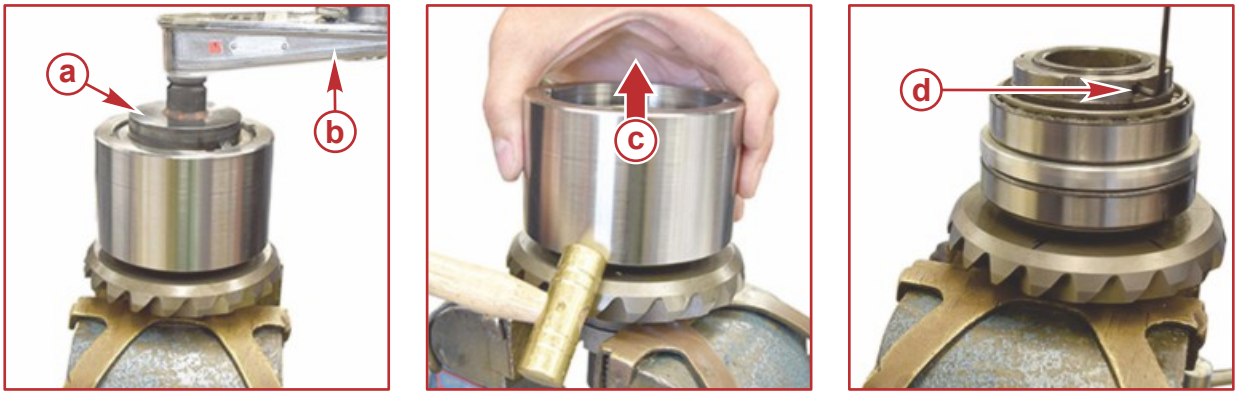
    b. If the rolling torque is within specification, remove the retaining nut wrench and preload driver alignment tool.

    NOTE: *It may be necessary to gently tap the preload driver alignment tool with a soft jaw hammer to release it from the gear assembly.*

    c. Install a new set screw to secure the retaining nut. Tighten the set screw to the specified torque using a 3/32 inch Allen wrench.

Description	Nm	lb-in.	lb-ft
Set screw	1.7	15	–

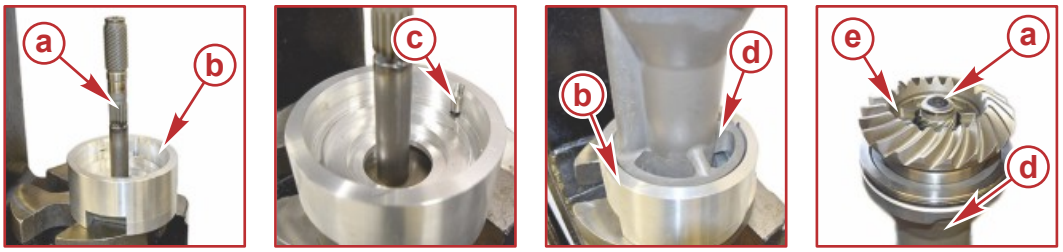
d. If the rolling torque is not within specification, verify that the bearing parts were assembled correctly.



64387

a - Retaining nut wrench
b - Torque wrench
c - Remove preload driver alignment tool
d - New set screw

17. Prepare the bearing carrier and rear gear bearing assembly for installation as follows.
    a. Place the threaded shaft tool on a press, then situate the press fixture base tool over the threaded shaft tool.
    b. Insert the bearing carrier alignment pin.
    c. Locate the alignment pin slot on the bearing carrier and place the bearing carrier over the threaded shaft tool so it is secured in the press fixture base tool.
    d. Set the rear gear bearing assembly onto the bearing carrier.



63998

a - Threaded shaft tool
b - Press fixture base tool
c - Alignment pin
d - Bearing carrier
e - Rear gear bearing assembly

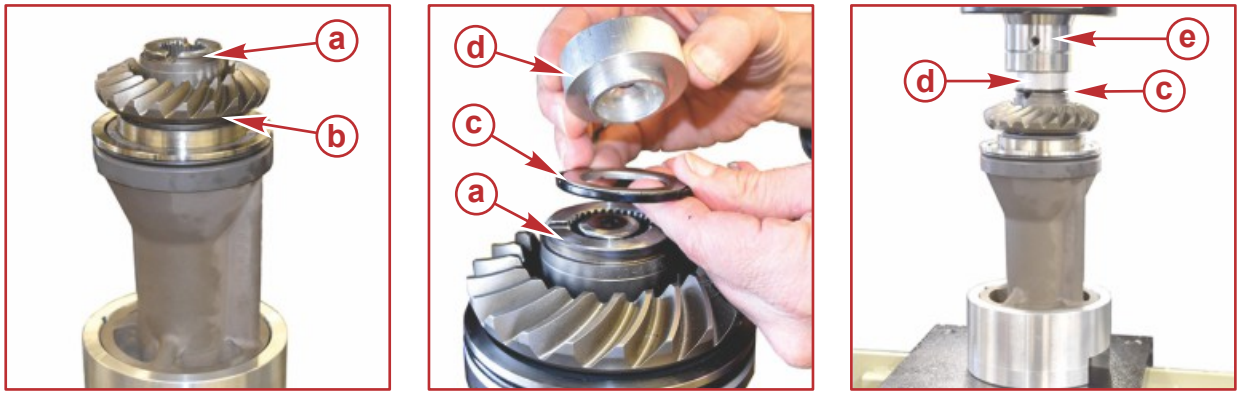
Threaded Shaft Tool	8M0142983
Press Fixture Base Tool	8M0142976

18. Press the rear gear bearing assembly into the bearing carrier as follows.

    NOTE: *It may be necessary to use a torch lamp to apply heat to the bearing carrier to aide in installation of the rear gear bearing assembly.*

    a. Set the threaded clutch assembly tool on top of the rear gear bearing assembly.
    b. Set the bearing tool on top of the threaded clutch assembly tool, then set the press fixture retainer tool on top of the bearing tool.

c. Press the rear gear bearing assembly into the bearing carrier until the gear stops rotating.



64000

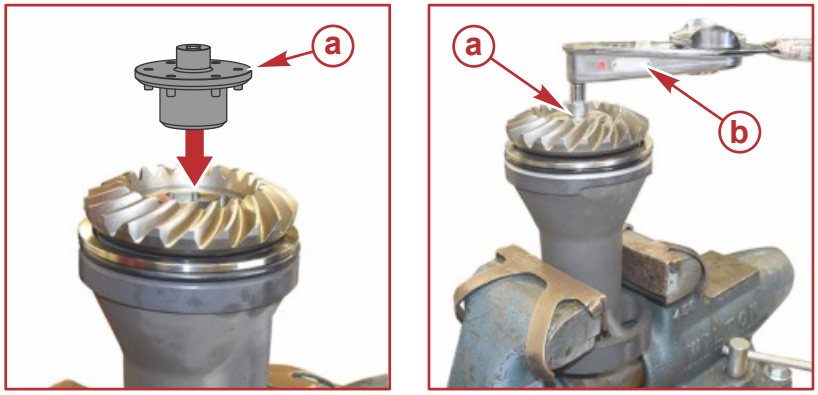
a - Threaded clutch assembly tool
b - Rear gear bearing assembly
c - Bearing tool
d - Press fixture retainer tool
e - Press

Torch Lamp	91- 63209
Threaded Clutch Assembly Tool	8M0145393
Bearing Tool	31-861792
Press Fixture Retainer Tool	8M0142974

19. Check the bearing carrier rolling torque as follows.
    a. Secure the assembled bearing carrier in a vise.
    b. Insert the gear assembly driver tool.
    c. Use a torque wrench to check rolling torque. Ensure that it is within the specified torque.

Description	Nm	lb-in.	lb-ft
Rolling torque	0.90–6.21	8–55	–

- If the rolling torque is within specification, bearing carrier assembly is complete.
- If the rolling torque is not within specification, the bearing carrier must be disassembled and the cause corrected.



64001

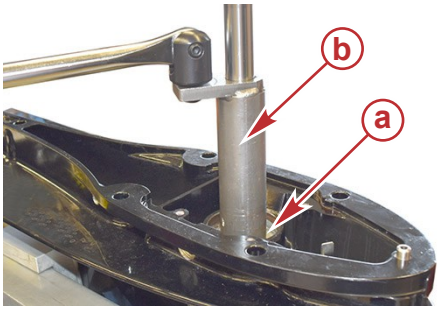
a - Gear assembly driver tool
b - Torque wrench

Gear Assembly Driver Tool	8M0142414

Driveshaft Removal, Inspection, Disassembly, and Assembly

Driveshaft Removal

1. Remove the driveshaft bearing retainer with the driveshaft bearing retainer wrench.

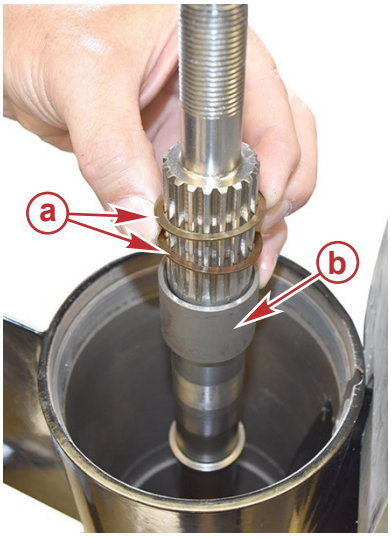


63643

a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

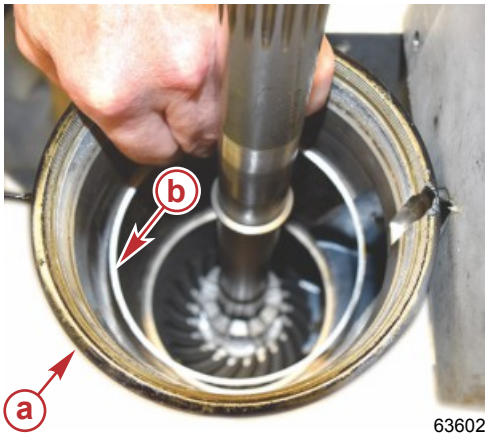
2. Remove the shims and spacer from the propeller shaft, if not already removed.



63655

a - Shims
b - Spacer

3. Ensure the bearing carrier shims are removed.

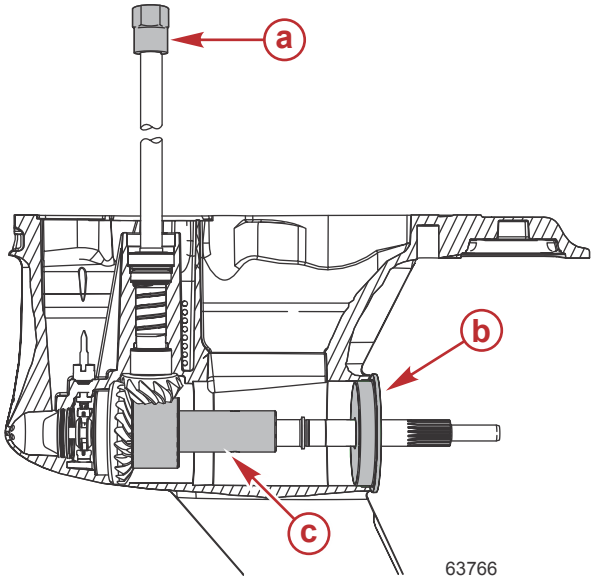


63602

a - Gear housing
b - Bearing carrier shims

4. Insert the pinion nut holder into the gear housing with the slot facing the pinion gear. It may be necessary to lift and rotate the driveshaft to align the pinion gear nut into the pinion nut holder.
5. Install the propeller shaft holder over the propeller shaft and into the gear housing to maintain the pinion nut holder alignment.
6. Install the driveshaft holding tool onto the driveshaft.

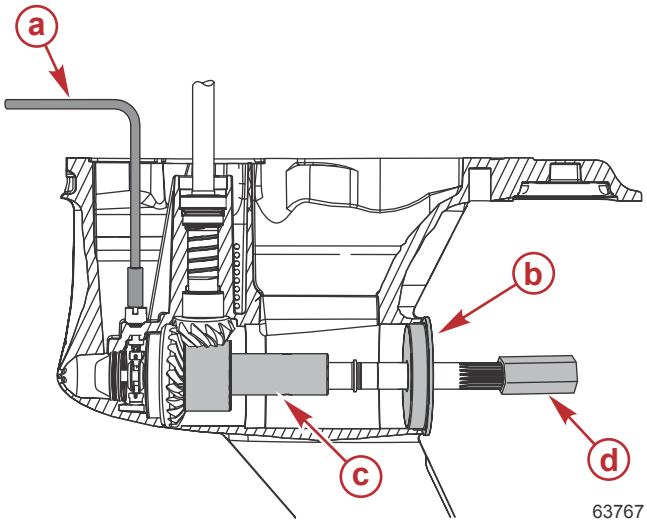
7. Use the driveshaft holding tool to loosen the pinion nut.



a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut holder

Driveshaft Holding Tool	91-889958T
Pinion Nut Holder	91-8M0036288
Propeller Shaft Holder	91-8M0035594

8. If the driveshaft is broken, place the propeller shaft adapter onto the propeller shaft splines. Use the shift shaft handle tool to hold the shift shaft against the rear gear, and loosen the pinion nut by rotating the propeller shaft counterclockwise.

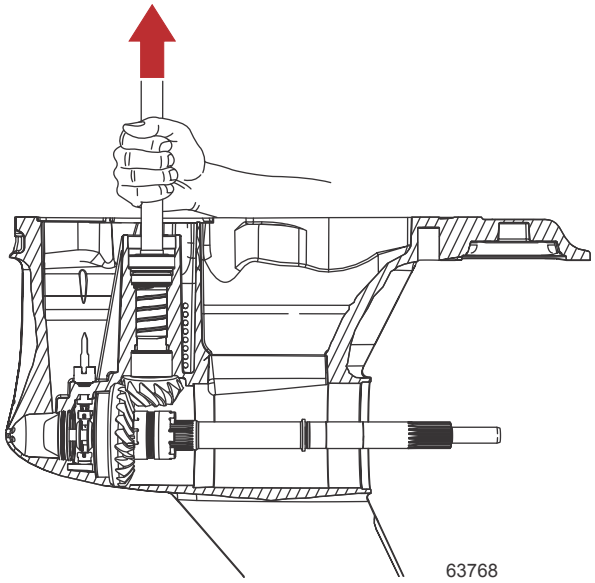


a - Shift shaft handle tool
b - Propeller shaft holder
c - Pinion nut holder
d - Propeller shaft adapter

Shift Shaft Handle Tool	8M0142973
Propeller Shaft Holder	91-8M0035594
Pinion Nut Holder	91-8M0036288
Propeller Shaft Adapter	8M0147118

9. Remove all of the tools.

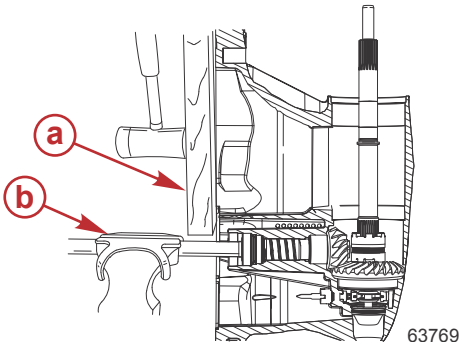
10. Remove the driveshaft by pulling the driveshaft straight out of the gear housing.



11. If the pinion gear is seized onto the driveshaft, clamp the driveshaft in a soft jaw vise. Place a block of wood on the gear housing mating surface. Use a mallet and carefully tap the gear housing away from the driveshaft.

    IMPORTANT: Striking a gear housing directly with a mallet can distort the gear housing causing gear housing failure.

    IMPORTANT: The pinion bearing rollers can fall out of the pinion bearing race after the driveshaft is removed. Do not lose the 21 rollers.

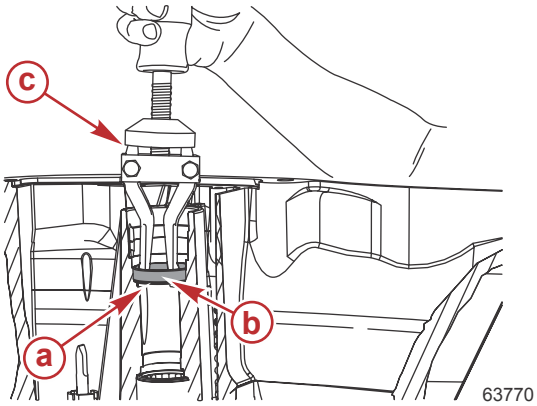


a - Wood block
b - Driveshaft in soft jaw vise

12. Move the propeller shaft downward to retrieve the pinion gear and nut from inside the gear housing.

    NOTE: *The washer will likely come out with the pinion gear. Do not lose the washer.*

13. Remove the driveshaft bearing cup and shims with a slide hammer. Retain the shims for installation.



a - Shims
b - Bearing cup
c - Slide hammer puller

Slide Hammer	91-34569A 1

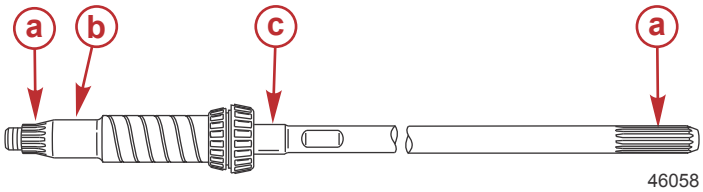
Driveshaft Inspection

1. Clean all parts with a suitable solvent and dry with compressed air. Do not spin the bearings.

⚠ 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 driveshaft bearing cups for pits, grooves, uneven wear, discoloration, or embedded particles. Replace the bearings and bearing cups if any of these conditions are found.
3. Inspect the pinion bearing surface on the driveshaft for pits, grooves, uneven wear, discoloration, or embedded particles. Replace the pinion bearing and the driveshaft if any of these conditions are found.
4. Inspect the splines at both ends of the driveshaft for a worn or twisted condition. Replace the driveshaft if any of these conditions are found.
5. Inspect the water pump base oil seals contact area of the driveshaft for grooves. Replace the driveshaft if grooves are found.



a - Splines
b - Pinion bearing surface
c - Seal surface

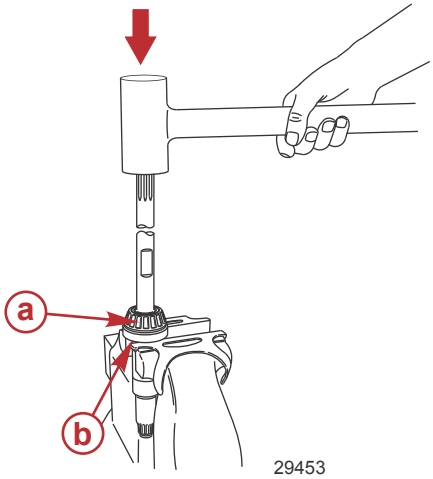
6. Inspect the pinion gear for pits, chipped or broken teeth, fractures, and excessive or uneven wear. Replace the pinion gear and the front gear as a set if any of these conditions are found.

Driveshaft Disassembly

NOTE: *Do not remove the tapered roller bearings from the driveshaft unless replacement is required. The bearings cannot be reused after removal.*

NOTE: *If one of the driveshaft tapered roller bearings is damaged, both tapered bearings must be replaced as a set.*

1. Use the lower bearing cup removed from the gear housing and place the cup on top of a vise, leaving the vise jaws open to allow the driveshaft to slide through.
2. Hold onto the driveshaft and tap on the top of the shaft with a dead blow hammer. Do not drop the driveshaft.

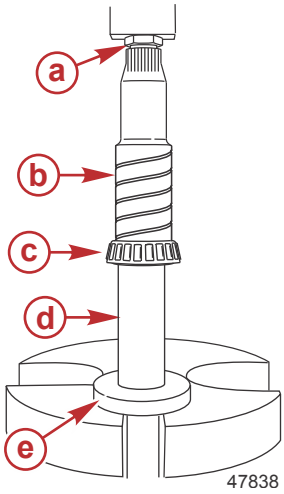


a - Upper and lower bearings
b - Lower bearing cup

Driveshaft Assembly

1. Apply High Performance Gear Lubricant on the inside diameter of the driveshaft tapered bearings.
2. Install the lower tapered roller bearing to the driveshaft, with the small outside diameter of the bearing facing towards the pinion gear end of the driveshaft.
3. Thread a used pinion nut onto the end of the driveshaft. Leave approximately 2 mm (1/16 in.) of nut threads exposed. The driveshaft threads must not extend beyond the nut or thread damage will result when pressing the bearing on.

4. Press the lower bearing onto the driveshaft with the driveshaft bearing installation tool.

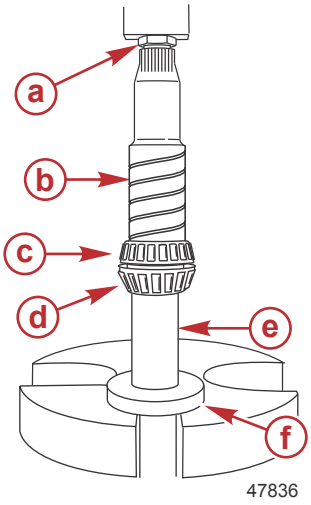


- **a -** Pinion nut
- **b -** Driveshaft
- **c -** Lower driveshaft tapered bearing
- **d -** Driveshaft bearing installation tool
- **e -** Flat washer (obtain locally)

Driveshaft Bearing Installation Tool	91-8M0052590

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of the driveshaft tapered bearings	92-858064K01

5. Install the upper bearing onto the driveshaft, with the large outside diameter of the bearing facing the pinion gear end of the driveshaft.
6. Press the upper bearing onto the driveshaft with the driveshaft bearing installation tool.



- **a -** Pinion nut
- **b -** Driveshaft
- **c -** Lower driveshaft tapered bearing
- **d -** Upper driveshaft tapered bearing
- **e -** Driveshaft bearing installation tool
- **f -** Flat washer (obtain locally)

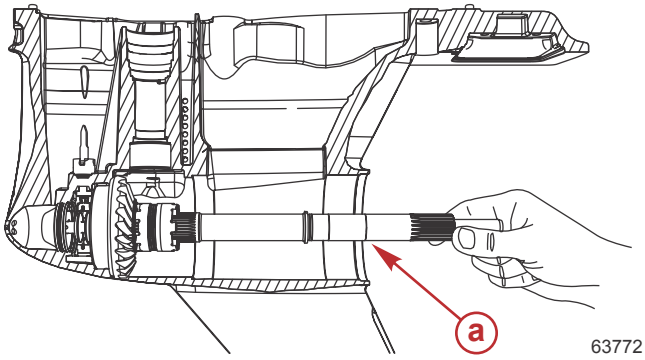
Driveshaft Bearing Installation Tool	91-8M0052590

Propeller Shaft Assembly and Front Gear Bearing Cup

Removal

NOTE: *The front gear and propeller shaft assembly can only be removed from the gear housing after the driveshaft and pinion gear have been removed.*

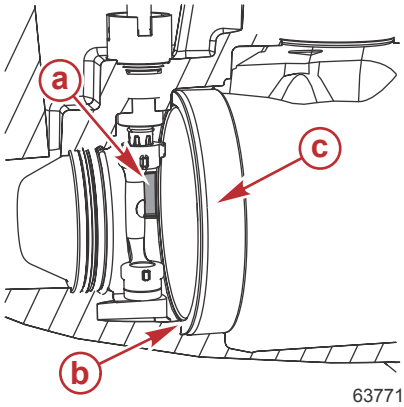
1. On right-hand rotation gear housings, tilt the propeller shaft to the starboard side of the gear housing and remove the shaft. On left-hand rotation gear housings, tilt the propeller shaft to the port side of the gear housing and remove the shaft.



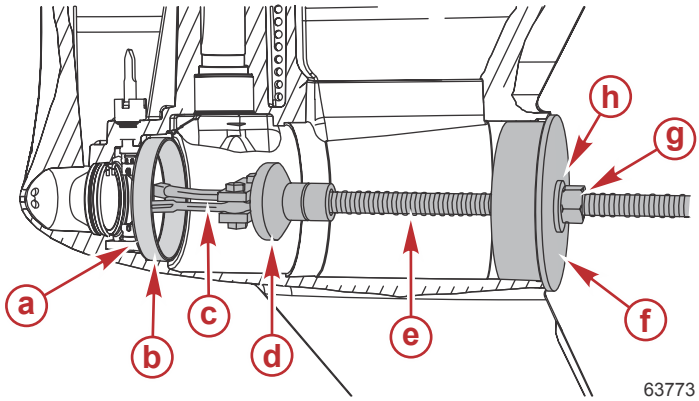
a - Propeller shaft

2. Remove the front gear bearing cup and shims. Measure and make note of the shim thickness. If the shims are not damaged, they may be reused.

NOTE: *Two notches are provided in the gear housing, just forward of the front gear bearing cup, to position the puller jaws for easier removal of the bearing cup and shims.*



a - Notches
b - Shims
c - Front gear bearing cup



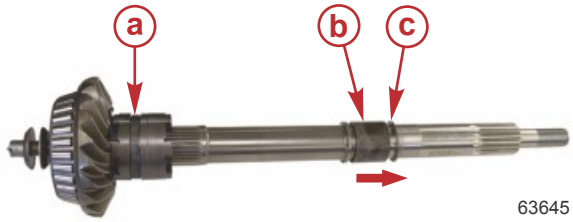
a - Shims
b - Bearing cup
c - Jaws (from slide hammer puller kit)
d - Puller head (from slide hammer puller kit)
e - Puller shaft
f - Propeller shaft holder
g - Nut
h - Washer

Slide Hammer	91-34569A 1
Bearing Removal and Installation Kit	91- 31229A 7
Propeller Shaft Holder	91-8M0035594

Component Disassembly

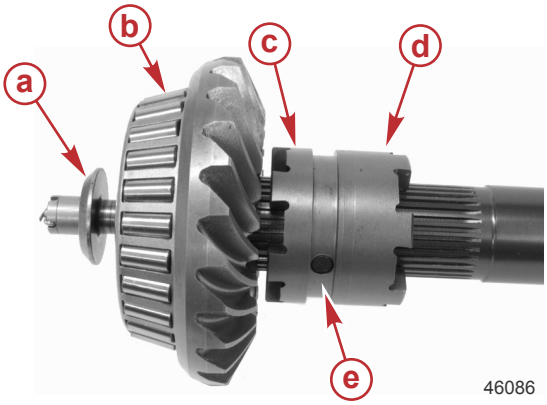
NOTE: *When performing the next step, all of the parts are free to come apart. Work closely over a workbench to avoid dropping or damaging the parts and to avoid personal injury.*

1. Ensure the propeller shaft thrust spacer and shims are removed.



a - Spring
b - Thrust spacer
c - Shims

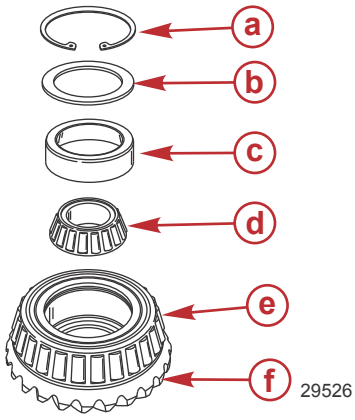
2. Remove the spring around the clutch, being careful not to overstretch it during removal. If the spring does not coil back to its normal position after it has been removed, it must be replaced.
3. Remove the cross pin that goes through the clutch.
4. Remove the remainder of the components.



a - Shift spool and actuating shaft assembly
b - Front gear assembly
c - Clutch
d - Long end of clutch (faces toward rear gear)
e - Cross pin

Inspection

1. Clean all the parts with a suitable solvent and dry the parts thoroughly with compressed air. Be careful not to spin the bearings.
2. Inspect the sliding clutch jaws for damage. Replace the clutch if the jaws are chipped or rounded off.
3. The propeller shaft uses two tapered roller bearing and cup assemblies for propeller shaft support.
   a. One tapered bearing is just forward of the bearing carrier seals. Refer to the **Bearing Carrier Disassembly** section for information on accessing this bearing for inspection.
   b. The other tapered bearing is located inside of the front gear assembly. Remove the front gear assembly from the propeller shaft. Remove the snap ring retainer and flat washer from the front gear assembly to remove the tapered bearing for inspection.

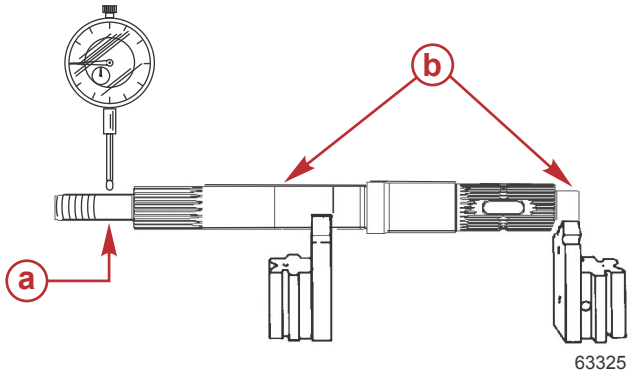


a - Snap ring
b - Flat washer
c - Inner tapered bearing cup
d - Inner tapered bearing cone
e - Outer front gear bearing cone
f - Front gear

NOTE: *The outer front gear bearing should not be removed from the front gear unless replacement is necessary. The bearing is not reusable if it 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 the V-blocks.
   b. Adjust the height of the V-blocks to level the propeller shaft.
   c. Position the dial indicator tip forward of the propeller shaft threads.
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

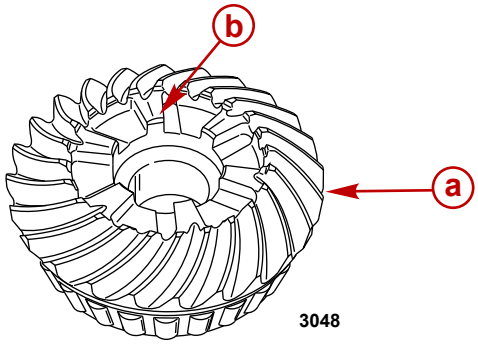
Propeller Shaft	
Runout	0.23 mm (0.009 in.)

Dial Indicator	91- 58222A 1

Front Gear Assembly

Component Inspection

1. Clean the front gear assembly and the front gear bearing cup with a suitable solvent and dry with compressed air. Be careful not to spin the bearings.
2. Inspect the gear for pits, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the front 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 front gear and pinion gear as a set if any of these conditions exist.



a - Front gear teeth
b - Clutch jaws

4. Inspect the propeller shaft tapered roller bearing on the inside of the front 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.
5. Inspect the tapered roller bearing pressed onto the front gear and the bearing surface on the front gear bearing cup. If either the roller bearing or the bearing surface of the front gear bearing cup is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles, replace the front gear bearing cup and remove and replace the tapered roller bearing.

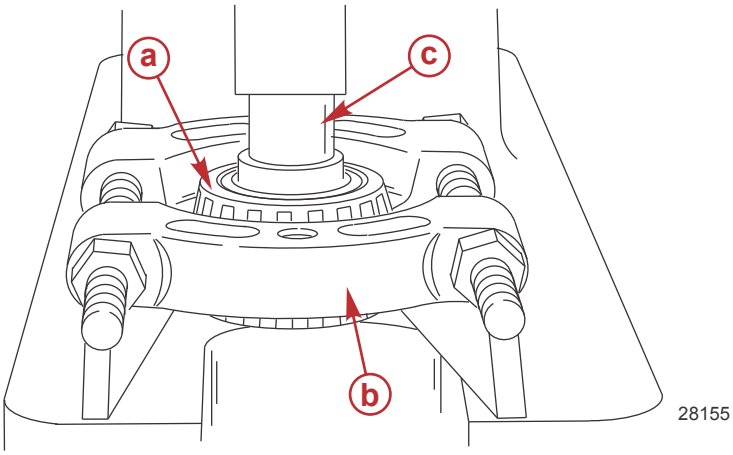
Disassembly

IMPORTANT: Do not remove the pressed on tapered roller bearing from the front gear unless replacement of the bearing is required. The bearing cannot be reused after it has been removed.

1. If inspection determines that replacement of the front gear tapered bearing is required, separate the gear from the bearing as follows:

a. Install the universal puller plate between the front gear and the tapered bearing.
b. Place the assembly on a press and press the gear out of the bearing with a suitable mandrel.

NOTE: *The tapered bearing cup and cone must be replaced as a set.*



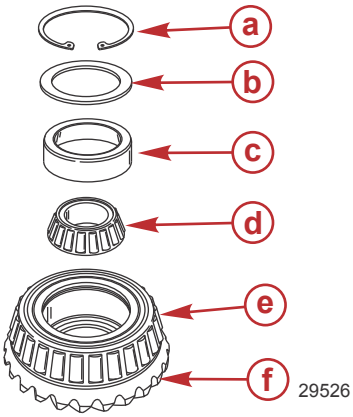
a - Front gear bearing
b - Universal puller plate
c - Mandrel

Universal Puller Plate	91-37241

2. If inspection determines that replacement of the propeller shaft tapered roller bearing is required, remove the bearing as follows:

IMPORTANT: Use suitable eye protection when removing or installing the snap ring.

a. Use snap ring pliers to remove the snap ring. Remove the tapered roller bearing assembly out of the inside of the front gear.

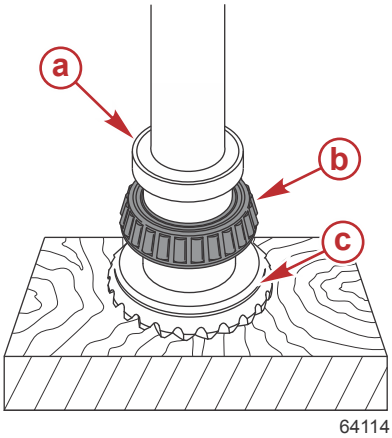


a - Snap ring
b - Flat washer
c - Tapered bearing cup
d - Tapered bearing cone
e - Front gear bearing cone
f - Front gear

Assembly

1. Use a suitable mandrel to press the tapered roller bearing onto the front gear. Press on the inner bearing race until the bearing contacts the gear.

IMPORTANT: Use a block of wood under the gear as shown to prevent damage to the gear while installing the bearing.

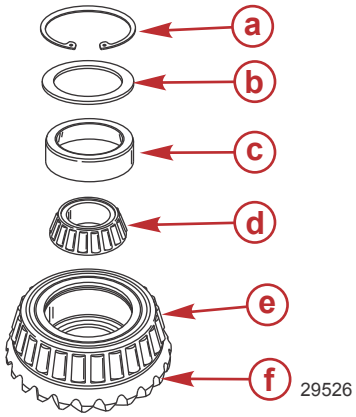


a - Mandrel
b - Tapered roller bearing
c - Front gear

2. Apply High Performance Gear Lubricant to the I.D. of the front gear. Install a new tapered roller bearing cone, race, and flat washer into the front gear until the bearing seats.

   IMPORTANT: Use suitable eye protection when removing or installing the snap ring.

3. Install the snap ring into the groove of the front gear to secure the tapered roller bearing assembly.



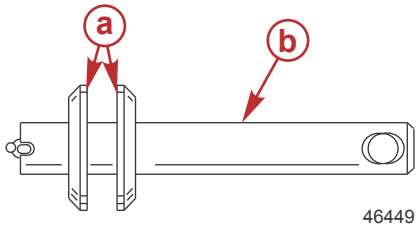
a - Snap ring
b - Flat washer
c - Tapered bearing cup
d - Tapered bearing cone
e - Front gear bearing cone
f - Front gear

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of front gear	92-858064K01

Shift Spool Assembly

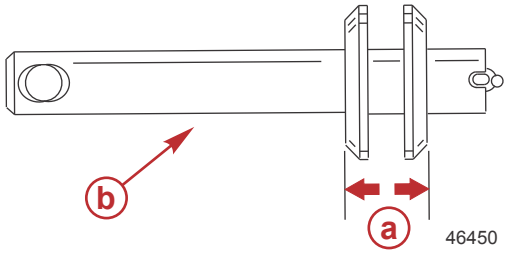
Inspection

1. Clean the assembly with solvent and dry all 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, replace the complete shift spool 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. Verify the spool spins freely.
5. Verify the spool has end play. The 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

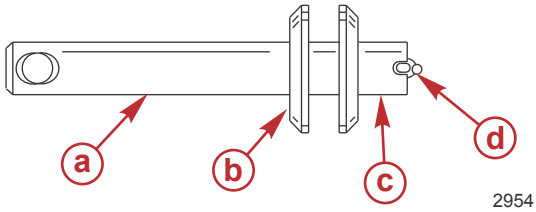
NOTE: *If the spool spins freely and has the proper clearance, it will not be necessary to disassemble and reassemble the spool. If the spool does not function properly, proceed with the following disassembly procedures.*

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, replace the 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

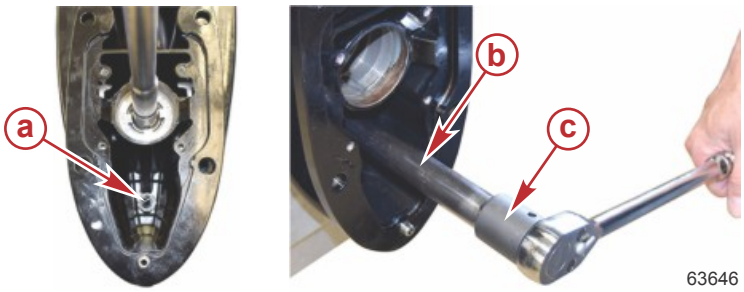
Shift Spool	
End play	0.05–0.25 mm (0.002–0.010 in.)

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, replace the shift spool assembly.

Shift Shaft Removal and Assembly

Removal

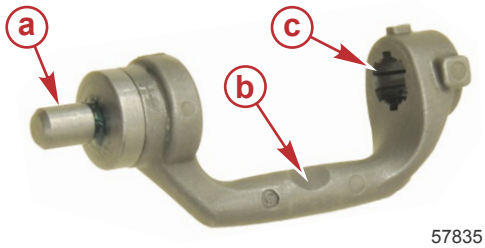
1. Remove the shift shaft assembly from the gear housing using the shift shaft tool and 1 in. socket.



a - Shift shaft
b - Shift shaft tool
c - 1 in. socket

Shift Shaft Tool	8M0142969

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 for wear in the areas that contact the shift spool and inspect the splines and the pivot pin for damage or wear.



a - Pivot pin
b - Contact area
c - Splines

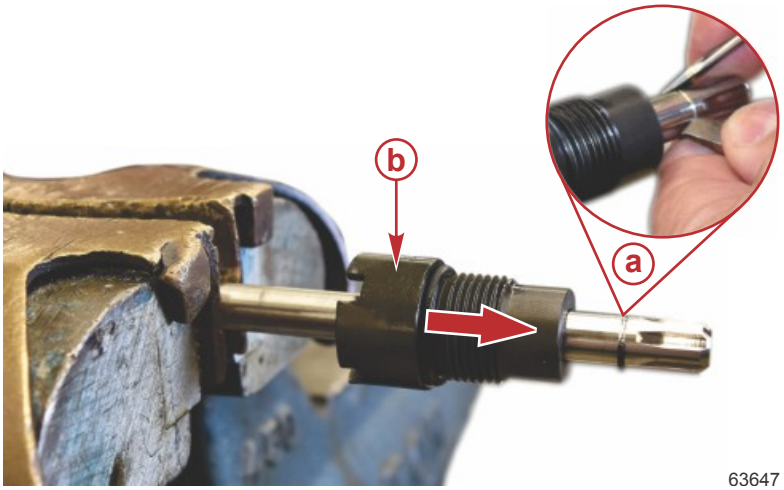
Disassembly and Inspection

1. Secure the shift shaft assembly in a vise as shown.

⚠ CAUTION

Wear eye protection when performing the following procedure. Failure to do so may cause personal injury.

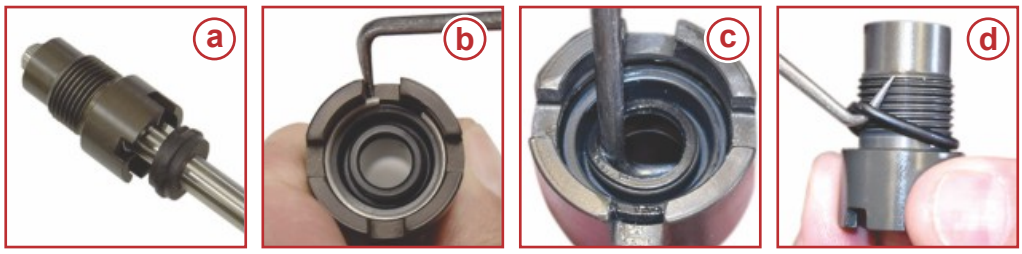
   a. Remove the snap ring from the end of the shift shaft.
   b. Remove the bushing from the shift shaft.



63647

a - Snap ring
b - Bushing

2. Remove the rubber grommet, snap ring, seal, and O-ring from the shift shaft bushing.



63648

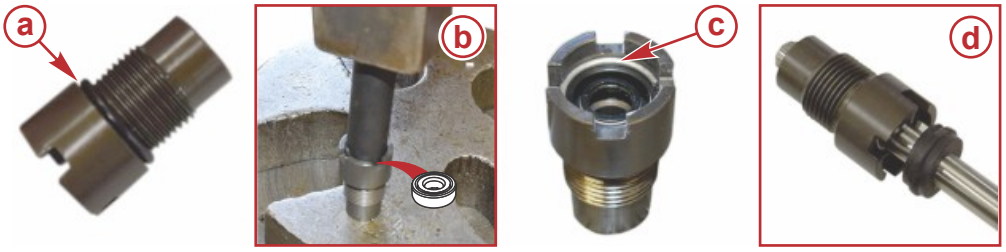
a - Rubber grommet
b - Snap ring
c - Seal
d - O-ring

3. Clean all components with a suitable solvent and dry with compressed air.
4. Inspect all of the components.
   a. Inspect the shift shaft bushing for damage or leaks.
   b. Inspect the O-ring and rubber grommet for damage or excessive wear.
5. Inspect the shift shaft splines and oil seal surface for corrosion or excessive wear. Replace the shift shaft if either of these conditions are found.

Assembly

1. Lubricate the O-ring with 2-4-C with PTFE and install onto the shift shaft bushing.
2. Using a suitable mandrel, press the oil seal into the shift shaft bushing with the lips of the seal facing out.
3. Lubricate the oil seal lips with 2-4-C with PTFE.

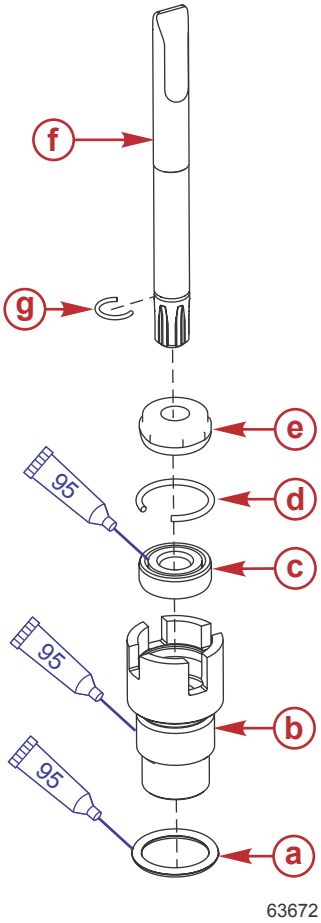
4. Install the snap ring to secure the seal.



63745

a - O-ring
b - Press seal into bushing
c - Snap ring
d - Rubber grommet

5. Install the rubber grommet onto the shift shaft.
6. Install the shift shaft bushing onto the shift shaft.
7. Install the snap ring on the end of the shift shaft.
8. Lubricate the threads of the shift shaft bushing with 2-4-C with PTFE.



63672

a - O-ring
b - Shift shaft bushing
c - Shift shaft seal
d - Snap ring—secures seal in bushing
e - Rubber grommet
f - Shift shaft—L shown, XL and XXL available
g - Snap ring—shift shaft

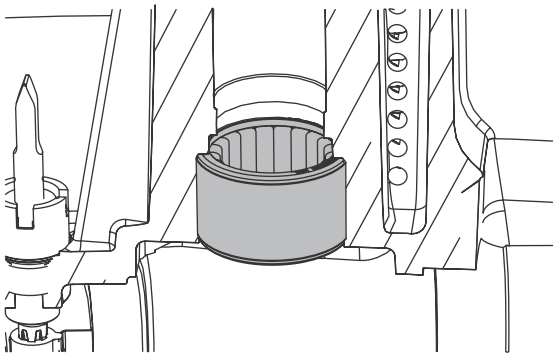
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift shaft bushing threads, O-ring, and oil seal lip	92-802859A 1

Pinion Bearing Removal

NOTE: *Inspect the pinion bearing surface on the driveshaft. The condition of the driveshaft at this location gives an indication of the condition of the roller bearing. Replace the 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.*

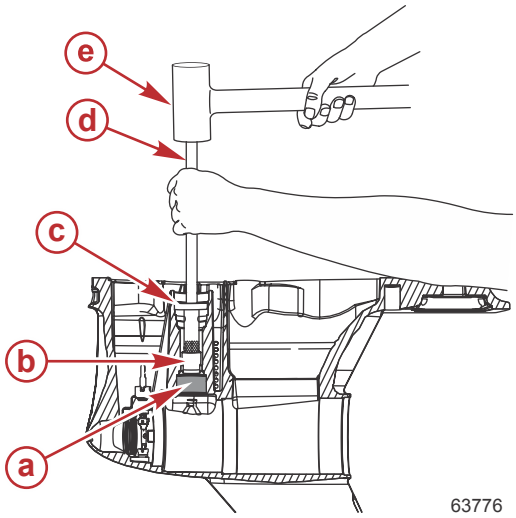
IMPORTANT: All roller bearings (21) must be in place inside the bearing race while driving the pinion bearing from the gear housing. It is recommended that the cardboard tube provided with a new pinion bearing be used to keep the bearings in place while driving out the old pinion bearing.

IMPORTANT: Do not use the bearing race or rollers after they have been removed.



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

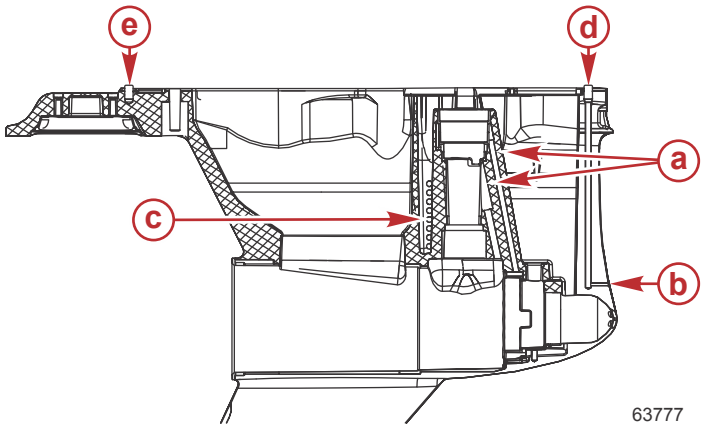
Pinion Bearing Removal Tool	91-8M0046348
Pilot Washer	91-36571T
Driver Rod	91- 37323

Gear Housing Inspection

1. Clean the gear housing with a suitable solvent and a hard bristle (not wire) brush. Dry the gear housing with compressed air. Ensure that all sealants, locking agents, and debris are removed.
2. Verify the two oil circulation holes in the driveshaft bore are clear and free of debris.
3. Inspect the gear housing for excessive corrosion, impact, or any other damage. Excessive damage or corrosion requires replacement of the gear housing.
4. Inspect the bearing carrier retainer threads in the gear housing for corrosion or stripped threads. Damage or corrosion to the threads requires replacement of the gear housing.

   NOTE: *The driveshaft bearing cups are 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 the bearing cone and cup contact area with the gearcase bearing bore for evidence of the bearing cup spinning. Check that the bearing cups are not loose in the bearing bores. A press fit type bearing bore in which the cup is loose will require replacement of the gear housing.

6. Inspect for blockage in the water inlet holes and the speedometer hole and 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
- **d -** Hollow locating pin for speedometer passage
- **e -** Locating pin

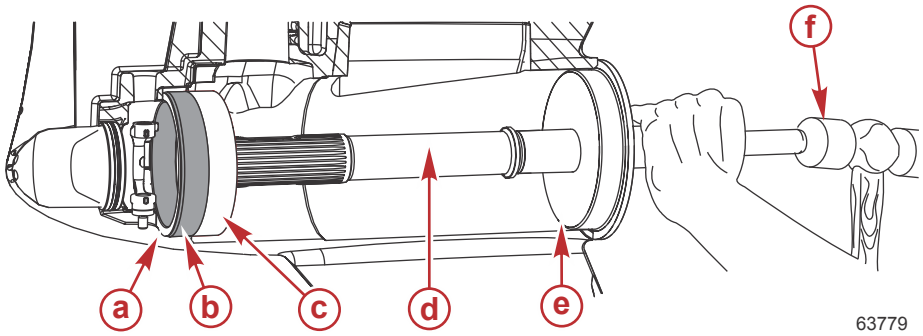
7. Verify the locating pins are in place in the gear housing and the corresponding holes in the driveshaft housing are not elongated. The driveshaft may break if the housings are not aligned properly due to missing locating pins or elongated holes.

Front Gear Bearing Cup Installation

NOTE: *If the front gear, front gear bearing and cup, or gear housing were not replaced, install the same measurement of shims that were removed. If the front gear, front gear bearing and cup, or gear housing were replaced, install 0.762 mm (0.030 in.) shims.*

1. Lubricate the front gear bearing cup bore with High Performance Gear Lubricant.
2. Install the shims into the front gear bearing cup bore.

IMPORTANT: Verify the bearing cup is positioned as straight as possible to avoid damaging the bore while pressing the bearing cup in.



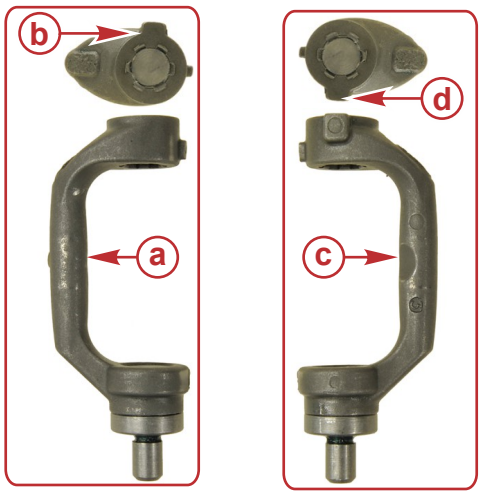
- **a -** Shims
- **b -** Front gear bearing cup
- **c -** Bearing cup driver
- **d -** Propeller shaft (old nonserviceable)
- **e -** Propeller shaft holder
- **f -** Mallet

Bearing Cup Driver	91-885592T
Propeller Shaft Holder	91-8M0035594

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Front gear bearing cup bore	92-858064K01

Shift Shaft Installation

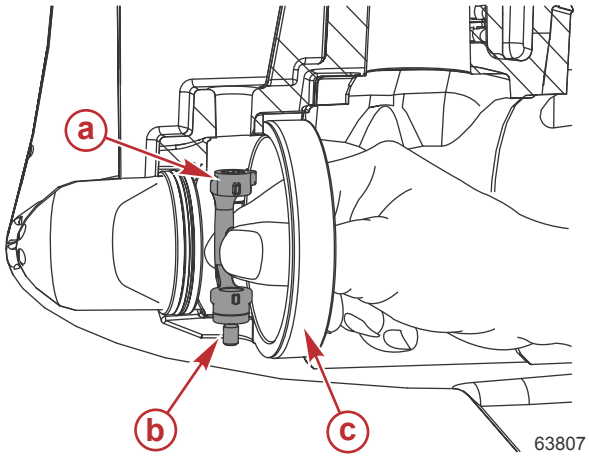
IMPORTANT: The shift crank has a tab on it. The tab faces aft in right-hand rotation gear housings. The tab faces forward in left-hand rotation gear housings.



Shift crank

- **a -** Left-hand rotation aft view—shift crank toward port
- **b -** Left-hand rotation top view—tab facing forward
- **c -** Right-hand rotation aft view—shift crank toward starboard
- **d -** Right-hand rotation top view—tab facing aft

1. Place the shift crank into the pivot pin hole in the forward section of the gear housing. Ensure that the shift crank faces towards the starboard side of the gear housing for right-hand rotation gear housings. Ensure that the shift crank faces toward the port side of the gear housing for left-hand rotation gear housings.



Right-hand rotation shown

- **a -** Shift crank
- **b -** Pivot pin
- **c -** Front gear bearing cup

2. Install the shift shaft assembly into the gear housing. Engage the splined end of the shift shaft with the shift crank. Ensure that the flat at the tip of the shift shaft is parallel with the direction of the shift crank.

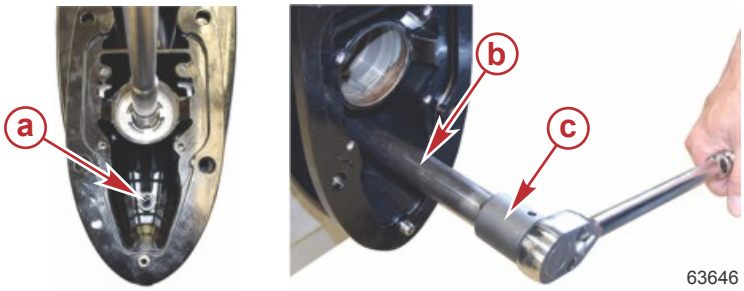
NOTE: *The shift crank is shown outside of the gear housing for clarity.*

63923

XL shift shaft shown

a - Left-hand rotation shift shaft and crank orientation
b - Right-hand rotation shift shaft and crank orientation
c - Incorrect shift shaft orientation

3. Tighten the shift shaft bushing to the specified torque using the shift shaft tool and a 1 in. socket.



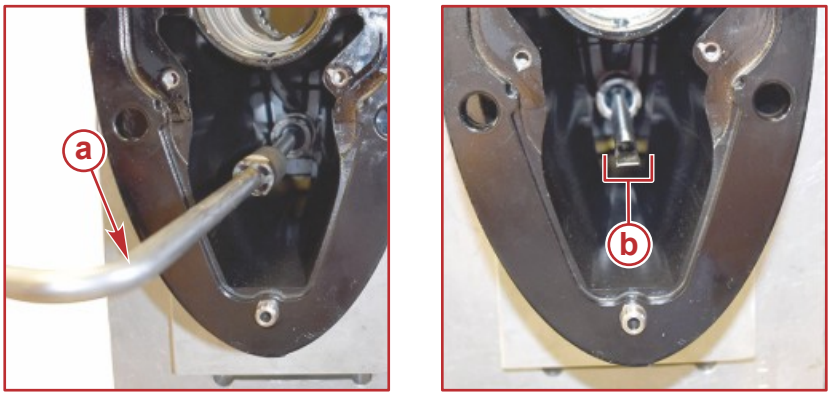
63646

a - Shift shaft
b - Shift shaft tool
c - 1 in. socket

Shift Shaft Tool	8M0142969

Description	Nm	lb-in.	lb-ft
Shift shaft bushing	54.2	–	40

4. Operate the shift shaft with the shift shaft handle tool to ensure it has engaged into the shift crank. The proper neutral position can be identified below.



63924

XL shift shaft shown

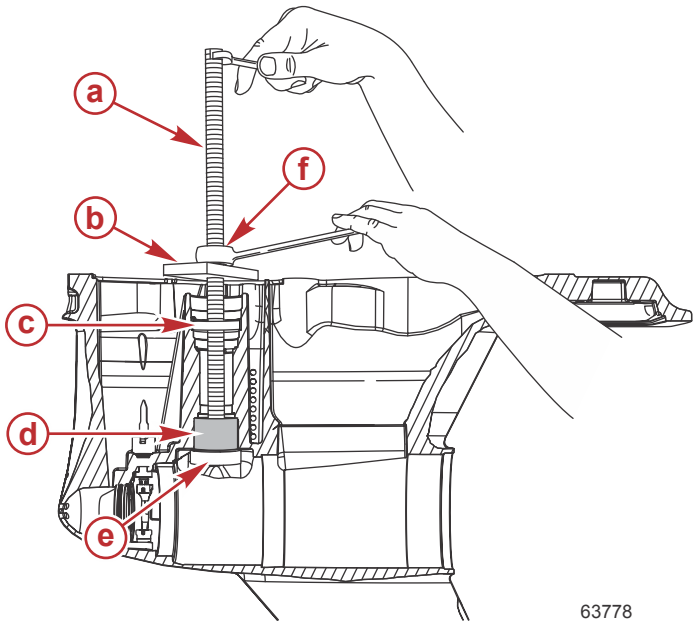
a - Shift shaft handle tool
b - Neutral position

Shift Shaft Handle Tool	8M0142973

Pinion Bearing Installation

IMPORTANT: Never install a pinion bearing that was removed from a gear housing. Always install a new pinion bearing.

1. Lubricate the gearcase pinion bearing bore with High Performance Gear Lubricant.
2. Install the pinion bearing onto the pinion bearing installation tool so the letter and number side of the bearing faces up.
3. Insert the pinion bearing installation tool and bearing into the gear housing pinion bearing bore.
4. Install the puller plate onto the puller rod and insert the puller rod into the gear housing driveshaft bore. Thread the puller rod into the pinion bearing installation tool.
5. Secure the puller rod and tighten the nut until the pinion bearing installation tool contacts the gear housing.



- **a -** Puller rod
- **b -** Puller plate
- **c -** Pilot washer
- **d -** Pinion bearing
- **e -** Pinion bearing installation tool
- **f -** Hex nut

Bearing Removal and Installation Kit	91- 31229A 7
Pinion Bearing Installation Tool	91-8M0046360

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Gearcase pinion bearing bore	92-858064K01

Driveshaft Bearing Rolling Torque and Pinion Gear Height

IMPORTANT: The sequence of setting up the driveshaft bearing rolling torque and pinion height must be completed before checking the front and rear gear backlash. Failure to set the driveshaft bearing rolling torque and pinion height prior to checking the front and rear gear backlash may cause errors in determining the correct lash, and will increase assembly time of the gear housing to factory specifications.

Driveshaft and Pinion Gear Installation

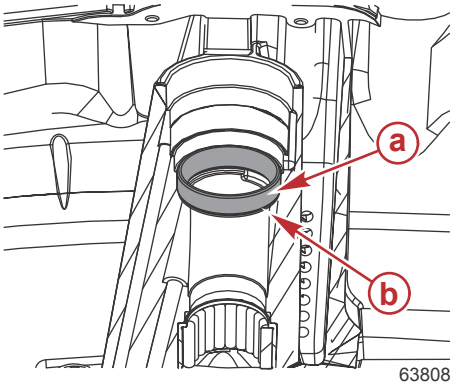
NOTE: *If the original shims were not retained, or if the pinion gear, driveshaft, driveshaft upper tapered roller bearing and cup, or gear housing were replaced, start by installing a 0.508 mm (0.020 in.) shim for the lower tapered roller bearing.*

NOTE: *If the original shims were retained or the measurement is known, and none of the above listed parts were replaced, install the same shims or same amount of shims.*

IMPORTANT: Do not apply Loctite 271 Threadlocker to the threads of the pinion gear nut until after the pinion height, pinion bearing rolling torque, and front gear backlash have been confirmed.

1. Place the lower tapered bearing shims into the driveshaft housing bore.

2. Install the lower tapered bearing cup into the driveshaft housing bore.

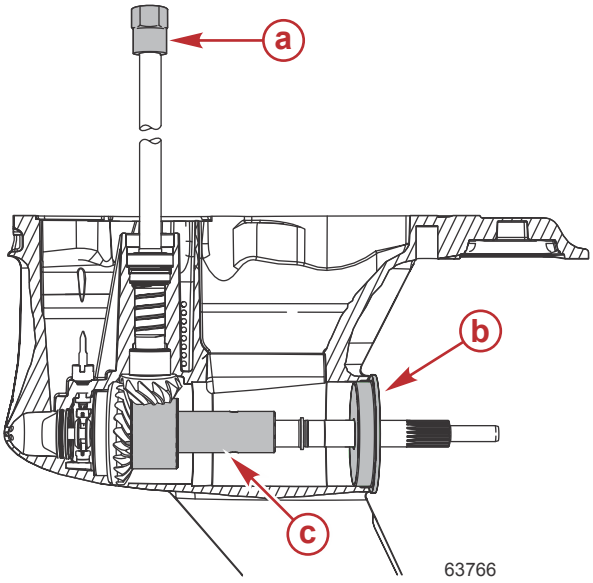


a - Tapered bearing cup
b - Shims

3. Install the front gear assembly.
   IMPORTANT: The front gear must be installed to support the pinion nut holding tool.
4. Install the pinion gear and driveshaft.
5. Secure the pinion gear with the pinion nut and washer.
   NOTE: *Install the pinion gear nut with the flat side of the nut away from the pinion gear.*
6. Install the upper driveshaft tapered roller bearing shim.
7. Install the upper driveshaft tapered roller bearing cup. Apply 2-4-C with PTFE to the retainer threads and install the retainer.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Retainer threads	92-802859A 1

8. Install the driveshaft holding tool.
9. Install the propeller shaft into the front gear.
10. Install the pinion nut holding tool over the propeller shaft and secure the pinion nut with the pinion nut holding tool.
11. Install the propeller shaft holder.
12. Use the driveshaft holding tool to tighten the pinion nut to the specified torque.



a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut holder

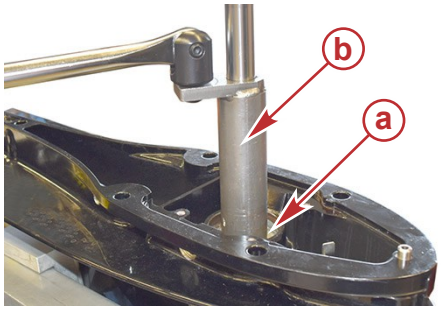
Driveshaft Holding Tool	91-889958T
Pinion Nut Holder	91-8M0036288
Propeller Shaft Holder	91-8M0035594

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	169.5	–	125

13. Remove the driveshaft holding tool, propeller shaft holder, pinion nut holding tool, propeller shaft, and front gear.

Driveshaft Bearing Rolling Torque

1. Use the driveshaft bearing retainer wrench to tighten the upper driveshaft bearing retainer to the specified torque.



63643

a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

2. Install the driveshaft holding tool.

Driveshaft Holding Tool	91-889958T

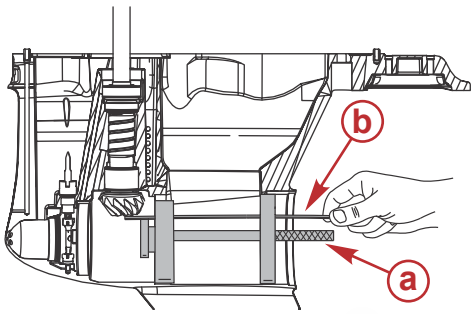
3. Use the driveshaft holding tool to check the driveshaft bearing rolling torque. Units correctly assembled to this point would be within the specified rolling torque range. If the rolling torque is not within specification, the shim under the upper tapered roller bearing cup will need to be changed and the rolling torque rechecked. If the rolling torque is too high, add shims under the upper bearing cup. If the rolling torque is too low, remove shims from under the upper bearing cup.

Description	Nm	lb-in.	lb-ft
Driveshaft bearing rolling torque	0.45–1.13	4–10	–

Checking and Adjusting Pinion Gear Height with Pinion Gear Locating Tool 91-8M0046443

NOTE: *The front gear, propeller shaft, and bearing carrier must be removed from the gear housing prior to checking the pinion gear height.*

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. Record the measurement.



63809

a - Pinion gear locating tool
b - Feeler gauge

Pinion Gear Locating Tool	91-8M0046443

3. Rotate the driveshaft 120° in a clockwise direction and measure the clearance (height). Record the measurement.
4. Repeat this process until three measurements have been recorded.
5. Add the three measurements together and divide the sum by three to get the average pinion gear height. Make note of this average measurement.

Pinion Gear Specification	
Height	0.635 mm (0.025 in.)

6. If the average pinion gear height is not within specification, add or subtract shims beneath the lower and upper driveshaft tapered bearing cups.

   IMPORTANT: Add or subtract shims beneath the lower and upper driveshaft bearing cups proportionally to maintain the driveshaft bearing rolling torque.

7. Install the removed components and tighten the retainer to the specified torque.

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

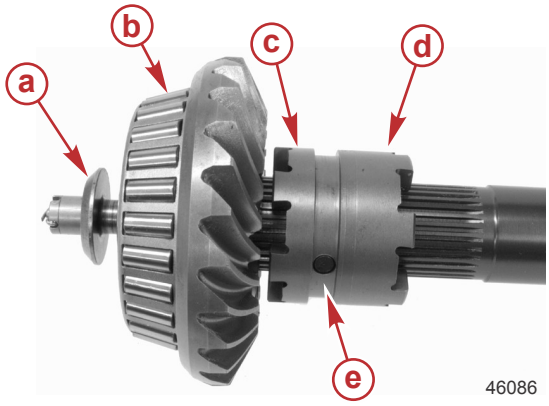
8. Rotate the driveshaft a minimum of three full turns in a clockwise direction. Check the pinion gear height. If the pinion gear clearance is not within specification, adjust the shim thickness and repeat this process until the average pinion gear height is within specification.
9. Verify the driveshaft bearing rolling torque is within specification.

Description	Nm	lb-in.	lb-ft
Driveshaft bearing rolling torque	0.45–1.13	4–10	–

10. Remove the pinion gear locating tool, driveshaft, pinion gear, and front gear.

Propeller Shaft Assembly

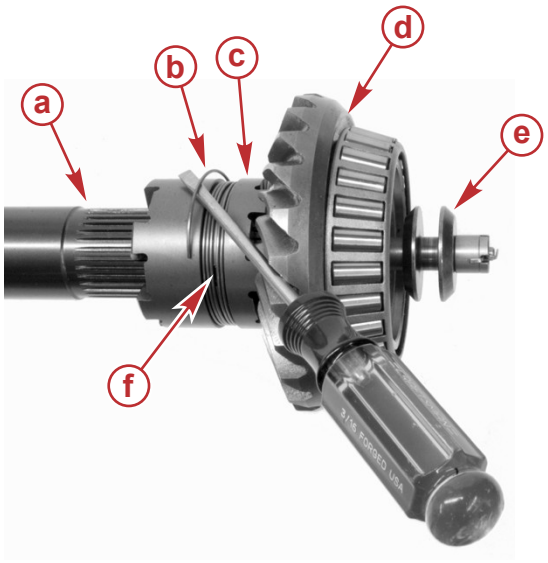
1. Install the sliding clutch, with the long end of the clutch facing toward the rear gear, onto the propeller shaft. Align the cross pin holes in the clutch with the slot in the propeller shaft.
2. Assemble the front gear assembly to the propeller shaft.
3. Assemble the shift spool assembly into the 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.



a - Shift spool and actuating shaft assembly
b - Front gear assembly
c - Clutch
d - Long end of clutch (facing toward the rear gear)
e - Cross pin

5. 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 or stretch 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.

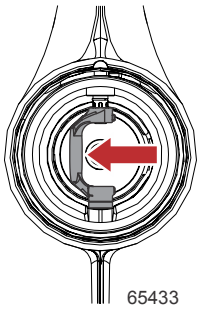


46087

- **a -** Propeller shaft
- **b -** Cross pin retaining spring
- **c -** Sliding clutch
- **d -** Front gear assembly
- **e -** Shift spool and actuating shaft assembly
- **f -** Cross pin (hidden)

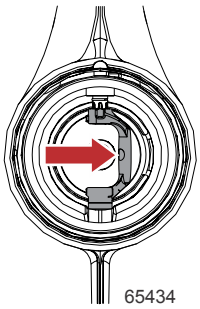
Propeller Shaft Installation

1. Verify the shift crank is positioned properly before installing the propeller shaft. The shift crank should face towards the starboard side of the gear housing for right-hand rotation gear housings, and should face toward the port side of the gear housing for left-hand rotation gear housings.



65433

Shift crank position—left-hand rotation

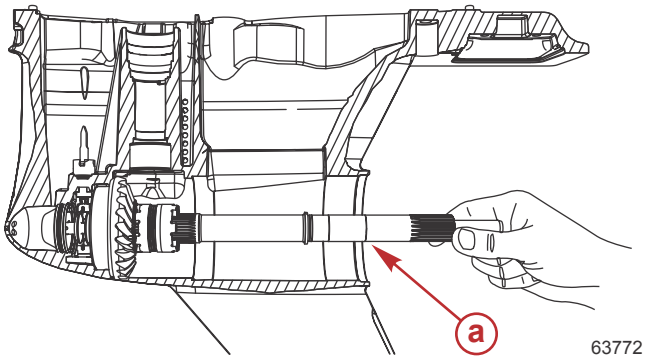


65434

Shift crank position—right-hand rotation

NOTE: *The shift/clutch assembly should be in the neutral position when installing the propeller shaft.*

2. To allow for the engagement of the shift spool with the shift crank, tilt the propeller end of the propeller shaft assembly to the starboard side of the gear housing for right-hand rotation gear housings and to the port side of the gear housing for left-hand rotation gear housings. Hold the shift shaft in neutral while installing the propeller shaft.



63772

- **a -** Propeller shaft

3. Operate the shift shaft to ensure it has been properly installed. On right-hand rotation gear housings, the sliding clutch should move forward when the shift shaft is turned counterclockwise. The sliding clutch should move aft when the shift shaft is turned clockwise. On left-hand rotation gear housings, the sliding clutch should move forward when the shift shaft is turned clockwise. The sliding clutch should move aft when the shift shaft is turned counterclockwise. Hold the shift shaft handle tool in the neutral position, and ensure that the propeller shaft rotates freely in either direction.

Shift Shaft Handle Tool	8M0142973

Driveshaft and Pinion Gear Final Installation

1. Apply Loctite 271 Threadlocker to the threads of the pinion gear nut and place the pinion gear nut and washer into the slot of the pinion nut holder.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Pinion gear nut threads	92-809819

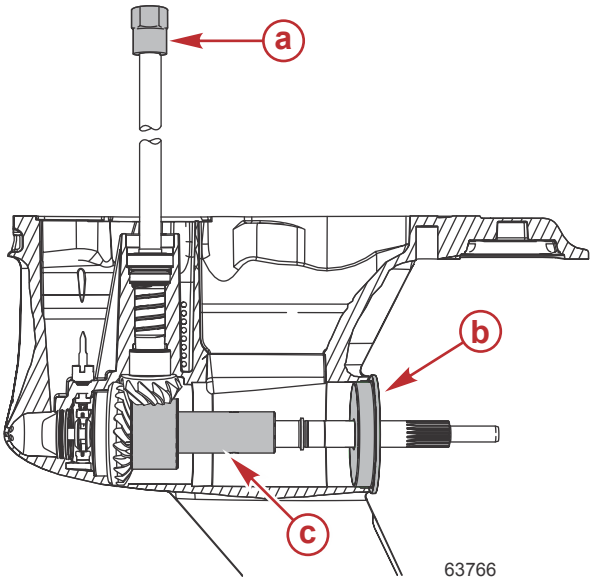
NOTE: *Install the pinion gear nut with the flat side of the nut away from the pinion gear.*

NOTE: *For ease of installation, glue the washer to the pinion gear using 3M Adhesive, Bellows Adhesive, or equivalent.*

Tube Ref No.	Description	Where Used	Part No.
27	Bellows Adhesive	Driveshaft pinion gear washer	92-86166Q1

NOTE: *Do not apply Loctite 271 Threadlocker to the pinion nut until the front gear backlash setting is finalized. Do not reuse the old pinion nut. Install a new pinion nut after backlash is finalized.*

2. Place the pinion gear into the gear housing.
3. With the propeller shaft horizontal, insert the pinion nut holder with the nut and washer into the gear housing.
4. 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.
5. Start the pinion nut onto the driveshaft threads by rotating the driveshaft until the nut is snug.
6. Install the propeller shaft holder into the gear housing to hold the propeller shaft and the pinion nut holder in position.
7. Tighten the pinion nut to the specified torque by turning the driveshaft using the driveshaft holding tool and torque wrench.

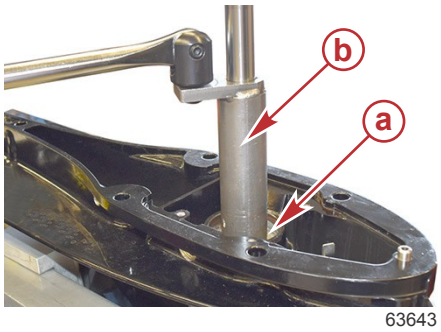


a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut holder

Driveshaft Holding Tool	91-889958T
Pinion Nut Holder	91-8M0036288
Propeller Shaft Holder	91-8M0035594

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	169.5	–	125

8. Apply 2-4-C with PTFE to the retainer threads and install the retainer. Tighten the retainer to the specified torque.



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 PTFE	Retainer threads	92-802859A 1

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

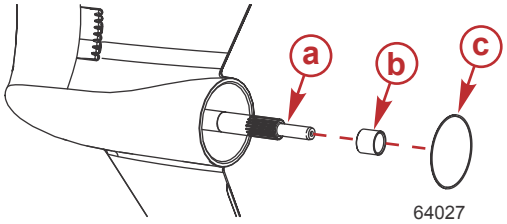
9. Remove the propeller shaft holder, pinion nut holder, and driveshaft bearing retainer wrench.

Front Gear Backlash

IMPORTANT: Backlash values are only valid if the pinion height is within specification.

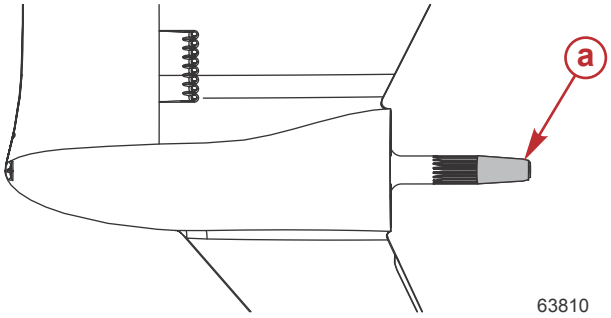
1. Install the propeller shaft thrust spacer onto the propeller shaft. Do not install the propeller shaft shims at this time.
2. Install the bearing carrier shims.

   NOTE: *If the original shims were not retained, start by installing a 0.559 mm (0.022 in.) shim in right-hand rotation gear housings, and a 0.813 mm (0.032 in.) shim in left-hand rotation gear housings.*



a - Propeller shaft
b - Thrust spacer
c - Bearing carrier shim

IMPORTANT: Prior to installing the bearing carrier into a gearcase equipped with the heavy-duty 31.75 mm (1.25 in.) diameter propeller shaft, install the bearing carrier installation tool over the propeller shaft. This tool will prevent the bearing carrier seal lips from being damaged by the propeller shaft splines. Remove the tool after the bearing carrier is installed.

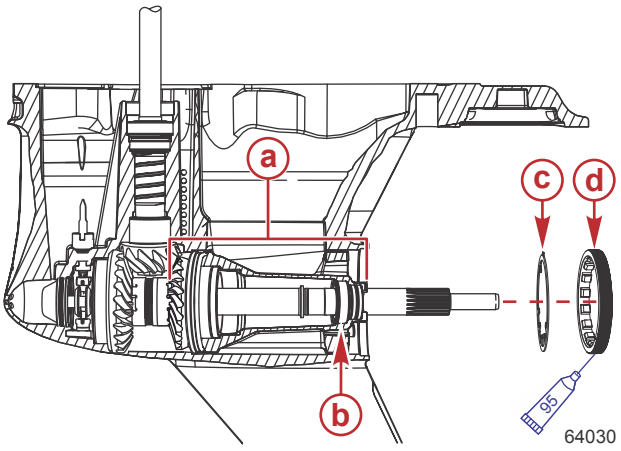


a - Bearing carrier installation tool

Bearing Carrier Installation Tool	91-8M0059911

3. Place the bearing carrier assembly into the gear housing. Carefully align the rear propeller shaft tapered bearing with the propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion and rear gears.

4. Lubricate the bearing carrier retainer nut threads with 2-4-C with PTFE. Install the locking tab washer and bearing carrier retainer into the gear housing. Use the bearing carrier retainer nut tool to thread the retainer on hand-tight.

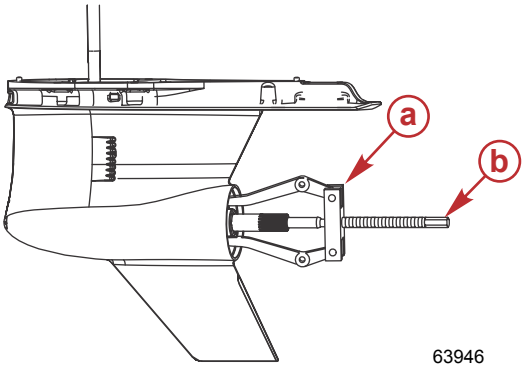


a - Bearing carrier assembly
b - Propeller shaft tapered bearing
c - Locking tab washer
d - Bearing carrier retainer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier retainer nut threads	92-802859A 1

Bearing Carrier Retainer Nut Tool	91-8M0046632

5. Apply forward pressure to the propeller shaft as follows.
   a. Install the puller jaws assembly onto the bearing carrier bosses and propeller shaft.
   b. Tighten the puller bolt to the specified torque. Rotate the driveshaft three turns clockwise and check the puller bolt torque.

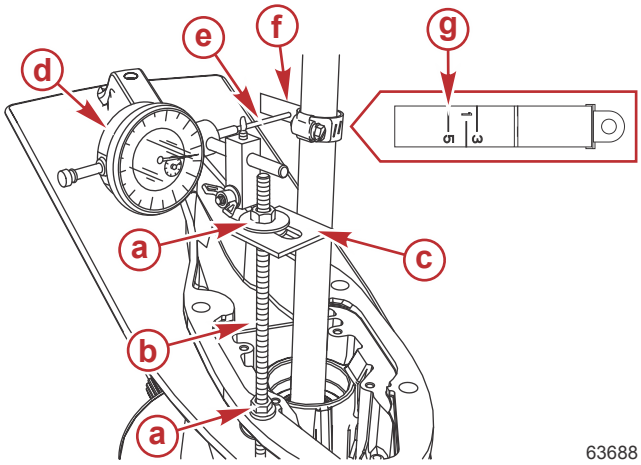


a - Puller jaws assembly
b - Puller bolt

Puller Jaws Assembly	91-46086A1

Description	Nm	lb-in.	lb-ft
Puller bolt	5.6	50	–

6. Install a dial indicator and align the pointer so it is perpendicular to the "5" mark on the backlash indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so the dial indicator needle makes one full revolution and comes to "0" on the dial indicator scale.



- **a -** Nuts (4) (obtain locally)
- **b -** Threaded rod (obtain locally)
- **c -** Dial indicator adapter
- **d -** Dial indicator
- **e -** Indicator pointer
- **f -** Backlash indicator tool
- **g -** Backlash indicator tool—5 mark

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Tool	91-8M0053505

7. Lightly turn the driveshaft back and forth. This is the amount of backlash. No movement should be noticed at the propeller shaft. Record the amount of backlash.
8. Loosen the indicator tool and rotate the driveshaft 120° clockwise.
9. Align the pointer so it is perpendicular to the "5" mark on the backlash indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so the dial indicator needle makes one full revolution and comes to "0" on the dial indicator scale.
10. Lightly turn the driveshaft back and forth. No movement should be noticed at the propeller shaft. Record the amount of backlash. Repeat this for a total of three backlash measurements.
11. Add the three measurements together and divide the sum by three. This is the average front gear backlash.

IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "5" mark and are only valid if the pinion height is within specification.

Front Gear Backlash Specification	
Right-hand rotation—forward	0.508–0.609 mm (0.020–0.024 in.)
Left-hand rotation—reverse	0.787–0.965 mm (0.031–0.038 in.)

12. If the backlash is less than the specification, remove shims in front of the front gear bearing cup to obtain the correct backlash.

Example (backlash is too low—right-hand rotation)	
Front gear backlash average specification:	0.56 mm (0.022 in.)
Subtract the front gear backlash measurement:	0.25 mm (0.010 in.)
Remove this quantity of shims:	0.31 mm (0.012 in.)
Provides backlash of:	0.56 mm (0.022 in.)

13. If the backlash is more than the specification, add shims in front of the front gear bearing cup to obtain the correct backlash.

Example (backlash is too high—right-hand rotation)	
Front gear backlash measurement:	1.02 mm (0.040 in.)
Subtract the front gear backlash average specification:	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.)

NOTE: *By adding or subtracting 0.025 mm (0.001 in.) shim, the backlash will change approximately 0.025 mm (0.001 in.).*

14. Remove the puller jaw assembly and puller bolt.

15. When the backlash is within specification, apply Loctite 271 Threadlocker to the threads of a new pinion nut and tighten to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Threads of pinion nut	92-809819

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	169.5	–	125

Rear Gear Backlash

IMPORTANT: Backlash values are only valid if the pinion height is within specification.

NOTE: *The propeller shaft shims must be removed from the propeller shaft to check the rear gear backlash.*

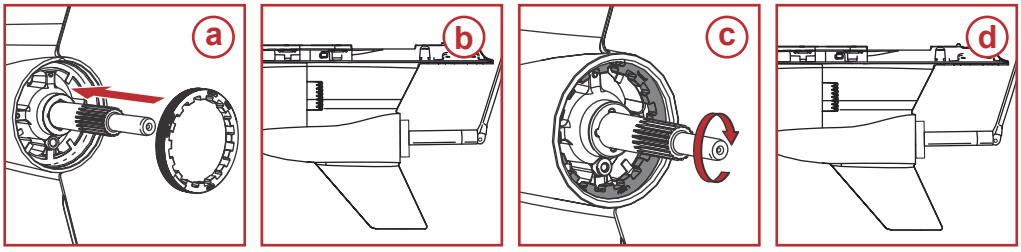
1. Tighten the bearing carrier retainer nut to the specified torque as follows:

   IMPORTANT: Before tightening the bearing carrier retainer to the specified torque, the gear housing must be bolted to the driveshaft housing or securely fastened in a gear housing holding fixture to avoid possible damage to the gear housing.

   a. Use the bearing carrier retainer nut tool to tighten the retainer nut to the first specified torque.

   b. Rotate the propeller shaft several times to seat the propeller shaft tapered roller bearings in their races.

   c. Use the bearing carrier retainer nut tool to tighten the retainer nut to the second specified torque.



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a - Install bearing carrier retainer nut
b - Tighten to first specified torque
c - Rotate propeller shaft
d - Tighten to final specified torque

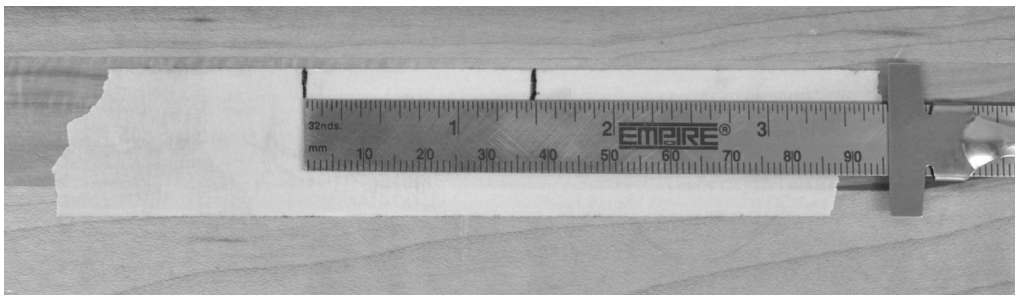
Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut (refer to NOTE)	**First**	135.5	–	100
	Second	285	–	210
	Final	Rotate an additional 3.8 cm (1.5 in.)		

NOTE: *Tighten the retainer nut to 135.5 Nm (100 lb-ft), and then check the rolling torque on the propeller shaft. If the torque is within specification, tighten the retainer nut to 285 Nm (210 lb-ft). Proceed to the next step to rotate the retainer nut an additional 3.8 cm (1.5 in.).*

Bearing Carrier Retainer Nut Tool	91-8M0046632

d. Tighten the retainer nut an additional 3.8 cm (1.5 in.) to achieve the final desired torque as follows:

   i. On a piece of masking tape, mark a distance of 3.8 cm (1.5 in.).



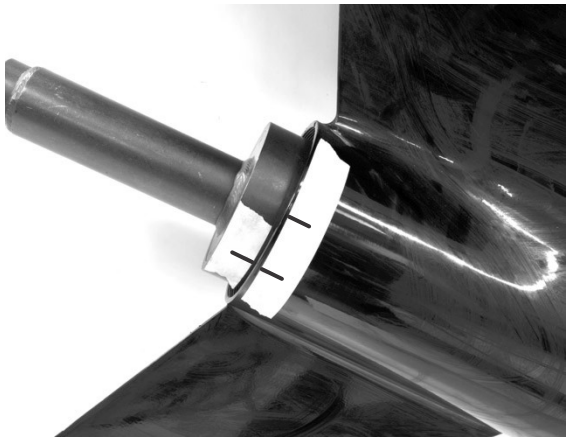
66380

ii. On a second piece of masking tape, mark it with a single line.

iii. With the bearing carrier retainer nut tool installed on the gear housing, place the masking tape with the distance mark onto the gear housing. Place the masking tape with the single line onto the bearing carrier retainer nut tool, aligning the marks on the masking tape.

66382

iv. Tighten the bearing carrier retainer nut so the masking tape with the single line aligns with the second mark on the masking tape.

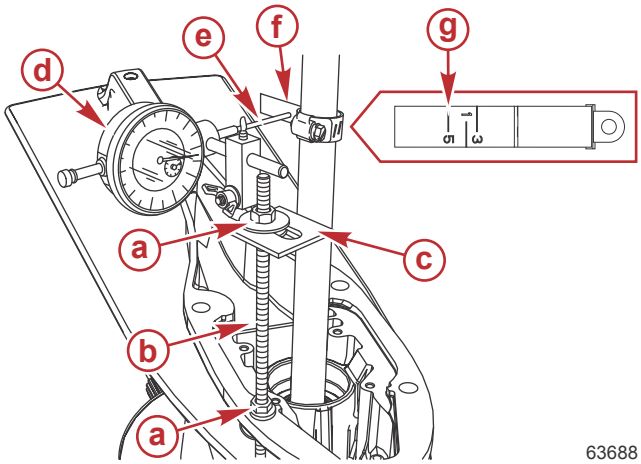


66383

e. Remove the bearing carrier retainer nut tool from the propeller shaft.

2. Install a dial indicator and align the pointer so it is perpendicular to the "5" mark on the backlash indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so the dial indicator needle makes one full revolution and comes to "0" on the dial indicator scale.

3. Apply pressure on the propeller shaft by holding the shift crank against the rear gear.



63688

a - Nuts (4) (obtain locally)
b - Threaded rod (obtain locally)
c - Dial indicator adapter
d - Dial indicator
e - Indicator pointer
f - Backlash indicator tool
g - Backlash indicator tool—5 mark

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Tool	91-8M0053505

4. Lightly turn the driveshaft back and forth. This is the amount of backlash. No movement should be noticed at the propeller shaft. Record the amount of backlash.
5. Loosen the indicator tool and rotate the driveshaft 120° clockwise.
6. Align the pointer so it is perpendicular to the "5" mark on the backlash indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so the dial indicator needle makes one full revolution and comes to "0" on the dial indicator scale.
7. Lightly turn the driveshaft back and forth. No movement should be noticed at the propeller shaft. Record the amount of backlash. Repeat this for a total of three backlash measurements.
8. Add the three measurements together and divide the sum by three. This is the average rear gear backlash.

   IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "5" mark and are only valid if the pinion height is within specification.

Rear Gear Backlash Specification	
Right-hand rotation 1.75:1 ratio—reverse	0.787–0.940 mm (0.031–0.037 in.)
Right-hand rotation 1.85:1 ratio—reverse	1.067–1.219 mm (0.042–0.048 in.)
Left-hand rotation—forward	0.457–0.584 mm (0.018–0.023 in.)

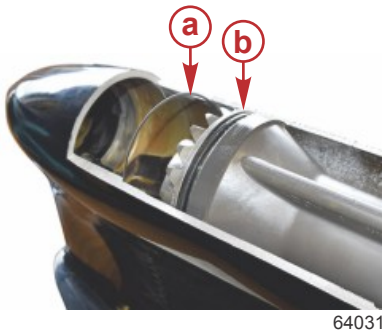
9. If the backlash is less than the specification, add shims in front of the bearing carrier thrust ring to obtain the correct backlash.

Example (backlash is too low—right-hand rotation 1.75:1 ratio)	
Rear gear backlash average specification:	0.86 mm (0.034 in.)
Subtract the rear gear backlash measurement:	0.56 mm (0.022 in.)
Add this quantity of shims:	0.31 mm (0.012 in.)
Provides backlash of:	0.86 mm (0.034 in.)

10. If the backlash is more than the specification, remove shims in front of the bearing carrier thrust ring to obtain the correct backlash.

Example (backlash is too high—right-hand rotation 1.75:1 ratio)	
Rear gear backlash measurement:	1.40 mm (0.055 in.)
Subtract the rear gear backlash average specification:	0.86 mm (0.034 in.)
Remove this quantity of shims:	0.46 mm (0.018 in.)
Provides backlash of:	0.86 mm (0.034 in.)

NOTE: *By adding or subtracting 0.025 mm (0.001 in.) shim, the backlash will change approximately 0.025 mm (0.001 in.).*



64031

a - Shim
b - Bearing carrier thrust ring

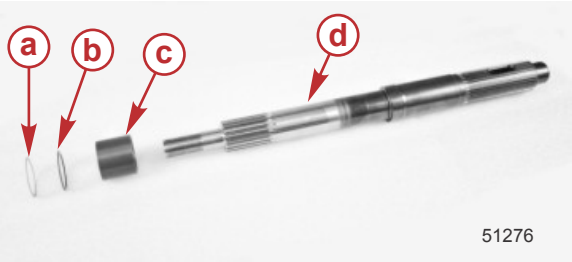
Propeller Shaft Bearing Preload

NOTE: *All gear housing components must be installed and correctly shimmed before checking propeller shaft bearing preload. The propeller shaft tapered roller bearing must be properly seated in the race during installation. The driveshaft retainer should be tightened to the specified torque.*

Description	Nm	lb-in.	lb-ft
Driveshaft retainer	135.5	–	100

IMPORTANT: Install a maximum of two shims on the propeller shaft to obtain the specified propeller shaft rolling torque. To obtain the specified rolling torque, shims of different thicknesses may have to be interchanged. Do not use a shim thinner than 0.51 mm (0.020 in.).

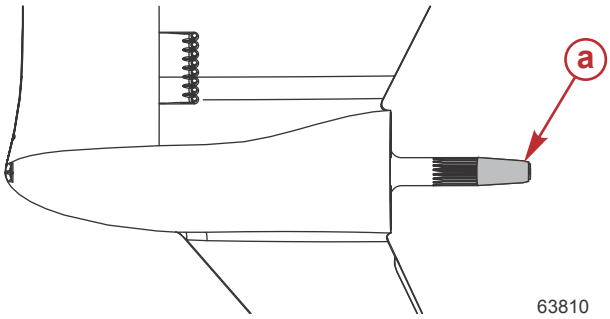
1. Remove the bearing carrier.
2. Install the new thrust spacer onto the new propeller shaft.
3. Install a shim onto the propeller shaft. Do not use a shim smaller than 0.51 mm (0.020 in.) shim thickness. A maximum of two shims may be installed on the shaft to obtain the specified rolling torque. If two shims are required, install the thinner shim last.



a - Thin shim if required (install onto propeller shaft last)
b - Shim
c - Thrust spacer
d - Propeller shaft

4. Install the bearing carrier installation tool onto the propeller shaft.

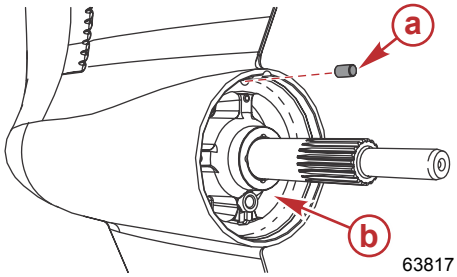
   IMPORTANT: Prior to installing the bearing carrier into a gear housing equipped with the heavy-duty 31.75 mm (1.25 in.) diameter propeller shaft, install the bearing carrier installation tool over the propeller shaft. This tool will protect the bearing carrier seal lips from being damaged by the propeller shaft splines. Remove the tool after the bearing carrier is installed.



a - Bearing carrier installation tool

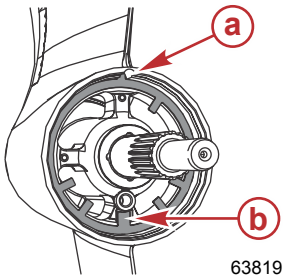
Bearing Carrier Installation Tool	91-8M0059911

5. Install the bearing carrier, aligning the rear propeller shaft bearing with the propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion gear with the rear gear.
6. Install the locating pin.



a - Locating pin
b - Bearing carrier assembly installed

7. Insert the small rectangular tab of the tab washer into its corresponding slot in the gear housing at the 12 o'clock position above the bearing carrier while aligning the large rectangular tab of the tab washer with its corresponding slot below the lubricant fill/drain hole in the bearing carrier.

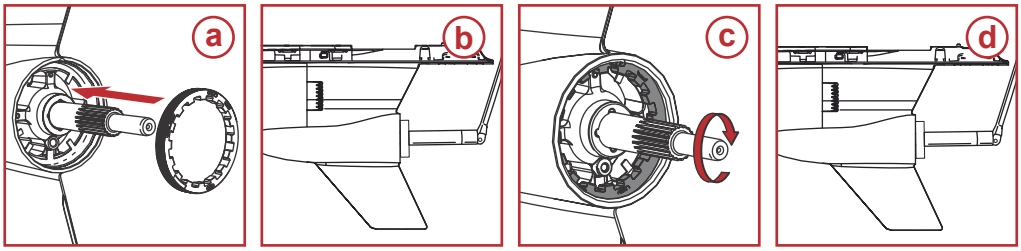


a - Small rectangular tab
b - Larger rectangular tab

8. With the gear housing in neutral, install the bearing carrier retainer nut.

   IMPORTANT: Before tightening the bearing carrier retainer nut to the specified torque, the gear housing must be bolted to the driveshaft housing or securely fastened in a gear housing holding fixture to avoid possible damage to the gear housing.

9. Use the bearing carrier retainer nut tool to tighten the retainer nut to the first specified torque.
10. Rotate the propeller shaft several times to seat the propeller shaft tapered roller bearings in their races.
11. Use the bearing carrier retainer nut tool to tighten the retainer nut to the second specified torque.



63820

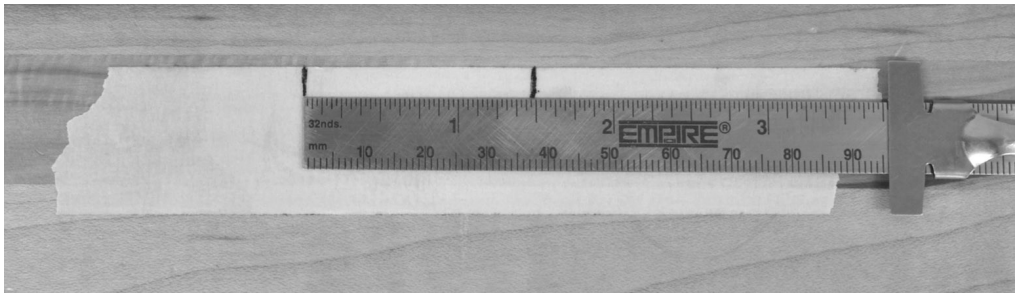
a - Install bearing carrier retainer nut
b - Tighten to first specified torque
c - Rotate propeller shaft
d - Tighten to final specified torque

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut (refer to NOTE)	**First**	135.5	–	100
	Second	285	–	210
	Final	Rotate an additional 3.8 cm (1.5 in.)		

NOTE: *Tighten the retainer nut to 135.5 Nm (100 lb-ft), and then check the rolling torque on the propeller shaft. If the torque is within specification, tighten the retainer nut to 285 Nm (210 lb-ft). Proceed to the next step to rotate the retainer nut an additional 3.8 cm (1.5 in.).*

Bearing Carrier Retainer Nut Tool	91-8M0046632

12. Tighten the retainer nut an additional 3.8 cm (1.5 in.) to achieve the final desired torque as follows:
    a. On a piece of masking tape, mark a distance of 3.8 cm (1.5 in.).



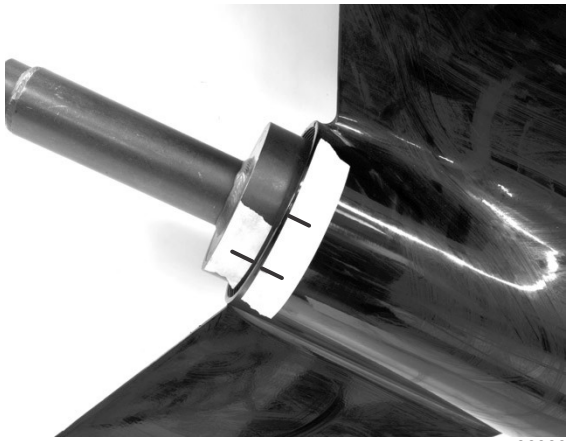
66380

    b. On a second piece of masking tape, mark it with a single line.

c. With the bearing carrier retainer nut tool installed on the gear housing, place the masking tape with the distance mark onto the gear housing. Place the masking tape with the single line onto the bearing carrier retainer nut tool, aligning the marks on the masking tape.

66382

d. Tighten the bearing carrier retainer nut so the masking tape with the single line aligns with the second mark on the masking tape.

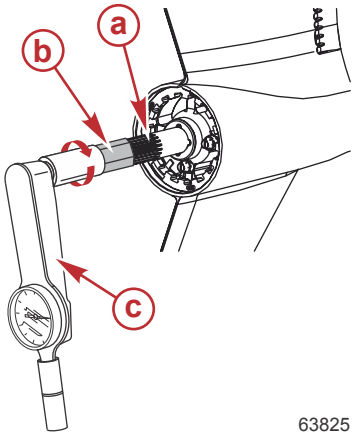


66383

13. Remove the bearing carrier retainer nut tool from the propeller shaft.
14. If the gear housing is secured in a stand, use the shift shaft handle tool to hold the clutch in the neutral position.

Shift Shaft Handle Tool	8M0142973

15. Install the propeller shaft adapter. Using a torque wrench, rotate the propeller shaft in the direction of normal rotation with a slow steady motion.



63825

a - Propeller shaft
b - Propeller shaft adapter
c - Torque wrench

Propeller Shaft Adapter	8M0147118

16. Verify the rolling torque is within specification for new or used bearings.

Description	Nm	lb-in.	lb-ft
Bearing rolling torque (new bearings)	1.1–2.0	10–18	–
Bearing rolling torque (used bearings)	0.45–1.1	4–10	–

NOTE: *Bearing preload will change approximately 0.056 Nm (0.5 lb-in.) of rolling torque per 0.025 mm (0.001 in.) of shim change.*

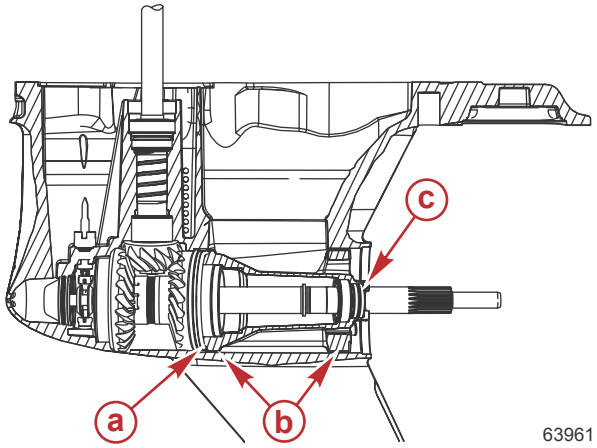
17. If the rolling torque is too high, install a thinner shim on the propeller shaft aft of the thrust spacer. If the torque is too low, install a thicker shim. Be certain the shims are installed aft of the thrust spacer.

IMPORTANT: Install a maximum of two shims on the propeller shaft to obtain the specified propeller shaft rolling torque. To obtain the specified rolling torque, shims of different thicknesses may have to be interchanged. Do not use a shim thinner than 0.51 mm (0.020 in.).

NOTE: *Each time the shims are changed, the tightening process for the bearing carrier retainer nut must be followed to ensure that the rolling torque is within specifications.*

Bearing Carrier Final Installation

1. Remove the bearing carrier and lubricate the following as specified:
   a. Lubricate the bearing carrier O-ring with 2-4-C with PTFE.
   b. Lubricate both the forward and aft outer diameters of the bearing carrier and gear housing area where the carrier will seat with 2-4-C with PTFE.
   c. Fill the space between the propeller shaft seals with 2-4-C with PTFE.

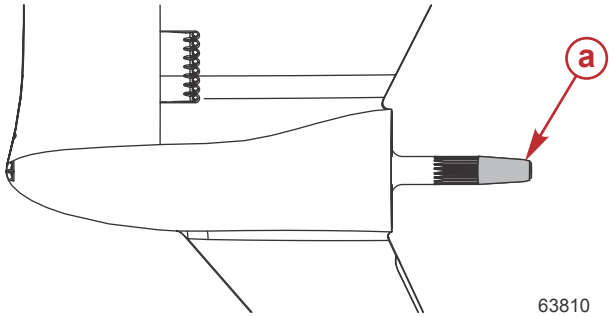


a - O-ring
b - Forward and aft outer diameters of bearing carrier
c - Propeller shaft seals

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier O-ring, forward and aft outer diameters of bearing carrier, gearcase area where bearing carrier will seat, space between propeller shaft oil seals	92-802859A 1

NOTE: *Applying 2-4-C with PTFE to the rear gear thrust bearing, thrust washer, spacer, and shim will help keep the components in alignment when installing the bearing carrier assembly into the gearcase.*

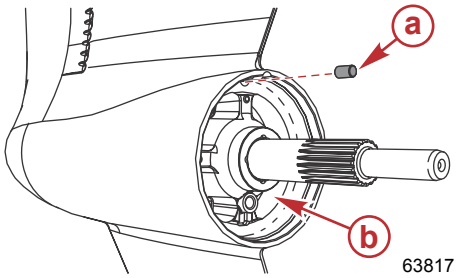
IMPORTANT: Prior to installing the bearing carrier into a gear housing utilizing the heavy-duty 31.75 mm (1.25 in.) diameter propeller shaft, install the bearing carrier installation tool over the propeller shaft. This tool will protect the bearing carrier seal lips from being damaged by the propeller shaft splines. Remove the tool after the bearing carrier is installed.



a - Bearing carrier installation tool

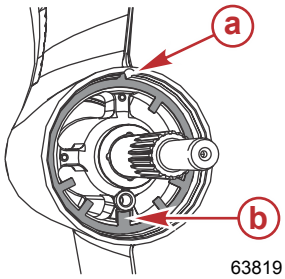
Bearing Carrier Installation Tool	91-8M0059911

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 gear and the rear gear.
3. Install the bearing carrier locating pin.



a - Locating pin
b - Bearing carrier assembly installed

4. Insert the small rectangular tab of the tab washer into its corresponding slot in the gear housing at the 12 o'clock position above the bearing carrier while aligning the large rectangular tab of the tab washer with its corresponding slot below the lubricant fill/drain hole in the bearing carrier.



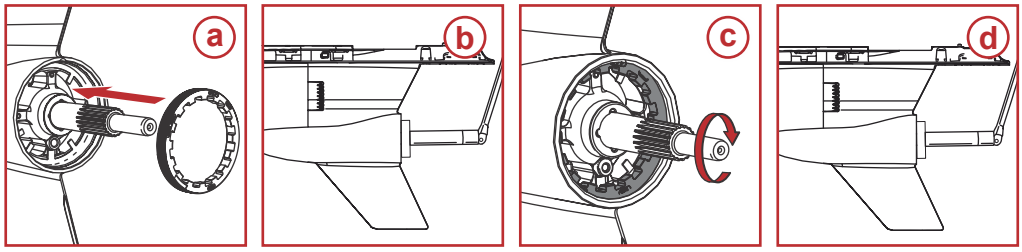
a - Small rectangular tab
b - Large rectangular tab

5. Apply 2-4-C with PTFE to the bearing carrier retainer nut threads and the corresponding gear housing threads. Install the retainer into the gear housing hand-tight.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier retainer nut threads and corresponding gear housing threads	92-802859A 1

IMPORTANT: Before tightening the bearing carrier retainer nut to the specified torque, the gear housing must be bolted to the driveshaft housing or securely fastened in a gear housing holding fixture to avoid possible damage to the gear housing.

6. Use the bearing carrier retainer nut tool to tighten the bearing carrier retainer nut to the first specified torque. Rotate the propeller shaft several times to seat the tapered roller bearings. The retainer nut can then be tightened to the second specified torque.



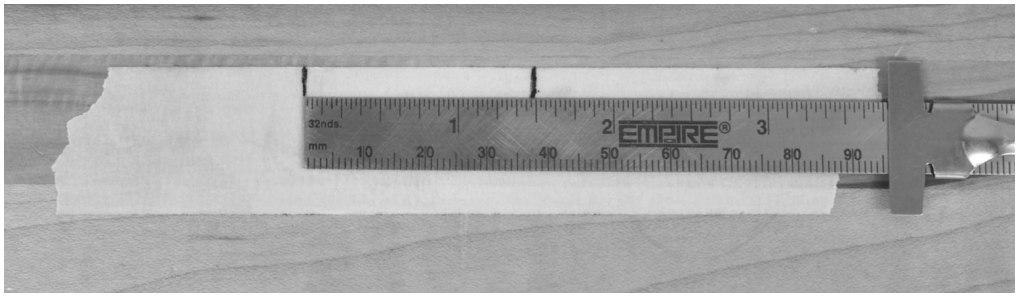
a - Install bearing carrier retainer nut hand-tight
b - Tighten to first specified torque
c - Rotate propeller shaft
d - Tighten to final specified torque

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut (refer to NOTE)	**First**	135.5	–	100
	Second	285	–	210
	Final	Rotate an additional 3.8 cm (1.5 in.)		

NOTE: *Tighten the retainer nut to 135.5 Nm (100 lb-ft), and then check the rolling torque on the propeller shaft. If the torque is within specification, tighten the retainer nut to 285 Nm (210 lb-ft). Proceed to the next step to rotate the retainer nut an additional 3.8 cm (1.5 in.).*

Bearing Carrier Retainer Nut Tool	91-8M0046632

7. Tighten the retainer nut an additional 3.8 cm (1.5 in.) to achieve the final desired torque as follows:
   a. On a piece of masking tape, mark a distance of 3.8 cm (1.5 in.).

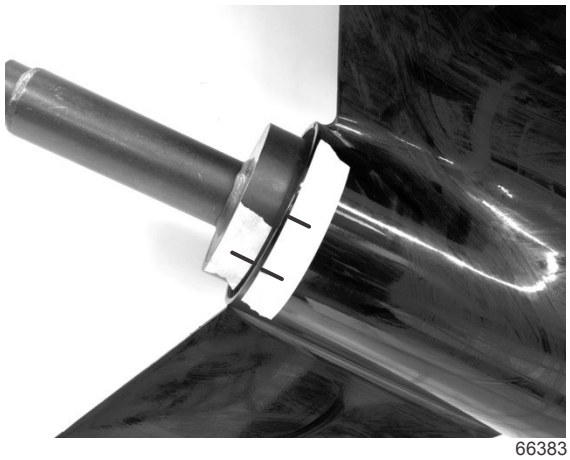


66380

   b. On a second piece of masking tape, mark it with a single line.
   c. With the bearing carrier retainer nut tool installed on the gear housing, place the masking tape with the distance mark onto the gear housing. Place the masking tape with the single line onto the bearing carrier retainer nut tool, aligning the marks on the masking tape.

66382

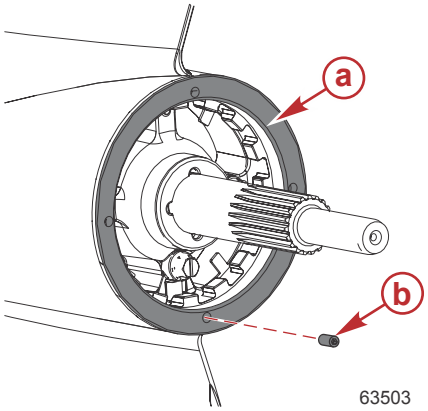
   d. Tighten the bearing carrier retainer nut so the masking tape with the single line aligns with the second mark on the masking tape.



66383

NOTE: *If one tab of the tab washer does not align between two of the notches on the retainer nut, continue to tighten the retainer nut until alignment is achieved. Do not loosen the retainer nut to achieve alignment.*

8. Bend one tab of the tab washer aft (outward) into a space between two of the notches of the retainer. Bend all the remaining tabs forward (inward).
9. Apply 2-4-C with PTFE to the torpedo ring threads.
10. Install the torpedo ring onto the gear housing. Tighten the ring to the specified torque.
11. Install the torpedo ring set screw with a 3/32 inch Allen wrench, and tighten to the specified torque.



a - Torpedo ring
b - Set screw

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Torpedo ring threads	92-802859A 1

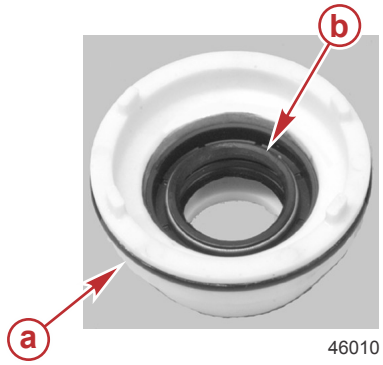
Torpedo Ring Installation Tool	91-8M0039309

Description	Nm	lb-in.	lb-ft
Torpedo ring	68	–	50
Set screw	2.8	25	–

Oil Seal Carrier Installation

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 PTFE.



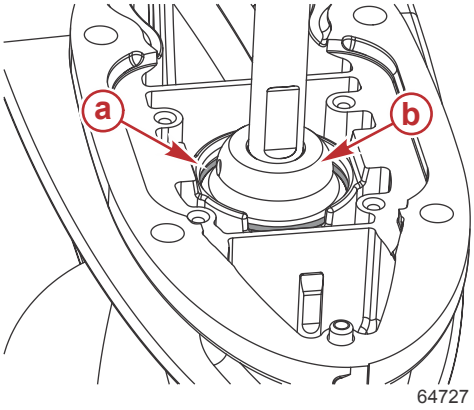
a - O-ring
b - Oil seal lips

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal carrier oil seal lips, space between the seals, and the O-ring	92-802859A 1

2. Install the oil seal carrier over the driveshaft and into the gearcase.

NOTE: *The oil seal carrier may be lightly tapped into position by sliding the driveshaft bearing retainer wrench over the driveshaft.*

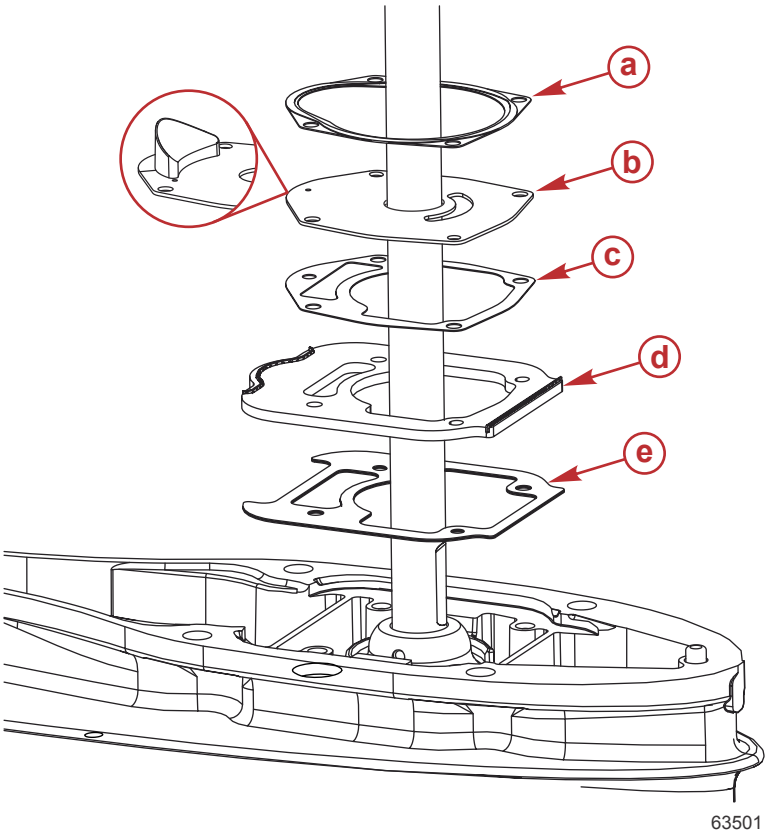
3. Install the retaining ring above the oil seal carrier.



a - Retaining ring
b - Oil seal carrier

Water Pump Installation

1. Install the lower gasket, top cover, rubber-coated stainless steel gasket, faceplate, and top beaded gasket.



a - Beaded gasket
b - Faceplate

NOTE: *Early models were equipped with a faceplate deflector. The deflector is no longer required.*

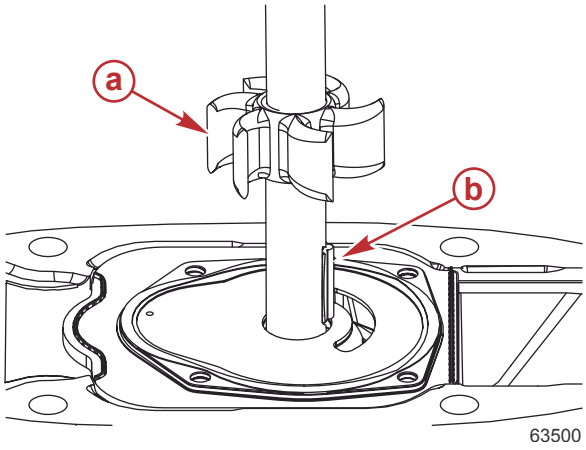
c - Rubber-coated stainless steel gasket
d - Top cover
e - Gasket

2. Apply a small amount of 2-4-C with PTFE onto the flat surface of the impeller key and install the key onto the driveshaft keyway.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Flat surface of impeller key	92-802859A 1

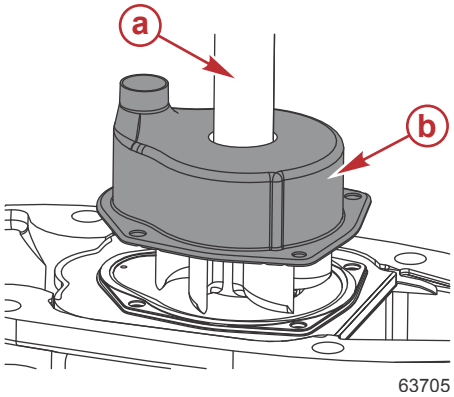
3. Install the water pump impeller onto the driveshaft and over the impeller key.

IMPORTANT: Do not install a used impeller with the blades oriented in a reversed direction from the original rotation. Premature impeller failure will occur.



a - Impeller
b - Impeller key

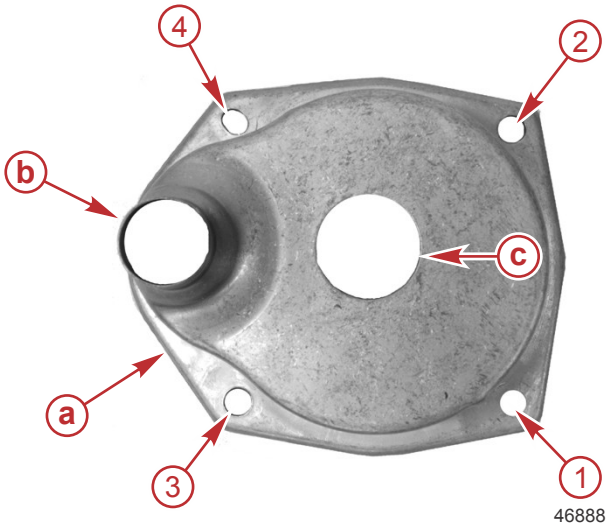
4. Apply 2-4-C with PTFE to the inside of the water pump cover. Position the water pump cover over the driveshaft. Rotate the driveshaft in a clockwise direction while pushing down on the water pump cover.



a - Rotate driveshaft clockwise
b - Water pump cover

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Inside of the water pump cover	92-802859A 1

5. Apply Loctite 271 Threadlocker to each water pump screw, and install the four screws into the water pump housing. Tighten the screws in the sequence shown to the specified torque.



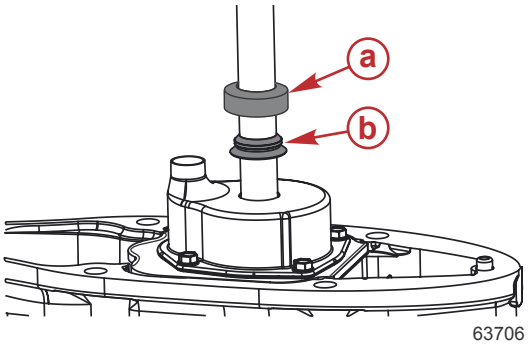
a - Water pump cover
b - Water outlet
c - Driveshaft access hole

Description	Nm	lb-in.	lb-ft
Water pump screws	6.8	60	–

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Water pump screws	92-809819

6. Install the driveshaft seal and use the tool provided in the seal kit or the water pump kit to press the seal down.

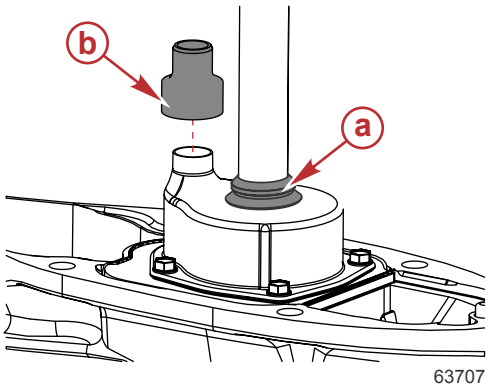
IMPORTANT: If the driveshaft seal is not installed at the proper height, air will be drawn into the water pump, causing the engine to overheat.



a - Driveshaft seal installation tool
b - Driveshaft seal

Driveshaft Seal Installation Tool	91-818769

7. If the tool is not available, press the seal against the water pump housing until the height of the seal is 11.1 ± 0.3 mm (0.437 ± 0.012 in.).



a - Driveshaft seal
b - Water seal coupler

IMPORTANT: After the water pump is installed, do not rotate the driveshaft counterclockwise.

8. Apply 2-4-C with PTFE to the O-ring in the water seal coupler. Install the water seal coupler onto the water pump cover.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Water seal coupler O-ring	92-802859A 1

Checking Gear Housing Operation

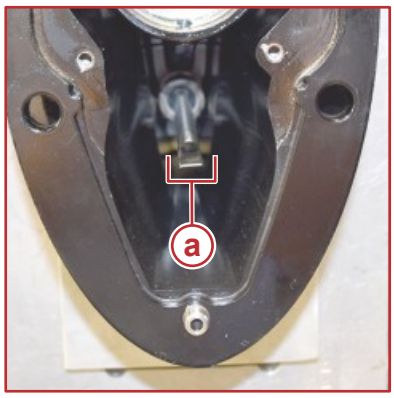
Prior to filling the gear housing with lubricant, check the gear housing for proper shift operation, as follows:

NOTE: *Rotate the driveshaft in a clockwise direction while performing these tests.*

Right-Hand Rotation

1. Rotate the shift shaft counterclockwise to the forward motion position. The propeller shaft should rotate clockwise and then lock.
2. Rotate the shift shaft clockwise to the reverse motion position. The propeller shaft should rotate counterclockwise and then lock.

3. Rotate the shift shaft to a point halfway between the forward and reverse motion position. This should be the neutral position. The propeller shaft should rotate freely both clockwise and counterclockwise.



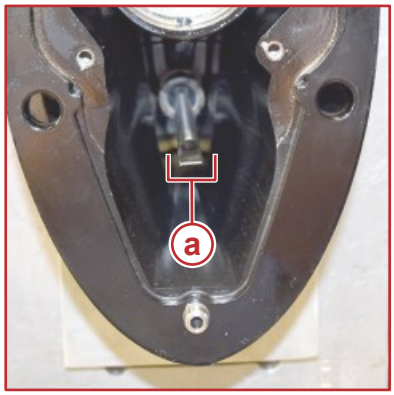
65169

a - Shift shaft in neutral position

IMPORTANT: If the shifting operation is not as described, the gear housing must be disassembled and the shift crank reversed. Refer to Shift Shaft Installation.

Left-Hand Rotation

1. Rotate the shift shaft counterclockwise to the forward motion position. The propeller shaft should rotate counterclockwise and then lock.
2. Rotate the shift shaft clockwise to the reverse motion position. The propeller shaft should rotate clockwise and then lock.
3. Rotate the shift shaft to a point halfway between the forward and reverse motion position. This should be the neutral position. The propeller shaft should rotate freely both clockwise and counterclockwise.



65169

a - Shift shaft in neutral position

IMPORTANT: If the shifting operation is not as described, the gear housing must be disassembled and the shift crank reversed. Refer to Shift Shaft Installation.

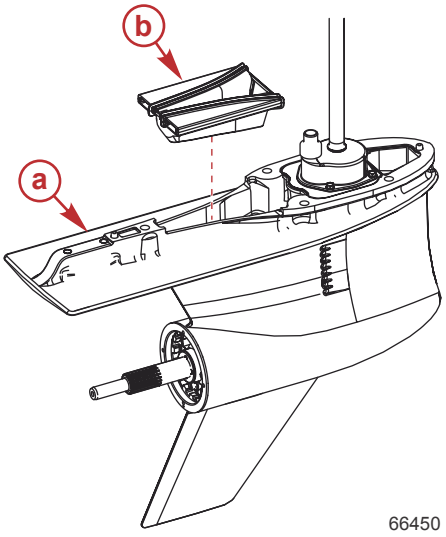
NOTE: *Before installing the gear housing to the driveshaft housing, check for any leaks. Refer to* ***Gear Housing Pressure Test*** *for instructions.*

Gear Housing Installation

⚠ WARNING

Accidental starting can cause serious injury. Before removing or installing the gear housing, disconnect and isolate the spark plug leads. Disable the ignition system by removing the keys from the ignition (if equipped) and engaging the lanyard stop switch to prevent the engine from starting.

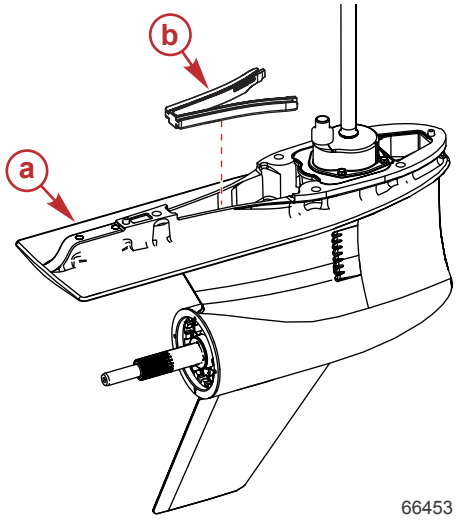
1. On AMS models, ensure that the lower exhaust relief muffler is installed. On CMS models, ensure that the lower relief plug is installed.



AMS models

a - Gear housing

b - Lower exhaust relief muffler



CMS models

a - Gear housing

b - Lower relief plug

2. Lubricate the splines of the driveshaft with Extreme Grease. Do not allow lubricant on top of the shift shaft or driveshaft.

NOTICE

Installing the gear housing to the powerhead without adequately cleaning the top of the driveshaft can result in severe product damage. Any lubricant trapped in the space between the driveshaft and the crankshaft prevent the two from properly engaging. Always clean the top of the driveshaft before installing the gear housing.

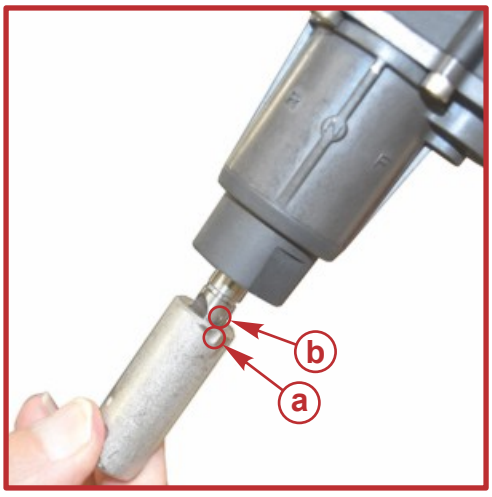
Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Shift shaft splines and driveshaft splines	8M0071842

3. On right-hand rotation gearcases, use the shift shaft tool to rotate the shift shaft counterclockwise into the front (forward) gear. For left-hand rotation gearcases, use the shift shaft tool to rotate the shift shaft clockwise into the front (reverse) gear.

NOTE: *It may be necessary to rotate the propeller shaft to ensure that the clutch is engaged.*

Shift Shaft Handle Tool	8M0142973

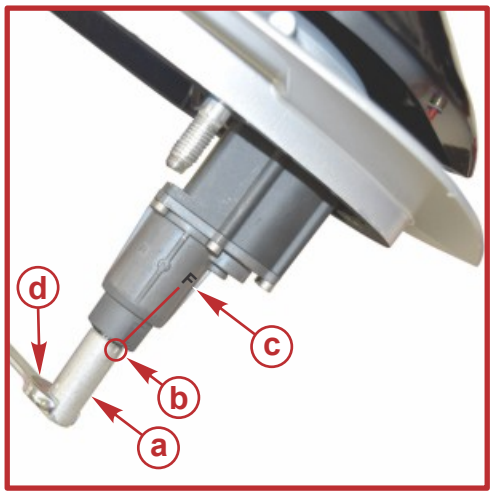
4. Ensure that the notch on the shift shaft coupler aligns with the notch on the shift actuator output shaft.



a - Notch on shift shaft coupler

b - Notch on shift actuator output shaft

5. On right-hand rotation gearcases, use a 15 mm wrench to rotate the shift shaft coupler so the notch on the coupler is aligned with the "F" marking on the shift actuator. For left-hand rotation gearcases, use a 15 mm wrench to rotate the shift shaft coupler so the notch on the coupler is aligned with the "R" marking on the shift actuator.



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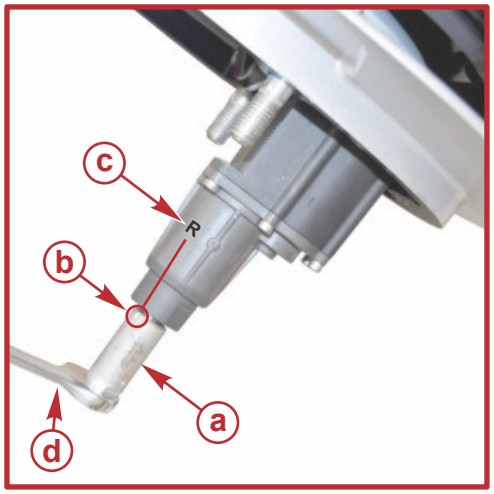


65128

Right-hand rotation models

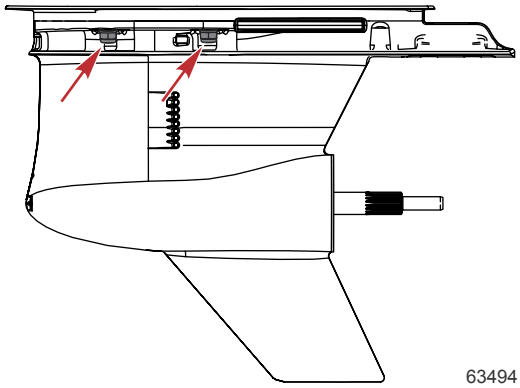
- **a -** Shift shaft coupler
- **b -** Tab on shift shaft coupler
- **c -** "F" marking on shift actuator
- **d -** Wrench

Left-hand rotation models

- **a -** Shift shaft coupler
- **b -** Tab on shift shaft coupler
- **c -** "R" marking on shift actuator
- **d -** Wrench

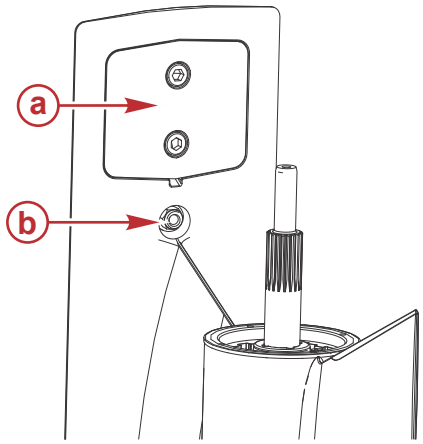
6. Position the gear housing so the driveshaft is protruding into the driveshaft housing.
7. Move the gear housing up toward the driveshaft housing while aligning the water pump coupler to the water tube and the shift shaft into the shift shaft coupler.

   NOTE: *If the driveshaft splines will not align with the crankshaft splines, rotate the propeller shaft slightly to reposition the splines.*
8. Secure the gear housing assembly to the driveshaft housing with four side mounting locknuts and washers; two on each side. Do not fully tighten the nuts at this time.



63494

9. Install the nut and washer to the underside of the anti-ventilation plate, just forward of the anode plate. Do not tighten the nut at this time.



a - Anode plate
b - Install nut and washer

10. Check the shift shaft spline engagement and correct if necessary.
11. Evenly tighten the four side mounting locknuts, and the nut on the underside of the anti-ventilation plate to the specified torque.

Description	Nm	lb-in.	lb-ft
Side mounting locknuts (4), and nut on underside of anti-ventilation plate (1)	60	–	44

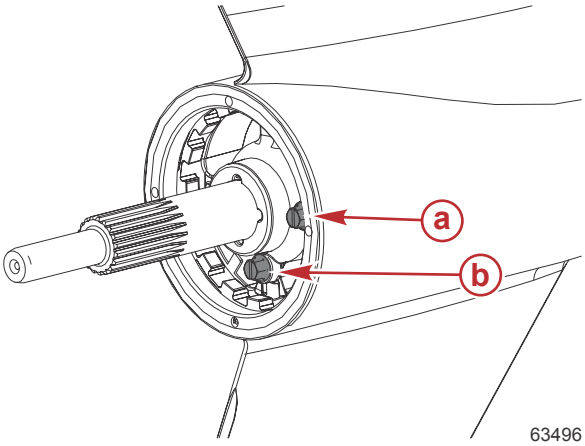
Gear Lubricant Filling Instructions—Non-SeaPro Models

NOTE: *After the gear housing has been serviced, perform a pressure test prior to filling with lubricant. Refer to* ***Gear Housing Pressure Test*** *for instructions.*

1. Remove the vent plug from the gear housing.
2. Remove the fill plug from the gear housing.
3. Inspect the fill and vent plug sealing washers for cuts or abrasions. Replace the washers if necessary.

   IMPORTANT: Never add lubricant to the gear housing without removing the vent plug. The gear housing cannot be filled if the vent plug is not removed because of trapped air. Fill the gear housing only when the housing is in a vertical position.
4. Slowly fill the housing through the fill hole with High Performance Gear Lubricant until the lubricant flows out of the vent hole and no air bubbles are visible.
5. Install the vent plug into the vent hole.

   IMPORTANT: Do not lose more than 15 cc (0.5 fl oz) of gear lubricant while installing the fill plug.
6. Remove the fill tube or hose from the fill hole and quickly install the fill plug into the fill hole. Tighten the fill and vent plugs to the specified torque.



a - Vent plug
b - Fill plug

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 plugs	11.3	100	–

Gear Lubricant Filling Instructions—SeaPro Models

NOTE: *After the gear housing has been serviced, perform a pressure test prior to filling with lubricant. Refer to* ***Gear Housing Pressure Test*** *for instructions.*

1. Place the outboard in the tilted up position.
2. Remove the upper vent plug.

   IMPORTANT: Never add lubricant to the gear housing without first removing the vent plug.
3. Remove the front fill/drain plug from the torpedo. Place the lubricant tube into the fill hole.
4. Add High Performance Gear Lubricant until it is visible at the upper vent plug hole.

   IMPORTANT: Inspect the fill/drain and vent plug sealing washers for cuts or abrasions. Replace the washers if damaged.
5. Stop adding the lubricant. Install the upper vent plug and sealing washer before removing the lubricant tube.
6. Remove the lubricant tube and quickly install the cleaned fill/drain plug and sealing washer. Tighten the front fill/drain plug and upper vent plug to the specified torque.

   IMPORTANT: Do not lose more than 30 cc (1 fl oz) of gear lubricant while installing the front fill/drain plug.

a - Remove upper vent plug
b - Remove front fill/drain plug
c - Add gear lube
d - Install upper vent plug
e - Install front fill/drain plug

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Gear housing	92-858064K01

Description	Nm	lb-in.	lb-ft
Upper vent plug/sealing washer	11.3	100	–
Front fill/drain plug	11.3	100	–

Notes:

Gear Housing

Section 6C - Torque Master

Table of Contents

6 C

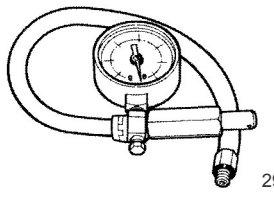
Gear Housing Specifications (Torque Master)

Gear Housing Specifications	
Gear ratio	1.75:1 (12/21 teeth)
Gearcase capacity—Torque Master	520 ml (17.6 fl oz)
Gear lubricant type	High Performance Gear Lubricant
Pinion height	0.635 mm (0.025 in.)
Front (forward) gear backlash	0.482–0.660 mm (0.019–0.026 in.)
Rear (reverse) gear backlash	1.27–1.47 mm (0.050–0.058 in.)
Gear housing pressure (without gear lubricant, 15 minutes without leakage)	103.4 kPa (15 psi)
Propeller shaft runout	0.23 mm (0.009 in.)

Lubricants, Sealants, Adhesives

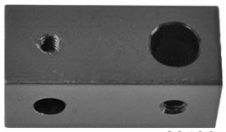
Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Shift shaft splines and driveshaft splines	8M0071842
7	Loctite 271 Threadlocker	Pinion gear nut threads	92-809819
		Threads of pinion nut	
		Water pump screws	
27	Bellows Adhesive	Driveshaft pinion gear washer	92-86166Q1
87	High Performance Gear Lubricant	Tapered bearing cup bore	92-858064K01
		Inside diameter of the driveshaft tapered bearings	
		Inside diameter of front gear	
		Front gear bearing cup bore	
		Pinion bearing bore	
		Gear housing	
95	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1
		O-ring	
		Shift shaft bushing threads, O-ring, and oil seal lip	
		Retainer threads	
		Bearing carrier retainer nut threads	
		Bearing carrier O-ring, forward and aft outer diameters of bearing carrier, gear housing area where bearing carrier will seat, space between propeller shaft oil seals	
		Bearing carrier retainer nut threads and corresponding gear housing threads	
		Oil seal carrier oil seal lips, space between the seals, and the O-ring	
		Flat surface of impeller key	
		Inside of the water pump cover	
		Water seal coupler O-ring	

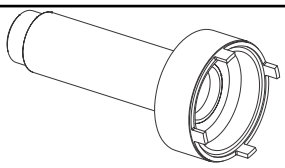
Special Tools

Leakage Tester Kit	FT8950
 29497	Used for pressure testing of closed systems (gearcase, fuel lines, cooling).

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.

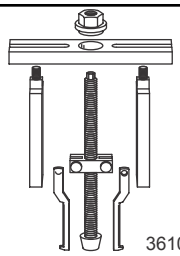
Dial Indicator Holding Tool	91- 89897
 29496	Secures the dial indicator to gear housing when checking backlash.

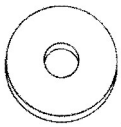
Bearing Carrier Retainer Nut Wrench	8M0057002
 46139	Installs and removes the bearing carrier retainer nut

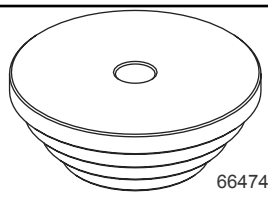
Puller Jaws Assembly	91-46086A1
 9514	Removes bearing carrier and bearing races; use with Puller Bolt (91-85716)

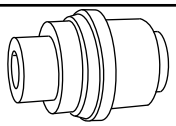
Torch Lamp	91- 63209
 8776	Heats surfaces to aid in the removal and installation of interference fit engine components.

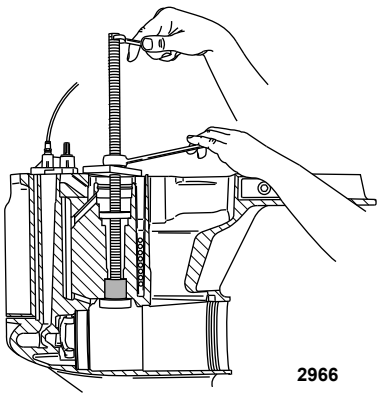
Slide Hammer	91-34569A 1
 6761	Aids in the removal of various engine components. Use with puller jaws.

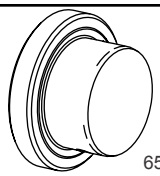
Bearing Puller Assembly	91- 83165T
 3610	Removes bearings, races and bearing carriers

Pilot Washer	91-36571T
 29490	Used in pinion gear and pinion bearing installation

Seal Driver Guide	8M0148864
 66474	Aids in the installation of bearing carrier seals and propeller shaft tapered bearing cup. Tool ID number 8M0145268.

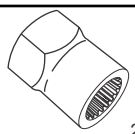
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
 **6229**	Installs bearing carrier cup and seals.

Bearing Removal and Installation Kit	91- 31229A 7
 **2966**	Installs and removes the bearings in all gearcases 91- 31229A 7 tool assembly includes the following components: 11- 24156 Hex Nut 12- 34961 Washer 91- 15755T Bearing Carrier 91- 29310 Plate 91- 30366T 1 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- 37312T Driver Head 91- 37323 Driver Head Rod 91- 37324T Pilot Washer 91- 37350T Pilot Mandrel 91- 38628T Puller/Driver Head 91-52393T Driver Needle Bearing 91-52394 Head Pull Rod

Bearing Installation Tool	8M0146935
 65775	Aids in the installation of the rear gear needle bearing. Tool ID number 8M0145045.

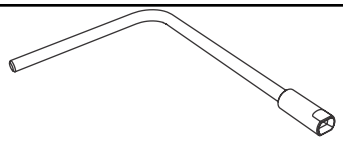
Gear Retainer Installation Tool	8M0148865
 65777	Aids in installation of the gear retainer. Tool ID number 8M0127024.

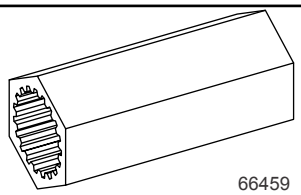
Driveshaft Bearing Retainer Wrench	91-43506T
 9520	Removes and installs the threaded bearing retainer

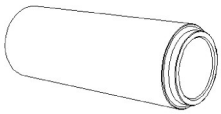
Driveshaft Holding Tool	91-889958T
 28677	Holds driveshaft during pinion nut removal on the Verado models

Propeller Shaft Holder	8M0075944
 39510	Stabilizes propeller shaft

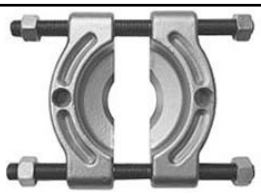
Pinion Nut Wrench	91- 61067T03
 29501	Holds the pinion nut when removing the pinion gear and driveshaft.

Shift Shaft Handle Tool	8M0142973
 63932	Used to rotate gear housing shift shaft. Tool ID number 8M0127025.

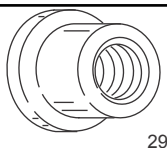
Propeller Shaft Adapter	8M0147118
 66459	Provides a hex surface to turn the propeller shaft. Tool ID number 8M0145218.

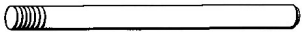
Driveshaft Bearing Installation Tool	91-8M0052590
 47416	Install upper and lower driveshaft bearings

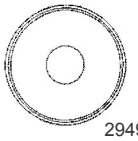
Guide Plate	91-816243
 4481	Centers the rod used to drive in the forward gear bearing on a standard rotation gearcase, and the reverse gear bearing on a counterrotation gearcase.

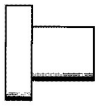
Universal Puller Plate	91-37241
 8505	Removes bearings from gears and the driveshaft.

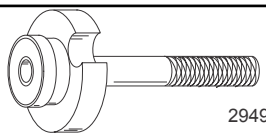
Shift Shaft Tool	8M0142969
 63663	Aids in removal or installation of the shift shaft. Tool ID number 8M0120169.

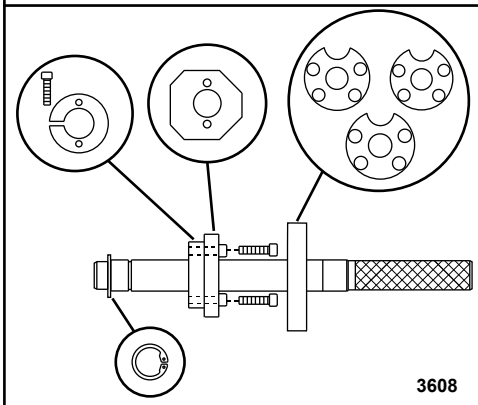
Driver Head	91- 36569T
 29499	Used in pinion gear and bearing installation.

Driver Rod	91- 37323
 25431	Aids in the removal and installation of various bearings and bearing races

Bearing Cup Driver	91-885592T
 29492	Installs front gear bearing cup

Puller/Driver Head	91- 38628T
 29491	Used in pinion gear and pinion bearing installation.

Pinion Gear Locating Tool	91- 56048001
 29493	Measures pinion gear height.

Pinion Gear Locating Tool	91- 12349A05
 3608	Measures pinion gear height.

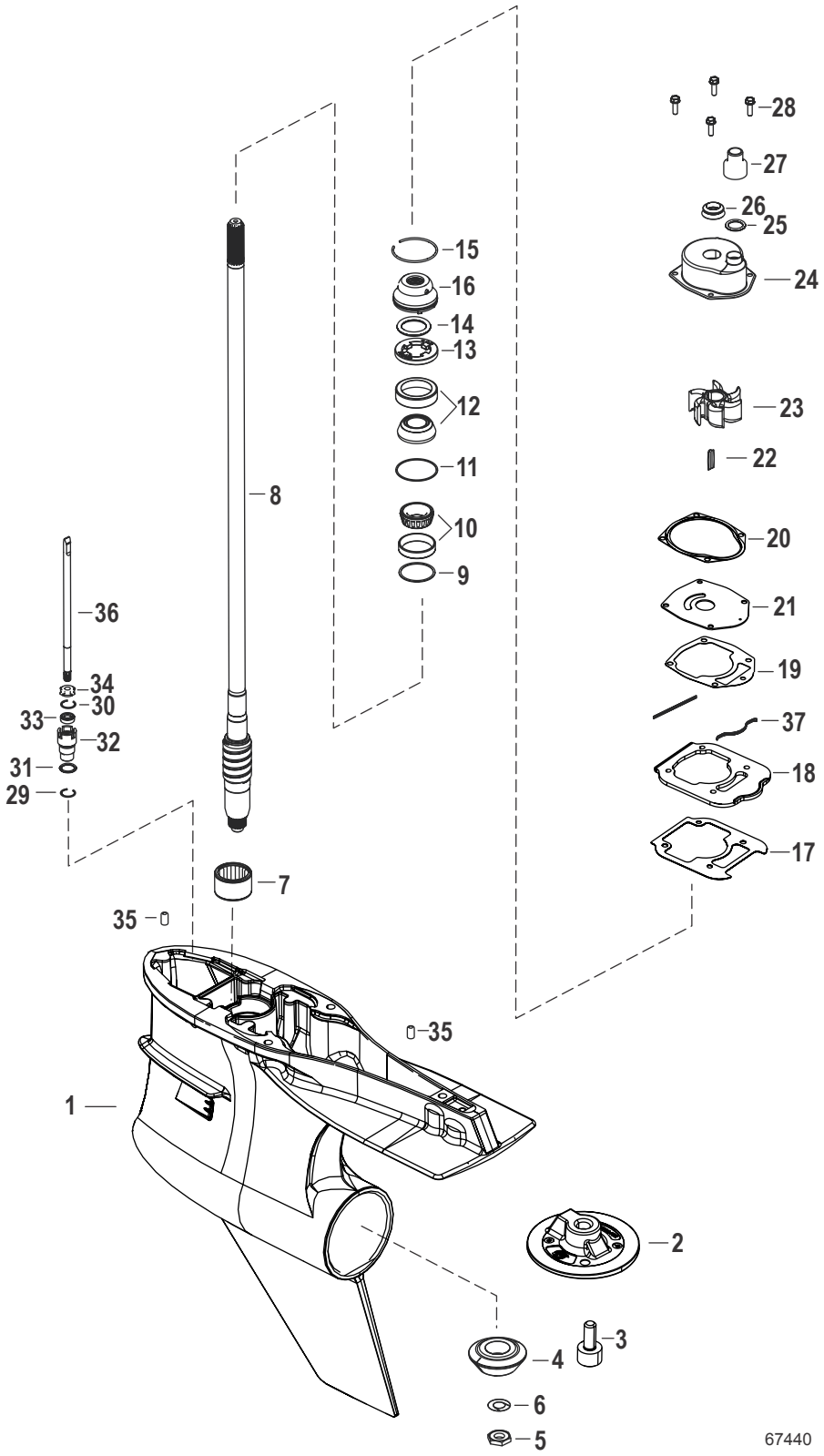
Bearing Carrier Installation Tool	91-8M0059911
 9518	Protects the seals when installing the bearing carrier on 19 spline (1-1/4 inch) propeller shaft. (Part of assembly 91-840393A1)

Backlash Indicator Rod	91-8M0053505
 46158	Aids in checking gear backlash.

Driveshaft Seal Installation Tool	91-818769
 47536	Sets driveshaft seal height

Gear Housing Components

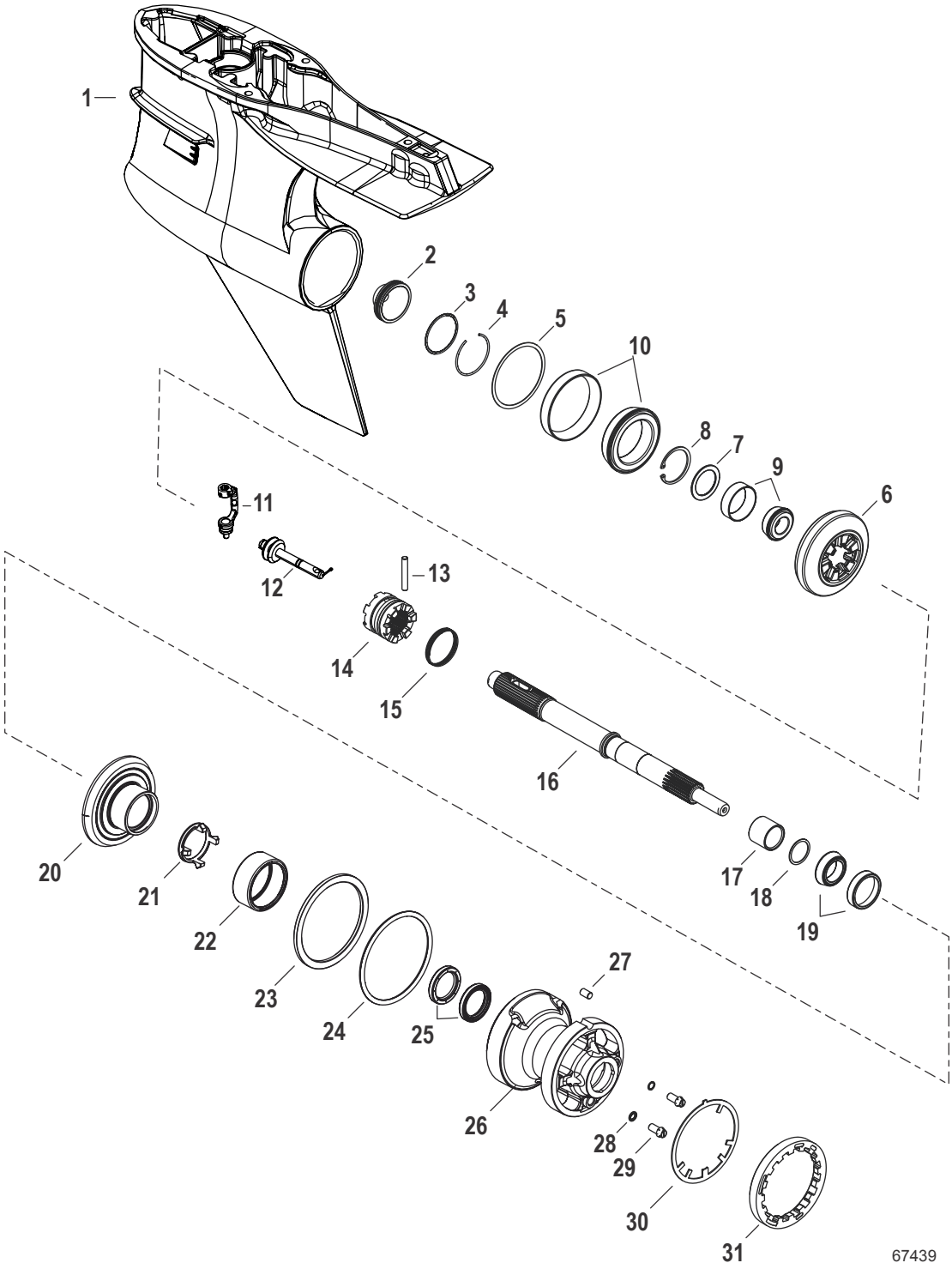
Gear Housing (Torque Master)—Driveshaft



Gear Housing (Torque Master)—Driveshaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing assembly			
2	1	Anode			
3	1	Screw	54.2	–	40
4	1	Pinion gear			
5	1	Pinion nut	101.7	–	75
6	1	Pinion washer			
7	1	Bearing assembly			
8	1	Driveshaft			
9	1	Shim			
10	1	Bearing assembly			
11	1	Shim			
12	1	Bearing assembly			
13	1	Retainer	135.5	–	100
14	1	O-ring			
15	1	Retaining ring			
16	1	Oil seal assembly			
17	1	Gasket			
18	1	Top cover			
19	1	Rubber-coated stainless steel gasket			
20	1	Beaded gasket			
21	1	Faceplate			
22	1	Key			
23	1	Impeller			
24	1	Water pump housing			
25	1	O-ring			
26	1	Face seal			
27	1	Water pump coupler			
28	4	Screw	6.8	60	–
29	1	Retaining ring			
30	1	Retaining ring			
31	1	O-ring			
32	1	Shift shaft bushing	54.2	–	40
33	1	Oil seal			
34	1	Rubber grommet			
35	2	Dowel pin			
36	1	Shift shaft			
37	2	Seal			

Gear Housing (Torque Master)—Propeller Shaft



Gear Housing (Torque Master)—Propeller Shaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gear housing assembly			
2	1	Torpedo plug			
3	1	O-ring			
4	1	Retaining ring			
5	1	Shim			
6	1	Forward gear			
7	1	Thrust washer			
8	1	Retaining ring			
9	1	Bearing assembly			
10	1	Bearing assembly			
11	1	Shift crank			
12	1	Spool			
13	1	Pin			
14	1	Clutch			
15	1	Spring			
16	1	Propeller shaft			
17	1	Spacer			
18	1	Washer			
19	1	Bearing assembly			
20	1	Reverse gear			
21	1	Gear retainer			
22	1	Needle bearing			
23	1	Thrust ring			
24	1	O-ring			
25	2	Oil seal			
26	1	Bearing carrier			
27	1	Pin			
28	2	Seal			
29	2	Fill and vent plugs	11.3	100	–
30	1	Tab washer			
31	1	Bearing carrier retainer	285[1.]		210[1.]

1. Tighten retainer to 135.5 Nm (100 lb-ft), then check rolling torque on propeller shaft. If torque is within specification, tighten retainer to 285 Nm (210 lb-ft).

General Service Recommendations

There may be more than one way to disassemble or reassemble a particular part. It is recommended that the entire procedure be read prior to repair.

IMPORTANT: Read the following before attempting any repairs.

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 that the sequence be followed without deviation to assure proper repairs. When performing partial repairs, follow the instructions to the point where the desired component can be replaced, then proceed to reassembly and installation of that component in the reassembly part of this section. Use the **Table of Contents** to find the correct page number.

Threaded parts are right-hand (RH), unless otherwise indicated.

When holding, pressing, or driving is required, use soft metal vise jaw protectors or wood for protection of parts. Use a suitable mandrel 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 the bearings with solvent and dry with compressed air. Air should be directed at the bearing so that it passes through the bearing. Do not spin the bearing with compressed air, as this may cause the bearing to score from lack of lubrication. After cleaning, lubricate the bearings with High Performance Gear Lubricant. Do not lubricate the tapered roller bearing cups until after inspection.

Inspect all bearings for roughness, catches, and bearing race side wear. Work the inner bearing race in and out, while holding the outer race, to check for side wear.

When inspecting the tapered roller bearings, determine the condition of the rollers and the inner bearing race by inspecting the bearing cup for pits, scoring, grooves, uneven wear, imbedded particles, and/or discoloration from overheating. Always replace the tapered roller bearing cone and cup as a set.

Inspect the gear housing for bearing races that have spun in their respective bores. If the race has spun, the gear housing must be replaced.

Roller bearing condition is determined by inspecting the bearing surface of the shaft that the roller bearing supports. Check the shaft surface for pits, scoring, grooves, embedded particles, uneven wear, and/or discoloration from overheating. The shaft and bearing must be replaced if the conditions described are found.

Shims

Keep a record of all shim amounts and their location during disassembly to aid in reassembly. Be sure to follow the shimming instructions during reassembly, as gears must be installed to the correct depth and have the correct amount of backlash to avoid noisy operation and premature gear failure.

Seals

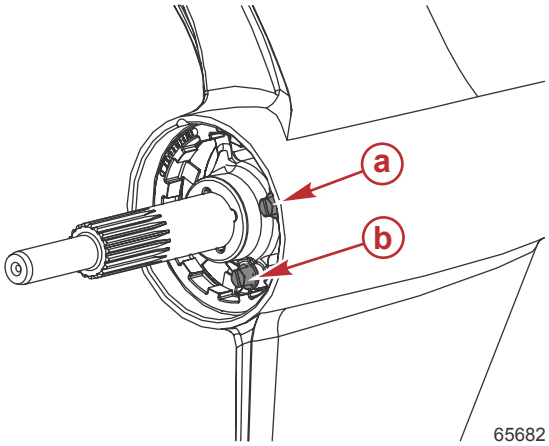
As a normal procedure, all O-rings and oil seals should be replaced without regard to appearance. To prevent leakage around oil seals, apply Loctite 271 Threadlocker to the outer diameter of all metal case oil seals. When using Loctite on seals or threads, the surfaces must be clean and dry. To ease installation, apply 2-4-C with PTFE on all O-rings. To prevent wear, apply 2-4-C with PTFE on the I.D. of oil seals.

Gearcase Serviceability Inspection

Draining and Inspecting Gear Housing Lubricant

1. Place the gear housing in a suitable holding fixture or vise with the driveshaft in a vertical position.

2. Position a clean drain pan under the gear housing and remove the plugs from the gear housing with a 10 mm socket or slot screwdriver.

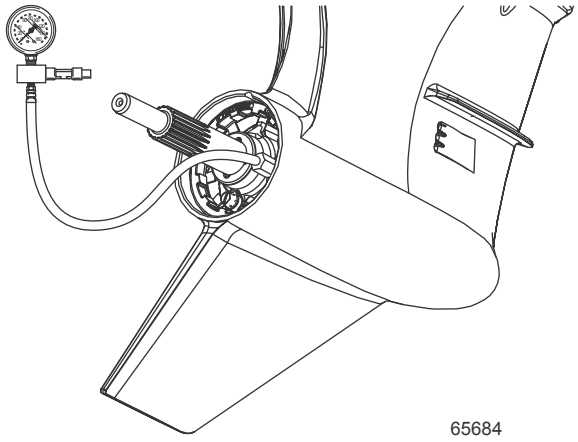


a - Vent plug
b - Fill/drain plug

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

Gear Housing Pressure Test

1. Tilt the engine up approximately 20° to prevent residual oil from coming out of the vent hole.
2. Remove the vent plug and install the pressure test gauge.



3. Pressurize the housing and observe the gauge for 15 minutes.
4. Rotate the driveshaft, propeller shaft, and shift shaft while the housing is pressurized to check for leaks.
5. If pressure drop is noted, immerse the housing in water.
6. Repressurize and check for air bubbles.
7. Replace the leaking seals, as necessary. Retest the housing after seal replacement.

Gear Housing Test Pressure	
Applied air pressure	103.4 kPa (15 psi)
Length of time	15 minutes

Leakage Tester Kit	FT8950

8. If air bubbles are noticed from the water inlet holes at the front of the torpedo, the gear housing must be replaced.
9. Remove the tester from the housing and install the vent plug and sealing washer.

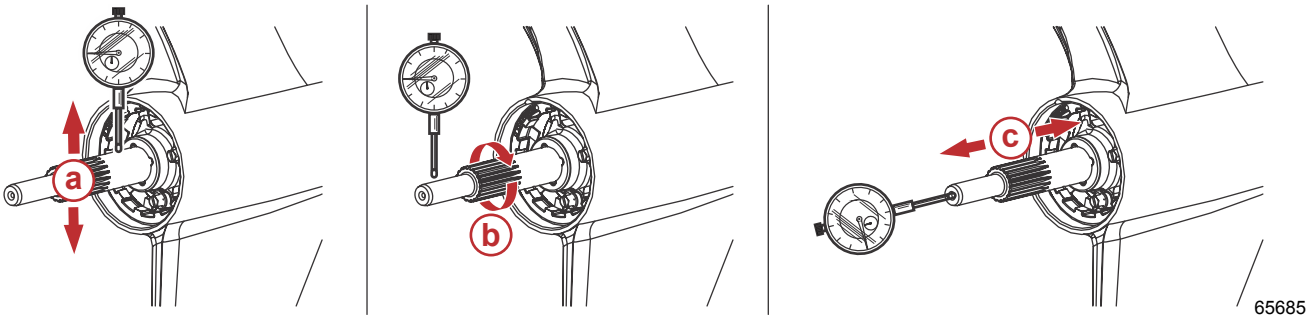
Propeller Shaft Inspection

1. Inspect the propeller shaft for up and down movement, as follows:

a. Position the dial indicator on the propeller shaft, just forward of the splines, as shown in the following illustration.
b. Push the propeller shaft down and zero the dial indicator.
c. Move the propeller shaft up while observing the dial indicator.
d. A shaft deflection of more than 0.08 mm (0.003 in.) indicates a worn propeller shaft bearing.

Dial Indicator	91- 58222A 1
Dial Indicator Adapter	91-83155
Dial Indicator Holding Tool	91- 89897

2. Check for a bent propeller shaft as follows:
   a. Reposition the dial indicator to the threaded end of the propeller shaft. Rotate the propeller shaft while observing the dial indicator.
   b. If the deflection is more than 0.23 mm (0.009 in.), the propeller shaft is bent and should be replaced.
3. 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 - Check propeller shaft deflection
b - Check for bent propeller shaft
c - Check propeller shaft end play

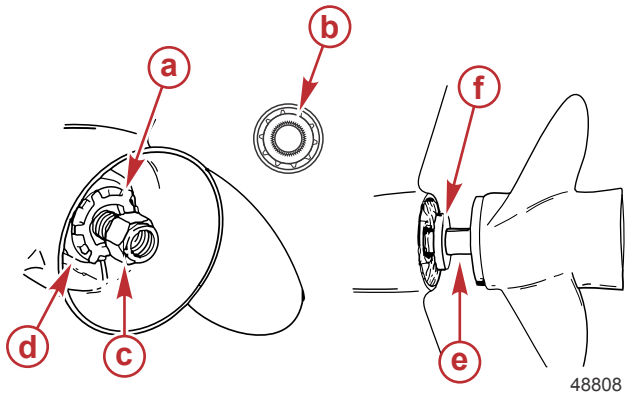
Gear Housing Removal

⚠ 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.

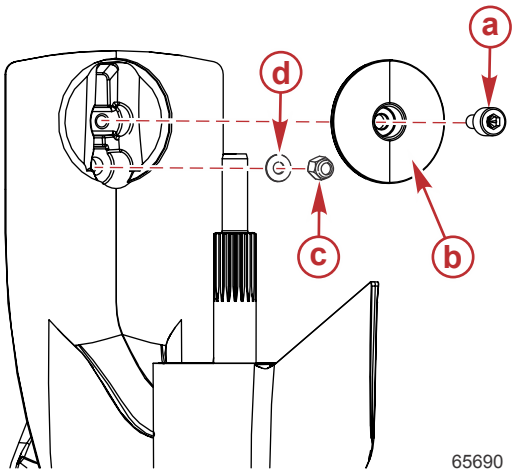
NOTE: *It is not necessary to drain the oil sump when removing the gearcase.*

1. Tilt the outboard to the trailer full up position and engage the tilt lock lever.
2. Bend the tabs of the propeller tab washer away from the rear thrust hub. Remove the propeller locknut, tab washer, rear thrust hub, propeller, and forward thrust washer from the propeller shaft.



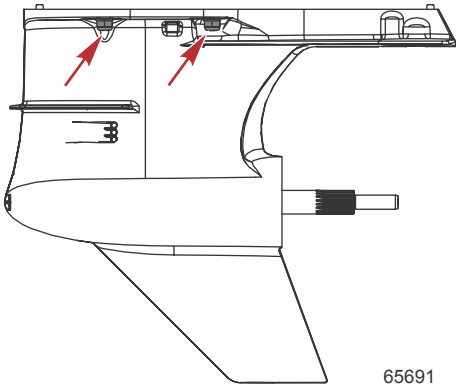
a - Tab washer
b - Continuity washer (if equipped)
c - Propeller locknut
d - Rear thrust hub
e - Propeller shaft
f - Forward thrust washer

3. Remove the screw securing the anode plate to the gear housing, and remove the anode plate. After the anode plate is removed, remove the nut and washer from inside the cavity.



a - Anode plate screw
b - Anode plate
c - Nut
d - Washer

4. Loosen the side mounting locknuts; two on each side. Do not attempt to remove one locknut before the opposite side is loosened sufficiently or the gear housing could be damaged.

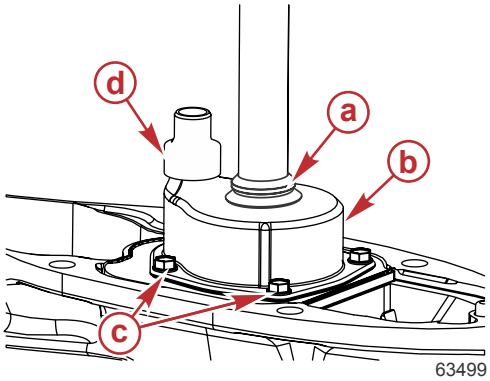


5. Pull the gear housing away from the driveshaft housing as far as the loosened locknuts will allow, then remove the loosened locknuts. Do not allow the gear housing to fall, as it is now free.
6. Pull the gear housing from the driveshaft housing.

Water Pump

Removal and Disassembly

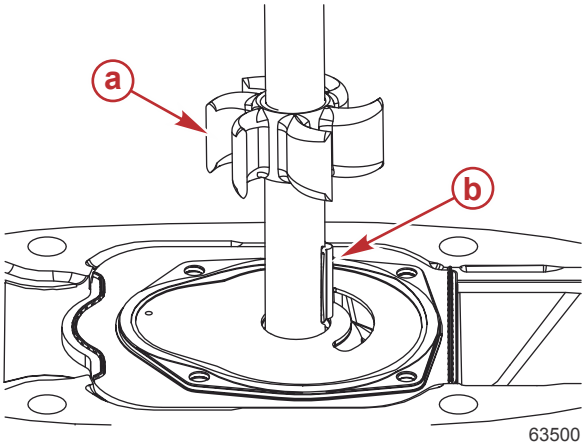
1. Remove the driveshaft seal, water pump screws, and the water seal coupler.



a - Driveshaft seal
b - Water pump cover
c - Screws (two each side)
d - Water seal coupler

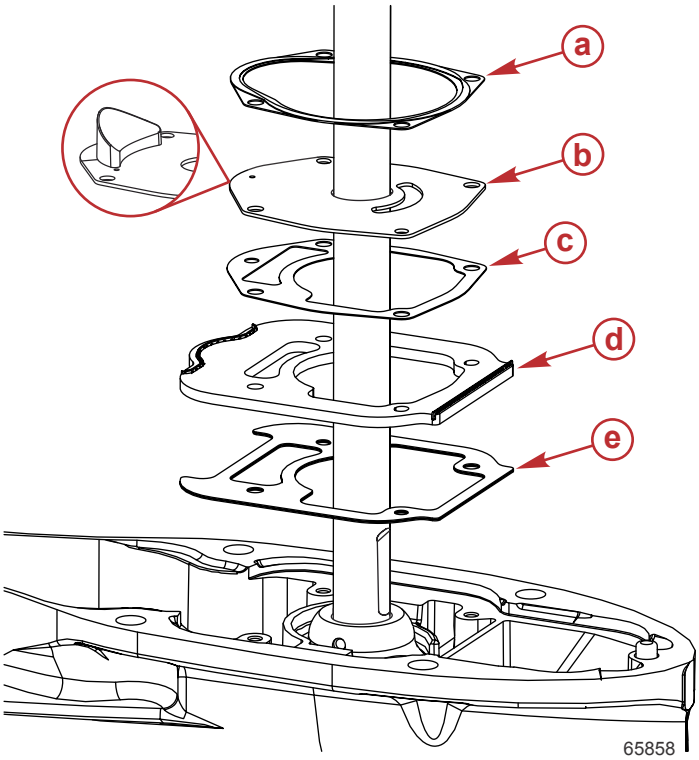
2. Lift the water pump cover straight up and off the driveshaft.

3. Remove the impeller and impeller key.



a - Impeller
b - Impeller key

4. Remove the top beaded gasket, faceplate, rubber-coated stainless steel gasket, top cover, and the lower gasket by lifting straight up and off of the driveshaft.



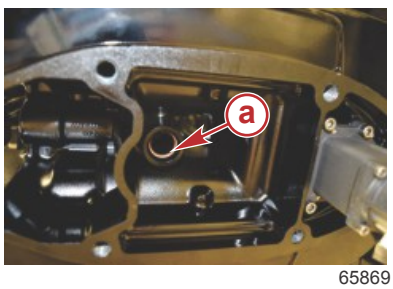
a - Beaded gasket
b - Faceplate

NOTE: *Early models were equipped with a faceplate deflector. The deflector is no longer required.*

c - Rubber-coated stainless steel gasket
d - Top cover
e - Gasket

Cleaning and Inspection

1. With the gear housing removed, inspect the water tube O-ring inside the driveshaft housing for wear or damage. Replace worn or damaged parts.



a - Water tube O-ring

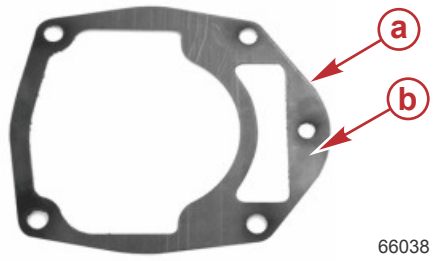
2. Inspect the water seal coupler and O-ring for wear or damage. Replace worn or damaged parts.

a - Water seal coupler
b - O-ring

3. Inspect the faceplate and water pump liner for grooves or rough surfaces.

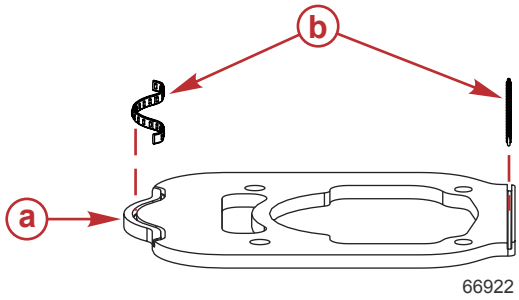
   IMPORTANT: The circular groove on the faceplate, formed by the impeller, will not affect water pump output.

4. Inspect all gaskets for damage and replace as required. Inspect the coated surface on the stainless steel gasket for scratches or damage. If the coating is scratched or damaged, replace the stainless steel gasket.



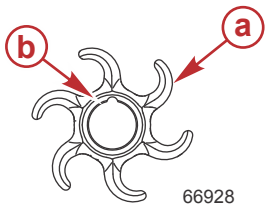
a - Stainless steel gasket
b - Coating

5. Inspect the top cover seals. Replace worn, damaged, or missing seals.



a - Top cover
b - Top cover seals (2)

6. Inspect the impeller seal surfaces and ends of the impeller blades for cracks, tears, and wear. Replace the impeller if any of these conditions are found.
7. Inspect the impeller hub for cracks, and ensure that the impeller is bonded to the hub.



a - Impeller
b - Hub

8. Inspect the impeller for a glazed or melted appearance, caused by operation without sufficient water supply. Replace the impeller if any of these conditions exist.

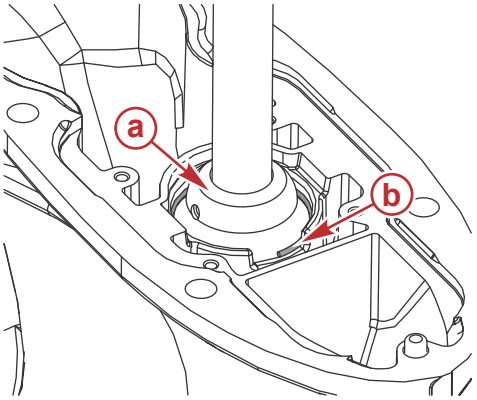
   IMPORTANT: When completing gear housing repairs that require removal of the water pump impeller, it is recommended the impeller be replaced. However, if the impeller must be used, do not install in reverse to original rotation; premature impeller failure will occur.

Oil Seal Carrier

Removal

NOTE: *Push down on the oil seal carrier to aid in the removal of the retaining ring above the oil seal carrier.*

1. While pushing down on the oil seal carrier, use a flat tip screwdriver to aid in the removal of the retaining ring above the oil seal carrier.

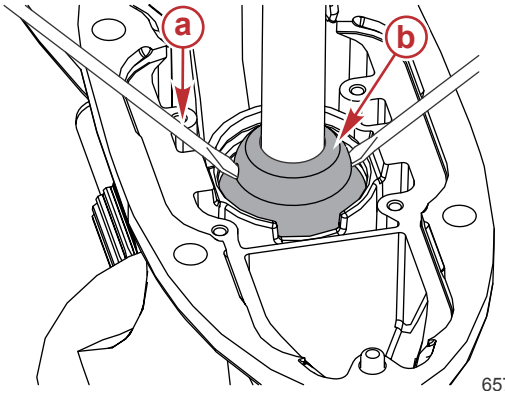


65700

a - Oil seal carrier
b - Retaining ring

2. Remove the oil seal carrier from the gear housing. It may be necessary to gently pry up on it with two screwdrivers.

NOTE: *When prying the oil seal carrier up, avoid contact with the painted surface of the gear housing, or protect the painted surface where the tools may contact the gear housing. This will prevent paint damage that could result in future corrosion.*



65701

a - Screwdrivers
b - Oil seal carrier

Disassembly

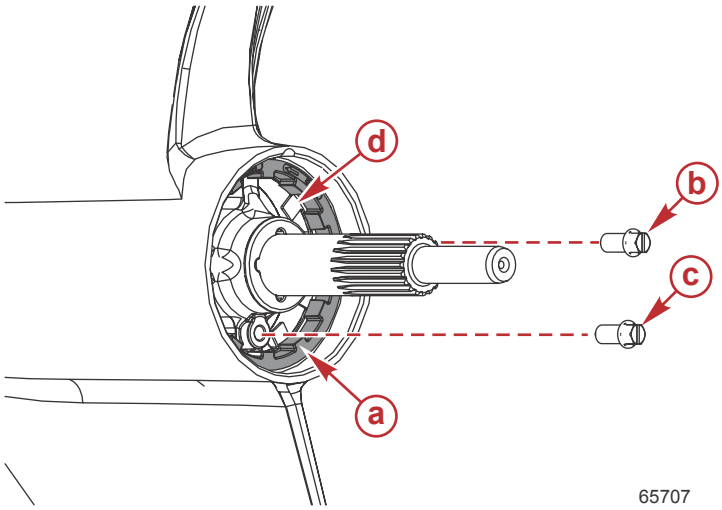
NOTE: *The oil seals within the oil seal carrier are not individually replaceable. If the oil seals require replacement, the oil seal carrier must be replaced as an assembly.*

Bearing Carrier

Bearing Carrier Removal

1. Straighten the tab on the tab washer that is bent into the bearing carrier retainer.

NOTE: *The vent and fill/drain plugs in the bearing carrier may have to be removed before using the bearing carrier retainer nut wrench to remove the bearing carrier retainer.*

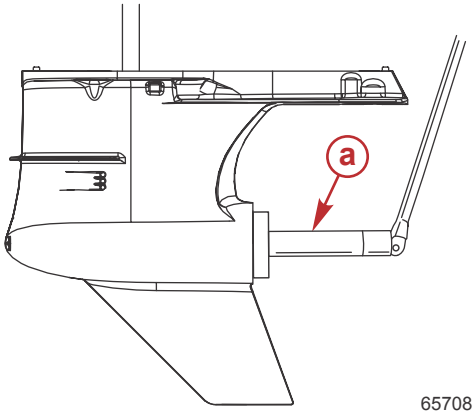


a - Bearing carrier retainer
b - Vent plug
c - Fill/drain plug
d - Lock tab on tab washer

2. Remove the bearing carrier retainer following step "a" or "b," as follows:

IMPORTANT: Drilling into the bearing carrier retainer can potentially damage the gear housing. Ensure that you do not drill into the gear housing when removing a seized retainer.

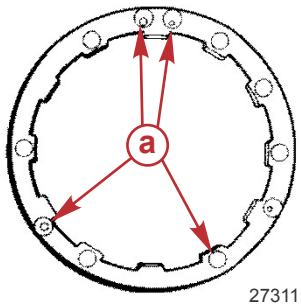
a. Remove the bearing carrier retainer by turning the retainer counterclockwise using a bearing carrier retainer nut wrench.



a - Bearing carrier retainer nut wrench

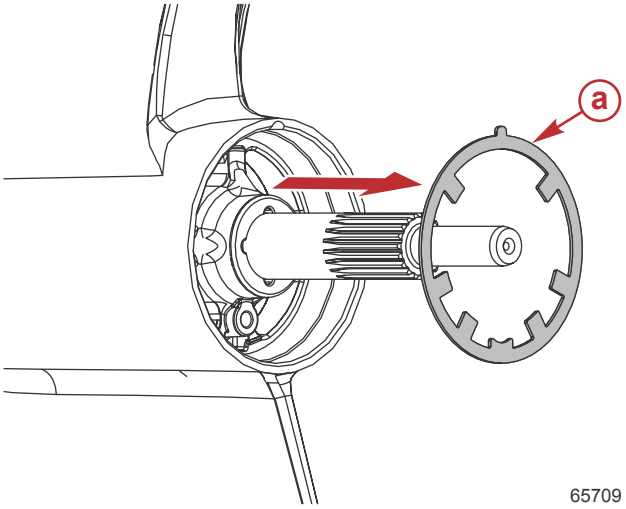
Bearing Carrier Retainer Nut Wrench	8M0057002

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

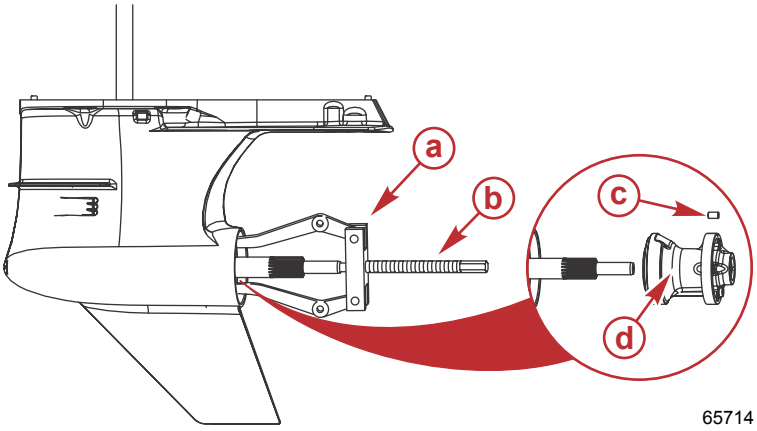
3. Remove the tab washer.



a - Tab washer

4. Pull the bearing carrier from the gear housing by pulling on the outer ring of the bearing carrier. Position the puller jaws close to the bosses in the carrier. The locating pin will likely come out with the bearing carrier. Be careful not to lose the locating pin.

   NOTE: *If the bearing carrier is seized in the gear housing, it may be necessary to use heat to loosen the carrier.*

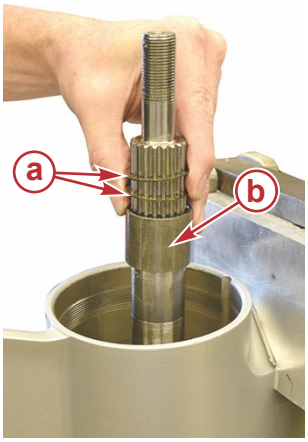


a - Puller jaws assembly
b - Puller bolt
c - Locating pin
d - Bearing carrier

Puller Jaws Assembly	91-46086A1

5. Remove the propeller shaft spacer and shims.

   NOTE: *The shims may stick to the bearing carrier when pulling it out. Check the bearing carrier if no shims are found on the propeller shaft.*



a - Propeller shaft shims
b - Propeller shaft spacer

Bearing Carrier—Inspection, Disassembly, Assembly

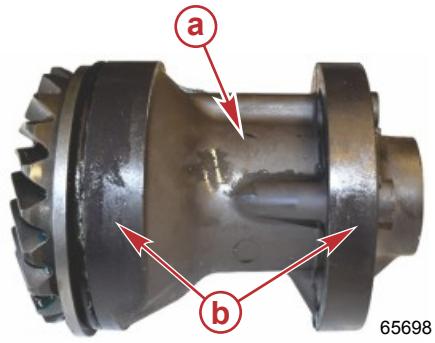
Inspection

IMPORTANT: All seals and O-rings should be replaced to assure effective repair.

⚠ 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.

1. Clean the bearing carrier with solvent and dry 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.



65698

a - Bearing carrier
b - Inspect for corrosion

3. Remove the rear gear from the bearing carrier by pulling it up and out.


65728

4. Remove the thrust ring. Remove and discard the O-ring.

65730

a - Bearing carrier
b - O-ring
c - Thrust ring

5. Inspect the remaining bearing carrier components as follows.

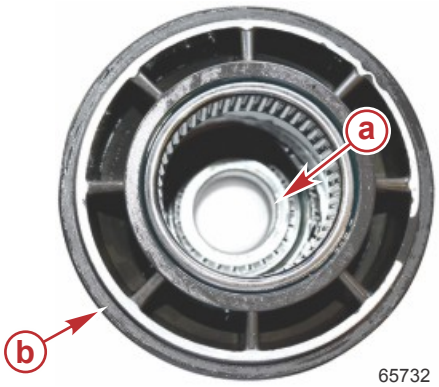
a. Inspect the rear gear needle bearing. Rotate the bearing while checking for rough spots or catches. Replace the bearing if any of these conditions exist.


65731

b. Inspect the aft propeller shaft tapered bearing cone and cup for pits, scoring, discoloration, or excessive looseness. Replace the bearing if any of these conditions exist.

NOTE: *The tapered bearing cone can be removed from the bearing carrier for inspection. Refer to* ***Disassembly*** *for removal of the bearing cup.*

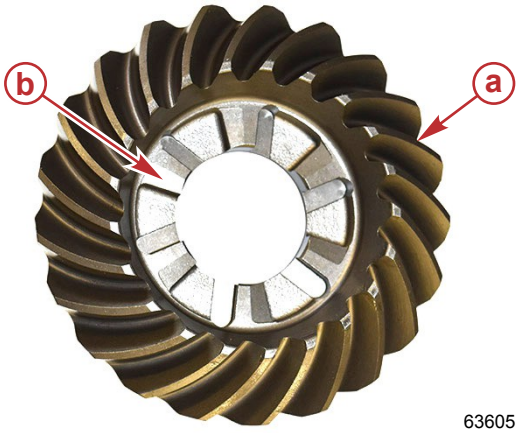
c. Inspect the bearing carrier oil seals.



65732

a - Tapered roller bearing cone (cup hidden under bearing)
b - Bearing carrier

6. Inspect the rear gear to pinion gear wear pattern. It should be even and smooth. If not, replace the rear gear, pinion gear, and front gear.
7. Inspect the rear gear for hairline fractures. Replace the rear gear and the pinion gear if any fractures are found. If extensive damage is observed, such as chips, spalling, or broken teeth, replace all gears.
8. Check the clutch jaws on the rear gear for damage. Replace the rear gear if damage is found on the clutch jaws.



63605

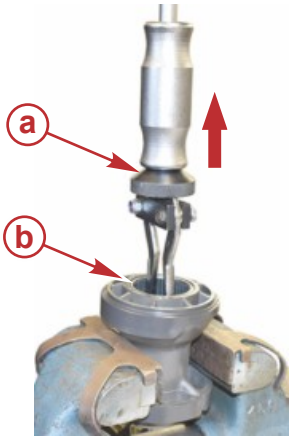
a - Rear gear
b - Clutch jaws

9. Do not proceed with disassembly unless the inspected parts require replacement.

Disassembly

1. Use the slide hammer with puller jaws to remove the needle bearing from the bearing carrier.

NOTE: *It may be necessary to use a torch lamp to heat the bearing carrier area surrounding the needle bearing.*

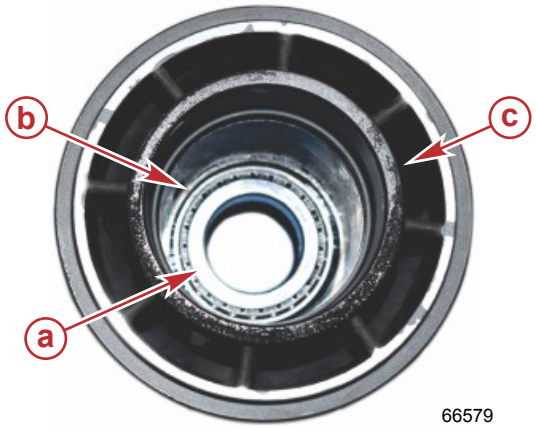


65733

a - Slide hammer with puller jaws
b - Needle bearing

Torch Lamp	91- 63209
Slide Hammer	91-34569A 1

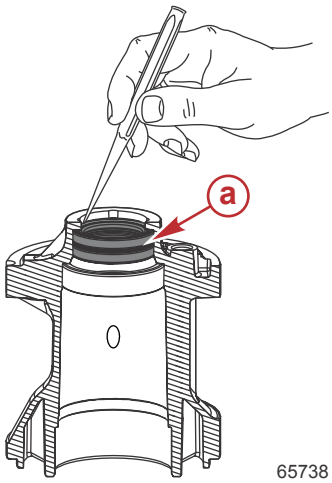
2. Discard the needle bearing after removal from the bearing carrier.
3. Replace the tapered bearing cone and bearing cup inside of the bearing carrier, if required.



66579

a - Tapered bearing cone
b - Bearing cup
c - Bearing carrier

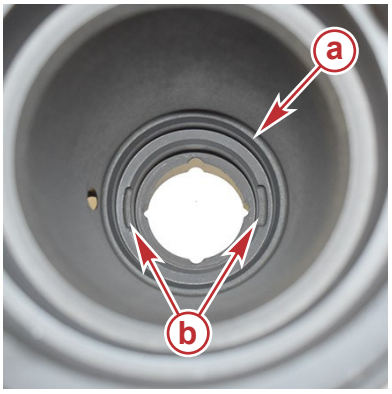
4. If damaged, replace the tapered bearing cup and bearing carrier seals as follows:
   a. **If replacing the seals only:** Remove the oil seals with a suitable punch, being careful not to damage the bore of the bearing carrier. Discard the seals.



65738

a - Seals

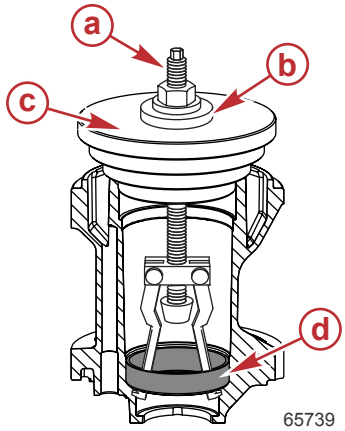
b. **If replacing the tapered roller bearing cup and seals:** Remove the seals with a punch as noted in the previous step. There are slots cast into the bearing carrier to aid in the removal of the bearing cup with puller jaws.



63725

a - Bearing carrier—bearing cup removed for clarity
b - Slots

c. Remove the tapered bearing cup from the carrier using a bearing puller assembly, pilot washer, and seal driver guide. Discard the bearing, cup, and seals.



65739

a - Bearing puller assembly
b - Pilot washer
c - Seal driver guide
d - Bearing cup

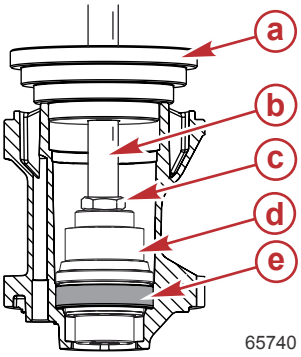
Bearing Puller Assembly	91- 83165T
Pilot Washer	91-36571T
Seal Driver Guide	8M0148864

Assembly

1. Clean the components with a suitable solvent and dry the parts with compressed air.
2. Lubricate the tapered bearing cup bore with High Performance Gear Lubricant.

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Tapered bearing cup bore	92-858064K01

3. Assemble the bearing cup onto the driver.
4. Press the bearing cup into the bearing carrier until the cup bottoms out in the bearing carrier.

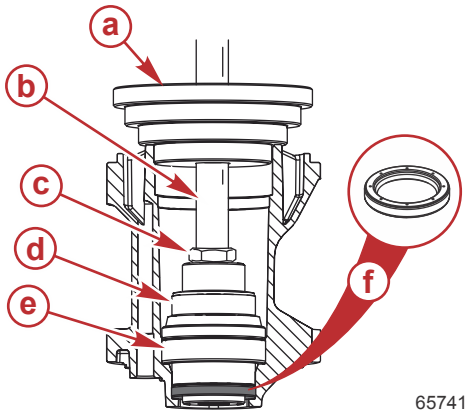


65740

a - Seal driver guide
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Tapered bearing cup

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Seal Driver Guide	8M0148864
Bearing Removal and Installation Kit	91- 31229A 7

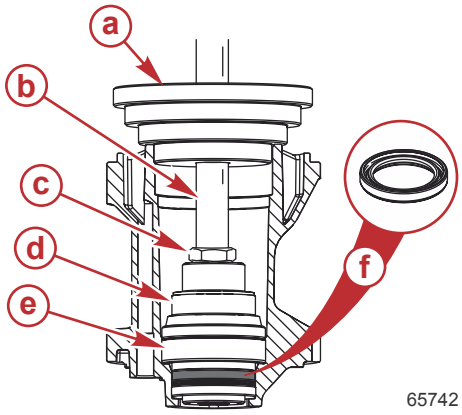
5. Thoroughly clean the bore in which the first seal is to be pressed.
6. Assemble the first seal, with the lips of the seal facing away from the driver shoulder, onto the long end of the oil seal driver.
7. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



a - Seal driver guide
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Bearing cup
f - Oil seal (first)

Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Seal Driver Guide	8M0148864
Bearing Removal and Installation Kit	91- 31229A 7

8. Assemble the second seal, with the lips of the seal facing the driver shoulder, onto the short end of the oil seal driver.
9. Press on the oil seal with the driver until the driver bottoms out on the bearing cup.



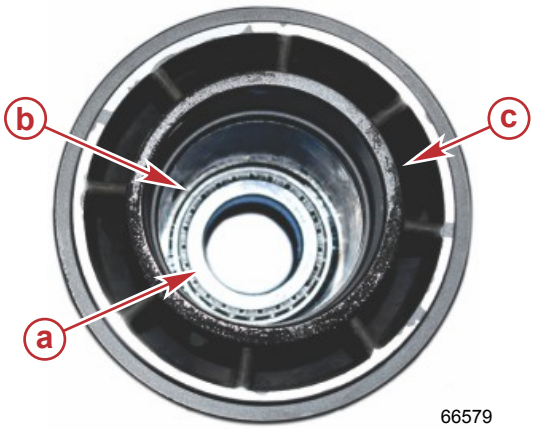
a - Seal driver guide
b - Driver rod
c - Hex nut
d - Bearing cup driver/oil seal installer
e - Bearing cup
f - Oil seal (second)

Seal Driver Guide	8M0148864
Bearing Cup Driver/Oil Seal Installer Tool	91-888414T01
Bearing Removal and Installation Kit	91- 31229A 7

10. Lubricate the seal lips and fill the area between the seals with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal lips and between oil seals	92-802859A 1

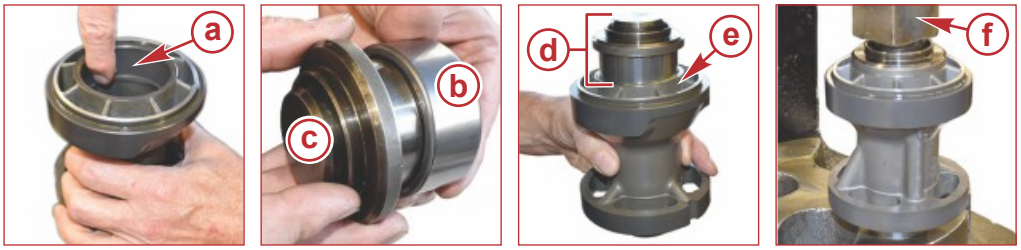
11. Install the propeller shaft tapered bearing cone into the bearing carrier.



66579

- **a -** Tapered bearing cone
- **b -** Bearing cup
- **c -** Bearing carrier

12. Press the new needle bearing into the bearing carrier as follows.
    a. Lubricate the inside of the bearing carrier bore.
    b. Install the bearing onto the bearing installation tool, with the numbers facing the tool.
    c. Set the needle bearing and bearing installation tool assembly on top of the bearing carrier as shown.
    d. Press the new needle bearing into the bearing carrier until the tool bottoms out. Remove the bearing installation tool.



65774

- **a -** Bearing carrier bore
- **b -** Needle bearing
- **c -** Bearing installation tool
- **d -** Needle bearing and tool assembly
- **e -** Bearing carrier
- **f -** Press

Bearing Installation Tool	8M0146935

13. After installation, inspect the rear gear needle bearing. Rotate the bearing while checking for rough spots or catches. Replace the bearing if any of these conditions exist.

65731

14. Lubricate the O-ring with 2-4-C with PTFE.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	O-ring	92-802859A 1

15. Install the O-ring and thrust ring onto the bearing carrier.

65730

a - Bearing carrier
b - O-ring
c - Thrust ring

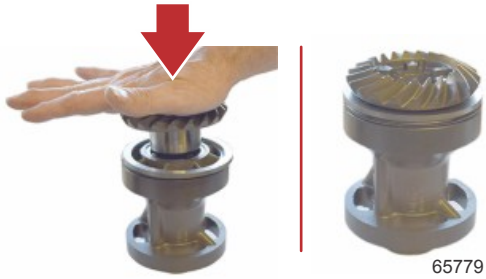
16. If necessary, assemble the gear retainer onto the rear gear as follows.
    a. Install the gear retainer onto the gear retainer installation tool.
    b. Set the gear retainer and gear retainer installation tool assembly on the rear gear as shown.
    c. Press down until the gear retainer snaps into place. Remove the gear retainer installation tool.

65776

a - Gear retainer
b - Gear retainer installation tool
c - Rear gear
d - Gear retainer and tool assembly
e - Press down
f - Gear retainer assembled into rear gear

Gear Retainer Installation Tool	8M0148865

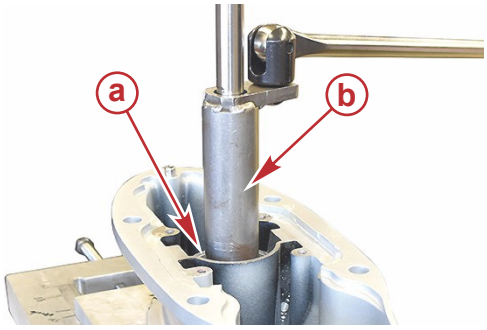
17. Install the rear gear into the bearing carrier as follows.
    a. With the bearing carrier in a vertical position, set the rear gear on top of the bearing carrier.
    b. Push the rear gear down by hand until the gear retainer snaps into place beneath the needle bearing.


65779

Driveshaft Removal, Inspection, Disassembly, and Assembly

Driveshaft Removal

1. Remove the driveshaft bearing retainer with the driveshaft bearing retainer wrench.

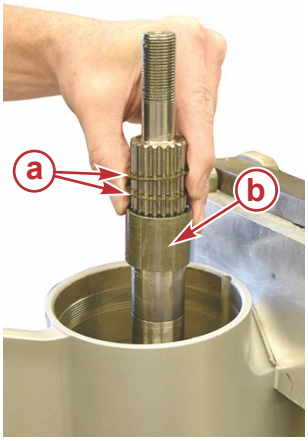


65781

a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

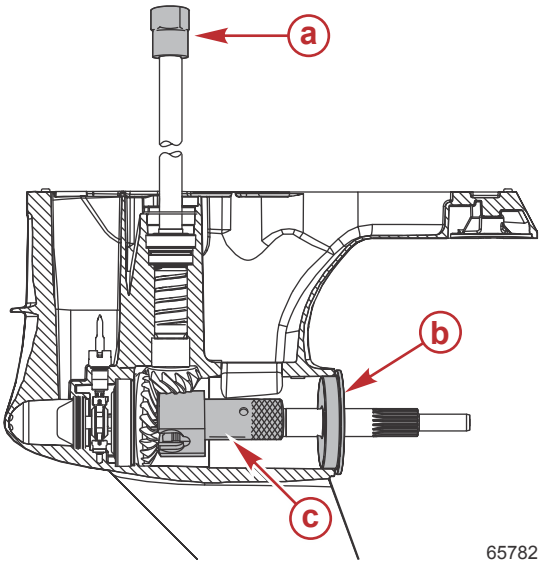
2. Remove the shims and spacer from the propeller shaft, if not already removed.



65722

a - Propeller shaft shims
b - Propeller shaft spacer

3. Insert the pinion nut wrench into the gear housing with the MR slot facing the pinion gear. It may be necessary to lift and rotate the driveshaft to align the pinion gear nut into the pinion nut wrench.
4. Install the propeller shaft holder over the propeller shaft and into the gear housing to maintain the pinion nut wrench alignment.
5. Install the driveshaft holding tool onto the driveshaft.
6. Use the driveshaft holding tool to loosen the pinion nut.

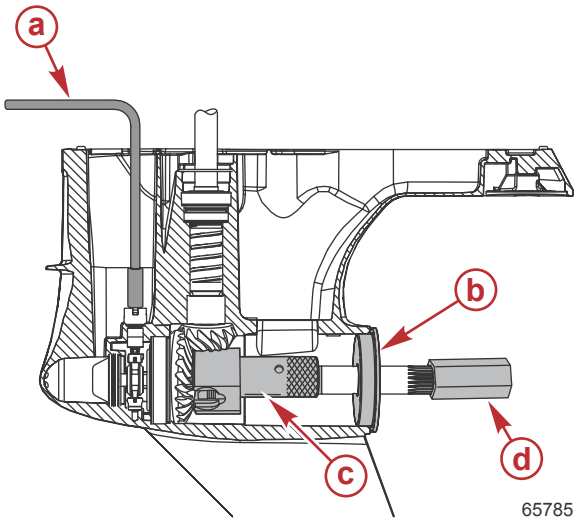


65782

a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut wrench

Driveshaft Holding Tool	91-889958T
Propeller Shaft Holder	8M0075944
Pinion Nut Wrench	91- 61067T03

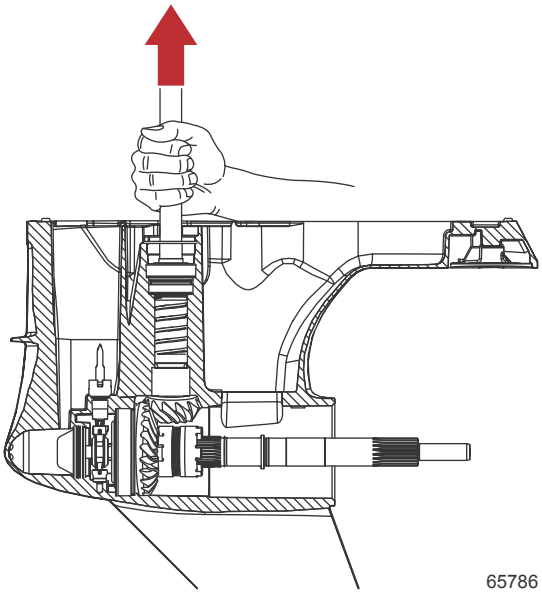
7. If the driveshaft is broken, place the propeller shaft adapter onto the propeller shaft splines. Use the shift shaft handle tool to hold the shift shaft against the rear gear, and loosen the pinion nut by rotating the propeller shaft counterclockwise.



a - Shift shaft handle tool
b - Propeller shaft holder
c - Pinion nut wrench
d - Propeller shaft adapter

Shift Shaft Handle Tool	8M0142973
Propeller Shaft Holder	8M0075944
Pinion Nut Wrench	91- 61067T03
Propeller Shaft Adapter	8M0147118

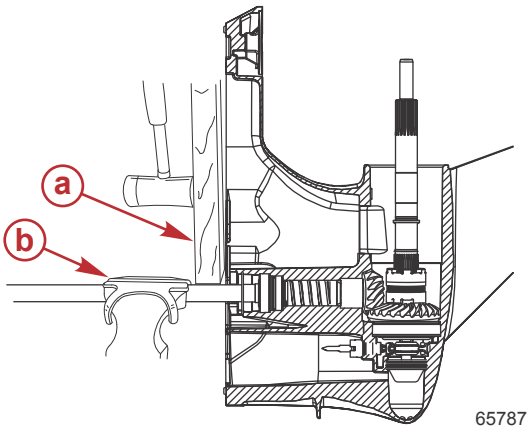
8. Remove all of the tools.
9. Remove the driveshaft by pulling the driveshaft straight out of the gear housing.



10. If the pinion gear is seized onto the driveshaft, clamp the driveshaft in a soft jaw vise. Place a block of wood on the gear housing mating surface. Use a mallet and carefully tap the gear housing away from the driveshaft.

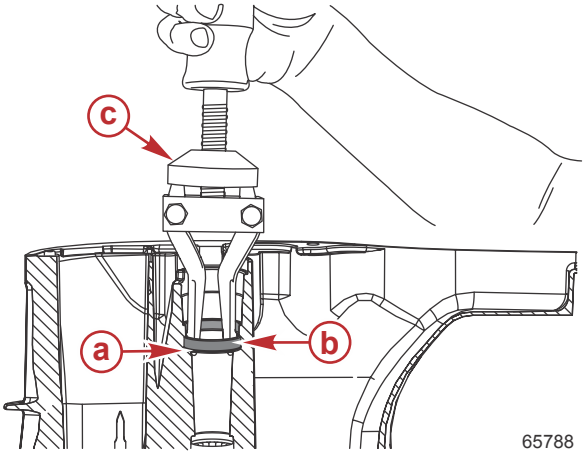
IMPORTANT: Striking a gear housing directly with a mallet can distort the gear housing causing gear housing failure.

IMPORTANT: The pinion bearing rollers can fall out of the pinion bearing race after the driveshaft is removed. Do not lose the 18 rollers.



a - Wood block
b - Driveshaft in soft jaw vise

11. Move the propeller shaft downward to retrieve the pinion gear and nut from inside the gear housing.
    NOTE: *The washer will likely come out with the pinion gear. Do not lose the washer.*
12. Remove the driveshaft bearing cup and shims with a slide hammer. Retain the shims for installation.

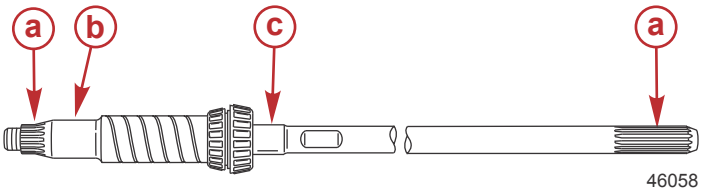


a - Shims
b - Bearing cup
c - Slide hammer puller

Slide Hammer	91-34569A 1

Driveshaft Inspection

1. Clean all parts with a suitable solvent and dry the parts thoroughly using compressed air. Do not 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 needles 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 the driveshaft for grooves where the water pump base oil seals contact the shaft. Replace the driveshaft if grooves are found.



a - Splines
b - Pinion bearing surface
c - Seal surface

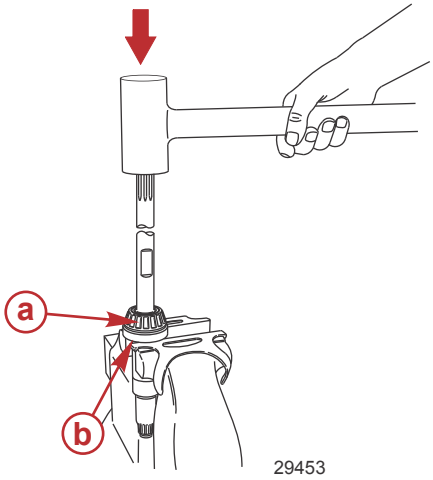
6. Inspect the pinion gear for pits, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the pinion gear and the forward gear as a set if any defects are found.

Driveshaft Disassembly

NOTE: *Do not remove the upper and lower tapered roller bearings from the driveshaft unless replacement is indicated. Bearings cannot be reused after removal from the driveshaft.*

NOTE: *If one driveshaft tapered roller bearing is damaged, both tapered bearings and spacer must be replaced as a set.*

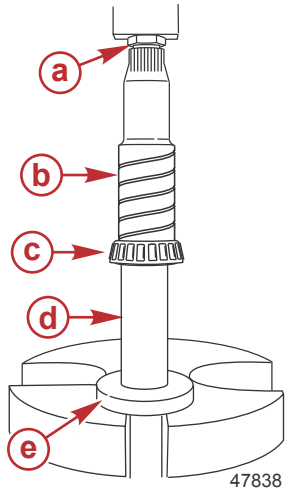
1. Both the upper and lower tapered roller bearings can be removed from the driveshaft in one operation. Using the bottom bearing cup removed from the gear housing, place the cup on top of a vise leaving the vise jaws open enough to allow the driveshaft to slide through.
2. Place the driveshaft through 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

Driveshaft Assembly

1. Apply High Performance Gear Lubricant on the inside diameter of the driveshaft tapered bearings.
2. Install the lower tapered roller bearing to the driveshaft, with the small outside diameter of the bearing facing towards the pinion gear end of the driveshaft.
3. Thread a used pinion nut onto the end of the driveshaft. Leave approximately 2 mm (1/16 in.) of nut threads exposed. The driveshaft threads must not extend beyond the nut or thread damage will result when pressing the bearing on.
4. Press the lower bearing onto the driveshaft with the driveshaft bearing installation tool.

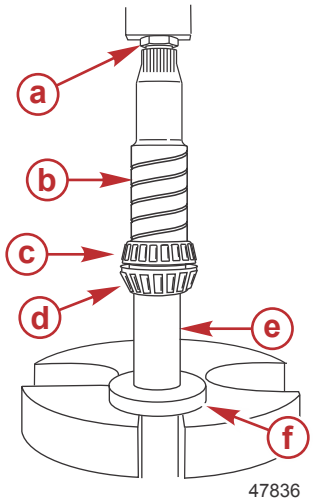


a - Pinion nut
b - Driveshaft
c - Lower driveshaft tapered bearing
d - Driveshaft bearing installation tool
e - Flat washer (obtain locally)

Driveshaft Bearing Installation Tool	91-8M0052590

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of the driveshaft tapered bearings	92-858064K01

5. Install the upper bearing onto the driveshaft, with the large outside diameter of the bearing facing the pinion gear end of the driveshaft.
6. Press the upper bearing onto the driveshaft with the driveshaft bearing installation tool.



- **a -** Pinion nut
- **b -** Driveshaft
- **c -** Lower driveshaft tapered bearing
- **d -** Upper driveshaft tapered bearing
- **e -** Driveshaft bearing installation tool
- **f -** Flat washer (obtain locally)

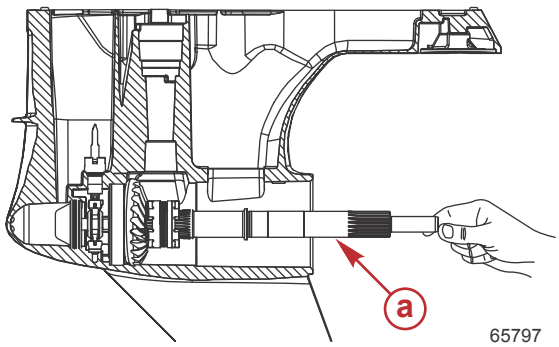
Driveshaft Bearing Installation Tool	91-8M0052590

Propeller Shaft and Front Gear Bearing Cup

Removal

NOTE: *The front gear and propeller shaft assembly can only be removed from the gear housing after the driveshaft and pinion gear have been removed.*

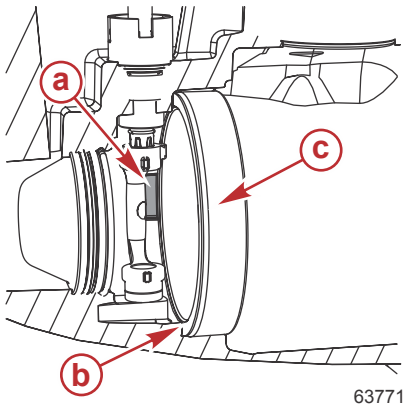
1. Tilt the propeller shaft to the starboard side of the gear housing and remove the shaft.



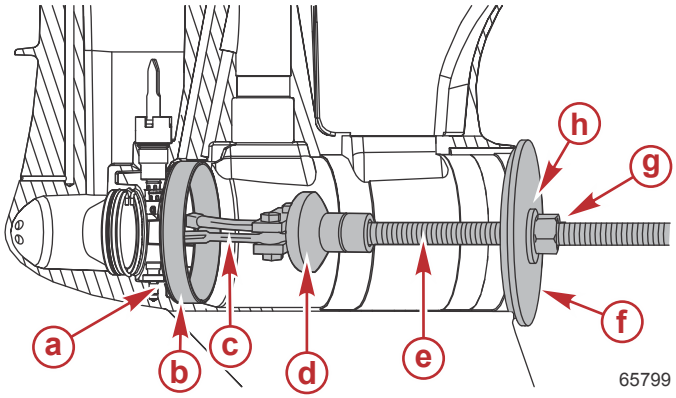
- **a -** Propeller shaft

2. Remove the front gear bearing cup and shims. Measure and make note of the shim thickness. If the shims are not damaged, they may be reused.

   NOTE: *Two notches are provided in the gear housing, just forward of the front gear bearing cup, to position the puller jaws for easier removal of the bearing cup and shims.*



- **a -** Notches (one on each side)
- **b -** Shims
- **c -** Front gear bearing cup



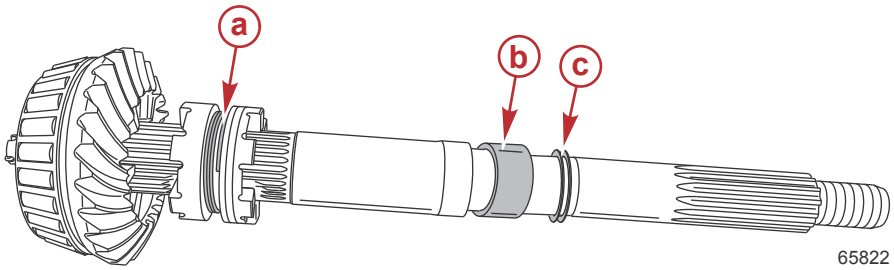
- **a -** Shims
- **b -** Bearing cup
- **c -** Jaws (from slide hammer puller kit)
- **d -** Puller head (from slide hammer puller kit)
- **e -** Puller shaft
- **f -** Guide plate
- **g -** Nut
- **h -** Washer

Slide Hammer	91-34569A 1
Bearing Removal and Installation Kit	91- 31229A 7
Guide Plate	91-816243

Component Disassembly

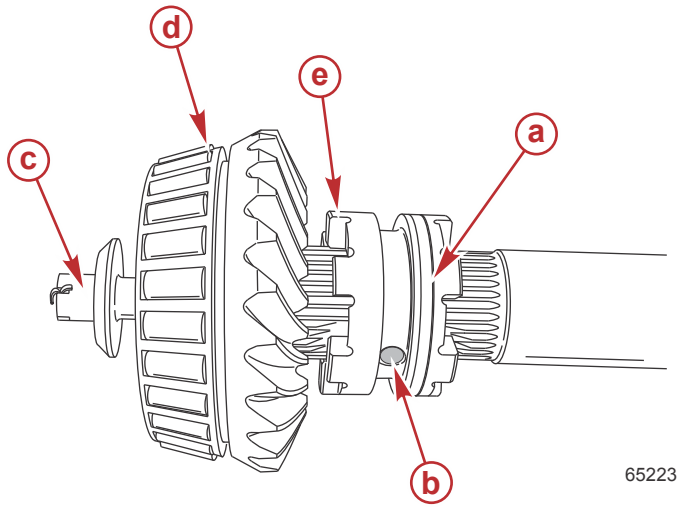
NOTE: *When performing the next step, all of the parts are free to come apart. Work closely over a workbench to avoid dropping or damaging the parts and to avoid personal injury.*

1. Ensure the propeller shaft thrust spacer and shims are removed.



- **a -** Spring
- **b -** Thrust spacer
- **c -** 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 after it has been removed, it must be replaced.
3. Remove the cross pin that goes through the clutch.
4. Remove the remainder of the components.

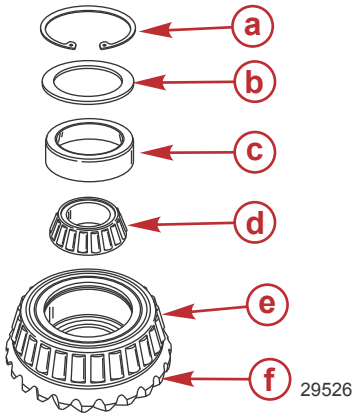


- **a -** Clutch band (faces toward rear gear)
- **b -** Cross pin
- **c -** Shift spool and actuating shaft assembly
- **d -** Front gear assembly
- **e -** Clutch

Inspection

1. Clean all the parts with a suitable solvent and dry the parts thoroughly with compressed air. Be careful not to spin the bearings.
2. Inspect the sliding clutch jaws for damage. Replace the clutch if the jaws are chipped or rounded off.

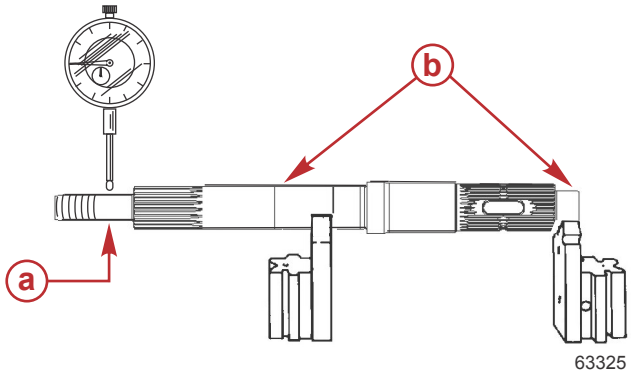
3. The propeller shaft uses two tapered roller bearing and cup assemblies for propeller shaft support.
   a. One tapered bearing is just forward of the bearing carrier seals. Refer to the **Bearing Carrier Disassembly** section for information on accessing this bearing for inspection.
   b. The other tapered bearing is located inside of the front gear assembly. Remove the front gear assembly from the propeller shaft. Remove the snap ring retainer and flat washer from the front gear assembly to remove the tapered bearing for inspection.



a - Snap ring
b - Flat washer
c - Inner tapered bearing cup
d - Inner tapered bearing cone
e - Outer front gear bearing cone
f - Front gear

NOTE: *The outer front gear bearing should not be removed from the front gear unless replacement is necessary. The bearing is not reusable if it 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 the V-blocks.
   b. Adjust the height of the V-blocks to level the propeller shaft.
   c. Position the dial indicator tip forward of the propeller shaft threads.
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

Propeller Shaft	
Runout	0.23 mm (0.009 in.)

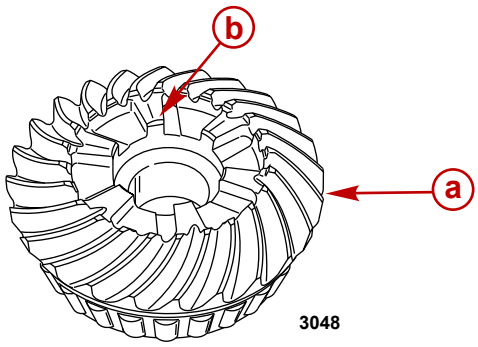
Dial Indicator	91- 58222A 1

Front Gear Assembly

Component Inspection

1. Clean the front gear assembly and the front gear bearing cup with a suitable solvent and dry with compressed air. Be careful not to spin the bearings.
2. Inspect the gear for pits, chipped or broken teeth, hairline fractures, and excessive or uneven wear. Replace the front 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 front gear and pinion gear as a set if any of these conditions exist.



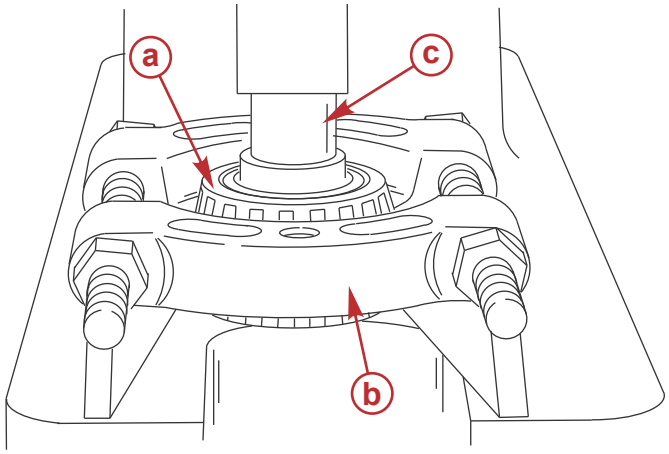
a - Front gear teeth
b - Clutch jaws

4. Inspect the propeller shaft tapered roller bearing on the inside of the front 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.
5. Inspect the tapered roller bearing pressed onto the front gear and the bearing surface on the front gear bearing cup. If either the roller bearing or the bearing surface of the front gear bearing cup is pitted, grooved, scored, worn unevenly, discolored from overheating, or has embedded particles, replace the front gear bearing cup and remove and replace the tapered roller bearing.

Disassembly

IMPORTANT: Do not remove the pressed on tapered roller bearing from the front gear unless replacement of the bearing is required. The bearing cannot be reused after it has been removed.

1. If inspection determines that replacement of the front gear tapered bearing is required, separate the gear from the bearing as follows:
   a. Install the universal puller plate between the front gear and the tapered bearing.
   b. Place the assembly on a press and press the gear out of the bearing with a suitable mandrel.
   NOTE: *The tapered bearing cup and cone must be replaced as a set.*



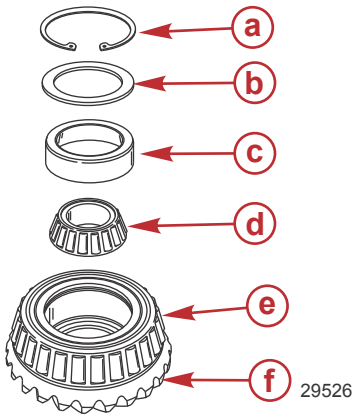
a - Front gear bearing
b - Universal puller plate
c - Mandrel

Universal Puller Plate	91-37241

2. If inspection determines that replacement of the propeller shaft tapered roller bearing is required, remove the bearing as follows:

   IMPORTANT: Use suitable eye protection when removing or installing the snap ring.

a. Use snap ring pliers to remove the snap ring. Remove the tapered roller bearing assembly out of the inside of the front gear.

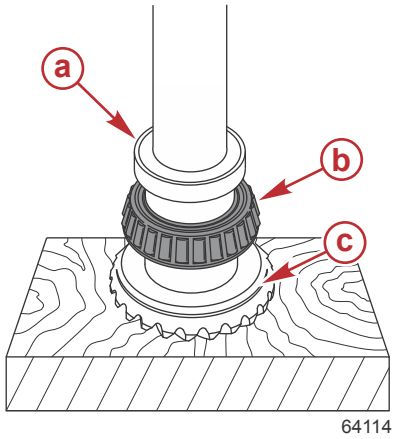


a - Snap ring
b - Flat washer
c - Tapered bearing cup
d - Tapered bearing cone
e - Front gear bearing cone
f - Front gear

Assembly

1. Use a suitable mandrel to press the tapered roller bearing onto the front gear. Press on the inner bearing race until the bearing contacts the gear.

   IMPORTANT: Use a block of wood under the gear as shown to prevent damage to the gear while installing the bearing.

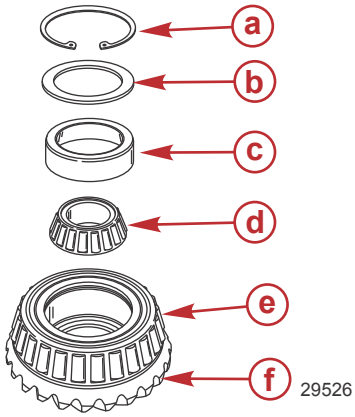


a - Mandrel
b - Tapered roller bearing
c - Front gear

2. Apply High Performance Gear Lubricant to the I.D. of the front gear. Install a new tapered roller bearing cone, race, and flat washer into the front gear until the bearing seats.

   IMPORTANT: Use suitable eye protection when removing or installing the snap ring.

3. Install the snap ring into the groove of the front gear to secure the tapered roller bearing assembly.



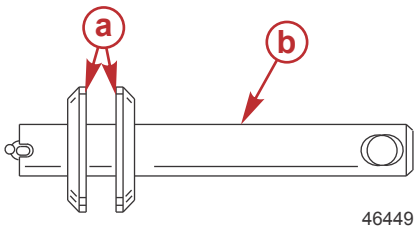
a - Snap ring
b - Flat washer
c - Tapered bearing cup
d - Tapered bearing cone
e - Front gear bearing cone
f - Front gear

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Inside diameter of front gear	92-858064K01

Shift Spool Assembly

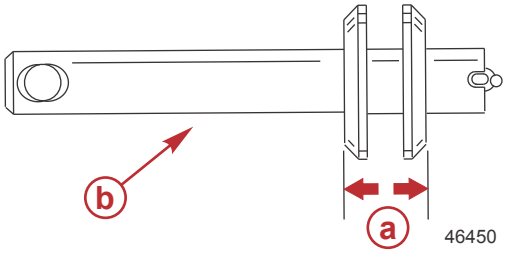
Inspection

1. Clean the assembly with solvent and dry all 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, replace the complete shift spool 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. Verify the spool spins freely.
5. Verify the spool has end play. The 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

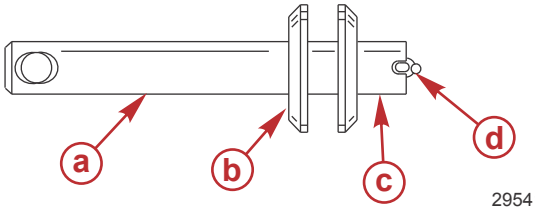
NOTE: *If the spool spins freely and has the proper clearance, it will not be necessary to disassemble and reassemble the spool. If the spool does not function properly, proceed with the following disassembly procedures.*

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, replace the 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

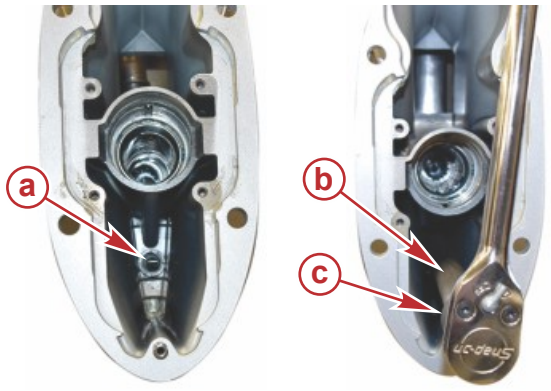
Shift Spool	
End play	0.05–0.25 mm (0.002–0.010 in.)

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, replace the shift spool assembly.

Shift Shaft Removal and Assembly

Removal

1. Remove the shift shaft assembly from the gear housing using the shift shaft tool and 1 in. socket.

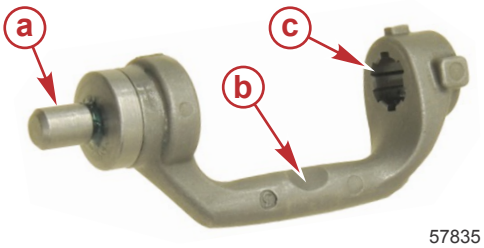


65824

a - Shift shaft
b - Shift shaft tool
c - 1 in. socket

Shift Shaft Tool	8M0142969

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 for wear in the areas that contact the shift spool and inspect the splines and the pivot pin for damage or wear.



57835

a - Pivot pin
b - Contact area
c - Splines

Disassembly and Inspection

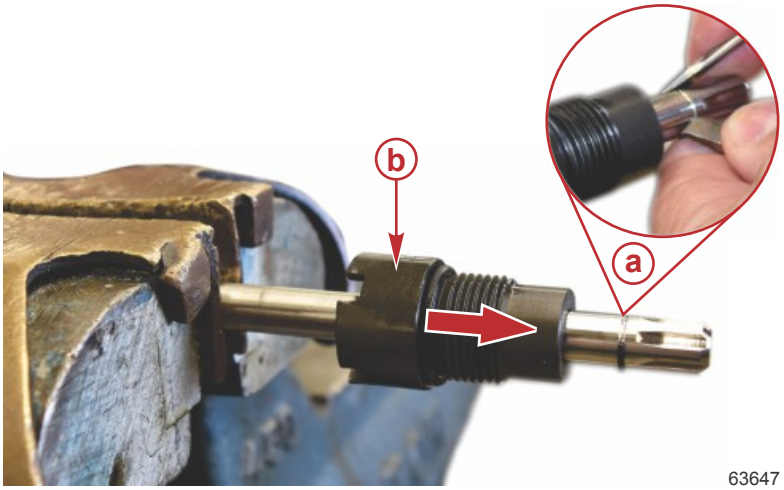
1. Secure the shift shaft assembly in a vise as shown.

⚠ CAUTION

Wear eye protection when performing the following procedure. Failure to do so may cause personal injury.

a. Remove the snap ring from the end of the shift shaft.

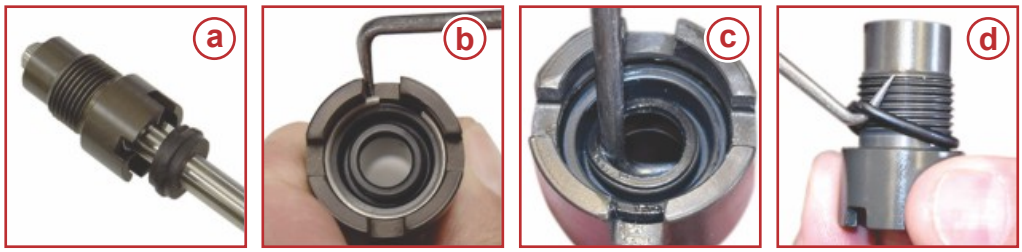
b. Remove the bushing from the shift shaft.



63647

a - Snap ring
b - Bushing

2. Remove the rubber grommet, snap ring, seal, and O-ring from the shift shaft bushing.



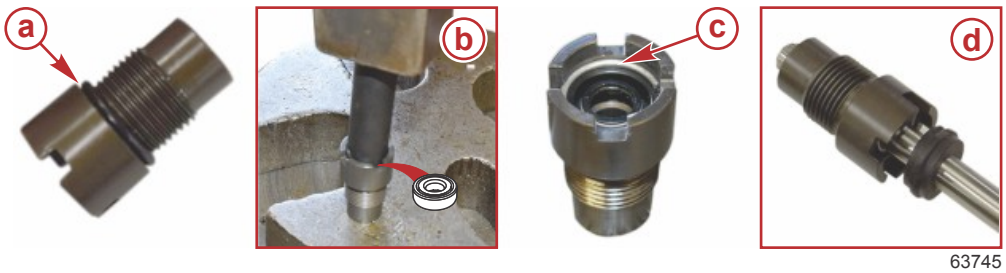
63648

a - Rubber grommet
b - Snap ring
c - Seal
d - O-ring

3. Clean all components with a suitable solvent and dry with compressed air.
4. Inspect all of the components.
   a. Inspect the shift shaft bushing for damage or leaks.
   b. Inspect the O-ring and rubber grommet for damage or excessive wear.
5. Inspect the shift shaft splines and oil seal surface for corrosion or excessive wear. Replace the shift shaft if either of these conditions are found.

Assembly

1. Lubricate the O-ring with 2-4-C with PTFE and install onto the shift shaft bushing.
2. Using a suitable mandrel, press the oil seal into the shift shaft bushing with the lips of the seal facing out.
3. Lubricate the oil seal lips with 2-4-C with PTFE.
4. Install the snap ring to secure the seal.

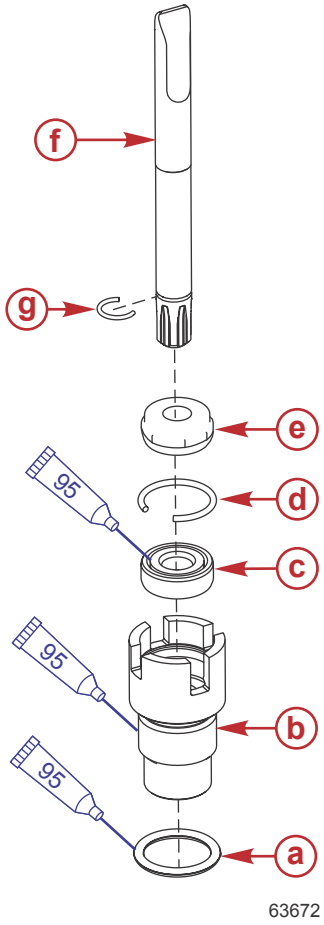


63745

a - O-ring
b - Press seal into bushing
c - Snap ring
d - Rubber grommet

5. Install the rubber grommet onto the shift shaft.
6. Install the shift shaft bushing onto the shift shaft.
7. Install the snap ring on the end of the shift shaft.

8. Lubricate the threads of the shift shaft bushing with 2-4-C with PTFE.



- **a -** O-ring
- **b -** Shift shaft bushing
- **c -** Shift shaft seal
- **d -** Snap ring—secures seal in bushing
- **e -** Rubber grommet
- **f -** Shift shaft
- **g -** Snap ring—shift shaft

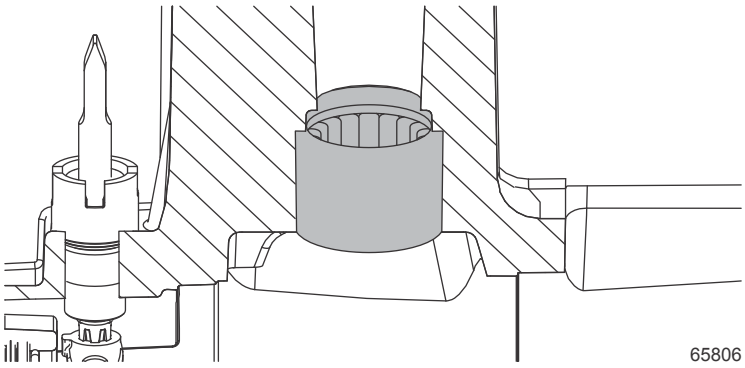
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift shaft bushing threads, O-ring, and oil seal lip	92-802859A 1

Pinion Bearing Removal

NOTE: *Inspect the pinion bearing surface on the driveshaft. The condition of the driveshaft at this location gives an indication of the condition of the roller bearing. Replace the 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.*

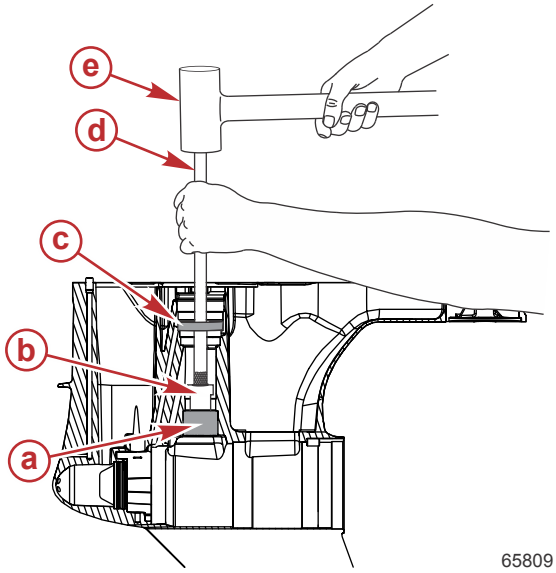
IMPORTANT: All the roller bearings (18) must be in place inside the bearing race while driving the pinion bearing from the gear housing. It is recommended that the cardboard tube provided with a new pinion bearing be used to keep the bearings in place while driving out the old pinion bearing.

IMPORTANT: Do not use the bearing race or rollers after they have been removed.



Pinion bearing

Remove and discard the pinion bearing race and rollers using the tools as shown.



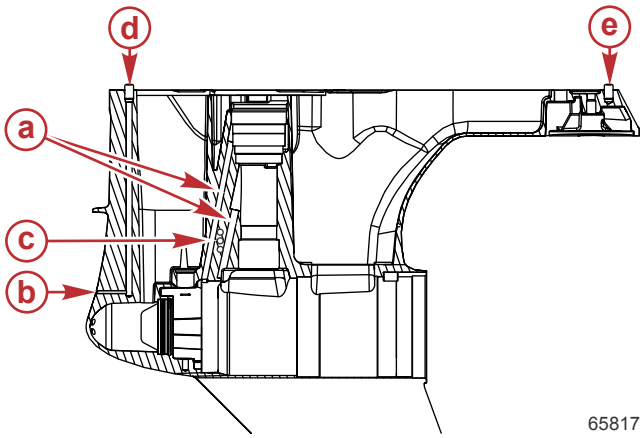
- **a -** Pinion bearing
- **b -** Driver head
- **c -** Pilot washer
- **d -** Driver rod
- **e -** Dead blow hammer

Driver Head	91- 36569T
Pilot Washer	91-36571T
Driver Rod	91- 37323

Gear Housing Inspection

1. Clean the gear housing with a suitable solvent and a hard bristle (not wire) brush. Dry the gear housing with compressed air. Ensure that all sealants, locking agents, and debris are removed.
2. Verify the two oil circulation holes in the driveshaft bore are clear and free of debris.
3. Inspect the gear housing for excessive corrosion, impact, or any other damage. Excessive damage or corrosion requires replacement of the gear housing.
4. Inspect the bearing carrier retainer threads in the gear housing for corrosion or stripped threads. Damage or corrosion to the threads requires replacement of the gear housing.

   NOTE: *The driveshaft bearing cups are 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 the bearing cone and cup contact area with the gearcase bearing bore for evidence of the bearing cup spinning. Check that the bearing cups are not loose in the bearing bores. A press fit type bearing bore in which the cup is loose will require replacement of the gear housing.
6. Inspect for blockage in the water inlet holes and the speedometer hole and 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
- **d -** Hollow locating pin for speedometer passage
- **e -** Locating pin

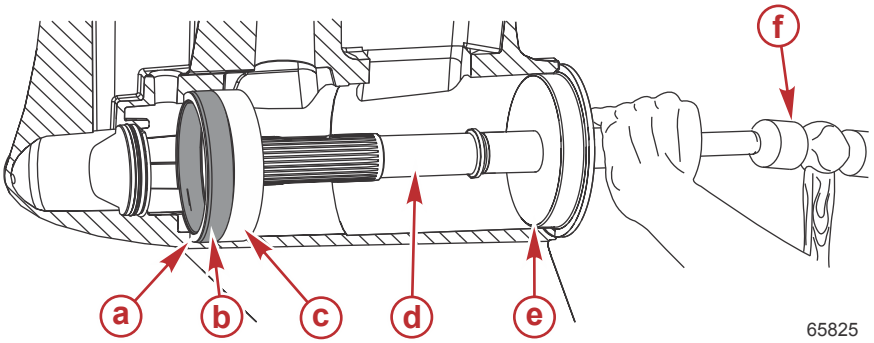
7. Verify the locating pins are in place in the gear housing and the corresponding holes in the driveshaft housing are not elongated. The driveshaft may break if the housings are not aligned properly due to missing locating pins or elongated holes.

Front Gear Bearing Cup Installation

NOTE: If the front gear, front gear bearing and cup, or gear housing were not replaced, install the same measurement of shims that were removed. If the front gear, front gear bearing and cup, or gear housing were replaced, install 0.762 mm (0.030 in.) shims.

1. Lubricate the front gear bearing cup bore with High Performance Gear Lubricant.
2. Install the shims into the front gear bearing cup bore.

   IMPORTANT: Verify the bearing cup is positioned as straight as possible to avoid damaging the bore while pressing the bearing cup in.



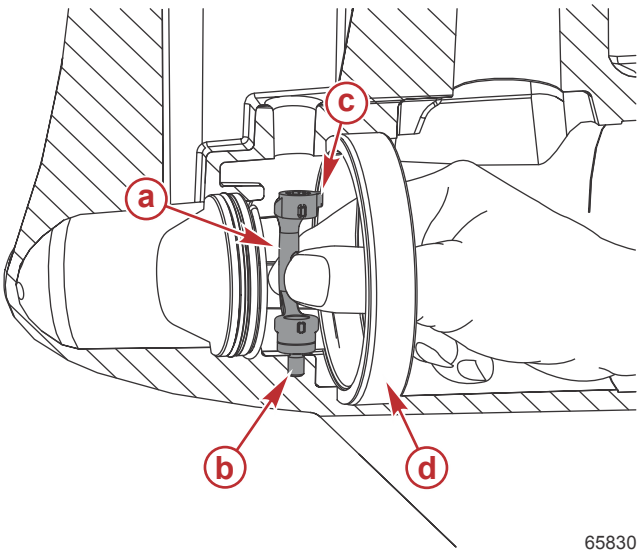
- **a -** Shims
- **b -** Front gear bearing cup
- **c -** Bearing cup driver
- **d -** Propeller shaft (old nonserviceable)
- **e -** Propeller shaft holder
- **f -** Mallet

Bearing Cup Driver	91-885592T
Propeller Shaft Holder	8M0075944

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Front 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 that the shift crank faces towards the starboard side of the gear housing. The tab on the shift crank should face aft.



- **a -** Shift crank
- **b -** Pivot pin
- **c -** Shift crank tab
- **d -** Front gear bearing cup

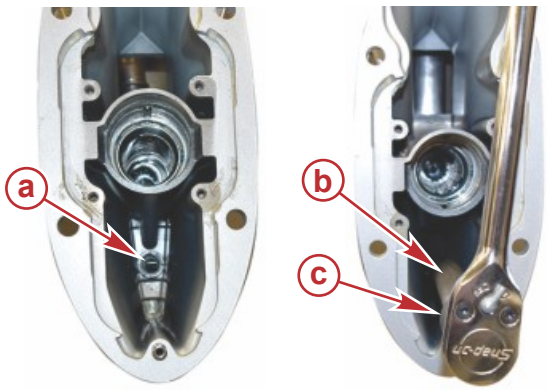
2. Install the shift shaft assembly into the gear housing. Engage the splined end of the shift shaft with the shift crank. Ensure that the flat at the tip of the shift shaft is parallel with the direction of the shift crank.

NOTE: *The shift crank is shown outside of the gear housing for clarity.*

65831

a - Shift shaft and crank orientation
b - Incorrect shift shaft orientation

3. Tighten the shift shaft bushing to the specified torque using the shift shaft tool and a 1 in. socket.



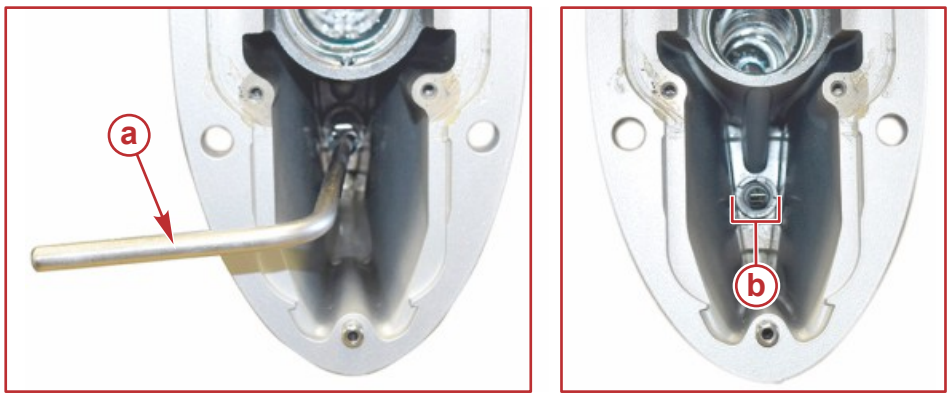
65824

a - Shift shaft
b - Shift shaft tool
c - 1 in. socket

Shift Shaft Tool	8M0142969

Description	Nm	lb-in.	lb-ft
Shift shaft bushing	54.2	–	40

4. Operate the shift shaft with the shift shaft handle tool to ensure it has engaged into the shift crank. The proper neutral position can be identified below.



65832

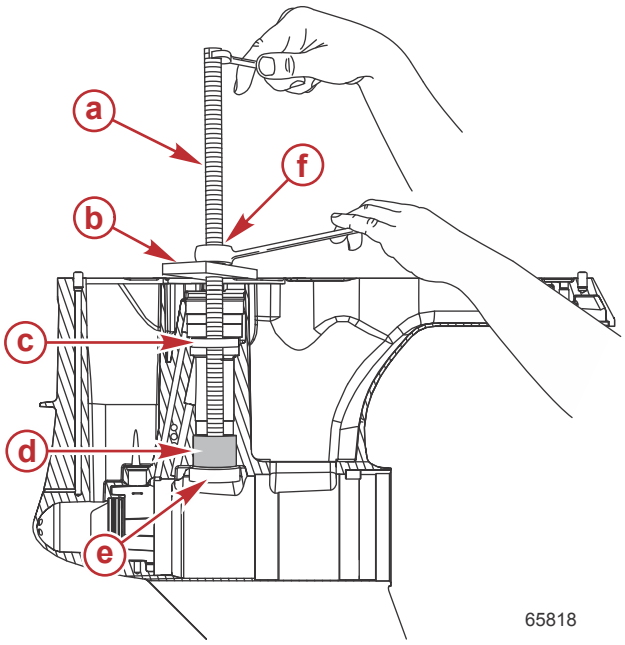
a - Shift shaft handle tool
b - Neutral position

Shift Shaft Handle Tool	8M0142973

Pinion Bearing Installation

IMPORTANT: Install only a new pinion bearing. Do not install 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, as shown.
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 washer
d - Pinion bearing
e - Driver head
f - Hex nut

Puller/Driver Head	91- 38628T
Bearing Removal and Installation Kit	91- 31229A 7

Tube Ref No.	Description	Where Used	Part No.
87	High Performance Gear Lubricant	Pinion bearing bore	92-858064K01

Driveshaft Bearing Rolling Torque and Pinion Gear Height

IMPORTANT: The sequence of setting up the driveshaft bearing rolling torque and pinion height must be completed before checking the front and rear gear backlash. Failure to set the driveshaft bearing rolling torque and pinion height prior to checking the front and rear gear backlash may cause errors in determining the correct lash and will increase assembly time of the gear housing to factory specifications.

Driveshaft and Pinion Gear Installation

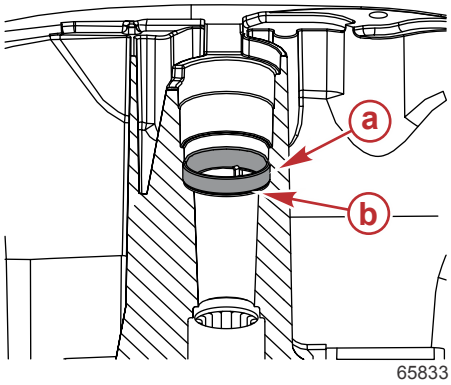
NOTE: *If the original shims were not retained, or if the pinion gear, driveshaft, driveshaft upper tapered roller bearing and cup, or gear housing were replaced, start by installing a 0.508 mm (0.020 in.) shim for the lower tapered roller bearing.*

NOTE: *If the original shims were retained or the measurement is known, and none of the above listed parts were replaced, install the same shims or same amount of shims.*

IMPORTANT: Do not apply Loctite 271 Threadlocker to the threads of the pinion gear nut until after the pinion height, pinion bearing rolling torque, and front gear backlash have been confirmed.

1. Place the lower tapered bearing shims into the driveshaft housing bore.

2. Install the lower tapered bearing cup into the driveshaft housing bore.

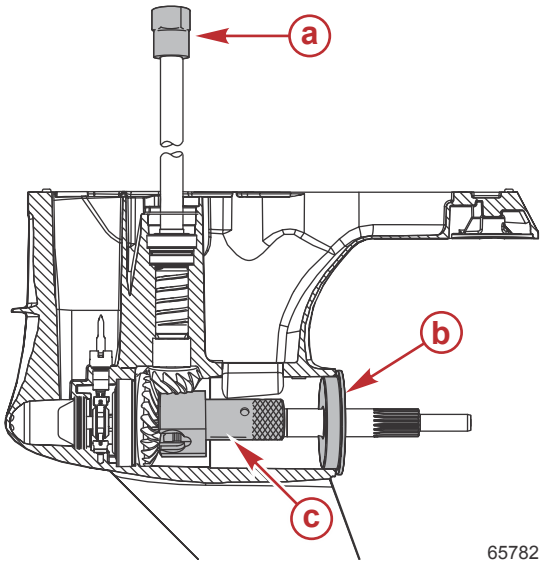


a - Tapered bearing cup
b - Shims

3. Install the front gear assembly.
   IMPORTANT: The front gear must be installed to support the pinion nut holding tool.
4. Install the pinion gear and driveshaft.
5. Secure the pinion gear with the pinion nut and washer.
   NOTE: *Install the pinion gear nut with the flat side of the nut away from the pinion gear.*
6. Install the upper driveshaft tapered roller bearing shim.
7. Install the upper driveshaft tapered roller bearing cup. Apply 2-4-C with PTFE to the retainer threads and install the retainer.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Retainer threads	92-802859A 1

8. Install the driveshaft holding tool.
9. Install the propeller shaft into the front gear.
10. Install the pinion nut wrench over the propeller shaft and secure the pinion nut with the pinion nut wrench.
11. Install the propeller shaft holder.
12. Use the driveshaft holding tool to tighten the pinion nut to the specified torque.



a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut wrench

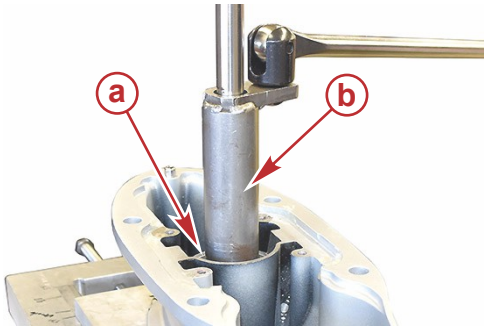
Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03
Propeller Shaft Holder	8M0075944

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	101.7	–	75

13. Remove the driveshaft holding tool, propeller shaft holder, pinion nut wrench, propeller shaft, and front gear.

Driveshaft Bearing Rolling Torque

1. Use the driveshaft bearing retainer wrench to tighten the upper driveshaft bearing retainer to the specified torque.



a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

2. Install the driveshaft holding tool.

Driveshaft Holding Tool	91-889958T

3. Use the driveshaft holding tool to check the driveshaft bearing rolling torque. Units correctly assembled to this point would be within the specified rolling torque range. If the rolling torque is not within specification, the shim under the upper tapered roller bearing cup will need to be changed and the rolling torque rechecked. If the rolling torque is too high, add shims under the upper bearing cup. If the rolling torque is too low, remove shims from under the upper bearing cup.

Description	Nm	lb-in.	lb-ft
Driveshaft bearing rolling torque	0.45–1.13	4–10	–

Checking and Adjusting Pinion Gear Height with Pinion Gear Locating Tool 91-56048001

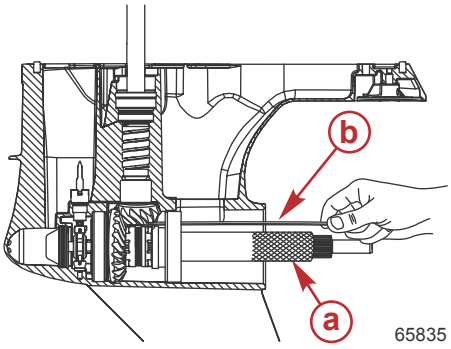
NOTE: *The propeller shaft and front gear can be installed when checking pinion height if this pinion gear locating tool is used.*

IMPORTANT: Do not apply Loctite 271 Threadlocker to the threads of the pinion gear nut until after the pinion height and pinion bearing rolling torque is confirmed.

1. Place the pinion gear locating tool into the gear housing, aligning the window in the tool with the 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 shimming tool. Record the measurement.



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 (height). Record the measurement.
4. Repeat this process until three readings have been recorded.
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.

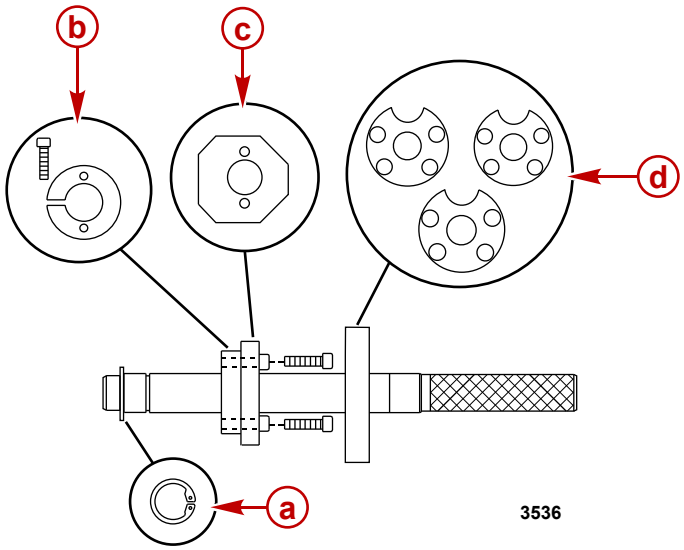
Pinion Gear	
Height	0.635 mm (0.025 in.)

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 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 at least three full turns in a clockwise direction. Check the pinion gear height. If the pinion gear height is not within specification, adjust the shim thickness and recheck. Repeat this process until the average pinion gear height is within specification.

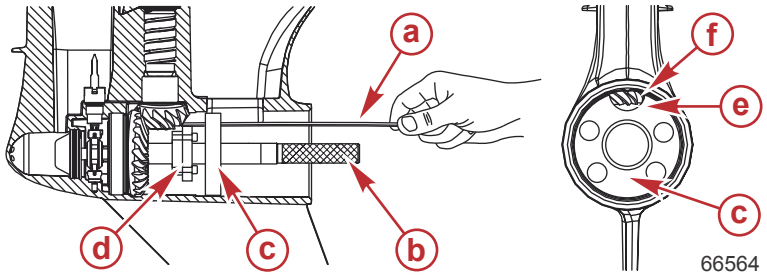
Checking and Adjusting Pinion Gear Height with Pinion Gear Locating Tool 91-12349A05



a - Retaining ring - relocate to first groove
b - Split collar
c - Gauging block - use flat #4
d - Locating disc - use disc #2

NOTE: *The front gear assembly must be installed when using pinion gear locating tool 91-12349A05.*

1. Install the retaining ring on the pinion height tool into the first groove of the arbor.
2. Using 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

NOTE: *Take the following measurements at three locations, rotating the driveshaft 120° 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 the high point of the shimming tool. Record the measurement.
4. Rotate the driveshaft 120 degrees in a clockwise direction and measure the clearance (height). Record the measurement.
5. Repeat this process until three measurements have been recorded.
6. Add the three measurements together and divide the sum by three to get the average pinion gear height. Make note of this average measurement.

Pinion Gear	
Height	0.635 mm (0.025 in.)

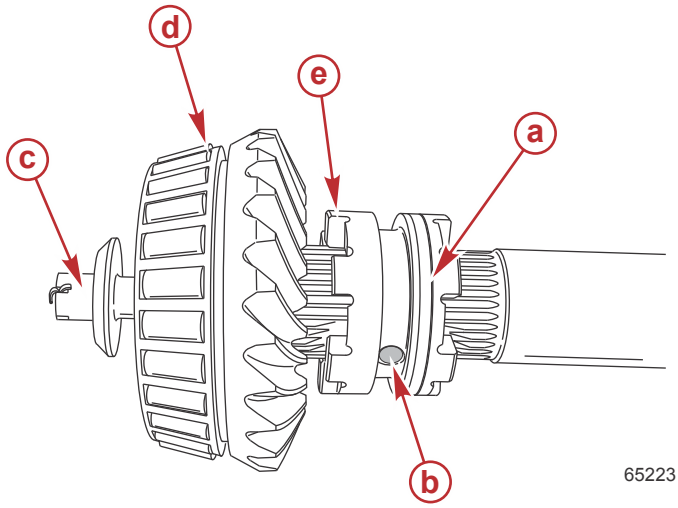
7. If the average pinion gear height is not correct, add or subtract shims beneath the lower driveshaft tapered bearing race.
8. Install all removed components and tighten the retainer to the specified torque.

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

9. Rotate the driveshaft a minimum of three full turns in a clockwise direction. Check the pinion gear height. If the pinion height is not within specification, adjust the shim thickness and recheck. Repeat this process until the average pinion height is within specification.

Propeller Shaft Assembly

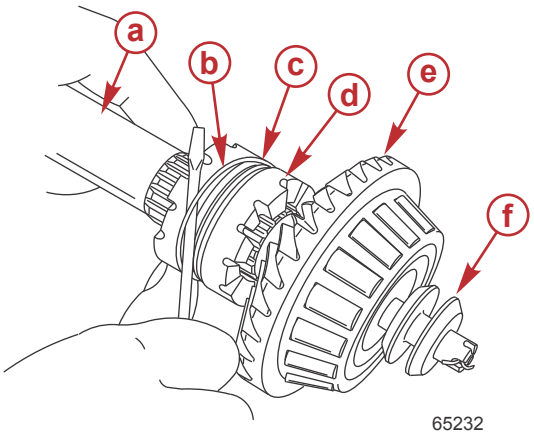
1. Install the sliding clutch onto the propeller shaft so the band on the clutch is facing aft. Align the cross pin holes in the clutch with the slot in the propeller shaft.
2. Assemble the front gear assembly to the propeller shaft.
3. Assemble the shift spool assembly to the propeller shaft, making 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.



a - Clutch band (faces toward rear gear)
b - Cross pin
c - Shift spool and actuating shaft assembly
d - Front gear assembly
e - Clutch

5. 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.

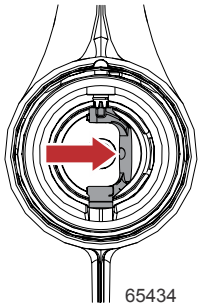
IMPORTANT: Verify the spring is wound on so that it does not cross over on itself and that it lies flat against the clutch once it is assembled. If it does not lie flat against the clutch, a new spring must be installed.



a - Propeller shaft
b - Cross pin retaining spring
c - Cross pin (hidden)
d - Sliding clutch
e - Front gear assembly
f - Shift spool and actuating shaft assembly

Propeller Shaft Installation

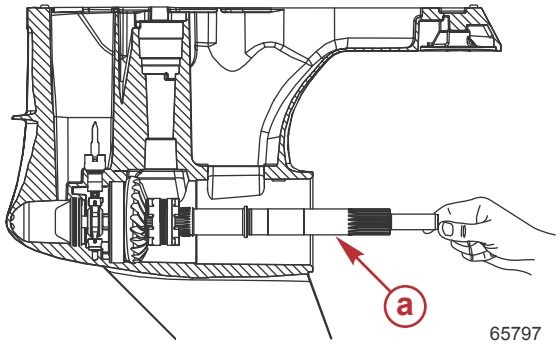
1. Verify the shift crank is positioned properly before installing the propeller shaft. The shift crank should face toward the starboard side of the gear housing.



Shift crank position

NOTE: *The shift/clutch assembly should be in the neutral position when installing the propeller shaft.*

2. To allow for the engagement of the shift spool with the shift crank, tilt the propeller end of the propeller shaft assembly to the starboard side of the gear housing. Hold the shift shaft in neutral while installing the propeller shaft.



a - Propeller shaft

3. Operate the shift shaft to ensure it has been properly installed. The sliding clutch should move forward when the shift shaft is turned counterclockwise. The sliding clutch should move aft when the shift shaft is turned clockwise. Hold the shift shaft handle tool in the neutral position, and ensure that the propeller shaft rotates freely in either direction.

Shift Shaft Handle Tool	8M0142973

Driveshaft and Pinion Gear Final Installation

1. Apply Loctite 271 Threadlocker to the threads of the pinion gear nut and place the pinion gear nut into the MR slot of the pinion nut wrench.

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.*

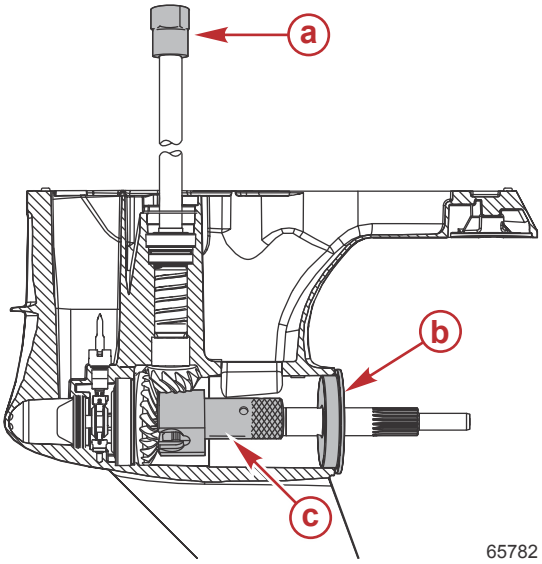
NOTE: *For ease of installation, glue the washer to the pinion gear using 3M Adhesive, Bellows Adhesive, or equivalent.*

Tube Ref No.	Description	Where Used	Part No.
27	Bellows Adhesive	Driveshaft pinion gear washer	92-86166Q1

NOTE: *Do not apply Loctite 271 Threadlocker to the pinion nut until the front gear backlash setting is finalized. Do not reuse the old pinion nut. Install a new pinion nut after backlash is finalized.*

2. Place the pinion gear into the gear housing.
3. With the propeller shaft horizontal, insert the pinion nut wrench with the nut and washer into the gear housing.
4. 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.
5. Start the pinion nut onto the driveshaft threads by rotating the driveshaft until the nut is snug.

6. Install the propeller shaft holder into the gear housing to hold the propeller shaft and the pinion nut wrench in position.
7. Tighten the pinion nut to the specified torque by turning the driveshaft using the driveshaft holding tool and torque wrench.

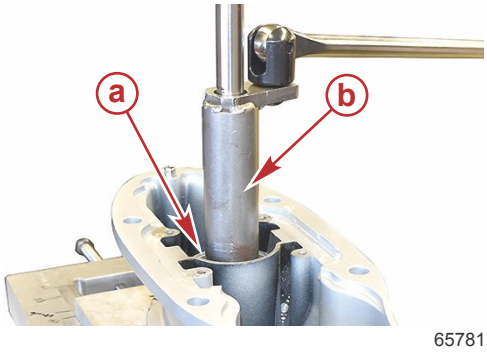


a - Driveshaft holding tool
b - Propeller shaft holder
c - Pinion nut wrench

Driveshaft Holding Tool	91-889958T
Pinion Nut Wrench	91- 61067T03
Propeller Shaft Holder	8M0075944

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	101.7	–	75

8. Apply 2-4-C with PTFE to the retainer threads and install the retainer. Tighten the retainer to the specified torque.



a - Retainer
b - Driveshaft bearing retainer wrench

Driveshaft Bearing Retainer Wrench	91-43506T

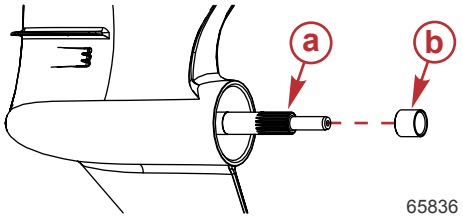
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Retainer threads	92-802859A 1

Description	Nm	lb-in.	lb-ft
Retainer	135.5	–	100

9. Remove the propeller shaft holder, pinion nut wrench, and driveshaft bearing retainer wrench.

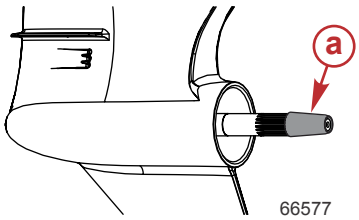
Front (Forward) Gear Backlash

1. Install the propeller shaft thrust spacer onto the propeller shaft. Do not install the propeller shaft shims at this time.



a - Propeller shaft
b - Thrust spacer

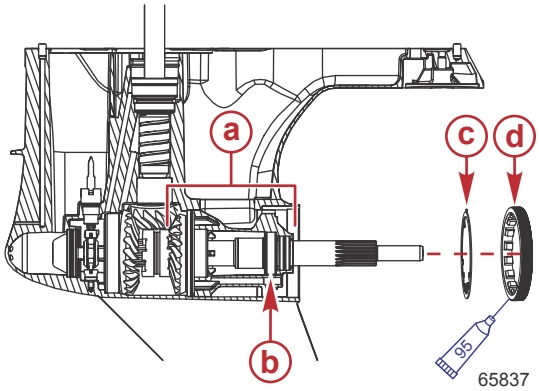
IMPORTANT: Prior to installing the bearing carrier into a gearcase equipped with the heavy-duty 31.75 mm (1.25 in.) diameter propeller shaft, install the bearing carrier installation tool over the propeller shaft. This tool will prevent the bearing carrier seal lips from being damaged by the propeller shaft splines. Remove the tool after the bearing carrier is installed.



a - Bearing carrier installation tool

Bearing Carrier Installation Tool	91-8M0059911

2. Place the bearing carrier assembly into the gear housing. Carefully align the rear propeller shaft tapered bearing with the propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion and rear gears.
3. Lubricate the bearing carrier retainer nut threads with 2-4-C with PTFE. Install the locking tab washer and bearing carrier retainer into the gear housing. Use the bearing carrier retainer nut wrench to thread the retainer on hand-tight.



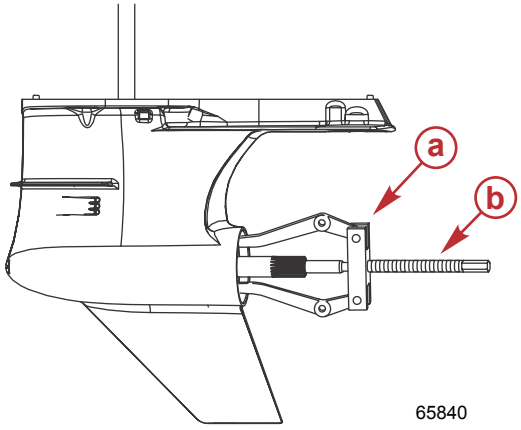
a - Bearing carrier assembly
b - Propeller shaft tapered bearing
c - Locking tab washer
d - Bearing carrier retainer

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier retainer nut threads	92-802859A 1

Bearing Carrier Retainer Nut Wrench	8M0057002

4. Apply forward pressure to the propeller shaft as follows:
   a. Install the puller jaws assembly onto the bearing carrier bosses and propeller shaft.

b. Tighten the puller bolt to the specified torque. Rotate the driveshaft three full turns clockwise and check the puller bolt torque.

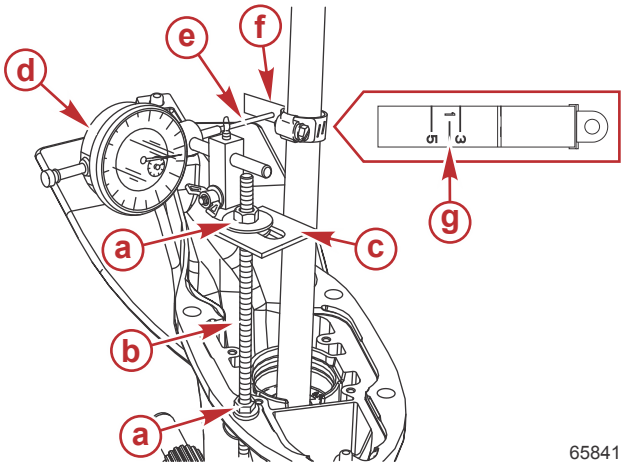


a - Puller jaws assembly
b - Puller bolt

Puller Jaws Assembly	91-46086A1

Description	Nm	lb-in.	lb-ft
Puller bolt	5.6	50	–

5. Install a dial indicator and align the dial indicator pointer so that it is perpendicular to and touching the "1" mark on the dial indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so that the needle in the dial makes 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 tool
g - Backlash indicator tool—1 mark

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Rod	91-8M0053505

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° in a clockwise direction.
   c. Repeat step **b** 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.

   IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "1" mark and are only valid if the pinion height is within specification.

Front (Forward) Gear	
Backlash specification	0.482–0.660 mm (0.019–0.026 in.)

8. If the backlash is less than the specification, remove shims in front of the front gear bearing cup to obtain the correct backlash.

Example (backlash is too low—right-hand rotation)	
Front gear backlash average specification:	0.56 mm (0.022 in.)
Subtract the front gear backlash measurement:	0.25 mm (0.010 in.)
Remove this quantity of shims:	0.31 mm (0.012 in.)
Provides backlash of:	0.56 mm (0.022 in.)

9. If the backlash is more than the specification, add shims in front of the front gear bearing cup to obtain the correct backlash.

Example (backlash is too high—right-hand rotation)	
Front gear backlash measurement:	1.02 mm (0.040 in.)
Subtract the front gear backlash average specification:	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.)

NOTE: *By adding or subtracting 0.025 mm (0.001 in.) shim, the backlash will change approximately 0.025 mm (0.001 in.).*

10. Remove the puller jaws assembly and puller bolt.
11. When the backlash is within specification, apply Loctite 271 Threadlocker to the threads of a new pinion nut and tighten to the specified torque.

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Threads of pinion nut	92-809819

Description	Nm	lb-in.	lb-ft
Pinion nut with washer	101.7	–	75

Rear (Reverse) Gear Backlash

Although reverse gear backlash is not adjustable, it may be checked as follows:

IMPORTANT: Backlash values are only valid if the pinion height is within specification.

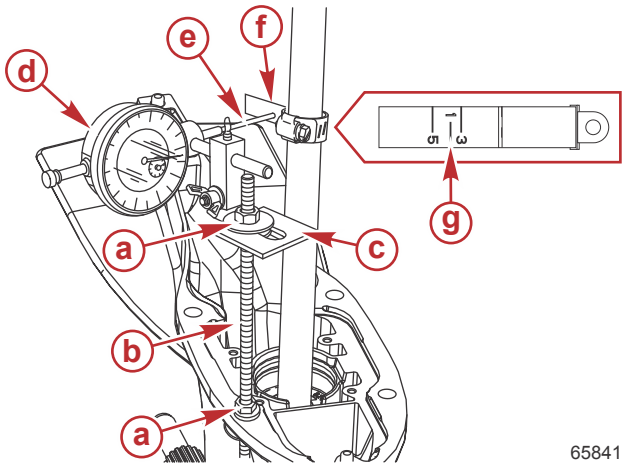
NOTE: *The propeller shaft shims must be removed from the propeller shaft to check the rear gear backlash.*

1. Tighten the bearing carrier retainer nut to the specified torque.

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5	–	100
	Second	285	–	210

NOTE: *Tighten the retainer to 135.5 Nm (100 lb-ft), then check rolling torque on the propeller shaft. If the torque is within specification, tighten the retainer to 285 Nm (210 lb-ft).*

2. Apply backward pressure on the propeller shaft by holding the shift crank against the rear gear.
3. Install a dial indicator and align the dial indicator pointer so that it is perpendicular to and touching the "1" mark on the dial indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so that the needle in the dial makes 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 tool
- **g -** Backlash indicator tool—1 mark

Dial Indicator Adapter	91-83155
Dial Indicator	91- 58222A 1
Backlash Indicator Rod	91-8M0053505

4. Lightly turn the driveshaft back and forth. This is the amount of backlash. No movement should be noticed at the propeller shaft. Record the amount of backlash.
5. Loosen the indicator tool and rotate the driveshaft 120° clockwise.
6. Align the dial indicator pointer so that it is perpendicular to and touching the "1" mark on the dial indicator tool. Tighten the indicator tool onto the driveshaft and rotate the driveshaft so that the needle in the dial makes one full revolution and comes to "0" on the dial indicator scale.
7. Lightly turn the driveshaft back and forth. No movement should be noticed at the propeller shaft. Record the amount of backlash. Repeat this for a total of three backlash measurements.
8. Add the three measurements together and divide the sum by three. This is the average rear gear backlash. If rear gear backlash is not within specification, the gear housing is not properly assembled or the parts are excessively worn and must be replaced.

   IMPORTANT: Backlash values are as measured with the backlash indicator tool set at the "1" mark and are only valid if the pinion height is within specification.

Rear (Reverse) Gear	
Backlash specification	1.27–1.47 mm (0.050–0.058 in.)

9. Remove the backlash indicator tool. Remove the dial indicator and all of its mounting components.

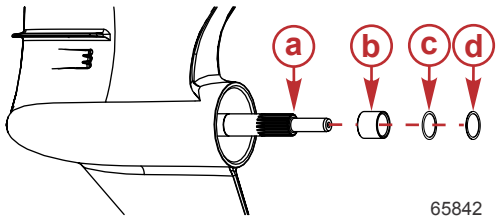
Propeller Shaft Bearing Preload

NOTE: *All gear housing components must be installed and correctly shimmed before checking propeller shaft bearing preload. The propeller shaft tapered roller bearing must be properly seated in the race during installation. The driveshaft retainer should be tightened to the specified torque.*

Description	Nm	lb-in.	lb-ft
Driveshaft retainer	135.5	–	100

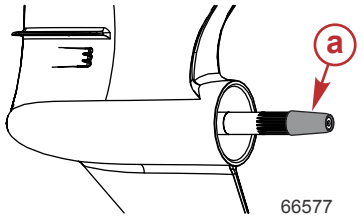
IMPORTANT: Install a maximum of two shims on the propeller shaft to obtain the specified propeller shaft rolling torque. To obtain the specified rolling torque, shims of different thicknesses may have to be interchanged. Do not use a shim thinner than 0.51 mm (0.020 in.).

1. Remove the bearing carrier.
2. Install the new thrust spacer onto the new propeller shaft.
3. Install a shim onto the propeller shaft. Do not use a shim smaller than 0.51 mm (0.020 in.) shim thickness. A maximum of two shims may be installed on the shaft to obtain the specified rolling torque. If two shims are required, install the thinner shim last.



a - Propeller shaft
b - Thrust spacer
c - Shim
d - Thin shim if required (install onto propeller shaft last)

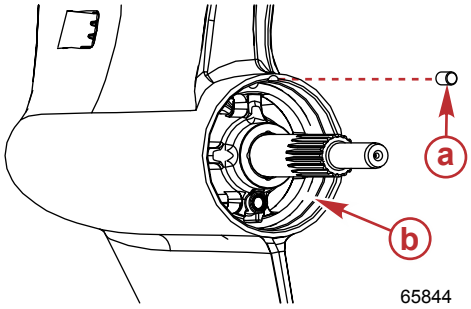
IMPORTANT: Prior to installing the bearing carrier into a gearcase equipped with the heavy-duty 31.75 mm (1.25 in.) diameter propeller shaft, install the bearing carrier installation tool over the propeller shaft. This tool will prevent the bearing carrier seal lips from being damaged by the propeller shaft splines. Remove the tool after the bearing carrier is installed.



a - Bearing carrier installation tool

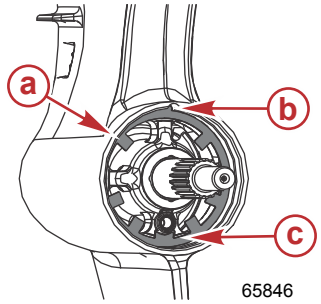
Bearing Carrier Installation Tool	91-8M0059911

4. Install the bearing carrier, aligning the rear propeller shaft bearing with the propeller shaft. It may be necessary to turn the driveshaft to align the teeth of the pinion gear with the rear gear.
5. Install the locating pin.



a - Locating pin
b - Bearing carrier assembly installed

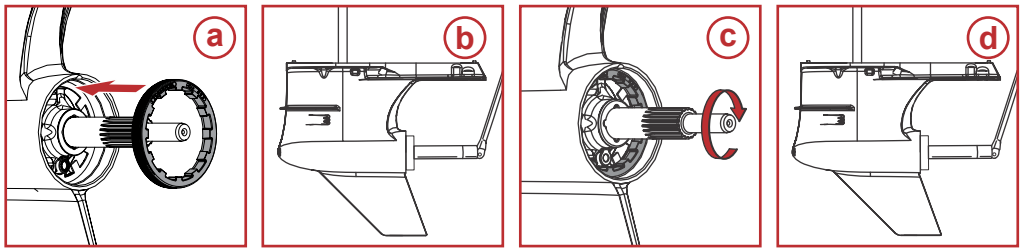
6. Insert the small rectangular tab of the new tab washer into its corresponding slot in the gearcase at the 12 o'clock position above the bearing carrier while aligning the U-shaped tab of the tab washer with its corresponding slot below the lubricant fill/drain hole in the bearing carrier.



a - Tab washer
b - Rectangular tab
c - U-shaped tab

7. With the gear housing in neutral, install the bearing carrier retainer nut.

   IMPORTANT: Before tightening the bearing carrier retainer nut to the specified torque, the gear housing must be bolted to the driveshaft housing or securely fastened in a gear housing holding fixture to avoid possible damage to the gear housing.
8. Use the bearing carrier retainer nut wrench to tighten the retainer nut to the first specified torque.
9. Rotate the propeller shaft several times to seat the propeller shaft tapered roller bearings in their races.
10. Use the bearing carrier retainer nut wrench to tighten the retainer nut to the final specified torque.



a - Install bearing carrier retainer nut
b - Tighten to first specified torque
c - Rotate propeller shaft
d - Tighten to final specified torque

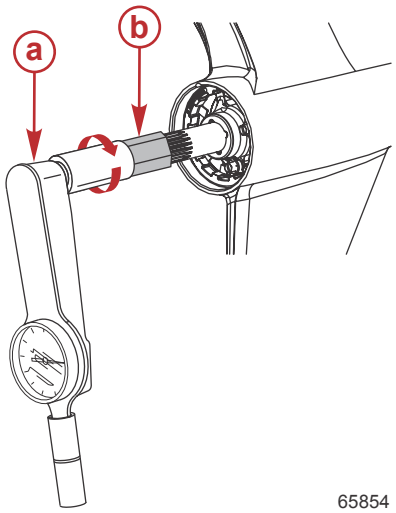
Bearing Carrier Retainer Nut Wrench	8M0057002

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5	–	100
	Final	285	–	210

11. Remove the bearing carrier retainer nut wrench from the propeller shaft.
12. Use the shift shaft handle tool to hold the clutch in the neutral position.

Shift Shaft Handle Tool	8M0142973

13. Install the propeller shaft adapter and using a torque wrench, rotate the propeller shaft in the direction of normal rotation with a slow steady motion.



a - Torque wrench
b - Propeller shaft adapter

14. Verify the rolling torque is within specification for new or used bearings.

Description	Nm	lb-in.	lb-ft
Bearing rolling torque (new bearings)	1.1–2.0	10–18	–
Bearing rolling torque (used bearings)	0.45–1.1	4–10	–

NOTE: *Bearing preload will change approximately 0.056 Nm (0.5 lb-in.) of rolling torque per 0.025 mm (0.001 in.) of shim change.*

15. If the rolling torque is too high, install a thinner shim on the propeller shaft aft of the thrust spacer. If the torque is too low, install a thicker shim. Be certain the shims are installed aft of the thrust spacer.

IMPORTANT: Install a maximum of two shims on the propeller shaft to obtain the specified propeller shaft rolling torque. To obtain the specified rolling torque, shims of different thicknesses may have to be interchanged. Do not use a shim thinner than 0.51 mm (0.020 in.).

Propeller Shaft Adapter	8M0147118

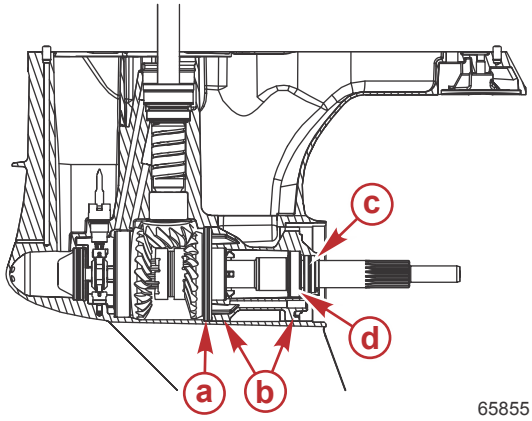
NOTE: *If the shims are changed, tighten the bearing carrier retainer nut to the first specified torque. Rotate the propeller shaft several times to seat the propeller shaft tapered bearing. Tighten the retainer nut to the final specified torque. Use the torque wrench to check the rolling torque. Repeat this procedure each time the shims are changed.*

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**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 bearing carrier O-ring with 2-4-C with PTFE.
   b. Lubricate both the forward and aft outer diameters of the bearing carrier and gear housing area where the carrier will seat with 2-4-C with PTFE.

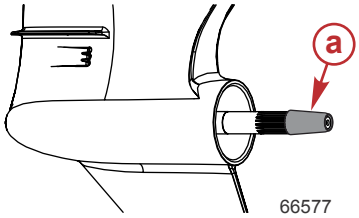
c. Fill the space between the propeller shaft seals with 2-4-C with PTFE.



a - O-ring
b - Forward and aft outer diameters of bearing carrier
c - Propeller shaft seals
d - Propeller shaft bearing

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier O-ring, forward and aft outer diameters of bearing carrier, gear housing area where bearing carrier will seat, space between propeller shaft oil seals	92-802859A 1

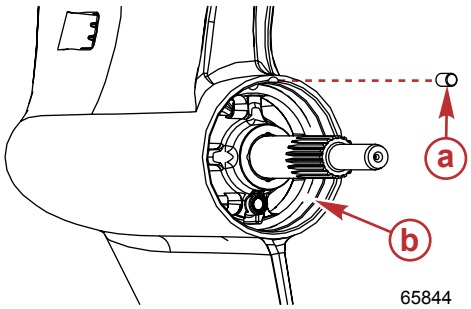
IMPORTANT: Prior to installing the bearing carrier into a gearcase using the heavy-duty 31.75 mm (1.25 in.) diameter propeller shaft, install the bearing carrier installation tool over the propeller shaft. This tool will prevent the bearing carrier seal lips from being damaged by the propeller shaft splines. Remove the tool after the bearing carrier is installed.



a - Bearing carrier installation tool

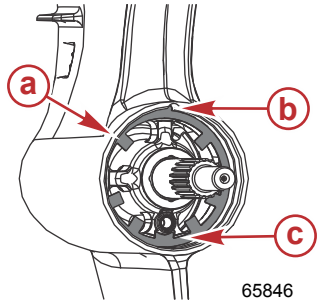
Bearing Carrier Installation Tool	91-8M0059911

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 gear and the rear gear.
3. Install the bearing carrier locating pin.



a - Locating pin
b - Bearing carrier assembly installed

4. Insert the small rectangular tab of the tab washer into its corresponding slot in the gear housing 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/drain hole in the bearing carrier.



a - Tab washer
b - Rectangular tab
c - U-shaped tab

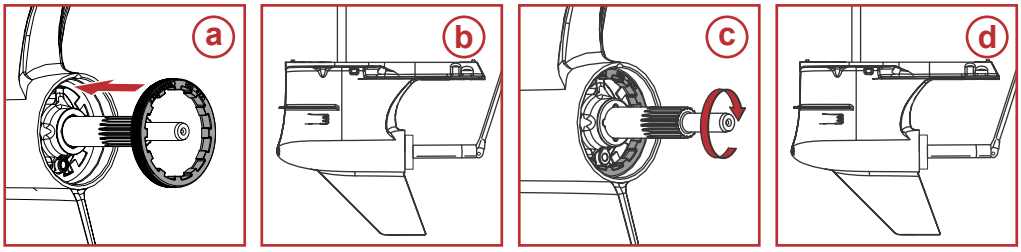
5. Apply 2-4-C with PTFE to the bearing carrier retainer nut threads and the corresponding gear housing threads. Install the retainer into the gear housing hand-tight.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Bearing carrier retainer nut threads and corresponding gear housing threads	92-802859A 1

IMPORTANT: Before tightening the bearing carrier retainer to the specified torque, the gear housing must be bolted to the driveshaft housing or securely fastened in a gear housing holding fixture to avoid possible damage to the gear housing.

NOTE: *Tighten the retainer nut to the first specified torque. Rotate the propeller shaft several times to seat the tapered roller bearings. The retainer nut can then be tightened to the final specified torque.*

6. Use the bearing carrier retainer nut wrench to tighten the bearing carrier retainer nut to the specified torque. If one tab does not align between two of the notches, continue to tighten the retainer until alignment is achieved. Do not loosen the retainer to achieve alignment.



65849

a - Install bearing carrier retainer nut hand-tight
b - Tighten to first specified torque
c - Rotate propeller shaft
d - Tighten to final specified torque

Description		Nm	lb-in.	lb-ft
Bearing carrier retainer nut	**First**	135.5	–	100
	Final	285	–	210

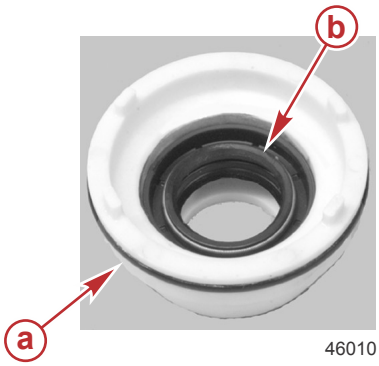
Bearing Carrier Retainer Nut Wrench	8M0057002

7. Remove the bearing carrier retainer nut wrench from the propeller shaft.
8. Bend one tab of the tab washer aft (outward) into a space between two of the notches of the retainer. Bend all the remaining tabs forward (inward).

Oil Seal Carrier Installation

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 PTFE.



46010

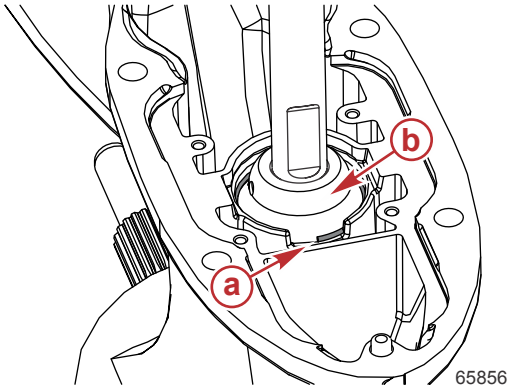
a - O-ring
b - Oil seal lips

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Oil seal carrier oil seal lips, space between the seals, and the O-ring	92-802859A 1

2. Install the oil seal carrier over the driveshaft and into the gearcase.

   NOTE: *The oil seal carrier may be lightly tapped into position by sliding the driveshaft bearing retainer wrench over the driveshaft.*

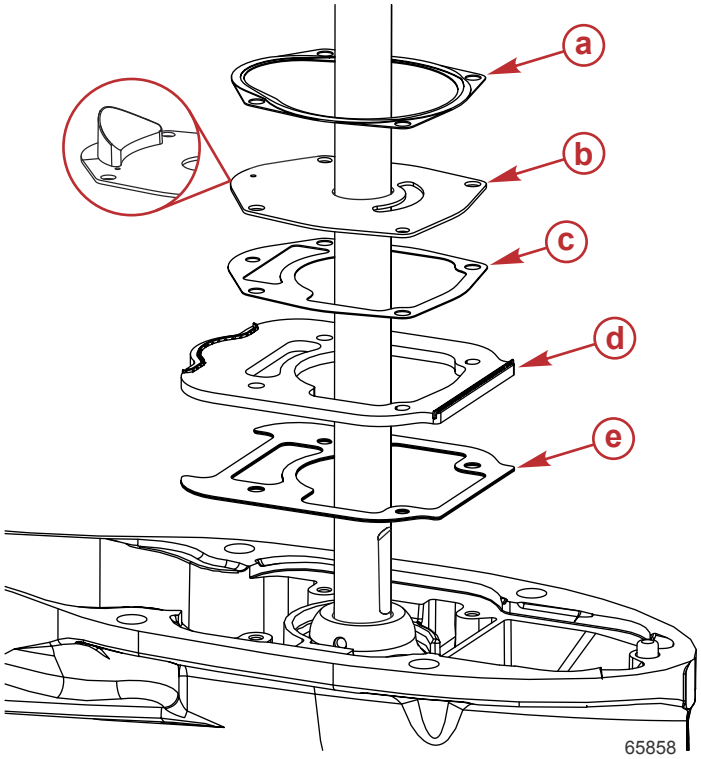
3. Install the retaining ring above the oil seal carrier.



a - Retaining ring
b - Oil seal carrier

Water Pump Installation

1. Install the lower gasket, top cover, rubber-coated stainless steel gasket, faceplate, and top beaded gasket.



a - Beaded gasket
b - Faceplate

NOTE: *Early models were equipped with a faceplate deflector. The deflector is no longer required.*

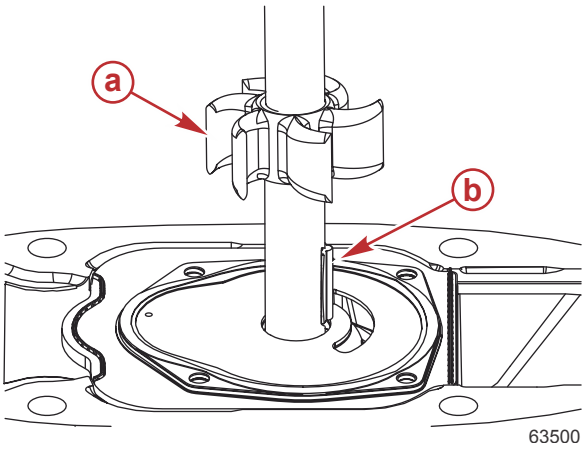
c - Rubber-coated stainless steel gasket
d - Top cover
e - Gasket

2. Apply a small amount of 2-4-C with PTFE onto the flat surface of the impeller key and install the key onto the driveshaft keyway.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Flat surface of impeller key	92-802859A 1

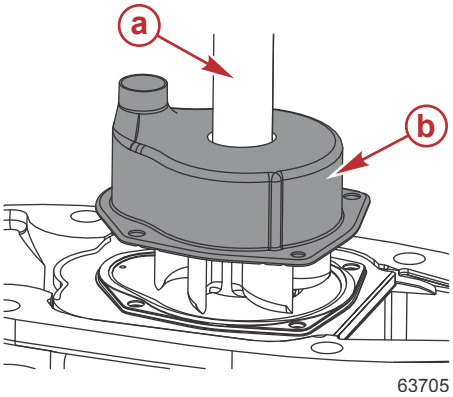
3. Install the water pump impeller onto the driveshaft and over the impeller key.

IMPORTANT: Do not install a used impeller with the blades oriented in a reversed direction from the original rotation. Premature impeller failure will occur.



a - Impeller
b - Impeller key

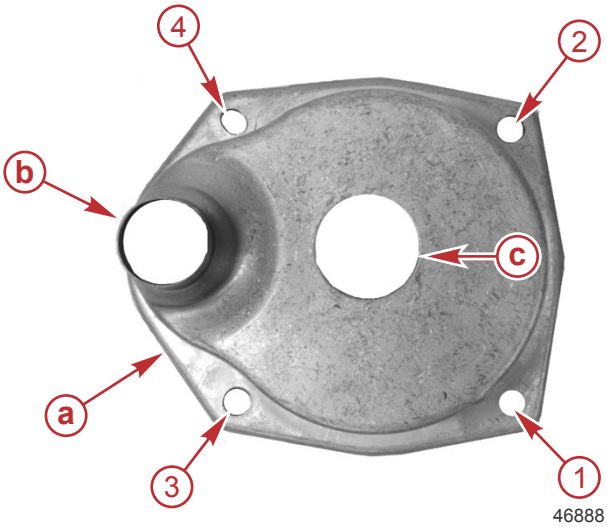
4. Apply 2-4-C with PTFE to the inside of the water pump cover. Position the water pump cover over the driveshaft. Rotate the driveshaft in a clockwise direction while pushing down on the water pump cover.



a - Rotate driveshaft clockwise
b - Water pump cover

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Inside of the water pump cover	92-802859A 1

5. Apply Loctite 271 Threadlocker to each water pump screw, and install the four screws into the water pump housing. Tighten the screws in the sequence shown to the specified torque.



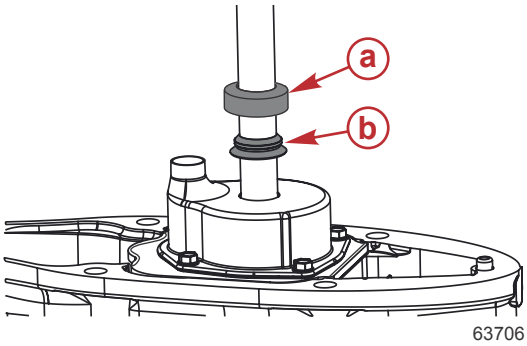
a - Water pump cover
b - Water outlet
c - Driveshaft access hole

Description	Nm	lb-in.	lb-ft
Water pump screws	6.8	60	–

Tube Ref No.	Description	Where Used	Part No.
7	Loctite 271 Threadlocker	Water pump screws	92-809819

6. Install the driveshaft seal and use the tool provided in the seal kit or the water pump kit to press the seal down.

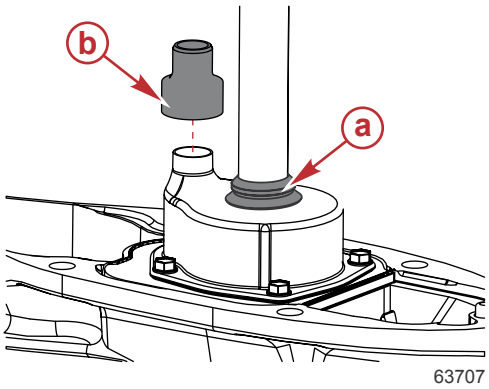
IMPORTANT: If the driveshaft seal is not installed at the proper height, air will be drawn into the water pump, causing the engine to overheat.



a - Driveshaft seal installation tool
b - Driveshaft seal

Driveshaft Seal Installation Tool	91-818769

7. If the tool is not available, press the seal against the water pump housing until the height of the seal is 11.1 ± 0.3 mm (0.437 ± 0.012 in.).



a - Driveshaft seal
b - Water seal coupler

IMPORTANT: After the water pump is installed, do not rotate the driveshaft counterclockwise.

8. Apply 2-4-C with PTFE to the O-ring in the water seal coupler. Install the water seal coupler onto the water pump cover.

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Water seal coupler O-ring	92-802859A 1

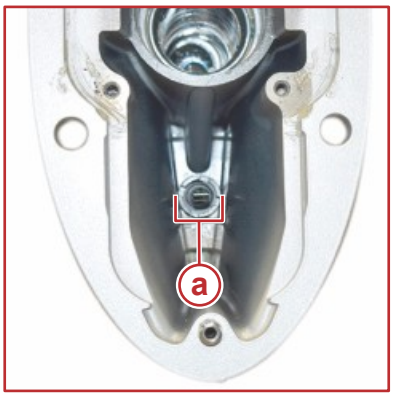
Checking Gear Housing Operation

Prior to filling the gear housing with lubricant, check the gear housing for proper shift operation, as follows:

NOTE: *Rotate the driveshaft in a clockwise direction while performing these tests.*

1. Rotate the shift shaft counterclockwise to the forward motion position. The propeller shaft should rotate clockwise and then lock.
2. Rotate the shift shaft clockwise to the reverse motion position. The propeller shaft should rotate counterclockwise and then lock.

3. Rotate the shift shaft to a point halfway between the forward and reverse motion position. This should be the neutral position. The propeller shaft should rotate freely both clockwise and counterclockwise.



65862

a - Shift shaft in neutral position

IMPORTANT: If the shifting operation is not as described, the gear housing must be disassembled and the shift crank reversed. Refer to Shift Shaft Installation.

NOTE: *Before installing the gear housing to the driveshaft housing, check for any leaks. Refer to* ***Gear Housing Pressure Test*** *for instructions.*

Gear Housing Installation

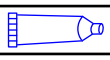
⚠ WARNING

Accidental starting can cause serious injury. Before removing or installing the gear housing, disconnect and isolate the spark plug leads. Disable the ignition system by removing the keys from the ignition (if equipped) and engaging the lanyard stop switch to prevent the engine from starting.

1. Lubricate the splines of the driveshaft with Extreme Grease. Do not allow lubricant on top of the shift shaft or driveshaft.

NOTICE

Installing the gear housing to the powerhead without adequately cleaning the top of the driveshaft can result in severe product damage. Any lubricant trapped in the space between the driveshaft and the crankshaft prevent the two from properly engaging. Always clean the top of the driveshaft before installing the gear housing.

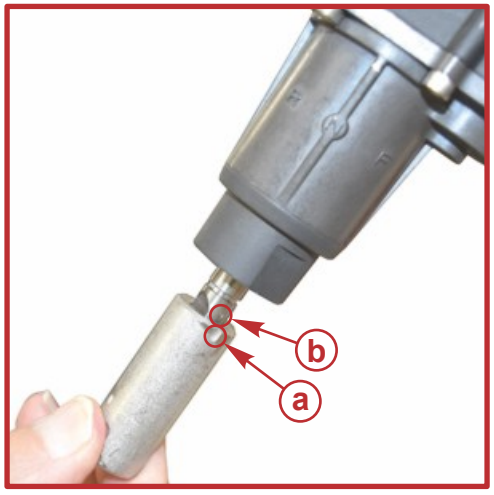
Tube Ref No.	Description	Where Used	Part No.
	Extreme Grease	Shift shaft splines and driveshaft splines	8M0071842

2. Use the shift shaft tool to rotate the shift shaft counterclockwise into the front (forward) gear.

NOTE: *It may be necessary to rotate the propeller shaft to ensure that the clutch is engaged.*

Shift Shaft Handle Tool	8M0142973

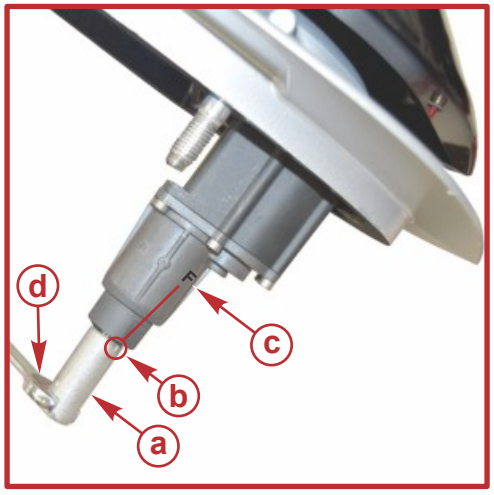
3. Ensure that the notch on the shift shaft coupler aligns with the notch on the shift actuator output shaft.



65132

a - Notch on shift shaft coupler
b - Notch on shift actuator output shaft

4. Use a 15 mm wrench to rotate the shift shaft coupler so the notch on the coupler is aligned with the "F" marking on the shift actuator.

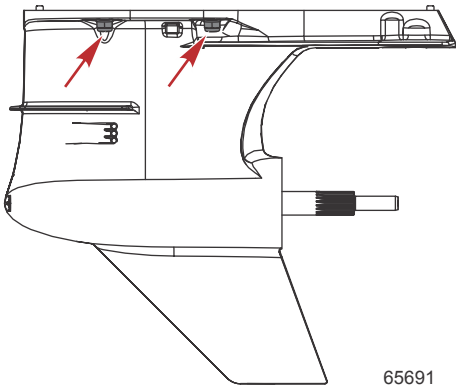


65127

a - Shift shaft coupler
b - Tab on shift shaft coupler
c - "F" marking on shift actuator
d - Wrench

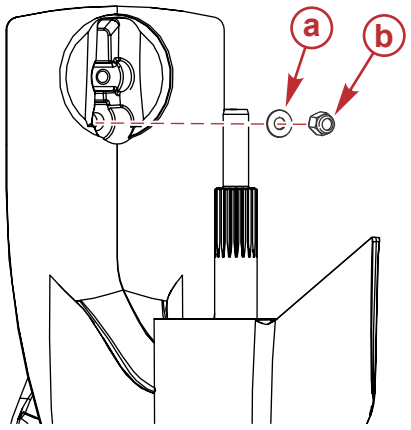
5. Position the gear housing so the driveshaft is protruding into the driveshaft housing.
6. Move the gear housing up toward the driveshaft housing while aligning the water pump coupler to the water tube and the shift shaft into the shift shaft coupler.

   NOTE: *If the driveshaft splines will not align with the crankshaft splines, rotate the propeller shaft slightly to reposition the splines.*
7. Secure the gear housing assembly to the driveshaft housing with four side mounting locknuts and washers; two on each side. Do not fully tighten the nuts at this time.



65691

8. Install the nut and washer on the underside of the anti-ventilation plate, inside of the anode plate recess. Do not fully tighten the nut at this time.

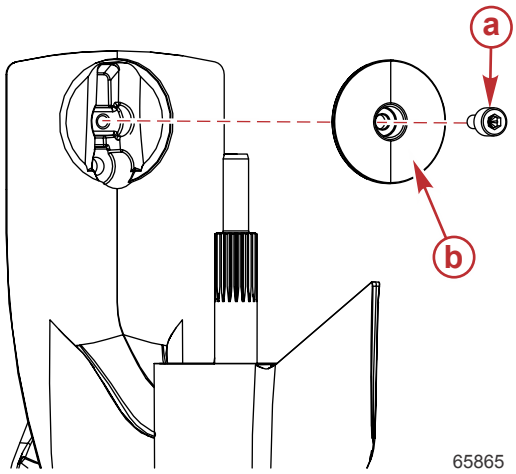


a - Washer
b - Nut

9. Check the shift shaft spline engagement and correct if necessary.
10. Evenly tighten the four side mounting locknuts, and the nut on the underside of the anti-ventilation plate to the specified torque.

Description	Nm	lb-in.	lb-ft
Side mounting locknuts (4), and nut on underside of anti-ventilation plate (1)	60	–	44

11. Install the anode plate on the underside of the anti-ventilation plate, and tighten the screw to the specified torque.



a - Anode plate screw
b - Anode plate

Description	Nm	lb-in.	lb-ft
Anode plate screw	54.23	–	40

Gear Lubricant Filling Instructions

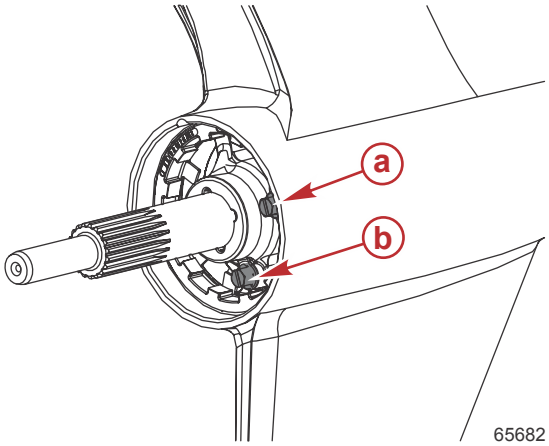
NOTE: *After the gear housing has been serviced, perform a pressure test prior to filling with lubricant. Refer to* ***Gear Housing Pressure Test*** *for instructions.*

1. Remove the vent plug from the gear housing.
2. Remove the fill plug from the gear housing.
3. Inspect the fill and vent plug sealing washers for cuts or abrasions. Replace the washers if necessary.

   IMPORTANT: Never add lubricant to the gear housing without removing the vent plug. The gear housing cannot be filled if the vent plug is not removed because of trapped air. Fill the gear housing only when the housing is in a vertical position.
4. Slowly fill the housing through the fill hole with High Performance Gear Lubricant until the lubricant flows out of the vent hole and no air bubbles are visible.
5. Install the vent plug into the vent hole.

   IMPORTANT: Do not lose more than 15 cc (0.5 fl oz) of gear lubricant while installing the fill plug.

6. Remove the fill tube or hose from the fill hole and quickly install the fill plug into the fill hole. Tighten the fill and vent plugs to the specified torque.



a - Vent plug
b - Fill plug

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 plugs	11.3	100	–

Notes:

Steering

Section 7A - Power Steering

Table of Contents

7
A

Power Steering Specifications

Power Steering Specifications	
Fluid type	Synthetic Power Steering Fluid SAE 0W-30
Capacity	Typical 1–2 liters (1–2 US qt)
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

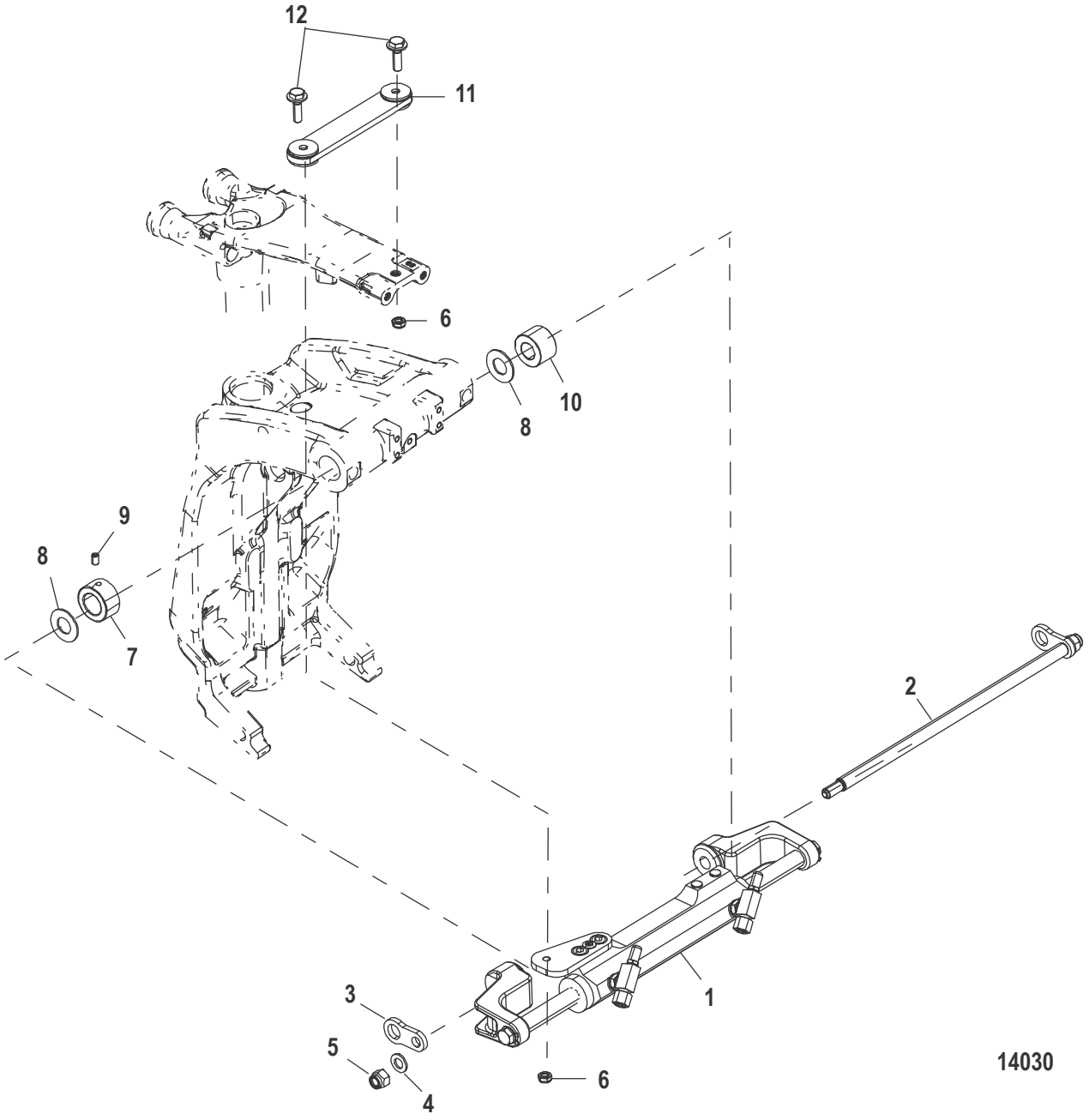
Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Steering cylinder tie rod surface	92-802859A 1
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Steering cylinder tie rod threads	Obtain Locally
138	Synthetic Power Steering Fluid SAE 0W-30	Power steering pump	92-858077K01
		Power steering pump tank	

Special Tools

Power Steering Module Primer Kit	91-895040K01
 5547	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

Steering System Requirements

⚠ CAUTION

Avoid a possible steering system failure due to incorrect steering cylinder installation. Mercury heavy-duty steering cylinders are designed to be gearcase/propeller rotation specific. Right-hand rotation outboards require a right-hand steering cylinder and left-hand (counterrotation) outboards require a counterrotation steering cylinder. Always confirm that the correct cylinder is paired with the correct outboard.

Mechanical Steering

IMPORTANT: Do not use mechanical steering with these engines.

Hydraulic Steering (Non-Power Steering)

Use Mercury heavy-duty steering cylinders fitted with compression fittings.

Hydraulic Power Steering

Use Mercury heavy-duty steering cylinders fitted with O-ring face seal fittings.

Multiple Engine Steering Installations

Dual Outboard Steering Options

Maximum Combined 500 HP

Single Cylinder/Dual Outboard: One right-hand HD steering cylinder mounted to a right-hand rotation outboard, using a tie bar kit to connect to the left-hand (counterrotation) outboard.

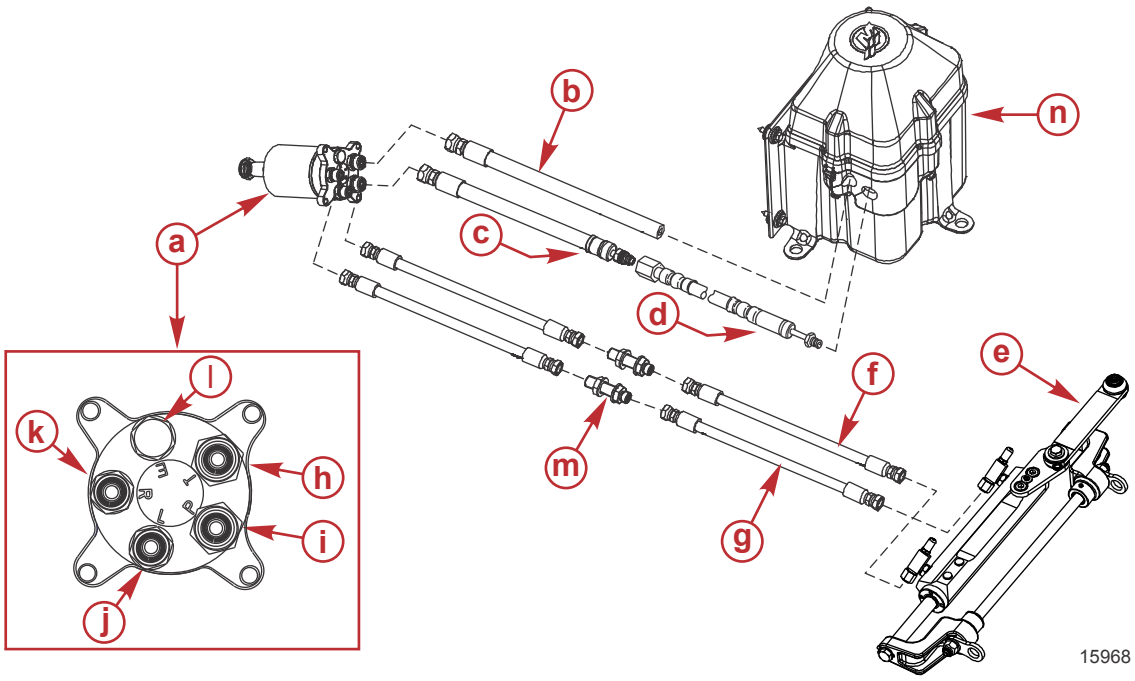
Maximum Combined 600 HP

Dual Cylinder/Dual Outboard: One right-hand HD steering cylinder mounted to the right-hand rotation outboard, and one left-hand HD steering cylinder mounted to the left-hand (counterrotation) outboard. Steering cylinders are connected using a dual outboard tie bar kit.

Triple Outboard Steering

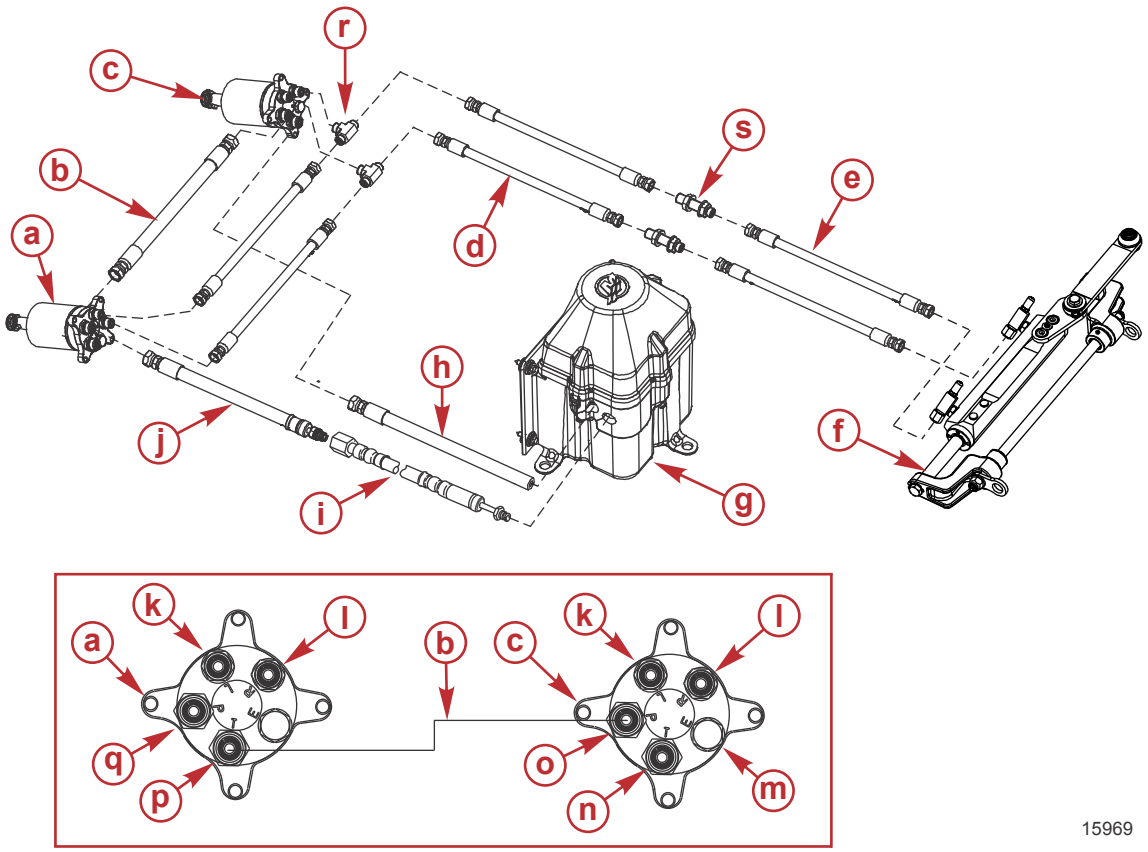
Triple Cylinder/Triple Outboard: One right-hand HD steering cylinder mounted to the right-hand rotation outboard (starboard outboard location), one left-hand HD steering cylinder mounted to the left-hand (counterrotation) outboard (port outboard location), and one HD steering cylinder from the triple outboard tie bar kit mounted to the center outboard. Steering cylinders are connected using tie bars and hardware from the triple outboard tie bar kit.

Single Helm - Single Cylinder



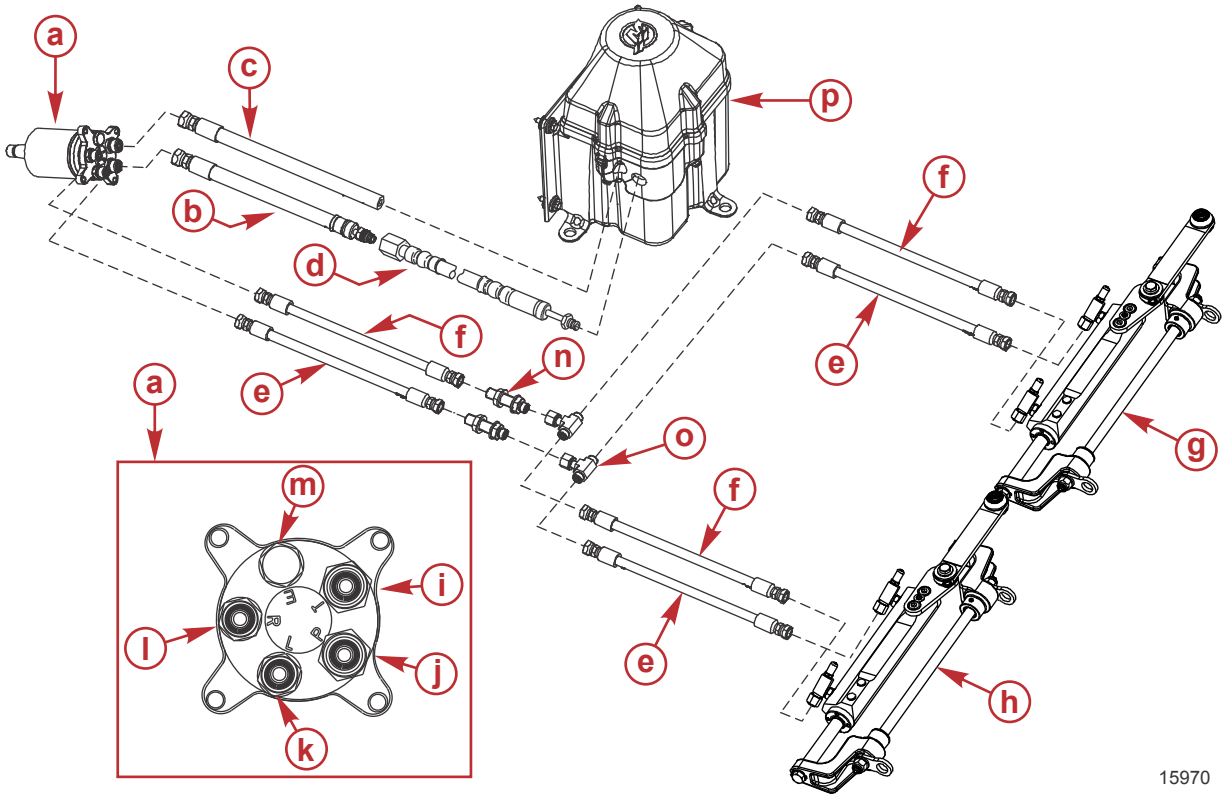
- **a -** Helm
- **b -** Tank hose (T)
- **c -** Pressure hose (P)
- **d -** Sound dampening hose
- **e -** Power steering cylinder
- **f -** Hose to port side of steering cylinder
- **g -** Hose to starboard side of steering cylinder
- **h -** "T" - Tank connection
- **i -** "P" - Pressure connection
- **j -** "L" - Starboard connection
- **k -** "R" - Port connection
- **l -** Plug
- **m -** Bulkhead fitting (2) (optional)
- **n -** Power steering pump module

Dual Helm - Single Cylinder



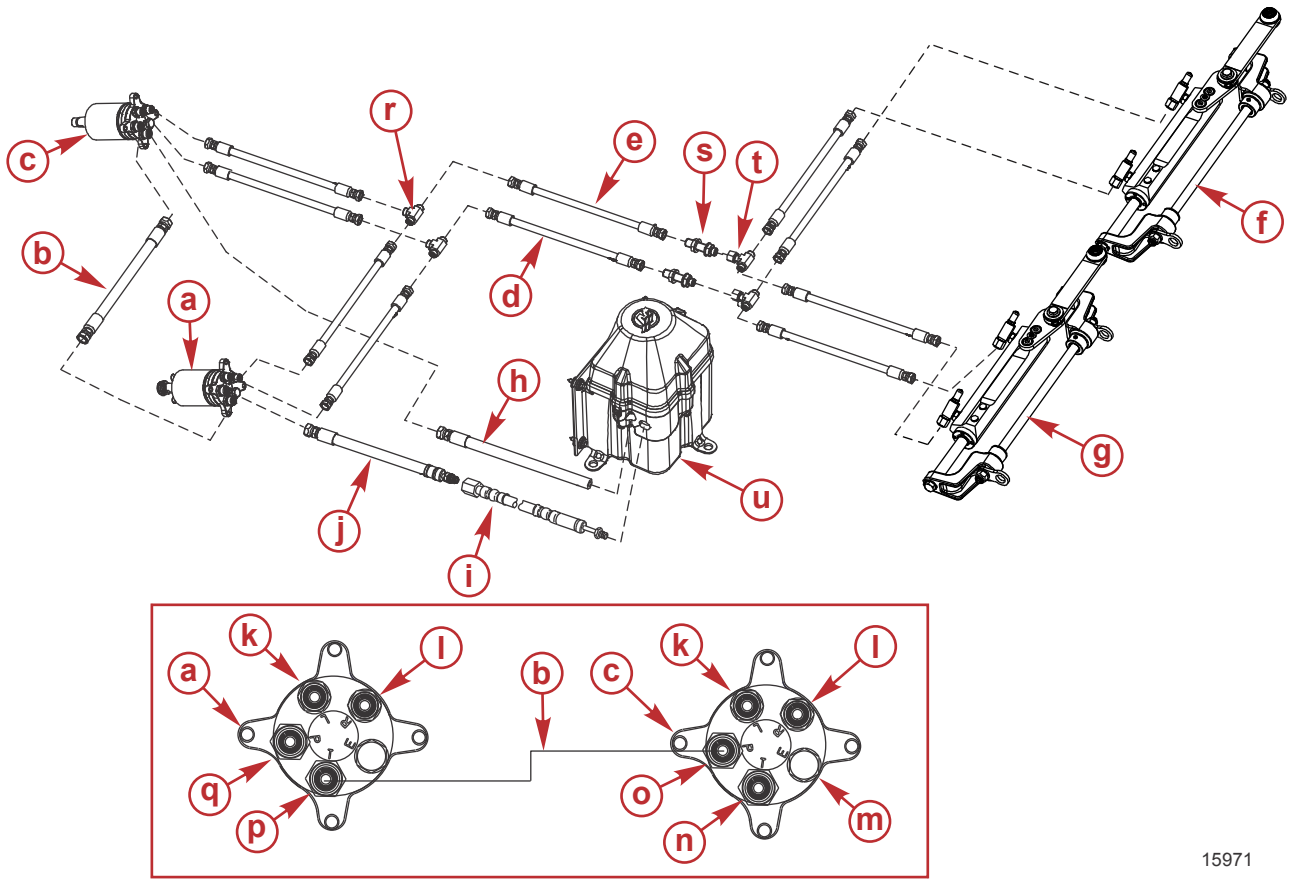
- **a -** Main helm
- **b -** Tank 1 to pressure 2 hose
- **c -** Second helm
- **d -** Hose to starboard side of steering cylinder
- **e -** Hose to port side of steering cylinder
- **f -** Power steering cylinder
- **g -** Power steering pump module
- **h -** Tank hose (T)
- **i -** Sound dampening 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

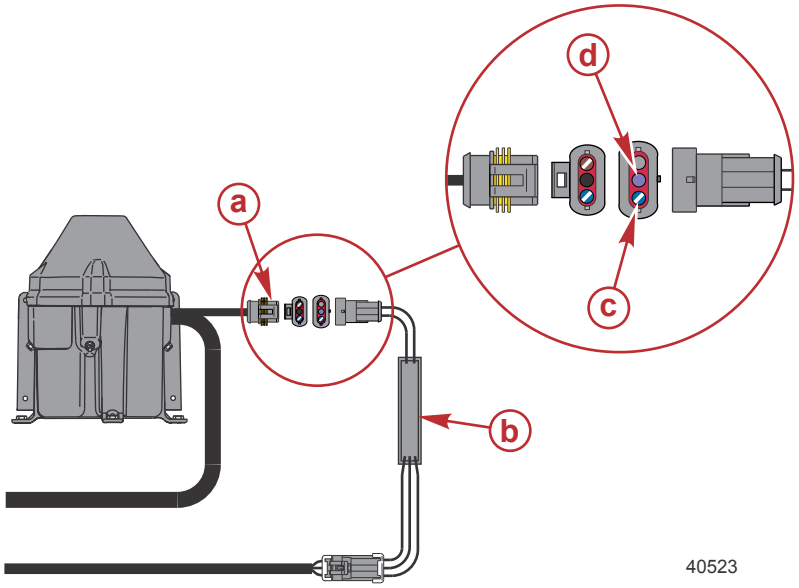
Troubleshooting the Power Steering System

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

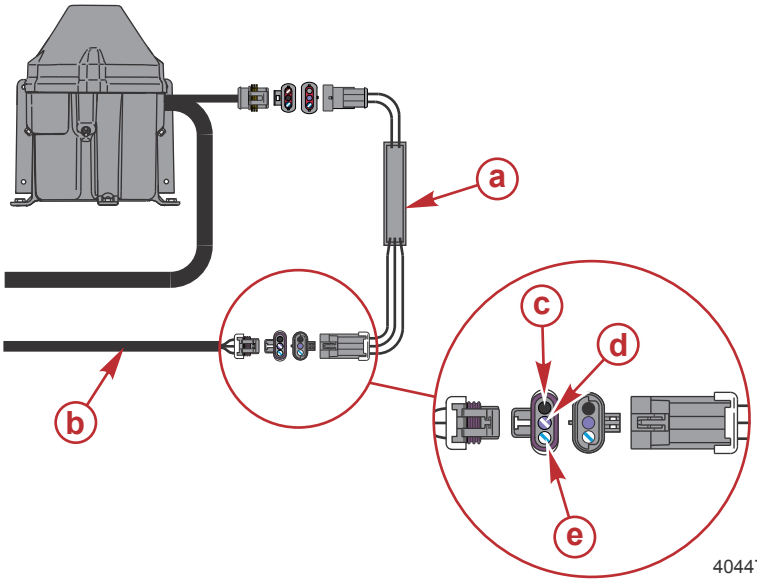
c. With the engine running, battery voltage should be present across the blue/white lead and engine/battery ground, and across the purple lead and engine/battery ground.

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 multiengine signal harness adapter will be installed on boats powered by multiple outboards. Be sure to check for the proper voltages before and after the multiengine 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	<2 volts

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	>5 volts

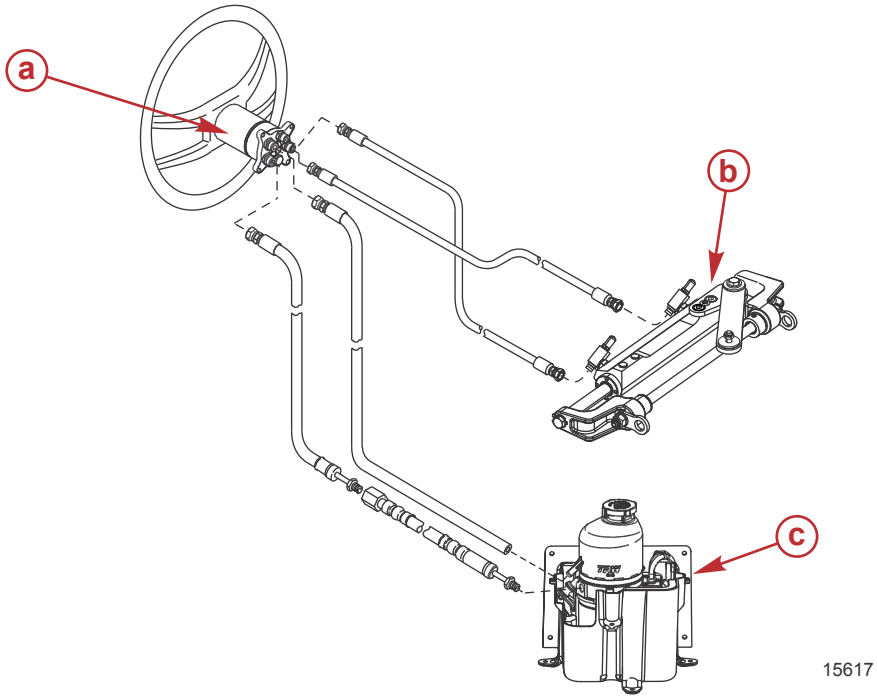
- If these voltages are not observed with a good battery and key switch harness, check for the same voltages at the engine wire harness which connects to the signal harness. If the listed voltages are not present, a problem may exist within the 3-wire circuit on the engine wire harness or the PCM. With 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 module primer, bypassing the engine and all boat harnessing. With battery power hooked to the power steering pump and the module primer 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 module primer kit.

Power Steering Module Primer Kit	91-895040K01

Power Steering Installation

Power Steering System



a - Steering helm
b - Steering cylinder on outboard
c - Power steering pump

Installation Procedure

Selecting a Location for the Power Steering Pump

⚠ WARNING

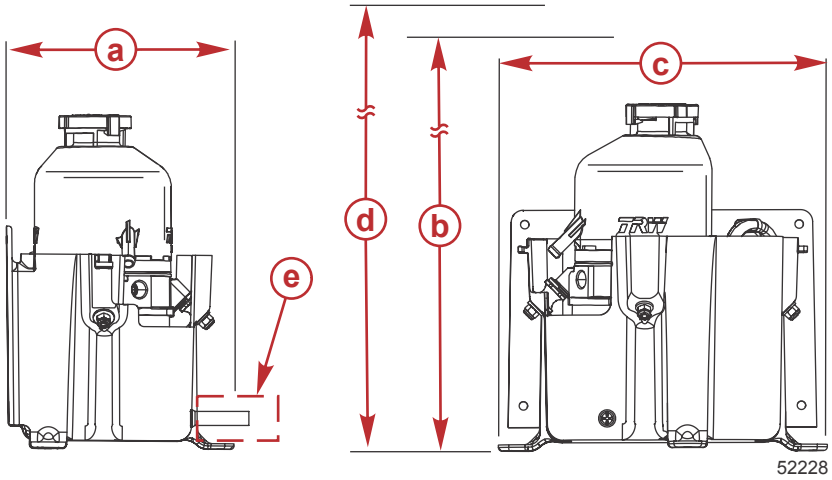
Dirt or contaminants in the hydraulic steering system can damage the steering system's internal components. Damaged components can lead to serious injury or death due to loss of boat control. Do not allow dirt or contamination to enter the helm, lines, or cylinder of this steering system and perform all hydraulic inspections, service, or assembly procedures in a clean work area.

Select a mounting location (on the floor or the side of the internal bulkhead) for the installation of the power steering pump that meets the following requirements:

- Do not mount the pump on an angle greater than 15° off of vertical.

- The pump electrical wiring must reach the battery.
- The power steering signal driver must reach the thrust vector module (TVM) using only the supplied extension harness.
- The pump should be mounted in an area that allows sound enclosure, cover removal, and easy access to the fill cap.
- Do not mount the pump in a location where the pump can fill with water.
- Install the pump in an area where bilge water will not contaminate the pump.
- The pump must be mounted with enough room to allow proper operation of the drain.
- To reduce transmitted noise, mount the pump on a wood or fiberglass surface. Avoid mounting the pump on aluminum or steel surfaces.
- To reduce noise on aluminum or metal hulls, isolate the steering hoses from the hull with suitable nonabrasive hangers.

Required Mounting Clearances for the Power Steering Pump



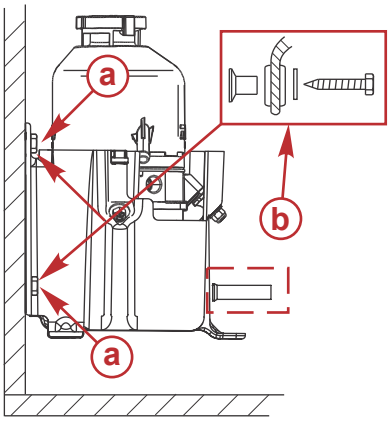
a - 215 mm (8-1/2 in.)
b - 310 mm (12-7/32 in.) to the top cover (not shown)
c - 285 mm (11-1/4 in.)

IMPORTANT: Leave enough room to the side of the pump to allow for the proper installation of the hydraulic lines.

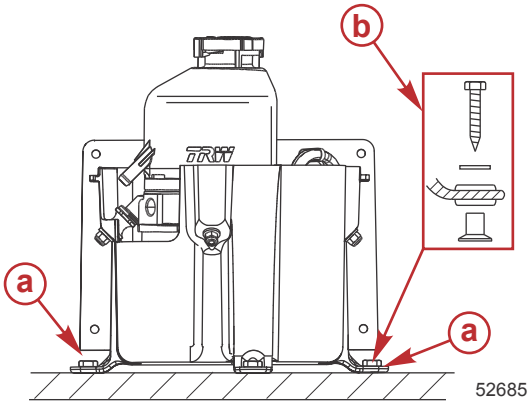
d - 432 mm (17 in.) clearance required for cover removal
e - 76 mm (3.0 in.) clearance in front of the unit for proper operation of the drain

Installing the Power Steering Pump

1. The power steering pump can be mounted in either of two ways:
   - On a side of the internal bulkhead
   - 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 the side of an internal bulkhead



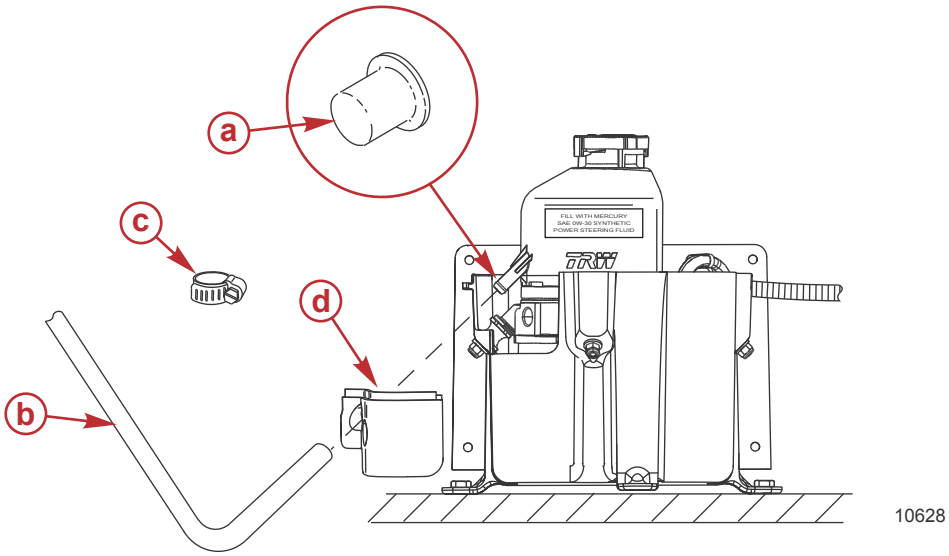
Mounted on the floor

a - Lag screws or through bolts (3 or 4)
b - Mounting hardware

Connection of the Hydraulic Hoses to the Power Steering Pump

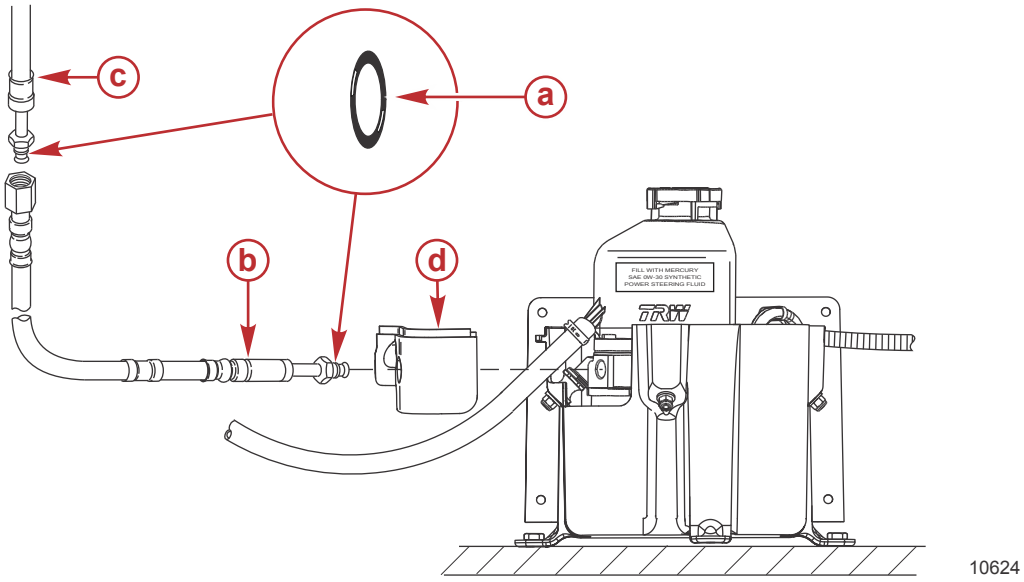
1. Remove and discard the yellow protector cap from the reservoir.

2. Connect the low-pressure hydraulic hose from the steering helm to the low-pressure fitting on the pump reservoir as shown. Fasten the hose to the 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 the cap and plug from the ends of the dampening hose.
4. Ensure that 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 that 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 the grommet onto the power steering pump enclosure.



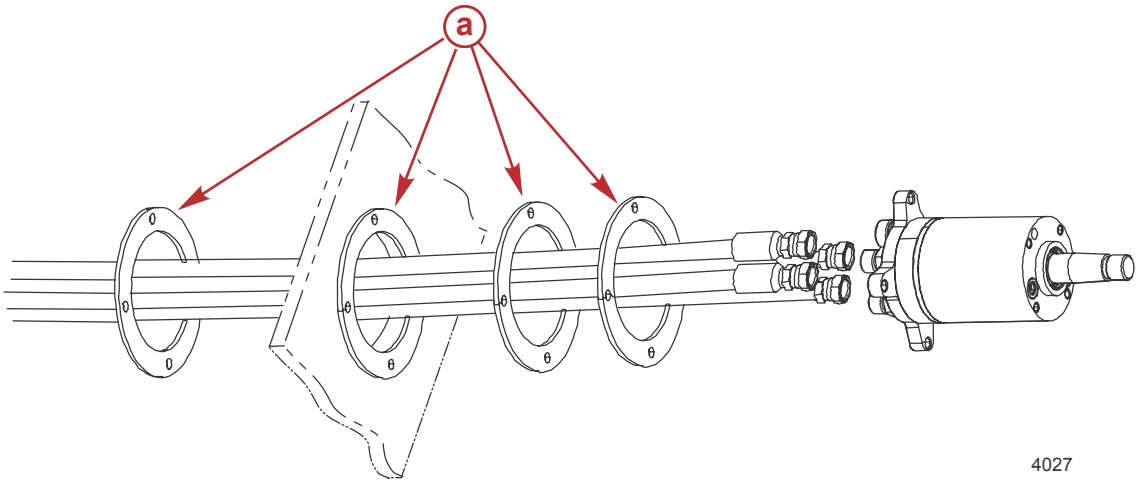
a - O-ring
b - Dampening hose
c - High-pressure hydraulic steering hose
d - Grommet

Connection of the Hydraulic Hoses to the Power Steering Helm

NOTE: *Hoses must be routed up through the steering helm opening in the dash and secured to the helm fittings prior to mounting the steering helm.*

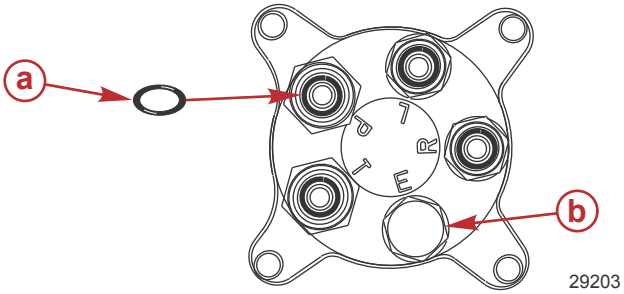
1. Place the steering hoses through one backing plate on the internal side of the dashboard. Route the steering hoses through the drilled opening, and place the required amount of backing plates on the hoses on the external side of the dashboard.

NOTE: *The number of backing plates varies depending on helm displacement.*



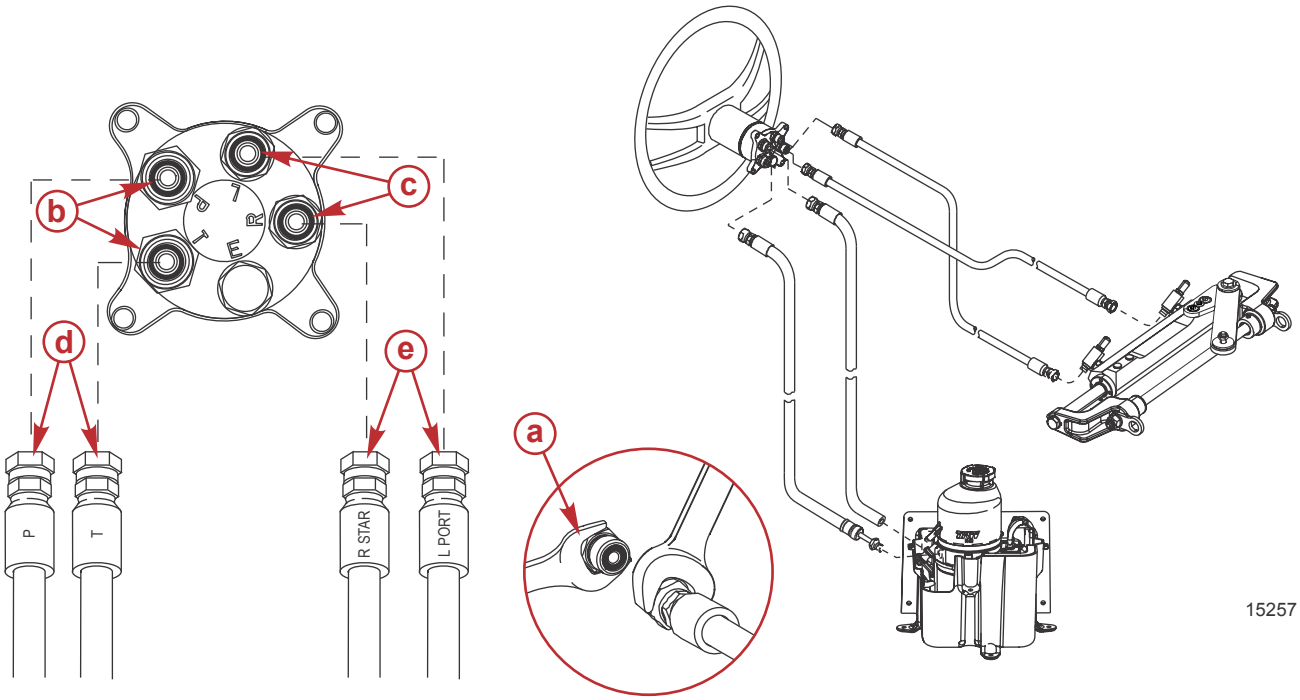
a - Backing plates

2. Remove and discard the shipping caps from the ends of the four fittings on the steering helm. Ensure that the O-ring seals did not lift off with the shipping caps.
3. Ensure that the O-ring seals are in place on the end of the 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.

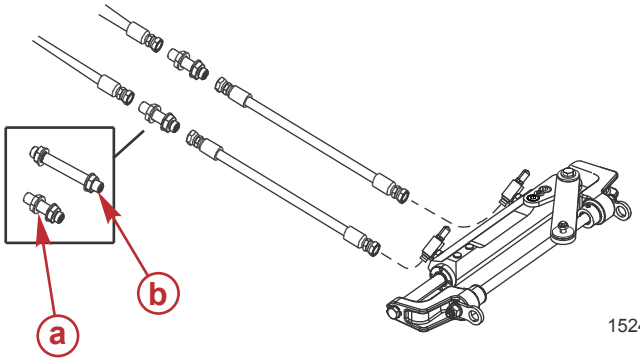


a - Thin wrench
b - Helm hex fitting wrench size (P and T) - 19 mm (3/4 in.)
c - Helm hex fitting wrench size (R and L) - 16 mm (5/8 in.)
d - Hydraulic hose hex fitting wrench size (P and T) - 21 mm (13/16 in.)
e - Hydraulic hose hex fitting wrench size (R STAR and L PORT) - 18 mm (11/16 in.)

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 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.

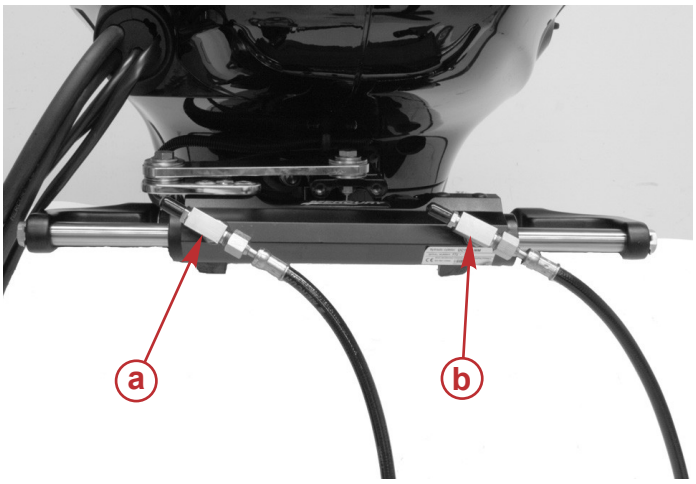


a - Bulkhead fitting - bulkhead thickness up to 1.9 cm (0.75 in.) (22-892517)
b - Bulkhead fitting - bulkhead thickness up to 7.62 cm (3 in.) (22-892518)

NOTE: *The 90° hose fittings are available and can be threaded onto the hose fittings if straight hose routing is desired.*

2. Position the hose fittings to the desired direction. Loosen the fastening nuts in order to rotate. Position the fittings and tighten the fastening nuts.
3. Ensure that the O-ring seals are in place on the end of each fitting.

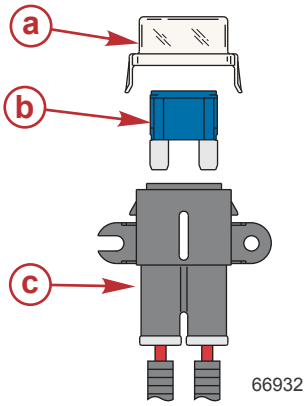
4. Make the hose connections to the steering cylinder as shown.



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 that the power steering pump harness battery ring terminals can reach the battery. Secure the fuse housing with appropriate hardware.



a - Fuse cover
b - 60-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	–

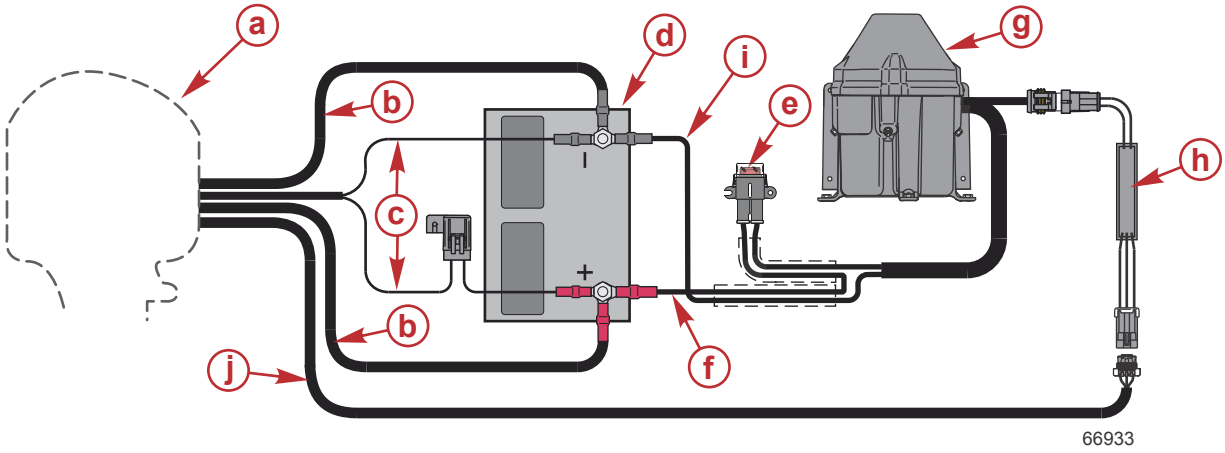
4. Connect the driver module harness connector to the power steering pump harness connector.
5. Connect the power steering signal harness to the driver module harness connector.

   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

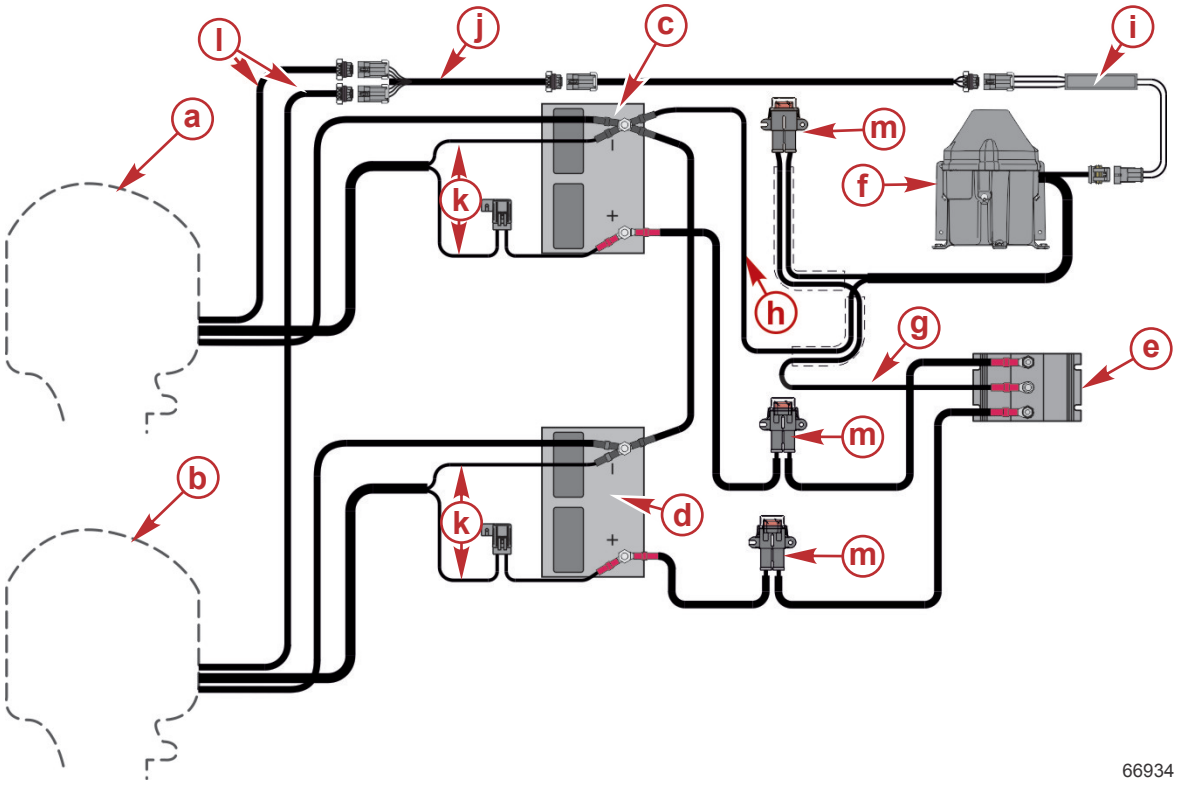
NOTE: *For single engine installation, the power steering pump battery cables should be connected directly to the outboard starting battery.*



Single engine application

- **a -** Engine
- **b -** Battery cables
- **c -** DTS power harness
- **d -** Battery
- **e -** Power steering fuse—60 amp
- **f -** Power steering pump 12-volt 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—60 amp

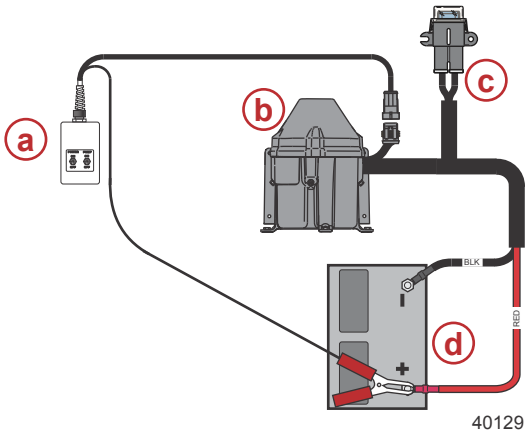
Filling Power Steering System with Engine Not Running

Use Synthetic Power Steering Fluid SAE 0W-30 in the power steering system. In an emergency, if the recommended power steering fluid is not available, 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	92-858077K01

1. Disconnect the power steering signal harness from the engine signal harness.

2. Connect the power steering module primer kit to the power steering pump and a 12-volt positive power source.

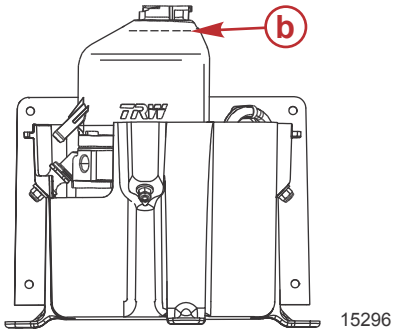


a - Power steering module primer kit
b - Power steering pump
c - 60-amp maxi fuse
d - 12-volt battery

Power Steering Module Primer Kit	91-895040K01

3. Remove the fill cap from the power steering pump.
4. Fill the pump tank with the recommended power steering fluid.

a - Fill cap
b - Full level



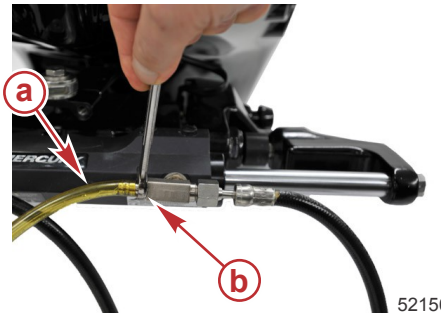
IMPORTANT: The power steering module primer has two switches, "POWER" - "ON" and "OFF," and "PUMP" - "ON" and "OFF." To power up and activate the power steering pump, there are two steps: 1) turn the "POWER" switch to the "ON" position to power up the pump, wait for two seconds, 2) turn the "PUMP" switch 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.

5. Power up and activate the pump until the fluid level stops dropping. Turn off both switches on the power steering module primer and refill the pump tank. Repeat this operation until the tank stays full.
6. Power up and activate the pump while slowly turning the steering wheel toward 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 lock to lock 10 times until the pump tank stays full.
7. 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.
8. 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.*

9. Open the bleed valve to release any remaining air in the power steering system. Allow adequate time, depending on the length of the power steering hose, for air to escape from the system. Tighten the bleed valve securely and remove the bleed hose.



a - Bleed hose
b - Bleed valve in steering cylinder

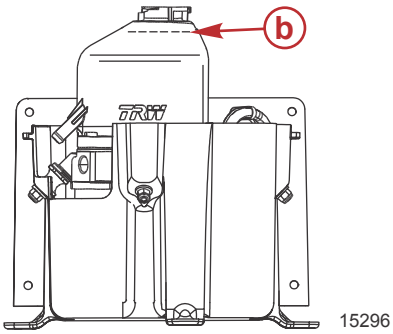
10. Turn the steering wheel opposite of the full lock position, and repeat the procedure for bleeding the steering system.
11. Replace the fill cap on the power steering pump.
12. Turn off both switches, remove the power steering module primer kit, and connect the power steering module extension harness 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.

a - Fill cap
b - Full level

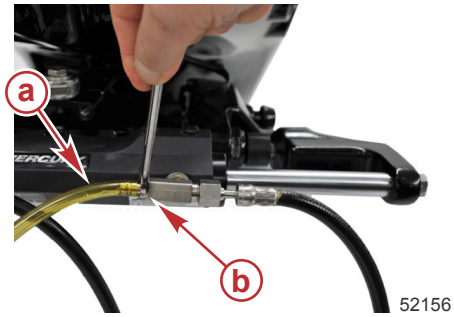


Tube Ref No.	Description	Where Used	Part No.
138	Synthetic Power Steering Fluid SAE 0W-30	Power steering pump tank	92-858077K01

3. Start and run the engine until the steering pump fluid level drops halfway. Turn off the engine and refill the pump. Repeat this operation until the pump stays full.
4. Start and run the engine while slowly turning the steering wheel toward the full lock position in one direction. Carefully monitor the fluid level until the fluid level drops halfway. Stop turning the wheel, turn off the engine, and refill the pump tank. Repeat this operation turning the steering wheel lock to lock 10 times until the pump tank stays full.
5. To bleed 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 the bleed hose into the pump tank.

   NOTE: *Do not bleed the power steering fluid into a different container, as this will only be pumping fluid out of the system that was just filled.*

7. Open the bleed valve to release any remaining air in the power steering system. Allow adequate time, depending on the length of the power steering hose, for air to escape from the system. Tighten the bleed valve securely and remove the bleed hose.

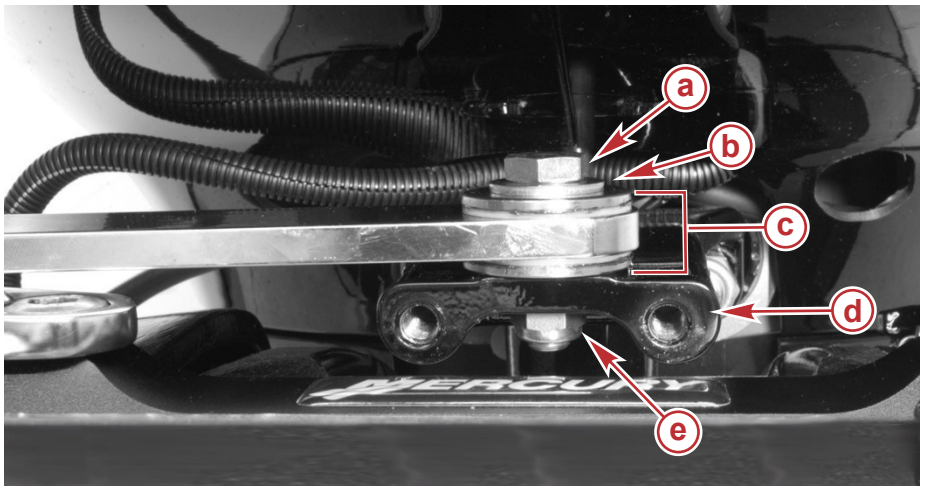


a - Bleed hose
b - Bleed valve in steering cylinder

8. Turn the steering wheel to the opposite full lock position, and repeat the procedure for bleeding the 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 be left in the system. Repeat the steps for bleeding the steering system, preceding.

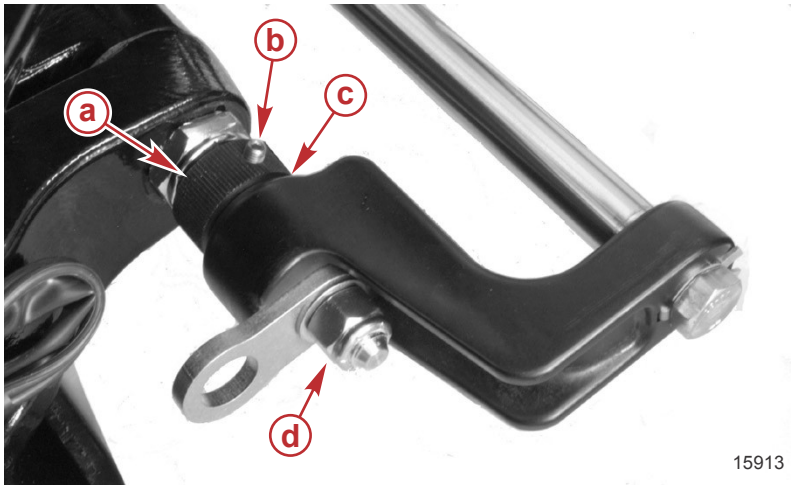
Steering Cylinder Removal

1. Remove the steering link from the steering arm by removing the locknut and bolt.



a - Bolt
b - Washer
c - Link components
d - Steering arm
e - Locknut

2. Remove the locknut from the starboard side of the tie rod assembly.
3. Remove the washer and lifting eye plate.



a - Collar
b - Set screw
c - Washer (not visible)
d - Locknut

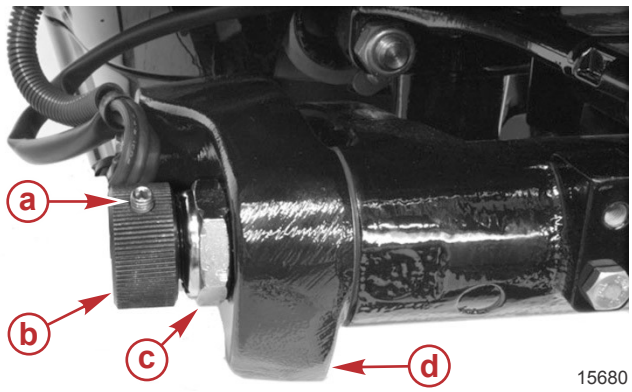
4. Remove the tie rod assembly, washer, and spacer from the steering cylinder/swivel bracket.
5. Remove the steering cylinder and two washers from the swivel bracket.

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

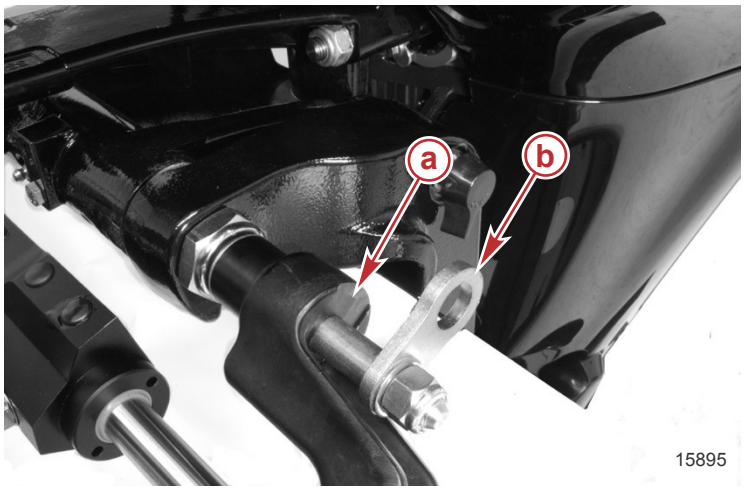
2. Apply 2-4-C with PTFE to the entire tie rod surface.
3. Partially insert the tie rod assembly (tie rod, lifting eye, washer, and locknut) into the steering cylinder bracket.
4. Assemble the spacer and a washer on the tie rod assembly.

5. Insert the 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 PTFE	Steering cylinder tie rod surface	92-802859A 1

6. Ensure the lifting eye is positioned in the undercut on the steering cylinder bracket.



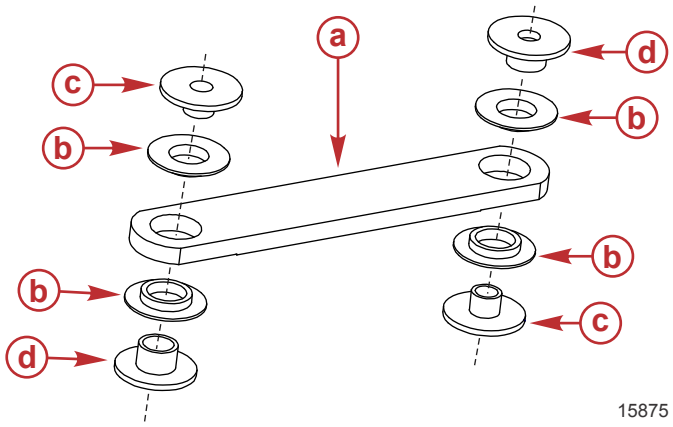
a - Undercut in steering cylinder bracket
b - Lifting eye

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

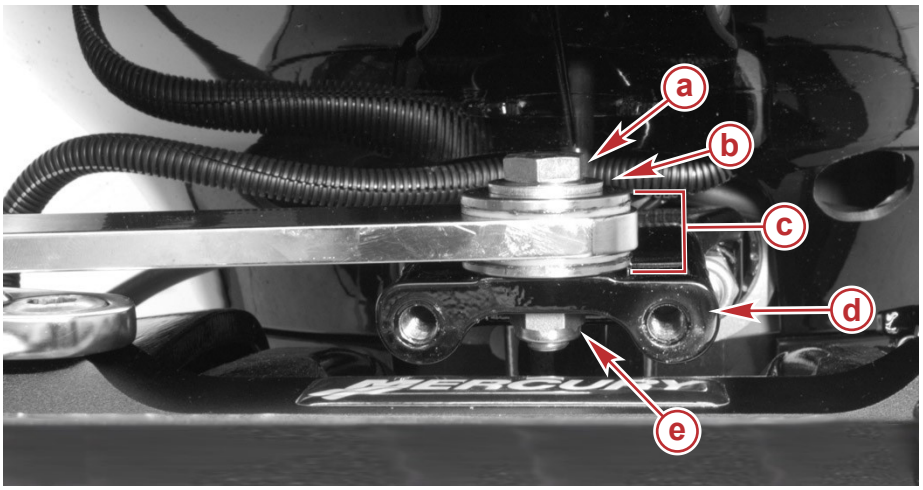
8. Install a washer, lifting eye, and locknut to the tie rod end. Do not tighten the locknut at this time.
9. Inspect the link assembly components for wear. Replace if necessary.

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.

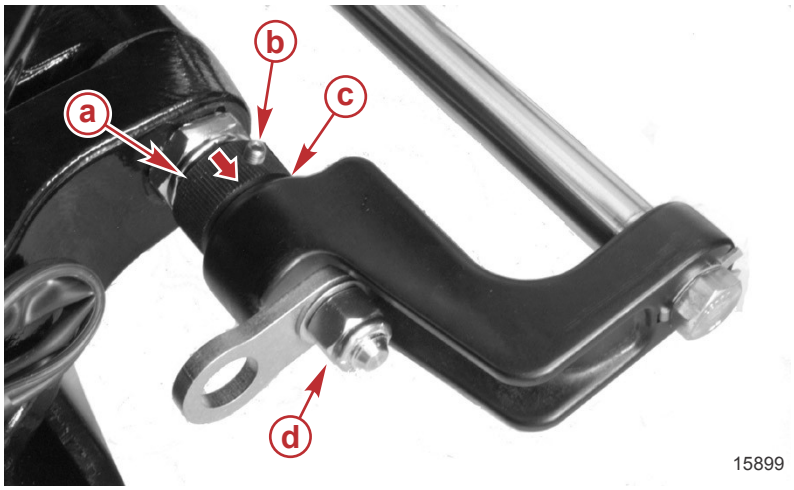


- **a -** Bolt
- **b -** Washer
- **c -** Link components
- **d -** Steering arm
- **e -** Locknut

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 7B - Hydraulic Steering

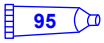
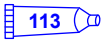
Table of Contents

7
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

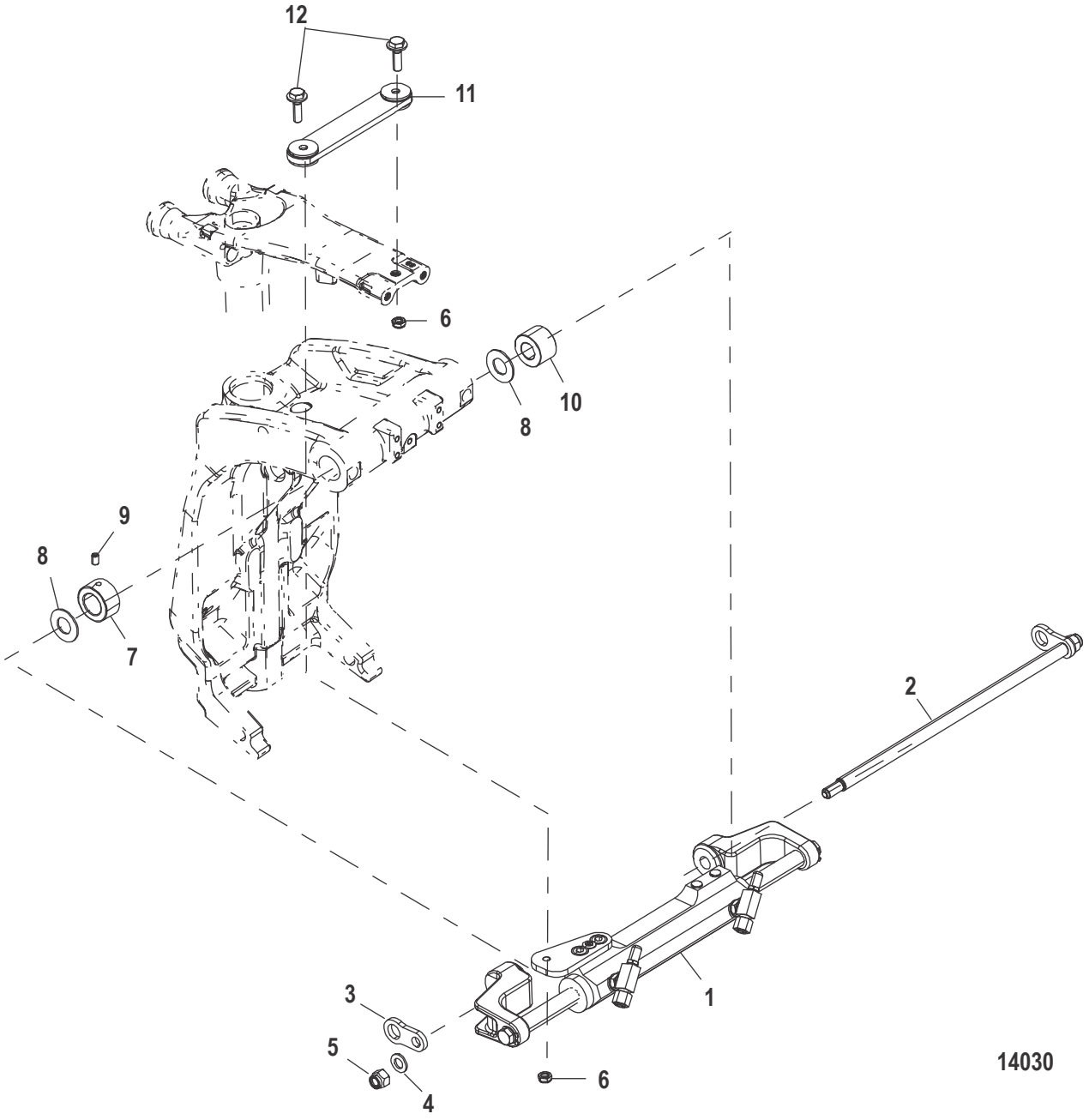
Tube Ref No.	Description	Where Used	Part No.
	2-4-C with PTFE	Steering cylinder tie rod surface	92-802859A 1
	Loctite Moly Paste (Molybdenum Disulfide Grease)	Steering cylinder tie rod threads	Obtain Locally

Special Tools

Steering Helm Fill Adapter	64-826525A 1
	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

Steering System Requirements

⚠ CAUTION

Avoid a possible steering system failure due to incorrect steering cylinder installation. Mercury heavy-duty steering cylinders are designed to be gearcase/propeller rotation specific. Right-hand rotation outboards require a right-hand steering cylinder and left-hand (counterrotation) outboards require a counterrotation steering cylinder. Always confirm that the correct cylinder is paired with the correct outboard.

Mechanical Steering

IMPORTANT: Do not use mechanical steering with these engines.

Hydraulic Steering (Non-Power Steering)

Use Mercury heavy-duty steering cylinders fitted with compression fittings.

Hydraulic Power Steering

Use Mercury heavy-duty steering cylinders fitted with O-ring face seal fittings.

Multiple Engine Steering Installations

Dual Outboard Steering Options

Maximum Combined 500 HP

Single Cylinder/Dual Outboard: One right-hand HD steering cylinder mounted to a right-hand rotation outboard, using a tie bar kit to connect to the left-hand (counterrotation) outboard.

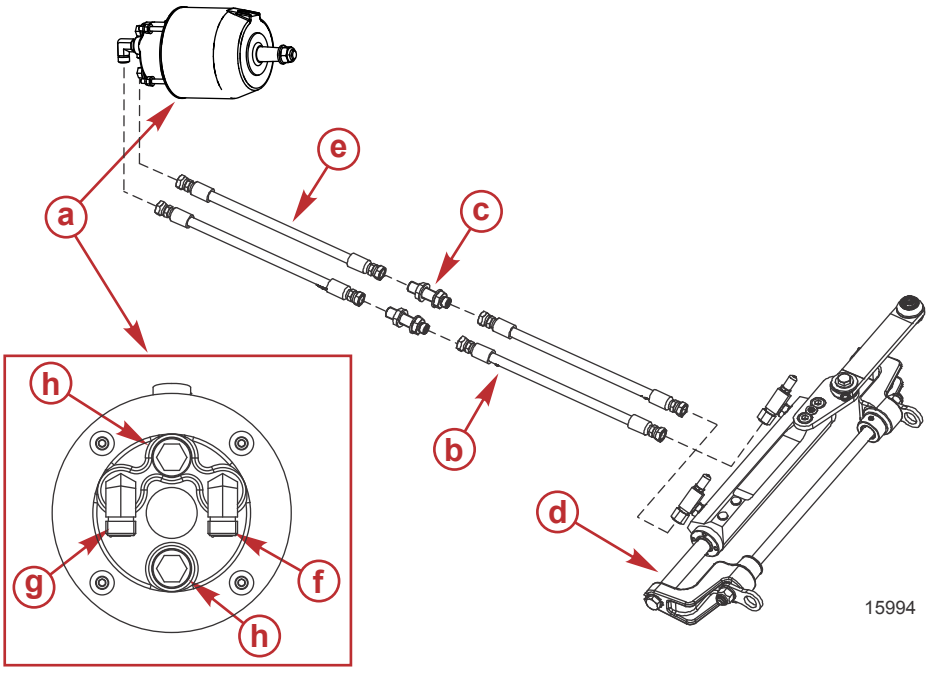
Maximum Combined 600 HP

Dual Cylinder/Dual Outboard: One right-hand HD steering cylinder mounted to the right-hand rotation outboard, and one left-hand HD steering cylinder mounted to the left-hand (counterrotation) outboard. Steering cylinders are connected using a dual outboard tie bar kit.

Triple Outboard Steering

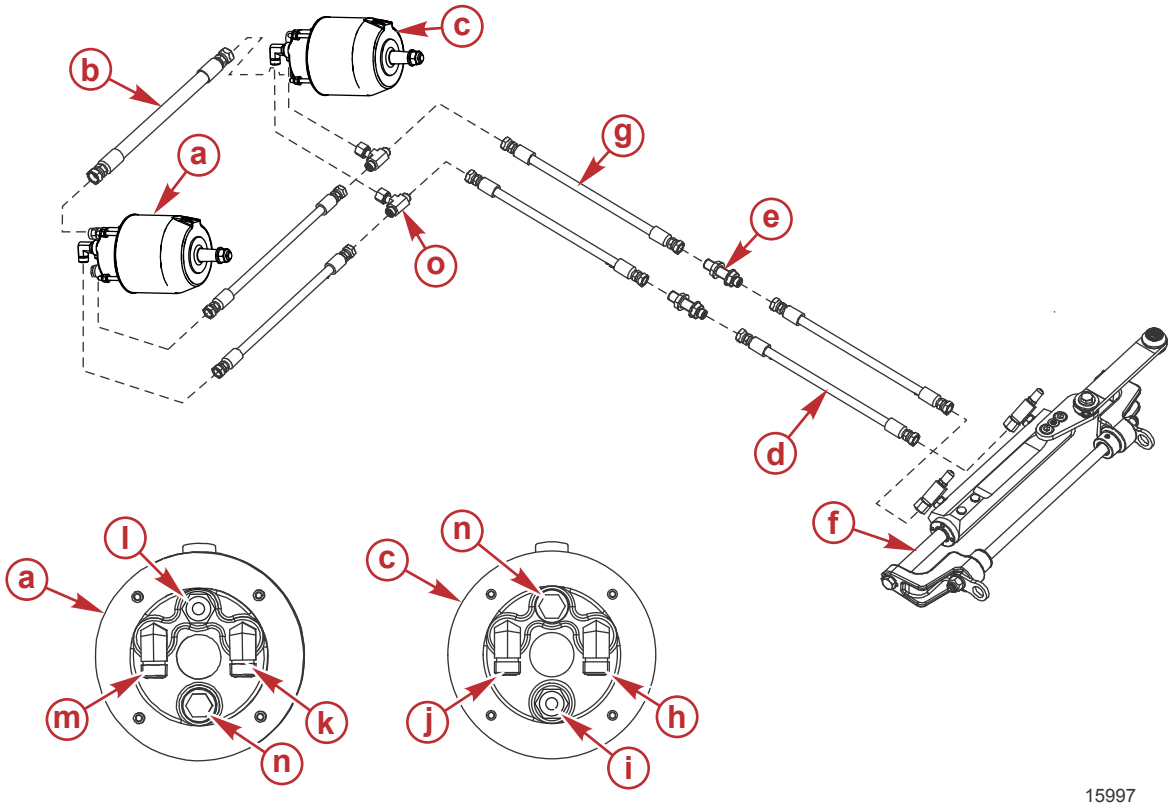
Triple Cylinder/Triple Outboard: One right-hand HD steering cylinder mounted to the right-hand rotation outboard (starboard outboard location), one left-hand HD steering cylinder mounted to the left-hand (counterrotation) outboard (port outboard location), and one HD steering cylinder from the triple outboard tie bar kit mounted to the center outboard. Steering cylinders are connected using tie bars and hardware from the triple outboard tie bar kit.

Single Helm - Single Cylinder



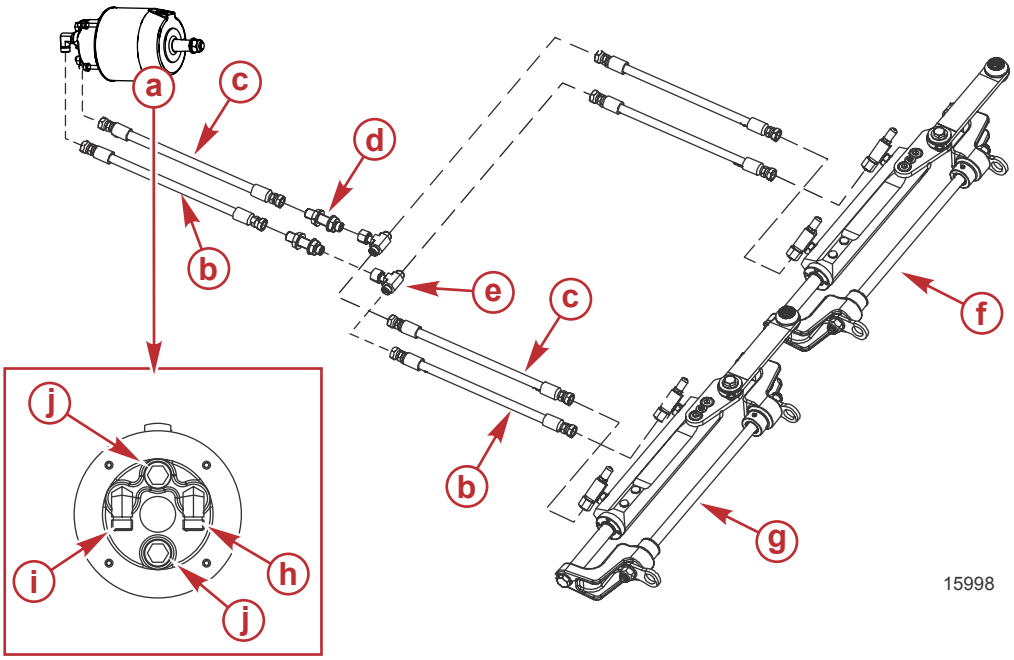
- **a -** Helm
- **b -** Hose to starboard side of steering cylinder
- **c -** Bulkhead fitting (2)
- **d -** Steering cylinder
- **e -** Hose to port side of steering cylinder
- **f -** Helm to starboard side of steering cylinder
- **g -** Helm to port side of steering cylinder
- **h -** Plug

Dual Helm - Single Cylinder



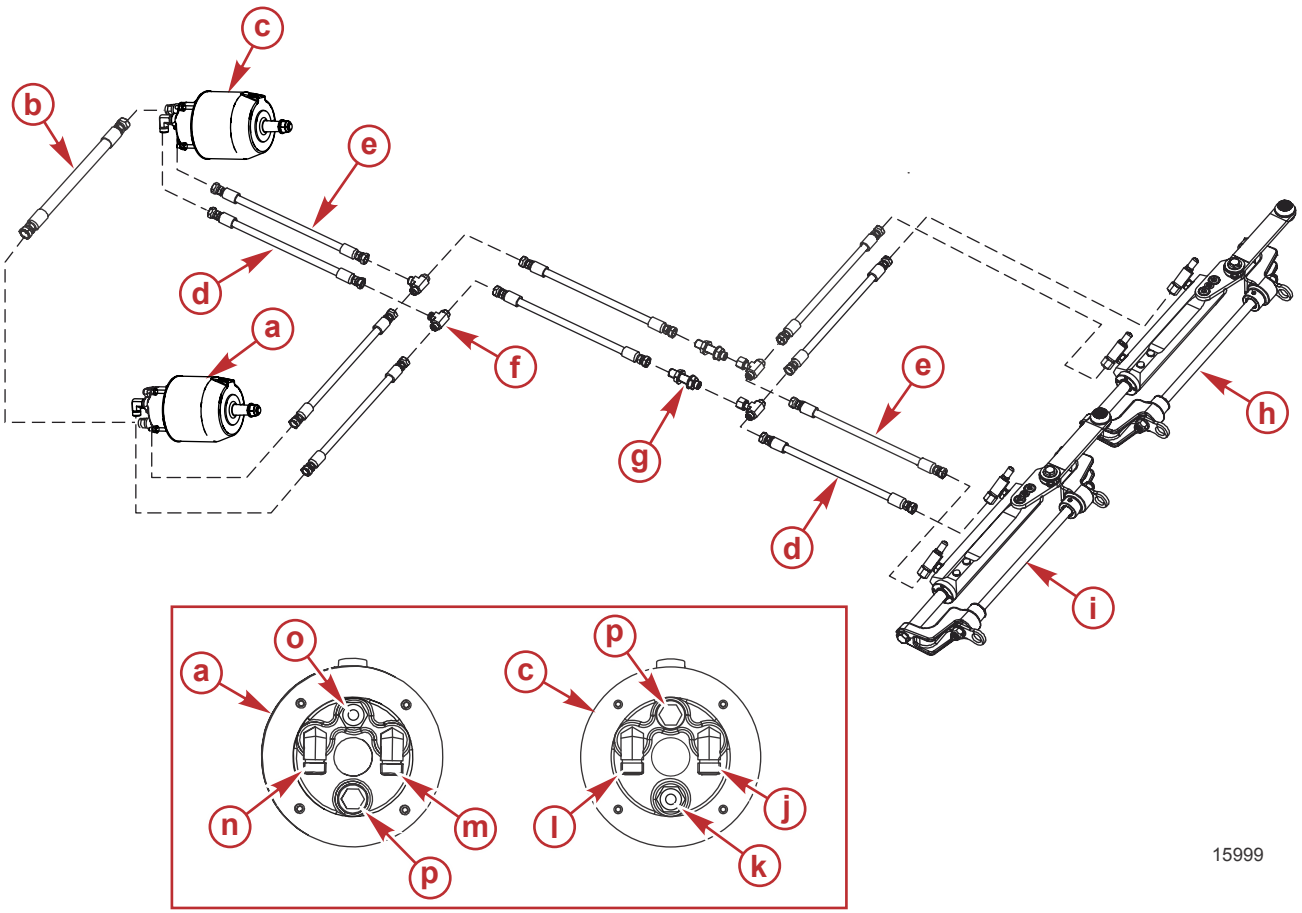
- **a -** Main helm
- **b -** Main helm to second helm hose
- **c -** Second helm
- **d -** Hose to starboard side of steering cylinder
- **e -** Bulkhead fitting (2)
- **f -** Steering cylinder
- **g -** Hose to port side of steering cylinder
- **h -** Helm to starboard side of steering cylinder
- **i -** 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 Helm - 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

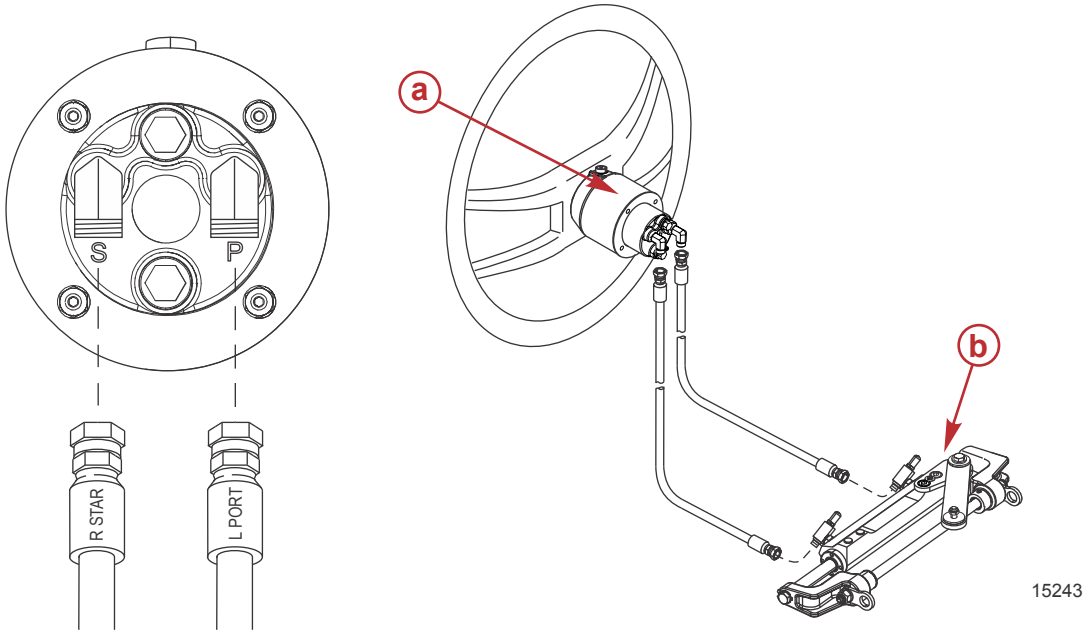
Dual Helm - Dual Cylinder



- **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

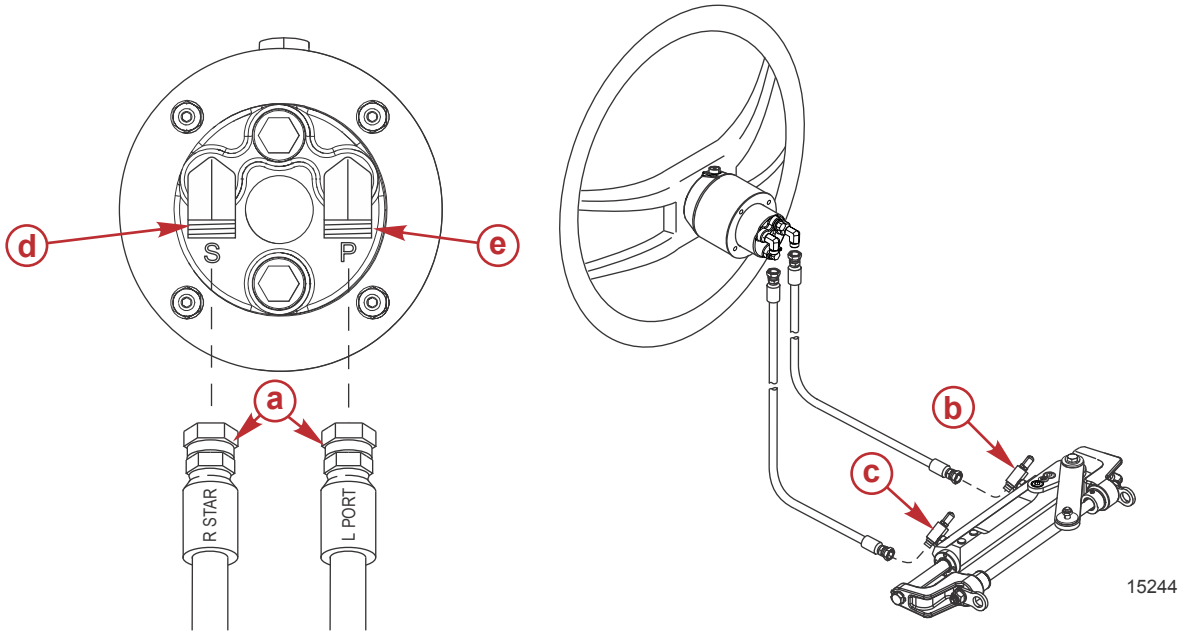
Hydraulic Steering System



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.

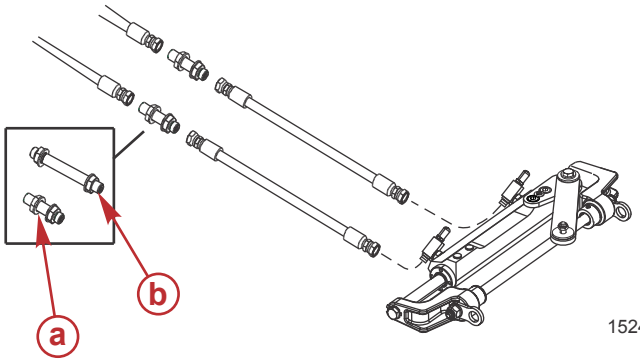


a - Hydraulic hose hex fitting wrench size (R STAR and L PORT) - 18 mm (11/16 in.)
b - Starboard fitting
c - Port fitting
d - S helm fitting
e - P helm fitting

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

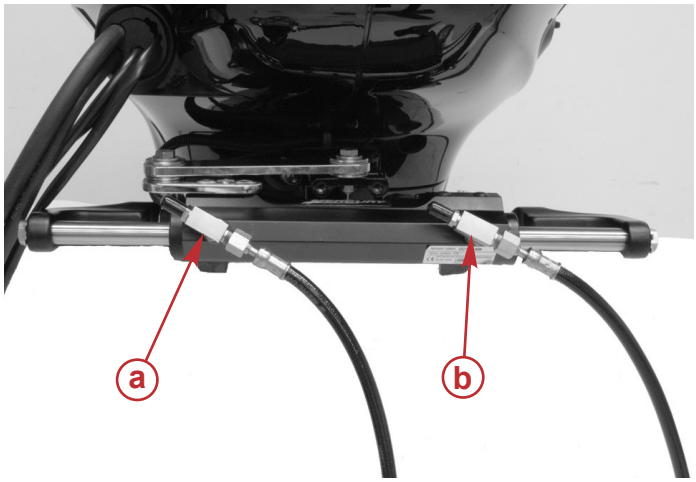
1. Route the hydraulic hoses to the outboard steering cylinder. Bulkhead fittings are available if an opening does not exist in the engine well.



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 the hose fittings to the desired direction. Loosen the fastening nuts in order to rotate. Position the fittings and tighten the fastening nuts.
3. Ensure that the O-ring seals are in place on the 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

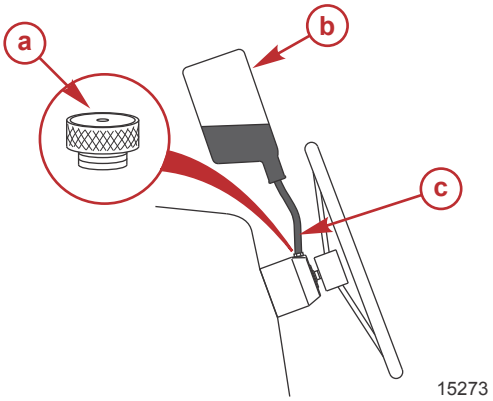
NOTE: *Start the filling of the system at the steering helm. On dual-steering systems, always start at the lower steering helm.*

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.

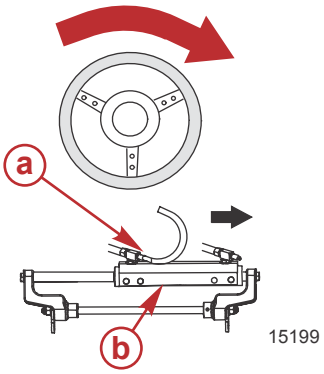
   NOTE: *Keep the fill tube full of fluid between the bottle of fluid and steering helm during the entire filling procedure. Replace the empty bottle while the fill tube is still full. If the system sucks in air, it will have to be bled again.*



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.

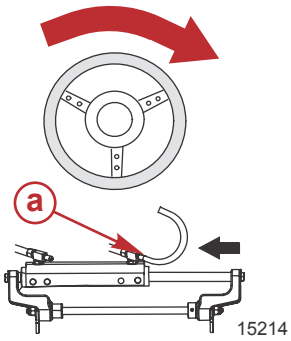


a - Port bleed fitting
b - Steering cylinder

Step 3

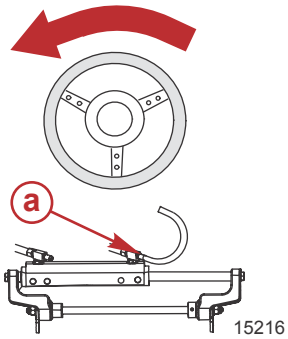
1. Attach a transparent bleed hose to the starboard bleed fitting. Route the other end of the bleed hose into a container to avoid spillage.
2. Open the starboard bleed fitting.

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.



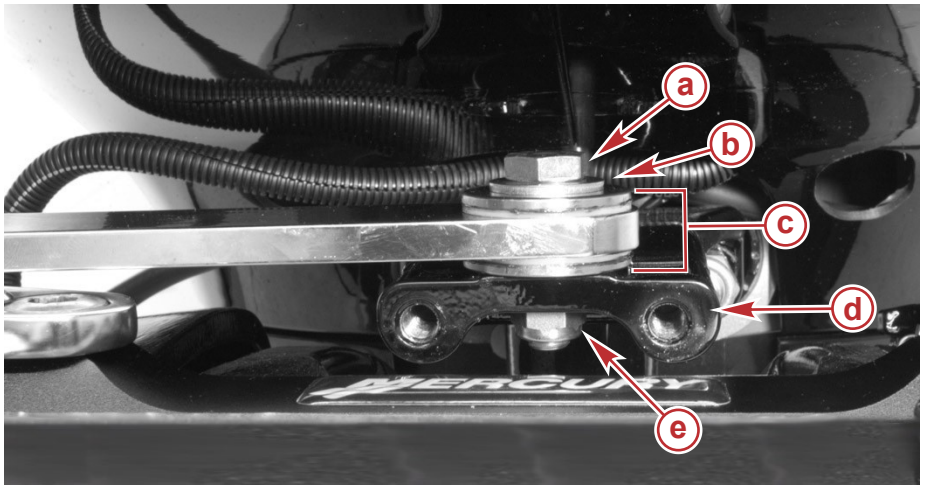
a - Starboard bleed fitting

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

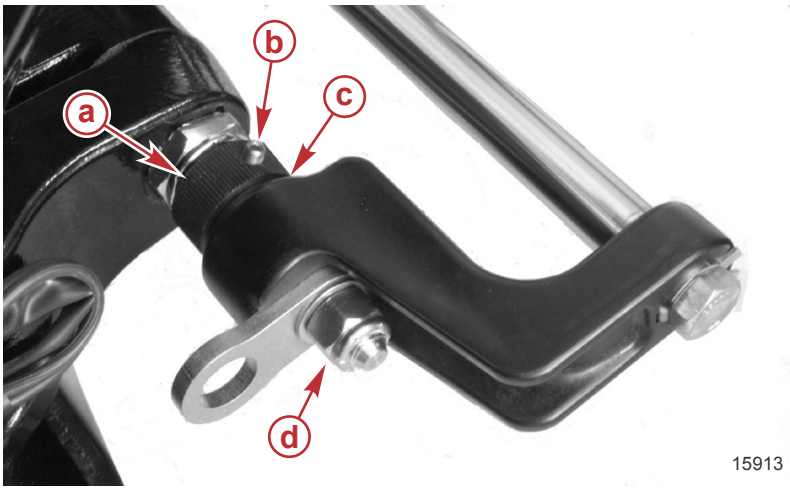
1. Remove the steering link from the steering arm by removing the locknut and bolt.



a - Bolt
b - Washer
c - Link components
d - Steering arm
e - Locknut

2. Remove the locknut from the starboard side of the tie rod assembly.

3. Remove the washer and lifting eye plate.



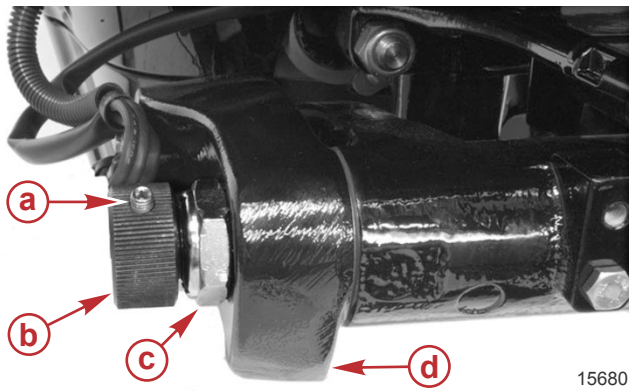
a - Collar
b - Set screw
c - Washer (not visible)
d - Locknut

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.



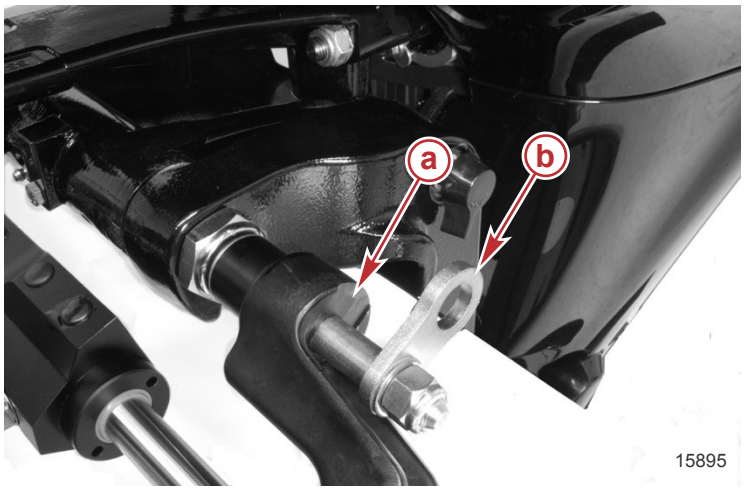
a - Set screw
b - Collar
c - Starboard side tilt tube locknut
d - Starboard transom bracket

2. Apply 2-4-C with PTFE 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 the 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 PTFE	Steering cylinder tie rod surface	92-802859A 1

6. Ensure that the lifting eye is positioned in the undercut on the steering cylinder bracket.



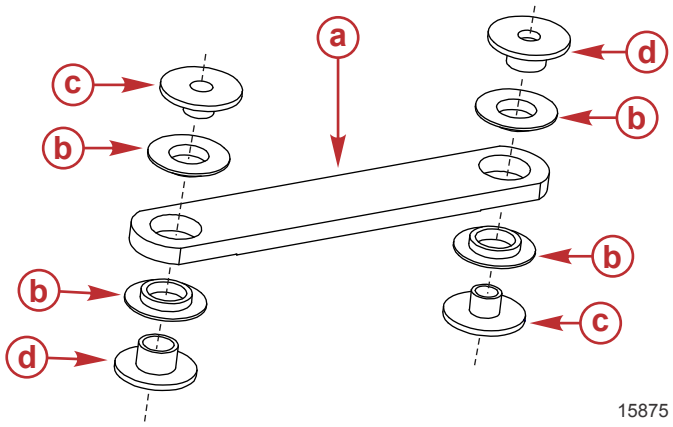
a - Undercut in steering cylinder bracket
b - Lifting eye

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

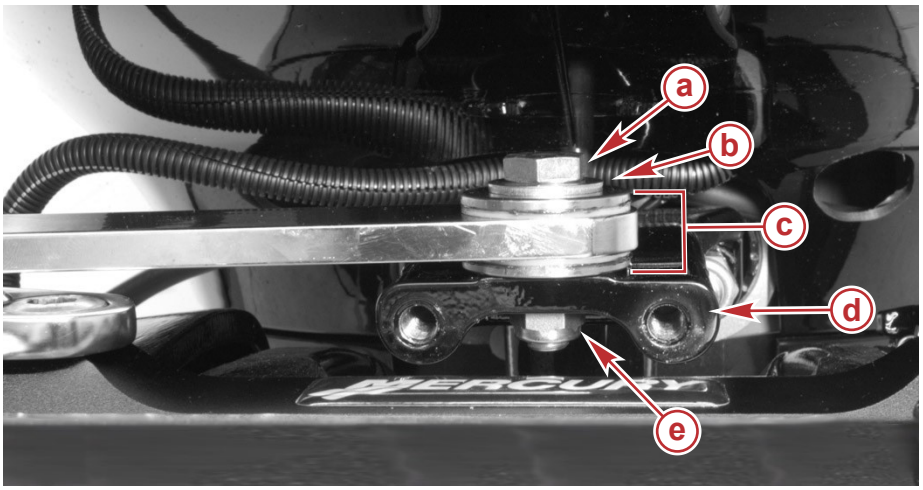
8. Install a washer, lifting eye, and locknut to the tie rod end. Do not tighten the locknut at this time.
9. Inspect the link assembly components for wear. Replace if necessary.

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.

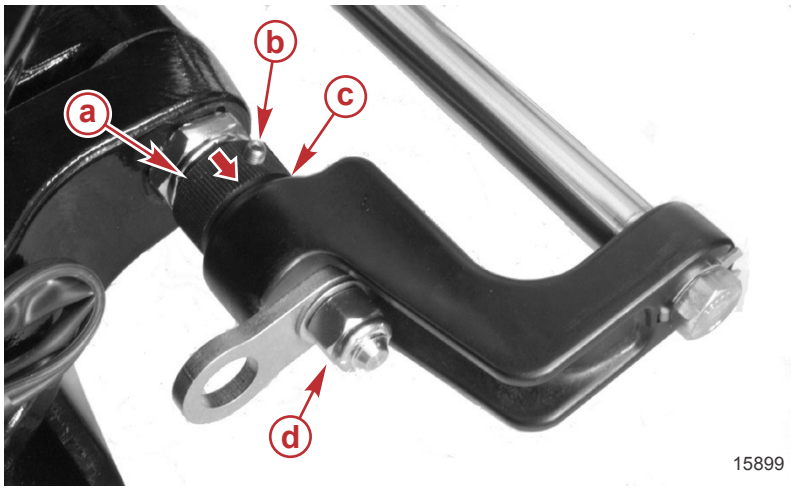


- **a -** Bolt
- **b -** Washer
- **c -** Link components
- **d -** Steering arm
- **e -** Locknut

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 Manually Filling and Purging the Hydraulic Type Steering System.

Notes:

Steering

Section 7C - CMS Tie Bar Kits

Table of Contents

7C

Lubricant, Sealant, Adhesives

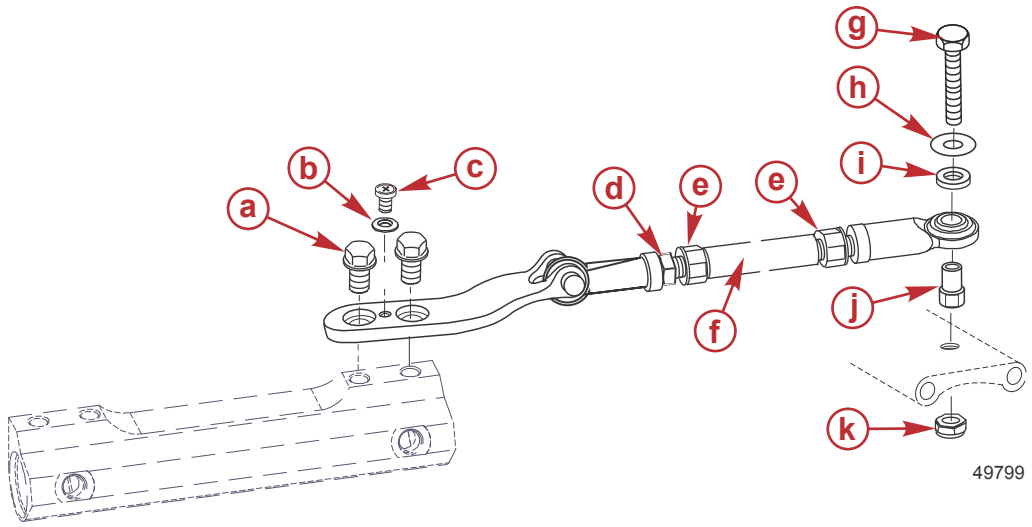
Tube Ref No.	Description	Where Used	Part No.
51	Loctite 222 Threadlocker	Retaining screw threads	92-809818
113	Loctite Moly Paste (Molybdenum Disulfide Grease)	Tie bar attaching bolt threads	Obtain Locally
138	Synthetic Power Steering Fluid SAE 0W-30	Steering system	92-858077K01

Special Tools

Power Steering Module Primer Kit	91-895040K01
 5547	Bleeds power steering system without running engine.

Dual Outboard, Single Cylinder Tie Bar Kit

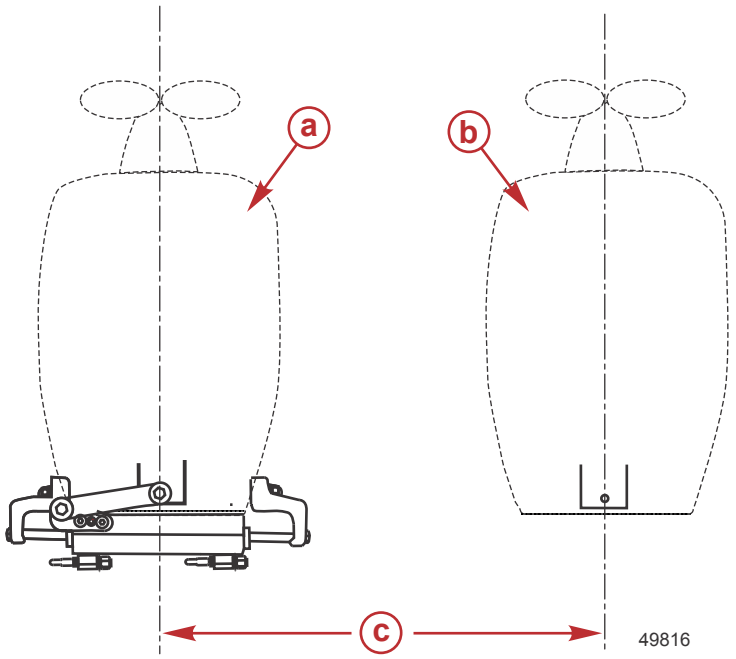
Components Contained in Kit



- **a -** Screw (2)
- **b -** Retainer
- **c -** Retaining screw
- **d -** Jam nut
- **e -** Plastic spacer
- **f -** Tie bar
- **g -** Bolt
- **h -** Flat washer
- **i -** Spacer
- **j -** Bushing
- **k -** Locknut

Tie Bar Kit Application

1. Position the outboards so they are facing straight forward. The distance between the centers of the bolt holes in the steering arms must be equal to the distance between the propeller shaft centerlines.
2. Measure the distance between the centerlines of the outboards. Use the correct tie bar kit that matches the outboard centerline spacing. The length of the tie bar can be adjusted to allow for a 12.7 mm (½ in.) ± tolerance between outboard centerline spacing.



a - Starboard outboard
b - Port outboard
c - Outboard centerline spacing

Kit Part Number	Kit Application
64-8M0063473	For outboard centerline spacing of 66.0 cm (26 in.)
64-8M0063474	For outboard centerline spacing of 71.1 cm (28 in.)
64-8M0063475	For outboard centerline spacing of 76.2 cm (30 in.)
64-8M0063476	For outboard centerline spacing of 81.3 cm (32 in.)
64-8M0063477	For outboard centerline spacing of 86.4 cm (34 in.)

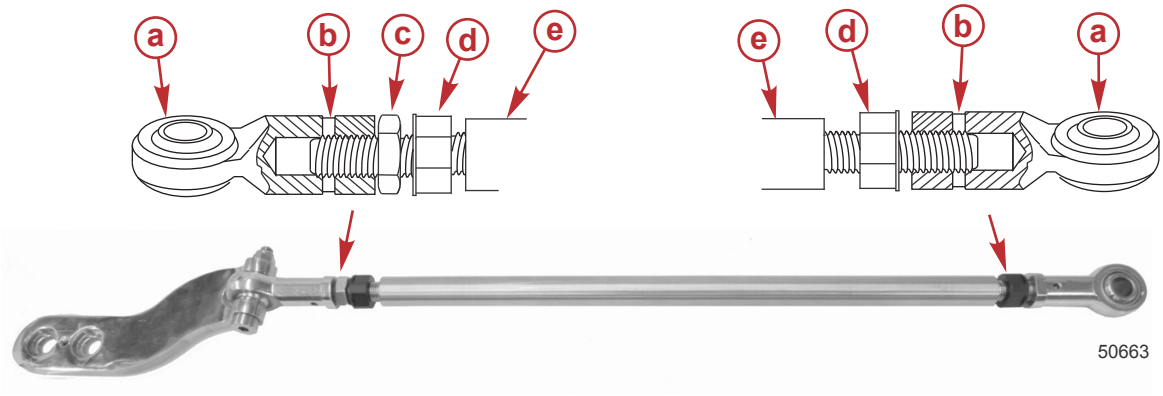
Installation

⚠ 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. Thread the steering eyes equally onto the threaded ends of the tie bar. The steering eyes must be threaded far enough on the tie bar so that the tie bar is visible in the inspection hole and that it covers the entire hole.

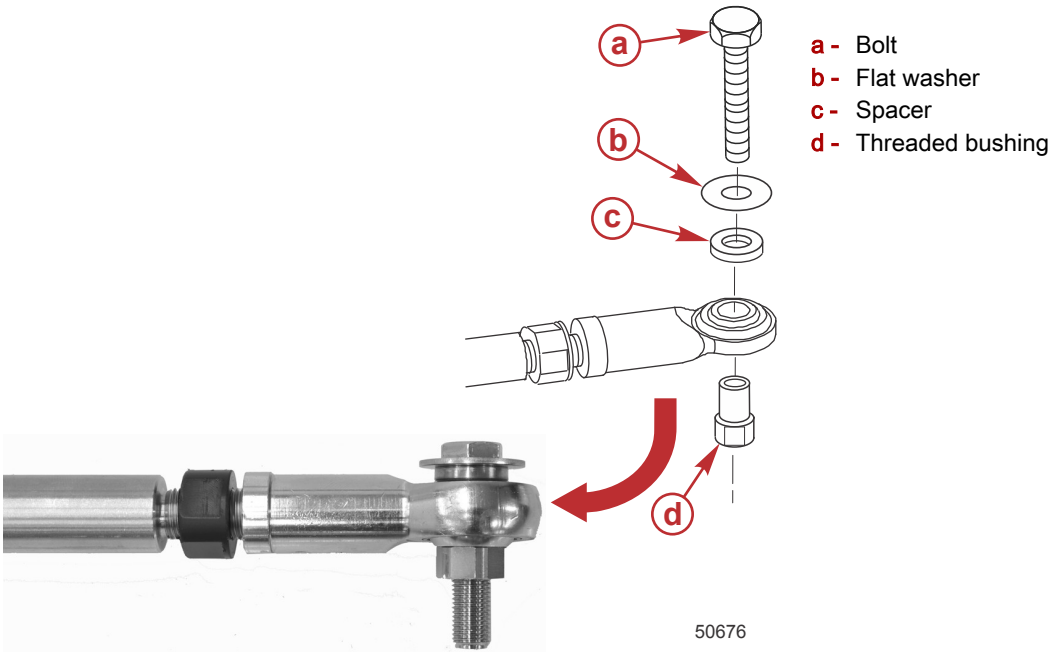
IMPORTANT: Each steering eye must be threaded far enough on the tie bar so that the tie bar is visible in the inspection hole and that it covers the entire hole. The jam nut must be tightened to specification against the steering eye to prevent the tie bar from turning. Insufficient engagement of the steering eye threads could result in the steering eyes pulling off of the tie bar and disengaging the steering.



a - Steering eye
b - Inspection hole - threaded tie bar must entirely cover hole
c - Jam nut
d - Spacer
e - Tie bar

2. Fasten the threaded bushing into the steering eye as shown. Tighten the threaded bushing to the specified torque.

Description	Nm	lb-in.	lb-ft
Threaded bushing into the steering eye	37	–	27

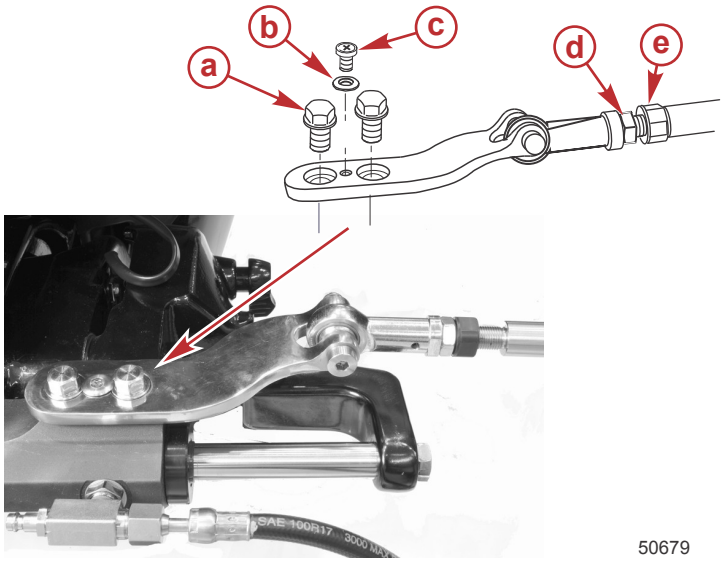


a - Bolt
b - Flat washer
c - Spacer
d - Threaded bushing

3. Install the tie bar to the steering cylinder as follows:
   a. Remove the two rubber plugs from the steering cylinder.
   b. Attach the tie bar plate to the 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.

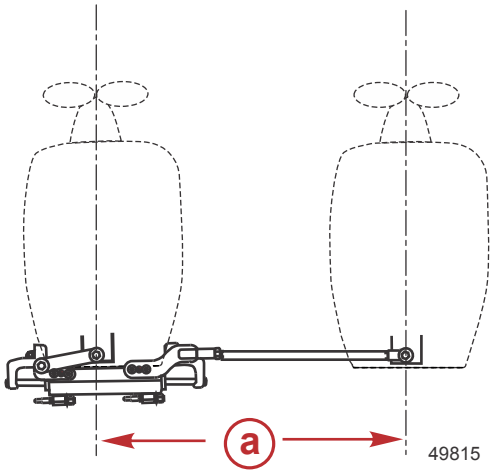
Tube Ref No.	Description	Where Used	Part No.
51	Loctite 222 Threadlocker	Retaining screw threads	92-809818

Description	Nm	lb-in.	lb-ft
Screws for attaching the tie bar plate	76	–	56
Retaining screw	2.7	24	–



a - Screw (2)
b - Retaining washer
c - Retaining screw
d - Jam nut
e - Plastic spacer

4. Position the outboards so they are facing straight forward. The distance between the centers of the threaded holes in the steering arms must be equal to the distance between the propeller shaft centerlines.



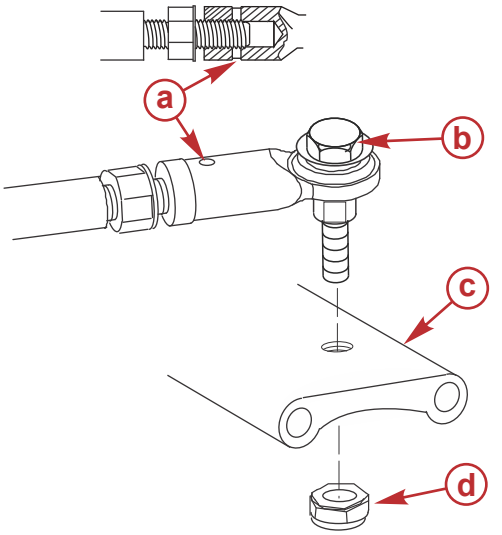
a - Equal distance - Between the center of the threaded hole in steering arms and propeller shaft centerlines

5. Adjust the length of the tie bar so that it reaches the threaded hole in the steering arm on the port engine. Thread the steering eyes equally onto the threaded ends of the tie bar. The steering eyes must be threaded far enough on the tie bar so that the tie bar is visible in the inspection hole and that it covers the entire hole.

   IMPORTANT: Each steering eye must be threaded far enough on the tie bar so that the tie bar is visible in the inspection hole and that it covers the entire hole. 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.

6. Install the tie bar to the steering arm on the port engine. Tighten the bolt to the specified torque, and then tighten the nylon insert locknut to the specified torque.

Description	Nm	lb-in.	lb-ft
Tie bar attaching bolt (port side outboard)	54	–	40
Nylon insert locknut located on the tie bar attaching bolt	27	–	20

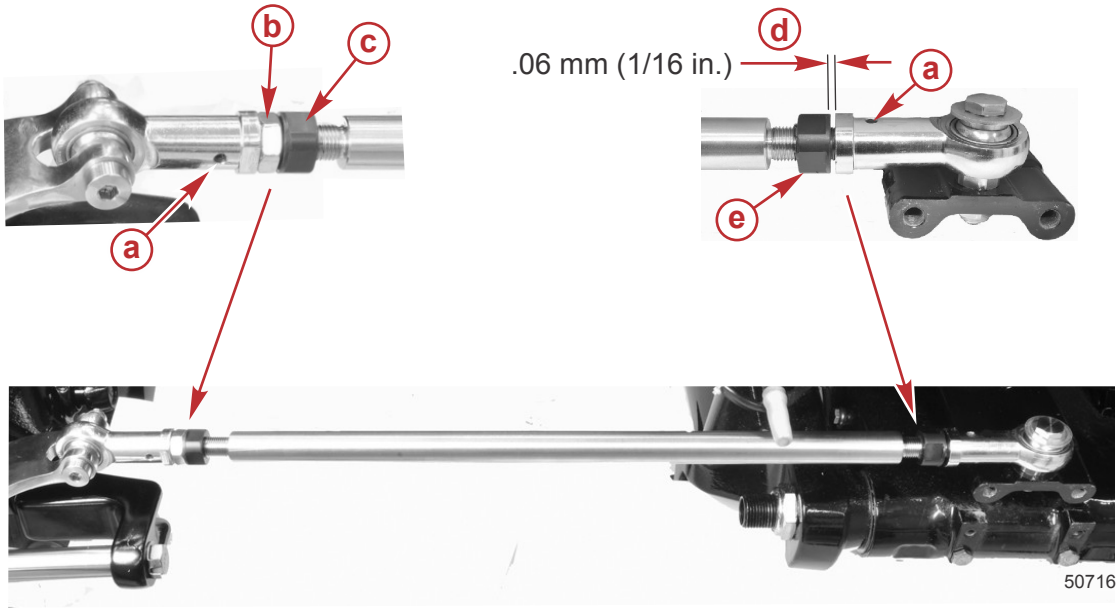


a - Inspection hole - tie rod must cover entire hole
b - Bolt
c - Steering arm - port engine
d - Nylon insert locknut

7. View the inspection hole in each steering eye and make sure the tie bar is visible in the hole and that it covers the entire hole.
8. On the steering cylinder side, tighten the jam nut against the steering eye. Tighten to the specified torque.

Description	Nm	lb-in.	lb-ft
Jam nut	27	–	20

9. On the steering cylinder side, tighten the plastic spacer against the jam nut.
10. On the port outboard side, position the plastic spacer to allow a 0.06 mm (1/16 in.) space between the steering eye and spacer. This allows rotation of the steering eye whenever a single outboard is raised or lowered.



a - Inspection hole - tie rod must cover entire hole
b - Jam nut
c - Plastic spacer - tighten against jam nut
d - Steering eye rotation space - between steering eye and plastic spacer
e - Plastic spacer - position to allow space shown

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).

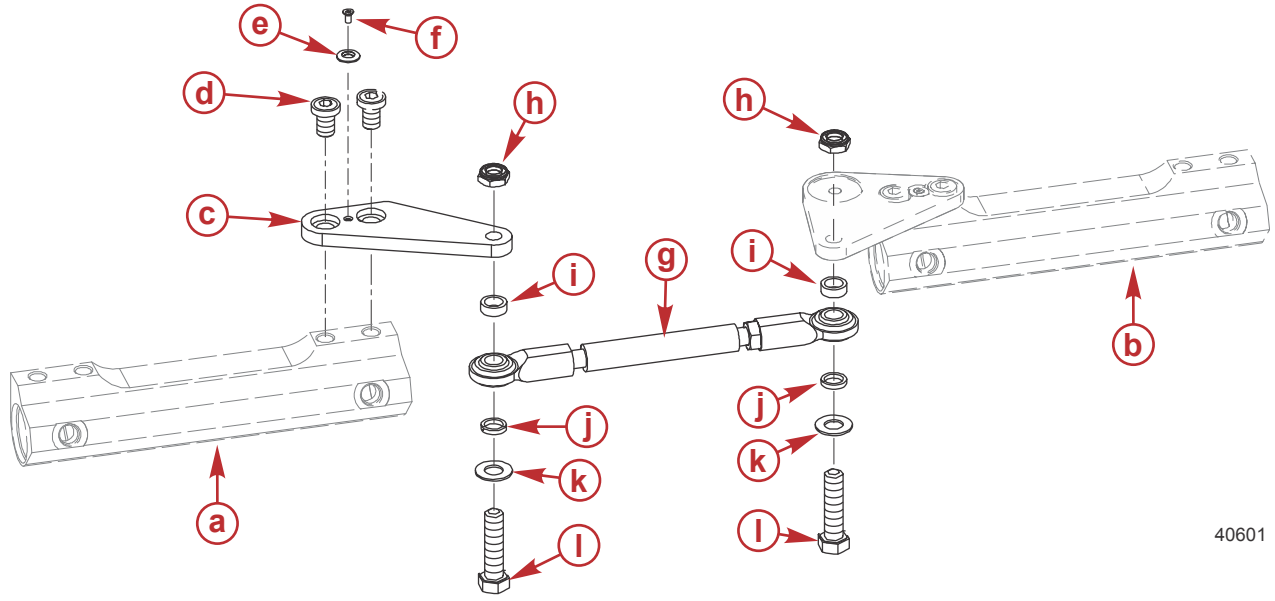
NOTE: *Operation in saltwater is considered severe service.*

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 bolt (port side outboard)	54	–	40
Locknut located on the tie bar attaching bolt	27	–	20
Jam nut against the steering eye	27	–	20

Dual Outboard, Dual Cylinder Tie Bar Kit

Components Contained in 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

Description	Nm	lb-in.	lb-ft
Retaining screw	2.7	24	–
Tie bar attaching bolts (0.50 in.-20)	54	–	40
Locknut (0.50 in.-20)	27	–	20
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.

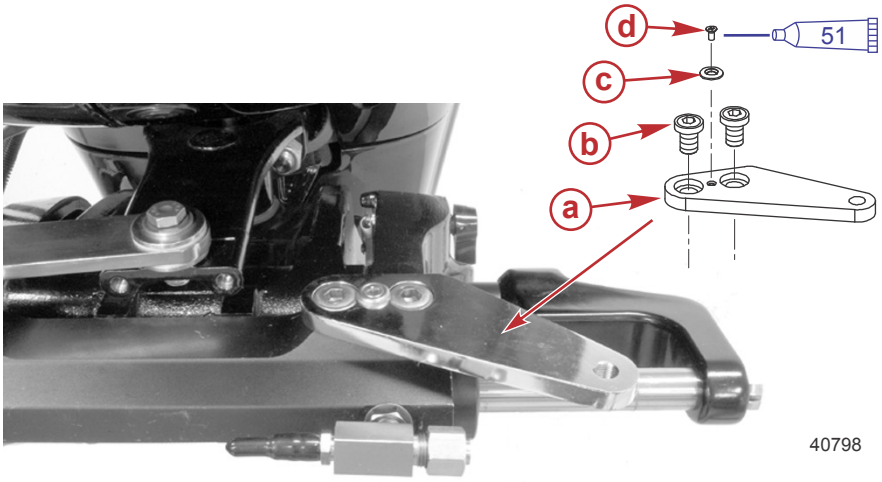
Kit Part Number	Kit Application
64-892789Q22	For outboard centerline spacing of 66.0 cm (26 in.)
64-892789Q23	For outboard centerline spacing of 71.1 cm (28 in.)
64-892789Q25	For outboard centerline spacing of 76.2 cm (30 in.)
64-892789Q26	For outboard centerline spacing of 81.3 cm (32 in.)
64-892789Q27	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.

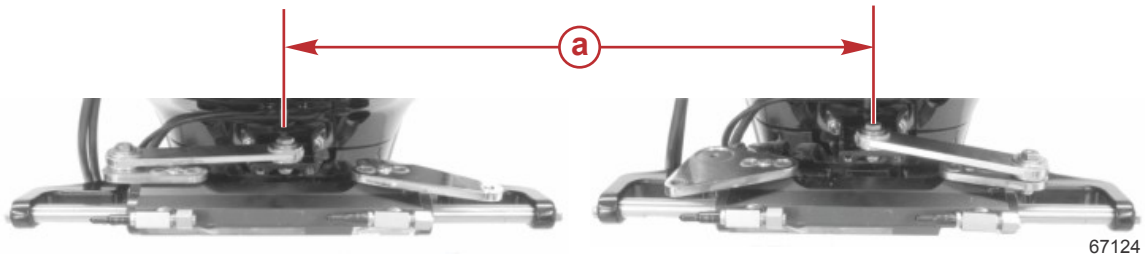


a - Starboard tie bar plate
b - Screw (5/16 in. internal hex)
c - Retaining washer
d - Retaining screw

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	–

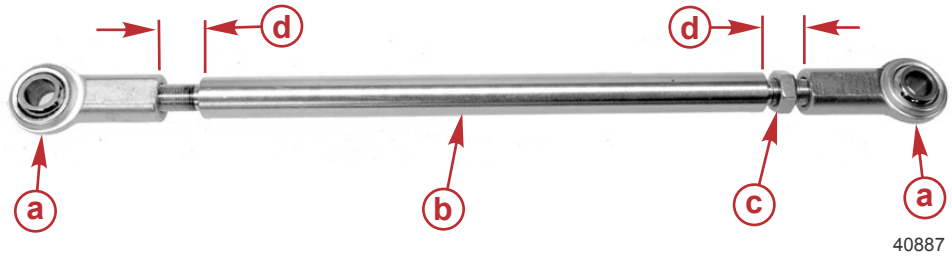
2. Position the outboards so they are facing straight forward. The distance between the centers of the hex bolts in the steering arms must be equal to the distance between the propeller shaft centerlines.



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.

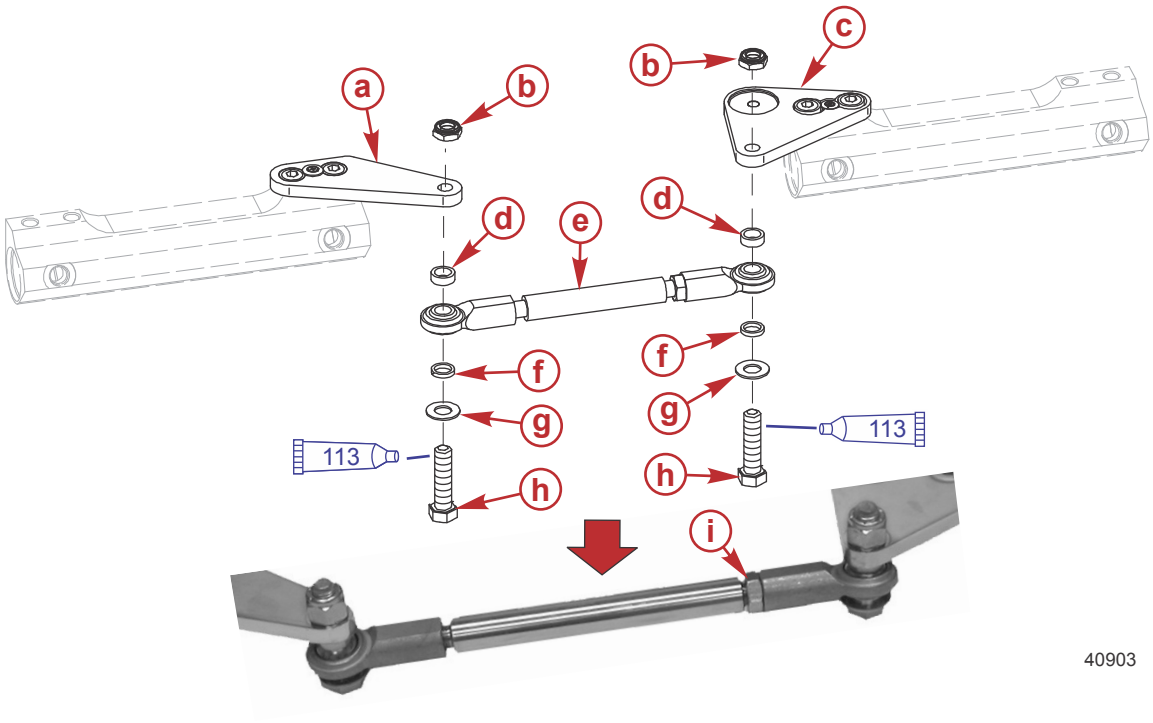
   IMPORTANT: Both steering eyes must be threaded onto the threaded ends of the tie bar 14.3 mm (9/16 in.) minimum. The maximum allowable amount of exposed thread extending out the steering eyes is 19 mm (3/4 in.). The jam nut must be tightened to specification against the steering eye to prevent the tie 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 the 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 occurs first.

Severe service—Every 25 hours of operation or 30 days, whichever occurs first.

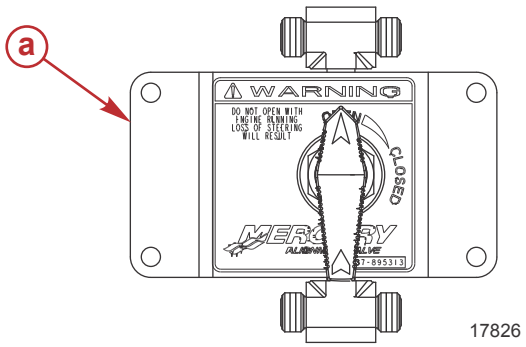
NOTE: *Operation in saltwater is considered severe service.*

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 specified torque.

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)

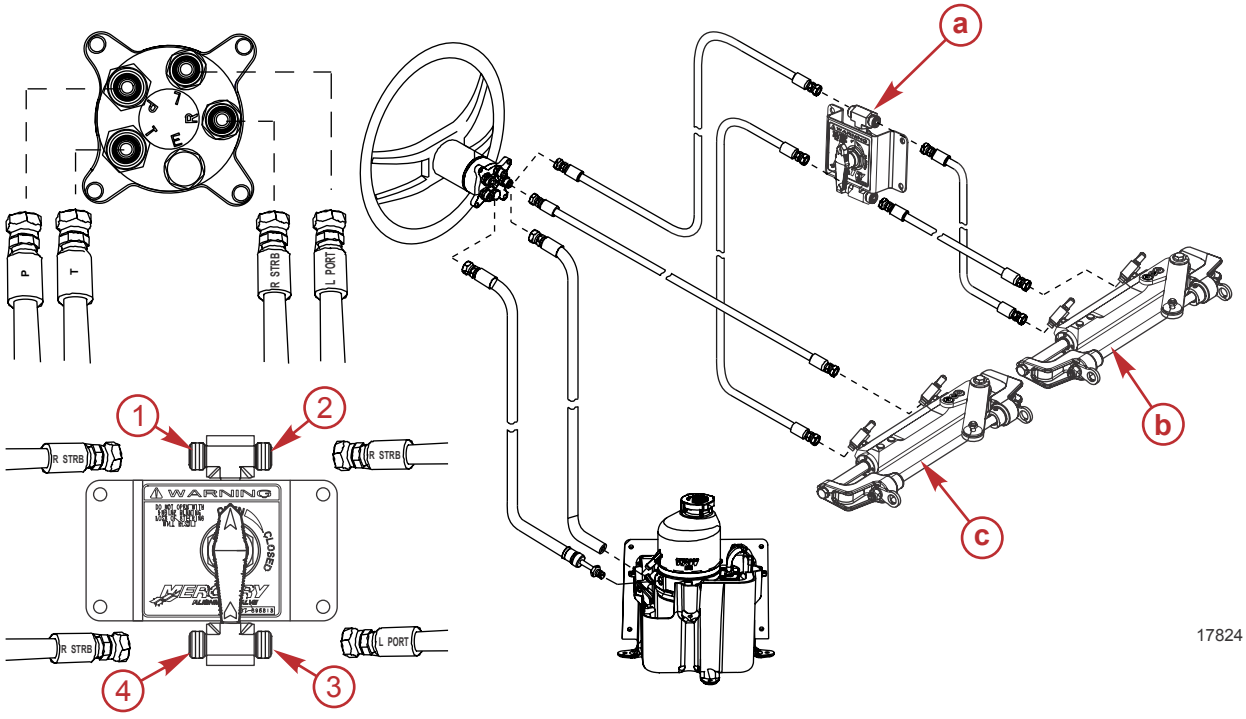


a - Tie bar valve

Liquid Tie Bar Installation

CMS Models 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 the hydraulic hoses to the steering helm and power steering pump following the instructions which accompany the steering helm and pump.
4. Connect the 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

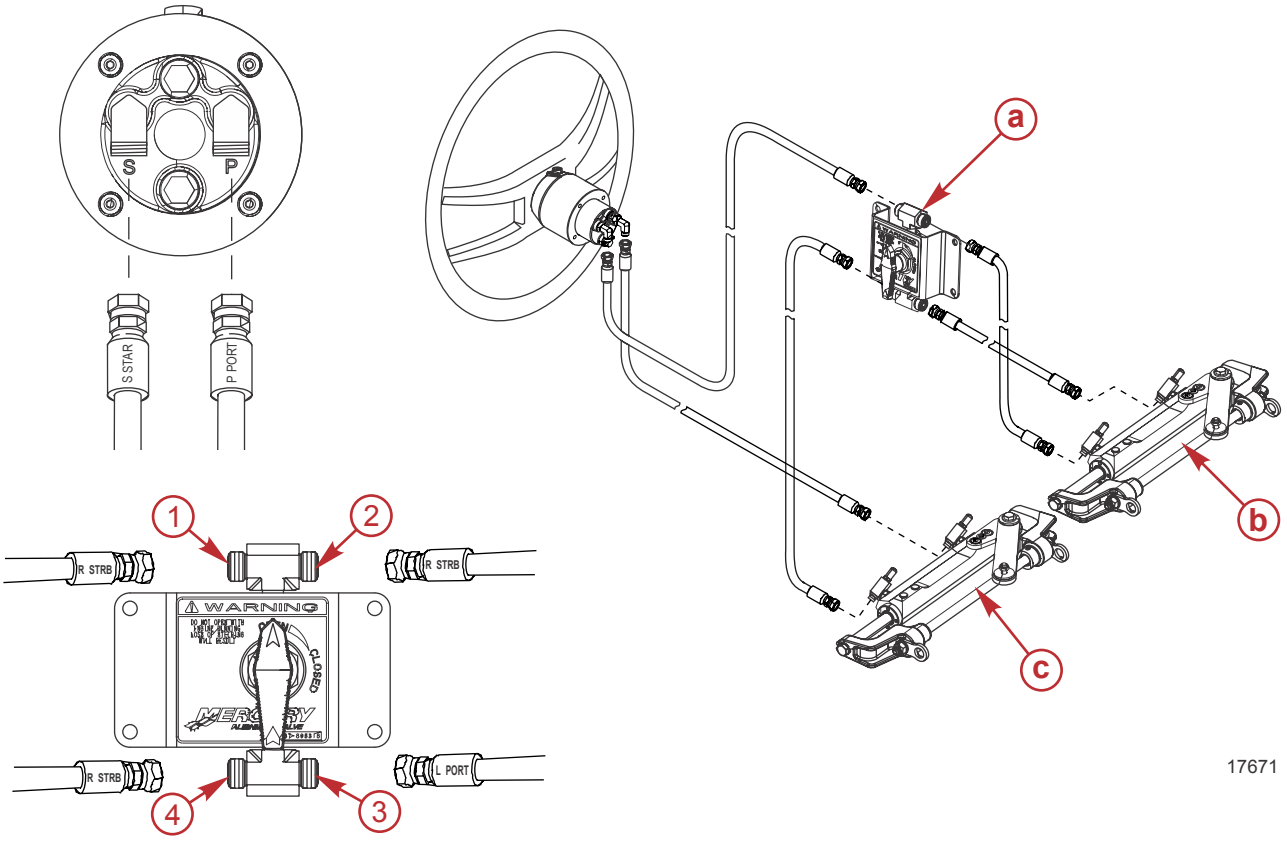
Tie Bar Valve Fitting ID	Hose ID Mark	Description
1	R STRB	Hose connects to R fitting on steering helm
2	R STRB	Hose connects to port side fitting on starboard steering cylinder
3	L PORT	Hose connects to starboard side fitting on starboard steering cylinder
4	R STRB	Hose connects to port side fitting on port steering cylinder

5. Open the tie bar valve.
6. Fill the 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	92-858077K01

CMS Models 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 the hydraulic hoses to the steering helm following the instructions which accompany the steering helm.
4. Connect the 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 the steering system with Hydraulic Helm Steering Fluid. Follow the filling instructions provided with the steering helm. Complete the bleeding instructions following.

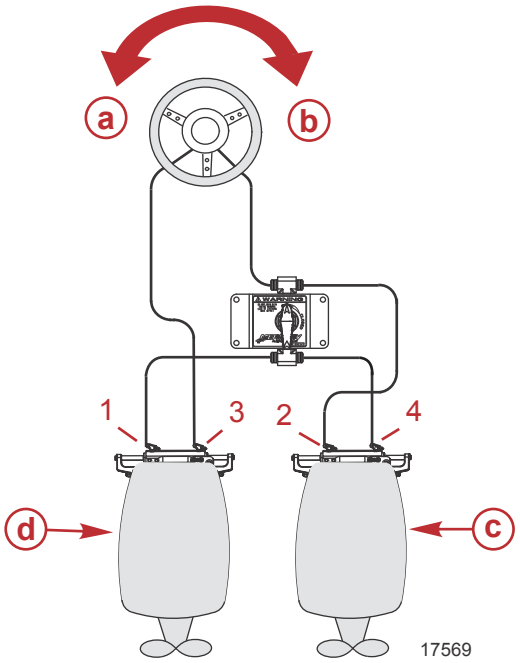
Fluid Type	Capacity	Mercury Part Number
Hydraulic Helm Steering Fluid	1–2 liter (1–2 US qt) depending on length of steering hoses	92-858078Q01

Bleeding Instructions

1. On models with power steering, 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 the power steering fluid into a different container, this will only be pumping fluid out of the system that was just filled up.*

3. Turn the 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 the steering wheel to starboard until an air free stream of fluid comes from the 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 the steering wheel to starboard until an air free stream of fluid comes from the fitting. Close bleed fitting 2.
5. Open bleed fitting 3. Turn the steering wheel to port until an air free stream of fluid comes from the fitting. Close bleed fitting 3.
6. Turn the 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 the 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.

Realignment Instructions

During normal usage, it is possible for the outboards to become misaligned. Outboard alignment should be checked before each use.

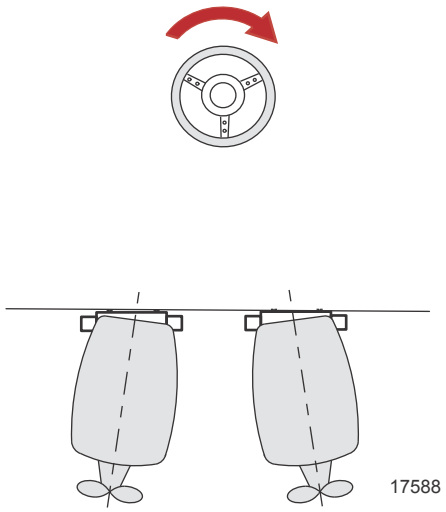
If misalignment occurs, complete the following steps to realign.

Propellers too Far Apart

1. On models with power steering, 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. The 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.



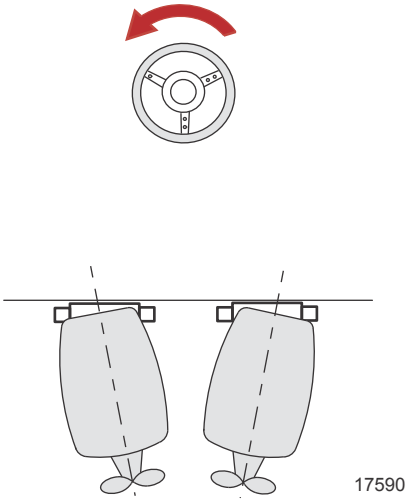
Propellers too Close Together

1. On models with power steering, 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. The 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.



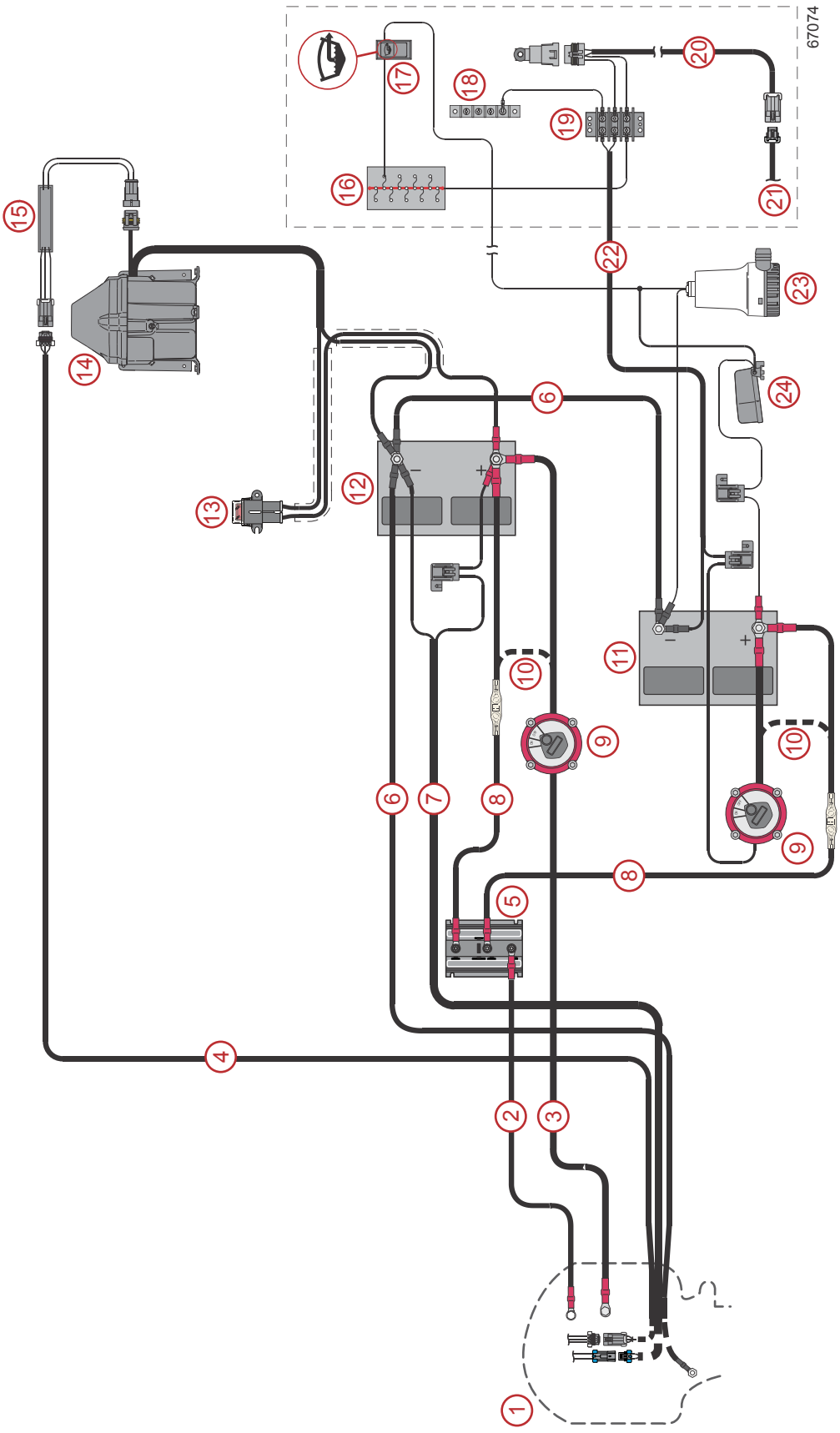
Notes:

Steering

Section 7D - Power Steering Wiring Diagrams

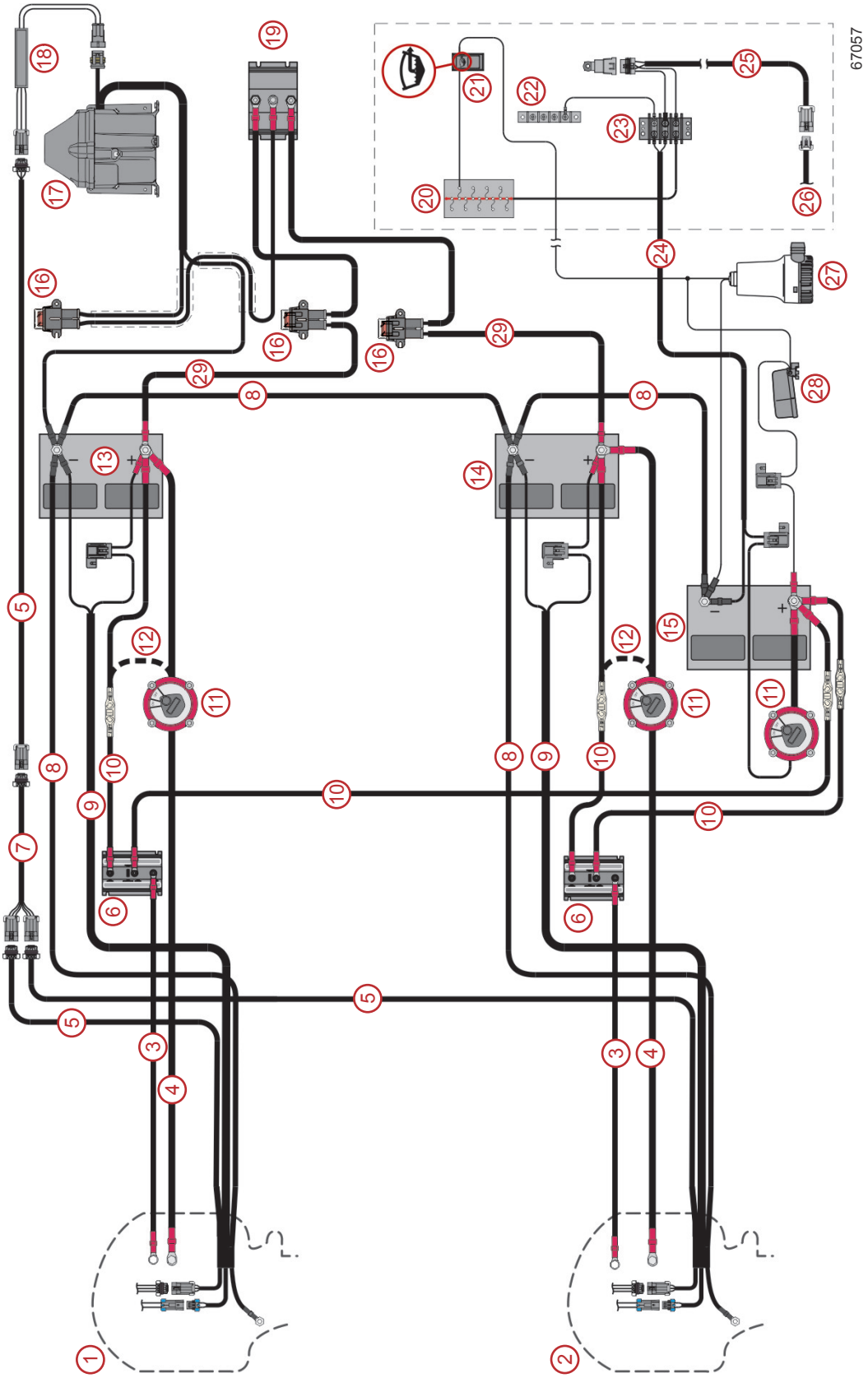
Table of Contents

Single-Engine Battery Architecture Diagram



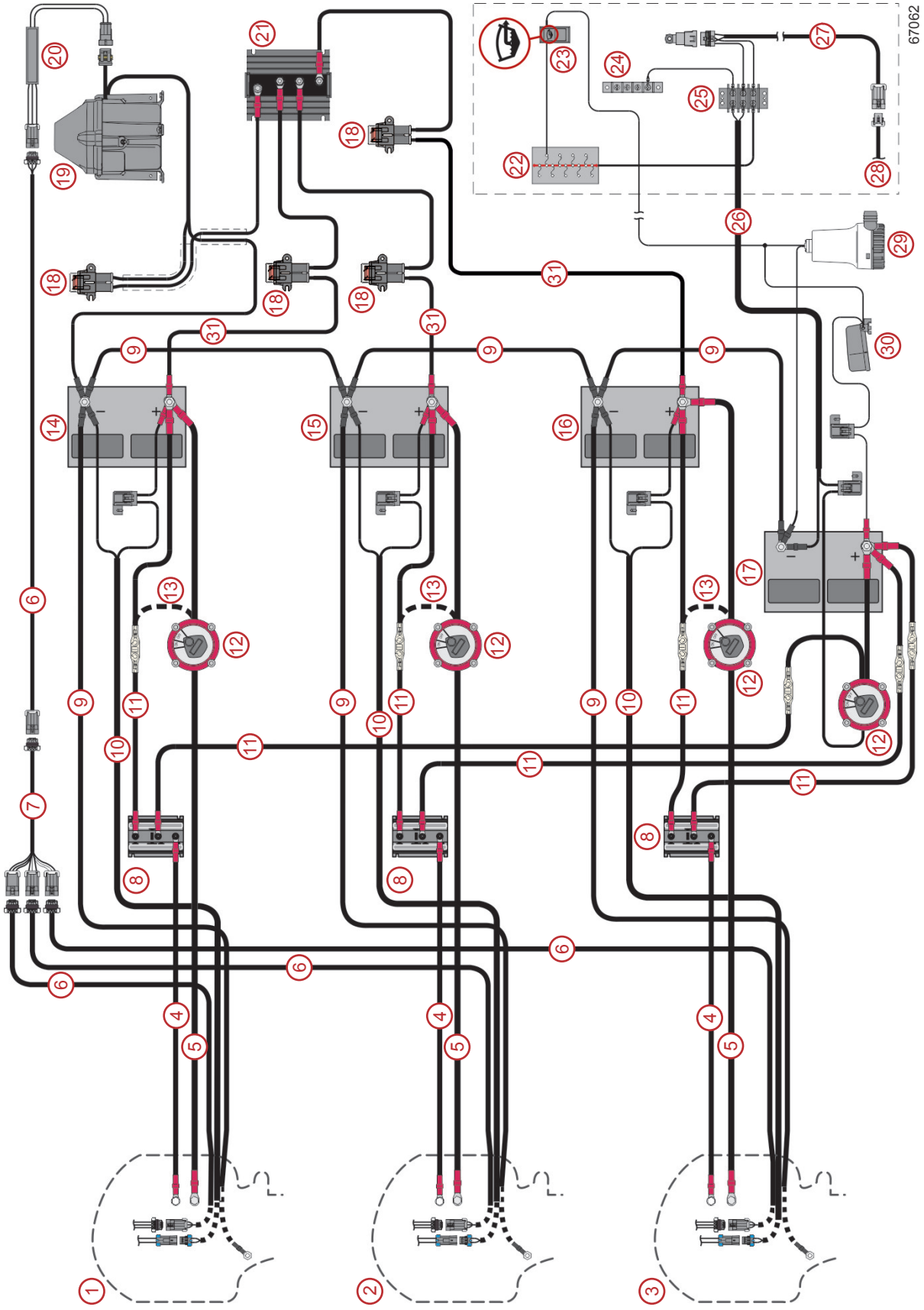
1 - Engine
2 - Alternator wire
3 - Positive battery cable
4 - Power steering signal harness
5 - Battery isolator
6 - Negative battery cable
7 - Clean power harness
8 - Fused harness
9 - Battery switch
10 - Alternate connection option
11 - Auxiliary battery
12 - Starting battery
13 - 60-amp maxi fuse
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 Battery Architecture Diagram



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 - Clean 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 - 60-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 60-amp maxi fuse

Triple-Engine Battery Architecture Diagram



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 - Clean 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 - 60-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 60-amp maxi fuse

Notes:

Steering

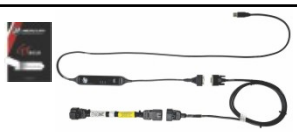
Section 7E - Tiller Handle

Table of Contents

Lubricants, Sealants, Adhesives

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	Positive terminal wire connections	92- 25711 3
		8 mm bolt terminal wire connections	
81	Anti-Seize Compound	Threads of the high-strength 3/8 in. x 1.375 in. bolt and locknut	92-898101389
		Threads of the tie rod and the locknut	
		Threads on the tie rod and locknut	
		Threads of the high strength 3/8 in. x 1-3/8 in. bolt and locknut	
95	2-4-C with PTFE	Shift and throttle cables	92-802859A 1
		Port side O-ring in the tilt tube	
138	Synthetic Power Steering Fluid SAE 0W-30	Capacity of 1–2 L (1–2 US qt)	92-858077K01

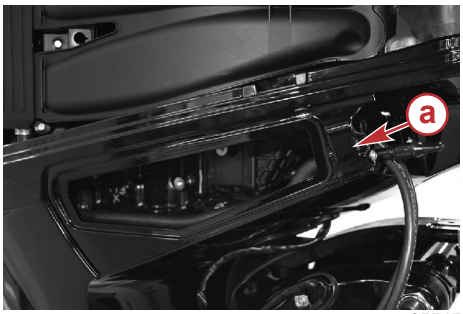
Special Tools

CDS G3 Interface Kit	8M0138392
 66165	CDS G3 License Key, Interface, Adapter, and Harness

Power Steering Module Primer Kit	91-895040K01
 5547	Bleeds power steering system without running engine.

Mounting the Tiller Handle

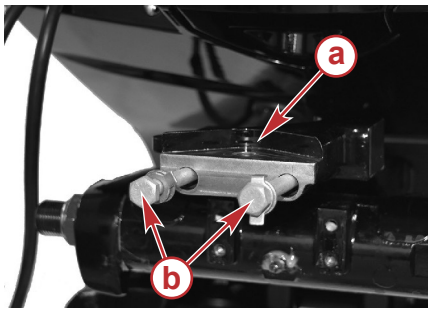
1. Remove the side access panel from the midsection cowl by pulling out the retaining pin.



65545

a - Retaining pin location

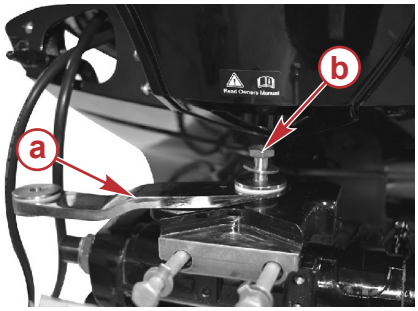
2. Install the tiller adapter spacer onto the steering arm using the two 5/16 x 5 in. screws. Turn the two 5/16 x 5 in. screws several turns into the steering arm.



65547

a - Adapter spacer
b - 5/16 x 5 in. screws

3. Apply a generous coating of Anti-Seize Compound on the threads of the high-strength 3/8 in. x 1.375 in. bolt and locknut. Position the power steering link arm on the adapter spacer with the 'T' imprint facing up. Install the high-strength bolt and locknut. Secure the high-strength bolt finger-tight at this time.

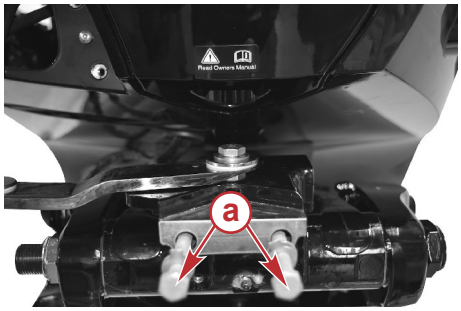


65550

a - Power steering link arm
b - High-strength 3/8 in. x 1.375 in. bolt

Tube Ref No.	Description	Where Used	Part No.
81	Anti-Seize Compound	Threads of the high-strength 3/8 in. x 1.375 in. bolt and locknut	92-898101389

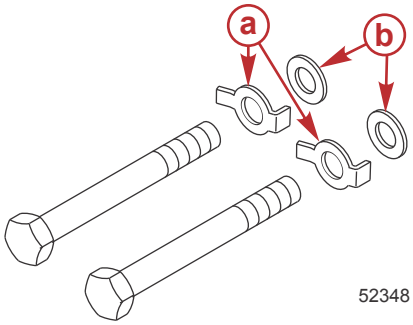
4. Remove the two 5/16 x 5 in. screws.



65551

a - 5/16 x 5 in. screws

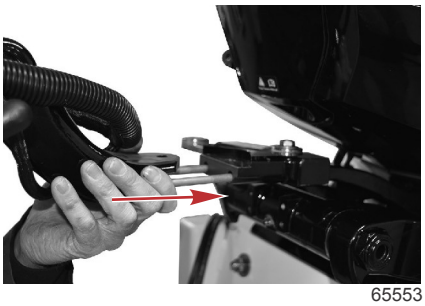
5. Place the tab washers and the flat washers onto the two 5/16 x 5 in. screws.



52348

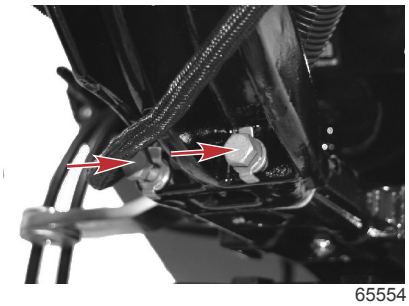
a - Tab washers
b - Flat washers

6. Insert the two 5/16 x 5 in. screws, tab washers, and flat washers into the Big Tiller assembly. Slide the Big Tiller assembly toward the adapter spacer on the outboard.



65553

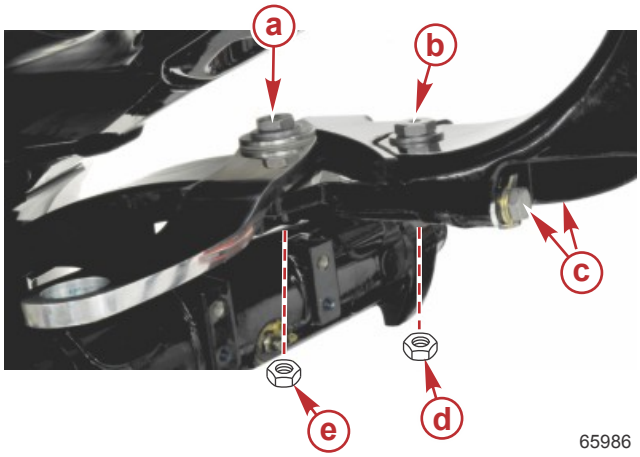
7. Finger-tighten the two 5/16 x 5 in. screws.



65554

8. Tighten all the fasteners to the specified torque, and in the sequence shown in the following table.

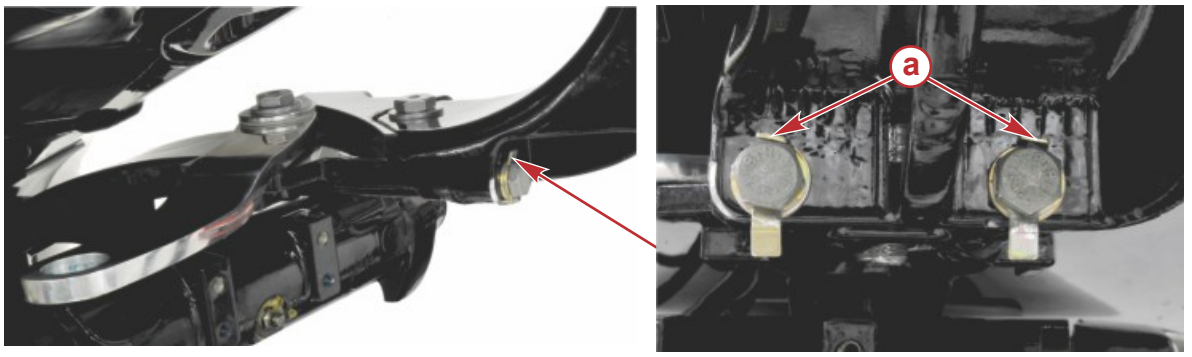
Torque Sequence Table



65986

Description	Nm	lb-in.	lb-ft
Step 1 - Tighten bolts "a" and "b" finger-tight	Finger-tight		
Step 2 - Tighten screws "c" to the first torque setting	7	62	–
Step 3 - Tighten bolts "a" and "b" to the specified torque	61	–	45
Step 4 - Tighten screws "c" to the final specified torque	30	–	22
Step 5 - Tighten locknuts "d" and "e" to the specified torque	20	177	–

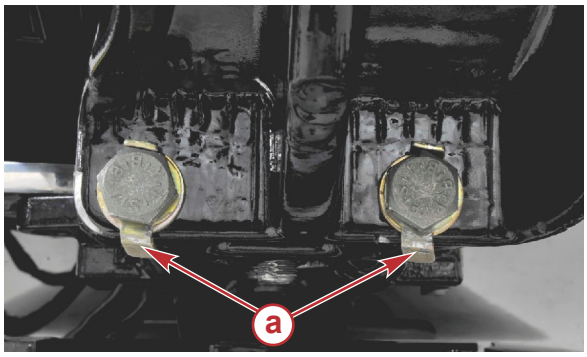
9. Bend the upper locking tabs of the washers against the heads of the two screws.



65988

a - Locking tabs

10. Bend the lower locking tabs of the washers against the bottom of the tiller arm assembly.

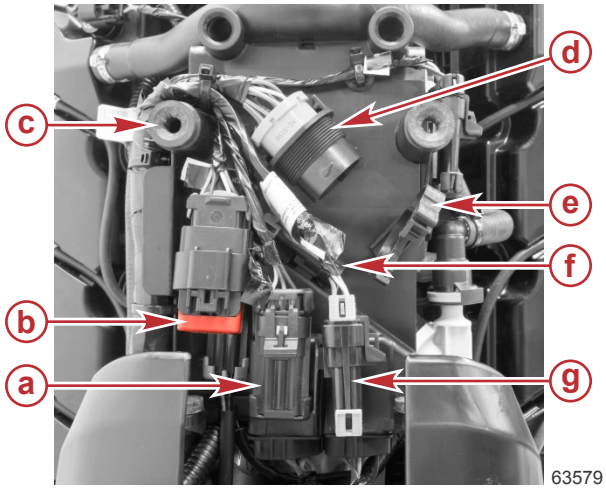


65989

a - Lower locking tabs

Harness Connections on the Engine

1. Remove the electrical panel cover.
2. Remove the weather caps from the boat harness connector and the power steering connector, if applicable.



63579

Electrical connections

a - 3-pin optional power steering harness connector

b - 10-pin CAN terminator

NOTE: *Remove only if an optional network cable or device is being connected. Refer to the instruction sheet accompanying the device or cable.*

c - Electrical panel cover grommet (one of four)

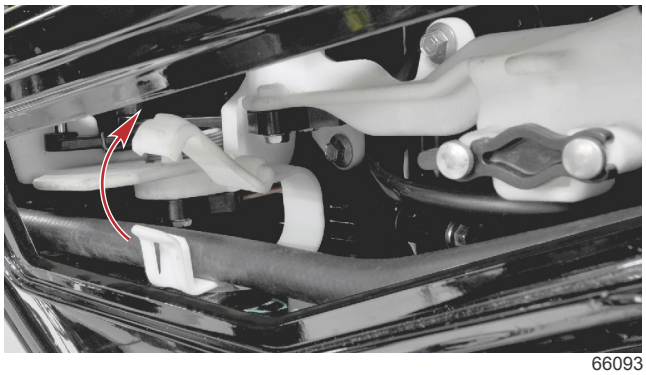
d - 14-pin connector

e - Ring clip for 14-pin data harness (one of two)

f - 2-pin clean power harness connector (behind power steering connector wires)

g - 6-pin boat harness connector with weather cap

3. On mechanical models, unlatch and open the cable keeper.



66093

Rigging the Engine

IMPORTANT: Leave sufficient slack in wiring harnesses, battery cables, and hoses that are routed between the rigging grommet and engine attachment points, to relieve stress and prevent hoses from being kinked or pinched.

Rigging Tube and Rigging Adapter

IMPORTANT: The use of the supplied rigging adapter, rigging grommet, and rigging tube is mandatory.

1. Thread the rigging tube into the rigging adapter in a counterclockwise direction.

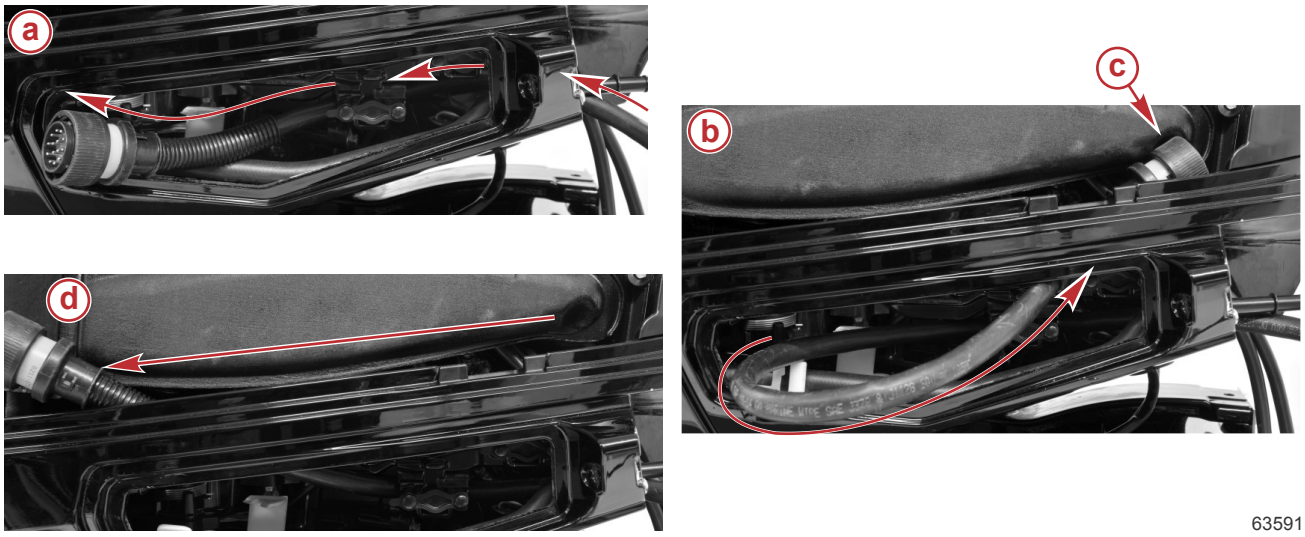
66018

2. Ensure that all applicable items are routed through the rigging tube and the rigging adapter, allowing enough slack to make the connections on the engine:
   - Battery cables
   - 14-pin data harness—provided with tiller handle
   - 2-pin clean power harness
   - 3-pin power steering harness. Refer to **Power Steering Pump Wiring and Battery Connections**.
   - Alternator output extension cable. Refer to **Accessory Battery and Battery Isolator Installation**.
   - 10-pin network device harness—optional; see device instruction sheet
   - 6-pin boat harness—optional; see device instruction sheet
   - Fuel line
   - Throttle and shift cables—mechanical engines only

Harness Connections

1. Route the 14-pin data harness to the rear of the engine. On mechanical models:
   a. Feed the connector through the inboard side of the ingress, route the harness behind the throttle bracket, and pull the connector out through the rigging access hole.
   b. Turn the connector back to the front of the engine, making a loop, and feed the connector back up by the intake runners.
   c. Pull the harness up past the notch in the lower intake runner.

d. With the connector above the top of the lower cowling, pull the harness around the engine until the connector has reached the electrical panel.

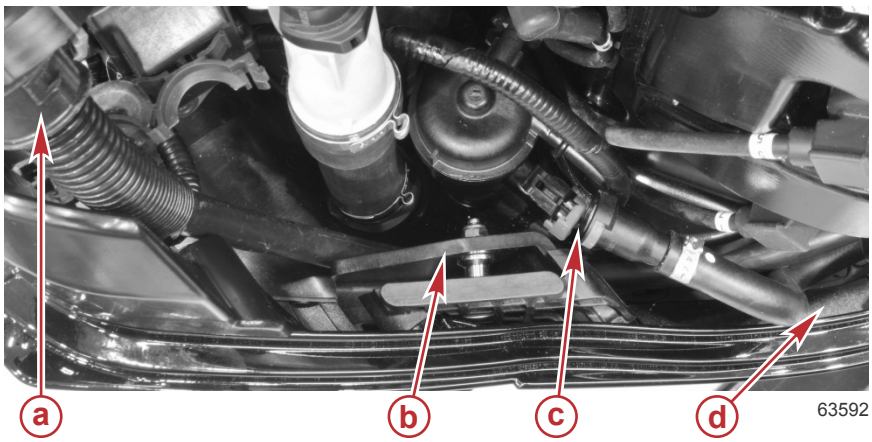


a - Feed the harness through the ingress, behind the throttle bracket, and out the rigging access hole
b - Loop the harness and feed it up by the intake runner
c - Notch in the intake runner
d - Pull the harness rearward

2. Route the 14-pin data harness to the electrical panel.

   IMPORTANT: There may be some residual fuel in the fuel line. Be certain to capture and properly dispose of any spilled fuel.

   a. Disconnect the fuel line from the fuel filter, and route the harness beneath the fuel line.
   b. Ensure that the harness lies beneath the throttle bracket, passes through the cable keeper (mechanical models), and passes below the cowl latch.



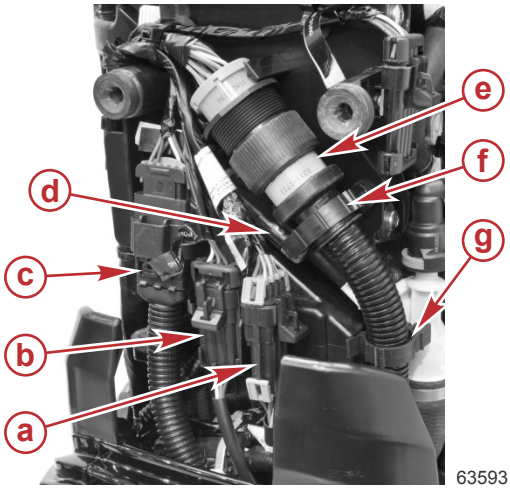
a - 14-pin data harness connector
b - Cowl latch
c - Fuel line disconnected at fuel filter
d - 14-pin data harness routed from rigging ingress

3. Connect the 14-pin data harness. Secure the harness with the two ring clips.

   NOTE: *On some models, it may be necessary to pull a little extra slack to make the connection. Be certain to remove the slack after the harness is secured.*

4. Reconnect the fuel line.
5. Route the remaining harnesses to the rear of the engine and connect to the appropriate engine harness connectors. It is easiest to route the harnesses according to connector size, from largest to smallest:
   a. 10-pin harness, if required
   b. 6-pin boat harness
   c. Optional 3-pin power steering harness

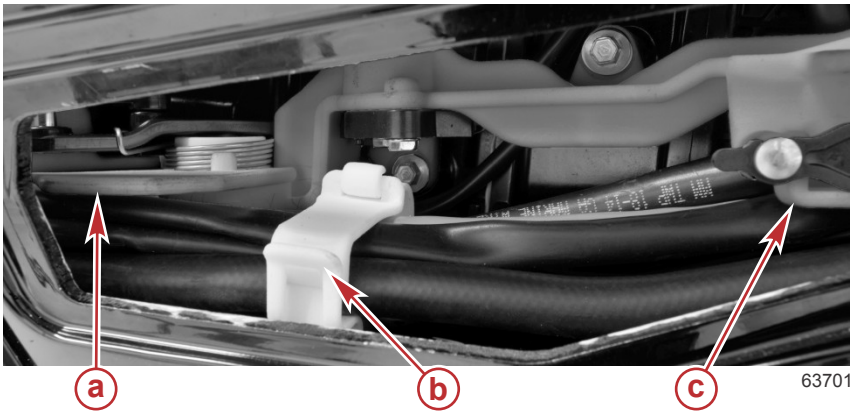
d. 2-pin clean power harness



Electrical connections

- **a -** 6-pin boat harness
- **b -** 3-pin power steering harness—optional
- **c -** 10-pin harness for network cable or device; see instruction sheet
- **d -** 2-pin clean power harness
- **e -** 14-pin data harness
- **f -** Large ring clip
- **g -** Small ring clip

6. Ensure that the cable keeper is closed and latched.



Some items shown lighter than actual coloring, for clarity

- **a -** Throttle arm guard—part of the throttle bracket
- **b -** Cable keeper latch
- **c -** Throttle bracket

IMPORTANT: When routing and connecting the harnesses:

- **On mechanical models, all harnesses must route behind or beneath the throttle and shift brackets.**
- **On mechanical models, all harnesses must route through the cable keeper. Keeping the fuel hose and 14-pin data harness toward the outside edge allowing the smaller harnesses to easily tuck under components.**
- **All harnesses must route beneath the rear cowl latch.**
- **As each connection is made, secure it to the appropriate tab on the electrical panel.**

Harness Connections - DTS Models

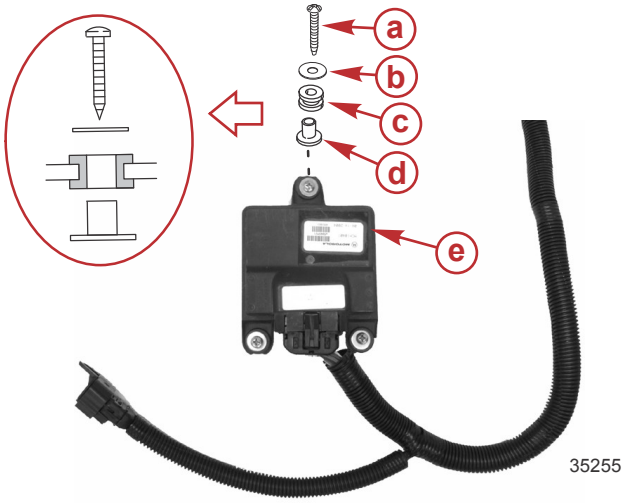
Command Module Installation and Harness Connection

⚠ 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.

1. Plug the command module connector into the command module. Make sure that the connector locks into place.
2. To minimize vibration, mount the command module with the supplied rubber grommets and bushings according to the following guidelines:
   - Mount in an area that is accessible from inside the boat.
   - Mount in an area where the wiring connections will not be stepped on or disturbed.
   - Mount in an area that stays relatively dry.
   - Mount with the connector on the command module facing downward (as shown below).
   - Fasten the command module harness to prevent flexing at the command module connection.

IMPORTANT: Avoid sharp bends in the cable. The minimum bend radius should be 76.2 mm (3 in.).

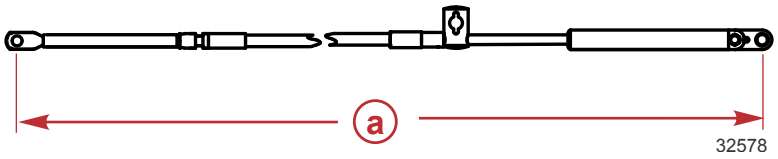


- **a -** Screw
- **b -** Washer
- **c -** Grommet
- **d -** Bushing
- **e -** Command module

Shift and Throttle Cable Installation onto the Tiller Handle

Cable Lengths

Refer to the following chart to determine the correct cable lengths.

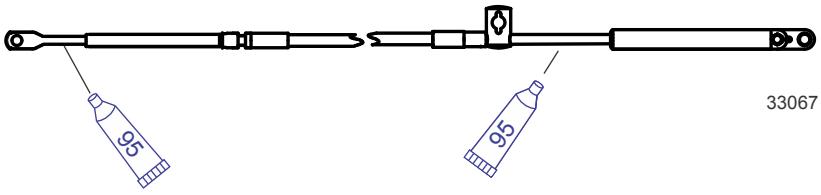


- **a -** Cable length

Cable Lengths			
Model	**Shift cable length**	**Throttle cable length**	**Kit (part number) containing both shift and throttle cables**
CMS models	889 mm (35 in.)	889 mm (35 in.)	8M0141907

Cable Installation

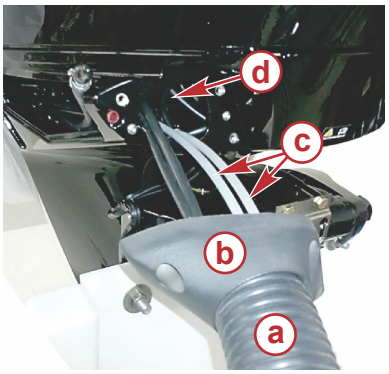
1. Lubricate the shift and throttle cables with 2-4-C with PTFE.



Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Shift and throttle cables	92-802859A 1

2. Remove the lower cover from the tiller handle assembly.

3. Route the engine end of both the throttle and shift cables through the rigging tube and into the ingress opening in the lower cowl.



66021

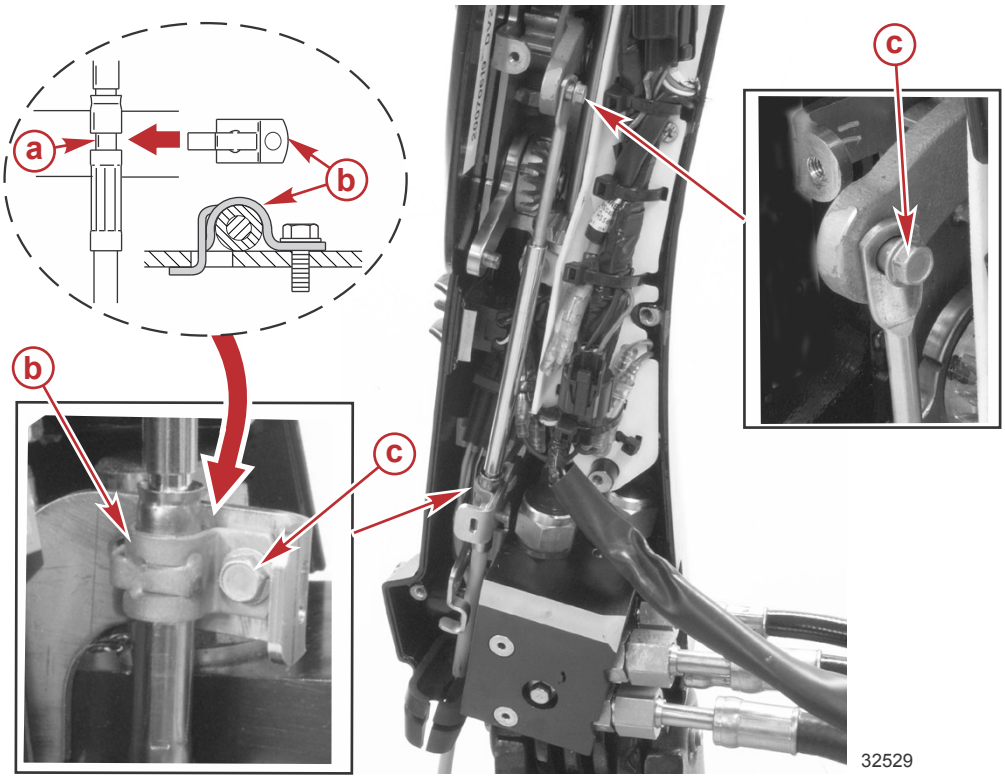
a - Rigging tube
b - Rigging adapter
c - Throttle and shift cables
d - Ingress opening

4. Secure the end of the shift cable to the shift lever pin with a screw. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Shift lever pin screw	2.8	24.8	–

5. Hook the cable clamp into the mounting bracket. Align the retaining groove on the shift cable with the flat on the cable clamp, and fasten the shift cable with the cable clamp and screw. Tighten the screw to the specified torque.

Description	Nm	lb-in.	lb-ft
Cable clamp screw	2.8	24.8	–



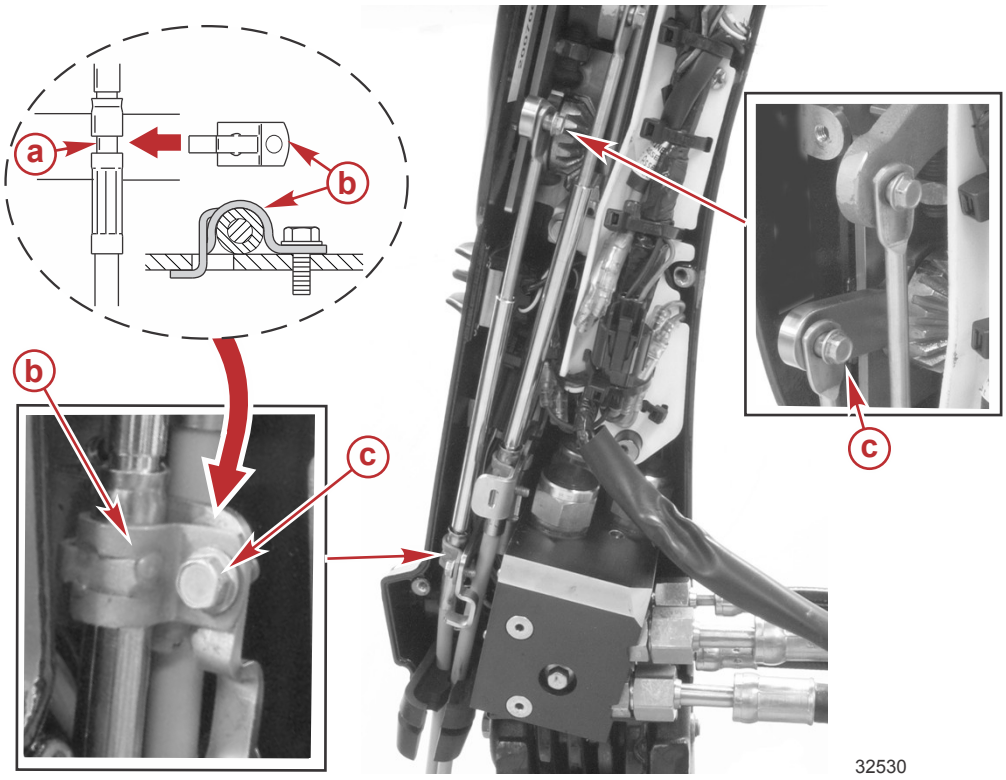
32529

a - Shift cable retaining groove
b - Cable clamp
c - Screw

Description	Nm	lb-in.	lb-ft
Cable clamp screw	2.8	24.8	–

6. Secure the end of the throttle cable to the throttle lever pin with a screw. Tighten the screw to the specified torque.

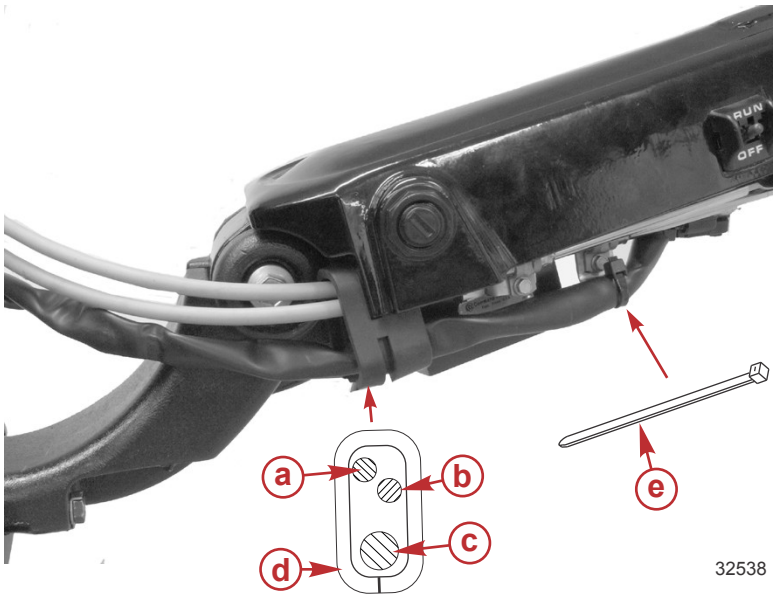
7. Hook the cable clamp into the mounting bracket. Align the retaining groove on the throttle cable with the flat on the cable clamp, and fasten the throttle cable with the cable clamp and screw. Tighten the screw to the specified torque.



a - Throttle cable retaining groove
b - Cable clamp
c - Screw

Description	Nm	lb-in.	lb-ft
Cable clamp screw	2.8	24.8	–

8. Place the cables and wiring harness into the rubber grommet, as shown.
9. Fasten the tiller handle 14-pin wiring harness to the mounting bracket with a cable tie.



a - Throttle cable
b - Shift cable
c - Tiller handle 14-pin wiring harness
d - Rubber grommet
e - Cable tie

10. Install the bottom cover. Tighten the eight cover screws securely, do not overtighten the screws.

Bottom cover screw locations

11. Route the throttle and shift cables through the rigging tube. The throttle cable must be secured to the engine before the shift cable is secured to the engine.

Throttle and Shift Cable Installation onto the Engine - Mechanical Models

Throttle Cable Installation

With the throttle cable inside the engine cowl:

1. Remove the rigging access panel, if installed.
2. Rotate the tiller handle grip to the start/shift position marked on the grip decal.
3. Install the throttle cable onto the throttle arm anchor pin and secure with the anchor pin latch.
4. Adjust the cable barrel so that the installed throttle cable will hold the throttle arm at idle stop (fully rotated rearward).
5. Place the cable barrel into the barrel retainer.
6. Lock the cable in place with the anchor pin latch.
7. Press on the anchor pin latch to ensure that the anchor pin latch locks onto the bracket.

Some items shown lighter than actual coloring, for clarity

a - Throttle arm
b - Anchor pin latch
c - Cable barrel
d - Cable latch (rotate clockwise to lock)

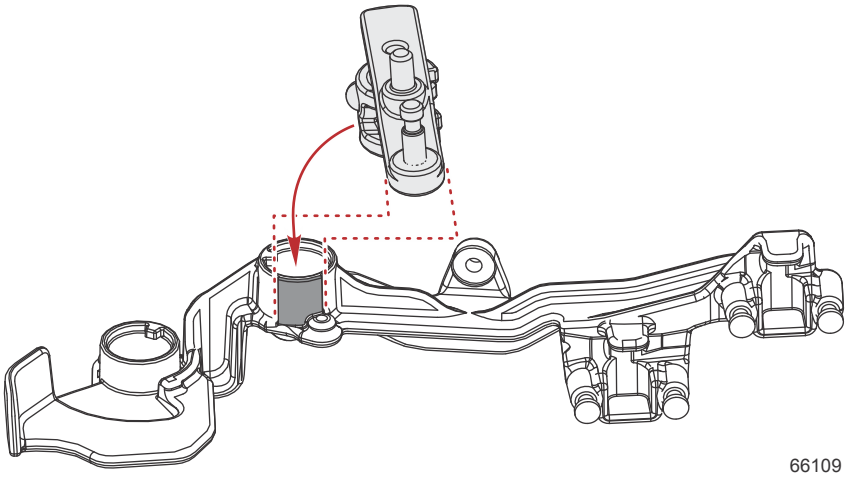
8. Pull up on the throttle cable near the cable latch to confirm the cable latch has locked onto the bracket.

Shift Cable Installation

With the shift cable inside the engine cowl:

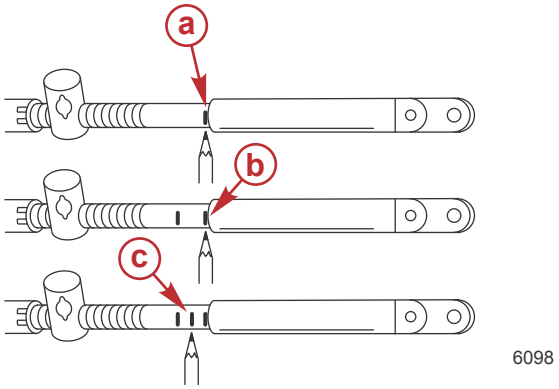
1. Position the shift mechanism on the outboard into the neutral position.

2. Center the shift cable anchor pin with the neutral detent alignment mark.



Parts removed and separated for clarity

3. Locate the center point of the slack or lost motion that exists in the shift cable as follows:
   a. Move the gear shift handle from neutral into forward. Slowly return the handle to the neutral position. Place a mark "a" on the cable against the cable end guide.
   b. Move the gear shift handle from neutral into reverse. Slowly return the handle to the neutral position. Place a mark "b" on the cable against the cable end guide.
   c. Make a center mark "c," midway between marks "a" and "b." Align the cable end guide against this center mark when installing the cable onto the engine.



4. Align the shift cable end guide with the center mark made in step 3. Place the shift cable on the anchor pin. Adjust the cable barrel so it slips freely into the barrel cup.
5. Secure the shift cable to the anchor pin with the shift cable retainer.

6. Lock the barrel in place with the cable latch retainer.

a - Anchor pin on shift arm (shown in neutral position with some components removed, for clarity)
b - Anchor pin latch
c - Shift arm (bottom view)
d - Cable barrel positioned in the barrel retainer
e - Cable latch (rotate clockwise to secure)

7. Pull up on the shift cable near the cable latch to confirm the cable latch has locked onto the bracket.

IMPORTANT: After the engine installation is complete and before commissioning the engine, check the shift cable adjustments with the key switch on, but the engine off, as follows:

1. **Place the gear shift handle into forward. The propeller shaft should be locked in gear. If not, adjust the barrel closer to the cable end.**
2. **Place the gear shift handle into neutral. The propeller shaft should turn freely without drag. If not, adjust the barrel away from the cable end, and repeat steps 1 and 2.**
3. **Place the gear shift handle into reverse while turning the propeller. The propeller shaft should be locked in gear. If not, adjust the barrel away from the cable end, and repeat steps 1 through 3.**
4. **Place the shift handle back to neutral. The propeller shaft should turn freely without drag. If not, adjust the barrel closer to the cable end, and repeat steps 1 through 4.**

Lever Adaptation - DTS Models

⚠ CAUTION

Avoid possible injury or equipment damage. Improper electronic calibration of the digital throttle and shift (DTS) system will make this control and/or the DTS system inoperable or unsafe. After installing this control, electronically calibrate the DTS system. Do not attempt any calibration unless you have been specifically trained in Mercury Marine's DTS systems.

CDS G3

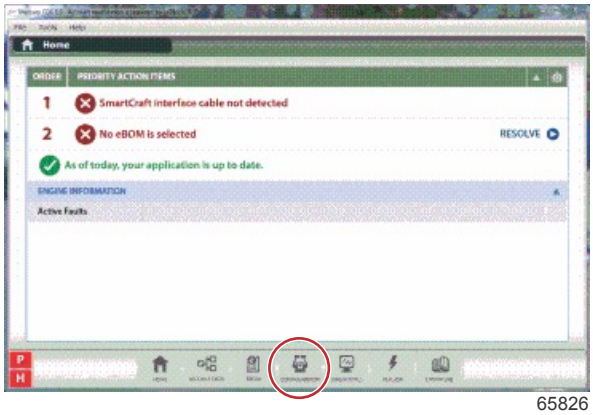
Connect the CDS G3 cable to the 10-pin connector on the rear of the engine.

CDS G3 Interface Kit	8M0138392

Navigation to the Lever Adapt Procedure

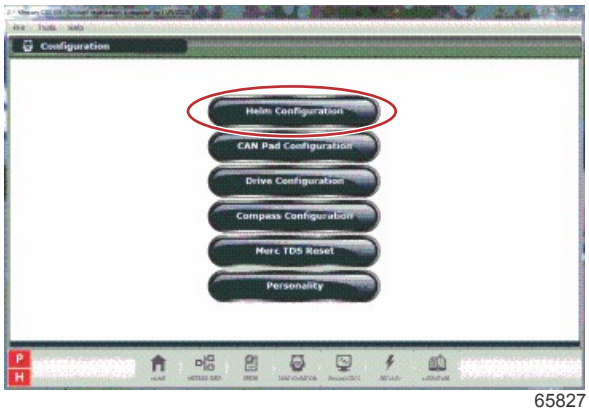
Navigate through the following selections to get to the Lever Adapt procedure.

1. From the CDS G3 home screen, select the Configuration Tab.



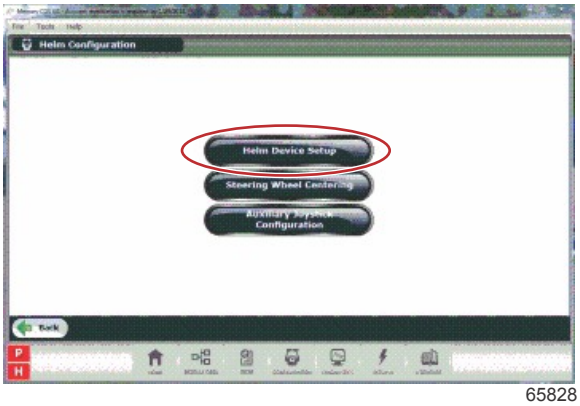
65826

2. In the Configuration screen, select the Helm Configuration option.



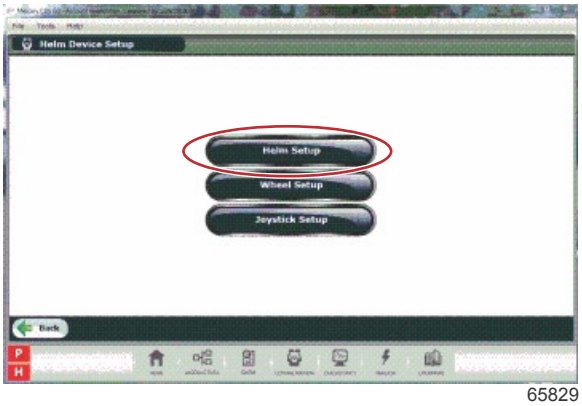
65827

3. In the Helm Configuration screen, select the Helm Device Setup option.



65828

4. In the Helm Device Setup screen, select the Helm Setup option.



65829

5. In the Helm Setup screen, select the Lever Adapt option.

66136

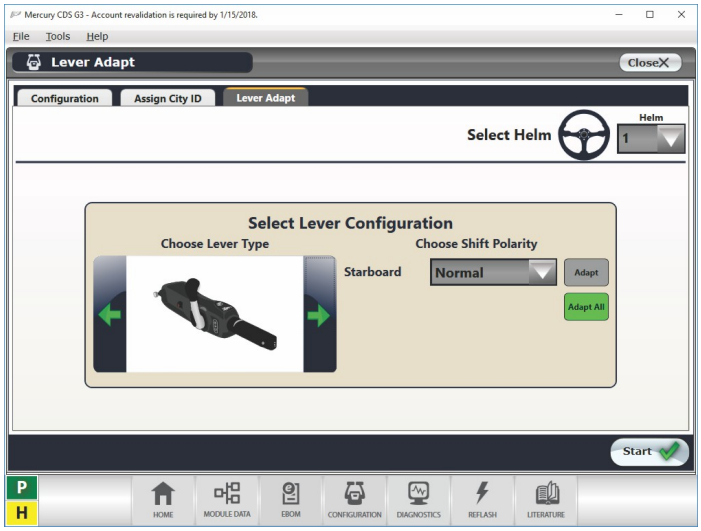
Lever Adapt Procedure

IMPORTANT: The key on the Big Tiller must be in the ON position with the engine not running to perform the Lever Adapt procedure.

1. Follow the on-screen instructions to choose the Big Tiller as the lever type.

65748

2. Once the Big Tiller selection is made, select Start.



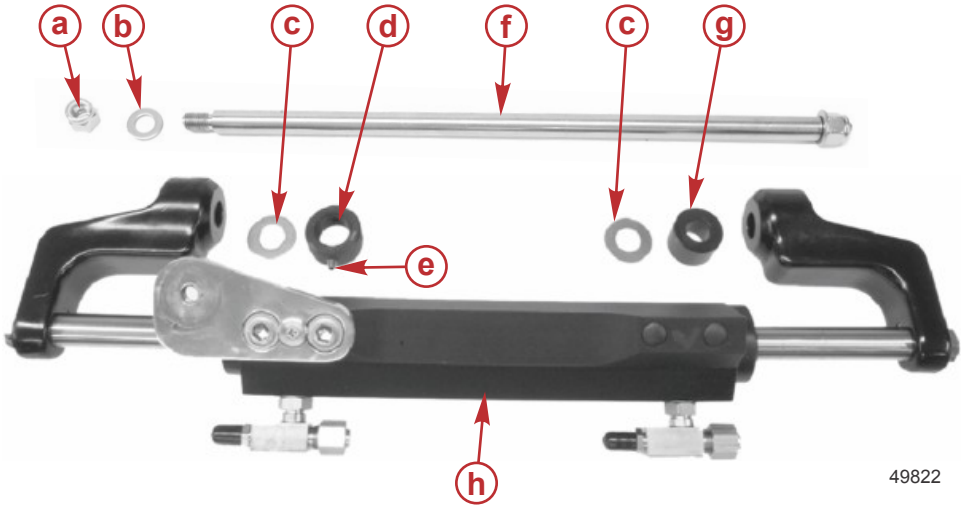
65749

3. Follow the on-screen instructions to complete the lever adapt procedure.

Power Steering

Installing the Steering Cylinder

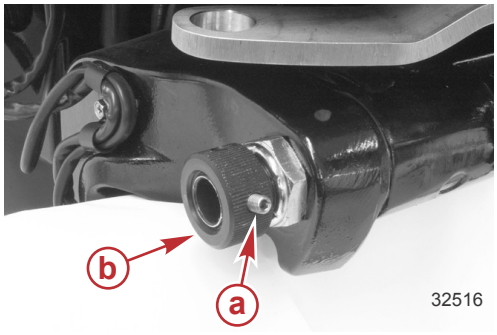
1. Locate the steering cylinder components.



49822

a - Locknut
b - Washer
c - Washer
d - Collar
e - Set screw
f - Tie rod
g - Spacer
h - Steering cylinder

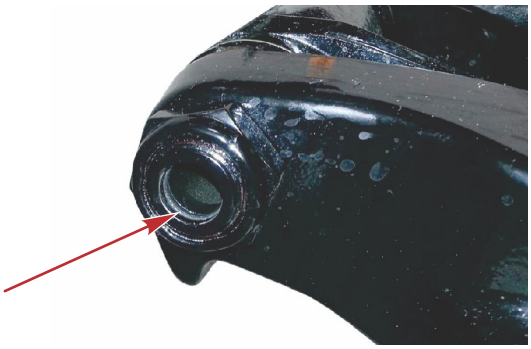
2. Thread the collar on the starboard end of the tilt tube. Do not tighten the set screw at this time.



32516

a - Set screw
b - Collar

3. Lubricate the O-ring located in the port side tilt tube with 2-4-C with PTFE.



66006

Tilt tube O-ring

Tube Ref No.	Description	Where Used	Part No.
95	2-4-C with PTFE	Port side O-ring in the tilt tube	92-802859A 1

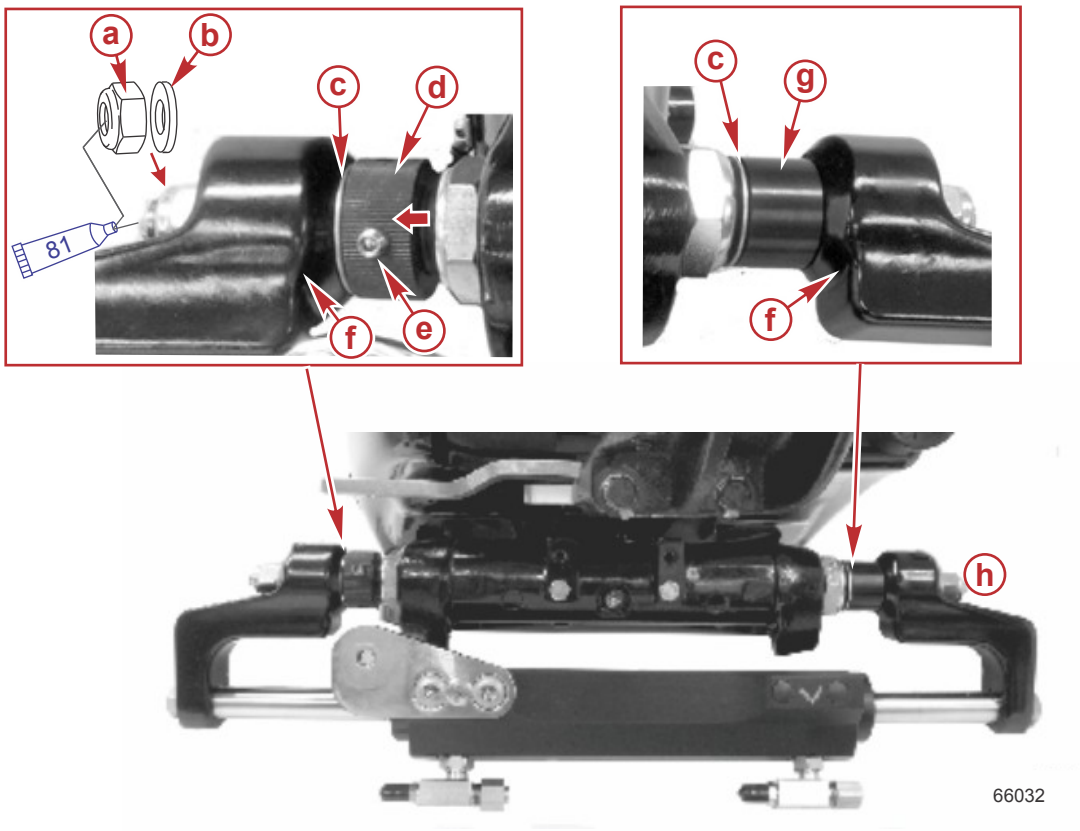
4. Apply a thin coating of Anti-Seize Compound to the threads on the tie rod, and locknut.

Tube Ref No.	Description	Where Used	Part No.
81	Anti-Seize Compound	Threads of the tie rod and the locknut	92-898101389

5. Install the steering cylinder to the outboard with the tie rod and locknut as shown. Tighten the locknuts onto the ends of the tie rod to the specified torque.

Description	Nm	lb-in.	lb-ft
Tie rod locknuts	88	–	64.9

6. Thread the collar against the washer to remove any play between the steering cylinder bracket and the washer. Tighten the set screw to the specified torque.



a - Locknut
b - Washer
c - Washer
d - Collar
e - Set screw
f - Steering cylinder bracket
g - Spacer
h - Tie rod

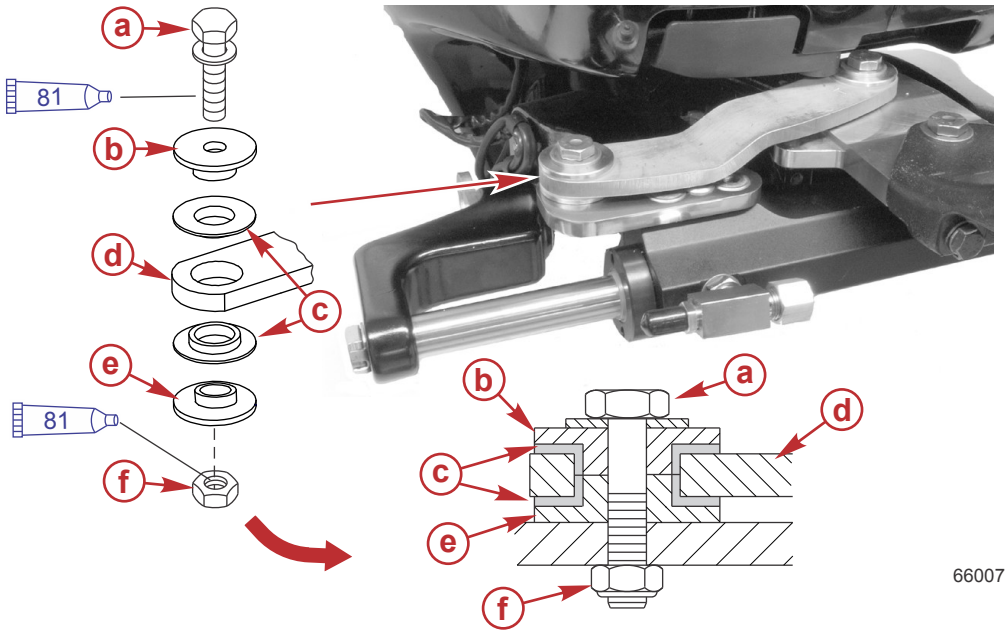
Tube Ref No.	Description	Where Used	Part No.
81	Anti-Seize Compound	Threads on the tie rod and locknut	92-898101389

Description	Nm	lb-in.	lb-ft
Set screw	9	79.6	–

7. Apply a thin coating of Anti-Seize Compound on the threads of the high strength 3/8 in. x 1-3/8 in. bolt and locknut.

Tube Ref No.	Description	Where Used	Part No.
81	Anti-Seize Compound	Threads of the high strength 3/8 in. x 1-3/8 in. bolt and locknut	92-898101389

8. Fasten the steering link arm to the power steering cylinder, as shown. Tighten the high strength 3/8 in. x 1-3/8 in. bolt and locknut to the specified torque.



- **a -** High strength 3/8 in. x 1-3/8 in. bolt and washer
- **b -** Stainless steel bushing - upper
- **c -** Nylon bushings
- **d -** Steering link arm
- **e -** Stainless steel bushing - lower
- **f -** Locknut

Description	Nm	lb-in.	lb-ft
Bolt	61	–	45
Locknut	20	177	–

Power Steering Pump Installation

Selecting a Location for the Power Steering Pump

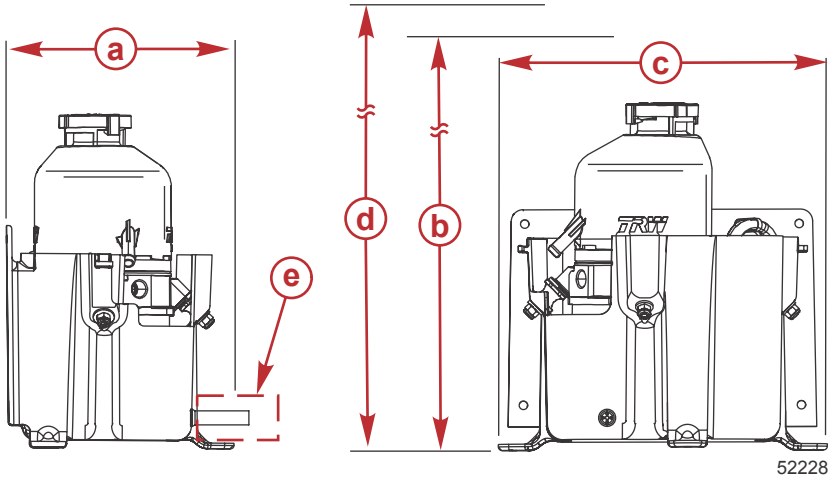
⚠ WARNING

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 for the power steering pump that meets the following requirements:

- Is on the floor, or the side of an internal bulkhead.
- Isolates the steering hoses from the hull with suitable non-abrasive hangers to reduce noise on aluminum or metal hulls.
- Is mounted no more than 15º from vertical.
- Is located so that the pump electrical wiring reaches the battery.
- Is mounted in an area that allows sound enclosure, cover removal, and easy access to the fill cap.
- Is not mounted in a location where the pump can fill with water.
- Is mounted in an area where bilge water will not contaminate the pump.
- Is mounted on a wood or fiberglass surface to reduce transmitted noise. Avoid mounting the pump on aluminum or steel surfaces.
- Has enough room to the side of the pump to allow for the proper installation of the hydraulic lines.

Required Mounting Clearances for the Power Steering Pump



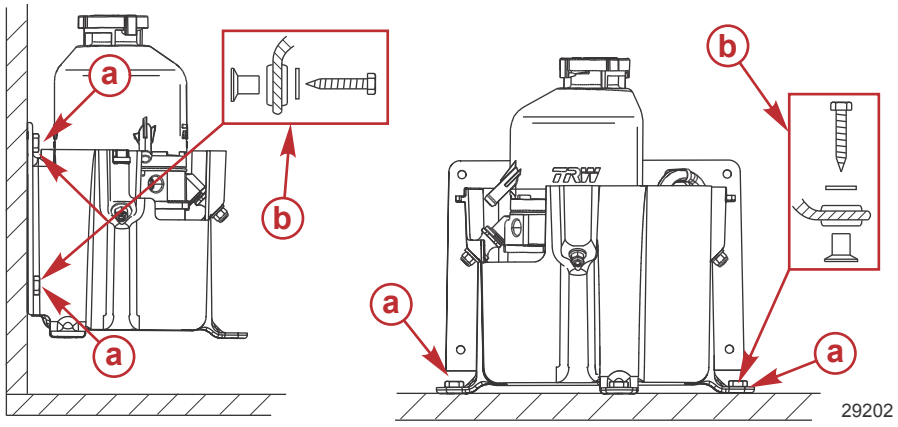
a - 215 mm (8-1/2 in.)
b - 310 mm (12-7/32 in.) to the top cover (not shown)
c - 285 mm (11-1/4 in.)

IMPORTANT: Leave enough room to the side of the pump to allow for the proper installation of the hydraulic lines.

d - 432 mm (17 in.) clearance required for cover removal
e - 76 mm (3.0 in.) clearance in front of the unit for proper operation of the drain

Installing the Power Steering Pump

Mount the power steering pump using fastening hardware suitable for the type of material and thickness of the mounting surface. Allow enough clearance in front of the pump unit for proper operation of the drain. Allow enough clearance to the side of the pump unit for the installation of the hydraulic lines.

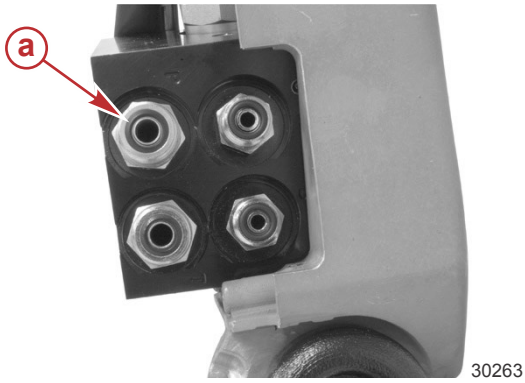


Mounted on the internal bulkhead **Mounted on the floor**

a - Lag screws or through bolts (3 or 4)
b - Mounting hardware

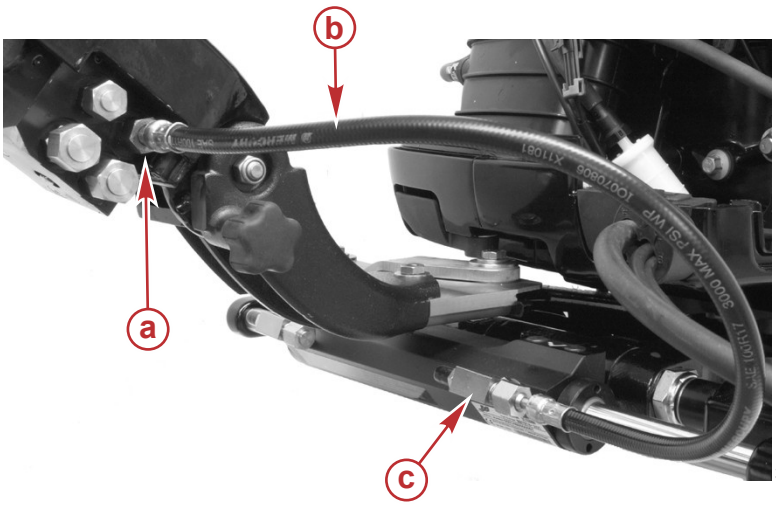
Hose Connections

1. Make sure the O-ring seal is in place on each tiller handle fitting when making the hose connection.



a - O-ring seals (4)

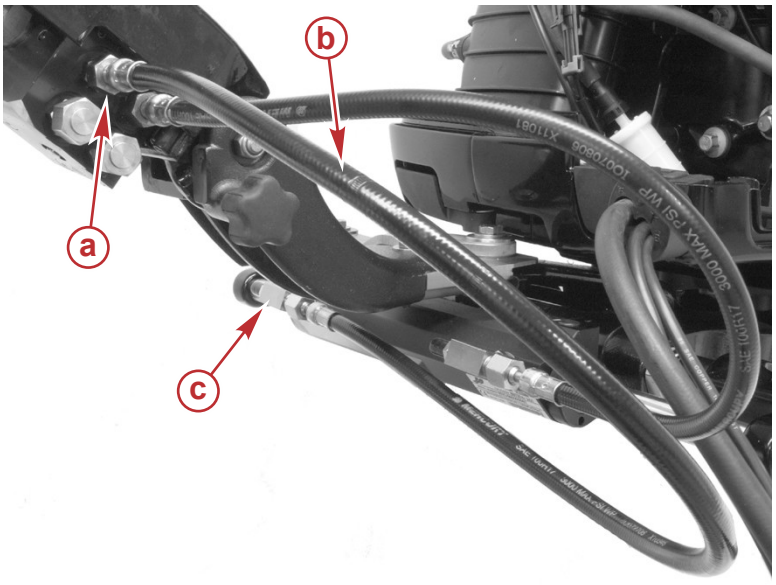
2. Connect the short hose between the top rear connection on the tiller handle and the port side connection on the steering cylinder.



32520

a - Top rear connection
b - Short hose
c - Port side connection

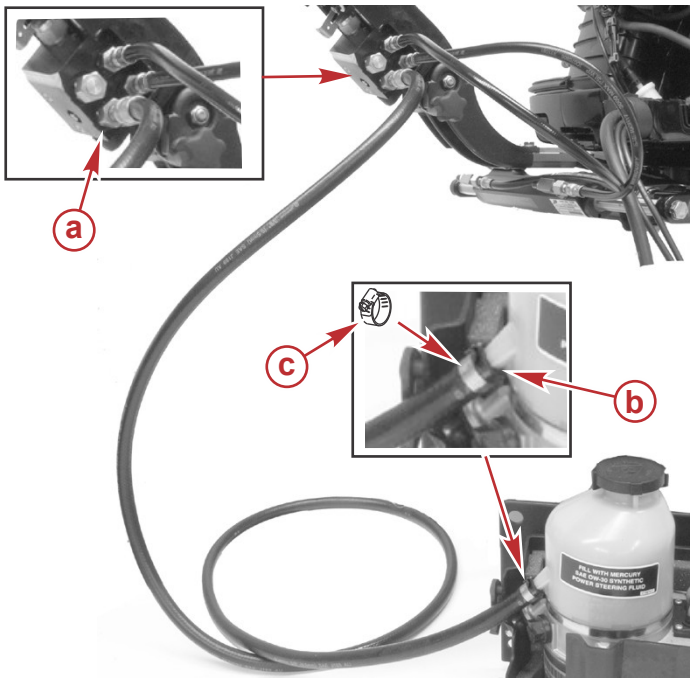
3. Connect the long hose between the top front connection on the tiller handle and the starboard side connection on the steering cylinder.



32522

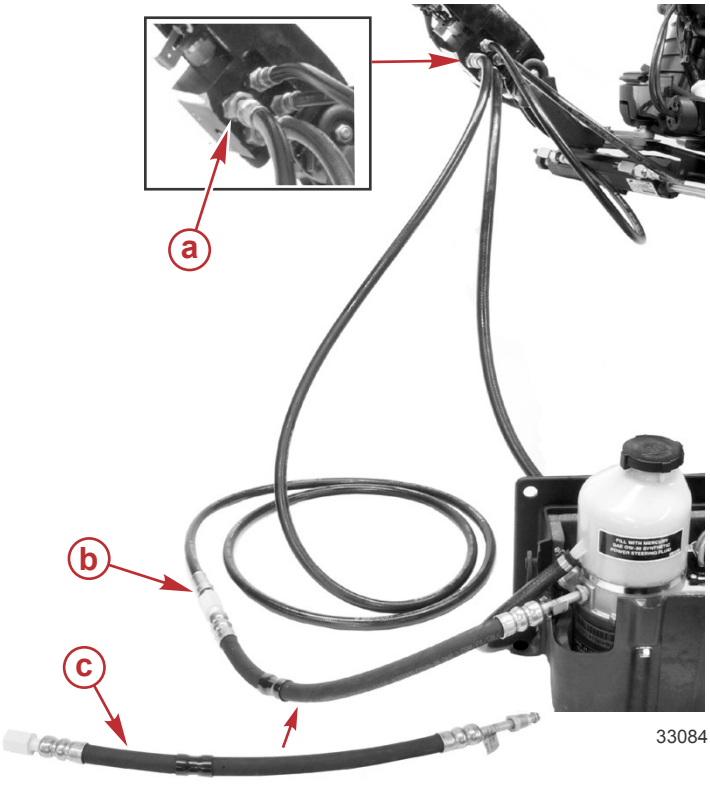
a - Top front connection
b - Long hose
c - Starboard side connection

4. Connect the low-pressure hose between the bottom rear fitting on the tiller handle and the low-pressure hose connection on the power steering pump. Fasten the hose to the fitting with a hose clamp.



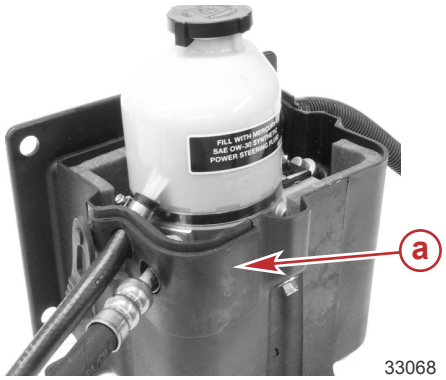
a - Bottom rear fitting
b - Low-pressure hose connection
c - Hose clamp

5. Connect the dampening hose to the power steering pump.
6. Connect the high-pressure hose between the bottom front fitting on the tiller handle and the dampening hose.



a - Bottom front fitting
b - High-pressure hose connection
c - Dampening hose

7. If removed, install the rubber grommet.



a - Rubber grommet

Wire Color Code Abbreviations

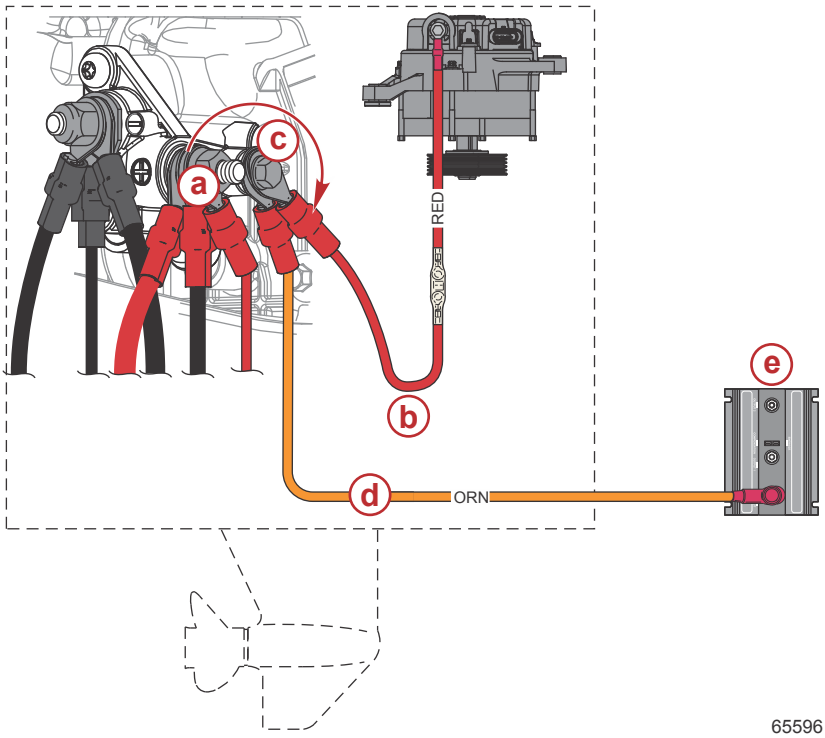
Wire Color Abbreviations				
BLK	Black		BLU	Blue
BRN	Brown		GRY or GRA	Gray
GRN	Green		ORN or ORG	Orange
PNK	Pink		PPL or PUR	Purple
RED	Red		TAN	Tan
WHT	White		YEL	Yellow
LT or LIT	Light		DK or DRK	Dark

Engine Wiring Changes - FourStroke CMS Models

IMPORTANT: For engines that are equipped with battery cables, disregard the battery cables supplied with the kit. For engines that do not have battery cables supplied, use the 366 cm (12 ft) 4 AWG supplied cables. Positive to positive, and negative to negative connections.

1. If connected, remove the battery cables from the battery.
2. Remove the alternator fused lead from the positive terminal. Attach the fused lead to the isolator terminal using the 8 mm bolt. Do not tighten the 8 mm bolt at this time as the alternator output extension cable will be added to this connection.
3. Clean the sealant from the positive terminal wire connections. Secure the wire connections to the positive terminal with the retained hex nut.

4. Seal the positive terminal wire connections with Liquid Neoprene.



- **a -** Positive terminal
- **b -** Alternator output lead
- **c -** 8 mm bolt terminal
- **d -** Alternator output extension cable—supplied in kit, 304.8 cm (10 ft)
- **e -** Battery isolator

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

Accessory Battery and Battery Isolator Installation

IMPORTANT: An accessory battery, battery isolator, and power steering signal module must be used on Digital Throttle and Shift models, as well as mechanical throttle and shift models. Failure to integrate an accessory battery, battery isolator, and a power steering signal module into the power steering electrical circuit will cause a significant delay in the initial starting operation of the power steering pump.

IMPORTANT: For engines that are equipped with battery cables, disregard the battery cables supplied with the kit. For engines that do not have battery cables supplied, use the 366 cm (12 ft) 4 AWG supplied cables. Positive to positive, and negative to negative connections.

Recommended Accessory Battery Rating

Recommended accessory battery rating	12 V AGM (absorbed glass mat) battery
Recommended USA (SAE) accessory battery rating	800 minimum MCA (marine cranking amps) with a minimum reserve capacity of 135 minutes RC25 rating
Recommended international (EN) accessory battery rating	975 minimum CCA (cold cranking amps) with a minimum of 65 amp hours (Ah)

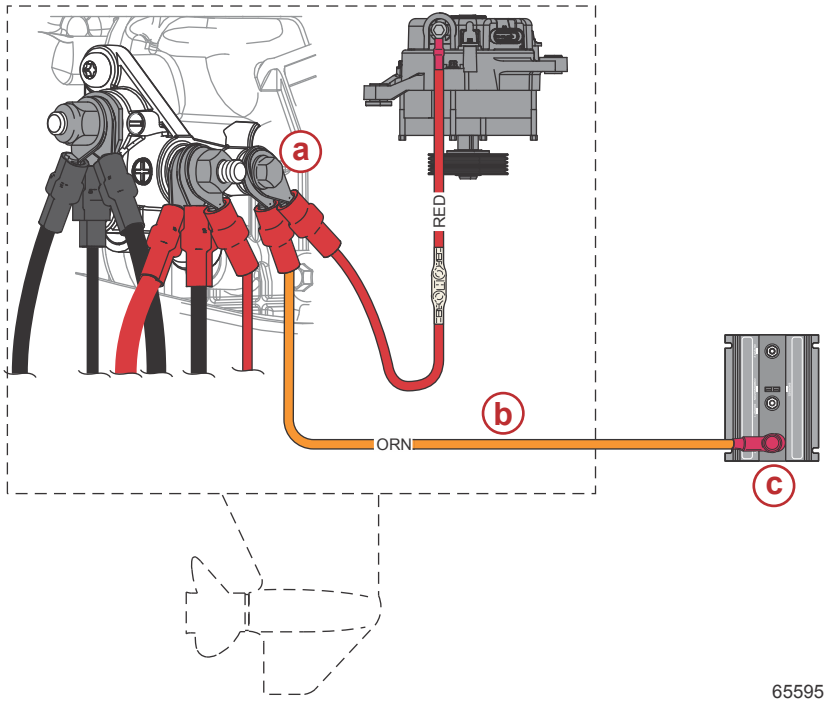
Battery Isolator Installation and Electrical Connections

IMPORTANT: For engines that are equipped with battery cables, disregard the battery cables supplied with the kit. For engines that do not have battery cables supplied, use the 366 cm (12 ft) 4 AWG supplied cables. Positive to positive, and negative to negative connections.

NOTE: *Mount the battery isolator near the batteries and in reach of the alternator output cable.*

- **a -** Alternator output extension cable, orange 304.8 cm (120 in.)
- **b -** Isolator to fuse/battery cable, red 81.4 cm (36 in.)
- **c -** Isolator to fuse/battery cable, 304.8 cm (120 in.)
- **d -** Boots
- **e -** Fuse kits

1. Mount the battery isolator in a protected location following the manufacturer's recommendations.
2. Connect the alternator output cable along with the alternator fused lead to the 8 mm bolt terminal on the engine. Seal the connection with Liquid Neoprene.

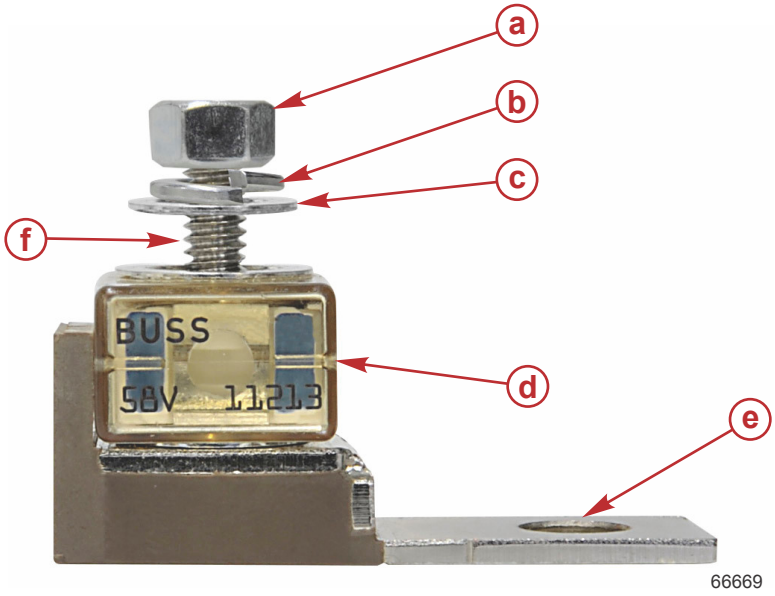


- **a -** 8 mm bolt terminal
- **b -** Alternator output extension cable–orange
- **c -** Insulator boot

Tube Ref No.	Description	Where Used	Part No.
25	Liquid Neoprene	8 mm bolt terminal wire connections	92- 25711 3

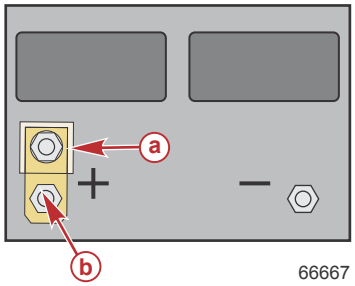
3. Route the orange alternator output extension cable out of the cowl through the rigging tube and to the input connection point on the battery isolator. Using a hex nut and lockwasher, fasten the alternator output extension cable to the input terminal on the battery isolator. Install an insulator boot over the connection.

4. Assemble the fuse kits to the positive battery terminals on both of the engine starting batteries, and the accessory battery.



66669

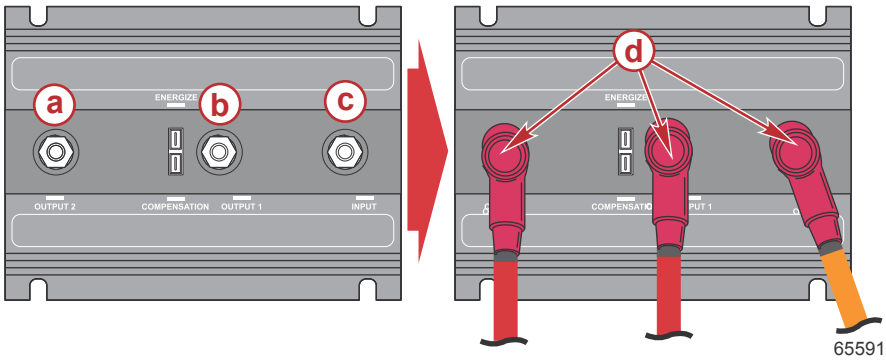
- **a -** Nut
- **b -** Lockwasher
- **c -** Small flat washer
- **d -** Fuse—125 amp
- **e -** Battery post connection plate
- **f -** Cable terminal location



66667

- **a -** Fuse assembly
- **b -** Positive battery connection stud

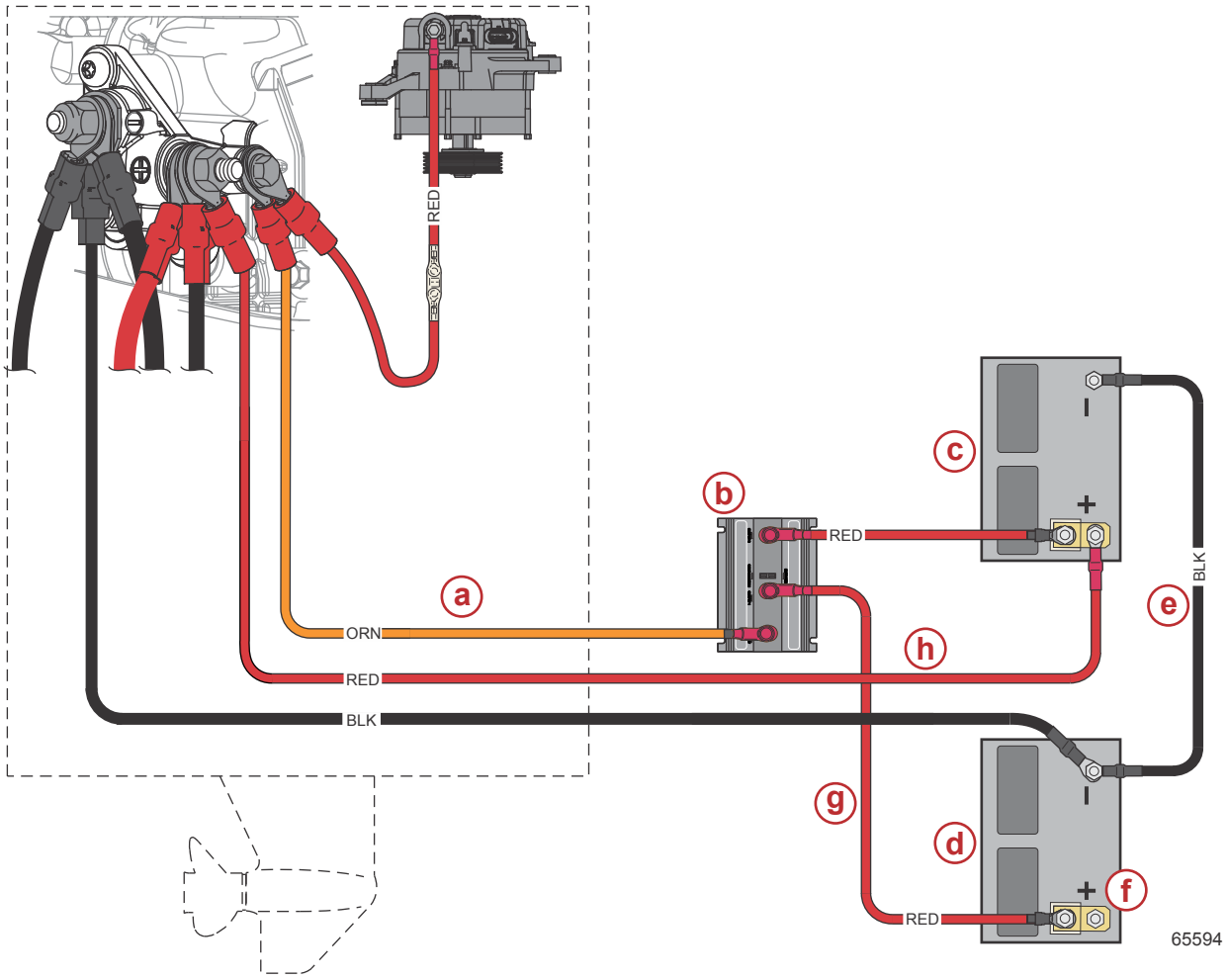
5. Connect the red isolator to the fuse/battery cables between the output terminals on the battery isolator and both fuse/battery connections, as shown in the wiring diagram. Using a hex nut and lockwasher, fasten each fused cable to the output terminal on the battery isolator, as shown. Install an insulator boot over each connection.



65591

- **a -** Battery output terminal 2
- **b -** Battery output terminal 1
- **c -** Alternator output extension cable connection input terminal
- **d -** Insulator boots (3)

6. Connect the starting battery and the accessory battery with a common ground bond cable.

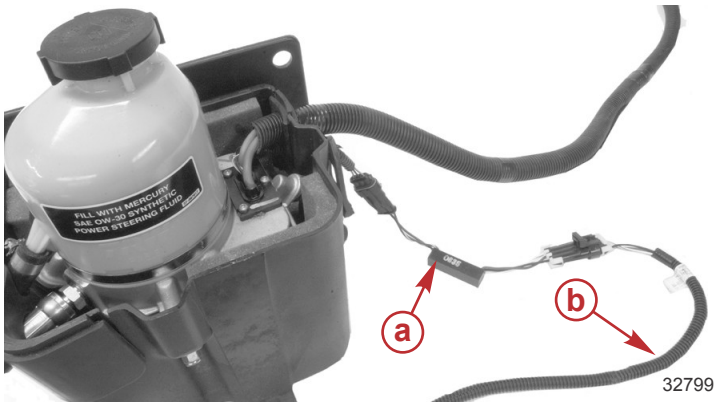


- **a -** Alternator output extension cable
- **b -** Battery isolator
- **c -** Accessory battery
- **d -** Starting battery
- **e -** Common ground bond cable
- **f -** Fuse kit—125 amp
- **g -** Isolator to fuse/battery cable
- **h -** Positive battery cable

Power Steering Pump Wiring and Battery Connections

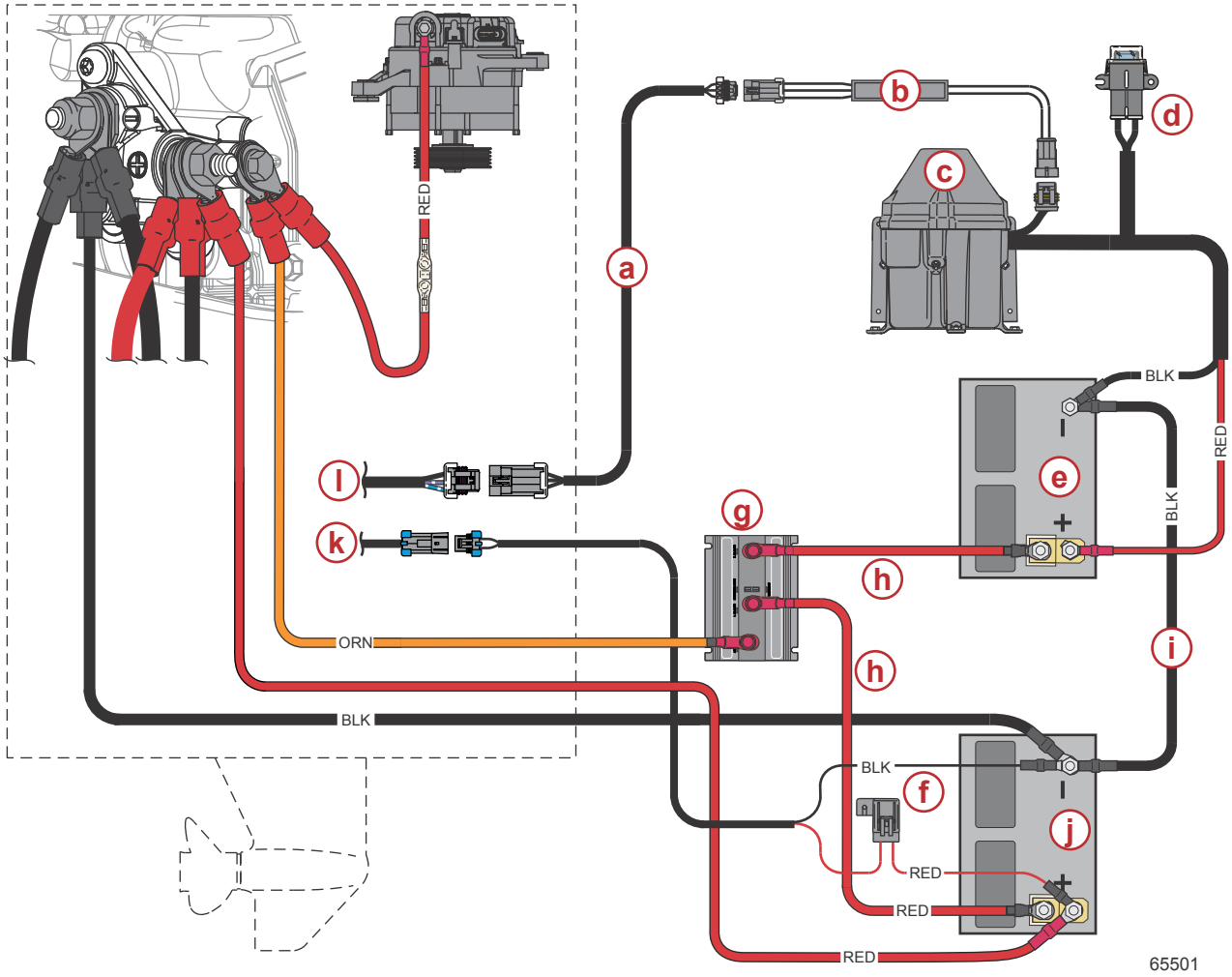
1. The power steering pump battery cables must be connected to the starting battery. The power steering pump red battery cable must be connected to the positive (+) battery terminal. Refer to appropriate model wiring diagram.

2. Connect the driver module and power steering signal harness to the power steering pump, as shown. Route the power steering signal harness through the front cowl opening and connect the harness to the 3-pin connector.



a - Driver module
b - Power steering signal harness

NOTE: The following drawing is representative of the most basic installation. If battery switches are used, then the isolator fuses can be relocated to the switches, to free up battery terminal connections. When relocated, the fuse can be on the switched or unswitched side of the battery switch.



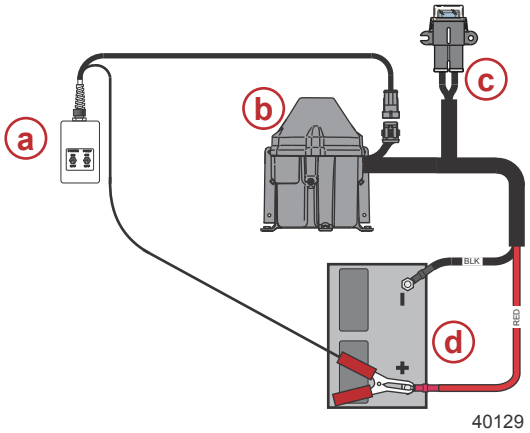
- **a -** Power steering signal harness
- **b -** Power steering driver module
- **c -** Power steering pump
- **d -** 60-amp MAXI fuse
- **e -** Accessory battery
- **f -** DTS power harness fuse
- **g -** Battery isolator
- **h -** Isolator to fuse/battery cables
- **i -** Common ground bond cable
- **j -** Starting battery
- **k -** 2-pin clean power harness
- **l -** 3-pin power steering harness

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 full synthetic engine oil 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	Capacity of 1–2 L (1–2 US qt)	92-858077K01

1. Connect the power steering module primer kit to the power steering pump and a 12-volt DC positive power source.

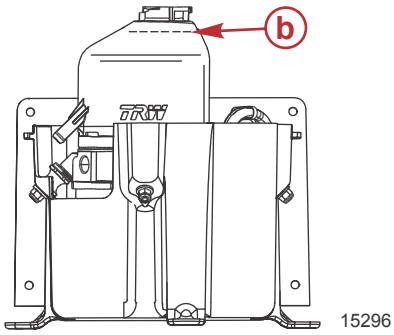


a - Power steering module primer kit
b - Power steering pump
c - 60-amp MAXI fuse
d - 12-volt battery

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



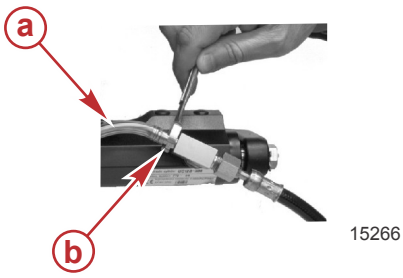
IMPORTANT: The power steering module primer has two switches, "POWER" - "ON" and "OFF," and "PUMP" - "ON" and "OFF." To power up and activate the power steering pump, there are three steps: 1) turn the "POWER" switch to the "ON" position to power up the pump, 2) wait for two seconds, 3) turn the "PUMP" 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 fill the pump tank. Repeat this operation until the tank stays full.
5. Power up and activate the pump while slowly pushing the tiller handle in one direction. Carefully monitor the fluid level. Stop pushing on the tiller handle and fill the pump tank. Repeat this operation pushing the tiller handle in the opposite direction. Stop pushing on the tiller handle and fill the pump tank. Push on the tiller handle for a full right turn and a full left turn five times.
6. Push the tiller handle 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 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. While pushing on the tiller handle, slowly open the bleed valve to release the air in the power steering system. Allow adequate time for the air to escape from the system. Tighten the bleed valve securely and remove the bleed hose.



a - Bleed hose
b - Bleed valve in steering cylinder

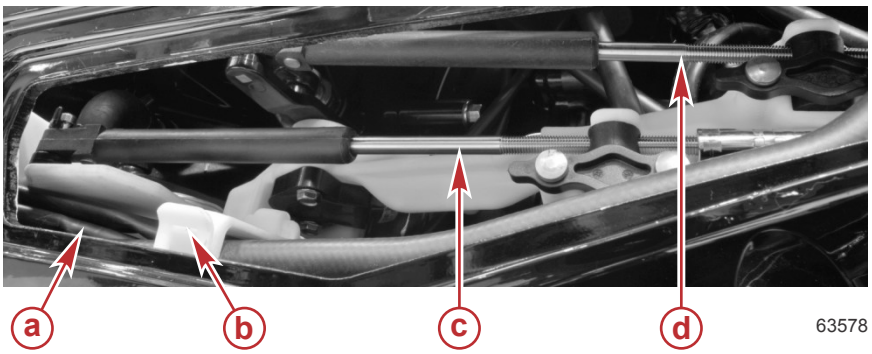
9. Push the tiller handle in the opposite direction to the full lock position and repeat Steps 7 and 8.
10. Replace the fill cap on the power steering pump.
11. Turn off both switches, remove the power steering primer module kit, and connect the power steering module extension harness to the pump.

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.*

Rigging Access Panel

Install the rigging access panel.

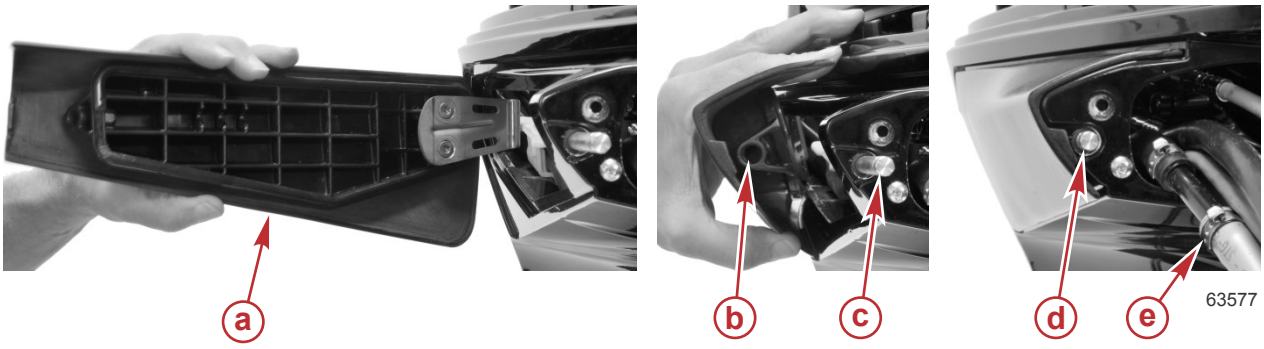
1. Ensure that all electrical cables and fuel line are routed under the throttle arm guard and through the cable keeper. Check that the cable keeper is properly snapped shut. Be certain that no hoses, cables, or harnesses interfere with the throttle and shift cables.



Some items shown lighter than actual color, for clarity

a - Cables routed under the throttle arm guard and through the cable keeper
b - Cable keeper latch
c - Throttle cable—mechanical engines only
d - Shift cable—mechanical engines only

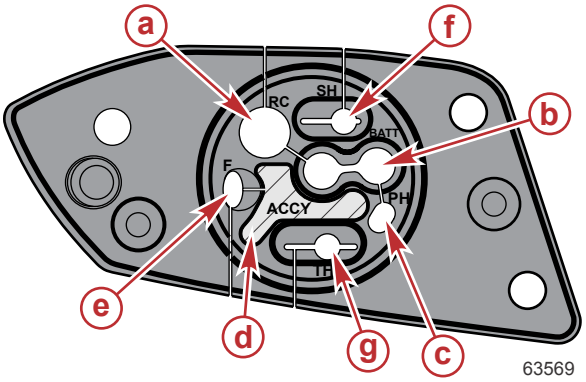
2. Latch the rear end of the panel inside the rigging access opening in the lower cowl, and swing the panel inward.
3. Secure the rigging access panel with the retaining pin. Ensure that the pin is fully seated.



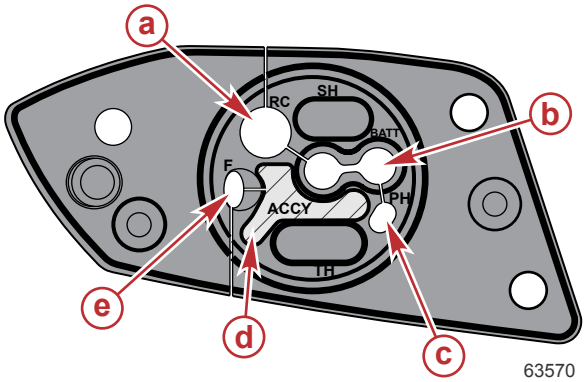
a - Rigging access panel
b - Socket in rigging access panel for retaining pin
c - Retaining pin
d - Retaining pin fully seated
e - Hose clamp on remote fuel line

Rigging Grommet and Rigging Tube

IMPORTANT: Use of the supplied rigging tube, rigging adapter, and rigging grommet is mandatory.



Mechanical models



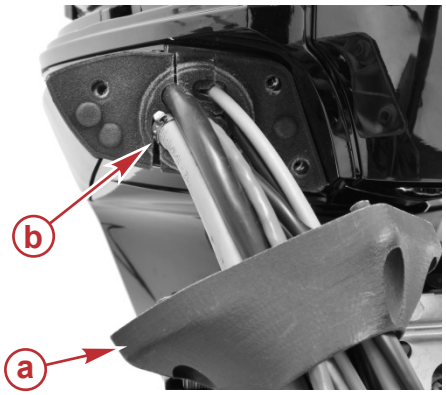
DTS models

Ref.	Marking	Opening used for
a	RC	14-pin data harness—from tiller handle
b	BATT	Battery cables
c	PH	2-pin clean power harness
d	ACCY	3-pin power steering harness, alternator output extension cable ***NOTE:*** *Use a knife to remove the material from this opening, and create an access slit from the fuel (F) opening.*
e	F	Fuel line ***NOTE:*** *The fuel line fitting should be inserted into the grommet, with the hose and hose clamp on the outside of the grommet.*
f	SH	Shift cable—mechanical models
g	TH	Throttle cable—mechanical models

1. Use a knife to remove the material from the ACCY portion—cross-hatched in the preceding illustration of the grommet. Cut an access slit from the fuel hose hole **F** to the new hole.
2. Arrange the harnesses, cables, and fuel hose in the approximate positions they will occupy in the rigging grommet.
3. Work the grommet around the harnesses, cables, and fuel hose. Start with the inward and innermost items, and work outward and toward outboard. One possible sequence follows:
   a. 2-pin clean power harness
   b. Battery cables
   c. 6-pin boat harness, power steering harness, CAN link harness, and accessories
   d. Throttle cable
   e. Shift cable
   f. 14-pin data harness—from tiller handle
   g. Fuel line fitting—flange should sit flush with the outside surface of the grommet
4. Press the rigging grommet into the opening.
5. Connect the remote fuel line to the fitting at the ingress.
   - The minimum fuel hose inside diameter (ID) is 9.5 mm (3/8 in.), with a separate fuel hose/fuel tank pickup for each engine.
   - Fasten the hose with a clamp. Position the clamp so that it will not chafe or cut into an adjacent wiring harness.

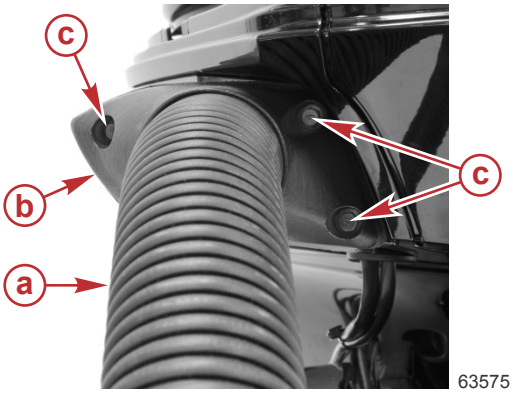
NOTICE
Inspect the position of the hose clamp located on the fuel hose to ensure that it will not chafe or cut into the adjacent wiring harnesses.

6. Slide the rigging adapter and rigging tube into place over the grommet.



a - Rigging adapter
b - Clamp on fuel line, outside of rigging grommet

7. Fasten the rigging grommet and rigging adapter with three screws. Tighten the screws to the specified torque.



a - Rigging tube
b - Rigging adapter
c - Screws (3)

Description	Nm	lb-in.	lb-ft
Screws for attaching the rigging adapter	8	70.8	–

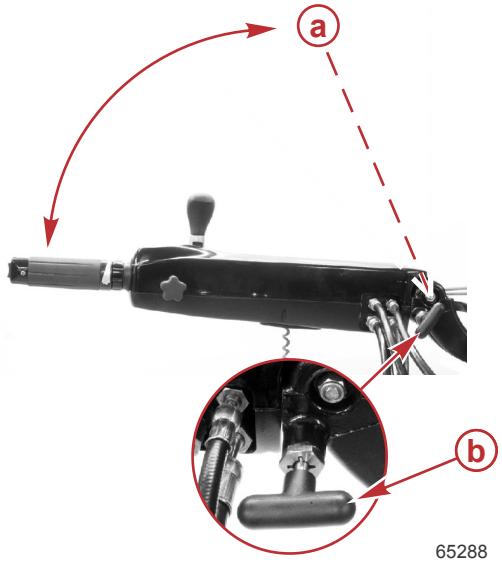
Checking for Tiller Handle Interference

If the tiller handle causes interference when the outboard is tilted up to the full position, the tilt limit can be reduced through the PCM using CDS G3.

Tiller Handle Tilt Lock

The Big Tiller for V6/V8 FourStroke outboards features a stop block designed to prevent the tiller handle and shift components from contacting the upper cowl of the outboard.

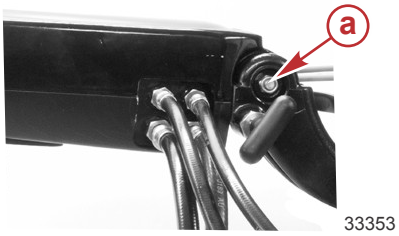
The tilt lock feature allows for the tiller handle to be tilted up and locked into the full tilt position. When using the tilt lock feature, raise the tiller handle to the full tilt position and rotate the tilt lock knob clockwise until the cross pin aligns with the locking slot. The tilt lock knob will engage the locking mechanism via the spring-loaded actuator in the knob. To release the lock, pull the tilt lock knob out and turn it counterclockwise so that the cross pin aligns and seats in the unlock detent.



a - Full tilt angle
b - Tilt lock knob

Tiller Handle Tilt Friction Adjustment

The tiller handle pivot bolt can be adjusted to increase or decrease the amount of effort needed to move the tiller handle up and down. Loosen the jam nut on the end of the pivot bolt and tighten or loosen the pivot bolt to obtain the desired friction setting on the tiller handle. Hold the pivot bolt from turning and tighten the jam nut to the specified torque.



a - Pivot bolt and jam nut

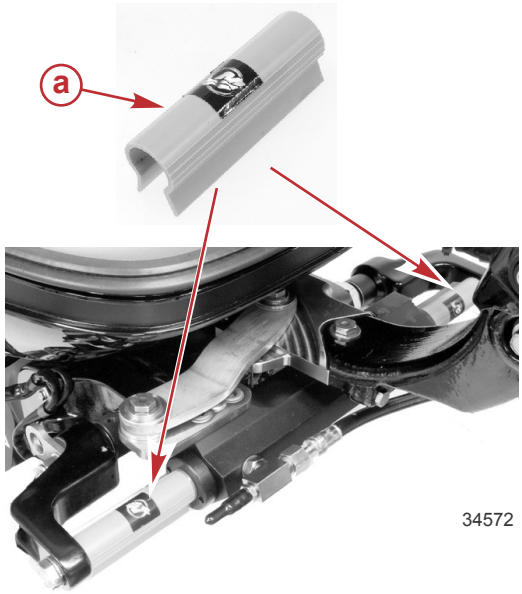
Description	Nm	lb-in.	lb-ft
Tiller handle tilt friction jam nut	47	–	34.7

Trailering Clips - Power Steering Models

If it is desired to have the outboard positioned straight while trailering the boat, a trailering clip can be placed on each side of the steering cylinder ram. The proper length of the trailering clips is 96 mm (3.78 in.).

NOTE: *Universal trailering clips may need to be trimmed to fit properly.*

Remove these clips before operating the outboard.



a - Trailering clip

Color Diagrams

Section 8A - Color Diagrams

Table of Contents

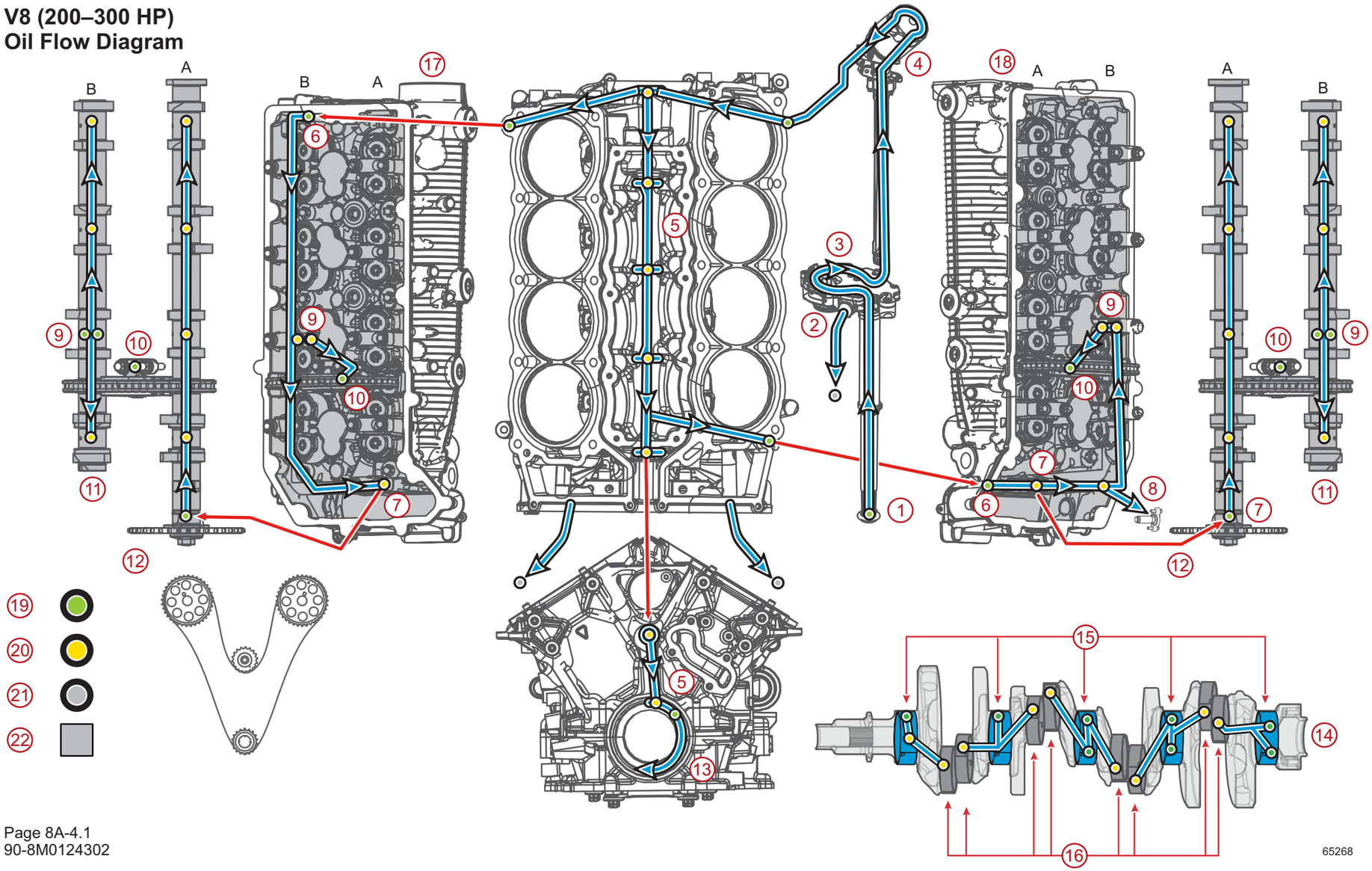
Notes:

Notes:

V8 (200–300 HP) Oil Flow Diagram

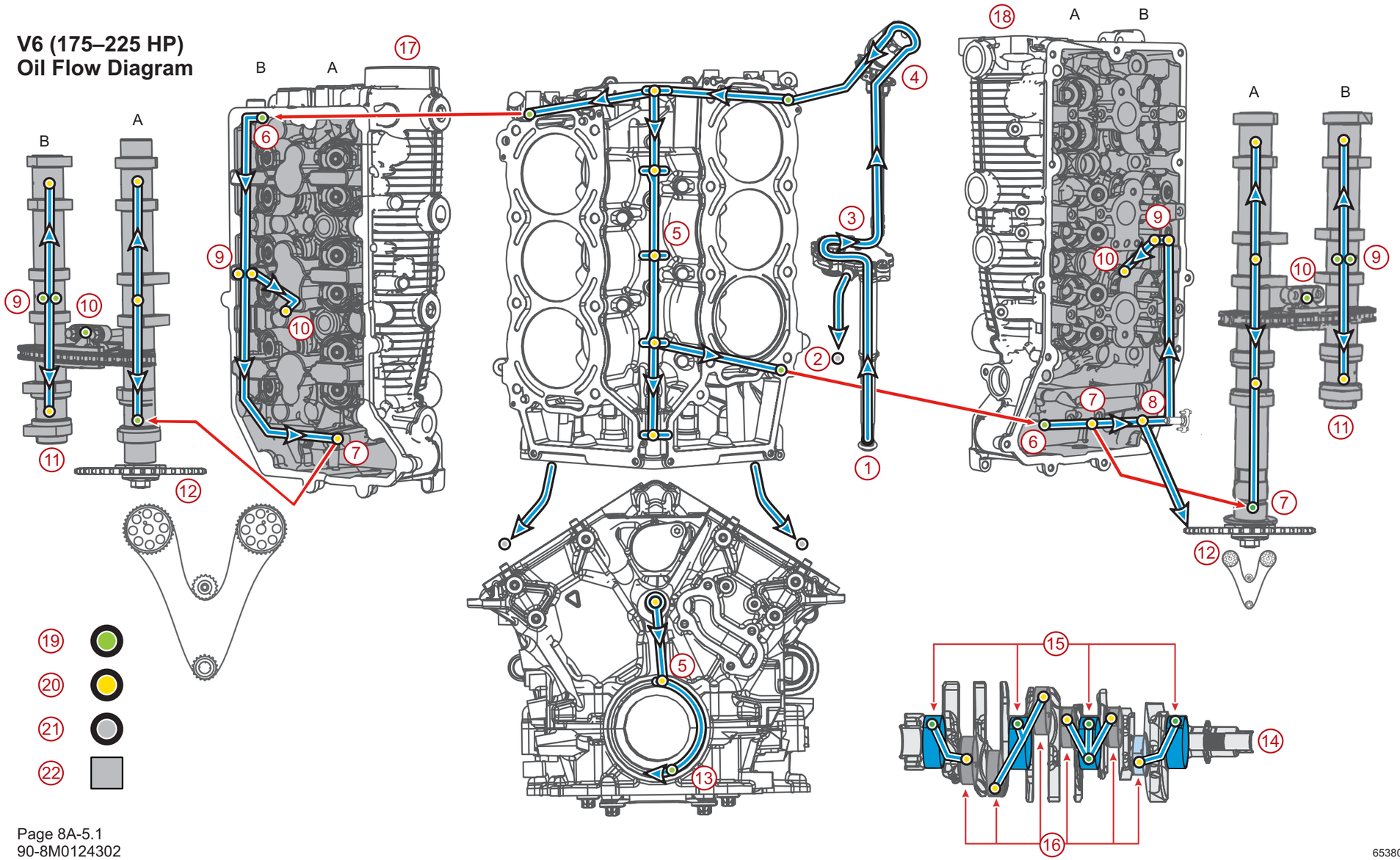
1 - Oil pickup
2 - Oil pressure relief valve
3 - Oil pump
4 - Oil filter
5 - Oil gallery
6 - High-pressure oil in
7 - Exhaust side camshaft oil feed
8 - Timing chain tensioner
9 - Intake side camshaft oil feed
10 - Oil feed to cam chain drive tensioner
11 - Intake camshaft
12 - Exhaust camshaft
13 - Bedplate
14 - Crankshaft
15 - Main bearing
16 - Connecting rod bearing
17 - Port cylinder head
18 - Starboard cylinder head
19 - Oil entry point
20 - Oil distribution point
21 - Oil return
22 - Oil wet surface

V8 (200–300 HP)
Oil Flow Diagram



65268

V6 (175–225 HP)
Oil Flow Diagram



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V6 (175–225 HP) Oil Flow Diagram

1 - Oil pickup
2 - Oil pressure relief valve
3 - Oil pump
4 - Oil filter
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6 - High-pressure oil in
7 - Exhaust side camshaft oil feed
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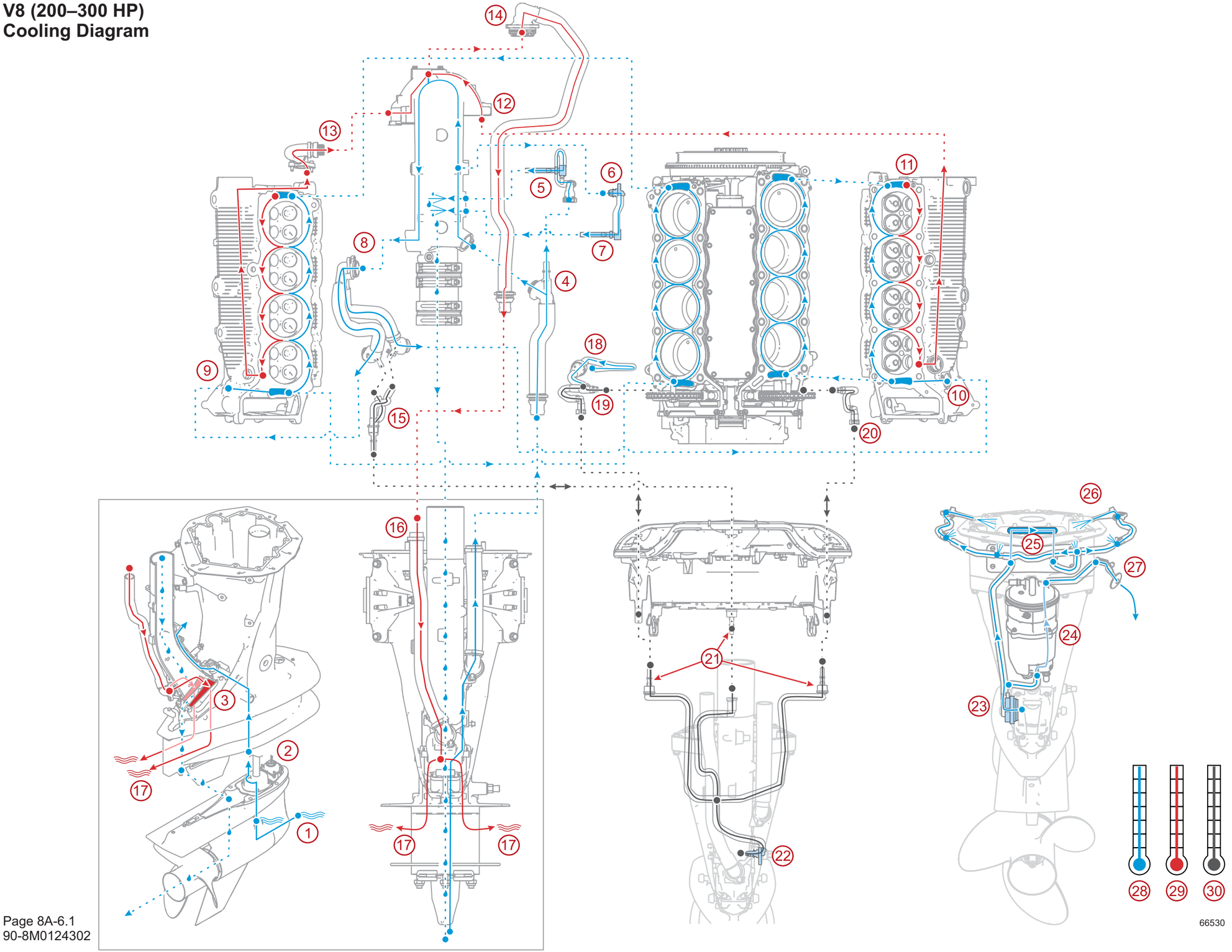
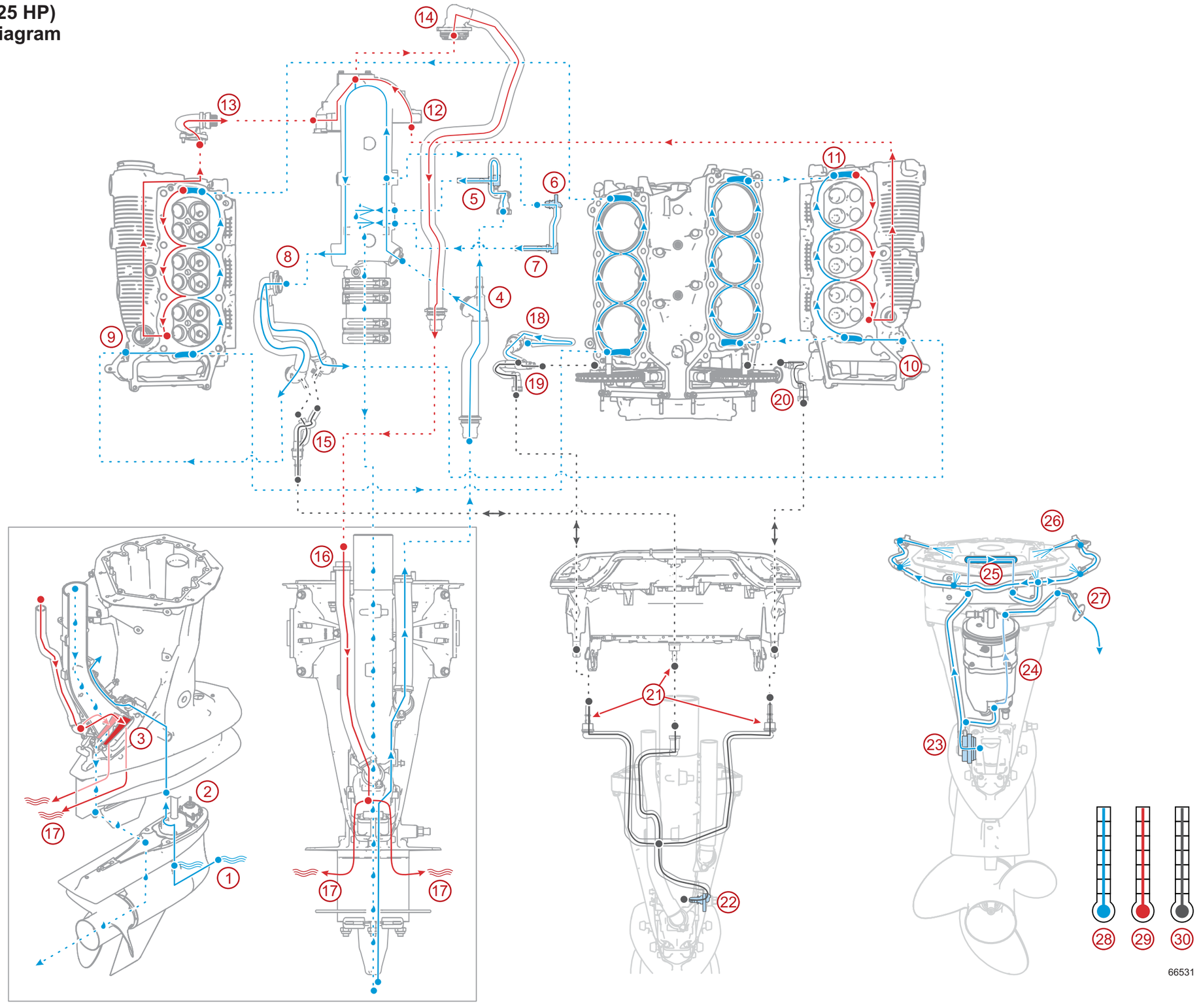
V8 (200–300 HP) Cooling Diagram

1 - Water pickups
2 - Water pump
3 - Lower exhaust tube grommet
4 - Exhaust tube sprayer strainer
5 - Exhaust sprayer
6 - Exhaust sprayer strainer
7 - Exhaust sprayer
8 - Engine water supply (to heads)
9 - Port head engine water supply fittings
10 - Starboard head engine water supply fittings
11 - Optional water pressure sensor
12 - Water temperature sensor
13 - Port engine water outlet
14 - Thermostat
15 - Head drain chap plate Y-fitting
16 - Thermostat outlet water
17 - Thermostat water exit
18 - Flush valve
19 - Port block drain and Y-fitting
20 - Starboard block drain
21 - Block and head drain quick-connect fittings
22 - Block and head drain strainer
23 - Water pump indicator midsection strainer
24 - Fuel supply module
25 - Engine mount cooler
26 - Midsection oil cooler sprayer
27 - Water pump indicator
28 - Cold water (supply)
29 - Hot water (return)
30 - Block and head drain

V8 (200–300 HP)
Cooling Diagram



V6 (175–225 HP)
Cooling Diagram



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V6 (175–225 HP) Cooling Diagram

1 - Water pickups
2 - Water pump
3 - Lower exhaust tube grommet
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Notes:

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