Installation

Aquamatic SX, DPS
Inboard

A
1(1)

D3

Content

Safety Information

This installation manual contains information required for the correct installation of your Volvo Penta product. Check that you have the correct manual.

Carefully read the chapters *Safety precautions* and *General information* in the manual before servicing or running the engine.

The following types of special warning messages can be found in this manual and on the engine:

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

IMPORTANT!

Indicates a situation which, if not avoided, could result in property damage.

NOTICE! Important information that facilitates the work process or item.

Set out below is a list of risks that must always be borne in mind and the safety precautions that must always be taken.

⚠ Plan ahead so that there is always sufficient space for safe installation and (future) disassembly. Lay out the engine compartment (and other compartments such as the battery compartment) so that all service points are accessible. Make sure not to come into contact with rotating components, hot surfaces or sharp edges when checking and servicing the engine. Make sure that all equipment (e.g. pump drives, compressors) has protective covers.

⚠ Make sure the engine cannot be started while work is in progress by not connecting the electrical system or by switching off electrical power to the engine at the main switches and locking them in the OFF position. Erect a warning sign at the helm station.

⚠ Only start the engine in well-ventilated areas. Remember that exhaust fumes are toxic and dangerous to inhale. Use an exhaust extractor to lead exhaust fumes away from the exhaust pipe and crankcase ventilator when the engine is run in a confined space.

⚠ Always wear protective goggles if there is a risk of splinters, sparks and splashes from acid or other chemicals. Eyes are extremely sensitive and injury may result in loss of sight!

⚠ Avoid getting oil on the skin! Prolonged or repeated contact with oil may lead to the disappearance of the skin's natural oils. This will cause irritation, dry skin, eczema and other skin problems. Old oil is more hazardous to health than new. Use protective gloves and avoid oil-soaked clothes and rags. wash regularly, especially before meals. Use special skin creams that facilitate cleaning and prevent the skin from drying out.

⚠ Most chemical used in the product (engine and reverse gear oil, glycol, gasoline and diesel) or chemicals intended for use in the workshop (degreasing agents, paints and solvents) are health hazards. Read the instructions on the product packaging carefully! Always follow safety instructions (the use of protective masks, protective goggles, gloves etc.). Make sure that other personnel are not inadvertently exposed to hazardous substances, e.g. in the air they breathe. Ensure good ventilation. Hand in used and surplus chemicals to a recycling station.

⚠ Take extreme care when searching for fuel system leaks and testing injectors. Wear protective goggles. The spray from an injector is at very high pressure and fuel can force its way into tissue and cause a serious risk of blood poisoning (septicemia).

⚠ Stop the engine and disconnect the power at the main switches before working on the electrical system.

⚠ Coupling adjustments must be made with the engine stopped.

⚠ Use the lifting eyes installed on the engine/ reverse gear when lifting off the drive. Always check that the lifting equipment is in good condition and has the capacity to lift the engine (engine weight including reverse gear and any auxiliary equipment installed).

⚠ If the engine has auxiliary equipment that has altered its center of gravity, special lifting devices may be required to obtain the correct balance for safe handling.

⚠ Never work on an engine that is suspended in an engine hoist.

⚠ It is mandatory that no work be carried out on a running engine. There are however adjustments that require the engine to be run. Approaching a running engine is a safety risk. Loose clothes and long hair can catch in rotating parts and cause serious injury. A careless movement or a dropped tool may result in injury when working in the vicinity of a running engine. Be careful to avoid hot surfaces (exhaust pipes, turbochargers, charge air manifolds, start elements etc.) and hot liquids in pipes and hoses on engines that are running or recently stopped. Re-install all protective covers that were removed during maintenance work before starting the engine.

⚠ Make sure that all warning and information decals on the product are always visible. Change decals that are damaged or painted over

⚠ Turbocharged engines: never start the engine without the air cleaner installed. The rotating compressor turbine in the turbocharger can cause severe injury. Foreign objects that enter the inlet ducts can also cause mechanical damage.

⚠ Never use start spray in the air intake. The use of such products may result in an explosion in the inlet manifold. Risk of injury.

⚠ Do not open the engine coolant filler cap (freshwater cooled engines) when the engine is hot. Steam or hot coolant may be ejected when system pressure is released. Open the filler cap slowly and release the system pressure carefully (freshwater cooled engines). Hot coolant may spray out if the filler cap or drain tap is opened, or if a plug or coolant pipe is removed from a hot engine.

⚠ Hot oil can cause burns. Avoid getting oil on the skin. Be sure to release the pressure from the lubrication system before starting work on it. Never start or run an engine without the oil filler cap attached. There is a risk of oil being ejected.

⚠ If the boat is in the water – stop the engine and close the seawater tap before working on the system.

⚠ All fuels, and many chemicals, are flammable. Make sure they are not exposed to open flames or sparks. Gasoline, certain solvents and hydrogen from batteries are extremely flammable and explosive in the right concentration in air. No Smoking! Make sure the workplace is well ventilated and take the necessary safety precautions before welding or grinding in the vicinity. Always have a fire extinguisher accessible at the workplace.

⚠ Store oil, fuel-soaked rags and old fuel and oil filters in the correct manner. Oil-soaked rags may ignite spontaneously in certain conditions. Old fuel and oil filters are harmful to the environment and must be handed to a recycling station for destruction.

⚠ Make sure the battery compartment is built according to current safety standards. Never allow open flames or electrical sparks in the vicinity of the batteries. Never smoke in the vicinity of the batteries. Batteries give off hydrogen gas during charging, which may combine with air to form an explosive mixture. The gas mixture is extremely volatile and easily ignited. Incorrect battery connection may cause sparks which in turn may cause an explosion. Do not change the battery connections when attempting to start the engine (risk for sparks) and do not lean over the batteries.

⚠ Make sure that the positive (+) and negative (–) battery cables are correctly connected to the corresponding battery terminals. Wrong connection may cause severe damage to electrical equipment. Refer to the wiring diagram.

⚠ Always wear protective goggles when charging or handling batteries. Battery electrolyte contains highly corrosive sulfuric acid. Wash immediately with soap and copious amounts of water if battery electrolyte comes into contact with the skin. Flush immediately with water and seek medical attention if battery acid gets in the eyes.

⚠ Never work alone when installing heavy components, even when using safe lifting equipment e.g. lockable blocks. Most lifting devices require the two people, one to take care of the hoist and the other to make sure no components catch or are damaged.

⚠ The components in the electrical system, ignition system (gasoline engines) and fuel system on Volvo Penta products are designed and manufactured to minimize the risk of fire and explosion. Do not run engines in areas where there are explosive materials.

⚠ Always use fuels recommended by Volvo Penta. Refer to the Operator's Manual. Poor quality fuel may damage the engine. Poor fuel quality in a diesel engine may cause the fuel control mechanism to bind which will lead to engine overspeeding with the risk of engine damage and personal injury. Low fuel quality may also lead to higher service costs.

⚠ Use an adjustable lifting beam to provide a safe lift and to avoid damage to components on the top of the engine. All chains and cables must run parallel and be as square as possible to the top of the engine.

General Information

Metric Conversion Chart

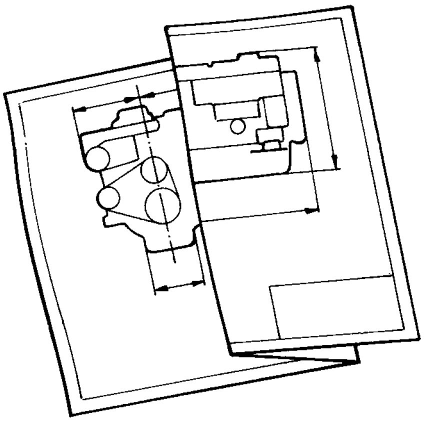
	Metric to U.S. or IMP. conversion factors:			**U.S. or IMP. to metric conversion factors:**		
	To convert from	**To**	**Multiply by**	**To convert from**	**To**	**Multiply by**
Length	mm	inch	0,03937	inch	mm	25,40
	cm	inch	0,3937	inch	cm	2,540
	m	inch	3,3808	foot	m	0,3048
Area	mm^2	sq. in.	0,00155	sq. in.	mm^2	645,3
	m^2	sq.ft.	10,76	sq.ft.	m^2	0,093
Volume	cm^3	cu. in.	0,06102	cu. in.	cm^3	16,388
	liter, dm^3	cu. ft.	0,03531	cu. ft.		28,320
	liter, dm^3	cu. in.	61,023	cu. in.		0,01639
	liter, dm^3	imp. gallon	0,220	imp. gallon		4,545
	liter, dm^3	U.S. gallon	0,2642	U.S. gallon		3,785
	m^3	cu. ft.	35,315	cu. ft.		0,0283
Force	N	lbf	0,2248	lbf	N	4,448
Weight	kg	lb.	2,205	lb.	kg	0,454
Power	kW	hk (metrisk)[1]	1,36	hk (metrisk)[2]	kW	0,735
	kW	bhp			kW	0,7457
	kW	BTU/min			kW	0,0176
Torque	Nm	lbf ft	0,738	lbf ft	Nm	1,356
Pressure	Bar	psi	14,5038	psi	Bar	0,06895
	MPa	psi	145,038	psi	MPa	0,006895
	Pa	mm Wc	0,102	mm Wc	Pa	9,807
	Pa	i Wc	0,004	i Wc	Pa	249,098
	kPa	i Wc	4,0	i Wc	kPa	0,24908
	mWg	i Wc	39,37	i Wc	mWg	0,0254
Energy	kJ/kWh	BTU/hph	0,697	BTU/hph	kJ/kWh	1,435
Work	kJ/kg	BTU/lb	0,430	BTU/lb	kJ/kg	2,326
	MJ/kg	BTU/lb	430	BTU/lb	MJ/kg	0,00233
	kJ/kg	kcal/kg	0,239	kcal/kg	kJ/kg	4,184
Fuel consump.	g/kWh	g/hph	0,736	g/hph	g/kWh	1,36
	g/kWh	lb/hph	0,00162	lb/hph	g/kWh	616,78
Inertia	kgm^2	$lbft^2$	23,734	$lbft^2$	kgm^2	0,042
Flow, gas	m^3/h	cu.ft./min.	0,5886	cu.ft./min.	m^3/h	1,699
Flow, liquid	m^3/h	US gal/min	4,403	US gal/min	m^3/h	0,2271
Speed	m/s	ft./s	3,381	ft./s	m/s	0,3048
	mph	knop	0,869	knop	mph	1,1508
Temperature	Celsius	Fahrenheit	°F=9/5 x °C +32	Fahrenheit	Celsius	°C=5/9 x (°F–32)

1) All hp figures stated in the catalogue are metric.

2) All hp figures stated in the catalogue are metric.

Installation Tools and Documentation

Publications



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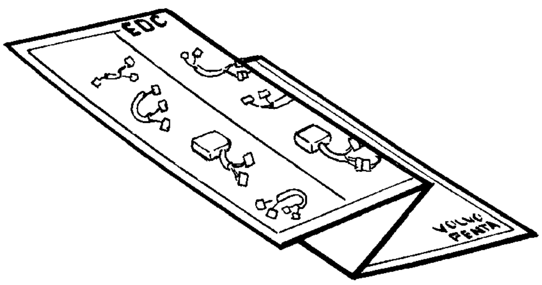
Drawings

Drawings in respect of the current program of leisure and professional applications are available at: http://www.volvopenta.com

P00004538

Printed material

- Volvo Penta accessories & maintenance parts
- Service Manuals
- Operators' Manuals
- Sales guide



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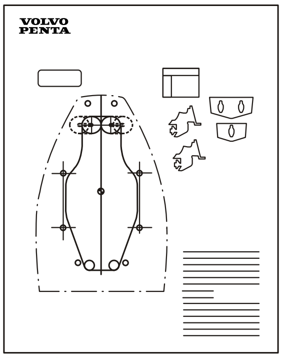
Posters

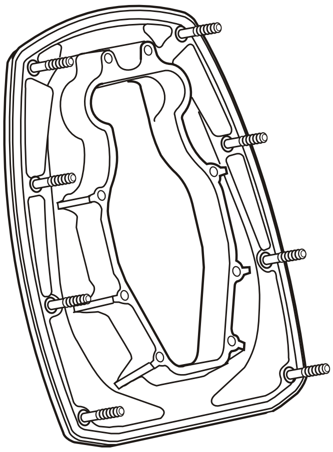
- Installation reference, D3 engine, Aquamatic
- Installation reference, D3 engine, Inboard
- Installation procedures, EVC (Electronic Vessel Control), gasoline and D3



P0008120

Templates

Templates for SX/DPS sterndrives and transom shields. Concerning templates for controls, keypads, instrument panels etc, refer to their installation instructions.



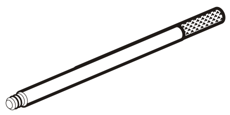
P0008121

Adapter kit, Transom

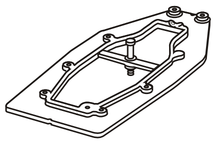
VP part # 3889814. Adapter for converting older type transom shields (type 290) to the current model.

Special Tools

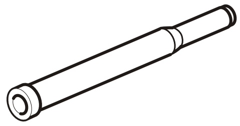
Aquamatic



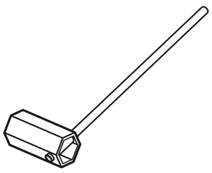
3850609 Handle
For sterndrives, used together with 3851083 Alignment tool



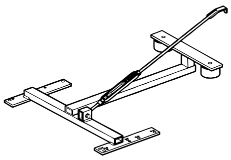
3851081 Fixture
Drilling holes in transom for shield installation



3851083 Alignment tool
Engine alignment on engine bed

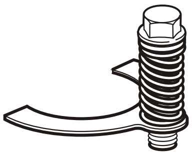


3855516 Rotation tool
Propeller nut tool kit for DPS sterndrives

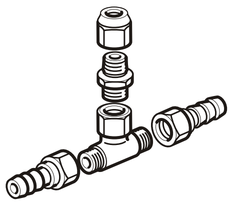


3588569 Drill jig
Laying out engine bed and forward engine mounts

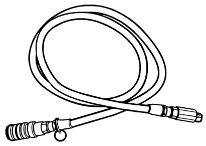
Aquamatic, inboard engines



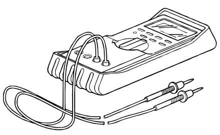
21244540 Measuring tool
Measuring engine mount compression



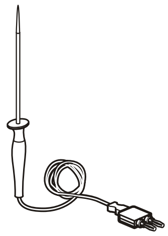
21433378 Nipple
Measuring fuel pressure



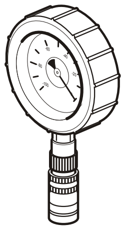
9998493 Hose
Used together with
9990150 Manometer



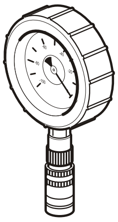
88890074 Multimeter



9812530 Measuring tool
Measuring exhaust gas temperature. Used together with
88890074 Multimeter

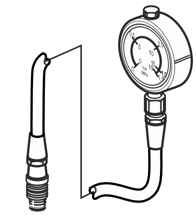


9990150 Manometer
Measuring pressure, fuel lines



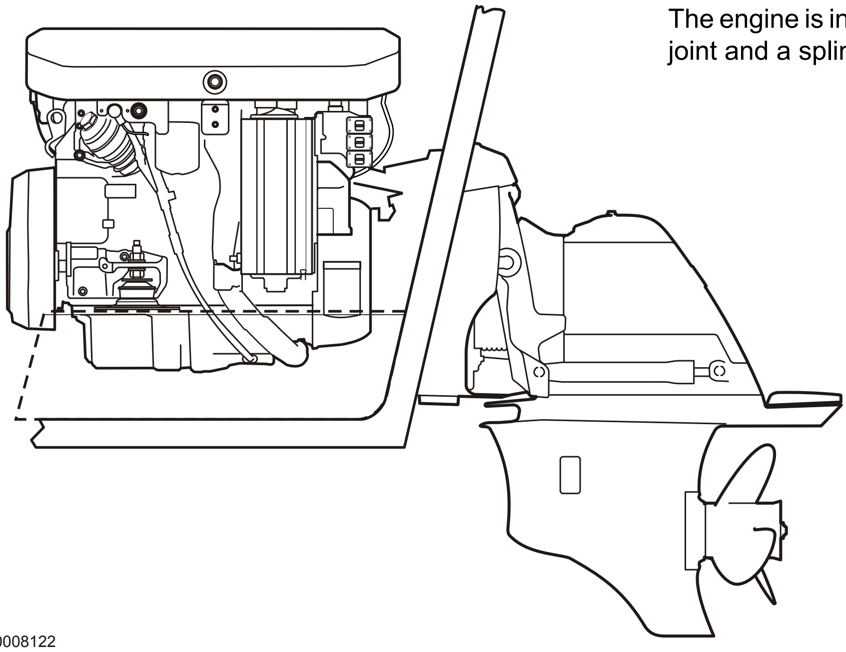
9996065 Pressure gauge
Measuring exhaust back pressure

9996666 Nipple
Exhaust back pressure



9996398 Pressure gauge
Measuring pressure, fuel lines

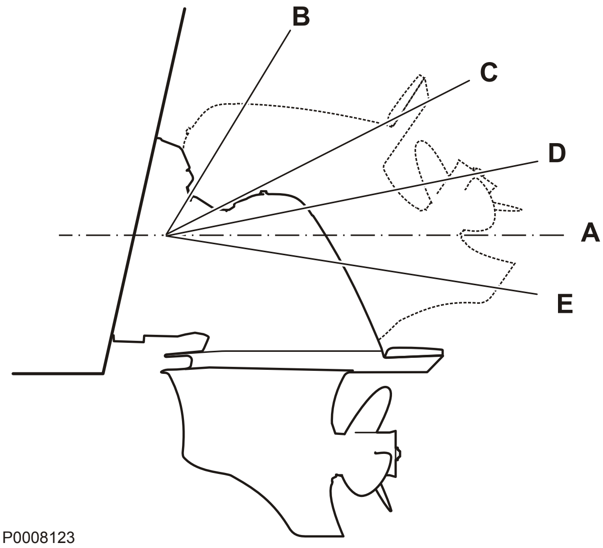
Design Concept of Propulsion Systems



P0008122

Aquamatic drive

The engine is installed next to the drive with a universal joint and a splined shaft coupling.



P0008123

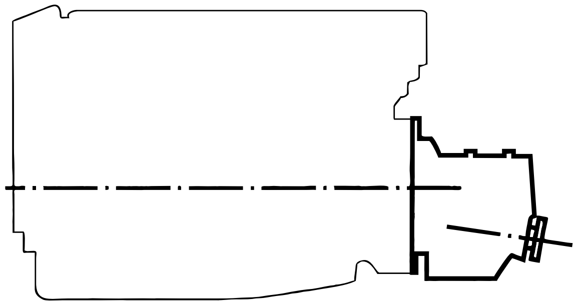
A Horizontal plane

Trim limits for SX and DPS sterndrives with EVC.

Max trim limits for sterndrives at 13° transom angle.	SX	DPS
Max tilt (B)	52°	52°
Beach trim (C)	30°	30°
Max trim (D)	12°	6°
Min. trim (E).	-5°	-5°

Reverse Gear

Drop center, down angle

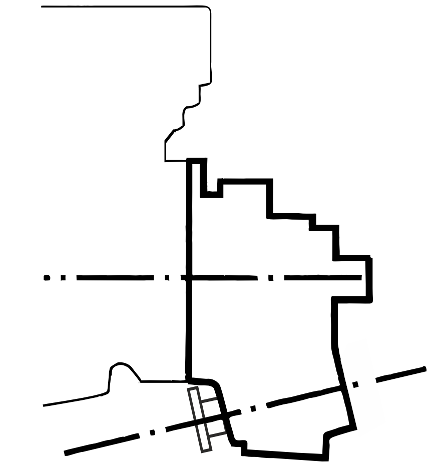


P0007457

Engine crankshaft and reverse gear output shaft are in different planes. Propeller shaft angle deviates from crankshaft angle.

Engine and reverse gear form a single unit. Propeller thrust is taken up by a bearing in the reverse gear.

IV drive

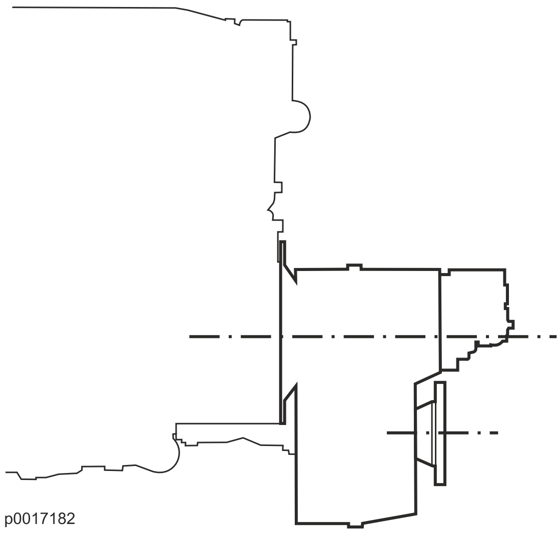


P0007458

Engine and reverse gear form a single unit. Propeller thrust is taken up by a bearing in the reverse gear.

This reverse gear creates a more compact installation, with the engine above the drive shaft.

Drop center, right angle



p0017182

Engine crankshaft and reverse gear output shaft are in different planes. Propeller shaft angle is straight at the same angle as the crankshaft.

Engine and reverse gear form a single unit. Propeller thrust is taken up by a bearing in the reverse gear.

Engine Characteristics

Engine Application Ratings

The engines described in this manual are primarily used for one operating condition, Rating 5, as described below.

The power requirements and operational conditions for the installation concerned must be accurately specified at a very early stage in order to place an order for a suitable engine with the right settings and equipment. This can save time that would otherwise be lost making modifications at a later stage.

Class 5

Leisure traffic

Only for leisure craft, operated by the owner for his or her recreation. Operated for fewer than 300 hours per year.

Full power may be used max 1 hour per 12 hour operating period.

Between full-throttle periods, engine revolutions must be reduced by at least 10% from full rpm.

Engine Performance

Marine engines and their environment

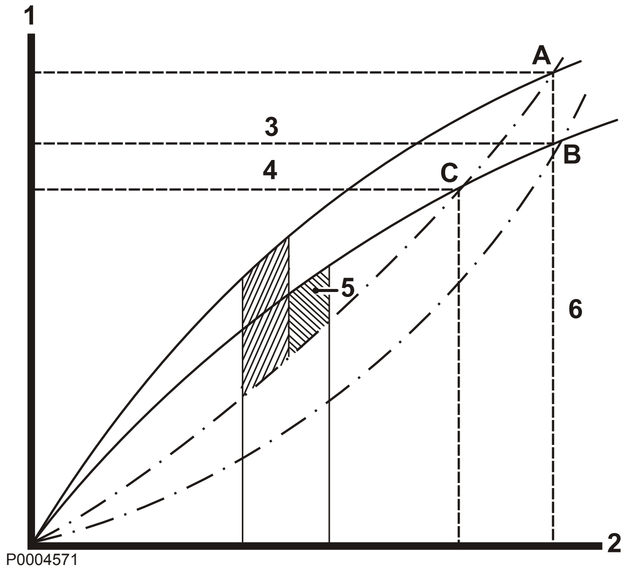
Marine engine power is specified, just like that of automobile and truck engines, according to one or more power norms. Power is expressed in kW, usually at maximum rpm.

Most engines provide the power specified on the condition that they have been tested in the conditions the power norms state, and have been broken in properly. According to ISO standards, tolerances are normally ±5 %, which is a reality that must be accepted for series-produced engines.

Power measurement

Engine manufacturers normally measure engine power at the flywheel, but before power reaches the propeller, losses occur in the drive train and propeller shaft bearings. These losses amount to 4 to 6 %.

All larger marine engine manufacturers state engine power according to ISO 8665 (supplement to ISO 3046 for pleasure boats), based on ISO 3046, which means that propeller shaft power is indicated. If an exhaust system is not included, engine tests are performed with a back pressure of 10 kPa (1.45 psi). If all engine manufacturers used the same test procedure it would be simpler for boat builders to compare products from different manufacturers.



The above graph shows the effect of variations in climate and propeller size.

1 Power

2 rpm

3 Power loss due to atmospheric conditions

4 Loss due to large propeller

5 Critical area

6 Indicated rpm

Engine performance

Engine power is affected by a number of different factors. Among the most important are air pressure, outdoor temperature, humidity, fuel calorific value and exhaust back pressure. Deviations from normal values affect diesel and gasoline engines in different ways.

Diesel engines use large amounts of air for combustion. If the mass of air is reduced, the first sign is an increase in black exhaust smoke. The effects of this are especially noticeable at the planing threshold when the engine must produce maximum torque.

If the deviation differs significantly from normal air flow, the diesel engine will also lose power. In the worst case the loss may be so great that torque is insufficient for the boat to overcome the planing threshold.

Point **A** is where the indicated engine power is equal to the power acting on the propeller. It is correct to select a propeller where the values at point **A** are reached in order to utilize indicated power to the maximum in a given combination of weather and load.

If atmospheric conditions cause power to drop to point **B**, the propeller plot will cross the engine power plot at point **C**. A secondary performance loss has occurred because the propeller is too big. The propeller reduces engine rpm.

By changing to a smaller propeller, the engine power plot crosses at point **B**, which makes it possible to regain the earlier rpm, but at reduced power.

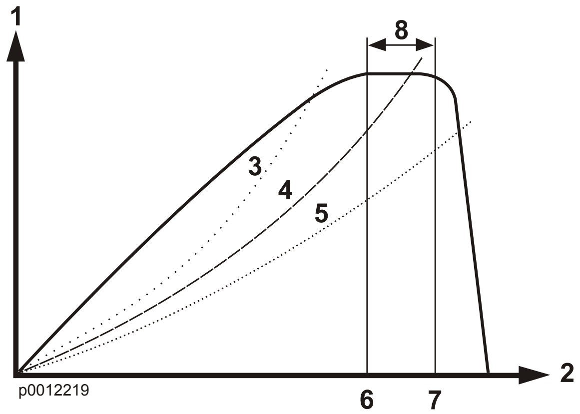
The critical area is the planing threshold for planing or semi-planing boats, which usually occurs at around 50-60% of cruising speed. In this case it is important that there be a sufficiently large distance between the engine max power plot and the propeller plot.

Other factors that influence performance

It is important to keep exhaust back pressure low. Power losses caused by back pressure are directly proportional to the increase in back pressure, which also increases exhaust temperature.

Boat weight is another important factor that influences speed. Increased boat weight has a great influence on speed, especially on planing or semi-planing hulls. A new boat that is tested with half full fuel and water tanks and without a load, will easily lose 2-3 knots when it is driven fully loaded with fuel, water and equipment for the voyage. This situation arises because the propeller is often chosen to provide max speed when the boat is factory tested. It is therefore advisable to reduce propeller pitch by an inch or two to compensate for load and a warm climate. Top speed is reduced somewhat, but overall performance will improve and provide better acceleration, even with a heavily laden boat.

Considering this, it is important to remember that boats made of GRP absorb water when they are in the water,



1 Engine power, kW
2 rpm
3 Propeller too large
4 Right size propeller
5 Propeller too small
6 Indicated engine power
7 Engine speed limitation
8 100% power. Full throttle range.

which makes the boat heavier over time. Marine fouling is an often-overlooked problem that greatly affects boat performance.

Choice of propeller

Propeller selection must be made by a boat builder, marine engineer or other qualified individual. The engine performance data required to select the right propeller is found in the technical literature.

When it comes to the choice of propeller, it is important to achieve the correct engine rpm. For this purpose we recommend the full throttle range (**8**).

The propeller must be selected for this operational area in order to provide best all-round performance.

When the prototype and first production boat are built, the boat builder and a representative from Volvo Penta carry out a full load trial with the boat under conditions similar to those the boat will meet with the customer.

The most important conditions during the tests are:

- Full fuel and water tanks onboard
- Ballast evenly distributed to represent the owner's equipment including such things as outboards, rubber boats etc.
- Alternator, air conditioning and all other equipment installed.
- A suitable number of passengers onboard.

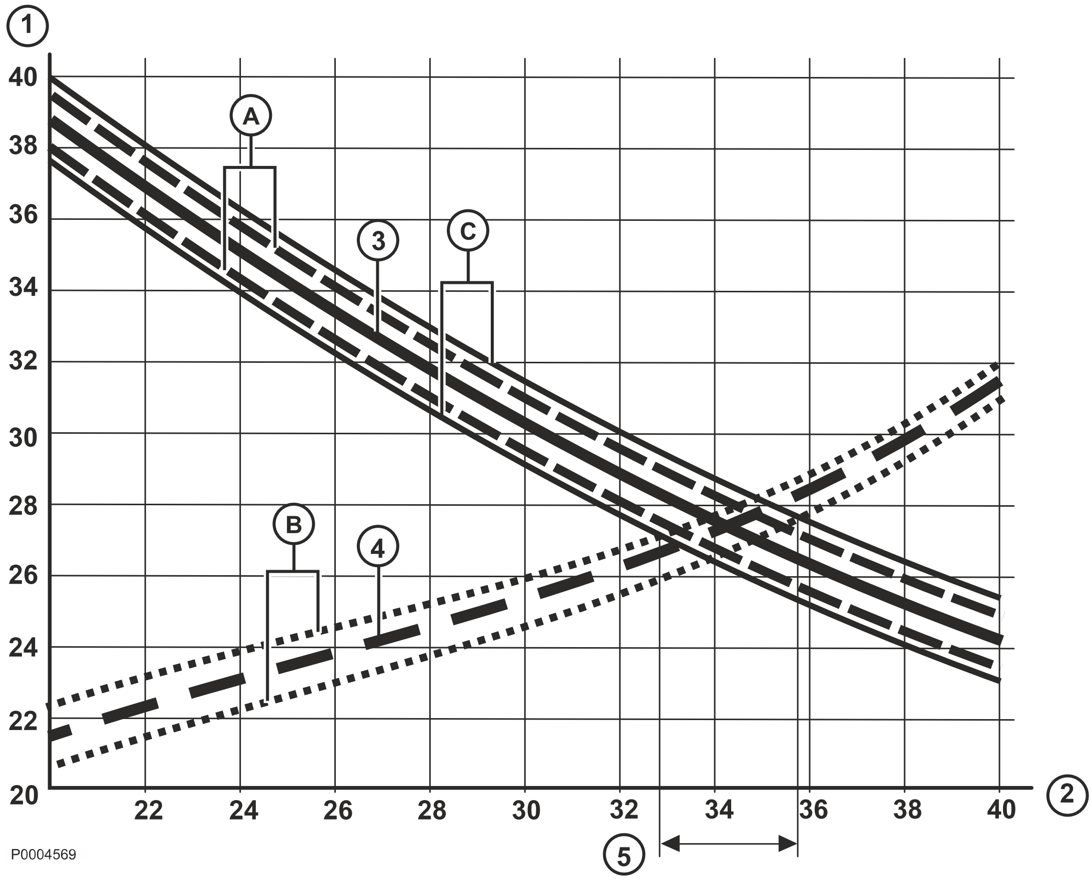
When the boat has been equipped according to the above, a complete engine/propeller test is carried out. All engine parameters such as rpm, fuel consumption, relative loads, reference rpm, charge pressure, exhaust temperature, engine compartment temperature etc. are analyzed.
When the right propeller has been selected on the basis of the tests, engine rpm must be within the “full throttle range” at full load.

It is however advisable to reduce pitch further in order to compensate for varying conditions and marine fouling. Therefore boat builders must check the relevant situations in their various markets.

A propeller that is selected for the highest speed performance must not be used for towing as the engine is loaded at the highest torque without reaching the correct speed range. The engine becomes overloaded resulting in the risk of permanent damage.

Relationship between influencing factors

The graph below describes a typical example of a planing hull and how displacement and deviations in engine power influence performance.



P0004569

1 Thrust/power

2 Speed (knots)

3 Engine power/thrust

4 Displacement / hull drag

5 Max deviation interval

P0004568 Nominal power

P0004565 Nominal displacement 13 tons

P0004567 Power ±3 %

P0004564 Displacement ±3 %

P0004566 Propeller precision tolerance ±3 %

Manufacturing tolerances

The correct propeller is crucial for ensuring optimal performance and long service life. The correct propeller selection allows the engine to provide its entire power and thus achieve the performance anticipated.

There are a number of factors whose tolerances can significantly affect boat performance. These must be identified before the correct engine and propeller combination can be selected.

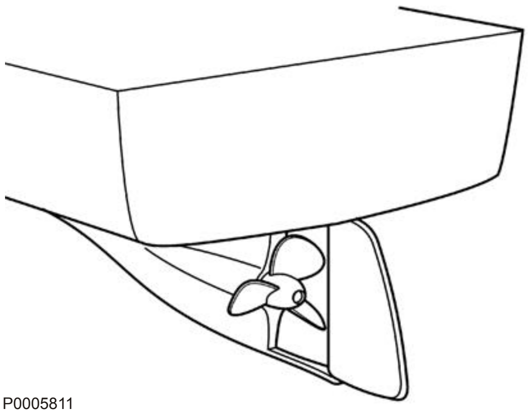
These factors are:

A Engine power may vary within international power norm tolerances.

B Calculated hull resistance and displacement may vary within certain limits.

C Propeller manufacturing tolerances generally influence engine rpm in that propeller power varies.

Arrangement and Planning


P0005811

Choice of Engine

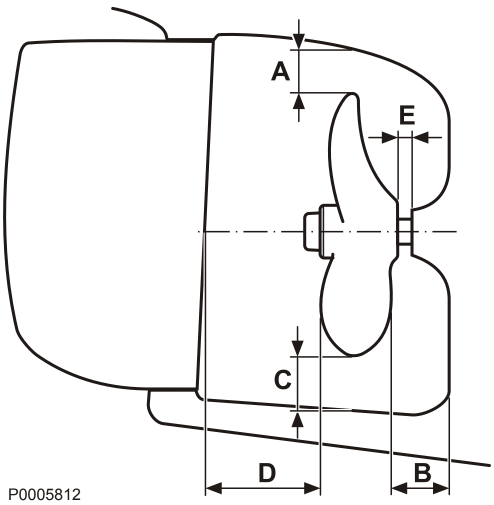
Propeller Selection

A propeller must be selected with great care. Take the distance between the hull and the keel strake into consideration. Refer to the recommendations for propellers and propeller shaft angles and the recommended clearance between propeller and hull. Refer to the section below.

Best propeller efficiency is achieved with as small an angle as possible between the propeller shaft and the waterline. The larger the angle, the lower the efficiency. If possible, avoid angles in excess of 12°. This means that when the boat is at rest, the propeller shaft angle may not exceed 12°. This is especially important on planing boats. Greater shaft angles may affect speed, noise and vibrations negatively.

Make sure there is sufficient clearance between the propeller, hull, keel, keel strake and rudder. It must be possible to slide the propeller shaft aft at least 200 mm (7.8") to allow removal of the reverse gear or propeller shaft flange. Also make sure that no transverse bulkheads hinder removal. There must be sufficient play, approximately 1 x shaft diameter, between the propeller and the stern bearing to prevent the propeller from pressing against the stern bearing. There must also be space for line cutters if such must be fitted. Refer to illustration, item (**E**).

In order to avoid propeller cavitation and vibrations the keel area around the shaft gland must be designed to be as slender as possible.



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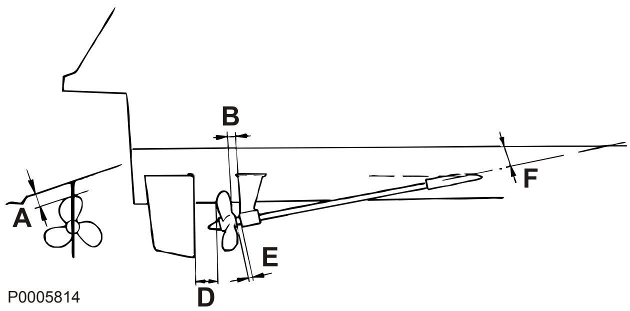


P0005814

Minimum distance to hull, keel, keel strake and rudder

Ø = Propeller diameter

A 0.10 x Ø

B 0.15 x Ø

C 0.08 x Ø

D 0.10 x Ø

E Approximately 1 x shaft diameter

F Shaft angle. If possible, avoid angles in excess of 12°.

Dimension (**A**) may never be less than 50 mm (2"). Classification authority requirements must be followed when the boat is classified.

Selection of gear ratios

The propeller shaft usually rotates more slowly than the engine crankshaft. This reduction is normally achieved in the reverse gear.

As a rule, the greatest possible reduction gearing must be selected for slow displacement boats. Thus propeller diameter can also be relatively large with high thrust within the applicable rpm range. Depending on hull type and speed range, a lower gear ratio may be selected for higher speed if required. Refer to the table. This is in order to achieve the highest thrust in the chosen speed range. Thrust may be lower than optimal calculated thrust if a non-recommended gear ratio is selected. The boat's top speed may not necessarily be affected.

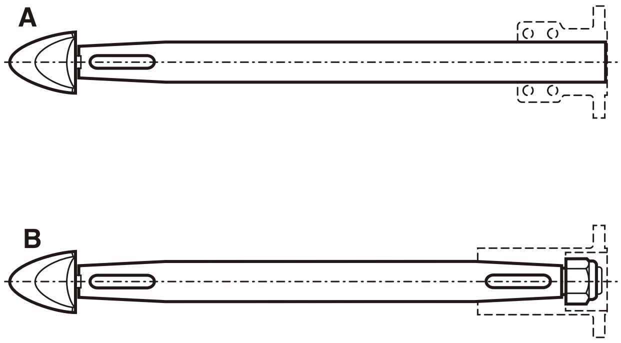
Always check that the hull has sufficient clearance for the propeller; refer to the information on the previous page.

Engine rpm range 2900–4100 rpm in a conventional shaft/propeller system

D3-110/150 engines Rated 3000 rpm	D3-140/170/200/220 engines Rated 4000 rpm	Main operational area	Speed range
2,48:1	2,48:1	Commercial boats Displacement boats Low speed planing boats generally low revolutions	7–15 knots
1.92:1–2.48:1 (D3-110) 2.03–2.48 (D3-150)	1,92:1–2,48:1	Semi-planing to planing boats, patrol boats Sport fishing boats Pleasure boats	16–30 knots
	1,92:1–2,48:1	Planing boats Patrol boats Sport fishing boats Pleasure boats	25–40 knots

Propeller Shaft Systems

Propeller shafts



P0005923

A Single taper shaft

B Double taper shaft

There are many things to take into consideration when selecting a propeller shaft for a given application. Shaft material and shaft dimensions must suit the individual vessel design and application.

The shaft material must be strong and corrosion resistant. Stronger materials have advantages in many sport boat applications thanks to their smaller diameter providing lower water resistance and turbulence for the propeller.

Depending on its length, a shaft may require supporting with bearings. The minimum distance from the shaft coupling to the first fixed bearing must be 6–10 x shaft diameter. The distance must be sufficient to allow the engine to move without exposing the shaft system to unreasonable stresses. The maximum distance between bearings is determined by shaft critical speed. This is calculated on the basis of the installation type and shaft characteristics.

It is of the utmost importance during installation to protect the shaft's precision straightness and polished surface finish. When lifting shafts it is best to use lifting straps and some kind of load distribution device to avoid shaft bending.

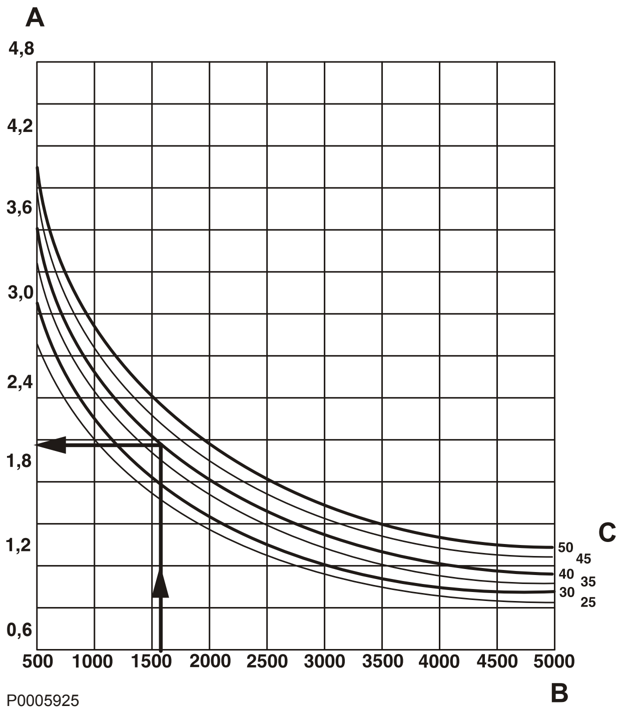
Always check propeller shaft straightness. Run-out may not exceed 0.3 mm (0.012") from 100 percent straightness per meter of shaft.

Propeller shaft dimensions and bearing distances

The propeller shaft must be dimensioned according to the torsional and bending forces it will be exposed to. There must also be a certain safety margin. The maximum distance between bearings has great influence on shaft dimension calculations.

Refer to the graph below: check the Volvo Penta computer program or ask the shaft supplier for advice to determine shaft dimensions and bearing distances.

The graph for calculating the distance between shaft bearings (or propeller shaft support bearings) shown here is based on the formula for shaft critical speed.



A Distance between bearings (m)

B Propeller shaft speed (rpm)

C Propeller shaft diameter (mm)

The graph is applicable to stainless steel SIS 2324-02 or equivalent.

Example:

Engine: D3, 170 hp

Engine speed: 4000 rpm

Gear ratio: 2.48:1

Shaft diameter: 40 mm

Material: Stainless steel SIS 2324-02

Do the following:

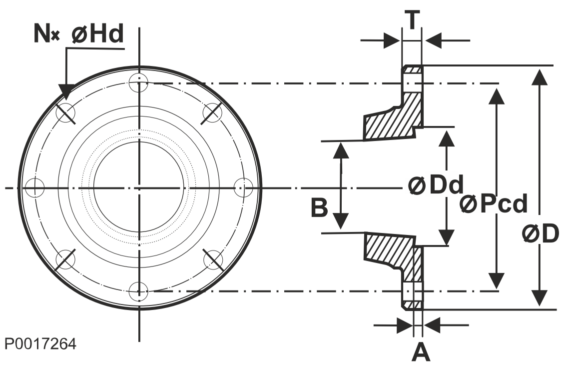
1 Calculate shaft rpm: 4000/2.48 = 1613 rpm.

2 Begin to the right of the graph, where the plot for the 40 mm shaft diameter begins.

3 Follow the plot to the left until it crosses the vertical line for propeller shaft speed (1 613 rpm).

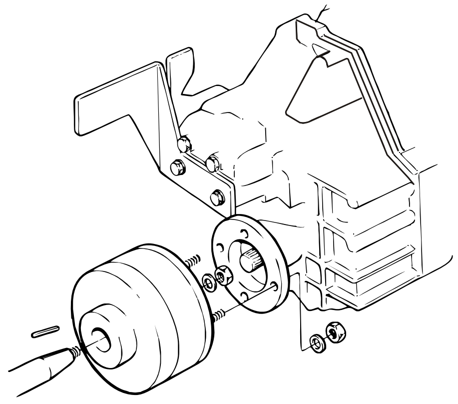
4 Draw a straight line to the left from this point (length in meters).

5 We arrive at a distance of approx 2.2 m (7.2 ft.) between bearings.



Reverse gear flange

Reverse gear	D mm (in.)	Pcd mm (in.)	d mm (in.)	T mm (in.)	A mm (in.)	N x Hd mm (in.)	B
HS25A	127 (5)	108 ±0.2 (4.25 ±0.008)	63.5 H8 (2.5 H0.3)	10 (0.39)	4.0 (0.15)	4 x 10.2 (0.45)	NA
HS45A	127 (5)	108 ±0.2 (4.25 ±0.008)	63.5 H8 (2.5 H0.3)	10 (0.39)	4.0 (0.15)	4 x 11.5 (0.45)	NA
HS63IV	133 (5.25)	108 ±0.1 (4.25 ±0.004)	63.5 H8 (2.5 H0.3)	9.5 (0.37)	6.0 (0.23)	4 x 11.5 (0.45)	ø 56
ZF45-1	152.4	120.6	76.2	14.2 (0.56)	6 (0.23)	6 x 13.2 (0.52)	NA



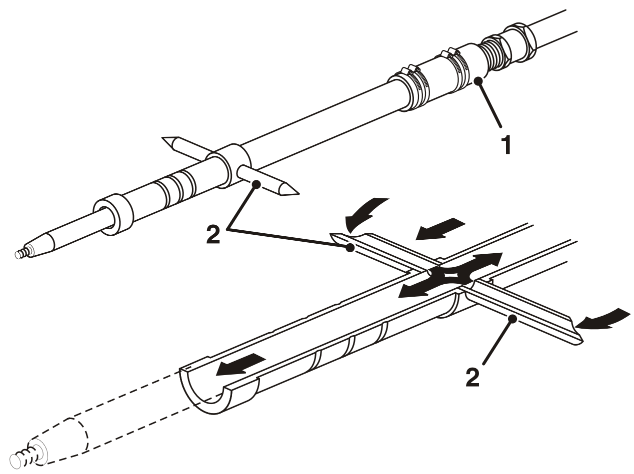
P0005931

Flexible propeller shaft coupling

If the engine has flexible mounts and a fixed packing box, the propeller shaft must be fitted with a flexible shaft coupling.

NOTICE! Engine alignment is just as important with flexible shaft couplings as it is with fixed couplings. The flexible packing box and the flexible propeller shaft coupling are not designed to absorb constant angular deviations.

The flexible shaft coupling must be installed as illustrated.



P0005932

1 Shaft sealing

2 Intake pipe

Packing boxes

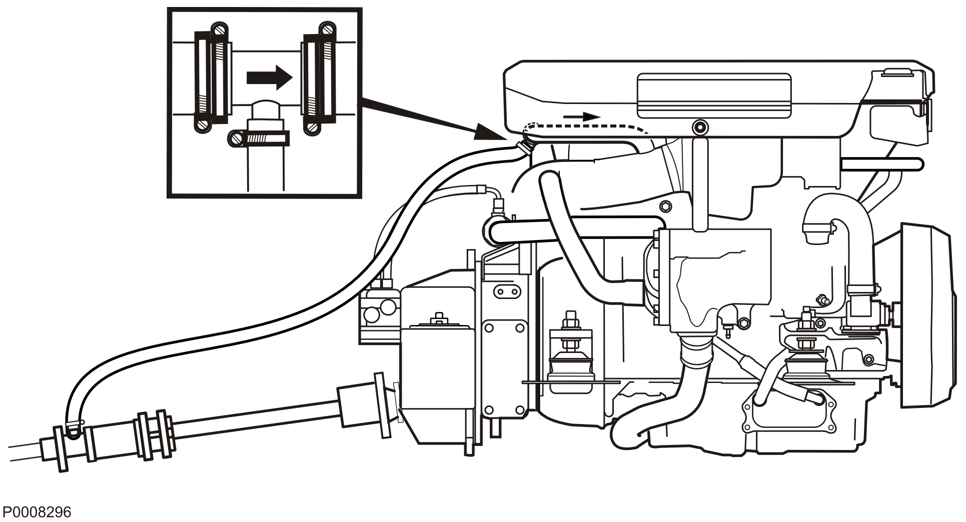
There are several ways to lubricate the shaft seal. The two most common are water-lubricated and grease-lubricated packing boxes. Make sure it is easy to maintain and inspect the packing box. Some packing boxes require a certain play toward the reverse gear coupling to allow changing without disconnecting the shaft.

Water-lubricated packing box

Water has two tasks in a water-lubricated packing box; lubrication and cooling. Water can be fed to the water-lubricated packing box in several ways. One method suitable for displacement boats is to use water intakes in the stern tube.

Intake tubes must be designed so that pressure is built up by boat movement through water.

When test driving a new installation it is important to check that water lubrication functions satisfactorily at full speed. Make sure that the pipes provide sufficient water flow.



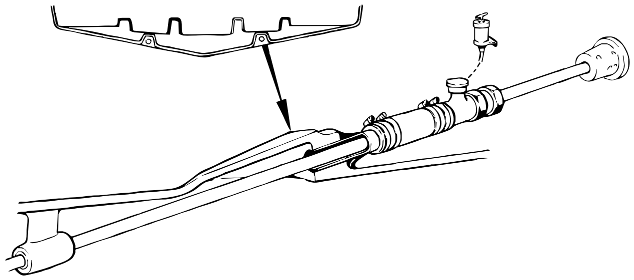
P0008296

Another method common in planing boats is to provide the packing box with water from the engine cooling system. Make sure that not too much water is bled off. If too much water is lost through the shaft seal outlet, the exhaust hose may overheat.

Cut the reverse gear oil cooler cooling water hose (internal diameter 32 mm (1.26")) and install a T-connector in the hose with the aid of hose clamps.

Attach a hose with max diameter 12 mm (0.47") to the T-connector and run it to the propeller shaft packing box.

When test driving a new installation it is important to check that water lubrication functions satisfactorily at full speed.

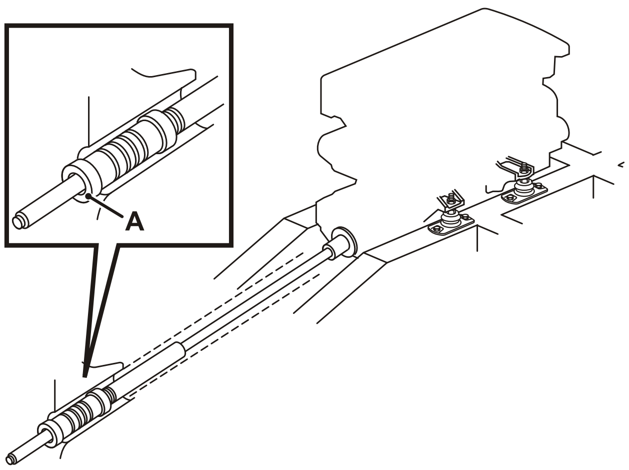


P0005934

Grease-lubricated packing box

Grease is fed to the packing box either through a grease nipple on the packing box, or from a separate grease packer. The grease packer cover must not be tightened too hard as this may cause propeller shaft overheating and wear.

Installation of propeller shaft tube and shaft bearing

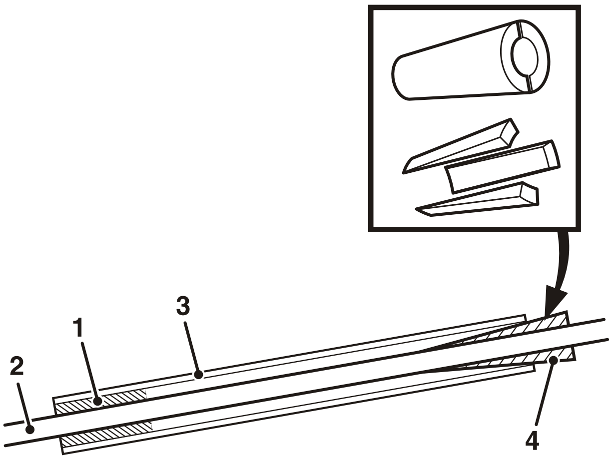


P0005935

The fixed point (**A**) is determined among other things by propeller size. The engine may be used as a fixture when deciding the location of the stern tube and bearing. The engine must be adjusted to its nominal position.

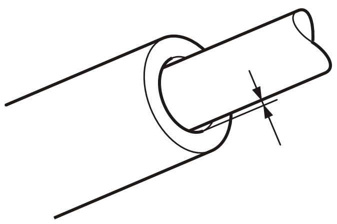
In series production, custom-made fixtures can often be used instead of the engine when positioning the stern tube.

Slide the propeller shaft into place and align the shaft and stern bearing with the reverse gear output shaft (reverse gear flange). To prevent the shaft from bending in the stern tube, center the shaft as follows:



P0005936

- Install the shaft bearing (**1**).
- Center the shaft (**2**) in the propeller shaft tube (**3**) using wedge-shaped guides (**4**).

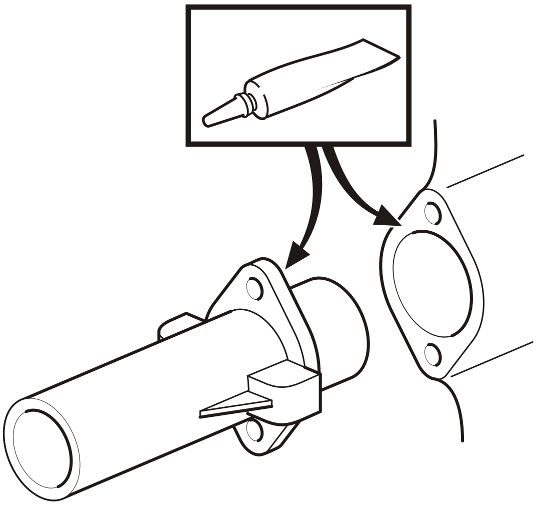


P0007861

Min 4 mm (0.16") play

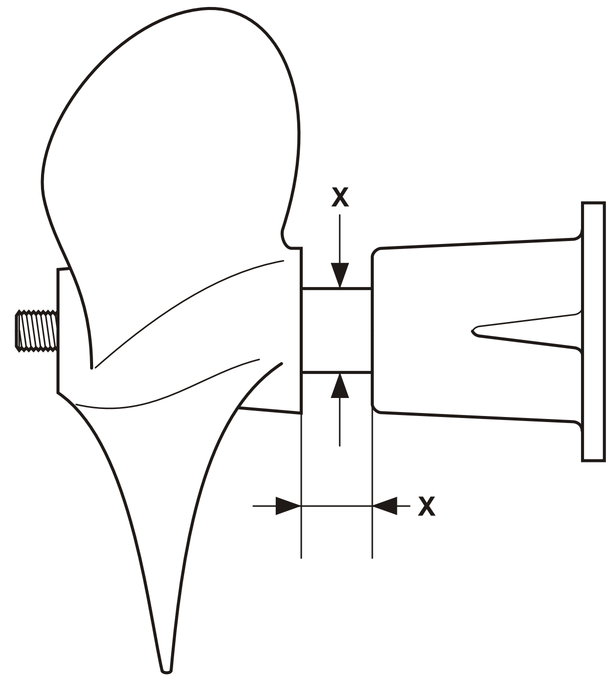
- The play between the internal sleeve surface and the propeller shaft must be **min 4 mm** (0.16").
- Check that the shaft is not bent forward of the tube; support the shaft as necessary.

Once accurate alignment has been achieved, the stern tube may be bolted or glued in place.



If the stern tube is to be bolted into the stern, the bearing flange contact surface must first be ground flat. Brush on sealing compound e.g. silicone rubber, and tighten the bearing retaining bolts.

NOTICE! Check the alignment after gluing.



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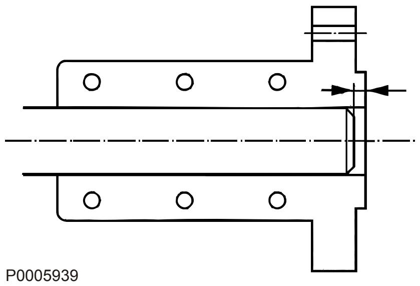
Cut the propeller shaft to the correct length. Bear in mind that the distance (**X**) between the stern bearing aft edge and the propeller must be 1 x propeller shaft diameter (**X**).



P0005939

There must be **2 mm** (0.08") play between the shaft forward end and the reverse gear flange (flexible coupling).

Engine Placement

Engine Inclination

To ensure the engine receives lubrication and cooling in a satisfactory manner, it is important that maximum engine inclination is not exceeded. Engine inclination must therefore be checked.

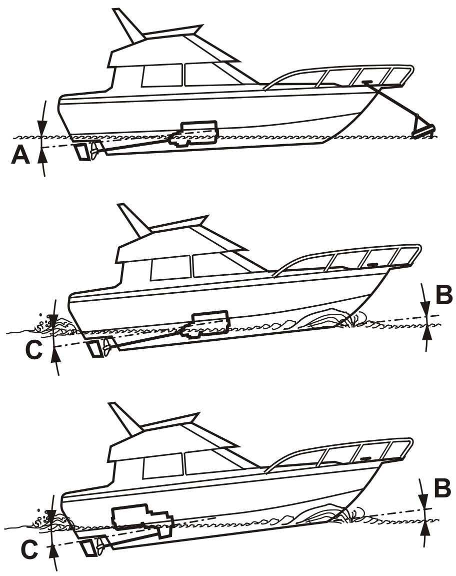
Make sure that the front of the engine is not lower than the flywheel, i.e. an exaggerated negative inclination that may impair engine lubrication and cooling system venting.

Each engine type has a **maximum permissible engine inclination** while the boat is under way. This inclination includes both the installation angle and the increase in trim angle when the boat moves at different speeds through the water.

A Static engine inclination.

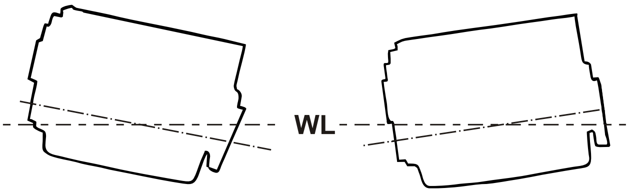
B Boat trim angle under way.

C Total engine inclination under way, maximum permissible inclination (**A**+**B**).



P0005822

Max. engine inclination

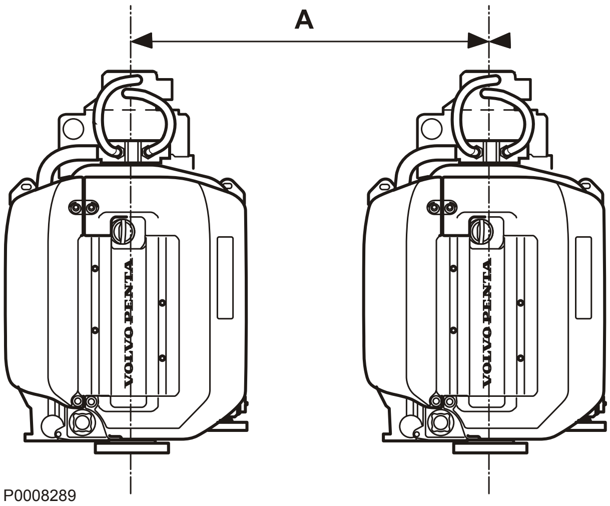


P0005830

Flywheel downward **Flywheel upward**

WL = Waterline

Standard lubrication system	Flywheel downward Max inclination	Flywheel upward Max inclination	Transverse Max inclination
Under way	20°	10°	20°
Static	5°	0°	0°



P0008289

Engine Center Distance

Twin installation

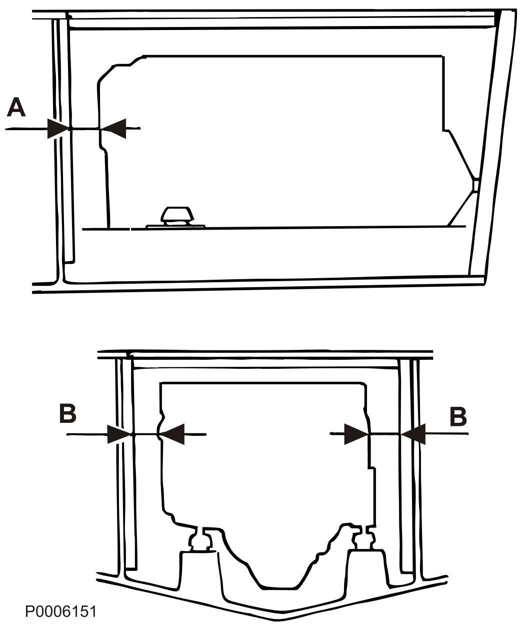
Consideration must always be given to the minimum distance between engine centerlines in a twin installation, in regard to service accessibility. Moreover, a greater distance provides improved maneuvering characteristics.

Use the installation drawings to calculate a suitable distance.

Generally speaking the minimum recommended distance between the engine centerlines (**A**) is **800 mm** (31.5") with conventional steering and **900 mm** (35.4") for electronic steering.

Engine Room

Accessibility for maintenance and repair



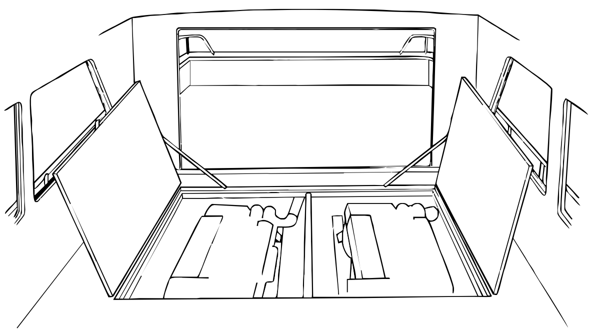
P0006151

When designing the engine installation, great emphasis must be placed on engine service accessibility. Also ensure that the complete engine can be lifted out without damage to the boat structure.

NOTICE! There must also be sufficient space for sound-dampening materials. The recommended minimum distance for sound-dampening materials (**A**) is 180 mm (7”) and (**B**) 200 mm (8”); see illustration.

Carefully study the installation drawings for the engine concerned. The minimum distance between engines in a twin installation is 800 mm (31.5") (installations with electronic steering: 900 mm (35.4")).

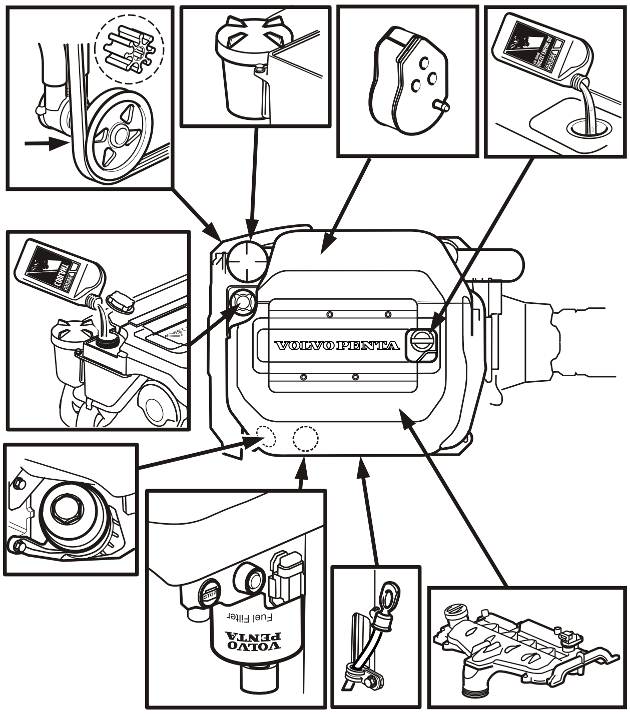
Accessibility for Maintenance



P0006152

Items that usually require maintenance accessibility:

- Oil change and filling (engine, power steering and Power Trim)
- Oil filter change
- Fuel filter change
- Air filter change
- Drive belt inspections
- Drive belt changes
- Removing the valve cover
- Impeller change, seawater pump
- Water filter, cleaning

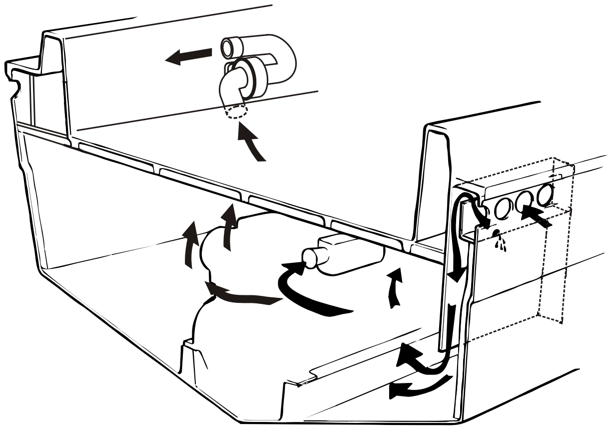


P0008124

Accessibility for repair

Items that require repair accessibility:

- Removal of injectors
- Removal of cylinder head
- Removal of charge air cooler
- Removal of oil cooler
- Removal or exchange of electrical components
- Removal of flywheel and vibration dampers
- Removal or exchange of steering equipment
- Removal of engine



Engine Room Ventilation

Engine performance

Engine power is affected by a number of different factors. Among the most important are air pressure, air temperature and exhaust system back pressure. Deviations from normal values influence engine performance and function.

Diesel engines require an excess of air for combustion. Deviations from normal values first present themselves as black smoke under load. This may be especially noticeable at the planing threshold when the engine must deliver the highest possible torque.

If the deviations from normal values that occur are great, the diesel engine will lose power. The power loss may be so great that a planing boat is unable to overcome the planing threshold.

In order for the engine to function properly and provide full power, it is absolutely essential that both inlet and outlet air ducts are dimensioned and installed correctly.

Two main conditions must be met:

A The engine must receive sufficient air (oxygen) for fuel combustion.

B The engine compartment must be ventilated such that the temperature can be kept at an acceptably low level.

Ventilation is also important to keep the temperature of electrical and fuel systems low, and to guarantee normal engine cooling.

Ventilation must also be suitably adapted if crew members will be present in the engine compartment.

NOTICE! Current national safety regulations and legislation must be followed. Each classification society has its own rules that must be followed when so required.

Engine power and air temperature

Specified engine power is measured in the following conditions: air temperature +25 °C (77 °F), atmospheric pressure 100 mBar (750 mm Hg), 30 % relative humidity, fuel temperature +40 °C (104 °F) and sea-water temperature +30 °C (86 °F). (In accordance with international test standards).

Satisfactory air supply and ventilation make it possible for the engine to provide the highest possible power and attain a long service life.

If engine inlet air cannot be kept below +25 °C (77 °F) **power will be reduced** by up to 1.5% for turbocharged engines and 1.0% for turbocharged engines with charge air coolers for each increase in air temperature of 10 °C (18 °F).

Engine power at high altitudes above sea level

In most cases marine engines are used at, or close to, sea level. However, there are lakes at high altitudes above sea level.

Operations at high altitudes involve a power loss owing to a drop in air density (and thereby oxygen levels) as altitude increases. This will result in the development of smoke and the turbocharger running at abnormally high rpm with increased wear.

However, power loss is not important below approx 500 m (1640 ft) above sea level.

At altitudes in excess of 500 m (1 640 ft.) above sea level, power loss is around 2% per 100 m (328 ft.).

Dimensioning of air intake and ducts

When planning an installation the following basic facts must be considered in calculations:

- All combustion engines, regardless of manufacture or type, require a certain level of oxygen (or air) for the combustion process. However, diesel engines work with a much larger air surplus than gasoline engines.
- Furthermore, all engines emit a certain amount of heat to the surroundings, i.e. the engine compartment.
- Heat radiation is smaller on modern, compact engines than on older, less compact engines. Modern engines enjoy a great advantage in this.

Ducts and pipes for inlet and outlet air

It is an advantage if ducts and pipes for inlet and outlet air can be planned as early as the design stage, as they can then be built into the hull or superstructure. This eliminates the requirement for separate ducts.

It is relatively simple to design a system for providing the engine with a sufficient quantity of combustion air, but significantly more difficult to ventilate heat radiation away.

The engine draws in air efficiently and naturally takes it from whatever direction it can. If inlet and outlet ducts are too small, the engine will draw in air from both ducts and no ventilation air will be expelled through the outlet duct. This will create dangerously high temperatures in the engine compartment.

Most of the engine heat radiation must be carried away from the engine compartment. It is a **absolute necessity** to keep engine compartment temperature below the maximum permissible limit.

NOTICE! The total inlet cross-sectional area can be calculated using the formula:
Total inlet cross-sectional area = engine air consumption + engine compartment ventilation

Fans

Normally an **extraction fan** must be installed in the outlet duct to ventilate the engine compartment more efficiently and thus keep engine compartment temperature low.

Conversely, fans may never be installed in the inlet duct as this may lead to engine compartment overpressure, with the risk of gases or air leaking into other parts of the boat.

For diesel engines the fan may very well be thermostat controlled; it must start at an engine compartment temperature of around +60 °C, measured in the engine compartment.

NOTICE! Fan hose connections for diesel engines must be located as high up in the engine compartment as possible to carry away hot air, while as low as possible for gasoline engines to carry away fumes.

Engine temperature

It is important that inlet temperature is kept as low as possible bearing in mind that engine performance figures apply at a test temperature of **+25 °C**.

Temperature	
≤ 25 °C	Full power
> 25 °C	Power loss approx. 1% per 10 °C

Inlet air temperature at the air filter may not be higher than **+25 °C** for full power. During sea trials the air temperature in the air filter must not be higher than **20 °C** above the outside temperature.

Actual engine temperature is rather high at certain points. Certain individual engine components such as charge regulators and relays must therefore be installed on bulkheads or other locations where the temperature is relatively low.

Maximum temperature at electrical component installation locations is **70 °C**. However, the starter motor and alternator have their given locations.

Engine compartment pressure

Volvo Penta recommends that the *negative pressure in the engine compartment does not fall below 0.5 kPa at full speed*. A slight negative pressure in the engine compartment is not harmful and it prevents gases from being forced out of the engine compartment into other boat spaces.

Engine air consumption

The engine consumes a certain amount of air during the combustion process. This requires the inlet duct to have a certain internal cross-sectional area.

This area can be calculated using the formula:
A = 1.9 × engine power

A = Area in cm^2
Engine power in kW

The value applies to inlets, without obstacles, that are up to 1 m with only one 90-degree bend. The bend radius must be at least twice the duct diameter.
If longer ducts or more bends are used, the area must be corrected by multiplying with the coefficient in table below.

Coefficient of bends

	Duct length (m)				
Quantity bends	1	2	3	4	5
1	1	1.04	1.09	1.13	1.20
2	1.39	1.41	1.43	1.45	1.49
3	–	1.70	1.72	1.74	1.78

Engine compartment ventilation

A large part of the heat radiation must be carried away from the engine compartment in order to keep the temperature down to permissible values. In other words, the heat must be ventilated away.

The same dimensions must be chosen for the outlet and inlet channels in order to achieve low flow speeds and low noise levels.

Ventilation cross-sectional area is calculated according to the following formula:

Inlet air = 1.65 x engine power

Outlet air = 1.65 x engine power
Area in cm^2
Engine power in kW.

These values must be corrected in accordance with table 1 in regard to bends and duct length.

Outdoor temperature is assumed to be +30 °C. Correction factors as described in table 2 must be used when appropriate.

Correction factor

Ambient temperature °C	Correction factor
+20	0.7
+30	1.0
+40	1.4

Choice of fan

The fan must be dimensioned for airflow according to the following:
Outlet air = 0.07 x engine power

Airflow volume in m^3/min
Engine power in kW.

The total pressure increase at the fan must be 10 mm water gauge (100 Pa).

These two values, flow and total pressure increase, are sufficient for selecting a fan. If the fan is installed directly on the bulkhead, i.e. without a connecting duct, the total pressure increase value may be reduced by 7 mm water gauge (70 Pa). This means that a somewhat smaller fan may be used.

Calculation of air ducts

Example 1

Two D3-220, 162 kW (220 hp) diesel engines
Calculating the area for **two** 162 kW engines with an unhindered air supply and an outdoor temperature of +30 °C.

The following is obtained for *each* engine:
Area for engine air consumption: 1.9 × 162 = 308 cm^2
No corrections according to tables*Coefficient of bends* and *Coefficient of bends*. The area 308 cm² gives a duct diameter of 198 mm for **a single** engine.

Ventilation, engine compartment:

1 **Inlet, engine compartment**: Area = 1.65 × 162 = 267 cm^2. This gives a diameter of 184 mm for one engine.

2 **Outlet, engine compartment:** Area = 1.65 × 162 = 267 cm^2. This gives a diameter of 184 mm for one engine.

3 **Capacity, extraction fan:** 0.07 × 162 (kW) = 11.3 m^3/min.

4 **NOTICE!** The figures must be multiplied by 2 as this is a twin installation.

Example 2

One D3-140, 103 kW (140 hp) diesel engine
Area calculation for **one** engine with a 2 m long duct, 2 bends and an outside temperature of +20 °C.

Area for engine air consumption: 1.9 × 103 = 196 cm^2

Correction for air temperature = 0.7 from table *Correction factor*, plus a correction for duct length and bends = 1.41 from table *Coefficient of bends*.

This gives 196 × 0.7 × 1,41 = 193.5 cm^2. The area 193.5 cm^2 is equivalent to a duct diameter of 157 mm.

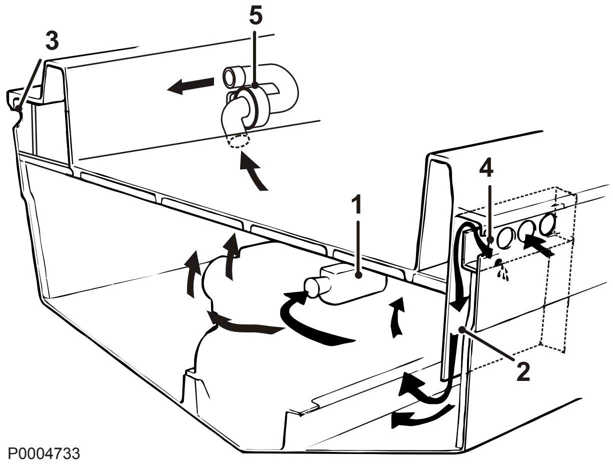
Ventilation, engine compartment:

1 **Inlet, engine compartment:** Area = 1.65 × 103 = 170 cm^2. This corresponds to a duct diameter of 147 mm.

2 **Outlet, engine compartment:** Area = 1.65 × 103 = 170 cm^2. This corresponds to a duct diameter of 147 mm.

3 *Correction, inlet and outlet:* Air temperature = 0.7 from table 2, plus a correction for duct length and bends = 1.41 from table *Correction factor*.
This gives 170 × 0.7 × 1.41 = 168 cm^2. This corresponds to a duct diameter of 146 mm for each inlet and outlet.

4 **Capacity, extraction fan:** 0.07 × 103 (kW) = 7.2 m^3/min.



P0004733

1 Engine air filter

2 Inlet duct, engine compartment

3 Ventilation

4 Water trap

5 Extraction fan

Location of Ventilators and Air Intakes

NOTICE! Air inlets and outlets may never be located on the transom. Air in this area mixes with water and exhaust fumes, and must never be allowed into the boat.

Air inlet function

Air inlets and outlets must function well even in bad weather and must therefore have efficient water traps. For the most part noise insulation must be built in.

Air inlets and outlets must be located as far away from each other as possible so that an effective through flow is achieved.

If inlets and outlets are too close to each other air is able to recirculate, which will provide inadequate ventilation.

Location of air ducts

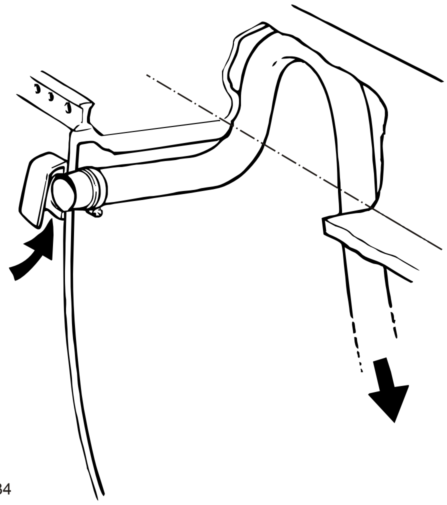
Ducts or pipes for engine air supply must be run to a place as close to the air filter as possible, but with a minimum distance of 20–30 cm (8–12") in order to definitely prevent water from entering the engine. Refer to the illustrations.

Example of how inlet and outlet air ducts may be installed in leisure craft and similar hulls with diesel engines.

The inlet ventilation duct for diesel engines must be led in far down into the engine compartment, but not so far down that any bilge water is able to block air supply. The outlet duct must be located diametrically opposite on the other side of the engine.

All ducts and pipes must be run such that there is the least possible flow resistance. Bends may not be sharp, but must be moderately rounded. The minimum radius is double the diameter. ***Obstacles or constrictions must always be avoided.***

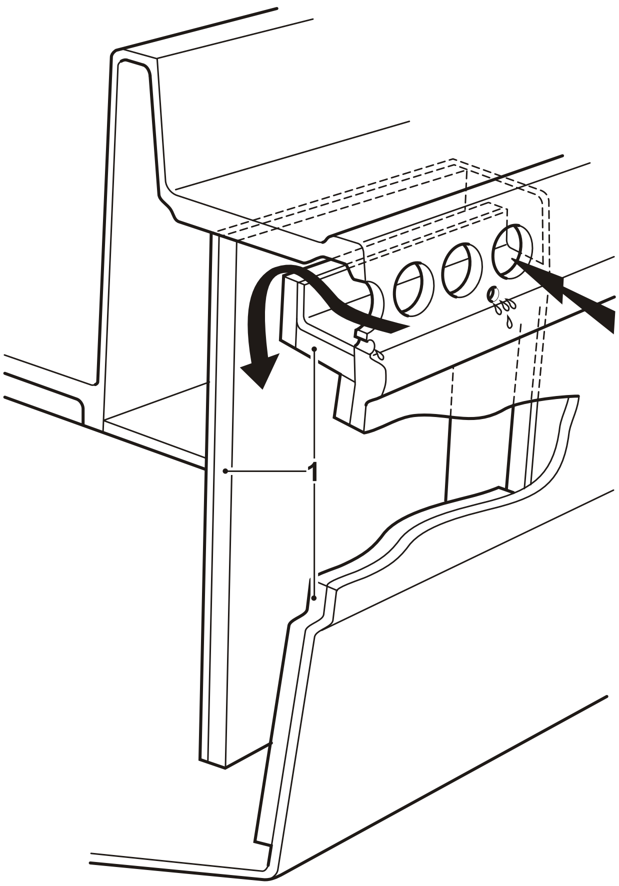
The ducts must be cut obliquely at the ends to provide best flow.



P0004734

In certain countries there are special regulations that must be followed.

If it is not possible to arrange drainage, ventilation hoses must be bent upwards somewhat in order to form a gooseneck that prevents seawater forcing its way into the engine compartment. Remember to build the engine compartment as spaciously as possible to facilitate engine service.



P0004735

Engine compartment noise baffles

Sound Absorption

The drive assembly must be installed so that noise and vibrations are minimized. The noise that occurs is party airborne noise and partly structural noise (vibrations).

Structural noise

Engine vibrations are transferred to the hull via the engine mounts and engine bed. Other transfer routes are through the transmission and propeller system, exhaust pipes, coolant pipes, fuel pipes and electrical and control cables.

Propeller pressure waves are transmitted through the water to the hull. Propeller drive pulses are transferred to the hull via support brackets, bearings and seals.

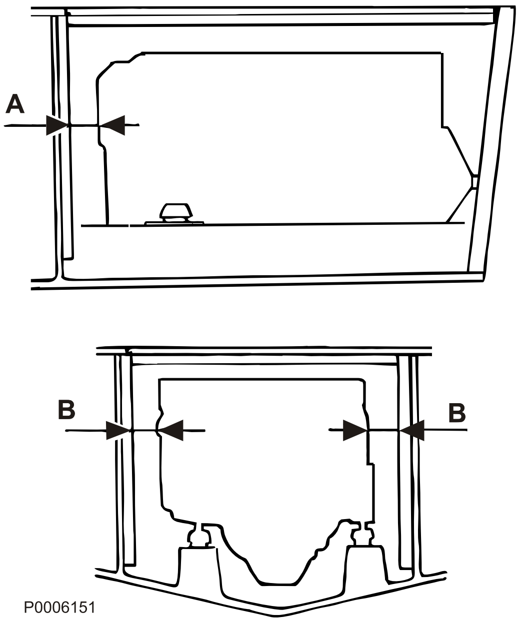
Airborne noise

This section concerns airborne noise from the engine compartment. The most important method of reducing airborne noise from the engine compartment is to seal it properly. Further noise reductions can be achieved by laying sound insulation material and by designing noise baffles in the air inlets.

The engine installation must be noise insulated to provide as low a noise level as possible. Build noise baffles into the engine compartment. There are different types of noise baffles to choose from. The illustration shows a type that also provides drainage.

It is important to ensure that the insulation material is sufficiently thick.

The greatest possible care must be taken to screen the noise source as much as possible. Screen off the entire bulkhead down to the hull, but leave a little gap so that bilge water does not force its way into the insulation material.



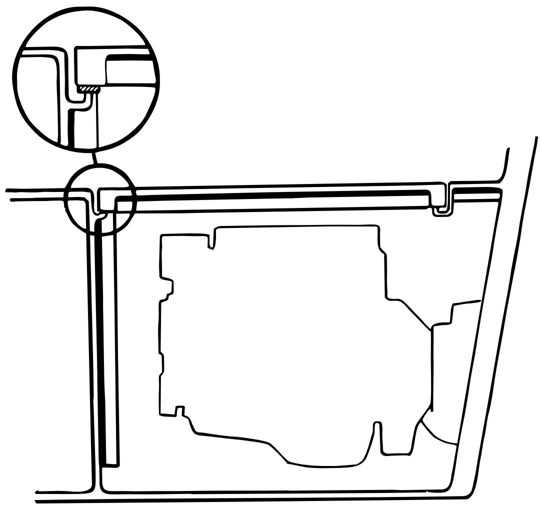
P0006151

A **Min. 180 mm** (7”)

B **Min. 200 mm** (8”)

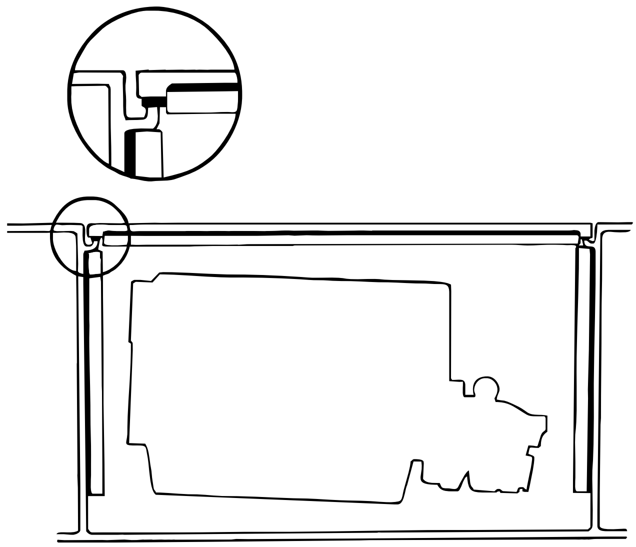
Cracks and openings etc. must be carefully sealed with insulation material. In cases where the engine is installed beneath the deck, all bulkheads and decks must be insulated.

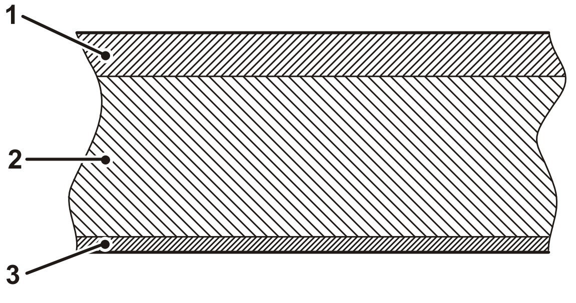
Make sure that there is sufficient space for inspections, service and repairs and for engine movement during operations before the insulation material is installed. Also make sure that all covers are properly insulated.



P0004738

Check cover sealing





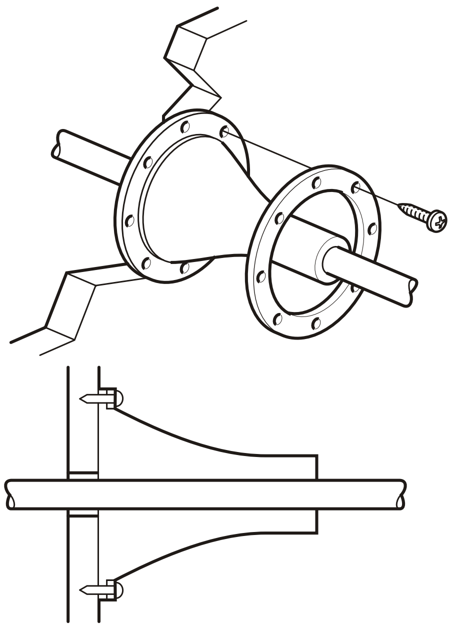
P0004739

Insulation material installed on wood (plywood):

1 Wood (plywood)

2 Flameproof absorbent layer

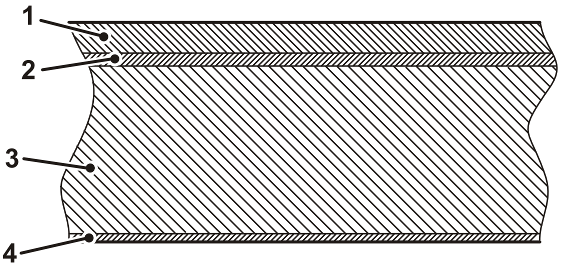
3 Flameproof, reflective and noise insulating foil



P0004741

Bulkhead bushings

Examples of insulation material design are shown below. This type of insulation material is glued to the frame.



P0004740

Insulation material installed on GRP:

1 GRP

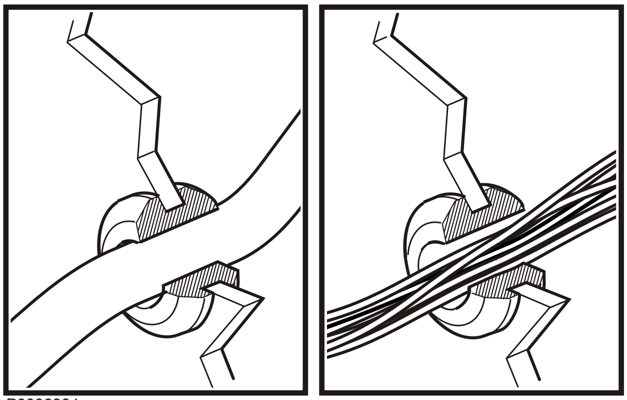
2 Iron/PVC, thickness 2.5 mm (0.1”)

3 Flameproof absorbent layer

4 Flameproof, reflective and noise insulating foil

NOTICE! The insulation materials look different depending on the material the frame is made of - GRP or wood.

When electrical cables are run through a bulkhead, it is advantageous to run them through a conduit or grommet that can be sealed properly. This also protects the cable against wear.


P0006334

Fuel hose protected by a grommet

Fuel hoses that are run through bulkheads must be protected by grommets. The grommet seals and protects the hose against sharp edges that may cause leaks.

Other lines such as electrical and battery cables can be run through a rubber hose or a special PVC pipe (installation pipe) built into the hull. Any gaps between the pipes and the cables can be sealed with insulating material or sealing compound.

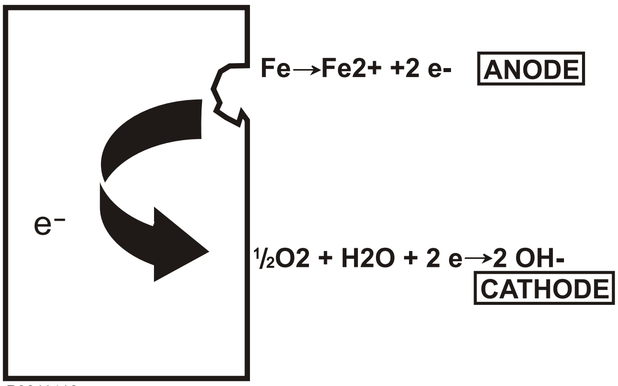
Electrochemical Corrosion

General

NOTICE! Refer to the Service handbook *Corrosion measurement, DPH/DPR & IPS* for further information.

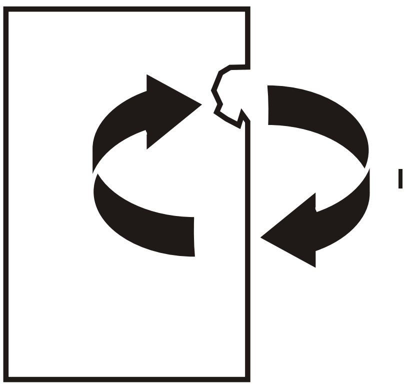
Corrosion theory

Corrosion in water is always electrochemical in nature. This means that a weak electric current occurs at the same time as chemical reactions takes place. Two chemical reactions are required to make a metal corrode, an oxidation reaction (metal dissolving) and a reduction reaction (generally oxygen consuming). Oxidation is referred to as an anode reaction and reduction is referred to as a cathodic reaction. In an oxidation reaction, electrons are freed which are transported in the metal to another point, where they are consumed in a cathodic reaction.



P0011416

Electrons are thus transported in the metal from the anode to the cathode. This causes a weak DC current in the opposite direction. An electric circuit must be closed. This is achieved by the transport of ions in the water.



P0011417

Anodic and cathodic reactions must always balance each other, which means that the electrons released at the anode must be consumed at the cathode. If the anodic and cathodic reactions occur evenly distributed across the entire surface, general corrosion occurs. The depth of attack then becomes basically equal across the entire surface. This commonly occurs on steel and bronze.

If the anodic and cathodic reactions occur at different points, local corrosion occurs, i.e. deeper attack at certain points. The attacks on materials which can be passivated, such as stainless steel and aluminum are generally localized. There are different types of local corrosion. The most common types of attack on stainless steels and aluminum are pitting corrosion and crevice corrosion.

In addition to these local attacks, attack can be caused by galvanic corrosion or stray currents. In areas where rapid water flow occurs, damage cause by cavitation can also occur.

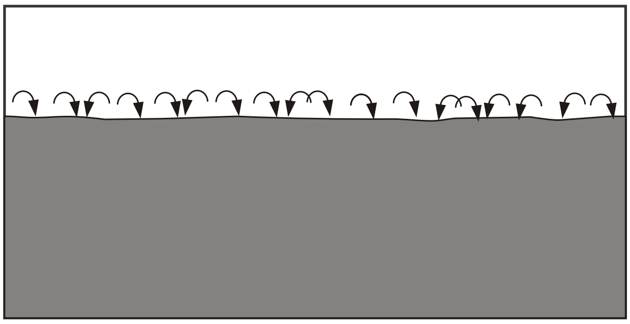
If we ignore attacks related to material defects, the following types of corrosion can occur:

- General corrosion.
- Pitting.
- Crevice corrosion.
- Galvanic corrosion.
- Stray current corrosion.
- Cavitation.

A brief description of each type of corrosion is given below.

General corrosion

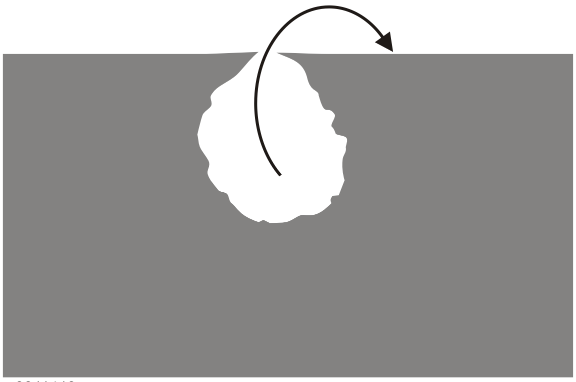
General corrosion is the most common type of corrosion. This results in even attack across all or large parts of the surface.



p0011418

In seawater, mild steel and bronze are subject to general corrosion, but not stainless steel. In stationary seawater, the corrosion rate of mild steel is about 0.1 mm/year (0.3 mm/year at the waterline) unless the steel is protected by cathodic protection. Bronze is initially attacked at a rate of 0.05 mm/year, but after some time the corrosion rate falls to a low level, since the corrosion products (black, brown) have a protective effect. Green/blue corrosion products are a sign of higher corrosion rates and that the protective layer has not been developed.

Aluminum can be subject to a certain amount of general corrosion in rapidly flowing water, but not in stationary water.

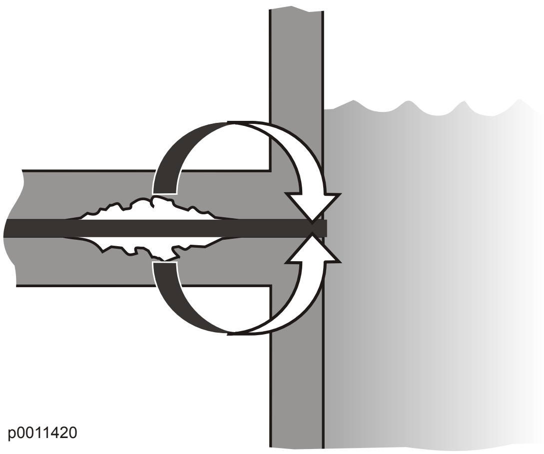


p0011419

Pitting corrosion

Pitting corrosion can occur on stainless steel and aluminum. The attack is caused by localized breakdown of the passive oxide film on the metal surface. In natural water, it is generally chloride ions that initiate the attack. The risk increases with rising water temperatures. There is a number of aluminum alloys with very good resistance to corrosion by seawater. If these are connected together with more noble metals, they will be attacked due to galvanic corrosion, however.

Very high levels of chromium and molybdenum are required, above all, to make stainless steel fully resistant to the risk of pitting corrosion. If there is weak cathodic protection (sacrificial anodes), excellent protection against pitting corrosion can be obtained on simpler steels. Alloys of lower grades than 316 should be avoided, however.



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Crevice corrosion

An attack in the gap between two metal surfaces, or between one metal surface and another materials is called crevice corrosion. A so-called oxygen depletion cell is formed when oxygen transport into the crevice is lower than oxygen transport out to the cell opening. Separate anodic and cathodic surfaces are formed.

The cathodic process, which requires access to oxygen, is formed in the gap opening and the anodic process, metal dissolving, takes place inside the gap. Crevice corrosion can occur on most metals, but the risk is greatest on metals that can be passivated, such as aluminum and stainless steel.

Deposit corrosion is closely related to crevice corrosion. It takes place under deposits and marine fouling such as barnacles.

Metals	From	To
Graphite	+0,19	+0.25V
Stainless steel 18-8, Mo, in passive state *	±0,00	-0.10 V
Stainless steel 18-8 in passive state *	-0,05	-0.10 V
Nickel	-0,10	-0.20 V
Nickel-aluminum-bronze	-0,13	-0.22 V
Lead	-0,19	-0.25 V
Silicon bronze (Cu, Zn, Si, Mn, Sn)	-0,26	-0.29 V
Manganese bronze (Cu, Zn, Si, Mn, Sn)	-0,27	-0.34 V
Aluminum brass (Cu, Zn, Al)	-0,28	-0.36 V
Solder (Pb, Sn)	-0,28	-0.37 V
Copper	-0,30	-0.57 V
Tin	-0,31	-0.33 V
Red brass (Cu, Zn)	-0,30	-0.40 V
Yellow brass (Cu, Zn)	-0,30	-0.40 V
Aluminum bronze	-0,31	-0.42 V
Stainless steel 18-8, Mo, in active state **	-0,43	-0.54 V
Stainless steel 18-8 in active state **	-0,46	-0.58 V
Cast iron	-0,60	-0.71 V
Steel	-0,60	-0.71 V
Aluminum alloy	-0,76	-1.00 V
Galvanized iron and steel	-0,98	-1.03 V
Zinc	-0,98	-1.03 V
Magnesium and magnesium alloy consumed	-1,60	-1.63 V

* Metals are in a passive state when they have a thin, corrosion inhibiting coating. This coating is not present in the active state.

** Still water.

Galvanic corrosion

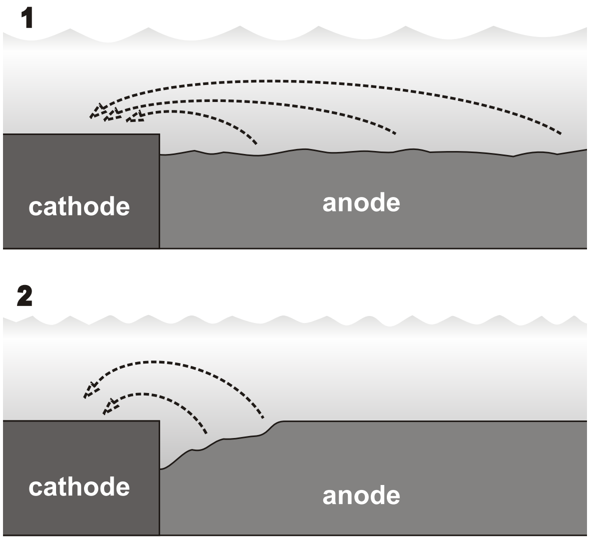
Galvanic corrosion is probably the most common type of corrosion. It occurs when two metals of different nobility are in electric contact and are submerged in the same body of water at the same time. The least noble metal is corroded.

Information about the nobility of different metals is obtained from galvanic potential tables which have been prepared in various fluids, such as seawater. See table to the left:

There are four factors which influence the seriousness of galvanic corrosion in each individual case. These are:

- Area relationship between the anode (less noble metal) and the cathode (more noble metal). If the anode is small in relation to the cathode, the depth of attack will be greater than if the situation was reversed.
- Conductivity of the water. Seawater conducts electricity better than fresh water, and corrosion takes place at a greater rate.
- Potential difference between the two metals. A large potential difference increases the power behind the process.
- Lower corrosion rate can be obtained if the more noble metal can be passivated. This means that stainless steel is more noble than copper, but the galvanic corrosion will be more severe on aluminum when connected to copper than when connected to stainless steel.

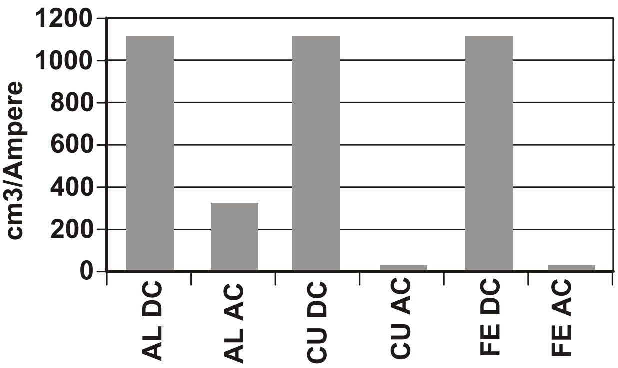
In seawater, total galvanic corrosion counted in grammes of metal, will be greater than in water which is not so salt. The greatest depth of corrosion on a metal can be equally large in brackish or fresh water. The better conductivity of seawater means that the attack will be distributed evenly across the entire surface. In fresh water, there will be more local attack close to the point of contact.



P0011421

1 Seawater

2 Fresh water



P0011422

The following should be considered, to counteract galvanic corrosion:

- Do not connect metals which are far away from each other in the galvanic potential table.
- Insulate different metals from each other by using plastic or rubber (must not contain graphite).
- Paint the structure. The surface of both metals should be painted. If painting is restricted to only the less noble metal, heavy galvanic corrosion could occur on surfaces where there is paint damage. The reason for this is that the cathode/ anode relationship will be unfavorable.
- Install cathodic protection.

Stray current corrosion

As we learned in the corrosion theory chapter, corrosion occurs when a DC current flows into the water from a metal surface. Similar stray currents from the drive can occur if there is a fault in the boat's electrical system, such as if couplings are exposed to dirt and moisture, components are incorrectly installed or damaged. Stray currents can come from shore current installations or adjacent boats. All metals, except a few noble metals, are corroded by stray currents. Corrosion rates can be very high.

The sacrificial anodes on the drive are not dimensioned to counteract any stray currents. If stray currents occur, the anodes will be consumed very quickly and the drive will be attacked.

Aluminum is particularly vulnerable to stray currents. If the current density on the surface is high, corrosion can also occur when there is a stray inwards current. AC currents can also cause damage. The AC corrosion rate for aluminum is 30% of the rate for DC. The corresponding rates for steel, copper and zinc are much lower, at 1 %. Please refer to the figure to the left.

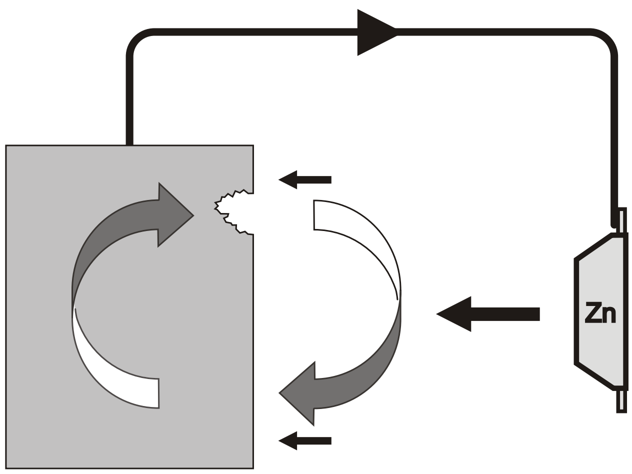
Corrosion protection

Drives are protected from corrosion by a number of measures.

- Alloys which are resistant to salt water.
- Avoidance of unsuitable combinations of metals. Where appropriate, a favorable relationship between anode and cathode is established.
- High quality surface treatment.
- Cathodic protection.
- Carefully designed electrical system.
- Recommendations to minimize external interference.

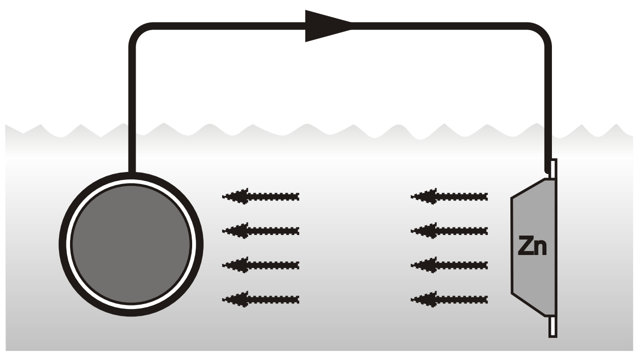
Recommendations from Volvo Penta and anti fouling manufacturers must be followed. In addition, the material must be resistant to the alkali that is formed on cathodically protected surfaces.

Cathodic protection is arranged by supplying a weak DC current from an anode to the protected object. The current which leaks in counteracts the corrosion current. The higher the protection current, the lower is the rate of corrosion.



P0011424

The current required for protection can be generated in two ways. These are either with sacrificial anodes or by applying a current. If sacrificial anodes are used, the current is generated by connecting the protected object with a less noble metal (anode). The difference in electric potential creates a protective galvanic current. It can be said that corrosion is transferred to the anode, which is why they are referred to as sacrificial anodes.



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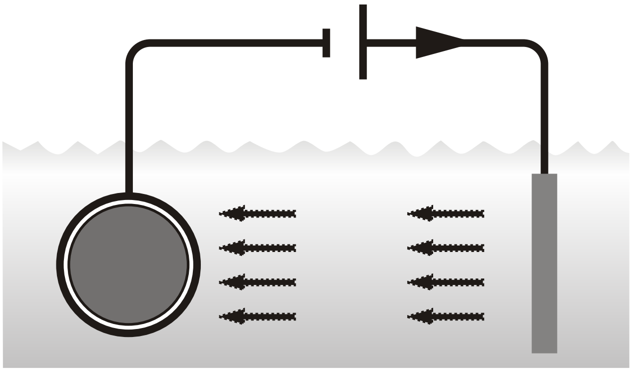

P0011426

If a current is applied, this is supplied from an external source (rectifier, battery).

The materials used in sacrificial anodes are zinc, aluminum, magnesium and iron. Please note that special alloys are used, to meet the following requirements:

- No passivation, i.e. they do not stop supplying current.
- Even consumption.
- Low polarization tendency, i.e. they retain a sufficient potential difference to the object.
- Low self-corrosion.

Only use original anodes. Never paint over the anodes.

Iron anodes can be used to protect stainless steel and bronze objects. Magnesium anodes can be used in fresh water where the current supplied by zinc anodes may not be enough in some cases. Please note that magnesium anodes give overprotection to aluminum in seawater. There is no risk of overprotection of aluminium if zinc or aluminum anodes are used for protection.

Anodes to use

Anodes are installed from the factory on all Volvo Penta drives and transom shield. Anodes are manufactured for different environments and will react to those. There are some general recommendations when choosing anodes. See chart below.

Zink and Aluminium anodes will if used in fresh water become covered with white crust of oxide which will stop the anode from working when returned to salt water. Zinc anodes react the same way in brackish water while the Aluminium anodes will work effectively in rivers estuaries and other brackish conditions.

Magnesium anodes are not designed for use in salt water so if you are taking your boat into salt water for more then 7 days you should consider changing the anodes. The same can also be applied for zinc and aluminium anodes if moving your boat between different waters.

It is important to inspect the anodes after shifting waters and if necessary also clean the anodes. The anodes can also be pacified just by being away from water. If the drive has been tilted or for example placed on a trailer for some time make sure to take a look on the anodes.

If an anode for example looks yellow or is covered in white crust it has been pacified and needs to be brushed or changed to provide protection. This can be done by brushing the anodes using sandpaper.

NOTICE! Never use a wire brush with steel bristles. Use sand paper without iron or iron oxide otherwise the anode might be pacified.

Make sure to inspect the anodes on a regular basis and change them if more then 1/3 has been used up by corrosion. All anodes do not share the same quality! Always use anodes produced by Volvo Penta since they have been tested to ensure maximum protection on stern drives and props.

Anode	Material	Water condition
Transom shield	Zinc	Salt water
Sterndrive	Zinc	Salt water
Transom shield	Aluminum	Brackish water
Sterndrive	Aluminum	Brackish water
Transom shield	Magnesium	Fresh water
Sterndrive	Magnesium	Fresh water

Definitions

Single-pole system

All D3 engines are single-pole.
In a single-pole system the actual engine block is used as the negative ground return for all components on the engine block.

Isolation transformer

A transformer with galvanically separated input and output windings.

The isolation transformer separates galvanic shore power from the boat and reduces the risk for galvanic corrosion and stray current corrosion as described in ABYC circuit diagram 8 and text E-11.7.2.2.1.4 thru 5. Corrosion damage caused by stray currents will not be compensated for under warranty.

Ground fault circuit interrupter (GFCI)

A health and safety protection device, the GFCI cuts the current to a circuit when current to ground exceeds a predetermined value.

Spark generation between live conductors and ground may occur at relatively low currents and will not trip circuit breakers. Moreover, very low currents may also constitute a danger for personnel. A GFCI must be installed on the boat side of the isolation transformer as ground fault protection in the boat. GFCI tripping sensitivity and tripping times must meet local standards.

A GFCI located on the boat side of the isolation transformer safeguards ground fault protection in the boat. This is supplement to ABYC E-11 that ensures a higher level of protection against electric shock.

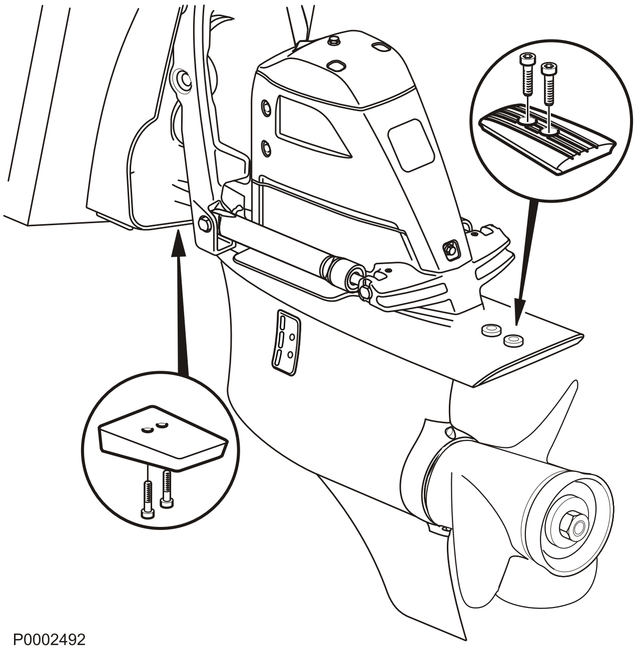
Protection against electrochemical corrosion

In order to avoid galvanic corrosion to underwater components such as hull penetrations, swim ladders etc., it is important that they be protected. Volvo Penta recommends that all components be connected to a protection anode installed on the transom. Trim planes may have their own protection.

NOTICE! Normally, the system connecting individual components must not have any contact with the negative circuit in the boat electrical system.

Local recommendations, e.g. ABYC, may state that the battery negative terminal shall be connected to the galvanic circuit. If a decision is made to connect the galvanic circuit to the battery negative terminal (-), the engine block must also be connected by a cable sufficiently large to conduct current at engine start; refer to the description in ABYC chapter E-11.

SX/DPS sterndrives

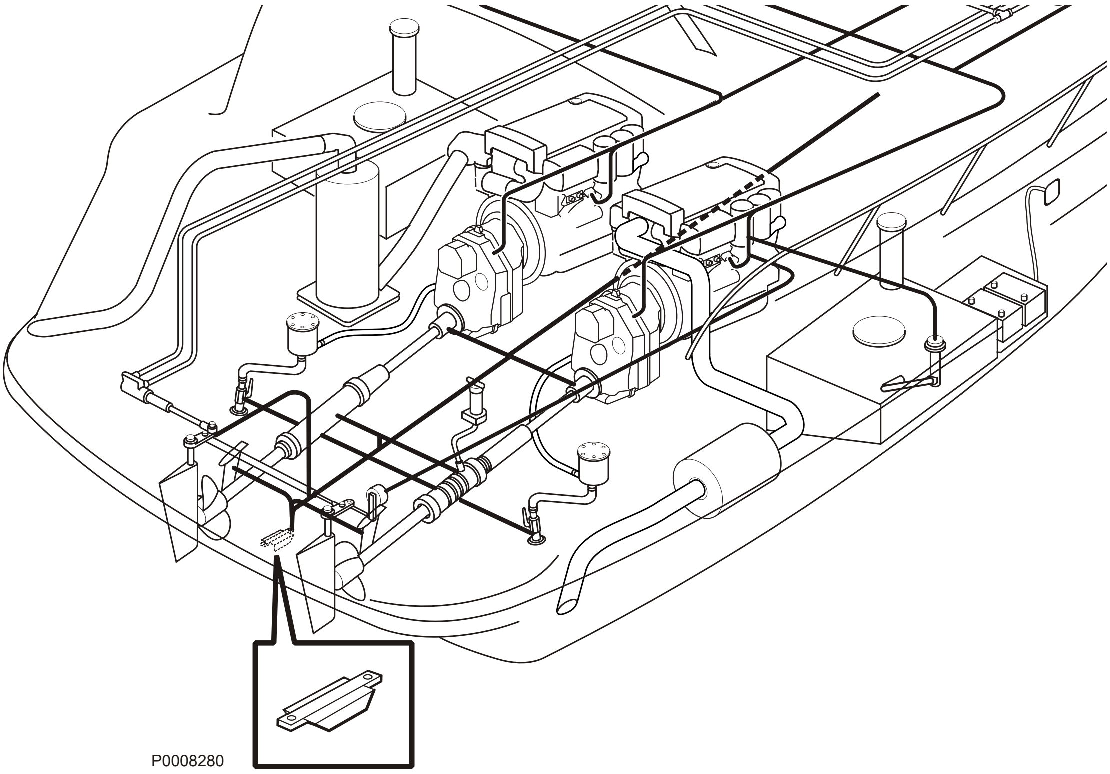


P0002492

SX/DPS sterndrives are manufactured in aluminum and protected against galvanic corrosion by their own protection anodes. SX/DPS sterndrive protection anodes only protect the actual drive and may not be connected to other components below the water line.

Inboard engines

Inboard engine installations must fulfill the requirements described in the section above.

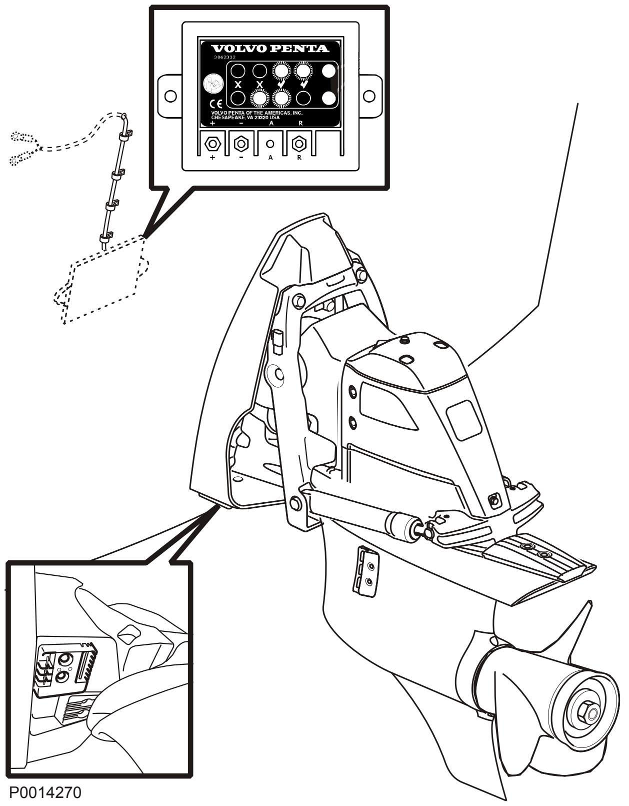


P0008280

Protection against electrostatic discharge and lightning

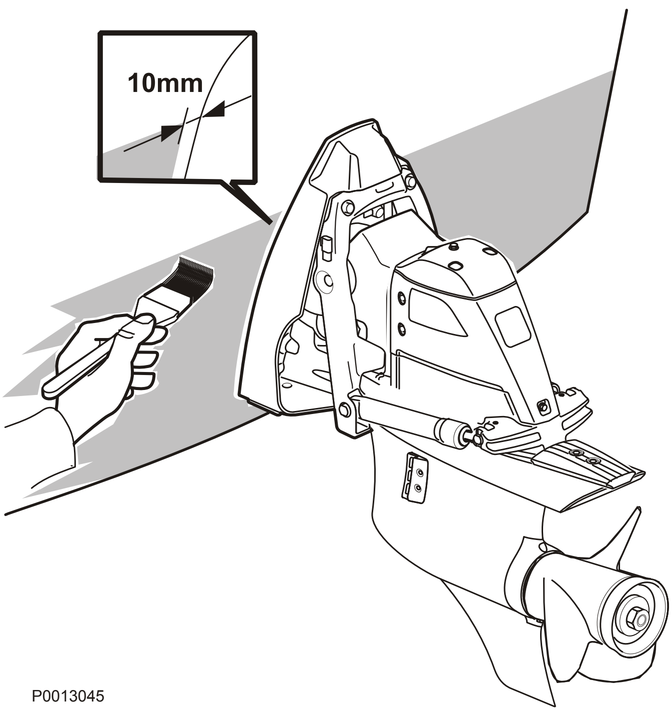
For advice on the prevention of hazards due to electrostatic discharge or lightning, please refer to relevant publications by national and international standardization bodies such as the International Electrotechnical Commission and the American Boat and Yacht Council.

In particular, the publications *IEC 60092-507:2000 Electrical installation in ships Part 507: Pleasure craft*, and *ABYC Standards and guidelines H-33 and E-4* may prove helpful.



P0014270

The illustration shows an ACPS installation where the anode/reference sensor is pre-installed on the transom shield.



P0013045

ACPS

Volvo Penta ACPS Active Corrosion Protection protects the sterndrive against galvanic corrosion by controlling an electric current that is monitored by a reference sensor.
ACPS acts as a secondary protection, i.e. as a complement to the existing sterndrive and transom shield anode protection. Where the primary anode (zinc or aluminum) has been consumed or is insufficient to maintain voltage in the (-900) – (-1100) mV range, ACPS does this instead.

ACPS consists of a combined active anode/reference sensor (**1**) that senses and supplies current as needed. This is done by means of an electronic unit (**2**) connected to the engine battery, with a constant power supply and its own circuit breaker.
Control lamps on the electronic unit show whether the ACPS system is correctly connected, if it is protecting in the proper manner and whether supplementary power is being supplied to the anodes.

The active anode/reference sensor is installed at the bottom of the transom shield. The electronic unit is installed on the inboard side of the transom, sufficiently high so as not to come into contact with water, and so that its control lamps are fully visible.

For further information about how ACPS is installed, refer to installation instruction 4776905.

Bottom Painting

Aquamatic

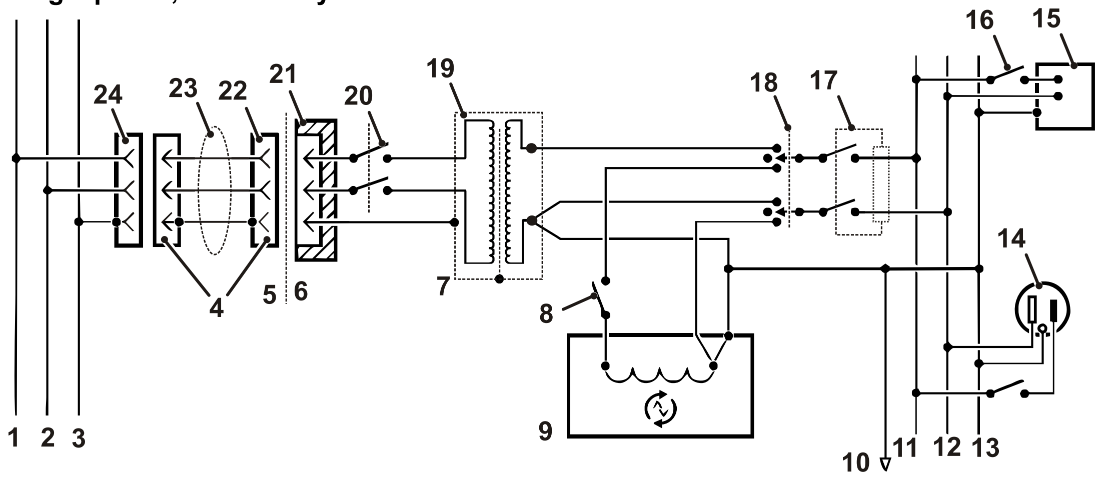
When bottom paint is applied to the hull, a **10–15 mm** (0.4–0.6") border must be left around the transom shield.

Shore supply and alternator installation

Example of an installation with isolation transformer

For installation, refer to local regulations.

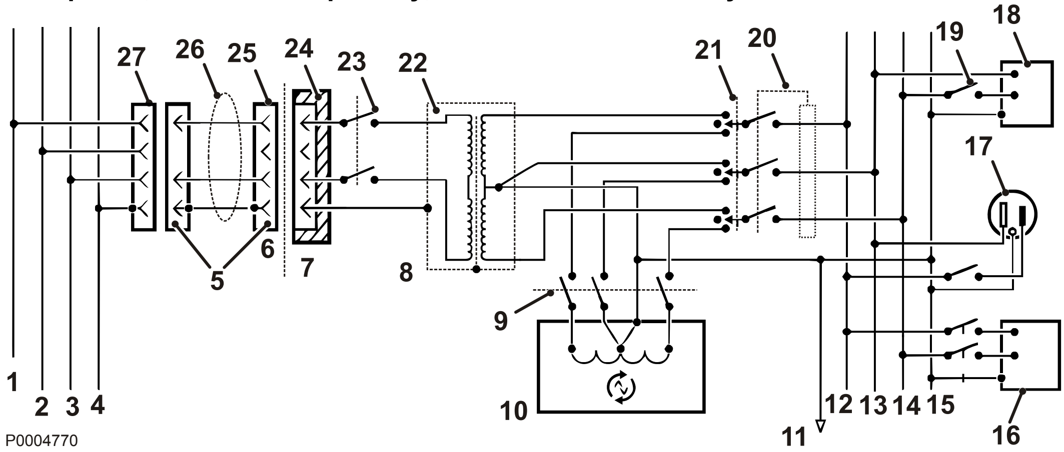
Single phase, 240 VAC system



P0004769

1 Phase
2 Zero
3 Protective ground
4 2-pole, 3-wire grounded contact and female socket
5 Shore side
6 Boatside
7 Transformer shield
8 Alternator circuit breaker
9 Alternator (accessory)
10 To DC negative buss and ground plate, boat
11 Phase
12 Zero
13 Protective ground
14 240 VAC ground, female socket
15 240 V AC apparatus
16 Separate circuit breaker (typical)
17 GFCI
18 Changeover switch, land / alternator
19 Encapsulated single-phase 1:1 isolated transformer with metal shield
20 Main switch, shore power, with overvoltage protection
21 Power supply (isolated electrically from boat)
22 Connector, shore power cable
23 Shore supply cable
24 Shore connection

Two-phase, 120/240 VAC primary, 120/240 VAC secondary



1 Phase
2 Zero
3 Phase
4 Protective ground
5 3-pole, grounded pin-type connector and 4-conductor socket
6 Shore side
7 Boatside
8 Transformer shield
9 Circuit breaker, alternator
10 Alternator (accessory)
11 To DC negative buss and ground plate, boat
12 Phase
13 Zero
14 Phase
15 Protective ground
16 240 VAC apparatus
17 120 VAC ground, female socket
18 120 VAC apparatus
19 Separate circuit breaker (typical)
20 GFCI
21 Changeover switch, land / alternator
22 Encapsulated single-phase 1:1 isolated transformer with metal shield
23 Main switch, shore power, with overvoltage protection
24 Power supply (isolated electrically from boat)
25 Connector, shore power cable
26 Shore power cable
27 Shore connection

Recommendations

In regard to personal safety and equipment care, Volvo Penta provides the following recommendations for the installation of AC shore power:
Installations should be carried out according to figures above.
Single phase, shows a single-phase installation for 240 VAC or 120 VAC.
Two-phase, shows an installation with a 240 VAC input, 120/240 VAC output.

The figures are based on *ABYC E-11 diagrams 8* and *11* but require a GFCI and an isolation transformer. The figures are considered to be best practice and follow recommendations from ABYC and ISO, and offer protection against electrochemical corrosion and electric shock.

The safety-related components are important for the following reasons:

Isolation transformer

Refer to *Definitions page 50* for further information.

GFCI

Refer to *Definitions page 50* for further information.

Ground plate

A common ground plate below the waterline must be connected to the AC/DC electrical system in order to guarantee crew safety.

Shore power

When shore power (120/230 V) is connected, shore power ground protection must not be connected to the engine or any other grounding point in the boat. Shore power ground protection must always be connected to the shore power connection box ground. Shore power ground protection in the boat must be galvanically separated.

⚠ WARNING!
Work on the low voltage circuits in the boats should be done by a person with electrical training or knowledge. Installation or work on land current equipment must only be done by a competent electrician, in accordance with local regulations for mains electricity.

Battery charging

Battery chargers directly connected to a shore connection must be of the type “Full Transformer” (galvanically separated windings) in order to reduce the risk for galvanic corrosion and stray current corrosion.

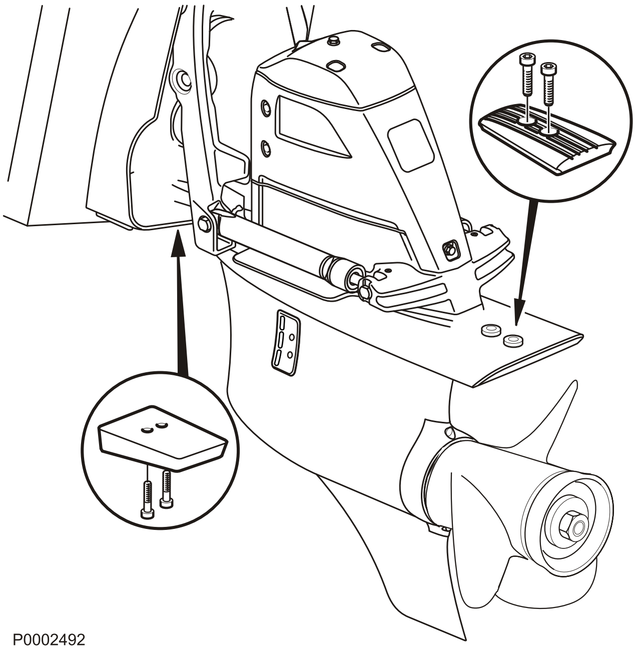
Prevention of stray current during installation

Correct installation reduces the risk of stray current throughout boat service life.

- All DC circuits must have an insulated ground return.
- All joints in the system such as connectors, connector rails etc., must be installed such that they are not exposed to moisture or bilge water. The same applies to switches and fuse holders etc.
- Cables must be run as high as possible above bilge water level. If a cable must be run such that it is exposed to water, it must be run in a watertight sheath, and the connectors must also be watertight.
- Cables that may be exposed to wear must be installed in self-draining conduits, sheaths, cable channels or similar.
- For information regarding the installation of batteries and main switches, refer to the *Installation page 156* and *Main switch page 161* chapters.
- Engines and drivetrains may not be used as ground connections for radio, navigation or other equipment where separate ground cables are used.
- All separate ground cables (ground cables for radio, navigation equipment, echo sounders etc.) must be connected to a common grounding point, e.g. a cable that in normal circumstances does not function as a ground return for the equipment.
- When shore power (120/230 V) is connected, ground protection must not be connected to the engine or any other grounding point in the boat. The ground protection must always be connected to the shore power connection box ground.
- Converters such as battery chargers connected to shore power, must have ground protection connected on the input side (120/230 V), but the negative connection on the output side (12/24 V) must not be connected to ground protection without being galvanically separated.

⚠ WARNING!

Work on the low voltage circuits in the boats should be done by a person with electrical training or knowledge. Installation or work on land current equipment must only be done by a competent electrician, in accordance with local regulations for mains electricity.



P0002492

Checking Protective Anodes

Note the position of the protection anodes in the illustration. One is to the front of the gear case above the cavitation plate and the other is attached below the gimbal housing.

IMPORTANT!

Make sure the anode has good metallic contact with the sterndrive and transom shield. Never paint the protection anodes. Never use a steel wire brush to clean the anodes. A steel brush will reduce galvanic protection.

Before the boat is launched, the anodes must be cleaned (activated) with sandpaper to remove the oxide layer.

IMPORTANT!

Check that the correct anodes are installed for the intended application.

Aluminum anodes

Sterndrives and transom shields are equipped with aluminum protection anodes as standard. Aluminum anodes are intended for brackish water/varying usage.

Zinc anodes

If the boat is driven in salt water zinc anodes must be used.

Magnesium anodes

If the boat is operated in freshwater, magnesium anodes must be used.

Active corrosion protection (accessory)

It is possible to install active corrosion protection in addition to the anodes.

In this system an electrical current protects sterndrives and transom shields from galvanic corrosion.

Propellers

Volvo Penta stainless steel propellers installed on DPS sterndrives are electrically insulated from the drive and will therefore not cause any anode consumption.

Checking for leakage from the electrical system

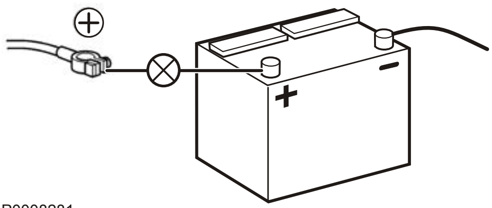
A simple way of testing the boat's electrical integrity is to employ the following procedure:

First check that fuses and circuit breakers are fitted and intact, that the battery main switches are on, and that all other switches and appliances are off. Theoretically, there should be no current flowing from the battery. Any flow will indicate a leak.

To check if any current is leaking

1. Disconnect equipment that may consume current even when switched off (clock or radio).

2. Lift off the positive battery terminal connector.

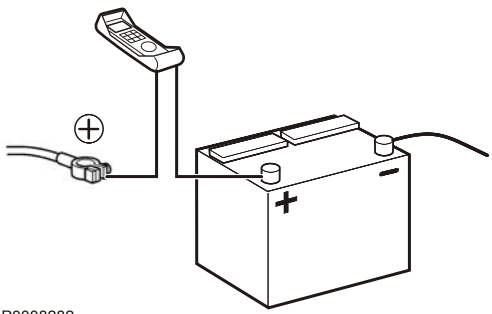


P0008281

3. Connect a 12 Volt, 3 W test lamp between the positive terminal and the loosened connector. You can also use a Voltmeter for this test.

If there is no leak, the lamp will fail to light. A faint glow indicates a small leak, and a bright light means that you have a more serious leak.

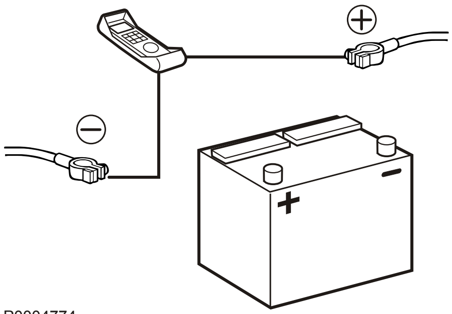
To check how much current is flowing



P0008282

1. Use a multimeter, and set it to read “DC Amps”.

2. Connect the red test lead to the battery positive terminal, and the black lead to the loosened connector. The meter will now show how much current is leaking. If you do not get a reading, change to the ’’DC mAmps’’ scale.



P0004774

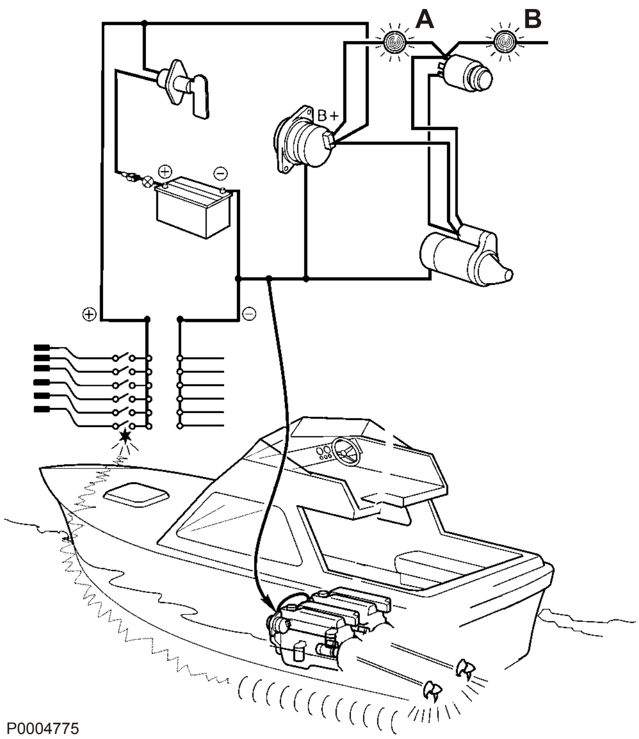
Double-check to see the resistance in the circuit

1. Set the multimeter to Ohms.
2. Connect the black test lead to the loosened negative connector, and the red test lead to the loosened positive connector. You should now see a reading of the resistance of the circuit.

NOTICE! Certain equipment may also cause a current drain when shut off, such as a radio, clock or automatic bilge pump. This equipment must be disconnected.

The rough guide below indicates what these readings means in practical terms:

- 10.000 Ohm up to open circuit A next to perfect circuit, no problems.
- 5.000 Ohm – There is a small leak.



A Charging

B Oil pressure

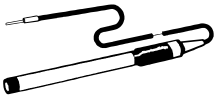
- 1.000 Ohm – There is a leak that must be found and corrected.
- 500 Ohms or less – A heavy leak. Disconnect the battery terminals. Repair as soon as possible.

To find the leak.

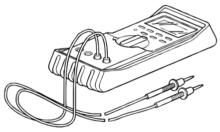
With the test lamp connected as step 1 above, loosen one fuse at a time and put it back again. When you remove a fuse and the test lamp goes out, then you have found the circuit that is causing the problem. Trace the circuit until the fault is found, and repair it.

Checking electrochemical corrosion

Tools:
88890074 Multimeter
21504294 Reference electrode



21504294 Reference electrode



88890074 Multimeter

Measuring galvanic current and stray current in water

Volvo Penta has developed a method for measuring galvanic current and stray current in water using a reference electrode.

21504294 Reference electrode (Ag/AgCl)[1] is connected to 88890074 Multimeter. The multimeter is used to measure the difference in potential.

NOTICE! If another multimeter is used, it must have an accuracy of 1 mV.

Depending on the method used, the results provide an average voltage for the whole measured object, e.g. a shaft, or the voltage an individual component produces.

Examples of such measuring points are rudders and water inlets etc.

NOTICE! The reference electrode may be used in water with varying salt levels, or in freshwater.

The process measures the difference in potential between the measured object and the reference electrode. The reference electrode has a known constant electrode potential. Thus the measured difference in potential is always related to a special reference electrode and the same electrolyte, i.e. the same water and water temperature. Water flow must always be the same if the results from different measurements are to be compared.

Measurement theory

The protection anode works by emitting an electrical current – protective current – in order to counteract corrosion current. When the protective current increases and corrosion current is reduced, the potential of the protected object is also reduced. When a given potential is reached, the corrosion current disappears and the object has complete cathodic protection.

Thus a given electrode potential for the metal serves as a guide to when cathodic protection is active and whether it is sufficient. The reference electrode is able

1. Ideally, do not combine the blue 885156 calomel electrode with the amber 21504294 Ag/AgCl electrode. In such cases the 40 mV must be added to the measured value from the Ag/AgCl electrode when comparing with the calomel electrode.

to measure whether the protective potential is provided for.

Checking galvanic electricity, reference electrode, Volvo Penta IPS

Connect 21504294 Reference electrode to 88890074 Multimeter.

Connect the multimeter to a suitable screw in contact with the drive unit. Set the multimeter for DC current measurement.

Carefully remove the protective sleeve from the reference electrode. The protective sleeve is filled with a saturated salt solution (NaCl). Clean the tip with a clean paper napkin or similar before replacing after measuring.

Dip the electrode into the water about 30 cm (12") from **the propeller and the propeller shaft**. The result is an average value for the entire propeller shaft. The result should be between (minus) -900 mV and -1100 mV.

To check individual components, the electrode must be pointed so that the tip is aimed at the object, about 5 mm (0.2") from the surface where the component is installed. Here too the measured result must be between -900 and -1100 mV.

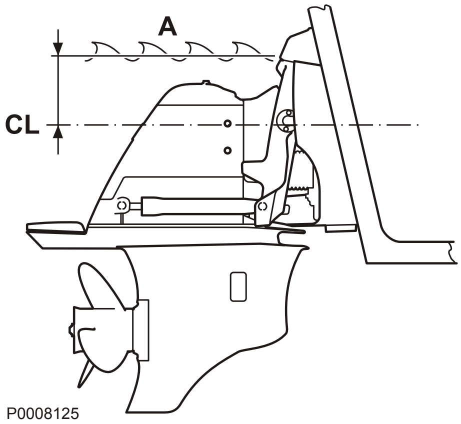
If the result is higher (e.g. a more positive result than -800) the proportion of “precious” metal in the stainless steel, bronze etc is too great for the zinc anode to overcome the corrosive current. The number of anodes must therefore be increased.

The result may also depend on stray current caused by faulty or incorrectly connected positive (+) cables, or positive (+) cables exposed to bilge water.

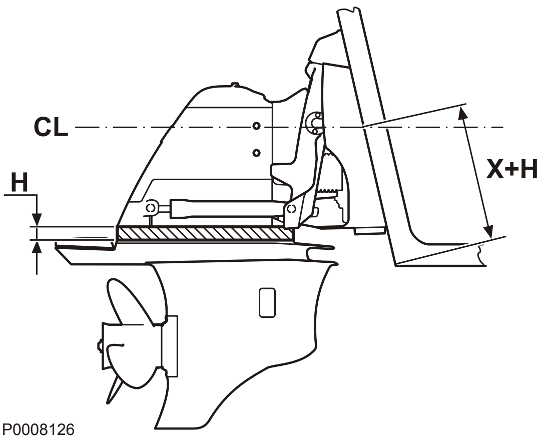
Over protection is present if the multimeter shows a value lower than -1100 mV. This may also be caused by stray current from separate ground cables from a VHF radio or other equipment fitted with an incorrectly connected ground cable.

The cause may also be that the anodes are emitting excessive protection current, e.g. magnesium anodes in saltwater.

Installation



P0008125



P0008126

Aquamatic drive

Transom Shield Installation

Water level at maximum load

IMPORTANT!

The highest waterline level (**A**) above the crankshaft center line (**CL**) must be in accordance with the data below.

NOTICE! In positioning the waterline, the boat must float on its static plane and the weather must be calm.

There are two measuring methods and two measurements depending on how the boat is loaded:

Method 1: Boat loaded with full fuel and full water. No extra load and no crew.
Water level above crankshaft: **Max. 200 mm** (7.9”).

Method 2: Boat loaded to the approved CE-regulation level. Crew must be located astern, and the other weight positioned at the boat’s center of gravity.
Water level above crankshaft: **Max. 350 mm** (13.8”).

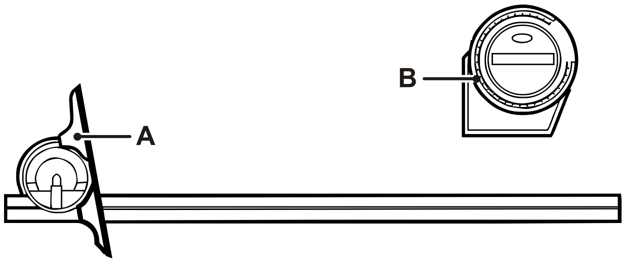
Extension

If there is a problem with the waterline level, an extension could be installed on the drive. This allows the engine and transom shield to be raised while maintaining propeller depth.

Extension height (**H**) = 25.4 mm (1”).

Follow mounting instructions in the extension kit. Calculate the position of the hole for the transom shield when an extension is installed.

Use the recommended X measurement and add the length of the extension (**H**), 25.4 mm (1”).

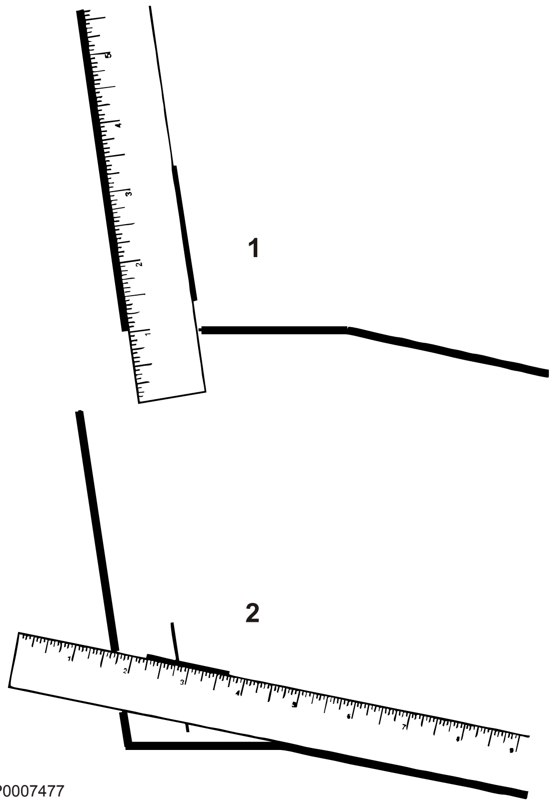


P0007475

Transom, support lines

Determine the transom angle

Boat transom angle can be measured with several different protractors or workshop instruments. Two protractors that are commonly used are the adjustable protractor (**A**) and the protractor with integral level (**B**). Both types of protractor can be bought in ay regular tool stores.



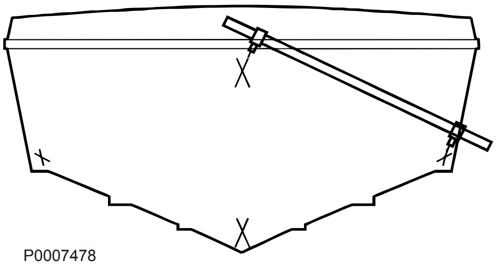
P0007477

Locate the transom centerline

1. Draw lines parallel with the boat's port and starboard sides.

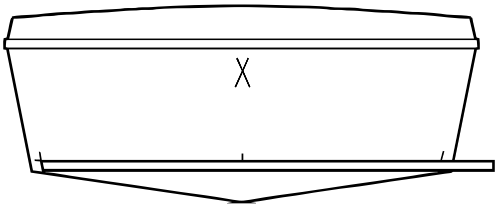
2. Draw intersecting lines parallel to, and at the same distance from, the boat bottom on the port and starboard sides. Mark the points where the lines intersect. The points make up the center for the two arcs that must be drawn when the transom centerline is marked out.

NOTICE! The transom centerline is most accurately determined with the aid of a beam compass. A practical beam compass can be made by securing a pivot point and a pen to a slat. A stiff wire with eyes at each end for the pivot point and pen may also work if used accurately.

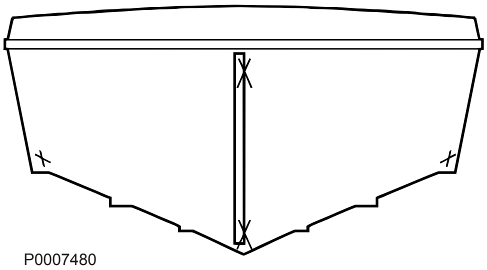


P0007478

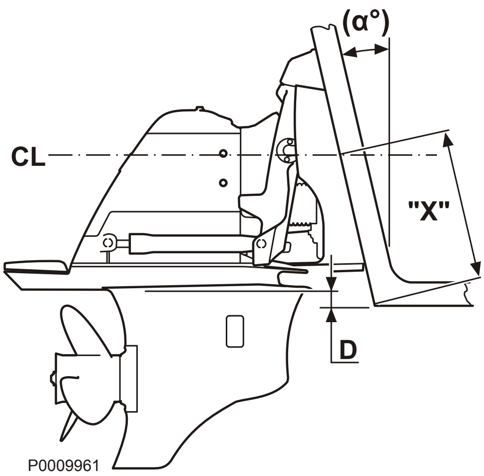
3. Draw an arc in the upper part of the transom using one side point as the center, and an intersecting arc from the other side point, without altering the radius of the beam circle. Exactly the same radius must be used for both arcs for the transom upper center point to be positioned precisely. Repeat the procedure to mark out the lower transom center point; if necessary use a different radius.


P0007479

4. If the boat bottom is flat, or has a very broad V shape, the lower center point can be located by measuring across the transom from side point to side point, and marking the center point on the transom.


P0007480

5. Draw a vertical line through the upper and lower center points. The transom centerline is used as a centerline for the transom shield on single installations, and as a reference line on twin installations.



P0009961

Single and twin installations (D)

SX = 20 mm (0.79”)

DPS = 20 mm (0.79”)

6. The dimension X is the position of the crankshaft centerline (**CL**) measured from the lowest point of the boat bottom at the transom, and determines the height at which the sterndrive must be located.

The recommended transom angle is 13° (**α**). Other transom inclinations specified in the table may also be used.

NOTICE! Refer to the table for recommended X dimensions in the penetration instructions section for single and twin installations.

Every combination of boat model and sterndrive is unique; water does not flow under the hull in exactly the same way on different boat models. The X dimension mentioned herinafter is a good choice for most boats, but the best installation height (X dimension) can only be determined by testing. The recommended Volvo Penta X dimension must be used as a starting point.

Volvo Penta recommends that the following routine be used to find the best installation height for a specific boat model:

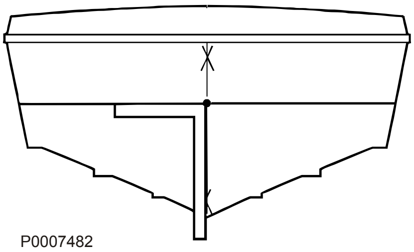
a Increase the recommended Volvo Penta X dimension by 15 mm (0.6") (“aise” the sterndrive 15 mm) on the first hull.

b Run the boat and carry out accurate performance tests at various trim angles and load conditions in order to assess the installation height.

c Install a 25 mm (1") extension to the sterndrive and repeat the tests.

d By comparing the results and the boat's overall qualities it will be possible to select the best X dimension for series manufacture.

By following the dimensions the underside of the sterndrive cavitation plate will end up higher than the boat bottom.



P0007482

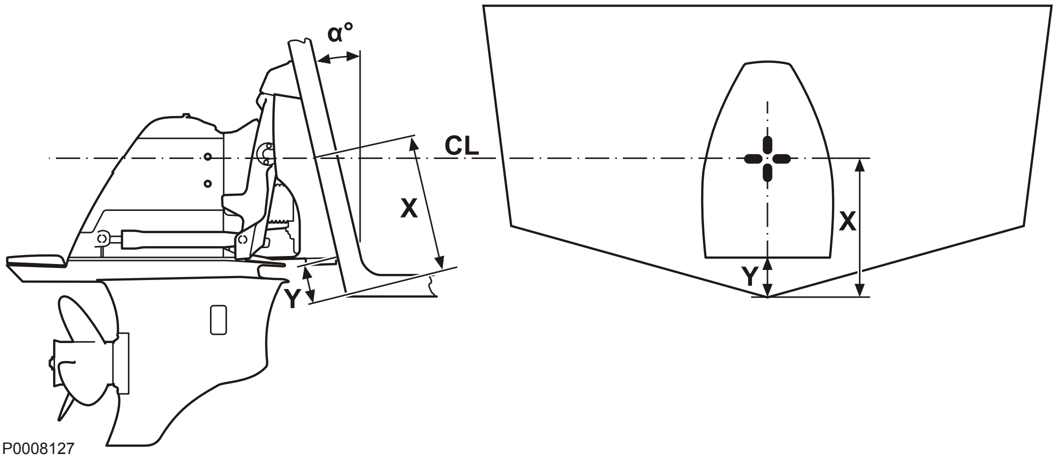
Single installation

7. Select an X dimension from the table below and mark out the height from the bottom of the boat to the crankshaft centerline (X dimension).

8. Use a set square to mark out a horizontal line at right angles to the vertical centerline at the crankshaft centerline mark.

9. Select an X dimension from the table below and mark out the height from the bottom of the boat to the crankshaft centerline (X dimension).

NOTICE! The check dimension Y is used to verify the right height after shield installation. The dimension can vary depending on the bottom radius.



P0008127

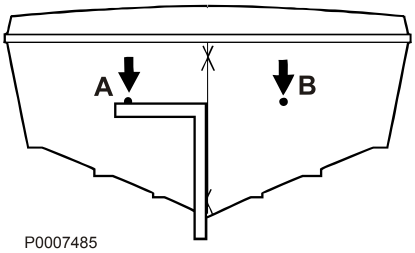
Recommended X-dimensions (the recommended transom angle is 13°).

Transom angle, **α°**	**16°**	**15°**	**14°**	**13°**	**12°**	**11°**	**10°**
Single installation X SX, DPS Sterndrives mm (")	360 (14.17)	358 (14.09)	356 (14.01)	**355 (13.97)**	354 (13.93)	352 (13.85)	351 (13.81)
Control dimension Y SX, DPS Sterndrives mm (")	95 (3.74)	93 (3.66)	91 (3.58)	**90 (3.54)**	89 (3.50)	87 (3.43)	86 (3.39)

Twin installation

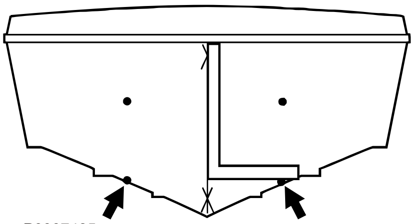
Minimum distance between transom shield centerlines:

Electronic steering	**900 mm** (35.4")
Conventional steering	**800 mm** (31.5")

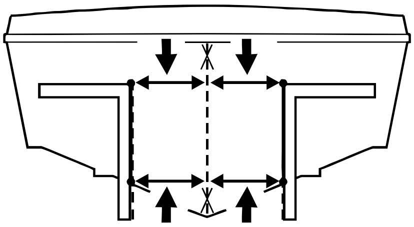


P0007485

1. Use a set square to mark out the transom. Place a mark (**A**) on the port side at the selected engine distance from the transom center line. Place a mark (**B**) on the starboard side at the selected engine distance from the transom center line.


P0007485

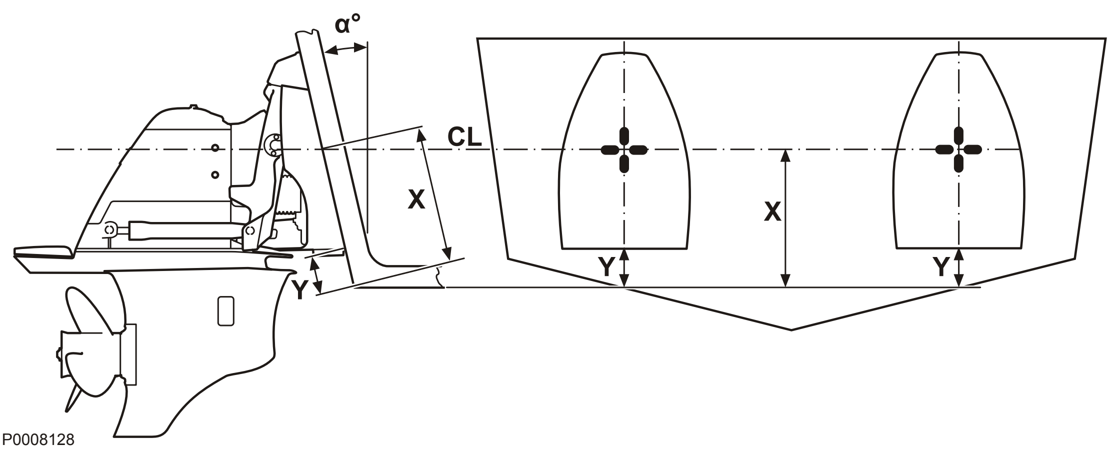
2. Take similar measurements from the transom center line close to the bottom to mark out the lower points.


P0007487

3. Use a set square or steel rule to join the two points on the port and starboard sides of the center line. Check the top and bottom distances to ensure that the shield centerlines are at the same distance from the transom centerline.

4. Select an X dimension from the table below and mark out the height from the bottom of the boat to the crankshaft centerline (X dimension).

NOTICE! The check dimension Y is used to verify the right height after shield installation. The dimension can vary depending on the bottom radius.

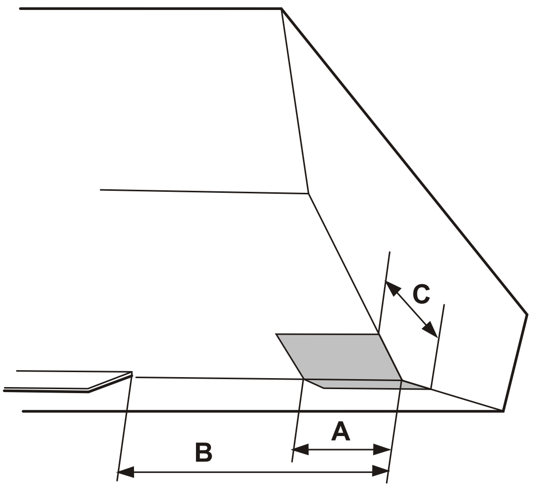


P0008128

Recommended X-dimensions (the recommended transom angle is 13°).

Transom angle, **α°**	**16°**	**15°**	**14°**	**13°**	**12°**	**11°**	**10°**
Twin installation, X SX, DPS Sterndrives mm (")	360 (14.17)	358 (14.09)	356 (14.01)	**355 (13.97)**	354 (13.93)	352 (13.85)	351 (13.81)
Control dimension Y SX, DPS Sterndrives mm (")	95 (3.74)	93 (3.66)	91 (3.58)	**90 (3.54)**	89 (3.50)	87 (3.43)	86 (3.39)

Transom



Single installation

Minimum distances

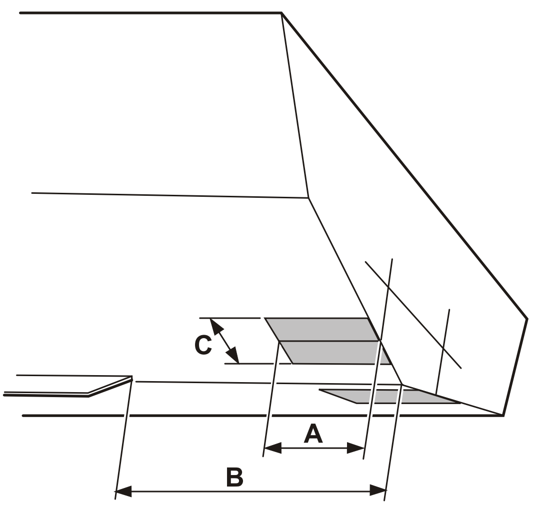
A **650 mm** (26")

B **1500 mm** (59")

C **800 mm** (32")

NOTICE! Make sure there is nothing forward of the sterndrive that can cause turbulence ahead of the propellers.
Log and echo-sounder sensors, etc. may not be located inside the shaded area.

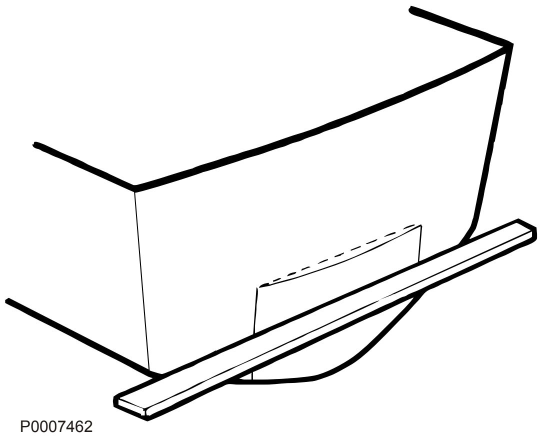
Keels, strakes, ladders, etc. may not be within distance B from the transom.



Twin installation

Twin installation

Critical areas may overlap one another depending on the distance between the engines.

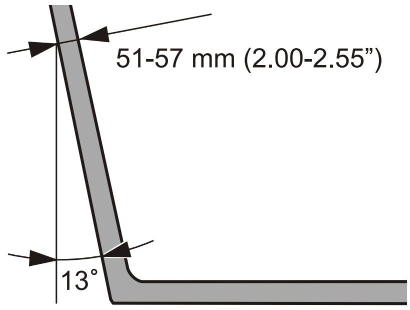


P0007462

The transom must be flat inside the area where the shield will be installed.

The inboard and outboard transom surfaces must be parallel to within ±3 mm (0.12").

The inboard transom surface must be flat to within ±3 mm (0.12"). The outboard transom surface must be flat to within ±1.6 mm (0.063").

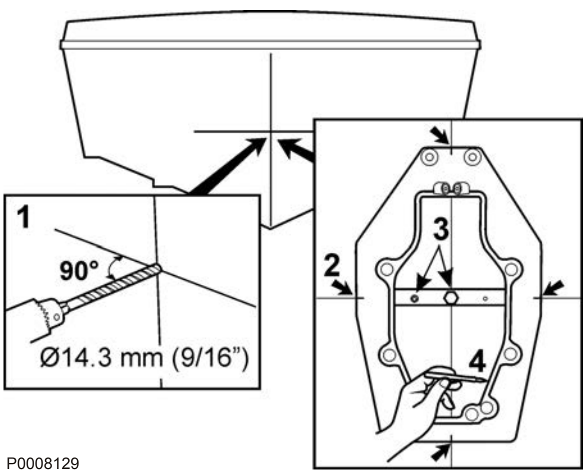


P0007463

The transom must be **51 - 57 mm** (2.00–2.25") thick. A somewhat thinner transom is permissible if engines with the lower power outputs are installed:
45 - 51 mm (1.75 - 2.00"). The recommended transom angle is 13°.

Transom, Cutout

Using drill fixture, special tool 3851081



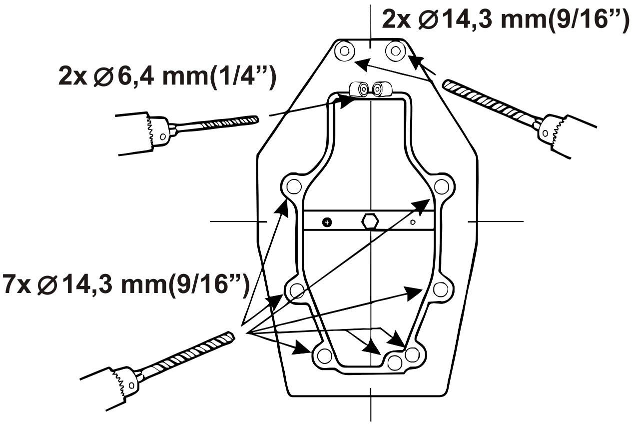
P0008129

1. Drill a Ø 14.3 mm hole in the crankshaft centerline.

2. Align the drill fixture notches with the aid of the vertical centerline and the transom shield base line (X dimension).

3. Attach the drill fixture to the transom with the 13 mm (0.51") bolts, flat washers and nuts supplied with the drill fixture. Screw a woodscrew into one of the small holes to prevent the fixture from rotating.

4. Mark out the shield hole on the transom using a pen.

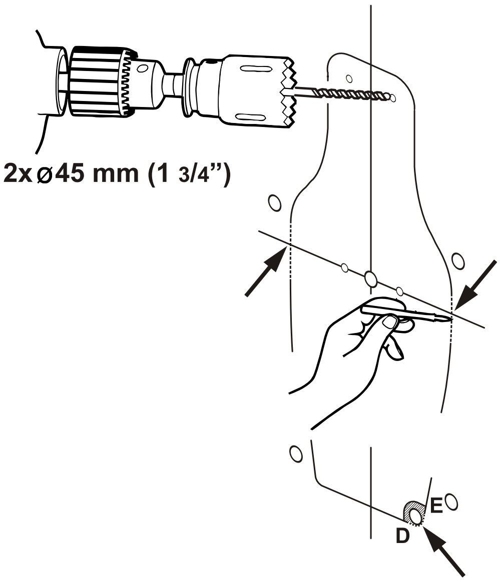


P0008130

5. Drill nine Ø 14.3 mm (9/6") as illustrated.

NOTICE! Drill these holes perpendicular to the transom.

6. Drill two Ø 6.4 mm (1/4") guide holes using a 152 mm (6") long, 6.4 mm (1/4") pilot rod (drill rod). Remove the drill fixture from the transom.



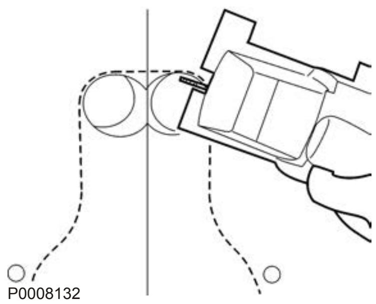
P0008131

7. Draw a dotted line around the outer edge of the guide hole for the hole saw and join points D and E. This lower corner (shaded area) must be removed when making the the cut-out in the transom.

8. Draw a line connecting to the vertical lines on both sides of the cut-out.

9. Remove the bit from a 45 mm (1.77") hole saw. Replace the bit with a 152 mm (6") long, 6.4 mm (1/4") pilot rod (drill rod).

10. Drill two 45 mm (1.77") holes with the aid of the guide holes.



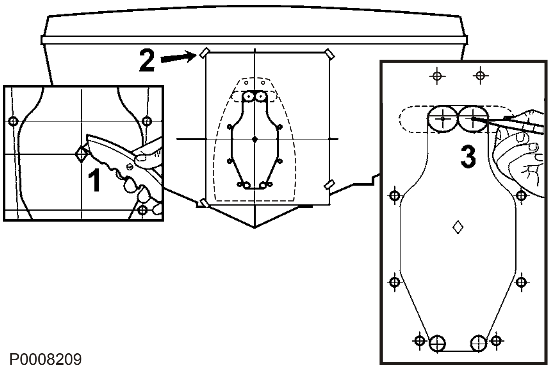
P0008132

11. Cut out the hole using the power jigsaw. Hold the saw perpendicular to the transom.

NOTICE! It is important to cut inside the marked line. If the cut is made too far inside the line the shield will be difficult to install. The shield stud installation holes will be weakened if the cut is made too far out.

Transom, Cutout

Using the paper template, publication # 7746008

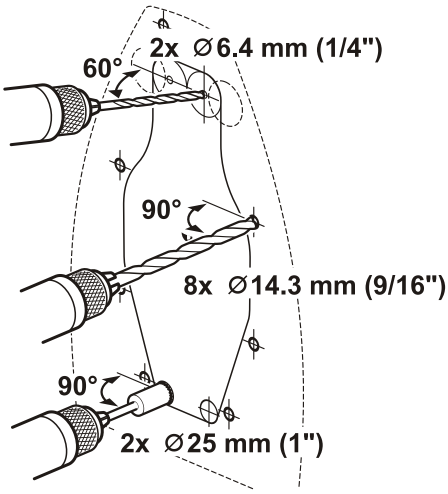


P0008209

1. Carefully cut out the template center rhombus.

2. Place the transom template on the transom. Align the template centerlines with the vertical centerline and the transom shield base line (X dimension) marked on the boat transom. Tape the template securely to the transom.

3. Mark the center points in the template holes.



P0008210

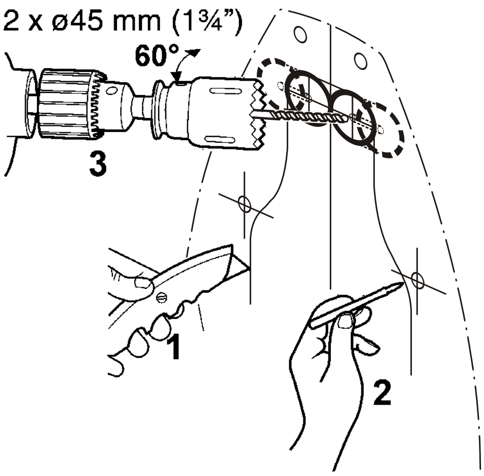
4. Drill the eight Ø 14.3 mm (9/16") shield bolt holes.

5. Drill two Ø 25 mm (1") holes at the bottom cut-out line.

6. Drill two Ø 6.4 mm (1/4”) guide holes with the long drill bit.

NOTICE! Be careful to drill absolutely perpendicular to the transom. Also take care that the holes are drilled in precisely the right locations. If this is unsuccessful it will be extremely difficult to install the transom shield. Use of a drill fixture is recommended.

Use a drill guide to ensure that the holes are drilled exactly perpendicular to the transom.



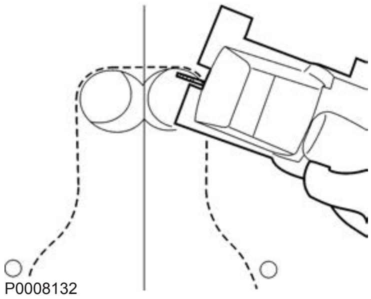
P0008211

7. Cut out the transom hole in the paper template. Mark out the shield holes on the transom using a pen.

8. Remove the bit from a 45 mm (1.77") hole saw. Replace the bit with a 152 mm (6") long, 6.4 mm (1/4") pilot rod (drill rod). Drill two 45 mm (1.77") holes with the aid of the guide holes.

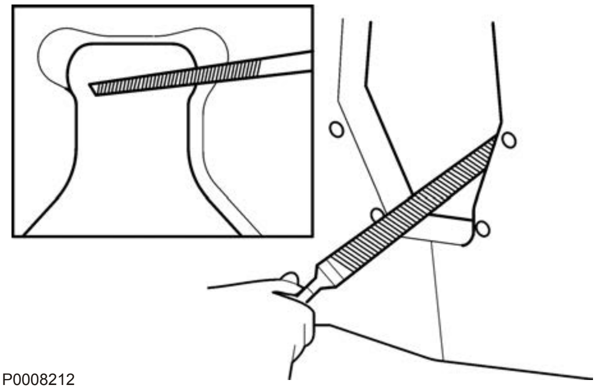
9. Remove the template.

10. Cut out the hole using the power jigsaw. Hold the saw perpendicular to the transom.


P0008132

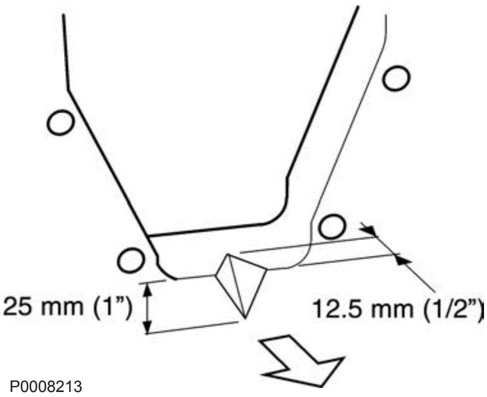
NOTICE! It is important to cut inside the marked line. If the cut is made too far inside the line the shield will be difficult to install. The shield stud installation holes will be weakened if the cut is made too far out.

Finishing the transom cut-out


P0008212

1. Clean and file away all rough saw cut marks. Bevel the inside lower edge on boats with a maximum transom thickness of 57 mm (2.25") to allow the exhaust pipe to keep clear.

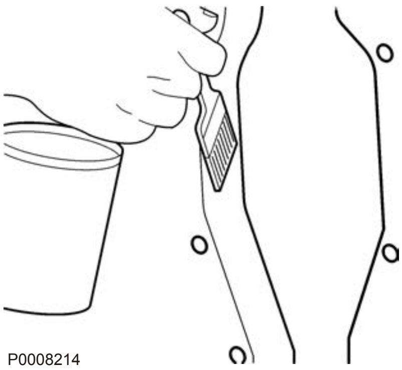
2. Round off sharp corners in the steering arm area.



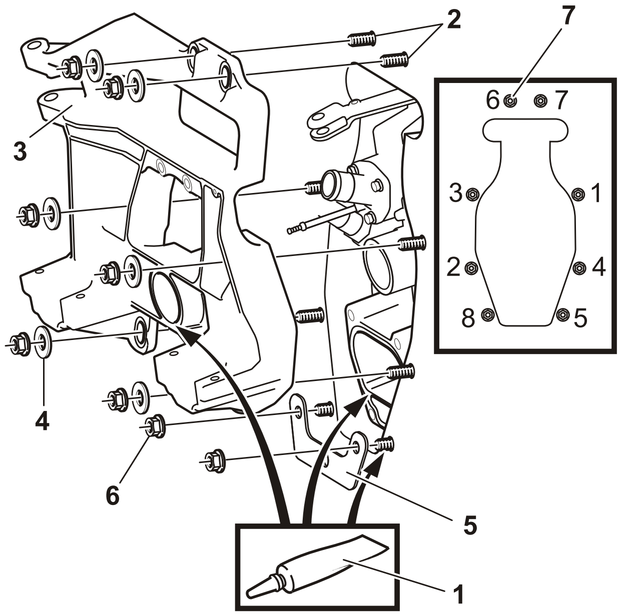
P0008213

The arrow points inboard

3. Saw or file a channel in the inside edge of the cut-out to drain trapped water to bilge.


P0008214

4. Seal the transom opening with a suitable sealant to prevent water from soaking into and damaging the transom.



P0008215

Shield and Inner Transom Plate, Installation

1. Make sure the trim cylinders are attached to a wood panel or similar.

2. Apply a thin coat of Volvo Penta waterproof grease (1), 828250, to the inner transom plate guide sleeve, transom shield studs. bolts and exhaust seal.

3. Align the transom shield studs (2) with the holes in the transom and press the shield against the transom.

4. Once the shield is in place, install the transom plate (3) with the washers (4), bearing plate (5) and nuts (6). Do not tighten them fully yet.

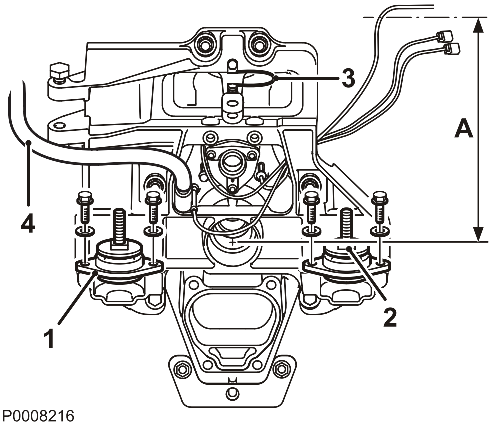
IMPORTANT!

Check that no hoses/wiring are pinched between the transom shield and the transom plate.

NOTICE! Install the bearing plate flat side against the transom.

5. Tighten the eight lock nuts (7) diagonally as illustrated. Tightening torque **27–34 Nm** (20–25 lbf.ft).

After installation, apply waterproof grease (VP part # 828250) to the threads protruding through the nuts (6).



P0008216

Rear Engine Mounting

1. Install the two rear engine mounts (**1**) on the inboard transom plate with bolts and washers. Torque the bolts to **27–34 Nm** (20–25 lbf.ft). The engine should rest on its engine mounts for 48 hours before correct alignment adjustment can be made.

IMPORTANT!

Make sure the expanding nut (**2**) above the engine mount is in the correct position. If not, adjust the position and tighten to **65 Nm** (48 lbf.ft).

2. Install the inboard transom plate ground cable (**3**) onto the steering arm with a nut and washer.

3. Install the shift cable before the hose (**4**) is clamped secure; refer to *Shift Cable, Connection page 99*.

Speedometer

Detach the speedometer from the shift cable and pull the cable out through the transom hole as with the other cables. Clamp it at least **350 mm** (13.8") (**A**) above the crankshaft center line, regardless of whether it is to be used or not.

Engine Foundation

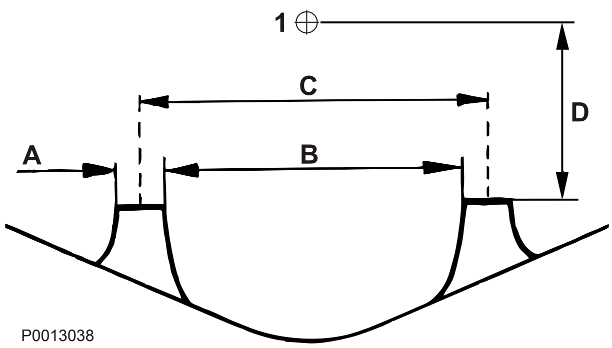
1. The engine bed must be built up in the following dimensions:

A Approx 110 mm (4.3")

B 474 mm (18.7")

C 572 mm (22.5")

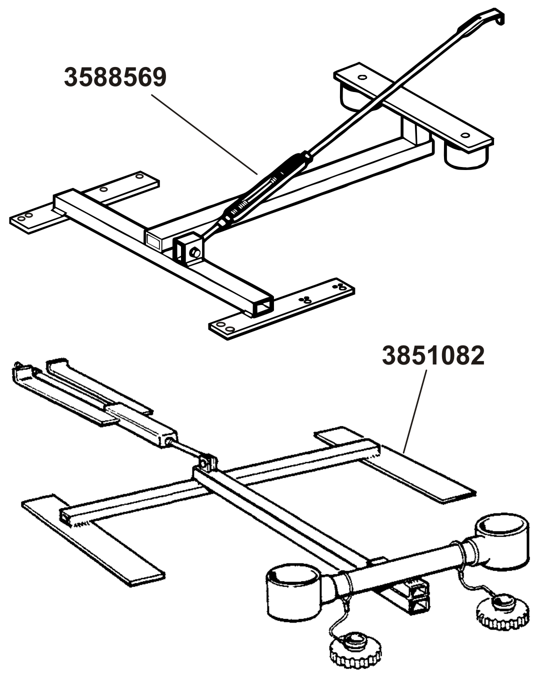
D Nominally 83 mm (3.3")



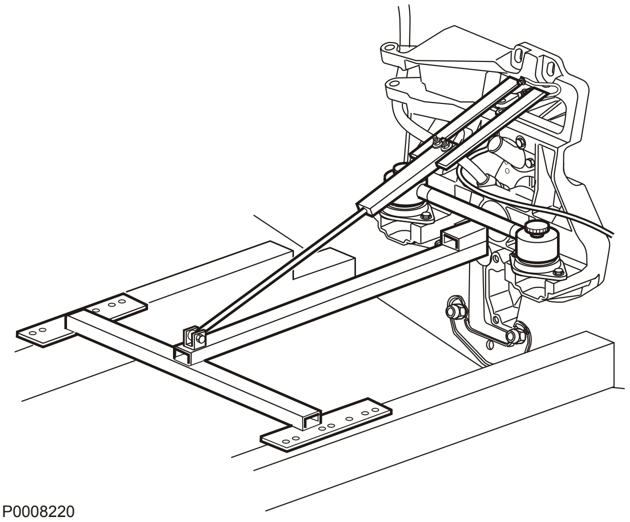
P0013038

1 Center, crankshaft

2. Install special tool 3588569 Drill jig above the engine bed. It is also possible to use the older tool 3851082 if it has been modified as described below.



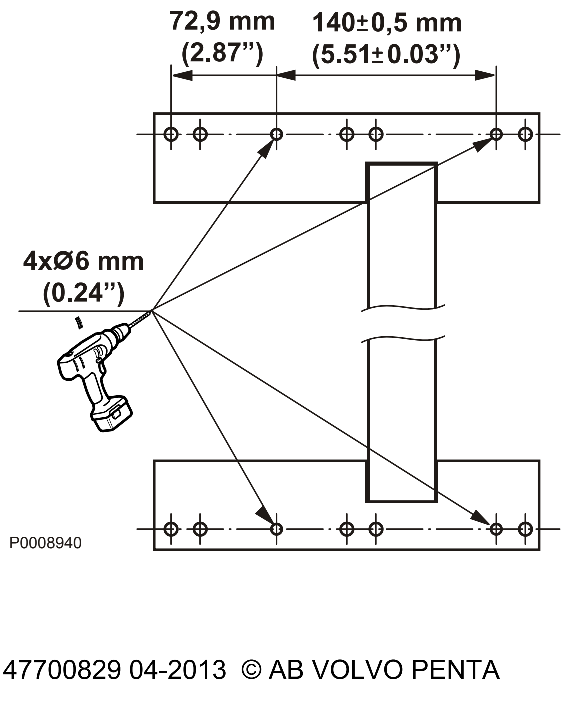
P0008129



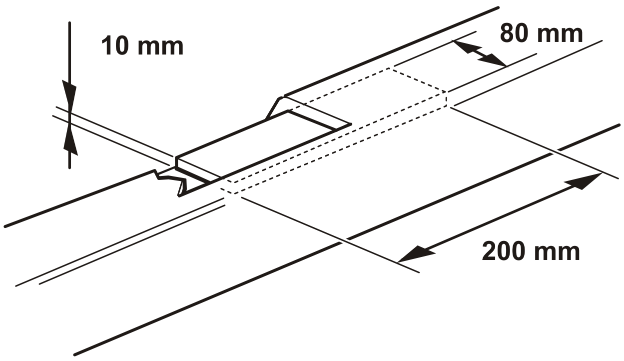
P0008220

3. If drill jig 3851082 is used, supplement the tool with holes for the D3 engine according to the dimensions illustrated.
For further information refer to Service Bulletin 08-5-8.

NOTICE! Note that there must be a recess in the side of the engine bed to accommodate the exhaust pipe.

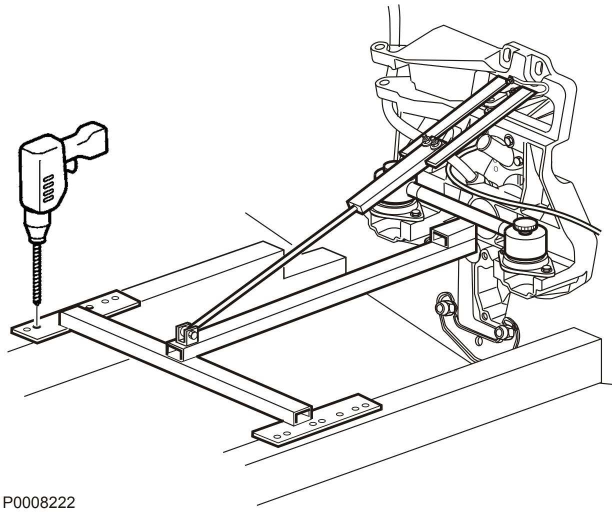


P0008940



P0008221

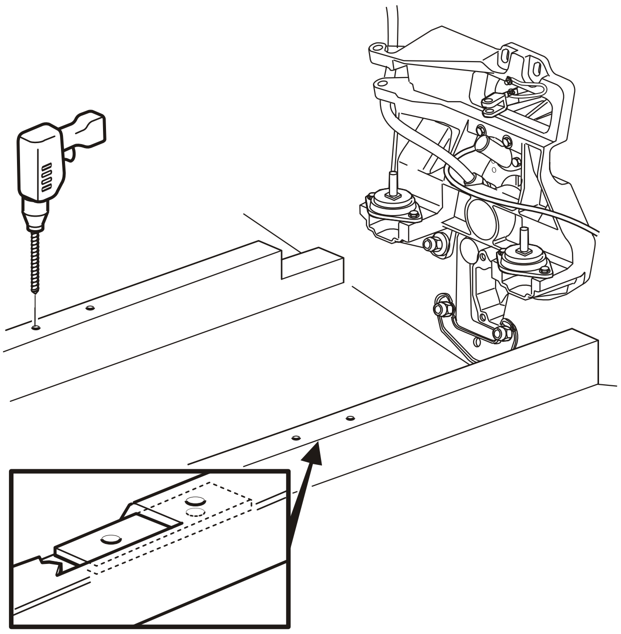
4. Build up the engine bed so that the undersides of the tool plates rest on the upper part of the bed. Build in a galvanized steel plate that is around 10 mm (0.4") thick, at least 80 mm (3.15") wide and 200 mm (7.85") long.



P0008222

5. Locate the flexible drill jig in the correct position. Mark out 6 mm (0.236") holes on the bed for the flexible engine mounts. Use the drill bushings marked D3. Then remove the flexible drill jig.

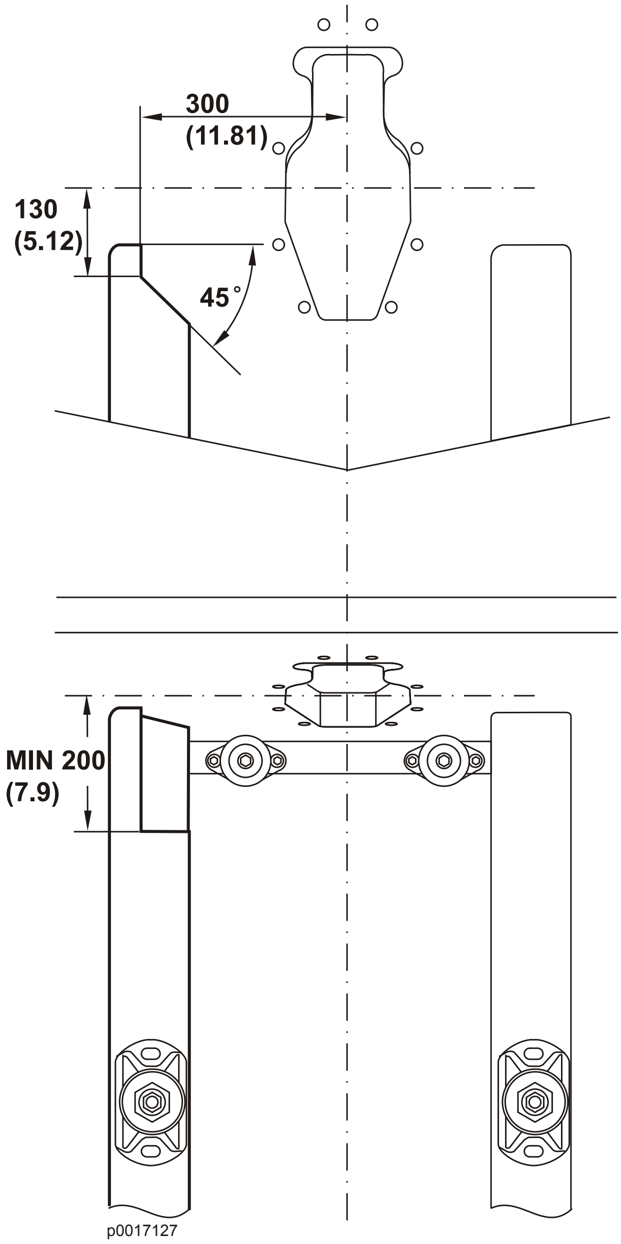
6. Drill and then tap the holes using a thread tap.



P0008223

IMPORTANT!

The thread must be **M10 mm (3/8" UNC)**.



Drawing showing the necessary recess in the engine bed to make room for the exhaust pipe.

Engine Installation

Preparing the engine

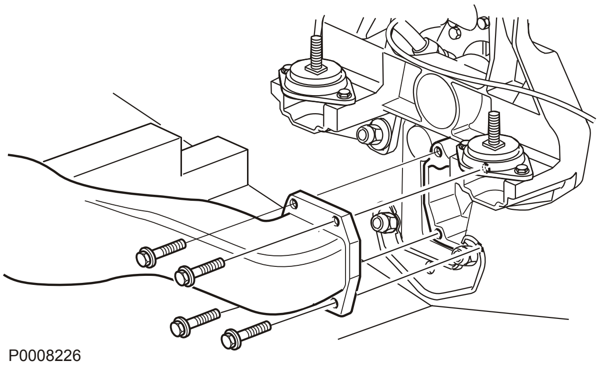
NOTICE! Before the engine is installed, installation of fuel, steering and electrical systems must be as complete as possible.

Fit extra equipment and accessories such as auxiliary alternator, hot water take-off, power take-off etc. to the engine before it is installed.

NOTICE! All engines are supplied by Volvo Penta without engine oil and coolant. Check that the oil drain plug, coolant drain taps and hot water taps are screwed in and closed.

Fill oil and coolant. Check that no leakage occurs.

IMPORTANT!
Wait 30 min. after filling oil and top up if required.

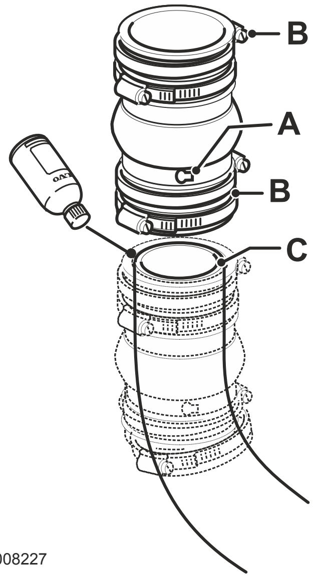

P0008226

Exhaust Outlet

1. Check that the large O-ring is in place on the transom shield.

2. Install the exhaust pipe and tighten the bolts.

Tightening torque: **30 Nm** (22 lbf.ft).



P0008227

Exhaust Bellow

1. Note the location mark on the bellows (**A**).

2. Apply rubber lubricant 3817243 to the exhaust outlet contact surface with the bellows.

3. Fit the four stainless steel hose clamps (**B**) and slide the bellows onto the exhaust outlet. Press the bellows down until its upper edge is in line with the upper edge of the pipe (**C**).

After engine installation:

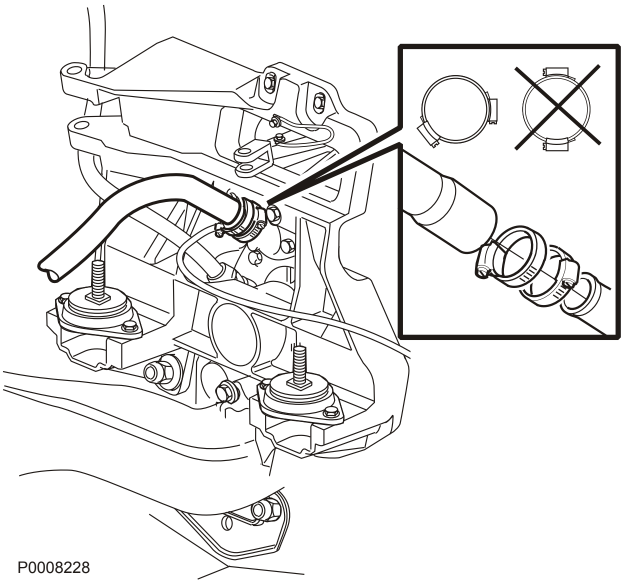
4. Slide the bellows up onto the turbocharger exhaust pipe until the lower bellows edge is in line with the plastic rim of the exhaust outlet.

IMPORTANT!

Allow the lubricant to dry for **one hour** before the clamps are tightened.

5. Rotate the clamps so that the screws are located on opposite sides of the bellows. First tighten the **lowest** clamp loosely. Then tighten the **uppermost** clamp loosely. Then loosely tighten the **second from bottom** and **second from top** clamps. Finally tighten all four clamps to **2.5–3 Nm** (1.8–2.2 lbf.ft).

6. After 1–1.5 h check that the bellows location is intact.



P0008228

Raw Water System

Place two stainless steel hose clamps opposite each other on the coolant hose. Press the hose onto the plastic sleeve and locate the clamps as illustrated. Tighten the hose clamps.

IMPORTANT!

Never locate the clamp screws under the plastic sleeve.

IMPORTANT!

Do not tighten the clamps too hard.

IMPORTANT!

Do not apply any lubricant.

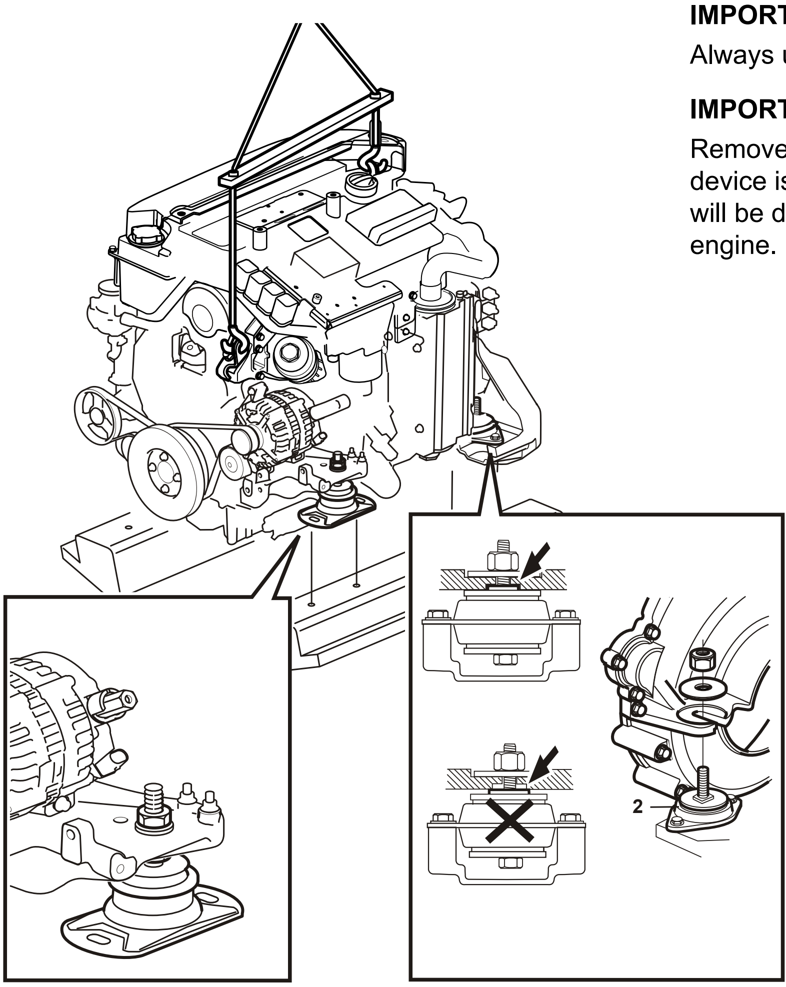
Engine, Installation

IMPORTANT!

Always use both lifting eyes when lifting the engine.

IMPORTANT!

Remove the engine cover (cold side) before the lifting device is connected and the engine lifted. The cover will be damaged if it is not removed before lifting the engine.



P0008231

1. Lower the engine carefully onto the engine bed and the rear engine mounts.

2. Install the rear engine mounts on the flywheel housing. Tightening torque **40 Nm** (30 lbf.ft). Counterhold the mount bolt when the nut is tightened.

NOTICE! Make sure the expander nut above the engine mount fits into the recess below the bracket.

NOTICE! If the expander nut has loosened and/or is located incorrectly, adjust its position and tighten to **65 Nm** (48 lbf.ft).

3. Fit the front engine mount bolts to the engine bed. Finger tighten.

After installation, apply waterproof grease (VP part # 828250) to the threads protruding through the nuts.

Engine Alignment

Correct engine alignment is extremely important for engine power transfer. Use alignment tool, part # 3851083 with universal handle 3850609, to check engine alignment.

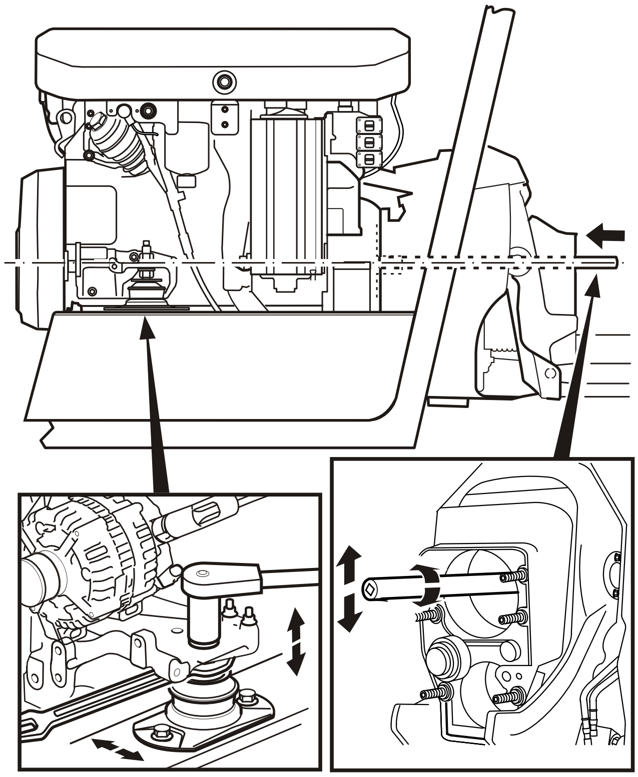
1. Rock the engine before and after adjustment for better engine weight distribution across the rubber engine mounts.

2. Slide the alignment tool through the driveshaft u-joint bearing.

3. Move the engine until the alignment tool makes contact with the companion flange. If the alignment tool catches when it is slid into the companion flange, the engine must be adjusted up, down or sideways so that the alignment tool can slide in and out of the companion flange without binding.

NOTICE! Once alignment is completed the engine may not be moved.

3. Tighten the engine mount bolts into the engine bed and the adjuster nuts on the mounts. Counterhold the nuts.
Tightening torque, engine bed bolts: **Tighten hard.**
Tightening torque, adjuster nuts: **70 ±5 Nm** (52 ±4 lbf.ft)

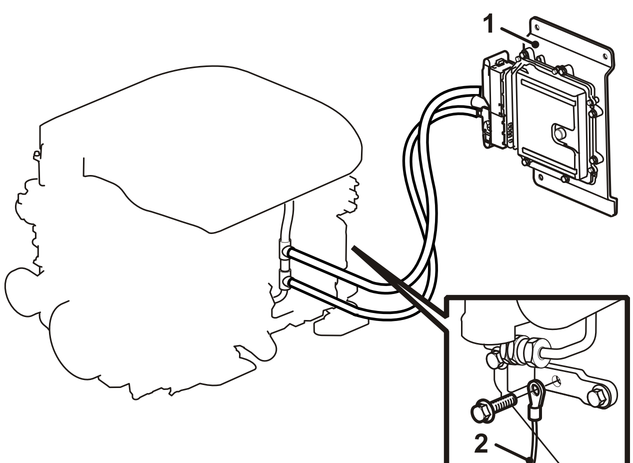


P0008232

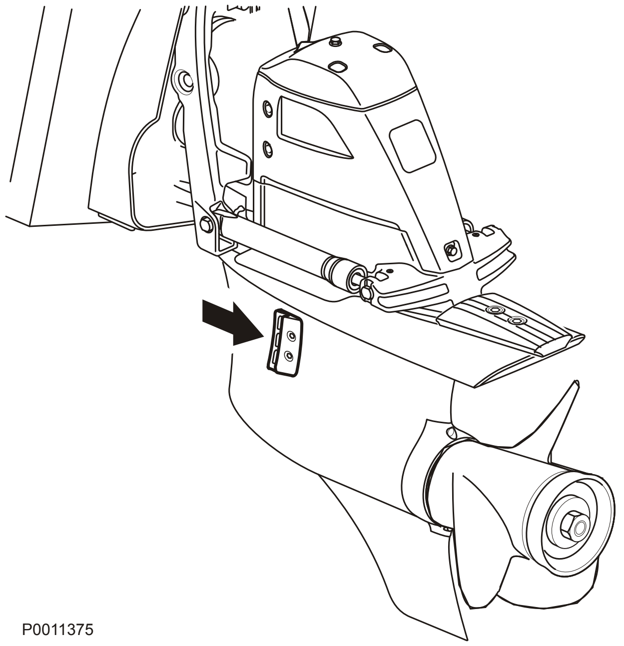
Engine Control Unit

Install the engine control unit (**1**) on a bulkhead with the cables facing downwards or to one side.

Connect the ground cable (**2**) from the transom shield to the engine stay center bolt on the flywheel housing.



P0011351



P0011375

Cooling System

Raw Water System

Aquamatic

The complete seawater system including seawater filter is supplied by Volvo Penta.

The water inlet is located in the sterndrive. Volvo Penta cooling systems are designed for seawater temperatures of maximum **30 °C** (86 °F).

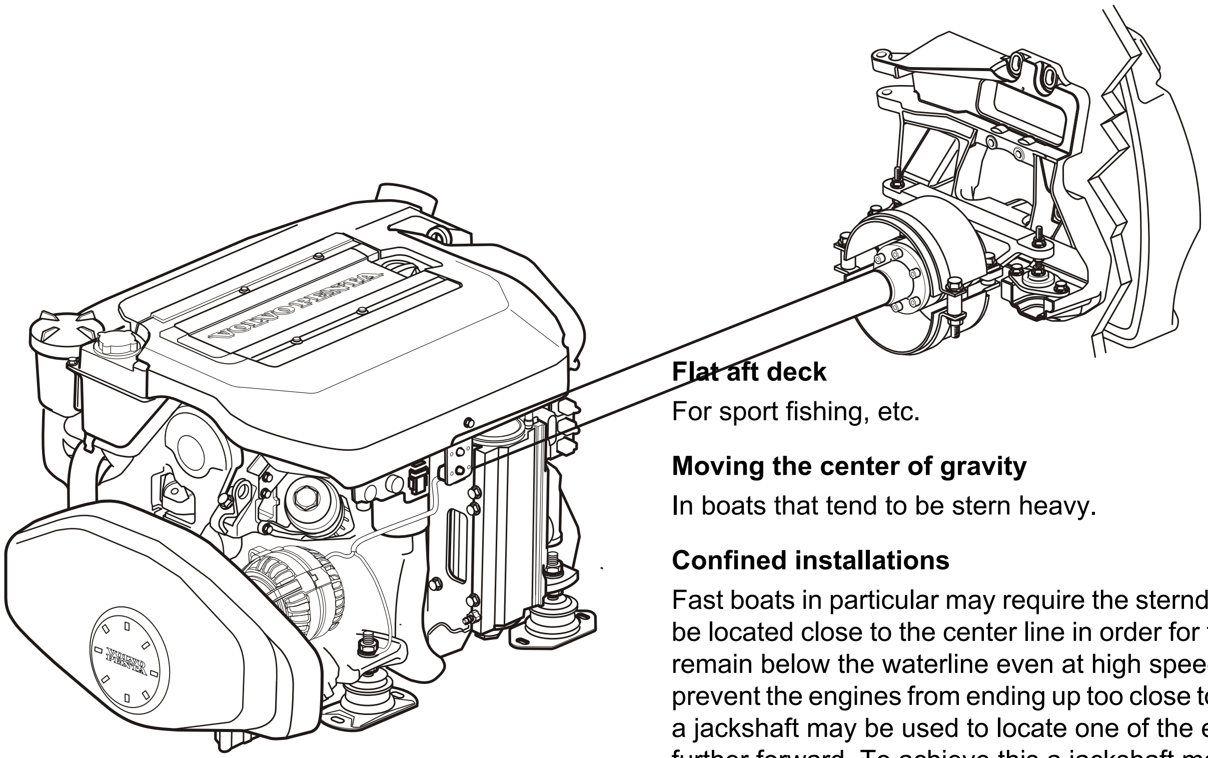
Water circulation from the seawater system cools:

- engine coolant
- engine oil.
- charge air
- power steering fluid
- exhaust

Jackshaft, Installation

General

In certain installations it is appropriate to move the engine forward in the boat while preserving the advantages of the sterndrive:



P0008260

Flat aft deck

For sport fishing, etc.

Moving the center of gravity

In boats that tend to be stern heavy.

Confined installations

Fast boats in particular may require the sterndrives to be located close to the center line in order for them to remain below the waterline even at high speeds. To prevent the engines from ending up too close together a jackshaft may be used to locate one of the engines further forward. To achieve this a jackshaft may be used between the sterndrive and the engine.
Before the jackshaft is installed, the boat must be on dry land with the engine and transom shield in position.

⚠ WARNING!

Working on, or in the vicinity of the jackshaft when the engine is running is extremely dangerous and must be avoided. Clothing, skin, hair and hands, etc. may get caught. This may cause serious injury.

Selecting a jackshaft

A CV21 (Aquadrive) jackshaft is for use for flange-to-flange distances up to 1400 mm (55.12"). This provides a maximum distance of 1715 mm (67.52") from the flywheel housing rear plane on the engine to the intersection point for the crankshaft centerline and the outside of the transom.
Other alternatives require a TVC calculation to be made.

IMPORTANT!

The D3 engine may only be run with a CV shaft.

For further information, refer to the *Installation instructions* included in the jackshaft kit.

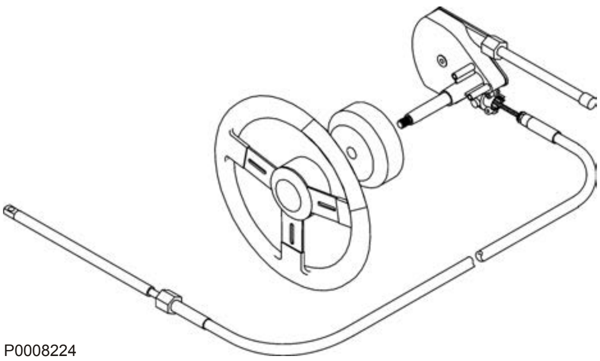
Steering System

General

DPS and SX stern drives are equipped with hydraulic power steering. The power steering pump is engine driven and the hydraulic fluid is cooled by the engine cooling system.

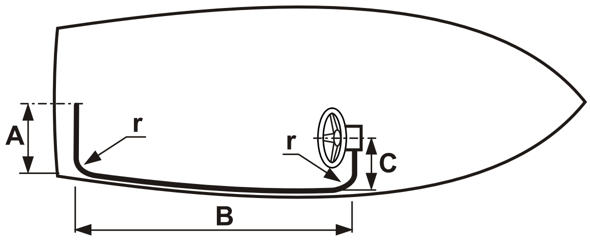
The steering cylinder is located on the inside of the transom shield and is controlled from the helm station by a cable. It is also possible to maneuver the stern-drive electronically via the EVC system, or hydraulically via an auxiliary steering cylinder.

Steering Cable



P0008224

Connect the steering cable to the wheel.



P0008202

Running the cable

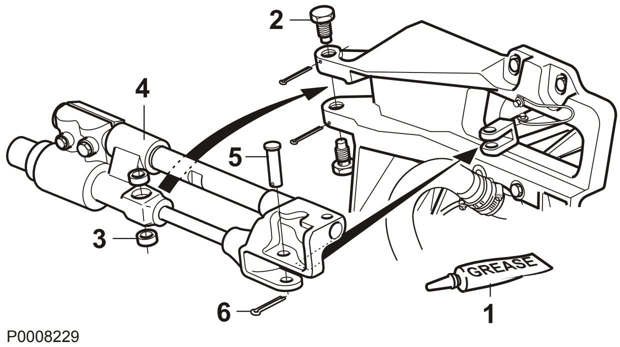
Select a suitable length of steering cable (**A** + **B** + **C**).

When installing a DS unit, take care to locate it in a dry, accessible place, preferably as close to the tiller as possible.

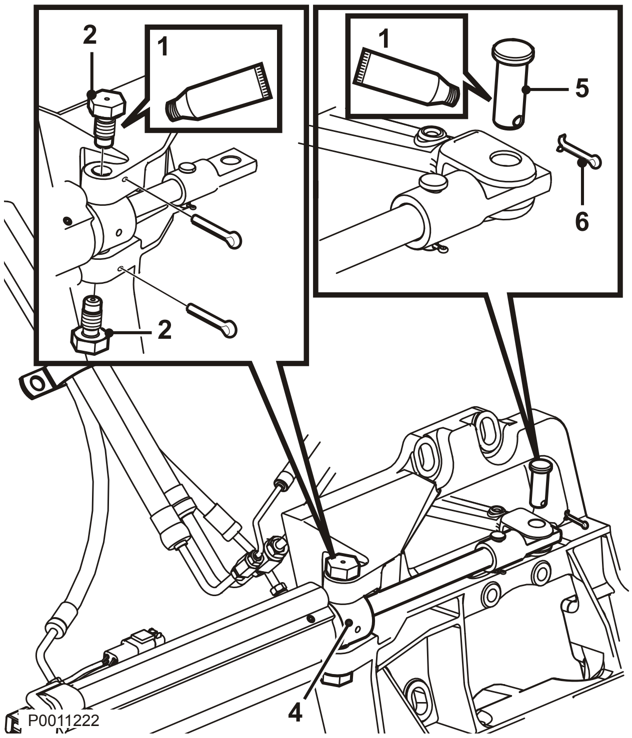
Attach cable clamps along the entire steering cable run. The distance between cable clamps must be around 250 mm (10").

NOTICE! Run the steering cable with as gentle bends as possible. Minimum radius (**r**): 250 mm (10"). If the radius is made smaller the control function will be stiff and there is risk of it binding.

Powersteering Cylinder, Installation



Conventional steering



Electronic steering

1. Apply Volvo Penta waterproof grease (part # 828250) (**1**) to all steering cylinder linkages.

2. Install the attachment bolts (**2**) level with the inboard transom plate inside.

3. Brush waterproof grease onto both steering cylinder bushes (**3**).

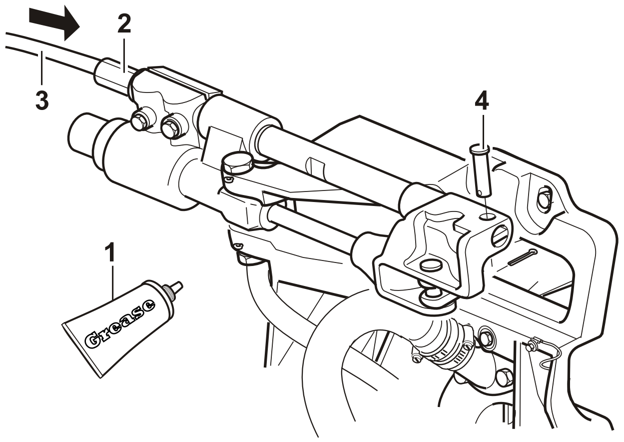
4. Install the steering cylinder (**4**) on the inboard transom plate. Align the steering cylinder bushes with the attachment bolts (**2**). Make sure the attachment bolts are guided into the bushes when they are tightened. Torque the bolts to **54–61 Nm** (40–45 lbf.ft). Install the cotter pin. Bend the cotter pin legs of the so that the attachment bolts are secured in place.

IMPORTANT!

If the attachment bolts are not aligned with the steering cylinder mounting hole, the engine mounts on the transom will break when the bolts are tightened.

5. Pull the hydraulic arm unit over the steering arm. Align the holes and install the large pin (**5**) from the top of the arm.

6. Install the cotter pin (**6**). Bend the cotter pin legs so that the large pin is secured in place.



P0008230

Steering Cable to Powersteering Cylinder, Installation

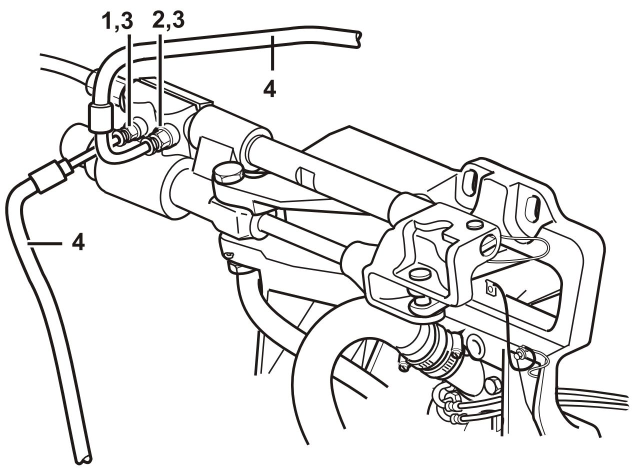
Refer to *Electronic Steering System page 91* for installation instructions regarding electronic steering.

1. Turn the wheel so that the steering piston is pushed fully out. Lubricate the full length of the steering piston with Volvo Penta waterproof grease (part # 828250) (**1**).

2. Hold back the attachment screw (**2**) on the cable sheath (**3**) to anchor the steering cable to the end of the steering pipe.

3. Force the piston through the bushing inside and at the end of the steering tube. Screw the anchor nut onto the tube until it bottoms on the end of the steering tube. Hold the steering cable sheath with an adjustable wrench. Tighten the steering cable attachment nuts to **10 Nm** (7 lbf.ft).

4. Turn the wheel so that the piston is pressed out. Align the hole in the steering cable piston with the hole in the hydraulic arm. Apply Volvo Penta waterproof grease (828250) to the small pin (**4**). Install the pin through the cable hole from above. Install the cotter pin. Bend the cotter pin legs so that the small pin is secured in place.



P0008233

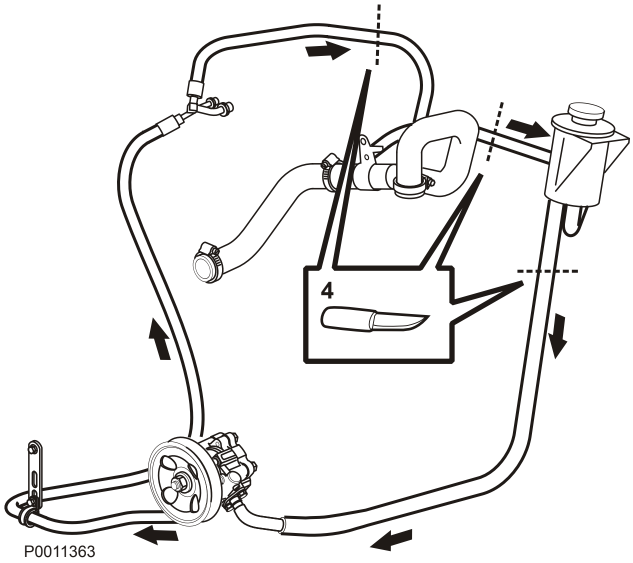
Powersteering Hoses, Installation

Refer to *Electronic Steering System page 91* for installation instructions regarding electronic steering.

1. Remove the small hose union from the companion flange. Remove the small plastic cover from the steering cylinder. Attach the hose union to the actuator.

2. Remove the large hose union from the companion flange. Remove the large plastic cover from the steering cylinder. Attach the hose union to the actuator.

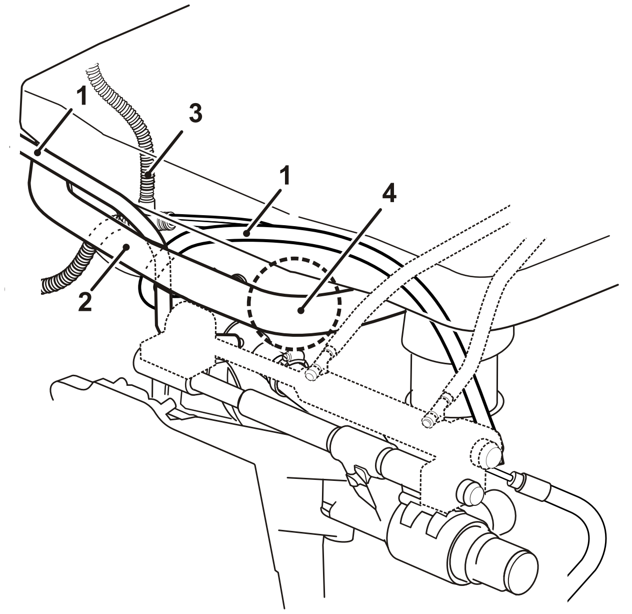
3. Tighten the small hose union to 14–16 Nm (10–12 lbf ft). Tighten the large hose union to 20–23 Nm (15–17 lbf ft).



4. Cut the hoses to the oil cooler and oil reservoir to a suitable length and connect as illustrated.

IMPORTANT!

Turn the wheel and make sure the steering cylinders do not catch anywhere.



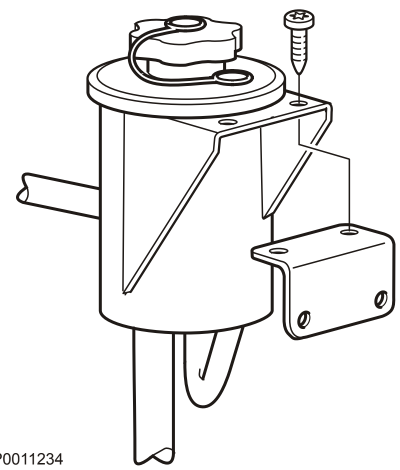
Running hoses for auxiliary steering

If a complete steering system is to be installed hoses must be run so that space is available for an auxiliary steering cylinder.

Run the power steering hoses (**1**) to the oil cooler behind the coolant hose (**2**) located above the oil cooler. Also re-route the electronic harness (**3**) so that it passes behind the coolant hose (**2**).

IMPORTANT!

Once the auxiliary steering cylinder is installed make sure its hydraulic unions do not touch the coolant hose bend (**4**) at any rudder angle.


P0011234

Powersteering Reservoir, Installation

Refer to for installation instructions regarding electronic steering.*Electronic Steering System page 91*

1. Install the power steering oil reservoir on the transom or a bulkhead. Install the rear piece first and then the reservoir using two screws.

2. Connect the oil cooler hose to the oil reservoir inlet. Fasten the hose with a hose clamp.

3. Connect the power steering pump hose to the reservoir outlet. Fasten the hose with a hose clamp.

NOTICE! SX and DPS sterndrives are equipped with self-venting power steering systems. When a system is used for the first time it is important that air in the system disappear quickly. Speed up the venting procedure by running the cylinders out to their end positions (port and starboard) 5–6 times. Once the air has left the system the fluid level will drop. Check and top up with fluid to the correct level.

Remaining air may cause harsh noises in the system.

NOTICE! The reservoir must not be installed on the engine.

NOTICE! The reservoir must be located higher than the steering cylinder.

Steering System, Function Check

1. Start the engine. Check that the steering system functions.

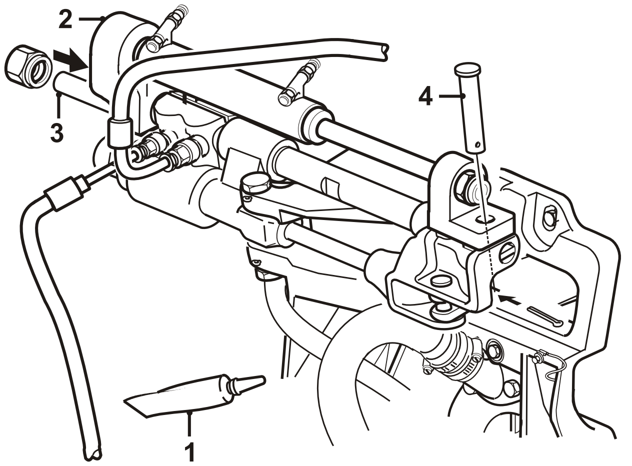
2. If the steering system does not function satisfactorily: Vent the system. Steer to end positions.

3. If the steering system still does not function: While under way carefully loosen the power steering pump pressure hose. Check that a little oil runs out. Tighten the hose again and try turning. Check the oil reservoir level.

Hydraulic Steering System

Volvo Penta does not market a purely hydraulic steering system for D3. However, a purely hydraulic steering system may be recommended in boats with several helm stations. To achieve this an auxiliary steering cylinder is installed on the existing power steering system cylinder.

The power steering system cylinder can be ordered on the following website:



P0011621

www.teleflexmarine.com [1]

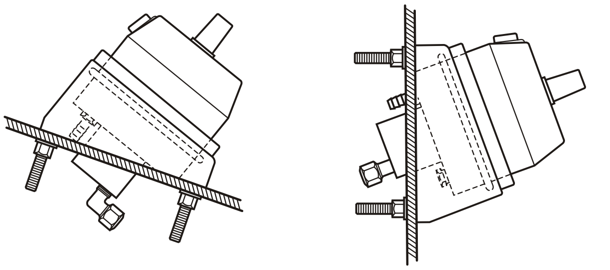
Installing an auxiliary steering cylinder

1. Apply grease to all moving parts on both steering cylinders.

2. Slide the auxiliary cylinder rear piece onto the existing cylinder. Install the nut and tighten.

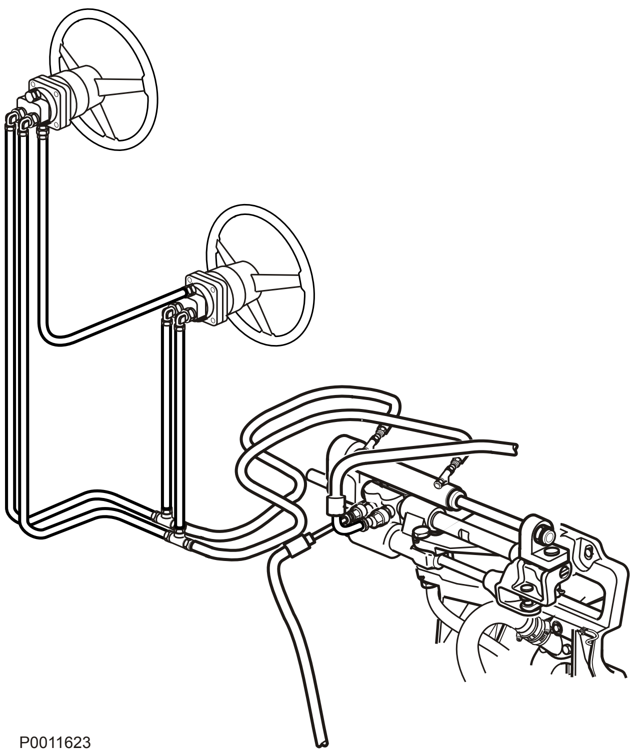
3. Slide the support stay through the cylinder.

4. Fit both cylinder's protruding parts to the end of the support stay. Slide the pin through all three components and secure them with a cotter pin.


P0008203

Steering pump location

Choose a suitable location for the steering pump. Check that there is enough space for the wheel and the steering pump.


P0011623

Running hydraulic hoses

Install the hydraulic hoses. Minimum bend radius: **60 mm** (2.5").

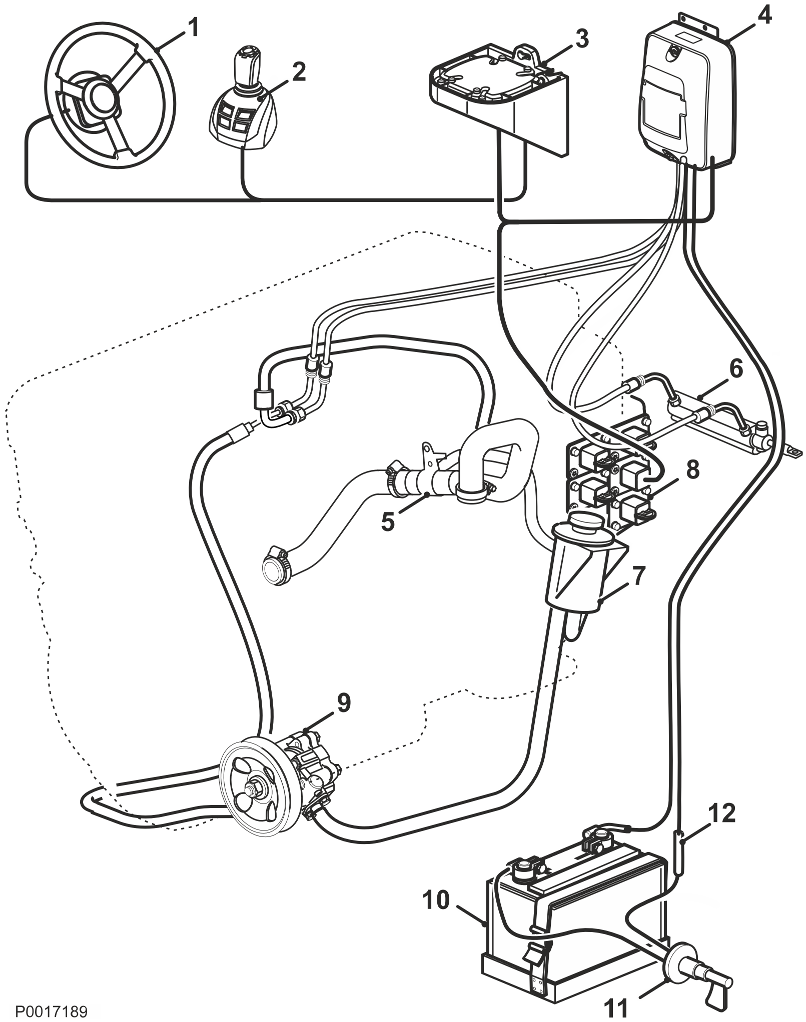
Make sure the hoses do not come into contact with hot surfaces. Secure the hoses together using plastic cable ties. The distance between cable ties must be around 250 mm (10"). Metal clamps may not be used!

Cut the lines with a knife to avoid swarf and burrs. Make sure the ends are completely clean and that they are cut square.

1. Search in the “Hydraulic Steering Selection Guide” catalogue.

Electronic Steering System

NOTICE! Refer to the EVC literature for instructions regarding how the helm steering unit, joystick and SCU are connected.

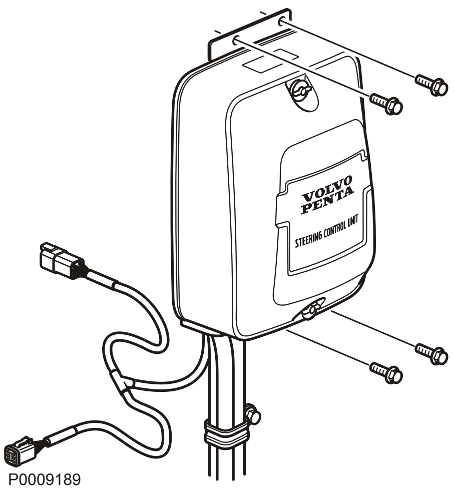


1 Helm steering unit
2 Joystick
3 HCU
4 SCU
5 Oil cooler
6 Steering cylinder
7 Power steering oil reservoir
8 Connection panel on engine
9 Power steering pump
10 Engine start battery
11 Main switch
12 Circuit breaker

Installation

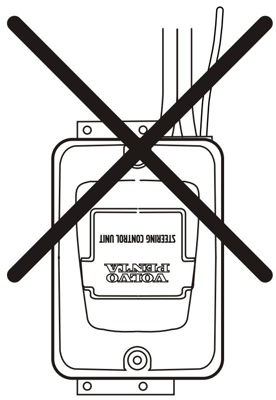
IMPORTANT!

Observe the strictest cleanliness when working on steering system hydraulics. Thoroughly clean the components externally before disassembly. The workplace must be clean and well lit.



P0009189

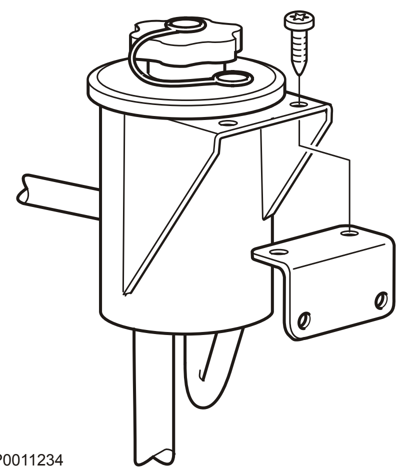
1 Install the SCU using four screws, suitably on the inboard side of the transom. Secure all steering cylinder hoses with clamps.



P0009197

IMPORTANT!

The SCU may be installed vertically, horizontally, or on the underside of a surface. However, the unit may not be installed with the hoses uppermost.



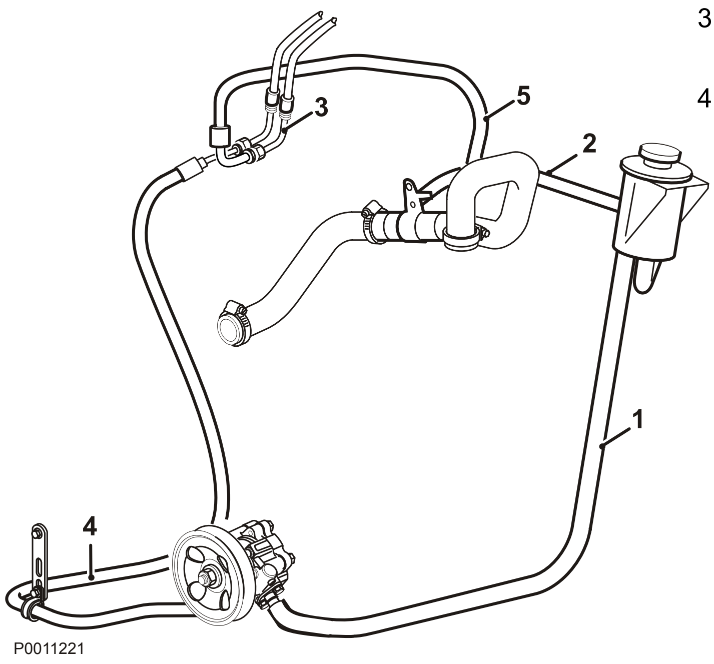
P0011234

2 Install the recovery tank in a suitable place, for example on a bulkhead. The tank must be located higher than the SCU.

IMPORTANT!

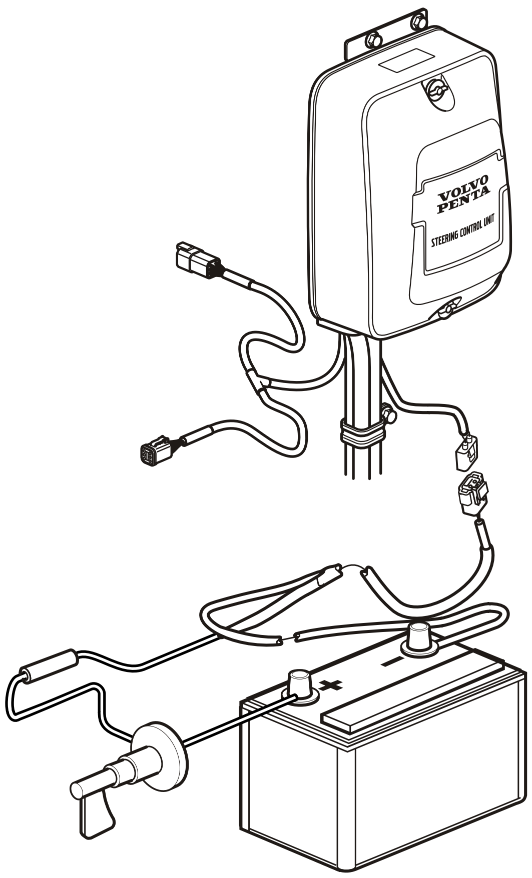
The tank may not be installed on the engine.

NOTICE! The tank must be located higher than the steering cylinder.



3 Connect the hoses from the power steering pump (**1**) and oil cooler (**2**) to the recovery tank.

4 Connect the two hoses **3**) from the SCU to the hose (**4**) from the power steering pump and the hose (**5**) from the oil cooler.



5 Connect power to the SCU from the engine start battery. Install the harness circuit breaker on the battery positive terminal. Also install a main switch to the battery positive terminal.

6 Fill the system with ATF oil of type Dexron II or III while the engine is running. Volvo Penta part # 1161995 is recommended.

If the system has lost a large quantity of oil during dismantling it must be vented. Go to "Calibration mode" so that alarms are switched off. Start the engine; no gear may be engaged.

Turn the stern drive hard aport. Wait around five seconds.
Now turn the stern drive hard astarboard. Wait around five seconds.

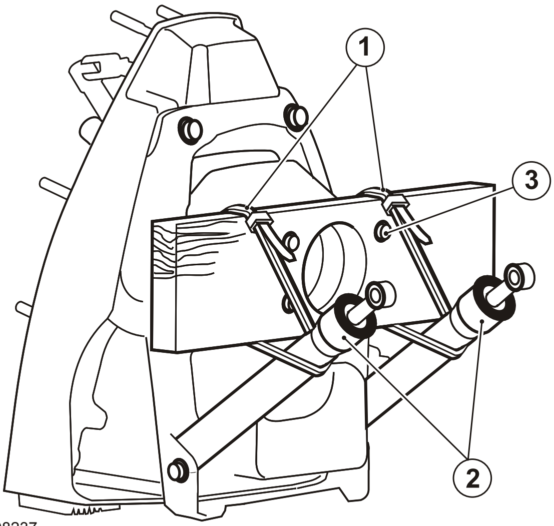
Repeat this a couple of times and then check that the system is vented.

Sterndrive Installation

Preparations

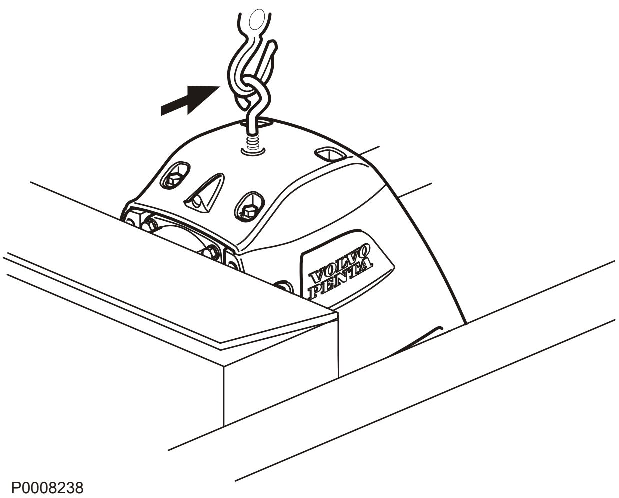
NOTICE! All components in the sterndrive drive system must be adapted either for single or twin installations. Engine, transom shield and sterndrive model numbers must match according to the separate sheet supplied with the sterndrive.

Model number locations are illustrated on the sheet supplied with the sterndrive. If engine and sterndrive are not correctly matched the result will be impaired boat performance and the risk of damage to the engine and sterndrive due to incorrect gear ratios.



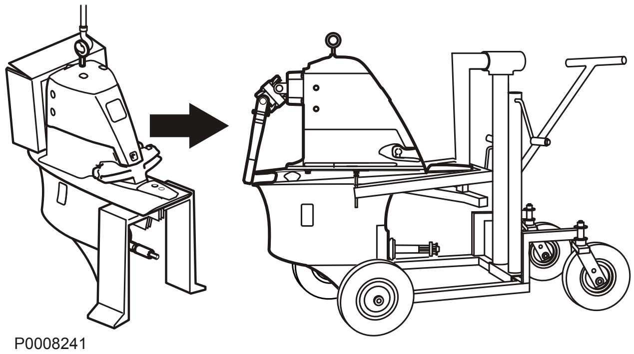
P0008237

1. Arrange support for the hydraulic trim/tilt cylinders before cutting the cable ties in order to avoid damage to hydraulic lines. Remove each cable tie and lower the hydraulic cylinders carefully.
Remove and save the two locking nuts for use in step 3 in *Sterndrive, Installation page 97*. Remove and dispose of the packaging material.



P0008238

2. Remove and save the oil dipstick and the gasket. Screw a lifting eye into the dipstick hole.


P0008241

3. Use a suitable lifting device to remove the sterndrive from the crate. Remove and dispose of the cardboard driveshaft support.

Remove

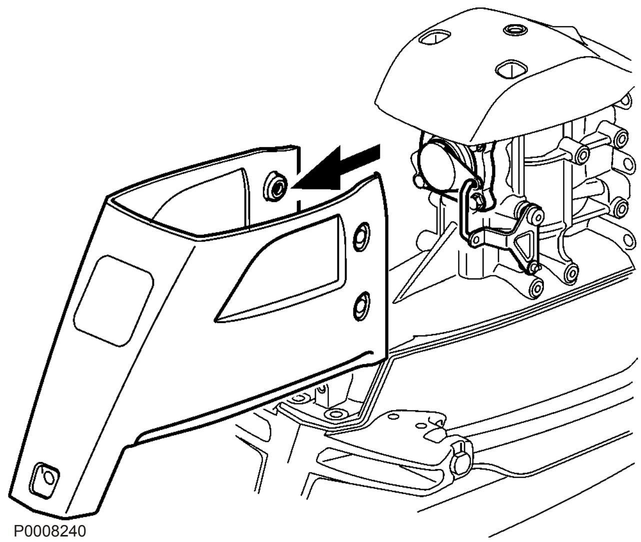
1 Remove the plastic bag from the greased driveshaft. Check the contents of the sterndrive installation kit: four locking nuts, two trim/tilt pins and two cotter pins for sterndrive installation.

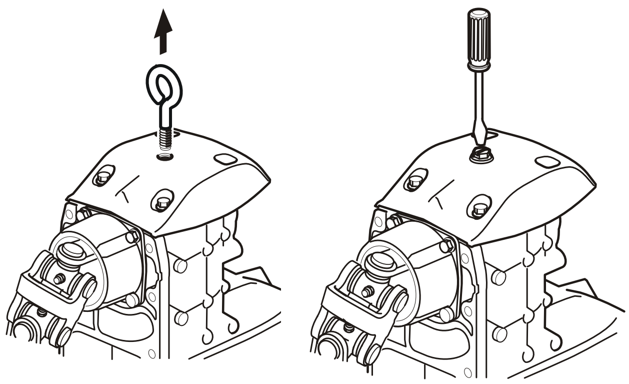
2 Remove and dispose of the protective propeller shaft box and inspect the propeller installation parts.

3 Remove the identification decals showing the sterndrive and transom shield model and serial numbers and fix them in the space provided on the engine serial number decal.

It may be necessary to move the sterndrive from the lifting device to a sterndrive cart depending on the design of the transom.

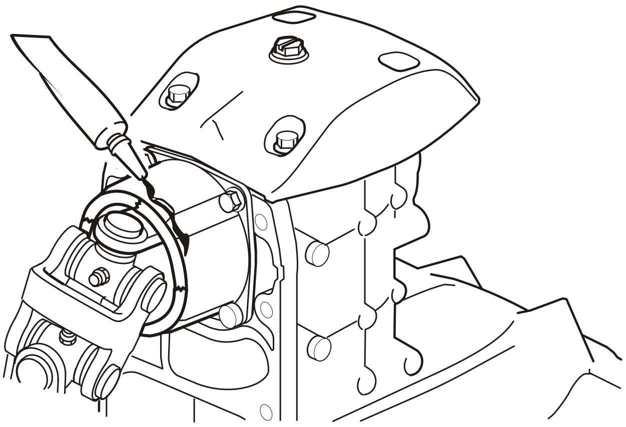
4. Remove and save the rear cover bolts and the cover.


P0008240


P0009215

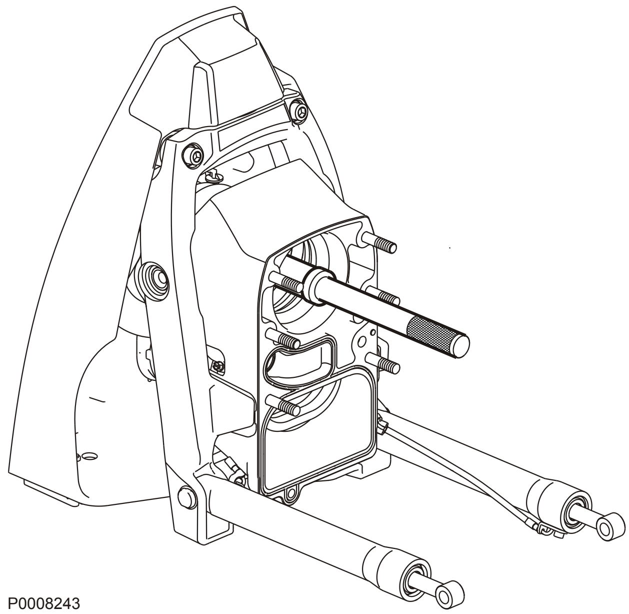
5. Remove the lifting eye from the upper housing. Check the oil level again using the dipstick.
Re-install the oil dipstick and the gasket. Tighten the oil dipstick so that it is properly secured.

6. Visually inspect the tapered part of the bearing housing to ensure that it is free from hacks and dents. Apply a thin coat of Volvo Penta waterproof grease, part # 828250, to the tapered part of the bearing housing. Lubricate the shaft splines, O-rings and water channels with grease.



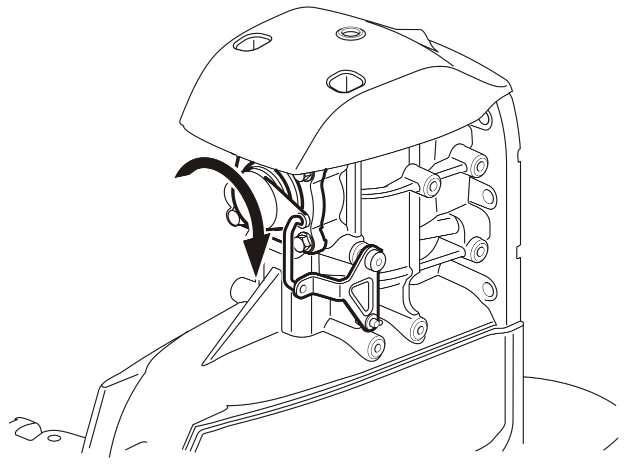
P0008242

7. Check that the molded rubber seal ring fits into its groove. Inspect and lightly lubricate the u-joint bellows with Volvo Penta waterproof grease, part # 828250. Also apply waterproof grease to the six studs.



P0008243

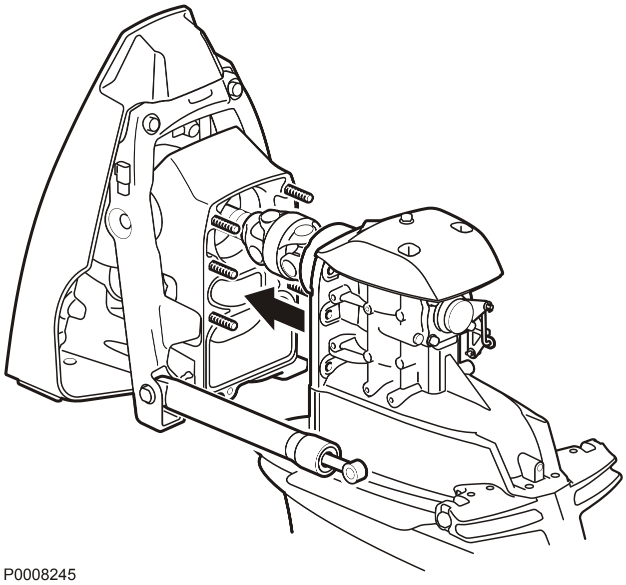
8. Slide the alignment tool, part # 3851083 through the driveshaft bearings. The alignment tool must slide easily through the u-joint bearing and into the engine coupling. If the alignment tool catches when it is slid into the engine coupling, the front engine mounts must be adjusted up or down in order for the alignment tool to be slid in and out of the coupling in the flywheel without binding.



P0008244

9. Select a gear by turning the eccentric piston arm up or down.

Sterndrive, Installation

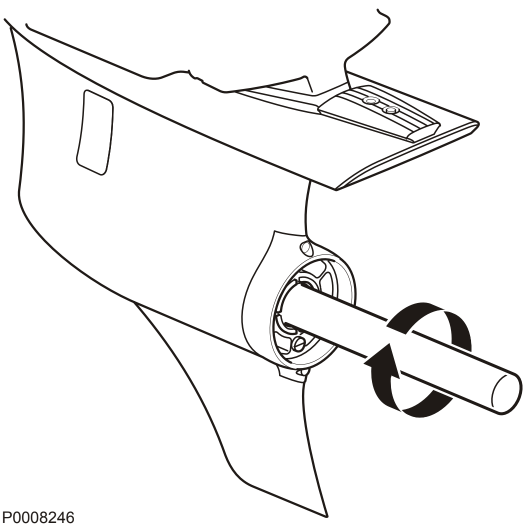


P0008245

1. Angle the trim cylinders up above the gear case splash plate. Slide the drive shaft through the gimbal bearing.

IMPORTANT!

If the shift cable is installed: Take care that it is not damaged when installing the sterndrive.

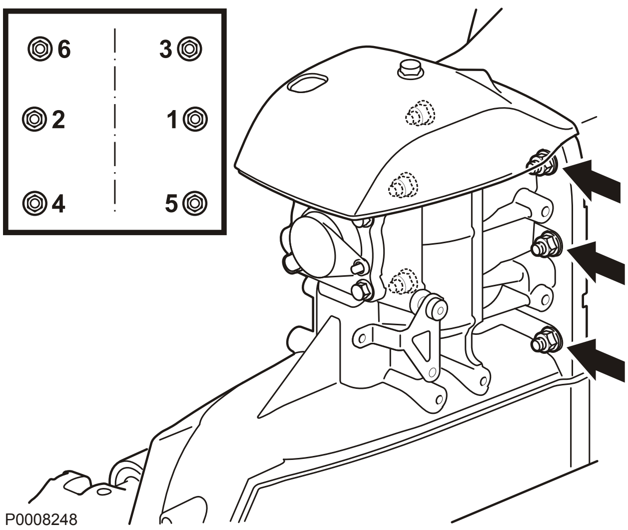


P0008246

2. In order to align the splines, turn the propeller until the splines grip the flywheel coupling. Use soft-nose pliers to turn the propeller shaft if it is difficult to do so by hand.

⚠ **CAUTION!**

Use gloves or a rag to protect hands. The propeller shaft splines may be sharp.



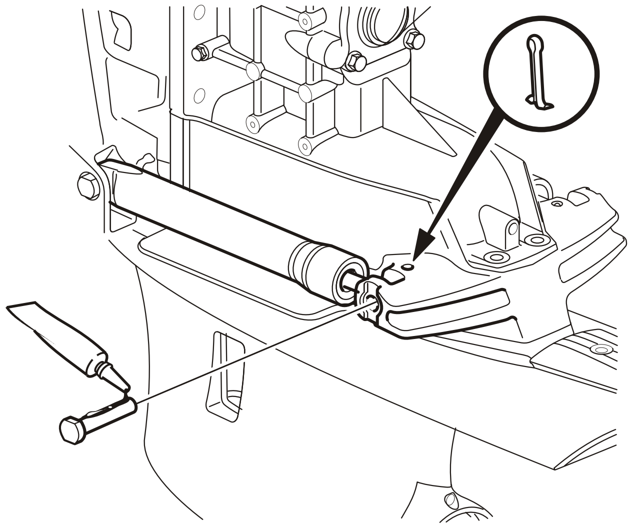
P0008248

3. Slide the sterndrive onto the six studs until it fits firmly against the pivot housing. Retrieve the two saved locking nuts and install them together with the four supplied (three on each side).

Tighten the nuts in two steps. Use a 3/8 drive and a 5/8 socket with a universal joint to tighten the nuts, initially to 34 Nm (25 lbf.ft). Begin with the center nut (1) and then work diagonally (2, 3, 4, 5, 6) up and down to secure the sterndrive in the pivot housing. Use the same diagonal pattern to finally tighten all six locking nuts to 68 Nm (50 lbf.ft).

IMPORTANT!

Do not use a pneumatic or any kind of electric rotary hammer to tighten the nuts. The stud and nut threads may be damaged.

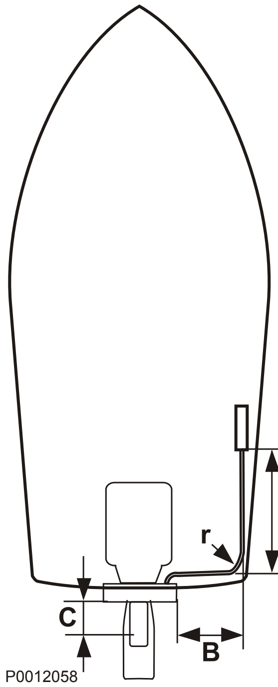


P0008247

4. Now remove any sterndrive cart used when installing the trim/tilt cylinders. Apply Volvo Penta waterproof grease, part # 828250, to the trim/tilt cylinder pivot pins. Align the trim/tilt cylinder end with the upper pivot point in the gear case.
Slide the trim/tilt pivot pins into the upper gear case.

5. Use the flat parts of the trim pins to align them with the cotter pin hole. Then install the cotter pin. Bend the cotter pin legs to secure it in place.

Shift Cable, Connection



IMPORTANT!

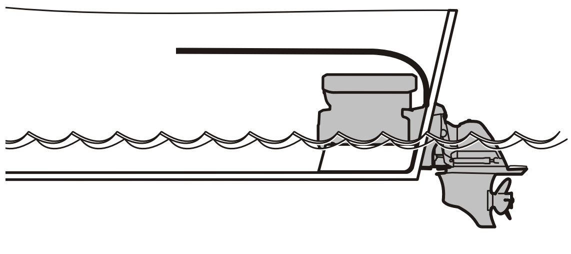
The quality of the cable sheath and cable are of great importance for shift function. Use only Volvo Penta **X-act** or **X-treme** shift cables.

The shift cable should have as few bends as possible and a total bend angle of 270°. The cable should also be as short as possible. A maximum length of 4.5 m (15 ft.) is recommended.

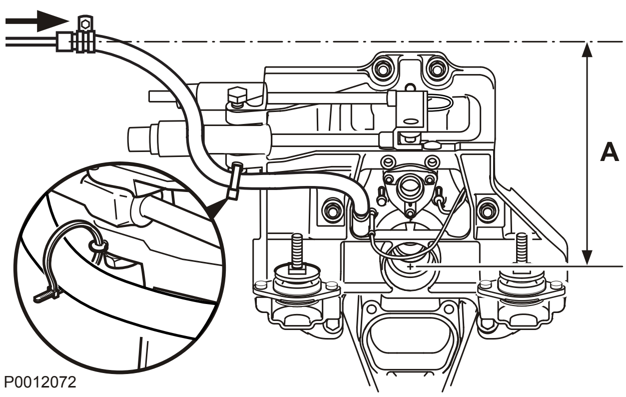
1. Choose a suitable location for the actuator. Calculate the required length(**A** + **B** + **C**) and select a shift cable based on this.

Minimum shift cable bending radius (**r**) is **200** mm (8"). The greater the installation radius the better.

C = **500 mm** (19.7")

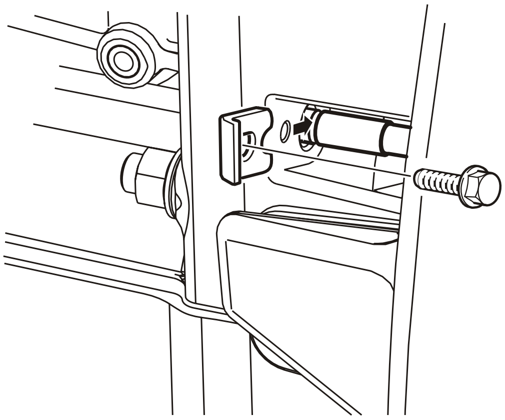


NOTICE! The shift cable must be run up above the waterline.



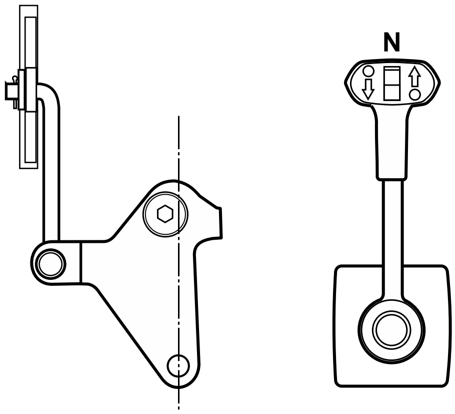
Pass the gearshift cable through the sheath and out through the transom. If necessary, end piece 40005050 may be screwed onto the cable to facilitate penetration. Secure the sheath with clamps at least **350 mm** (14") (**A**) above crankshaft centerline. Clamping must take place at the steering cylinder pin as illustrated.

NOTICE! Turn the sterndrive to starboard to facilitate installation.



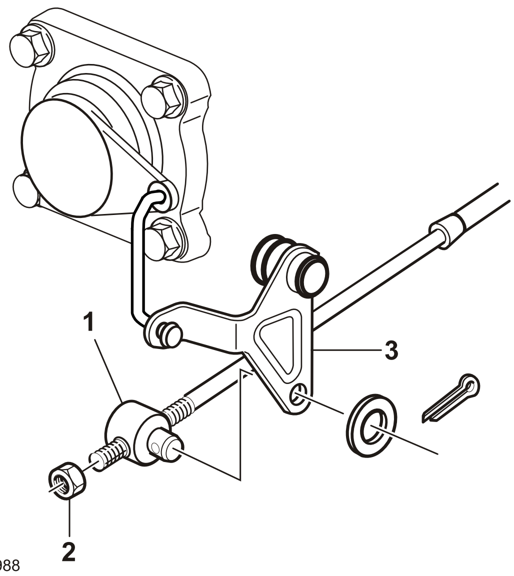
P0011986

3. Loosen the shift cable attachment plate on the sterndrive (the bolt need not be removed). Slide the sheath through the hole and secure it with the plate. Torque the bolt to **7 Nm** (5.2 lbf.ft).



P0017171

4. Make sure the sterndrive shift bracket is in the neutral position.



P0011988

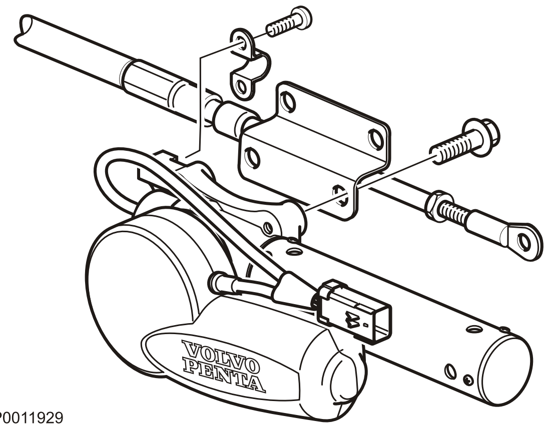
5. Screw the barrel adjuster (**1**) and locking nut (**2**) onto the cable. Make sure that around 3 mm (0.12") remains on each side for any further adjustment. Tighten the locking nut.

6. Secure the barrel adjuster to the shift bracket (**3**) with a cotter pin and washer. Bend out the cotter pin legs fully.

Actuator

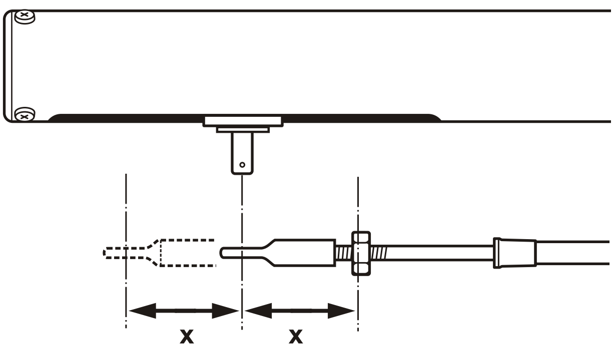
1. Connect the shift actuator to the EVC system and start up. Put the control lever in the neutral position and wait while the actuator is automatically calibrated.

⚠ **CAUTION!**
Pinch hazard. Keep fingers clear.



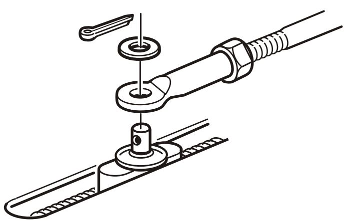
P0011929

2. Screw the locking nut and eye onto the cable stay and clamp the cable sheath to the actuator. Install the actuator attachment bracket.

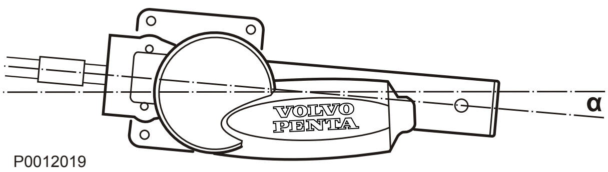


P0012044

3. The cable will have a certain amount of play in the sheath. Screw the eye onto the cable stay to a position where the hole is in line with the actuator connection point and the play is equal in both directions. Tighten the locking nut.


P0012057

4. Secure the cable with a cotter pin and washer. Bend out the cotter pin legs fully.



P0012019

5. Install the actuator above the waterline on the transom or a bulkhead. The actuator must be installed at an angle with the cable inclined upwards.

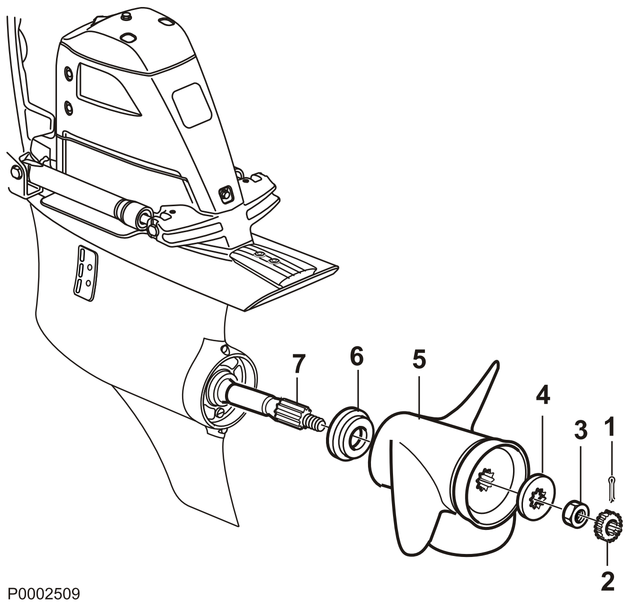
α = Min. 5°

Propeller, Installation

General

The sterndrive is not supplied with a propeller. The right propeller must be selected to match the engine and boat as a unit in order to provide the longest engine service life and the best fuel economy and performance. The boat manufacturer must carry out tests to determine the optimum propeller for every combination of boat and engine. Also refer to the tables regarding propeller selection in the Propeller section of the Sterndrive/Transom shield maintenance manual.

SX models

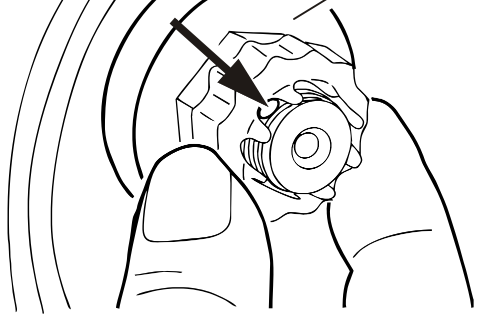


P0002509

1 Switch on the ignition and move the control lever to neutral. Remove the ignition key from the ignition switch.
2 Thoroughly lubricate the propeller hub and propeller shaft with Volvo Penta grease (part # 828250).
3 Install the bushing (**6**) with the inner cone facing the sterndrive.
4 Install the propeller (**5**) on the propeller shaft (**7**); align the splines and slide the propeller toward the bushing until the splines are visible.
5 Install the spacer (**4**) on the propeller shaft splines.
6 Switch on the ignition and move the control lever to the reverse position so that the propeller shaft is locked. Remove the ignition key from the ignition switch.

NOTICE! The shaft may also be locked by placing a piece of wood between a propeller blade and the anti-cavitation plate.

7 Install and tighten the propeller nut (**3**) so that the propeller and the bushing (**6**) bottom completely.
8 Undo the propeller nut and screw it back against the spacer by hand. Tighten the propeller nut to **96–108 Nm** (71–80 lbf.ft)
9 Align the lock washer (**2**) against the propeller nut so that it lines up with the cotter pin hole.
10 Install the cotter pin (**1**) and bend out the ends to secure the nut. Use a new cotter pin if necessary.
11 Turn the shift arm to the neutral position. Attach the wire to the shift arm. Install a new cotter pin.
12 Switch on the ignition and move the control lever to neutral. Check that the propeller can be turned easily.



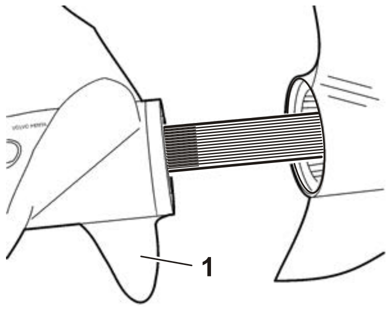
P0008249

DPS models

IMPORTANT!

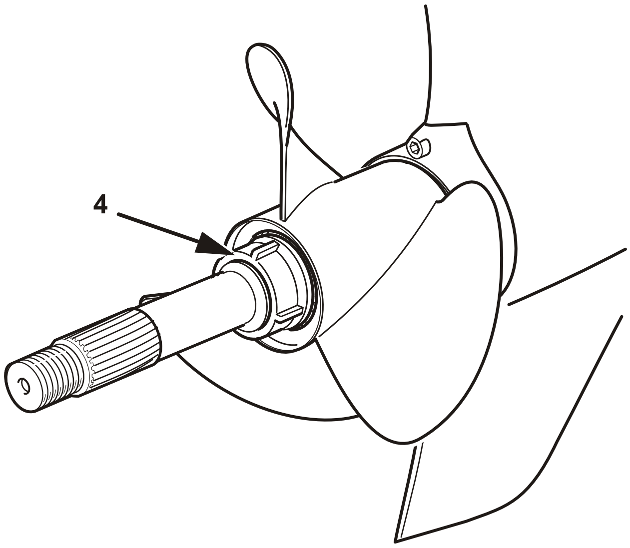
Aluminum S-series propeller kits used on Duoprop applications are not recommended for use on engine/ boat combinations that handle speeds of more than 35 knots. Stainless steel F-series propeller kits must be used in such applications. If aluminum D-series propeller kits are used, a trim limiter, part # 3857598 must also be fitted.

NOTICE! The propeller shafts may be locked through selecting a gear or by using a piece of wood between a propeller blade and the anti-cavitation plate.



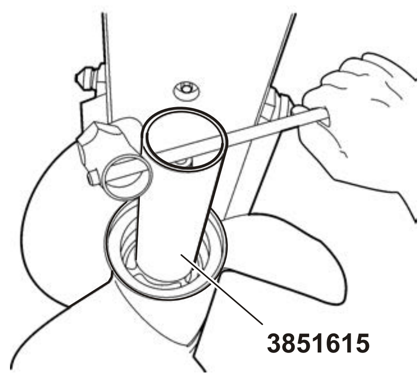
P0008251

1. Apply Volvo Penta waterproof grease, part # 828250, along the entire length of both propeller shafts.
2. Select FORWARD mode with the control lever to lock the propeller shafts. Fit the forward propeller (1).



P0008252

3. Install and tighten the forward propeller nut (4) to **60 Nm** (44 lbf.ft). Use propeller tool, part # 3851615.

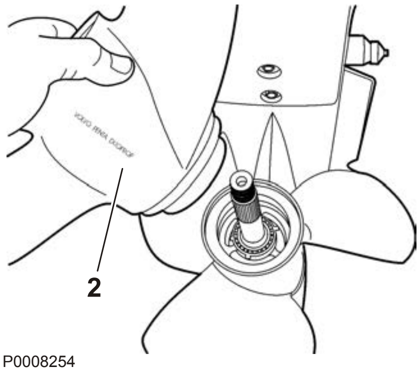


P0008253

IMPORTANT!

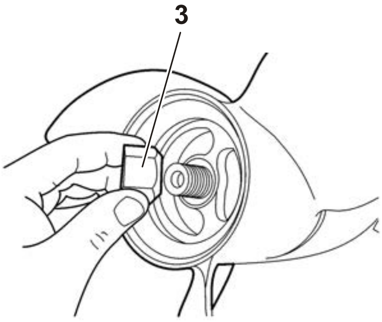
Check that the beveled edge of the propeller nut faces forward. If the propeller nut is not installed in the correct way the propeller may come loose and damage the unit and/or the propeller.

4. Select REVERSE mode with the control lever to lock the propeller shafts.



P0008254

5. Install the aft propeller (2).

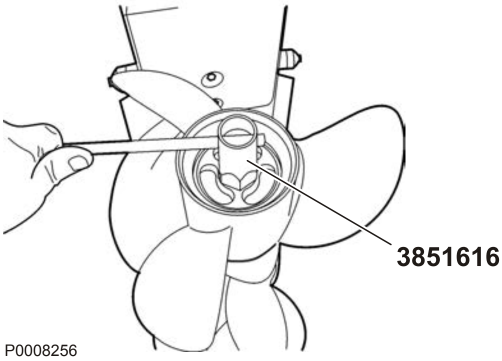


P0008255

6. Install the aft propeller nut (3) with the narrower end toward the propeller and tighten to **70 Nm** (52 lbf.ft). Use propeller tool, part # 3851616 or a 30 mm socket and a torque wrench.

IMPORTANT!

If the propellers are not installed as described, the aft propeller may fall off and damage the unit.



P0008256

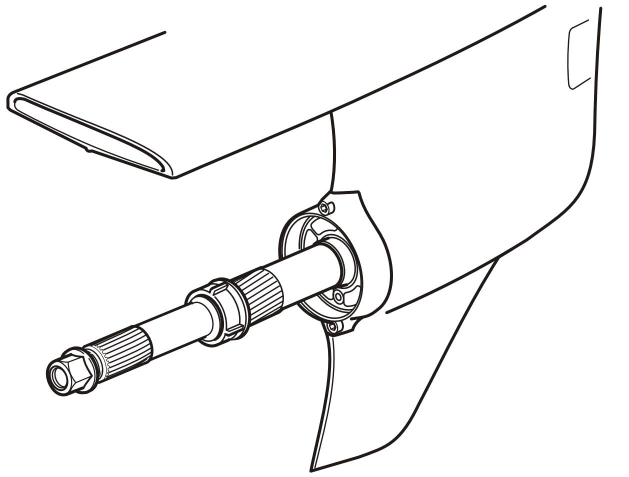
7. Move the control lever to the NEUTRAL position. Both propellers must be able to move freely.

DPS models with Helical Splines

NOTICE! The propeller shafts may be locked through selecting a gear or by using a piece of wood between a propeller blade and the anti-cavitation plate.

1. Apply Volvo Penta waterproof grease, part # 828250, along the entire length of both propeller shafts.

2. Select FORWARD mode with the control lever to lock the propeller shafts. Fit the forward propeller (1).



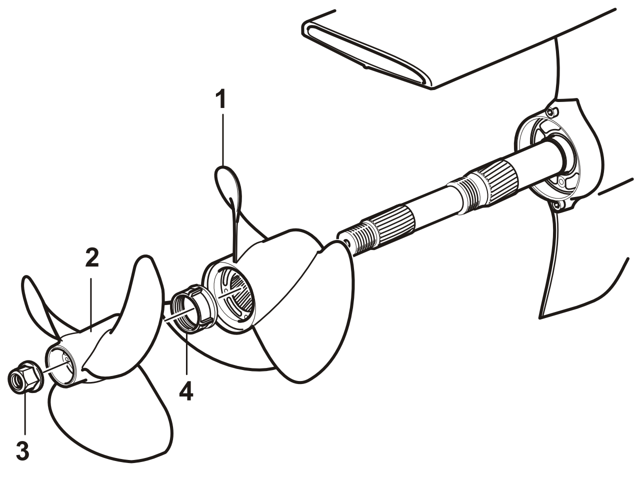
P0014762

3. Install and tighten the forward propeller nut (4) to **60 Nm** (45 lbf.ft). Use propeller tool, part # 3851615.

Important

Check that the beveled edge of the propeller nut faces forward. If the propeller nut is not installed in the correct way the propeller may come loose and damage the lower unit and/or the propeller.

4. Select REVERSE mode with the control lever to lock the propeller shafts.



P0014763

5. Install the aft propeller (2).

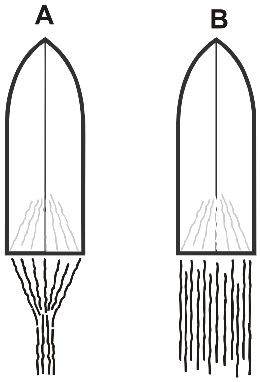
6. Install the aft propeller nut (3) and tighten to **101 Nm** (75 lbf.ft). Use propeller tool, part # 3851616 or a 30 mm socket and a torque wrench.

Important

If the propellers are not installed as described, the aft propeller may fall off and damage the unit.

7. Move the control lever to the NEUTRAL position. Both propellers must be able to move freely.

Propulsion Unit Positions, Calibration



P0007790

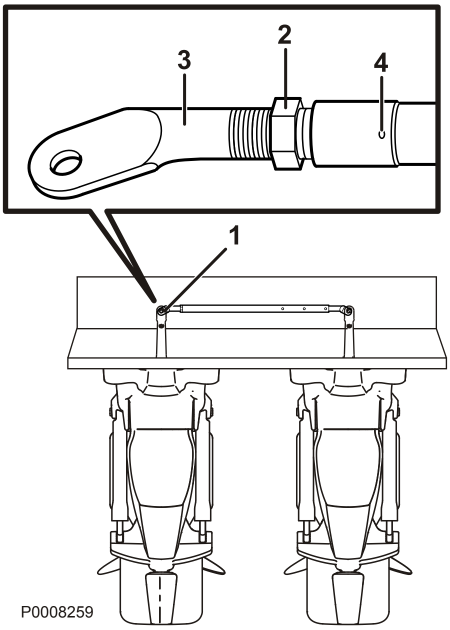
A Low speed

B High speed

To achieve good performance and rudder feel on twin installations, toe-in must be adjusted. Refer to the EVC system literature for configuration of electronic steering installations.

Because water flow aft of the transom differs depending on hull form and boat speed, toe-in can be adjusted to optimize top speed or cruising speed. The boat manufacturer will need to test every new boat design at various settings to achieve the best toe in.

- Deeper V hulls require more toe in (more inwardly oblique sterndrive settings).
- Higher speeds require less toe in (straighter sterndrive settings).



P0008259

1 Remove the steering arm from the port tiller (**1**).

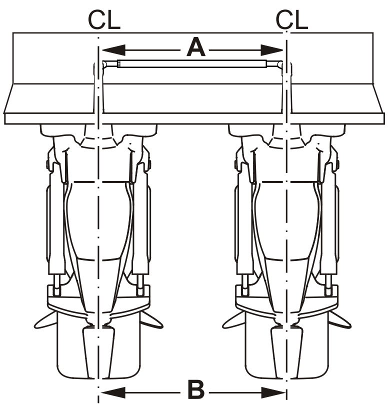
2 Loosen the adjustment screw locknut (**2**) on the rocker arm. Undo the locking nut 1.6–2.6 mm (0.063–0.102") as necessary.

3 Screw in the port end of the parallel rod (**3**). Tighten the locking nut again.

4 The port parallel rod threads must be visible in the inspection hole (**4**) to ensure that sufficient threads have contact between the rod and the tube.

⚠ WARNING!

If the steering rod is not sufficiently screwed in it may result in the component breaking and the loss of steering.



P0008257

Standard recommendation:

Use **A** = **B** as the starting point for planing boats, which generally provides good results. For optimal results set the dimension **B** somewhat smaller than dimension **A** so that a suitable toe-in configuration is achieved.

An optimal result can only be achieved by trial and error, and the precise toe-in angle varies from boat to boat.

For tie-bar installation, please refer to Installation instruction 3855217.

Helm station

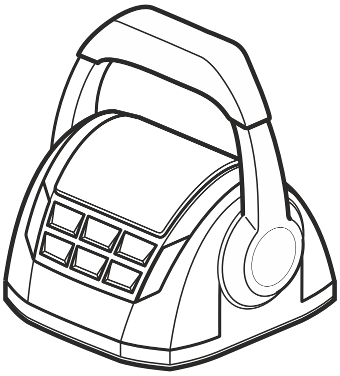
Controls

General

For the boat to be steered and operated in a comfortable and safe manner the helm station must be designed so that levers, steering, instruments, navigation equipment and alarm systems are laid out in a practical way. This applies to every helm station.

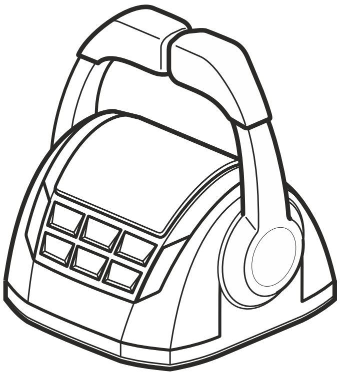
Levers for EVC engines (Electronic Vessel Control)

Refer to the EVC system installation manual regarding the installation of controls and other EVC system components.



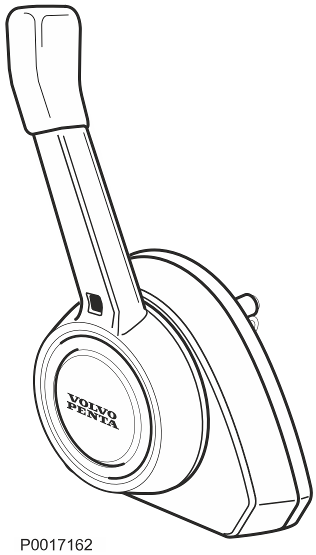
p0017173

Top-mounted control for single engine



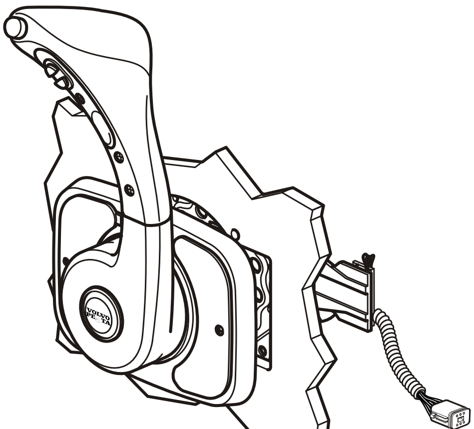
p0017160

Top-mounted control for twin engines



P0017162

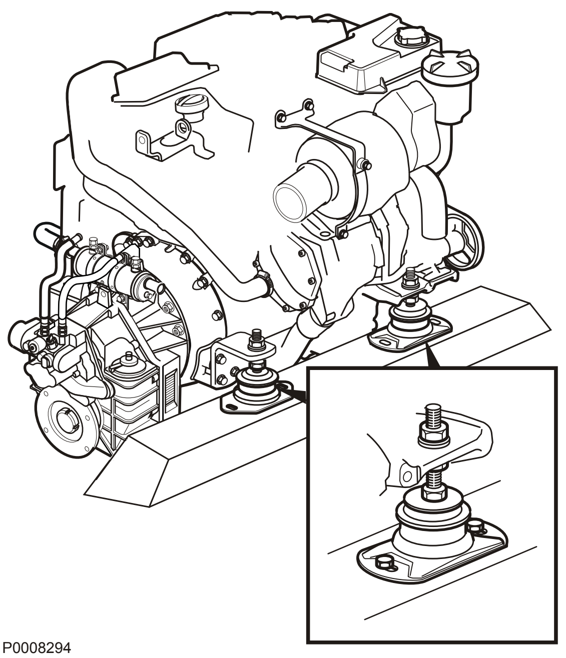
Side-mounted control for single engine



P0004816

Side-mounted electronic control with neutral position lock

This control has a locking function, i.e. a mechanical lock that locks the lever in the neutral position. The control also has integrated Powertrim control buttons and cables.


P0008294

Inboard Applications

Engine Foundation

Engine Suspension

Flexible installation

A sufficiently rigid engine bed is a precondition for rubber mounts to work as effective vibration dampers. The bed must also be parallel with the engine so that tension is not built up in the engine mounts. Tension can increase vibration levels and also shorten engine mount service life.

NOTICE! Rubber mount flexibility must never be used to compensate for deviations in the engine bed.

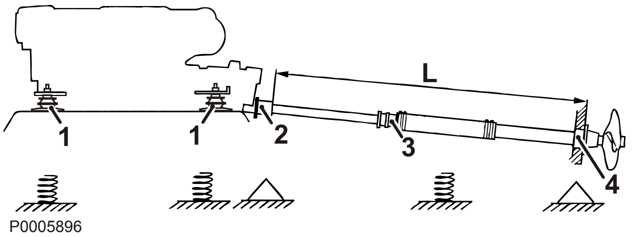
Flexible engine mounts provide good vibration dampening between the engine and bed, and thus also reduce noise levels.

Engine suspension and propeller shafts

Stainless steel propeller shafts are available in different diameters. The choice of shaft dimensions must be based on engine power, gear ratio, distance between supports points and propeller shaft material.

NOTICE! A flexible shaft coupling may never be installed together with a flexible packing box; this may cause vibration problems.

The following alternative installations and combinations are recommended:

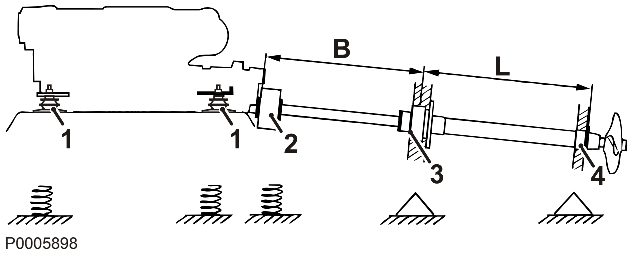


1 **Flexible engine mounts and flexible shaft seal**

NOTICE! In this example, a flexible shaft coupling may not be installed.

1 Flexible engine mounts
2 Rigid shaft coupling
3 Flexibly installed shaft seal
4 Water-lubricated stern bearing

L: Maximum distance between support points; refer to *Propeller Shaft Systems page 18*.

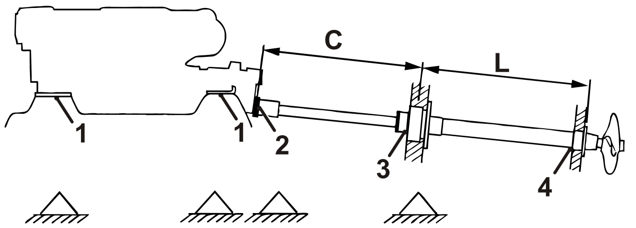


2 **Flexible engine mounts and rigid shaft seal**

1 Flexible engine mounts
2 Flexible shaft coupling
3 Rigid forward stern bearing and shaft seal
4 Water-lubricated stern bearing

L: Maximum distance between support points; refer to *Propeller Shaft Systems page 18*.

B: Distance between reverse gear flange – support point.
Minimum recommended B is 6-10 x shaft diameter.
Max B is calculated in the same way as max L.



P0005899

3 **Rigid mounts and rigid shaft seal**

1. Rigid engine mounts[1]
2. Rigid shaft seal (flexible coupling as an alternative).
3. Rigid forward stern bearing and shaft seal
4. Water-lubricated stern bearing

L: Maximum distance between support points; refer to *Propeller Shaft Systems page 18*.

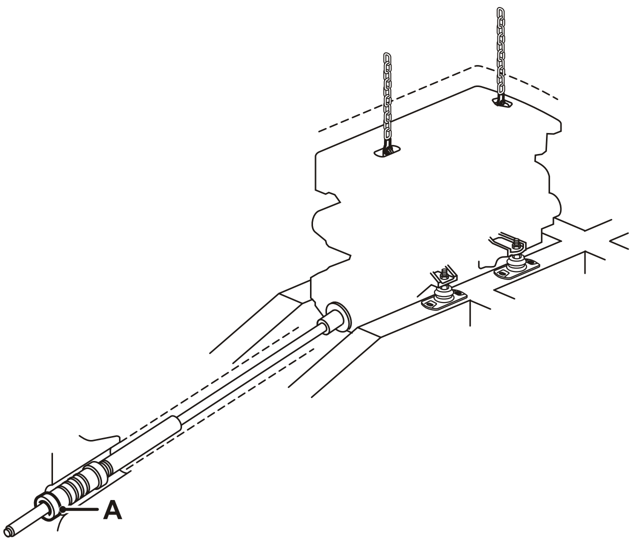
C: Distance, reverse gear flange – support point. Max C is calculated in the same way as max L.

Building the Engine Bed

The engine can be used as a fixture to determine engine bed location.

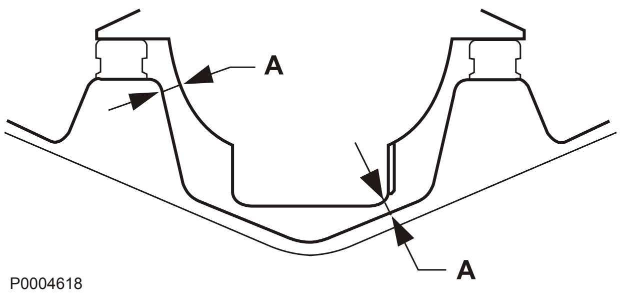
Lay out the engine, propeller shaft and stern bearing in their places. The engine must be attached to the propeller shaft.

Begin building up the bed in relation to the engine mount locations.



P0005920

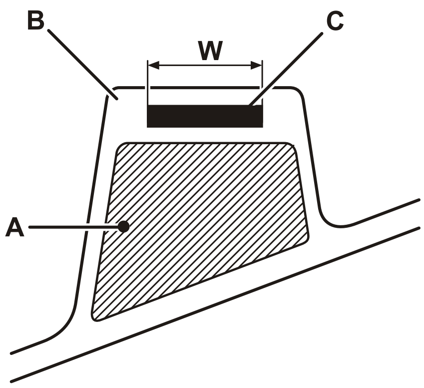
A = Fixed point. The stern tube is neither fixed, molded nor bolted fast.



P0004618

When the engine bed is complete, check that the space for the flywheel housing, oil sump bottom and sides etc. has a clearance (**A**) of **at least 20 mm** (3/4").

1. Rigidly installed engine mounts are recommended only for plastic molding e.g. Chockfast.



P0007702

A. Spacing material, preferably high density material

B. GRP, approx. 10-15 mm (0.4–0.6")

C. Galvanized steel strip, approx. 10 mm (0.4") thick

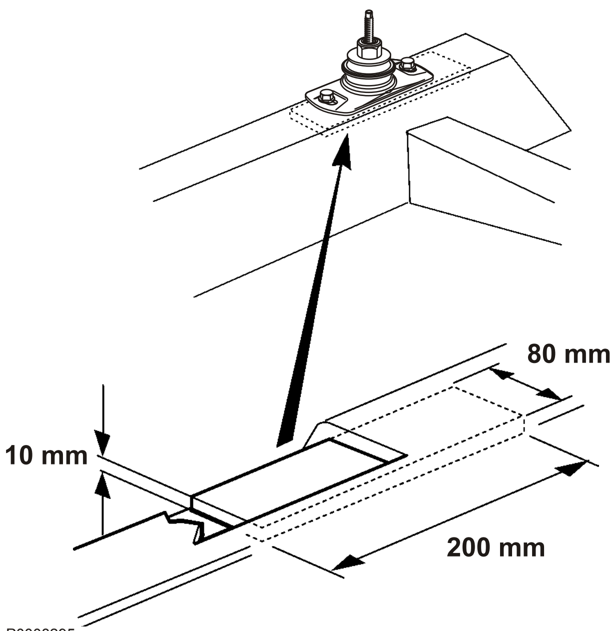
W. Steel strip, width: min. 75 mm (3")

Minimum engine bed width: 112 mm (4.4")

GRP engine bed

The engine bed must be filled to reduce noise and vibrations. Make sure the filling material is not water absorbent. High density material is generally better at dampening noise.

Build up the engine bed with spacing material (**A**) so that the undersides of the engine mounts/rubber mounts almost rest on the bed. There must be room for the steel strip and GRP.

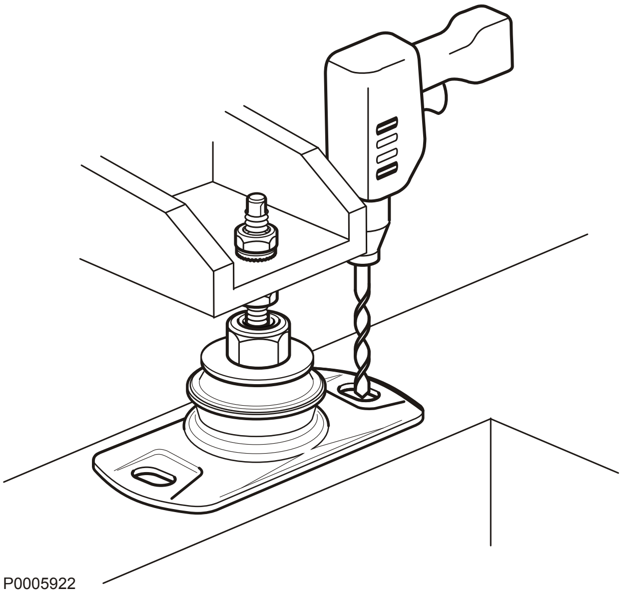


P0008295

The steel plate must be 10–12 mm (0.39"-0.47") thick

Build in a galvanized steel plate that is around 10–12 mm (0.39"-0.47") thick, at least 80 mm (3") wide and 200 mm (7.9") long.

Build in drainage channels so that bilge water is able to run to the bilge pump.



P0005922

Drilling holes for the engine mounts

It is of course a good idea to drill and tap the bolt holes at an early construction stage, after accurate measurement and the use of fixtures. In series production and other frequent installations, more sophisticated methods may be desirable, and may therefore be used.

NOTICE! If the engine and engine mount is used as a drill jig, the engine mount/flexible mount holes must be drilled in conjunction with engine installation in the boat.

Drilling the holes for the engine mounts

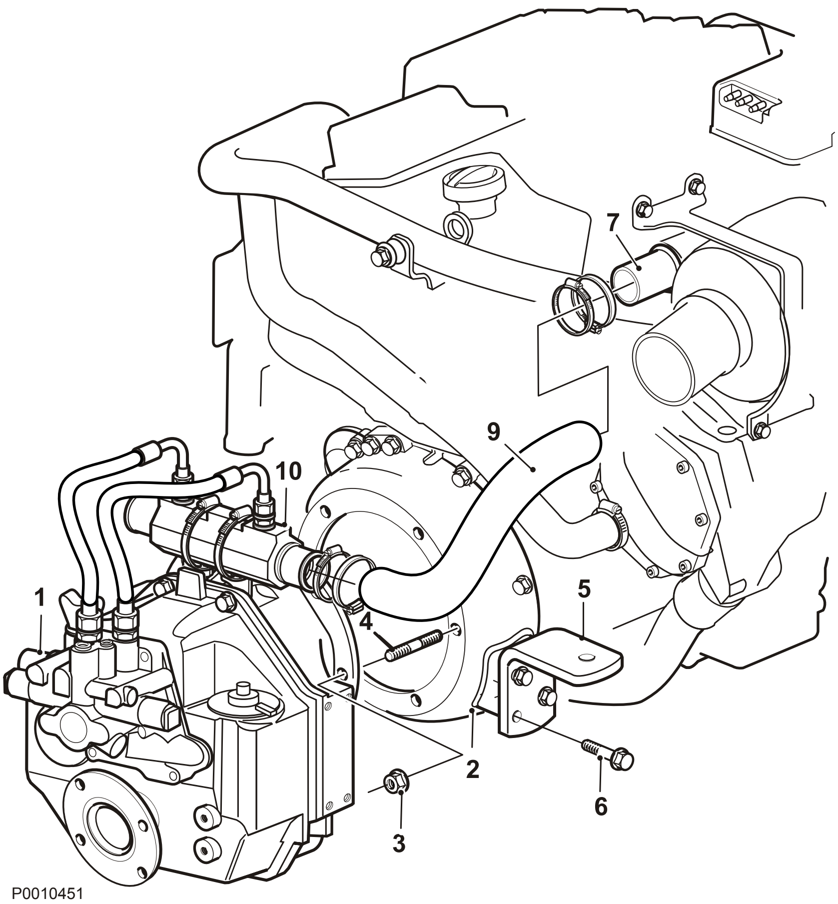
1 Align the engine with the propeller shaft and mark out the engine mount holes.

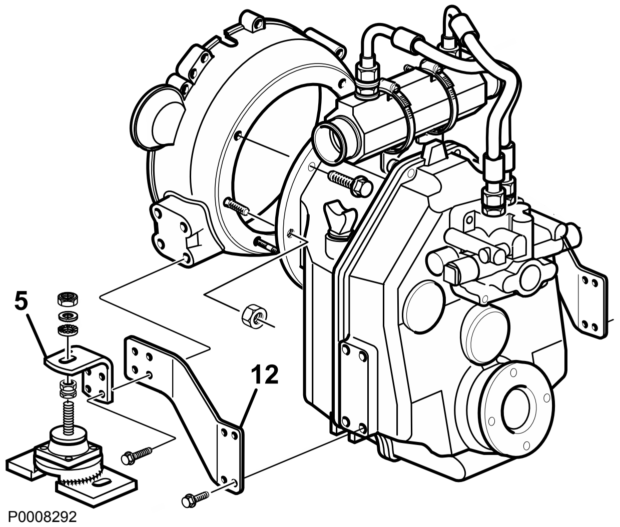
2 Drill and tap the holes in the engine bed steel strips.

IMPORTANT!
Use bolt size **M10** or **3/8" UNC**.

Engine Installation

Reverse Gear





IV drive

Install the six studs (**4**) in the flywheel housing (**2**). Lift the reverse gear (**1**) onto the studs and screw on the nuts (**3**). Tighten the nuts in a diagonal sequence.

Install the aft engine mounts (**5**) on the flywheel housing (including the stiffening plates (**12**) for the IV drive).

Install the seawater hose (**9**) between the oil cooler (**10**) and the adapter (**7**). Secure the hose with twin clamps.

Engine Installation

IMPORTANT!

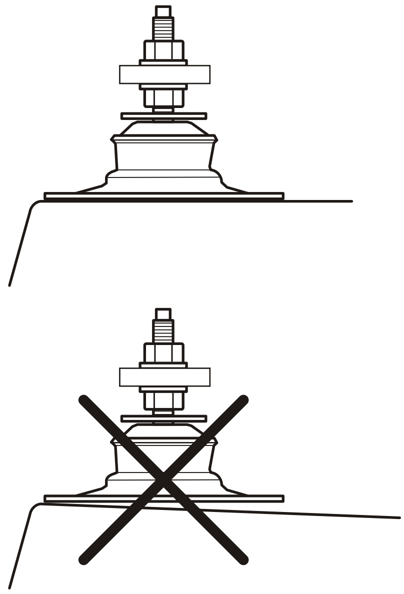
Always use both lifting eyes when lifting the engine.

The engine bed must be in one single plane.

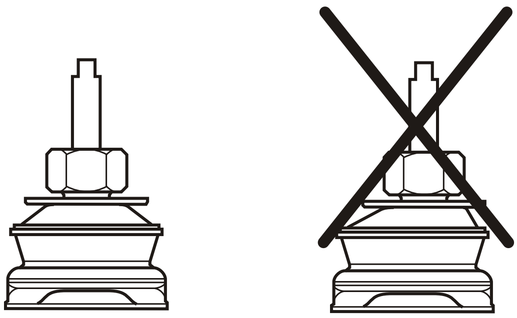
Check that the engine bed surfaces where the engine mounts are to be installed are parallel to the engine mount bottom plates, and that bed incline is correct (use a graduated angle spirit level).

Never use engine cushions other than those intended for each specific engine type.
NOTICE! Check that the engine cushions are installed so that there is no preload or any side forces once the engine is installed and aligned with the propeller shaft.

Once the engine is installed the load on the starboard mounts must be equal to the load on the port mounts. Check rubber mount loads by measuring compression using special tool 21244540 Measuring tool

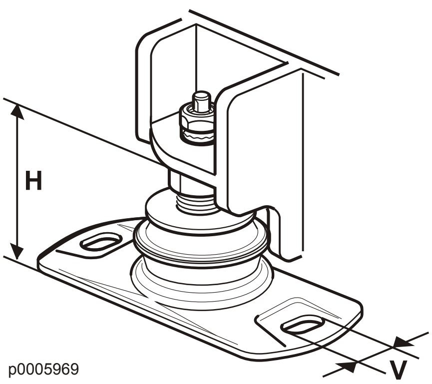


P0008298



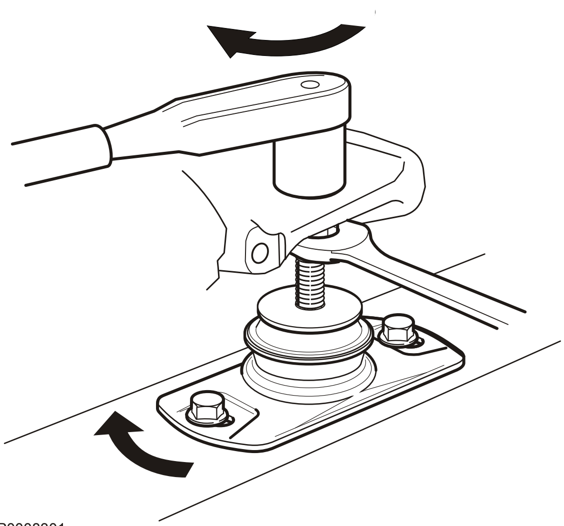
p0005944

Adjustable engine mount initial positions must be centered in the attachment plate holes. The attachment plates have oblong adjustment holes. These can be turned forwards or backwards, whichever provides best accessibility.



p0005969

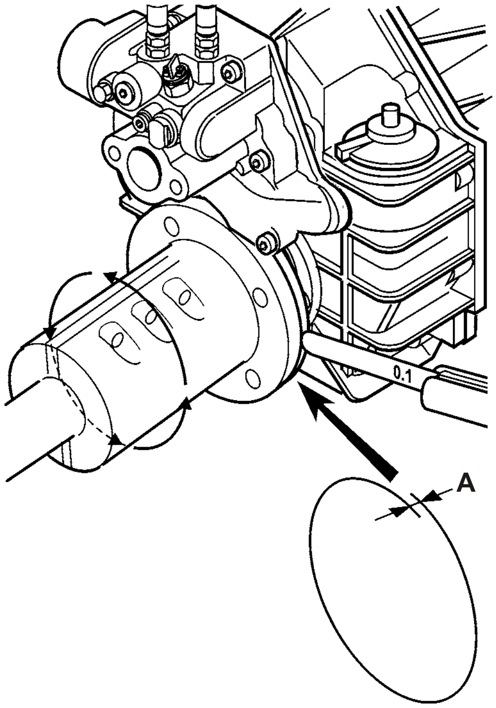
A = Nominal height ± adjustment: **±8 mm** (±0.3")
V = Lateral adjustment: **±7 mm** (±0.3")



P0008301

When the engine beds are determined to be parallel, the propeller shaft is correctly aligned and the loads on the mounts are correct, the upper nuts on all four mounts may be tightened.

Tightening torque, engine bed bolts: **Tighten hard.**
Tightening torque, adjuster nuts: **70 ±5 Nm** (52 ±4 lbf.ft)



P0008302

Alignment

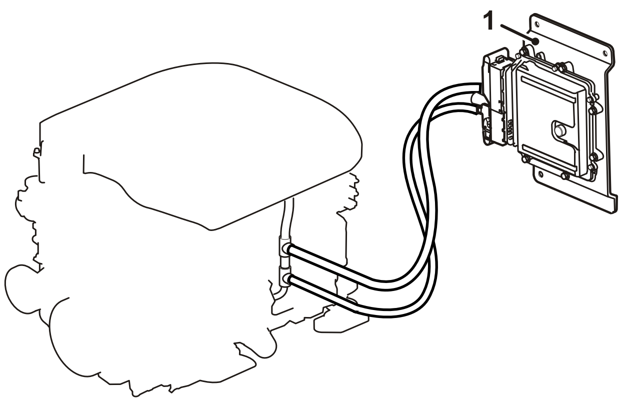
Check that the flange connection surfaces are parallel before the propeller shaft is attached to the reverse gear flange.

Fit the flanges so that the guide pin slots in. With the flanges pressed together, check that they are parallel and that it is not possible to introduce a 0.10 mm (0.004") feeler gauge anywhere between them (**A**). Then rotate the flanges 90°, 180° and 270° and repeat the feeler gauge checks. Make sure that the flanges are pressed together throughout the checks. If the deviation is greater than **0.10 mm** (0.004"), the alignment must be readjusted.

Remove any aids and bolt the shaft to the reverse gear flange or the flexible coupling.

IMPORTANT!

The alignment must be checked again a few days after launch when the boat is ready and rigged (sailboats).



P001410

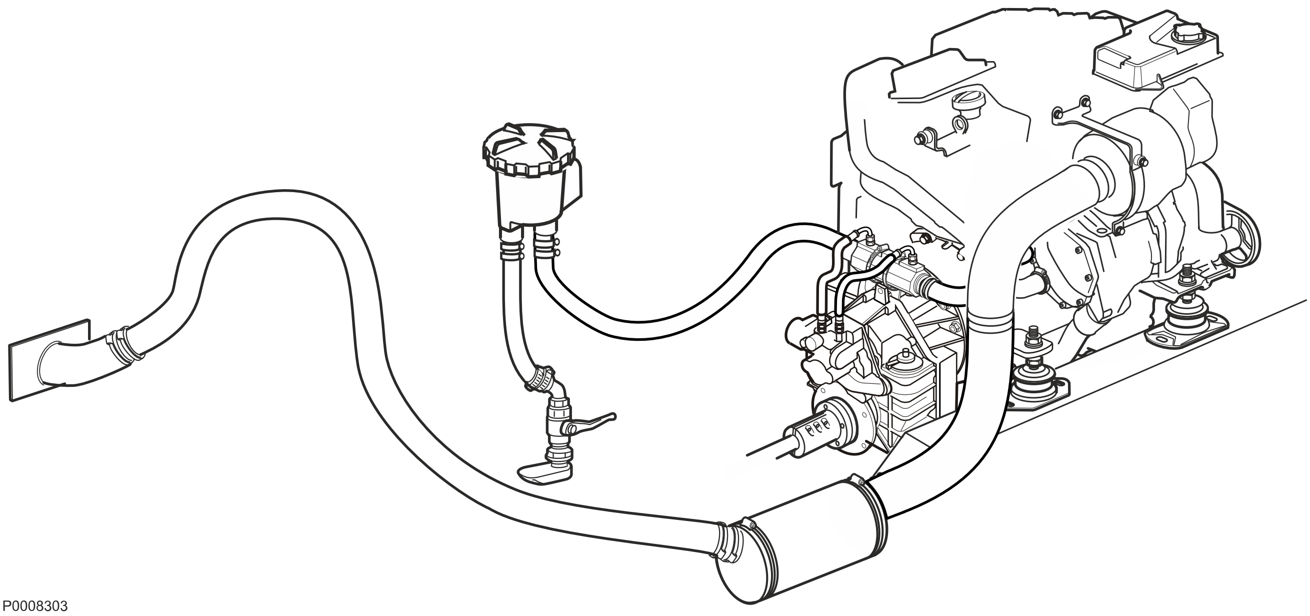
Engine Control Unit

Install the engine control unit (**1**) on a bulkhead with the cables facing downwards or to one side.

Exhaust System

General

The term “wet exhaust system” means that cooling water that has passed through the engine is fed into the exhaust system to cool the gases and silence engine noise.



P0008303

Volvo Penta supplies complete exhaust systems for such engines.

A wet exhaust system may for the most part be constructed from oil and heat-resistant rubber hoses. They are therefore easy to install and also contribute to comfort and sound dampening.

Marine engine manufacturers do not usually make complete wet exhaust systems. Instead it is equipment manufacturers, wharves, and boat builders, etc. that design systems, select components and carry out trials to develop finalized exhaust systems that fulfill all requirements.

The recommendations in this section must be seen as an empirical framework; they apply to complete systems with a maximum length of **10 meters and a maximum of 4 x 90° bends**.

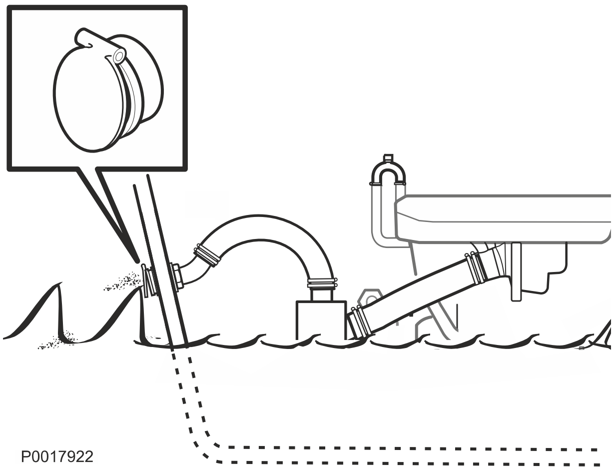
All systems with silencers, especially Aqualift, contribute to total system back pressure. Each silencer's contribution must be assessed and carefully calculated, and measurements must be taken during sea trials.

Exhaust Line, Dimensioning

Exhaust systems must be dimensioned to avoid harmful back pressure. This is especially important for turbocharged engines. Excess back pressure will mean power loss and may cause functional faults such as increased smoke levels and shorter service life. Graphs in the *Back pressure* chapter provide recommendations.

Exhaust hose diameter

The standard dimension for wet exhaust hoses is 89 mm (3.5"). Note that a complete exhaust system may require a larger diameter depending on length, silencers and outlet configuration.

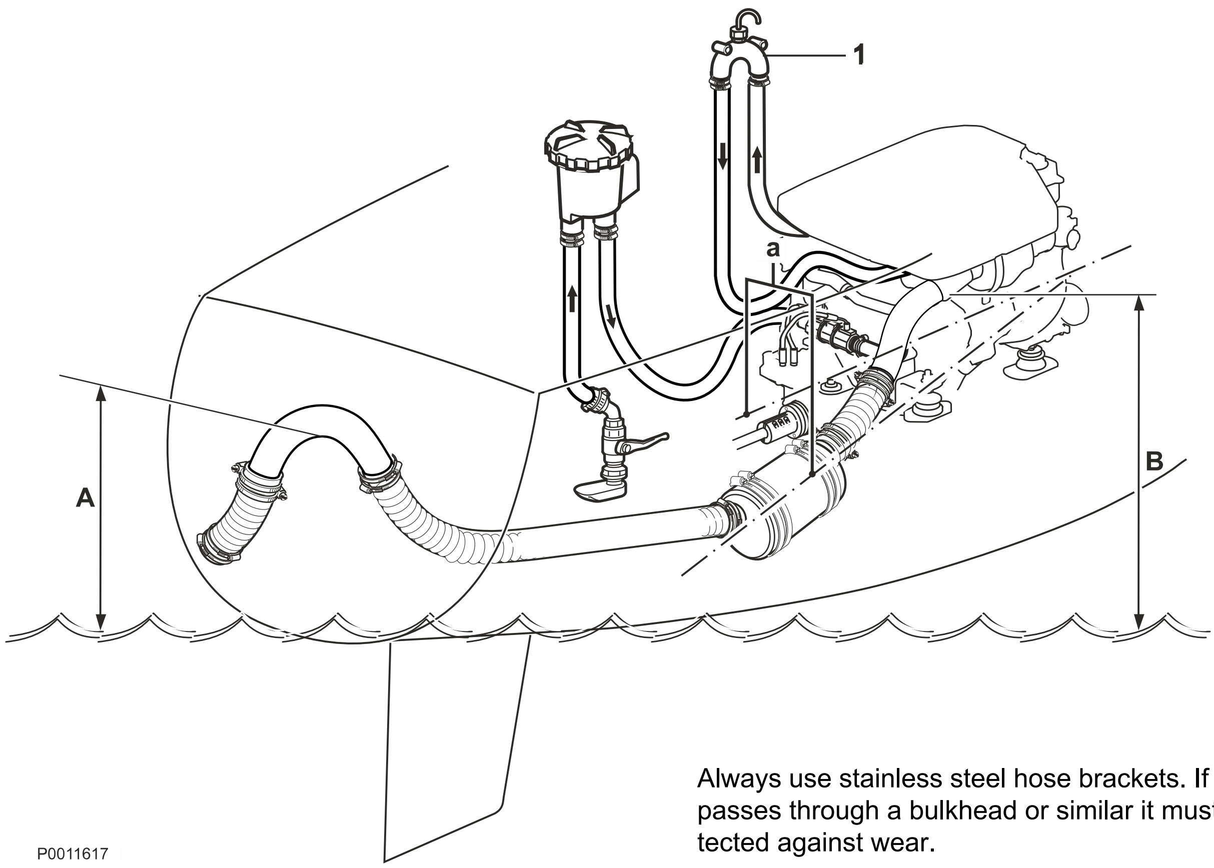


P0017922

We recommend the use of a rubber disk in from of the exhaust pipe outlet to prevent water from forcing its way into the exhaust system e.g. on trailer boats where the transom meets the surface of the water on launching. This is also ideal on boats in exposed locations where waves break onto the exhaust outlet.

Principal System for Sailing Yachts

The last part of the exhaust line must be run in a bend (gooseneck) to prevent water entering from the stern. The bend must be at least **350 mm** (13.8”) (**A**) above the waterline when the boat is loaded.

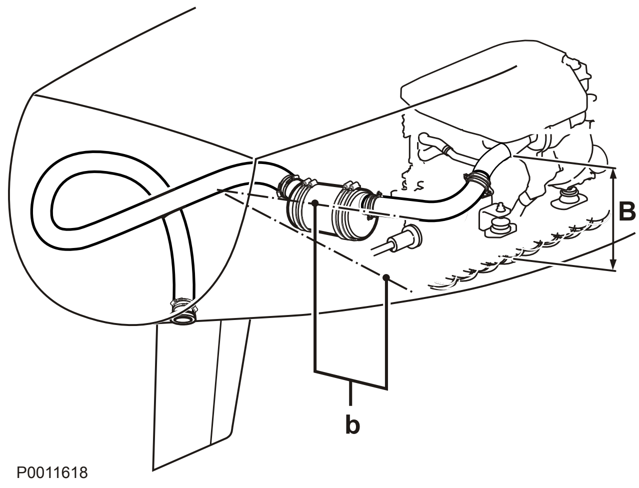


1 Anti-siphon valve

A Min. 350 mm (13.8")

B 200 mm (7.9")

a 5°–7.5°



Always use stainless steel hose brackets. If the hose passes through a bulkhead or similar it must be protected against wear.

Volvo Penta silencers must be angled 5°–7,5° (**a** and **b**) with the inlet pointing upward.

It is recommended that the exhaust outlet be located at the side of the hull and close to the transom to reduce the risk of backdraughting.

NOTICE! If a Volvo Penta silencer is installed transversely in the boat, it must be angled 25°–45° (**b**) with the inlet pointing upwards. The angle is important to prevent water from forcing its way into the engine when the boat heels (especially on sailboats).

Anti-siphon valve (vacuum valve)

Exhaust elbow height above the waterline (**B**) must be at least **200 mm** (7.9"), as illustrated. If the height is lower an anti-siphon valve (**1**) is required in the cooling system to avoid water entry through the exhaust system.

Silencer

There are different types of silencer depending on the installation.

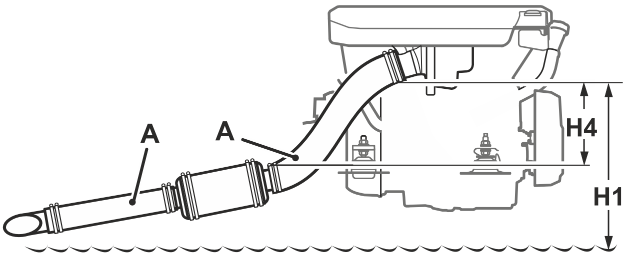
Two very common types are:

1 Straight, horizontal silencers

2 Aqualift silencers

NOTICE! Volvo Penta recommends self-draining silencers.

Exhaust system with straight, horizontal silencer, wet exhaust line



P0008305

A is the internal diameter for bends, silencer and silencer outlet.

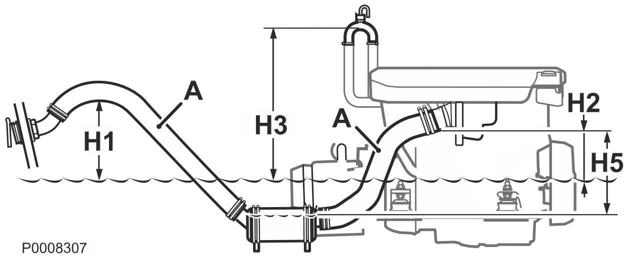
A - hose dia = 89 mm (3.5")

H1 - min = 350 mm (13.8")

H4 - min = 200 mm (7.9")

A straight, horizontal silencer is most suitable when the exhaust outlet is located high in relation to the waterline, such that an acceptable down angle can be achieved. It is important that the system drains when the engine is switched off.

The dimension in the drawing is measured from the lower edge of the turbocharger outlet. Installation back pressure must be checked if there is even the slightest doubt regarding excessive pressure (refer to the exhaust back pressure information further on in the manual).



P0008307

Acceptable exhaust installation heights (H).

A is the internal diameter for bends, silencer and silencer outlet.

A - hose dia = 89 mm (3.5")

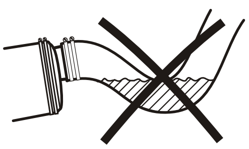
H1 - min 350 mm (13.8")

H2 - min 200 mm (7.9"). Must be greater than 200 mm (7.9"). If not, see H3.

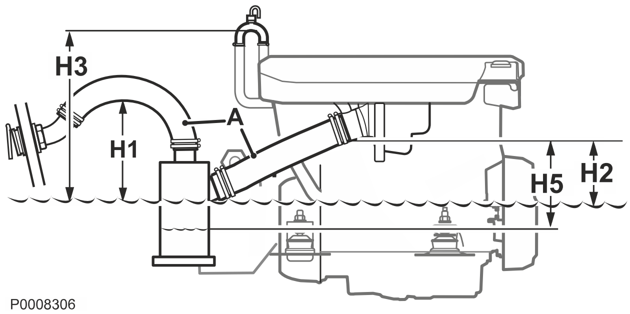
H3 - min 500 mm (19.7"). If H2 is less than 200 mm (7.9"), an anti-siphon valve must be installed. Locate the valve as close to midships as possible. Valve height must be at least 500 mm (19.7").

H5 - min 200 mm (7.9") measured from the water level in the silencer. Check that the silencer has sufficient volume to accommodate the quantity of water that drains when the engine is stropped.

Installation back pressure must be checked if there is even the slightest doubt regarding excessive pressure (refer to the exhaust back pressure information further on in the manual).


P0008308

The hose between the exhaust elbow and the silencer may not sag; see illustration. A support can remedy this situation.



P0008306

Exhaust system with Aqualift, wet exhaust line

If an Aqualift silencer is used, check that it has sufficient volume to contain the amount of drained water once the engine is switched off.

A is the internal diameter for bends, silencer and silencer outlet.

NOTICE! The minimum height between the lower edge of the turbocharger outlet and the waterline must be 350 mm (13.8") unless a gooseneck is installed in the system. Refer to the illustrations.

A - hose dia = 89 mm (3.5")

H1 - min 350 mm (13.8")

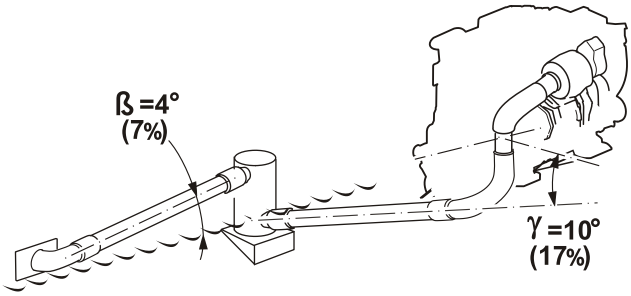
H2 - min 200 mm (7.9"). If H2 is less than 200 mm (7.9"), an anti-siphon valve must be installed. Locate the valve as close to midships as possible. Valve height must be at least 500 mm (19.7").

H3 - min 500 mm (19.7"). If H2 is less than 200 mm (7.9"), an anti-siphon valve must be installed. Locate the valve as close to midships as possible. Valve height must be at least 500 mm (19.7").

H5 - min 200 mm (7.9") measured from the water level in the silencer.

Installation back pressure must be checked if there is even the slightest doubt regarding excessive pressure (refer to the exhaust back pressure information further on in the manual).

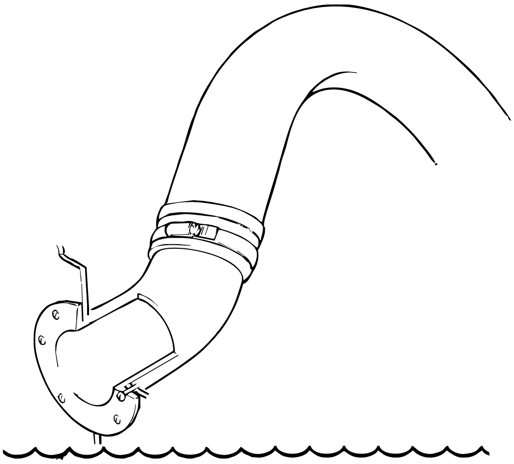
For further instructions, refer to the information from the
Aqualift manufacturer.



P0008309

All transverse exhaust lines, before and after the silencer, must have an **average drop** of **at least 10° (17 %)** angle (γ).

For sailboats, refer to *Main systems for sailboats*.



P0008067

Exhaust Outlet

Hull fittings must be located in a suitable place above the waterline of a loaded boat. If hull fittings end up below the waterline, a shut-off valve must be installed at the outlet, or have a pipe connected to it.

This type of outlet is a standard component, and must not be located on flat transoms due to the risk of back-draughting.

Back Pressure

The exhaust system will give a certain resistance to exhaust gas flow. This resistance, or back pressure, must be kept within given limits.

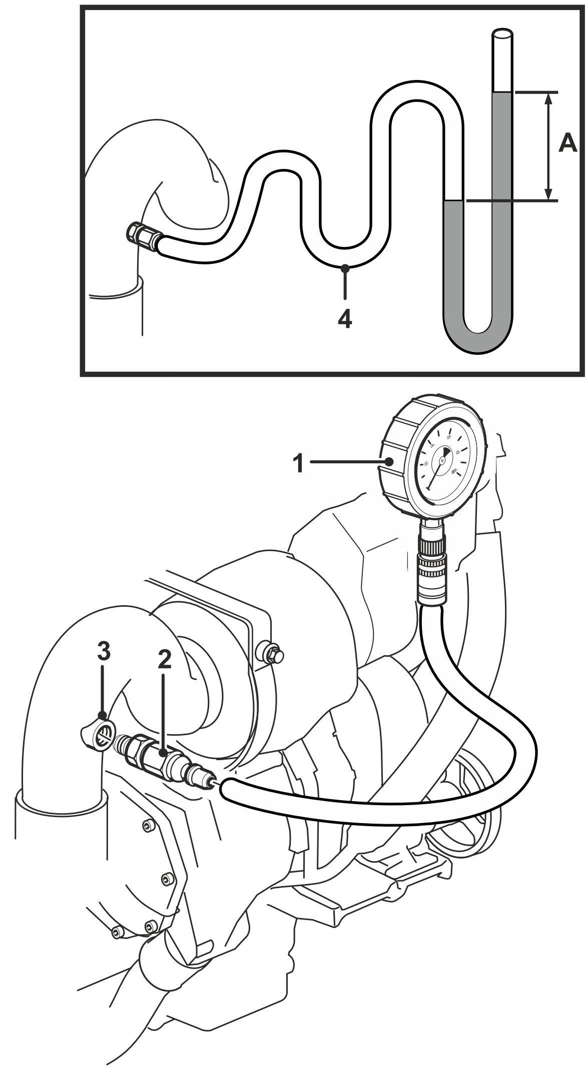
Excessive back pressure may cause damage and lead to:

- Exhaust outlet values being exceeded
- Loss of power
- Lower fuel economy
- High exhaust temperature

Such conditions will cause overheating and excessive engine smoke, and will reduce valve and turbocharger service life.

Permissible exhaust system back pressure for given engine rpm

D3-110	-	-	-	Permissible	-	-	-	-
D3-140–150	-	-	-	-	Permissible	-	-	-
D3-170	-	-	-	-	-	Permissible	-	-
D3-200–220	-	-	-	-	-	-	Permissible	-
kPa	0	5	10	15	20	25	30	35
psi	0	0.7	1.5	2.2	2.9	3.6	4.4	5.1
mm water column	0	510	1020	1530	2040	2550	3060	3570



P0010913

Measuring exhaust back pressure

Back pressure must always be checked after the exhaust line has been installed.
When the test is done, the engine must be run under full load long enough to provide a stable value.

Measuring procedure

1 Connect a pressure gauge (**1**) to the exhaust bend with union (**2**) to the nipple (**3**).

2 Run the engine at full load and max rpm for several minutes, and check that back pressure is not higher than the permissible value. Permissible exhaust system back pressure: refer to table above

NOTICE! Alternatively, a transparent plastic tube (**4**) can be connected to the measuring flange as illustrated. The difference between the water columns shows exhaust system back pressure in mm water column (the dimension **A** can be up to 4 000 mm).

NOTICE! A suitable connection nipple (**3**) is attached to the exhaust elbow close to the turbocharger. Dimension of nipple, ⅛ - 27 NPSF

Cooling System

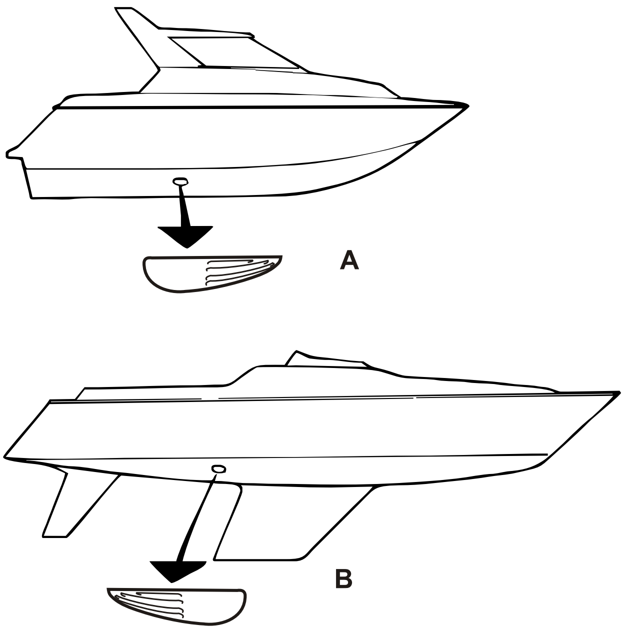
Raw Water System

Water circulation from the seawater system cools:

- Engine coolant
- Engine oil
- Charge air
- Reverse gear oil
- Exhaust gases

Volvo Penta cooling systems are designed for seawater temperatures of **max 30 °C** (86 °F).

Seawater inlet



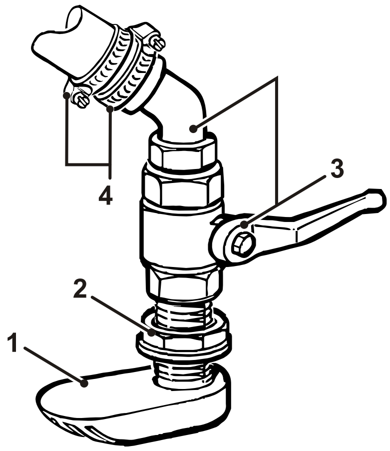
The seawater inlet should ideally be made in bronze alloy (brass is unsuitable as it corrodes owing to its high zinc content). However, in the case of steel hulls, the same material the boat is made of may be used. If the materials in the hull and seawater inlet are dissimilar, it may be necessary to galvanically insulate the inlet from the hull using a plastic or rubber plate to avoid galvanic corrosion. Note that the hull is also insulated.

The seawater inlet, sea cock and strainer must have sufficiently high flow to avoid capacity losses and a consequent reduction in water supply to the pump. Suction at the seawater pump inlet may not be lower than **-30 kPa** (-4.35 psi).

The seawater inlet must have a diameter that fits a hose with an internal diameter of:
32 mm (1¼")

The seawater inlet strainer must have a minimum flow cross section of:
1.5 x hose internal cross section area

The seawater inlet must be located deep enough so that it is underwater even when the boat rolls or is moving through heavy seas. Do not locate the seawater inlet too far forward in the boat.



P0008188

1 Strainer

2 Nut

3 Hose union and sea cock

4 Hose clamps

Sea cock

Install the inlet (**1**) with the opening facing forward (**A**) except on sailboats where the opening (strainer) must point aft (**B**) to prevent water being forced up into the coolant line when the boat is under sail. The sea cock must be closed when the boat is being towed.

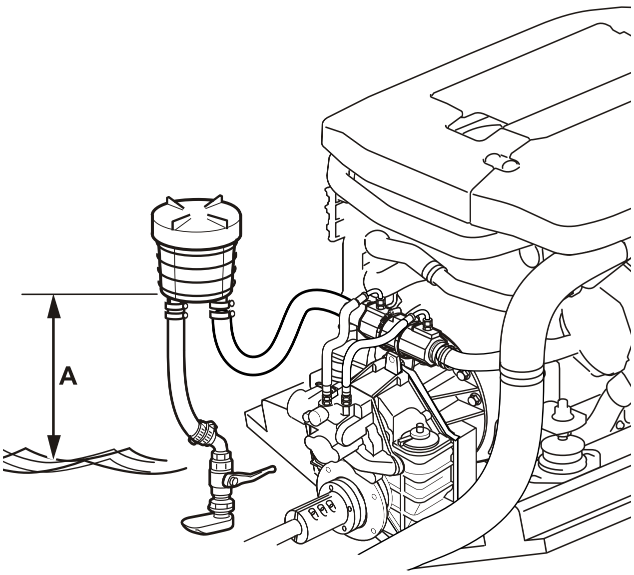
Brush a suitable sealant, e.g. silicone rubber, on the sealing surfaces. Tighten the inlet using the nut (**2**).

Install the sea cock and hose union (**3**). Use a non-hardening sealant.

NOTICE! Always use two hose clamps on all hose unions in the seawater system. Align the hose clamp screws (**4**) as illustrated.

The seawater line must have gradual bends to avoid unnecessary stresses and flow restrictions. Use reinforced rubber hose that can withstand negative pressure.

NOTICE! The hose between the seawater inlet (seawater filter) and the engine must not be under tension; a certain flexibility must be allowed. If the hose passes through a bulkhead or similar it must be protected against chafing.



P0009791

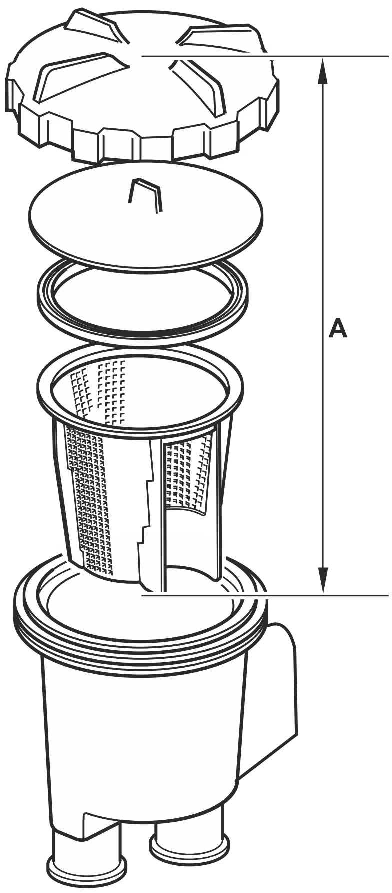
Seawater filter

During operations in shallow areas and harbors, etc. it is impossible to prevent particles, sludge and sand from entering the seawater inlet. These foreign objects can be caught by a filter in the suction line. A seawater filter contributes to longer pump service life and also prevents engine damage that may occur due to insufficient cooling in the charge air cooler or heat exchanger.

The seawater filter must be installed in an accessible location, at **least 200 mm** (8") (**A**) above the waterline in a laden boat, e.g. on an easily accessible bulkhead. If the filter is installed in a sailboat, this installation dimension must also be applicable at full heel.

Inlet from sea cock, diameter:
32 mm (1¼")

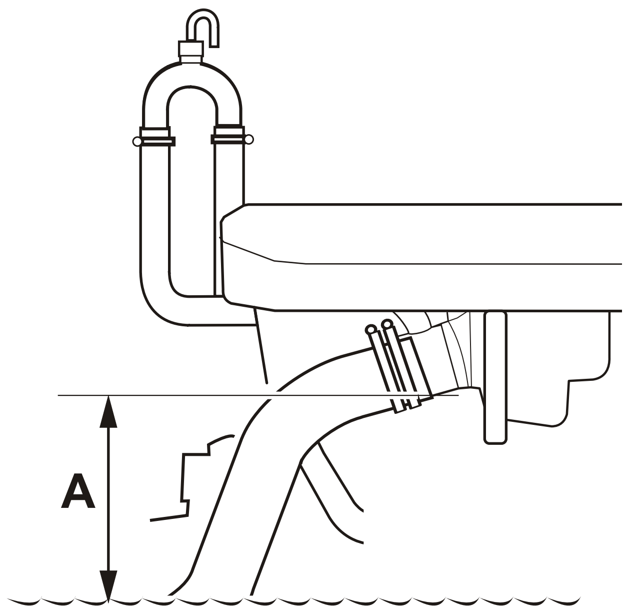
Seawater pump outlet diameter:
32 mm (1¼")



p0017180

Space for removal of filter cartridge:

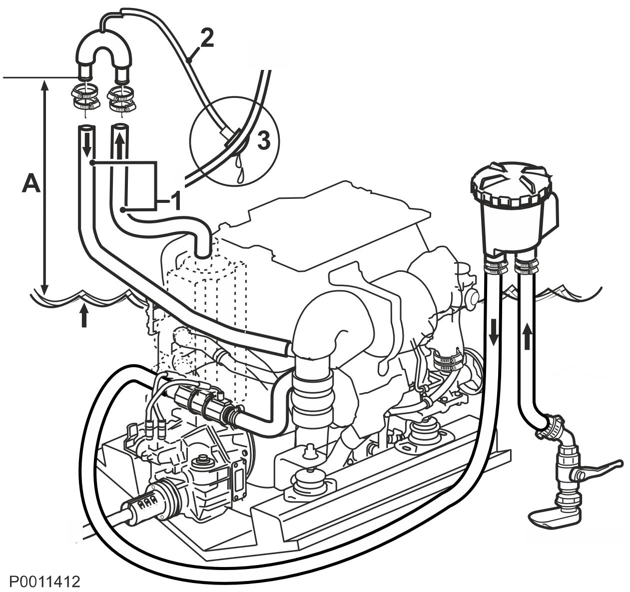
A **120 mm** (4.72")



P0011387

Anti-siphon valve

An anti-siphon must be installed in cases where the engine is mounted so far down in the boat that the distance (**A**) between the exhaust pipe flange (lower edge) and the waterline is less than **200 mm** (8"). If the valve is correctly installed, water will be prevented from siphoning into the engine.



P0011412

1 Hose Ø 32 mm (1¼")

2 Hose Ø min 6 mm (¼")

3 Hull fitting

NOTICE! The anti-siphon valve must be installed at least **500 mm** (20") (**A**) above the waterline of a laden boat.

The valve is not supplied by Volvo Penta. It must be specially made.

Make sure that there is at least **120 mm** (5") space above the filter to allow removal of the filter insert.

Hose dimensions

Internal diameter, hose (**1**): **32 mm** (1¼")

Internal diameter, hose (**2**): **min 6 mm** (¼")

Freshwater System

General

Freshwater circulates through the engine cooling ducts and heat exchanger with the aid of a centrifugal pump.

As long as the coolant is cold the thermostat is closed, which prevents the coolant from passing through the heat exchanger. The coolant passes instead through a bypass/shunt line back to the suction side of the pump. This means the engine quickly reaches its working temperature. The thermostat also controls correct temperature under low power and loads.

Coolant

We recommend “Volvo Penta Coolant, Ready Mixed”, or “Volvo Penta Coolant” (concentrated) mixed with pure water according to specifications; refer to Water quality. Only coolant of this grade is suitable and approved by Volvo Penta.

Coolant must contain good quality ethylene glycol of a suitable chemical composition in order to achieve the right engine protection. The use of corrosion protection alone is not permitted in Volvo Penta engines. Never use water alone as the coolant.

IMPORTANT!

Coolant must be used all year round. This is in order to ensure that the engine has the proper corrosion protection even though there may never be any risk of freezing. Future warranty claims related to the engine and accessories may be declined if the wrong coolant has been used, or if the instructions for coolant mixture have not been followed.

”**Volvo Penta coolant**” is a concentrated coolant that must be mixed with water. It has been developed to function optimally in Volvo Penta engines and it provides excellent protection against corrosion, cavitation and freeze damage.

”**Volvo Penta coolant, ready mixed**” is a ready mixed coolant comprised of 40% ”Volvo Penta coolant” and 60% water. This concentration protects the engine from corrosion, cavitation damage and the risk of freezing down to -28 °C (18 °F).

Coolant mixture

⚠ WARNING!

All coolant is hazardous and harmful to the environment. Do not consume. Coolant is flammable.

IMPORTANT!

Ethylene glycol may not be mixed with other types of glycol.

Mix 40% ”Volvo Penta coolant” (con. coolant) with 60% water.

This mixture protects the engine against corrosion, cavitation and freezing temperatures down to -28 °C; (a 60% glycol mixture reduces the freezing point to -54 °C). Never mix more than 60% concentrate (Volvo Penta Coolant) in the coolant mixture as this reduces cooling effect, increases the risk for overheating and provides reduced protection against freezing.

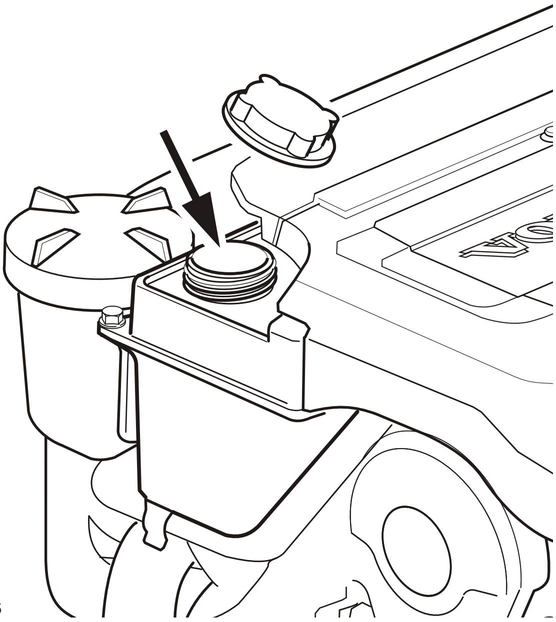
IMPORTANT!

The coolant must be mixed with **clean** water. Use **distilled/deionized water**. The water must fulfill requirements specified by Volvo Penta; refer to *Water Quality page 140*.

IMPORTANT!

It is extremely important that the system be filled with the correct coolant concentration. Mix the liquids in a separate, clean container before filling the cooling system. Check that the liquids mix properly.

NOTICE! From and including 2011 all Volvo Penta engines use yellow glycol (VCS). Volvo Penta coolant (green glycol) may under no circumstances be mixed with VCS (yellow glycol). The expansion tank is marked with the type of glycol to be used.


P0009045

Coolant, Filling

NOTICE! Coolant must be filled when the engine is stopped and cold.

Fill the system carefully through the opening in the expansion tank, around 5 l (1.3 US gal)/min so that the system vents during filling.

Coolant system volume including heat exchanger: 8.2 l (2.2 US gal.)

1. Fill the system until it is completely full, including the expansion tank. The coolant must reach up to the lower edge of the filler hole.

2. Start the engine and let it run without load at 1000–1500 rpm for around 5 minutes. Check the coolant level.

External systems: If external systems are connected to the engine cooling system, system taps must be open and system units vented during filling. Special venting nipples may be installed in the external circuits; this applies especially to systems located above the engine.

IMPORTANT!

Do not start the engine until the system is completely filled with coolant.

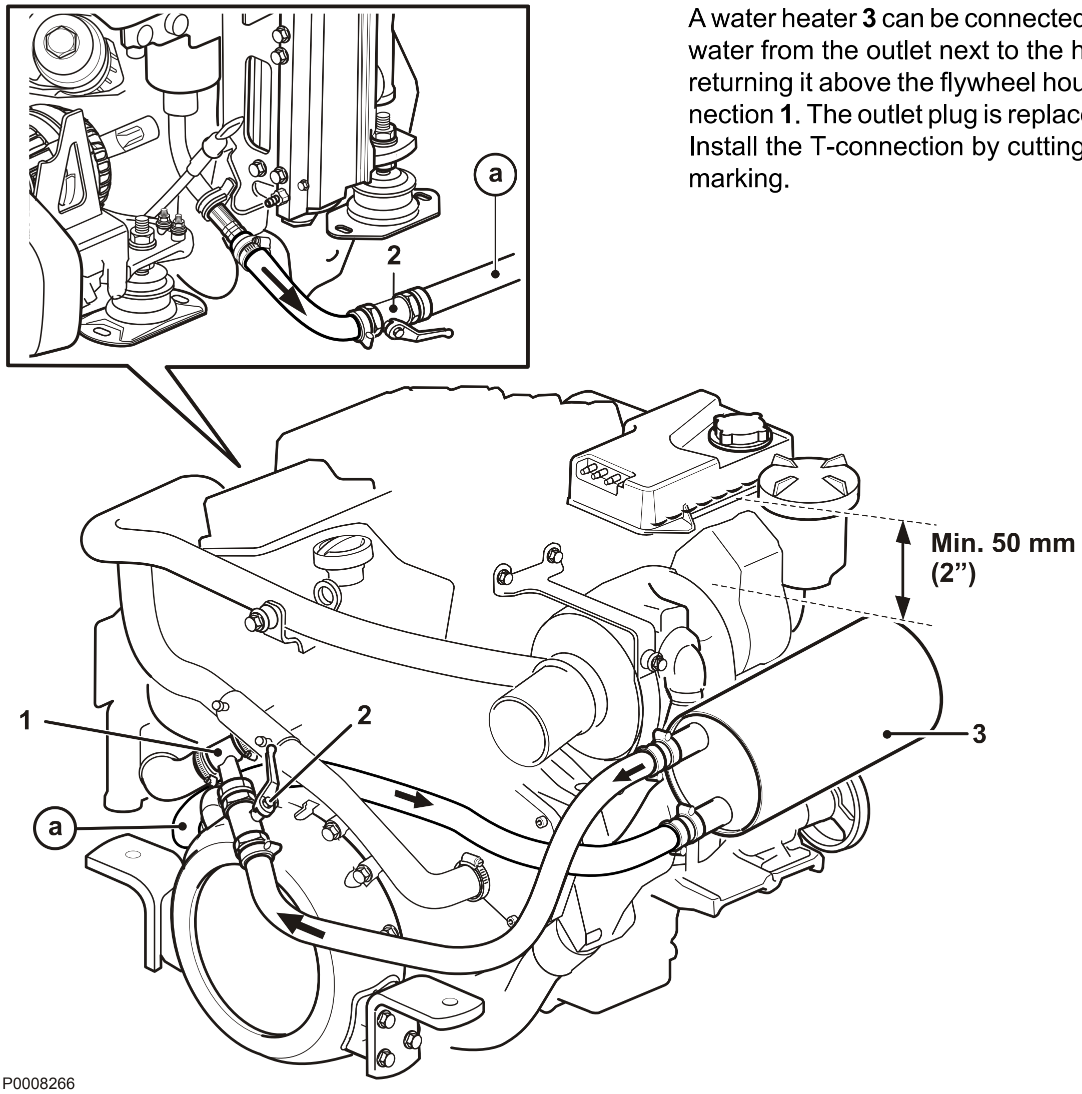
⚠ WARNING!

Do not open the coolant filler cap when the engine is warm. Steam or hot fluid could spray out, causing severe burns.

IMPORTANT!

If steam or hot water spurts out the system will lose working pressure. Low system pressure causes insufficient cooling!

Hot water connections

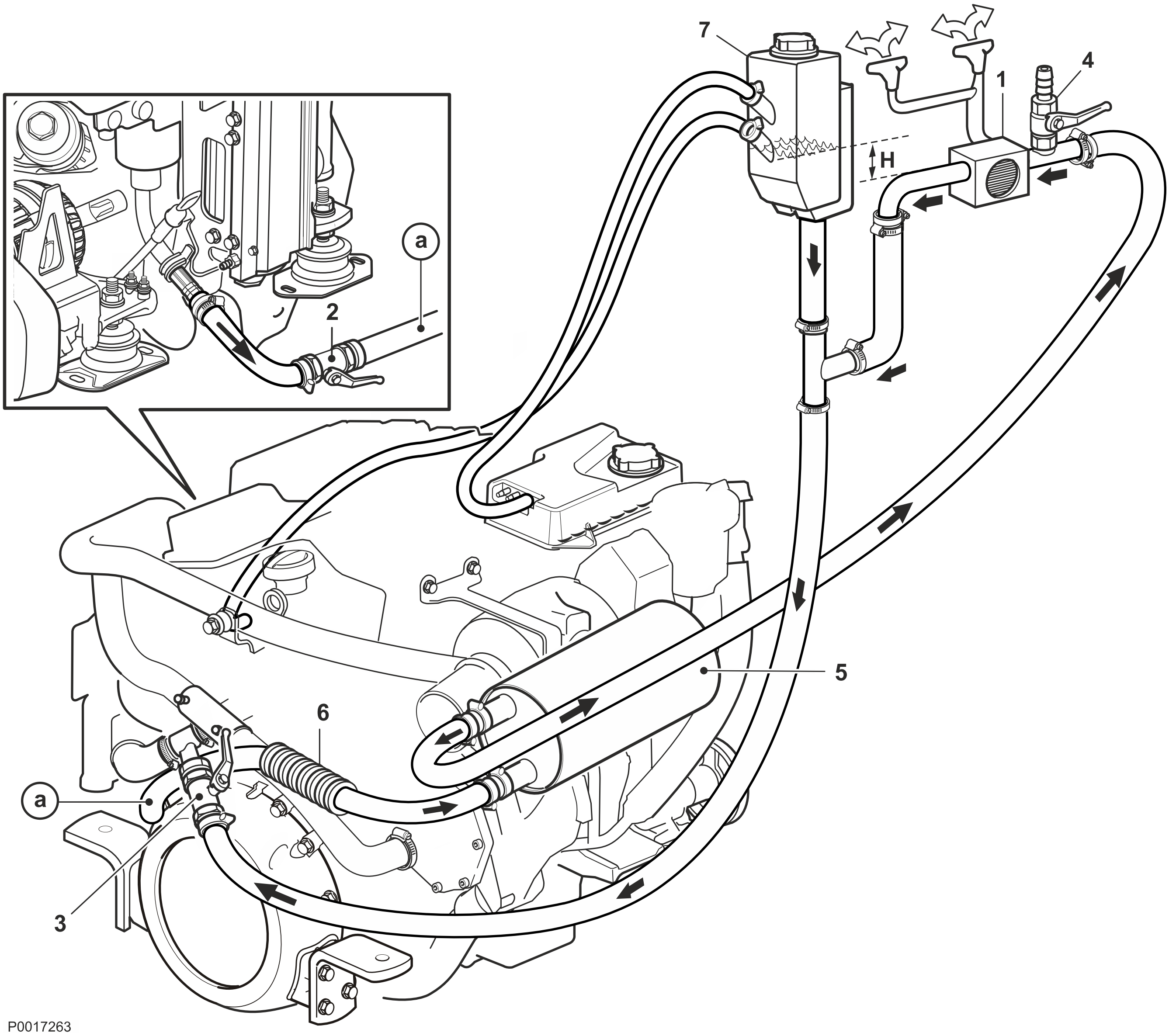


A water heater **3** can be connected to engine by taking water from the outlet next to the heat exchanger and returning it above the flywheel housing using a T-connection **1**. The outlet plug is replaced by a hose nipple. Install the T-connection by cutting the hose at its marking.

Install the extra hot water circuit so that its highest point is at least 50 mm (2") lower than the coolant level in the expansion tank. If this cannot be arranged a separate expansion tank must be installed.

Shut off valves

Volvo Penta recommends that shut-off valves **2** should be installed in the extra circuit on both the supply and return sides. Locate the valves as close to the engine as possible.



1 Venting hose from cylinder head (1a original run, 1b new run).

2 Venting hose

3 Hot water heater

Extra expansion tank

Capacity, freshwater system (standard) and auxiliary circuits

The volume of the engine freshwater system may be increased with an auxiliary circuit.

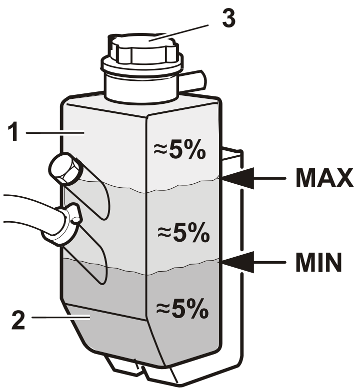
Maximum additional volume: **8.0 liter** (2.1 US gal.).

If the volume is increased further or if an additional circuit is located **above** the engine, the cooling system must be fitted with an auxiliary expansion tank.

Hot water circuits and cabin heating are examples of auxiliary circuits.

An auxiliary expansion tank must be installed with the minimum level mark at least **50 mm** (2") and at most **1200 mm** (47") (**A**) above the highest engine point, or the highest point in the external circuit.

The auxiliary expansion tank must be located so that it is easily accessible for level checks and filling.



1 Pressurization volume, approx 5%

2 Reserve volume, approx 5%

3 Pressure cap

Running hoses

Disconnect the hose (**1**a) between the cylinder head and the expansion tank at the tank connection. Connect the hose instead to the auxiliary expansion tank lower connection (**1**b).

Connect a venting hose (**2**) between the upper connection on the auxiliary expansion tank and the engine expansion tank connection where the hose from the cylinder head was previously located. The venting hose (**2**) may not be run below its connection point on the engine expansion tank, (must be run straight without hanging bends).

	Volume in engine including heat exchanger, liters (US gal.)	Maximum additional volume in auxiliary circuit with standard, engine-mounted expansion tank, liters, (US gal.)
D3	8.2 (2.2)	8.0 (2.1)

Expansion tank volume must be 15% of **total cooling system capacity**.

Of this volume:

5% is for water vapor (gas) for system pressurization,

5% is intended for the difference between the **MAX** and **MIN levels, and**

5% is spare volume.

The engine expansion tank must have a separate venting line to the new auxiliary tank, connected below the MIN level.

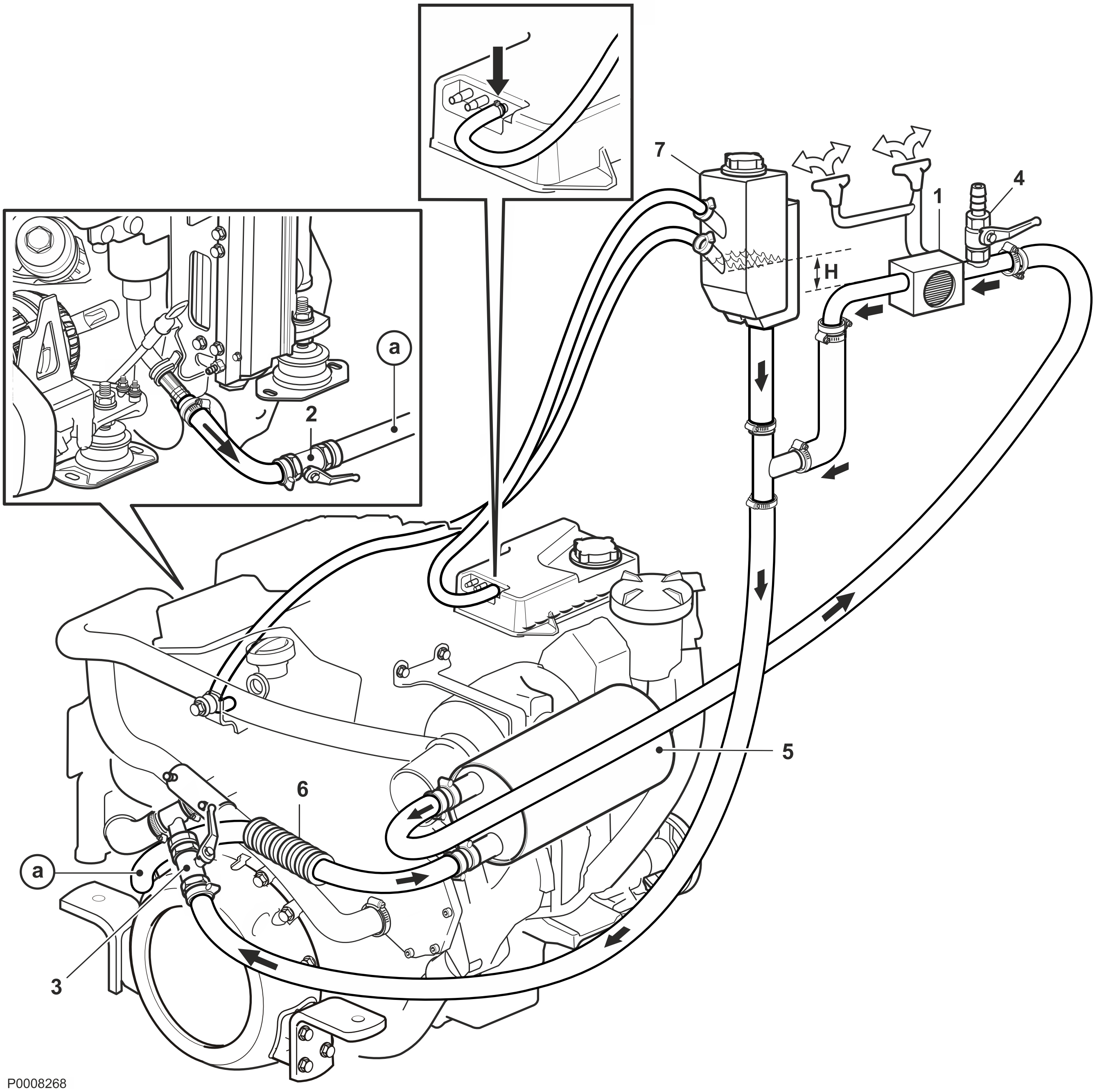
The hose must be able to withstand temperatures of up to **115 °C** (240 °F).

The engine pressure cap must be replaced with a sealed cap. The regular engine venting hose from the thermostat housing may be connected to the auxiliary expansion tank below the **MIN** level to facilitate venting when coolant is filled.

NOTICE! The Volvo Penta auxiliary expansion tank kit must be used when installing accessories such as cabin heaters, etc. The accessory must be installed above the engine-mounted expansion tank. The additional fluid volume may not exceed 8 liter (2.1 US gal).

Venting the system

In most cases (as in the system illustrated) the system is self-venting to the expansion tank.



P0008268

1 Cabin heater with defroster unit

2 Outlet valve (hot water outlet).

3 Inlet valve, (return water, engine)

4 Venting nipple

5 Hot water heater

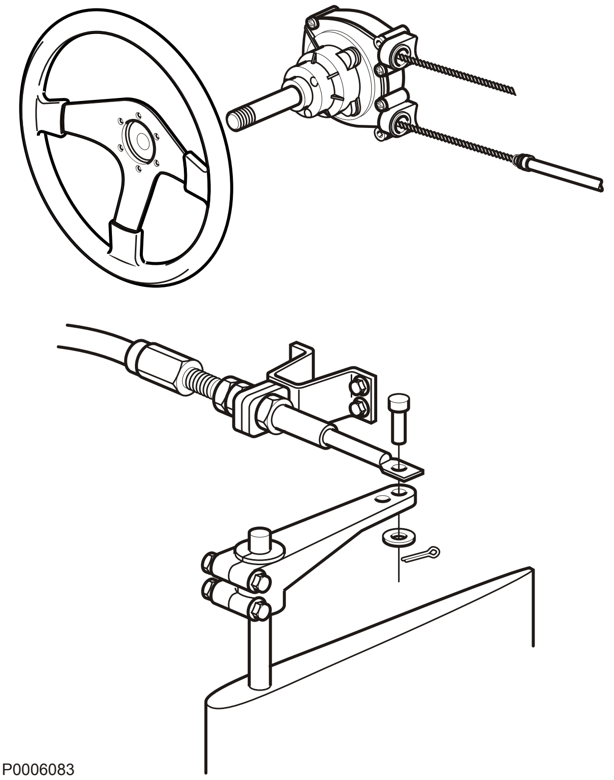
6 Heater

7 Expansion tank

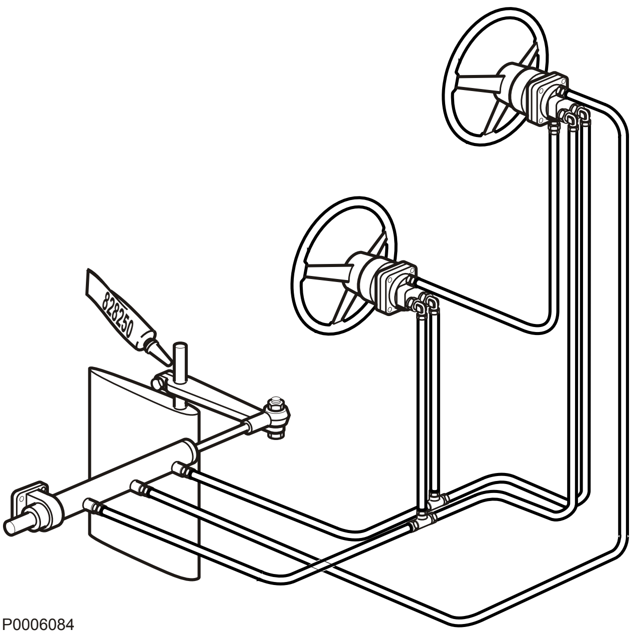
If an auxiliary system does not normally vent to the expansion tank, a separate venting nipple (**4**) must be installed.

IMPORTANT!

Make sure the system is vented after installing a hot water heater. Then check the coolant level.



Mechanical system



Hydraulic systems

Steering System

General

The following instructions provide general information applicable to all types of installations.

IMPORTANT!

It is important that all components are installed correctly when the steering system is installed. Incorrect installation may endanger the boat's maneuvering capabilities and in the worst case render it impossible to steer. Also refer to the *Installation instructions* supplied with the parallel stay kit.

IMPORTANT!

Hydraulic steering systems: Observe exceptional cleanliness. Make sure the working area is free from dust and dirt. Keep protective plugs on unions until pipes and hoses are connected. Make sure that pipes and hoses are clean and free from dirt etc. Use a knife to cut hoses and suchlike.

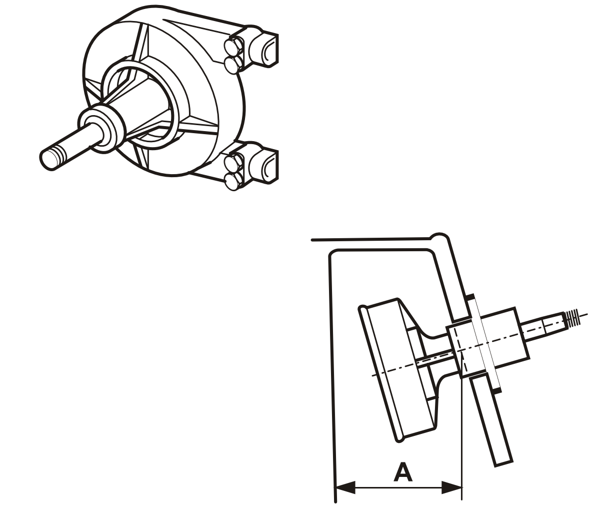
Single helm station

The mechanical steering system control cable must not be longer than 9 m (30 ft). This includes installations with 3 x 90° bends and unbracketed cables. Installations that require cable lengths of 9–12 m (30–40 ft) must be tested in each individual case. When it comes to such a very long cable it is extremely important that it be installed as straight as possible and bracketed. However, it would be better to install hydraulic steering in such cases.

Twin helm stations

It is generally speaking better to use a hydraulic steering system in installations with two helm stations. When a mechanical steering system is used with a DS unit, a maximum DS unit cable length of 7 m (23 ft.) is recommended. This includes 3 x 90° bends for each cable. The DS unit has a 2.25 m (7.38 ft.) cable as standard, which means that a maximum cable length of 9.25 m (30.33 ft.) is permissible between the steering position and the rudder when a DS unit is installed.

The following instructions provide general information applicable to all types of installations.



P0008201

Location of mechanical steering box

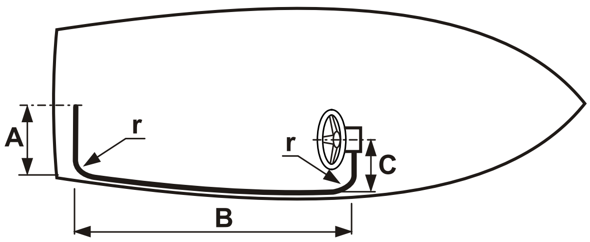
Choose a suitable installation location for the steering box to avoid bending the steering cable too much. If possible, avoid more than one bend.

Make sure there is enough space for the wheel and for a comfortable operating posture.

The space (**A**) behind the steering box must be at least **200 mm** (8").

Steering may be installed on either the port or starboard side of the boat.

NOTICE! Remember to locate gear shift and engine rpm controls such that the steering cable can be installed without extra bends.



P0008202

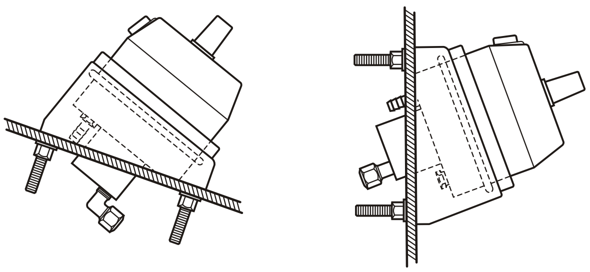
Running cables

Select the correct length steering cable.
A + **B** + **C** = steering cable length.

If a rudder angle indicator is installed, the unit must be located in a dry, accessible place. It must preferably be located as close to the tiller as possible.

Finally, attach cable brackets along the entire length of the steering cable. Distance between brackets: approx. 250 mm (10").

NOTICE! Run the steering cable with bends as gentle as possible. Minimum radius (**r**): **250 mm** (10").



P0008203

Hydraulic steering, location of steering pump

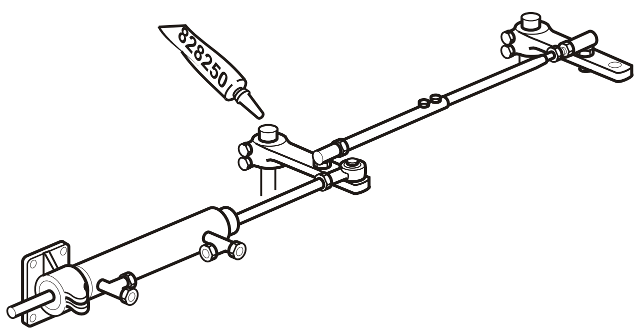
Choose a suitable location for the steering pump. Check that there is enough space for the wheel and the steering pump.

Running hydraulic hoses

Install the hydraulic hoses. Minimum bend radius: **60 mm** (2.5").

Make sure the hoses do not come into contact with hot surfaces. Bind the hoses together using plastic cable ties. The distance between cable ties must be around 250 mm (10"). Metal clamps must not be used.

Cut the hoses to the correct length. Use a knife to cut to avoid swarf and burrs. Ensure that the ends are cut square and that they are completely clean.



P0006085

Hydraulic system with parallel stays

Helm station

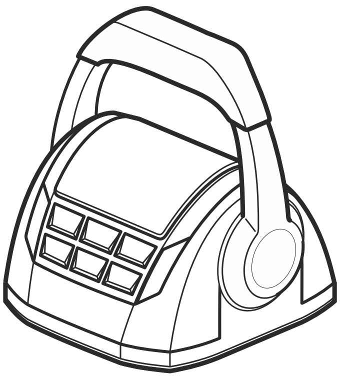
Controls

General

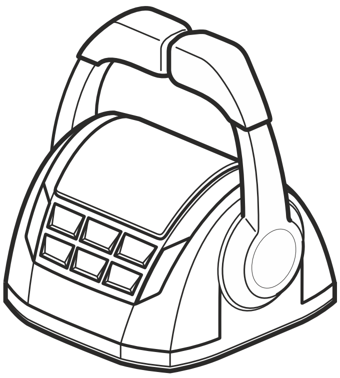
For the boat to be steered and operated in a comfortable and safe manner the helm station must be designed so that levers, steering, instruments, navigation equipment and alarm systems are laid out in a practical way. This applies to every helm station.

Levers for EVC engines (Electronic Vessel Control)

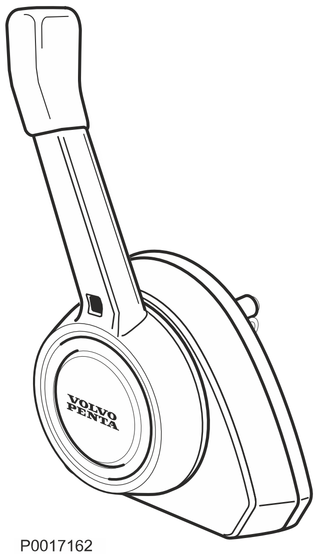
Refer to the EVC system installation manual regarding the installation of controls and other EVC system components.



Top-mounted control for single engine

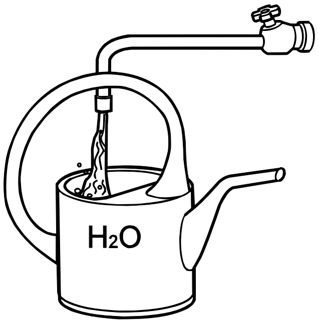


Top-mounted control for twin engines



Side-mounted control for single engine

D3-140A-D



P0002094

Cooling System

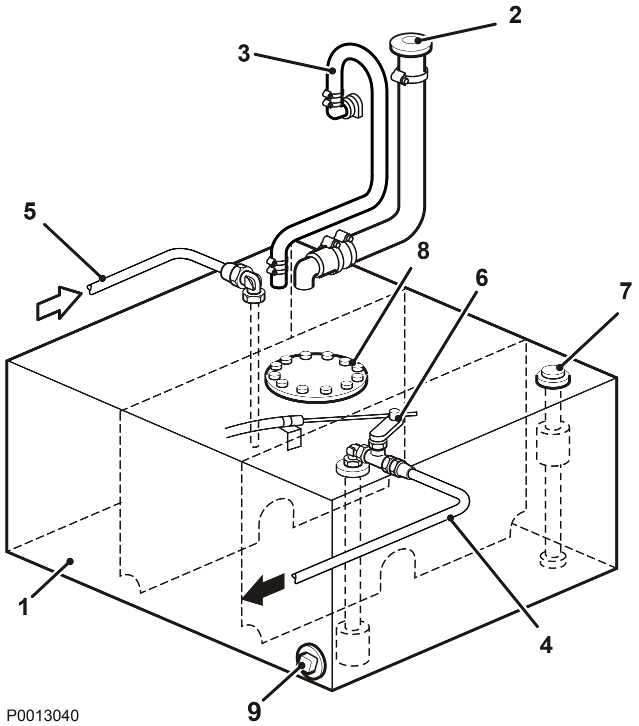
Water Quality

ASTM D4985:

Total solid particles	<340 ppm
Total hardness	<9,5° dH
Chloride	<40 ppm
Sulfate	<100 ppm
pH value	5.5–9
Silica (acc. ASTM D859)	<20 mg SiO_2/l
Iron (acc. ASTM D1068)	<0.10 ppm
Manganese (acc. ASTM D858)	<0.05 ppm
Conductivity (acc. ASTM D1125)	<500 µS/cm
Organic content, COD_{Mn} (acc. ISO8467)	<15 mg $KMnO_4$/l

Fuel System

General



1 Fuel tank
2 Filler cap
3 Ventilation pipe
4 Suction line
5 Tank hatch
6 Remotely operated fuel shut-off valve
7 Fuel level sensor
8 Return line
9 Bottom plug

The installation of fuel system components – fuel tank, taps, fuel pipes and auxiliary fuel filters etc., must be carried out very carefully in order to ensure sufficient fuel to the engine and that the requirements for perfect sealing and fire safety are met.

Plan the locations of the tanks carefully before starting work. Use quality taps to avoid leakage. A leaking fuel system always entails great risk of functional faults and fire.

Use first-class quality components.

The taps must preferably be installed on the outside of the engine compartment, or be remotely operable.

Fuel may be divided up between several tanks in order to keep the center of gravity low and also to allow longitudinal center of gravity adjustment.

If the tanks are to be built in, the surrounding space must have good ventilation.

NOTICE! There may be local legislation that always sets aside engine manufacturer literature and recommendations.

In Europe, materials and installation of fixed fuel systems must fulfill the requirements of ISO 10088. In the USA the installation must fulfill the requirements of the ABYC and USCG.

Take especial care not to bend the high pressure pipes between the injection pump and the injectors. Do not stand on pipes due to the risk of damaging fuel pipes or components.

Do not fix any of the high pressure pipes.

When working on the fuel system, it is important to keep it clean and free from dirt.

Fuel Tanks

If possible, the tanks must be located so that they are on the same level as, or a little higher than, the engine. If they are located lower, consideration must be given to the fact that the fuel feed pump maximum suction height varies between 1.5–2.0 m (60–78") for the engines. Note that the suction height must be measured from the suction line lower opening, i.e. 25 mm (1") above the tank bottom. More information about fuel lines and suction heights can be found in the *Installation page 146*chapter.

The return line must be installed at a distance from the suction line, and about 15 mm (0.6") above tank bottom in order to prevent air entering when the engine is stopped.

If the tanks are located lower than the level permitted by the common rail suction height, fuel must first be pumped up to a day tank using a hand pump or electric pump. In this case, return fuel must be led back to the day tank.

The fuel tanks may not be located higher than 1.0 m (3 ft) above the engine valve cover. If the boat has a fuel tank installed high up that is not used for long periods, the fuel system shut-off valves must be closed.

Twin tanks must be cross-connected at the base by a pipe equipped with shut-off taps. The lower cross-connection pipe must have an inner diameter of at least 25 mm (1") so that the tanks can be filled from one side of the boat. It is acceptable to use alternative fuel tank shapes if these are adapted to the installation geometry. Regardless of the shape chosen it is important to design the tank such that there is a lower section where water and sludge can be drained off.

IMPORTANT!

An auxiliary fuel filter with water separator must be installed for use with all Volvo Penta engines.

If a day tank is installed, it is advisable to connect the return line to this tank.

A shut-off tap must be installed in the feed line, between the tank and the filter. It must be possible to operate this tap from the outside of the engine compartment.

Suitable materials for fuel tanks are stainless steel and aluminum sheet. The material must be corrosion resistant in a marine environment.

⚠ **WARNING!**
Hot fuel can cause burns.

Fuel cooler

Volvo Penta supplies fuel cooler kits for D3 A-C engines. A fuel cooler is recommended if a thermoplastic tank is used. In hot regions the fuel in the tank can reach extremely high temperatures and may cause thermoplastic fuel tanks to melt.
For reasons of comfort, it is also expedient to fit a cooler in installations where fuel tanks are built into furnishings.
D3 D-E engines do not require fuel coolers. (These engine versions do not reach the same high fuel temperatures).

Heat emitted to the return flow

Return fuel temperature at rated full power on D3-220 D-E engines is 48°C (118°F) under the following conditions: ambient air temperature 20°C (68°F), seawater temperature 25°C (77°F) and fuel feed temperature 40°C (104°F). Return flow is approx 160 liters per hour (42 US gal/h). Fuel heat output under these conditions is approx 610 W.

Return fuel temperature at rated full power on D3-190 A-C engines is 78°C (173°F) under the following conditions: ambient air temperature 20°C (68°F), seawater temperature 25°C (77°F) and fuel feed temperature 40°C (104°F). Return flow is approx 57 liters per hour (15 US gal/h). Fuel heat output under these conditions is approx 1030W.

The boat builder must take the above-mentioned temperatures and flows into consideration when choosing a plastic fuel tank

IMPORTANT!

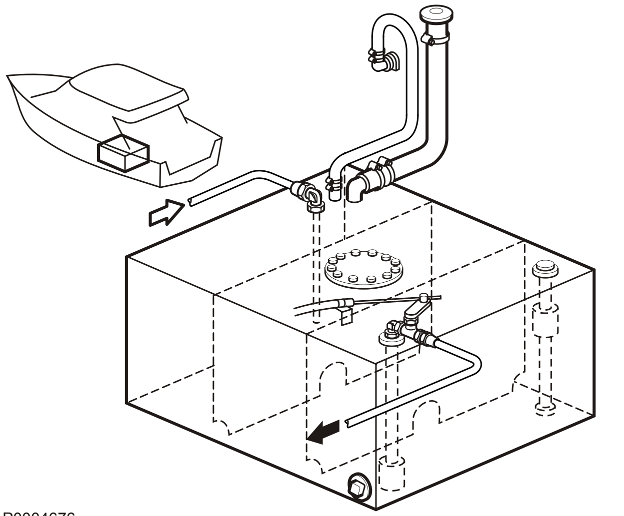
All tanks must be equipped with at least one slosh baffle per 150 l (37 US gal) volume. Check to see if there are special restrictions regarding volumes and slosh baffles.

Filling and ventilation connections may not be located on the sides of the tank.

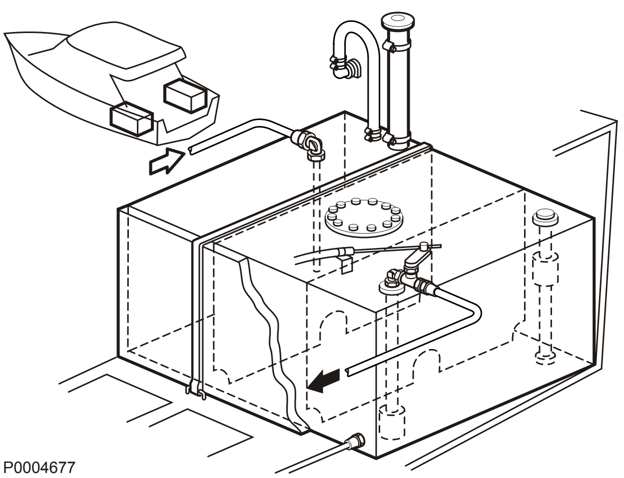
The fuel tanks have connections for filling, ventilation, suction lines, return lines and fuel level sensors and an inspection hole with cover. The suction and return lines must always be separated as illustrated.

A shut-off valve must be fitted to the suction line as close to the tank as possible. The shut-off valve may be remotely controlled by cable or similar. Some markets require electrically controlled shut-off valves.

Diesel engine return lines must be run back to the bottom of the tank in order to prevent air entering when the engine is stopped.



P0004676

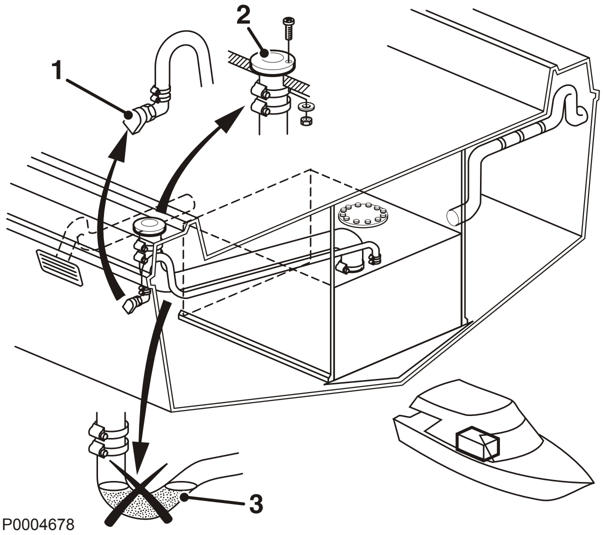


P0004677

Place the tank on a soft base. Do not mount the tank on wooden blocks or other type of uneven base as this may cause uneven loading with the attendant risk of fatigue cracks in the tank.

Install the tank in the boat. Secure the tank with clamps to prevent it from moving in heavy seas. The fuel tank must be located by itself in a cool space in order to avoid fuel being heated or spread to other parts of the boat in the event of a leak.

In boats where space is limited, the tank may be shaped in order to fit under the aft deck or similar space.



1 Vent line

2 Deck filler (gland)

3 Prohibited sag

The tank must be well ventilated. The tank ventilation line (**1**) must have an inner diameter of **12 mm** (1/2"). Run the hose with an upward bend inboard in the boat in order to prevent water entry.

The deck filler (**2**) must be designed such that it accepts hose connections of **at least 50 mm** (2.0") diameter. The hose between the deck filler and the tank must overlap the hose connections at both ends by **at least 75 mm** (3.0") and be secured using two hose clamps at each end. The hose clamps must be made of corrosion-resistant material.

No common ground conductor for the fuel tank, fuel filler, etc. is normally required for diesel installations. However, regional authorities may require this for all boats.

IMPORTANT!

Install the filler and ventilation hoses so that no sags (**3**) are formed where fuel is able to collect.

IMPORTANT!

The fuel filler and ventilation must be installed such that overfilling is prevented and that fuel cannot enter the air inlets.

Piping

All fuel lines must be installed and fastened correctly close to the bottom of the boat in order to avoid heat absorption. Air temperature is lower in the bottom section of the engine compartment.

Refer to the *Installation page 142* chapter for information regarding fuel tank location.

Fuel pressure

The negative pressure in the inlet line may at most be **-35 kPa** (-5.1 psi) immediately before the fuel pump. Return back pressure in the line out from the engine may be **max 100 kPa** (14.5 psi).
These pressures are valid on a new fuel filter.

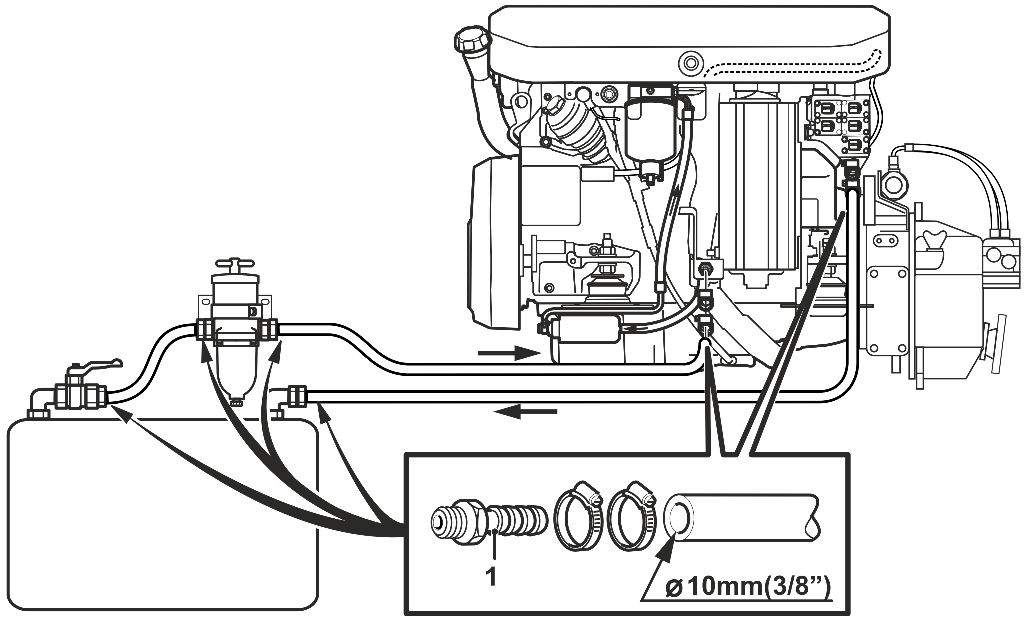
Measure fuel pressure by installing a T-connector at the measuring point (fuel feed pump inlet when measuring inlet pressure). Connect the measuring equipment to the T-connector.

Rubber hoses

Fasten the fuel lines using brackets. Distance between brackets: approx. **300 mm** (12").

NOTICE! Some classification societies and other authorities do not allow rubber hoses as fuel lines, or require such hoses to meet certain specifications. Check to see if the boat will be used in such areas.

Make sure the hose cannot become damaged by sharp edges or has bend radii that are too small (min. 60 mm (2.4”)).

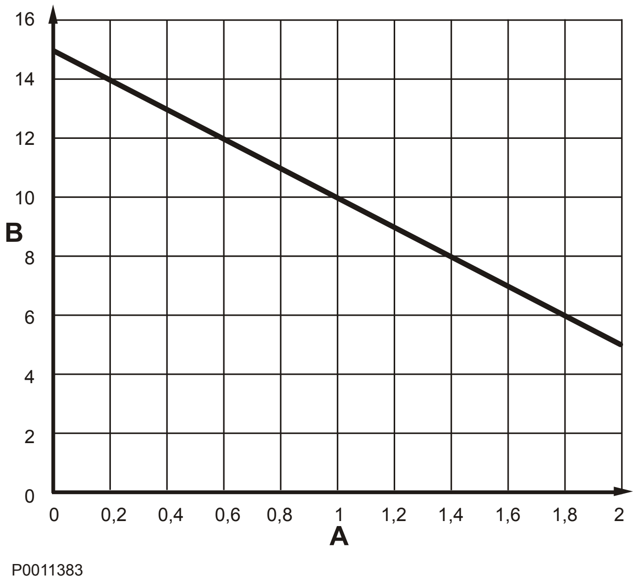


P0009730

Minimum *inner diameter* required for

- fuel feed line: **10 mm** (3/8")
- return hose: **10 mm** (3/8")

NOTICE! Use only approved flexible hoses.



A Suction height (m)

B Suction pipe length (m)

Length and suction height

Refer to the adjacent graph. In order for the necessary feed pressure to be maintained, the permissible line length is reduced if the suction height is raised.

The tank may be located with its upper edge max **1,0 m** (3.3 ft.) above the valve cover.

Nipples (1)

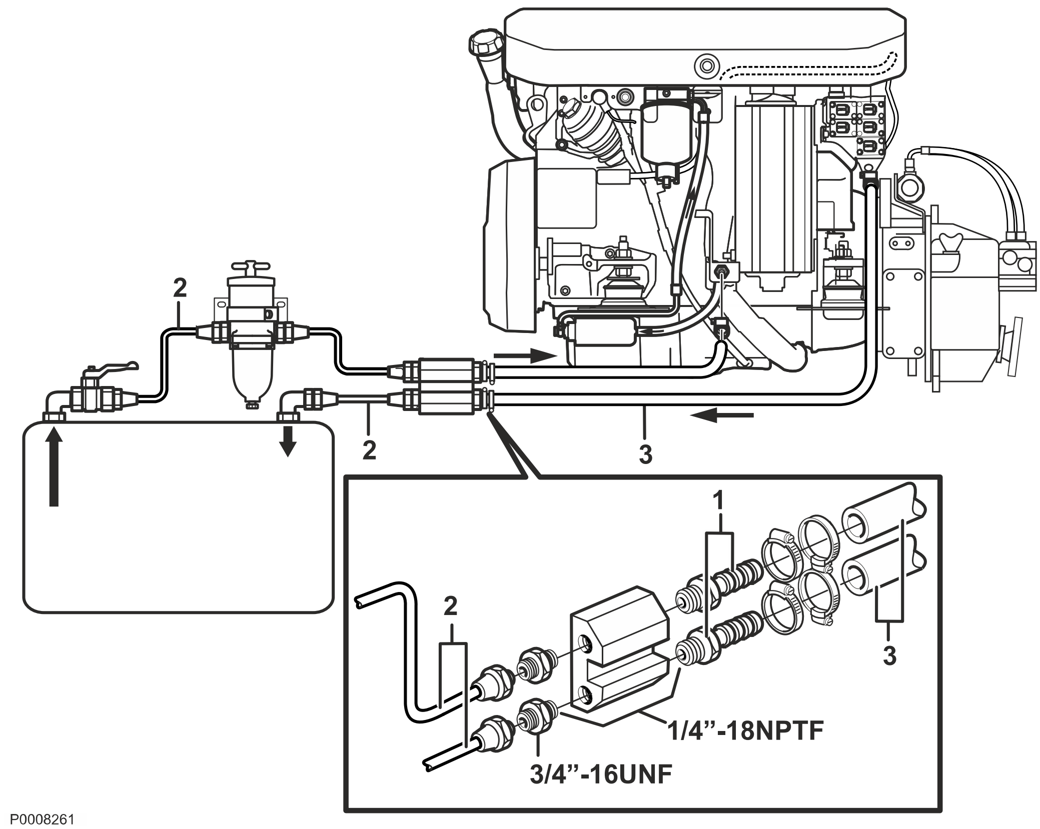
Minimum inner diameter: **7.0 mm** (0.28")
Male thread: **1/4" NPTF**
Volvo Penta part #: 3825000

Steel and copper pipes

Fuel pipes, fittings and nipples must be made of materials that are corrosion resistant in a maritime environment.

Fasten the fuel lines using brackets. Distance between brackets: approx. **300 mm** (12").

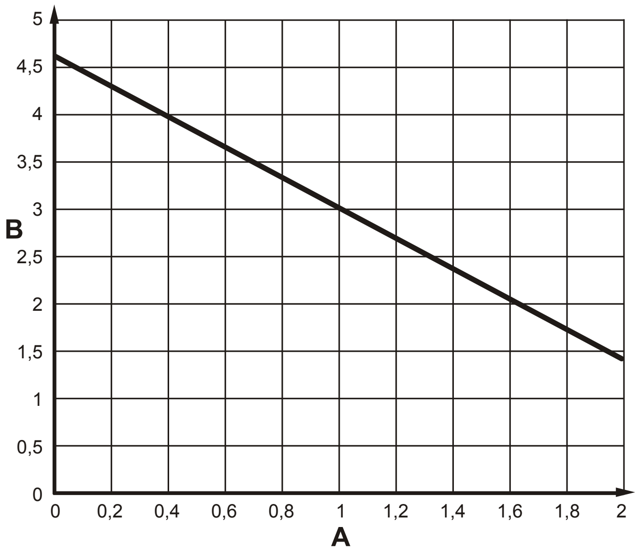
When steel and copper pipes are used there must be a flexible connection (hose) between the pipe and the engine.



The illustration shows the transition from flexible hose (**3**) to steel or copper pipe (**2**).

Minimum *inner diameter* required for

- fuel feed line: **7.0 mm** (0.28")
- return line **7.0 mm** (0.28")



P0011384

A Suction height (m)

B Suction pipe length (m)

Length and suction height 7.0 mm (0.28"), feed line

Refer to the adjacent graph. In order for the necessary feed pressure to be maintained, the permissible line length is reduced if the suction height is raised.

Nipples (1)

Minimum inner diameter: **7.0 mm** (0.28")
Male thread: **1/4" NPTF**
Volvo Penta part #: 3825000

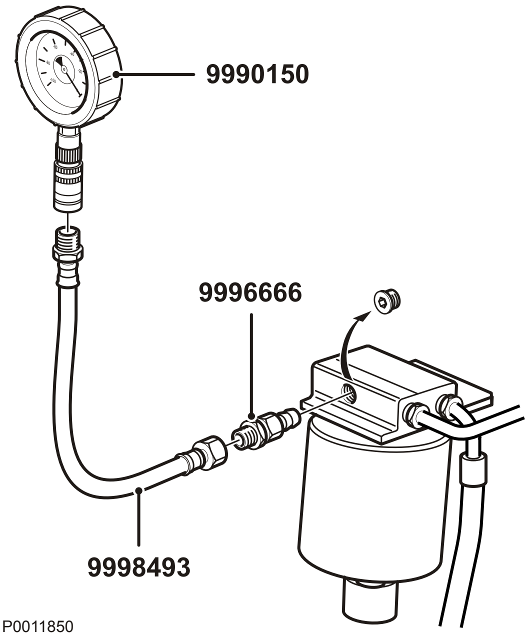
Fuel Flow

Fuel flow comprises the amount of fuel that passes through the fuel line from the tank to the engine, which includes both the fuel that is consumed and that which returns to the tank.

Maximum fuel flow on D3 engines is **210 l/h** (55 US gal./h).

Fuel filter

Select a fuel pre-filter dimensioned for the engine fuel flow. The pre-filter must have a water-separating function.



Fuel Pressure

Fuel Feed Pressure, Check

NOTICE! It is not normally necessary to check fuel pressure. This need only be done if there is a suspicion of too great a resistance in the system. Follow the procedure below as necessary.

NOTICE! Measurements must be made with new filter elements fitted.

Remove the port engine cover. Remove the fuel filter housing plug.

Install nipple 9996666; connect hose 9998493 and manometer 9990150.

Start the engine and check the feed pressure.

Nominal pressure	**380–420 kPa** (3.8–4.2 Bar)
Min pressure	**350 kPa** (3.5 Bar)
Max pressure	**550 kPa** (5.5 Bar)

Insufficient pressure

Check the following:

- Fuel filter
- Suction; refer to *Fuel Hoses, Supply, Suction page 153*

Excessive pressure

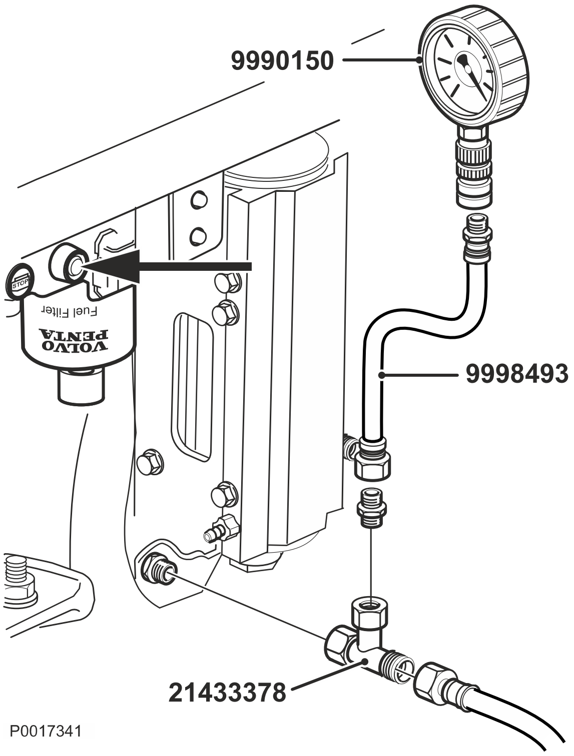
Excessive feed pressure may occur because the inlet and return lines are transposed. The feed pump has an integral safety valve with a working range of 600–800 kPa (6–8 Bar) which means that the pressure cannot exceed kPa (8 Bar).

NOTICE! In continual operations in the max position there is a risk that the pump will be damaged.

Check the following:

- Return fuel pressure; refer to *Fuel Return Pressure, Check page 154*

Fuel Hoses, Supply, Suction



It is of the utmost importance that negative pressure in fuel lines, prefilters and water separators does not exceed the maximum permissible value. A vacuum gauge is connected upstream of the feed pump in order to obtain the total value from the fuel tank to the feed pump.

Two consequences of a faulty value are that the high pressure pump has difficulty in governing rail pressure and that cavitation damage may occur in the pump.

NOTICE! Measurements must be made with new filter elements fitted.

Unscrew the fuel connection. Install nipple 21433378 and connect hose 9998493 and pressure gauge 9990150.

NOTICE! The engine does not need to be started to check under pressure.

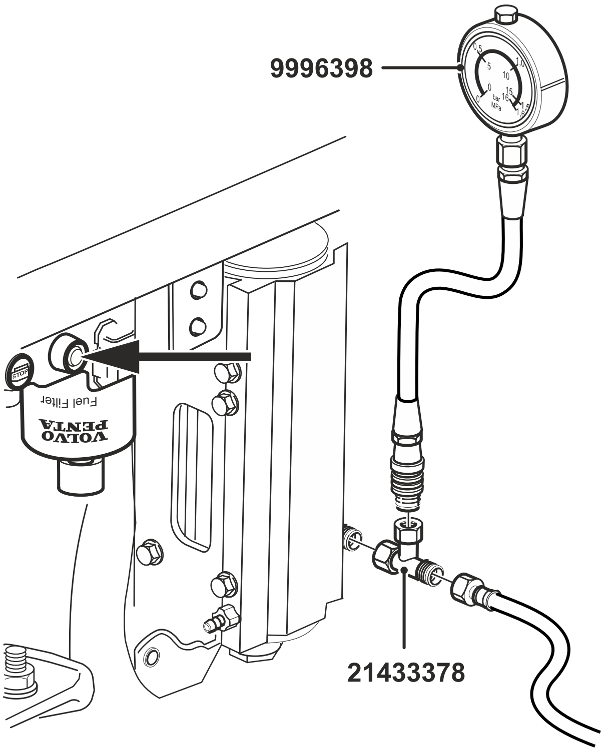
Pump up fuel by pressing the fuel feed button for around 10 seconds. Check fuel pressure while doing this.

Nominal pressure	**0 - (-) 30 kPa** (0 - (-) 0.3 Bar)
Min pressure	**-30 kPa** (0.3 Bar)

Insufficient pressure

Check the following:

- Fuel filter/prefilter
- Fuel lines from tank
- Fuel tank
- The installation in regard to line dimensioning



P0017262

Fuel Return Pressure, Check

Disconnect the fuel return line from the engine and install nipple 21433378. Connect the line to the nipple and connect pressure gauge 9996398.

NOTICE! The engine does not need to be started to check return pressure.

Pump up fuel by pressing the fuel feed button for around 10 seconds. Check fuel pressure while doing this.

Nominal pressure	**0 - 100 kPa** (0 - 1 Bar)
Max pressure	**100 kPa** (1.0 Bar)

Excessive pressure

If the return fuel pressure exceeds 100 kPa (1 Bar), check:

- Fuel pipes
- Fuel line dimensions; refer to *Installation page 146*

Electrical System

General

The electrical installation must be planned very carefully and installed with the greatest of care. Strive for simplicity when designing the electrical system.

Cables and connectors used in the installation must be approved for marine use. The cables must be run in protective sheaths and securely fastened.

Be careful not to run cables too close to engine hot spots or close to other heat sources. The cables must not be subjected to mechanical wear. Where necessary, the cables must be run through conduits.

Strive to minimize the number of joints in the system. Make sure that the cables and particularly the joints are accessible for inspection and repair.

There must be a circuit diagram in the boat covering the entire system. This will considerably simplify fault tracing and the installation of further equipment.

NOTICE! Make sure that all components used are suitable for marine environments. Take care to ensure that no joints in the engine compartment are located deep. All joints must be located higher than the alternator.

IMPORTANT!

Supply cables – batteries, alternators, distributors, starter motors and heavy loads must be installed separately from the EVC buss cable and the control unit cables in Volvo Penta IPS installations.

Positive (+) and minus cables (-) must be fixed next to one another, not separately.

Power supply

IMPORTANT!

Large power consumers such as bow thrusters, capstans etc. must be connected to a separate auxiliary battery and not to the start batteries.

One-pole system

D3 engines have a one-pole system.

In a one-pole system the actual engine block is used as the negative ground return for all components on the engine block.

There is an insulation kit for the engine which will galvanically isolate it.

Batteries

Battery terminology

Capacity

Capacity is measured in ampere hours (Ah). Start battery capacity (Ah) is normally specified as the battery 20-hour capacity, i.e. that the battery will be discharged by a constant current over 20 hours until it reaches a final voltage of 1.75 V per cell. For example: If a battery is able to produce 3 A over 20 hours, its capacity is 60 Ah.

The ampere value at cold start (CCA) measures battery start capacity. The SAE (Society of Automotive Engineers) specifies the following test: A battery at a temperature of -18 °C (0 °F) must be able to provide current equivalent to the ampere value during a 30-second cold start with a constant voltage level above 1.2 V per cell or 7.2 V for a 12 V battery. There are other CCA tests defined by DIN, JIS, and ETN etc. These tests give other CCA values than the SAE test.

Battery capacity is influenced by temperature. Battery capacity is specified at +20 °C (68 °F). Cold considerably reduces a battery's ability to release energy. The following table shows capacity differences at +20 °C (68 °F) and -18 °C (0 °F).

Temperature	**+20 °C** (68 °F)	**-18 °C** (0 °F)
Capacity	100 % 70 % 40 %	50 % 35 % 25 %

Connecting batteries

If the boat has several batteries, the following connection method must be used:

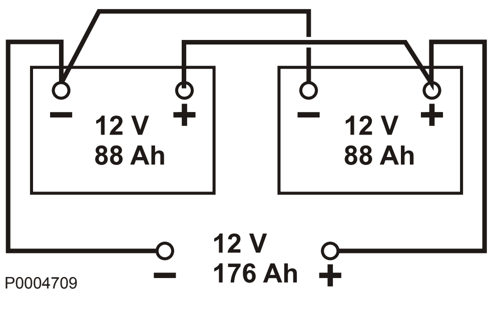
Parallel connection:

Two (or more) 12 V batteries are connected in parallel to increase capacity. Boat system voltage is the same as battery voltage.

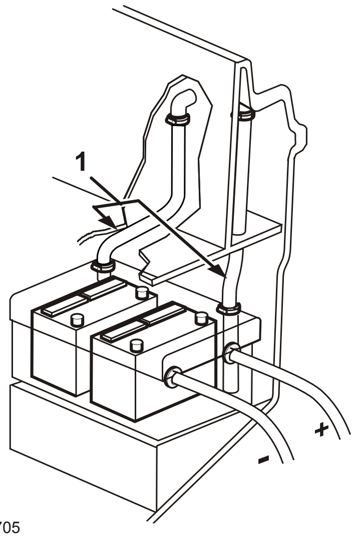
- The batteries must have the same nominal voltage.
- The batteries must be of the same type, voltage, capacity and age.

When two batteries are connected in parallel voltage remains the same, but capacity is the sum of the respective battery capacities. During charging each battery receives a charging current lower than that specified on the charger. Measure the charging current at each battery using an ammeter in order to assess charge current to each battery.

If one of the batteries in a parallel connection has a shorted cell, the nominal system voltage will be around 10 V.



Example: When two 12 V batteries, each with a capacity of 88 Ah, are connected in parallel, voltage will be 12 V and the total capacity 176 Ah.



P0004705

Batteries, Installation

Install the batteries in a box with a tight-fitting lid. Ventilate the box with min. 25 mm (1”) hoses (**1**). The ventilation hoses must lead to the outside of the boat in order to release the flammable gas the batteries produce.

The batteries must be fastened.

⚠ WARNING!
Risk of fire and explosion. Never allow an open flame or electric sparks near the battery or batteries.

Batteries that are not sealed may only be installed in the engine compartment if they are installed in a separate, sealed and well-ventilated battery box. Battery gas is highly inflammable and extremely volatile.

Starting Group Battery Capacity

The battery size specified below is recommended for Volvo Penta engines at temperatures down to -5 °C (23 °F). Battery voltage is 12 V.

NOTICE! Battery capacity drops by around 1% per degree Celsius from +20 °C (68 °F), which must be taken into consideration in extreme temperatures.

Single installation

Engine:	**Battery capacity (SAE)**
D3 (one battery per engine)	**Min. 750 CCA** and 75 Ah **Max. 800 CCA** and 110 Ah

CCA = Cold Cranking Amps (current at cold start)

Twin installation

Common start battery array (one start battery is used to supply both engines)

Engine:	Battery capacity (SAE)
D3	**Min. 800 CCA** and 75 Ah **Max. 800 CCA** and 110 Ah

CCA = Cold Cranking Amps (current at cold start)

Twin installation

Separate start battery arrays (one start battery per engine)

For installations with Electronic Steering separate starting batteries for each engine shall be installed.

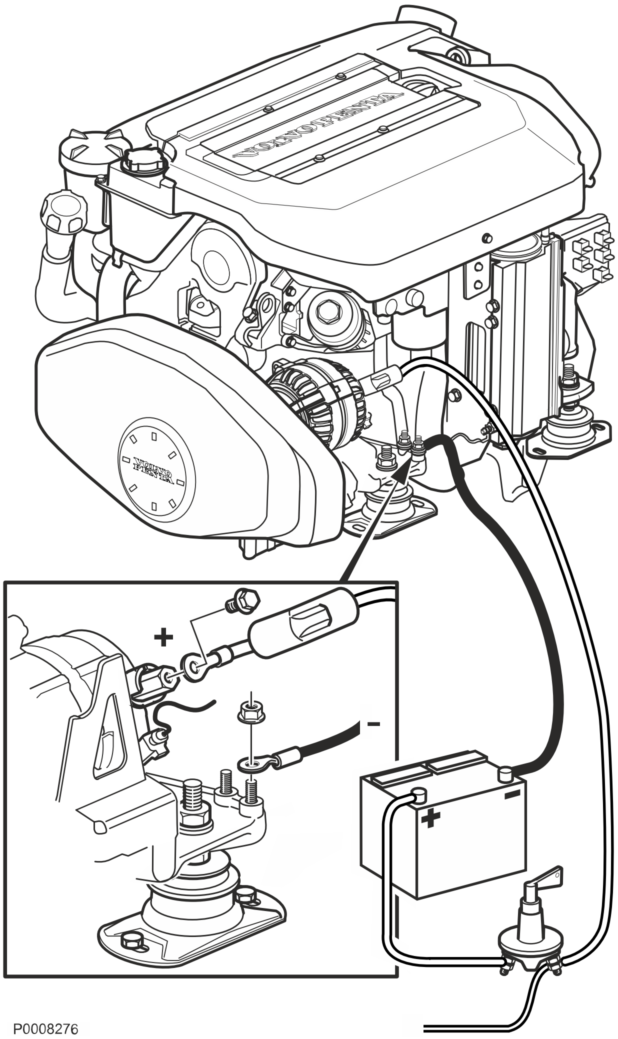
Engine:	Battery capacity (SAE) (per engine)
D3 (one battery per engine)	**Min. 750 CCA** and 75 Ah **Max. 800 CCA** and 110 Ah

CCA = Cold Cranking Amps (current at cold start)

Accessory Battery

The use of a separate battery array for service power consumption is mandatory.

Volvo Penta recommends the use of a charge distributor to charge the service batteries.



Starting Battery Cable Area

In order to obtain sufficient start current from the battery to the starter motor, Volvo Penta recommends cable cross-sectional areas as described below.

Measure the **total cable length** from the battery positive terminal (+) via the main switch to the starter motor positive connection (+), and from the starter motor negative connection (-) back to the battery negative terminal (-).

Then select the recommended cable area according to the table below for **both** the negative cable (-) and the positive cable (+).

Because the cable must absorb generated heat, the cross-sectional area must not be less than **50 mm²** (0 AWG).

Start battery total cable length and cable area

Total length of positive (+) and negative (-) cables, max. length m (ft)	5.0 (16)	8.0 (26)	10.0 (33)	13.0 (43)
Cable area, mm² (AWG)	50 (0)	70 (00)	95 (000)	120 (0000)

Battery Charging

IMPORTANT!

Always connect the battery charger directly to the battery positive (+) and negative (-) terminals.

When a battery charger is used in a 12 V system, battery voltage rises quickly to around 12.9 V and then increases slowly to 13,8–14,4 V at which point it begins to generate gas. The charge current must be reduced by the charger when gas generation begins.

High speed charging and intensive gas generation result in the following:

- Battery service life is reduced
- Capacity is reduced
- There is a risk of shorting in the battery
- There is an explosion risk

The following parameters govern charge period time:

- How discharged the battery was at commencement of charging.
  • Charger capacity (how much current the charger is able to supply).
  • Battery size (capacity in Ah).
  • Battery temperature. A longer charging time is required when the battery is cold. The battery is not able to receive a high charging current at low temperatures.

It is better to charge at 10 A for 5 hours than at 50 A for 1 hour, even though the total charge is 50 Ah in both cases. The battery may have difficulty in receiving a high charge current.

NOTICE! Moderate gas generation is normal. At the end of the charge voltage climbs quickly to 15 to 16 V. This value will not be exceeded even if charging continues.

Explosion risk

Gas is generated in the battery during charging. A short circuit, open flame or sparks in the battery vicinity may cause a powerful explosion. Ensure thorough ventilation, especially if batteries are charged in confined spaces.

NOTICE! Always switch off charge current before the connections are removed.

Alternator

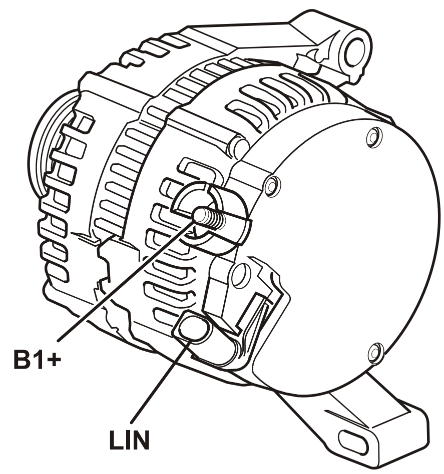
Main switch

A main switch must be installed on the positive side. When the cables are run through bulkheads both the positive and negative cables must be fitted with rubber bushings. Locate the main switch on the outside of the engine compartment. The main switch should be located as close to the batteries as possible to reduce the length of unprotected cables.

Technical requirements, main switch

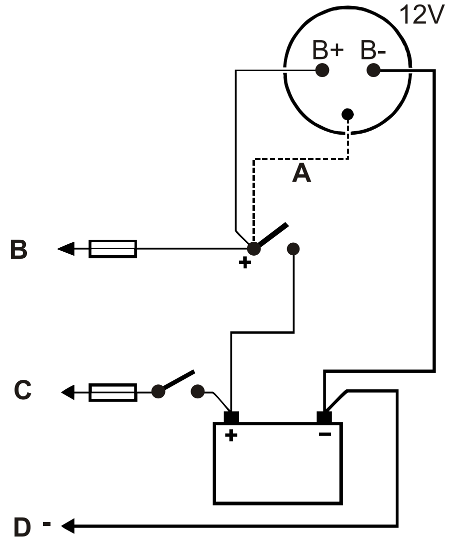
Normal voltage	Nominal capacity: Continuous	Under 5 sec.	Under 5.5 min.	Operating temperature, max.	Standard	Protection rating
≤48 V	180 A	1 000 A	450 A	+85 °C +185 °F	SAE marine J1171	IP 66

Alternator connnections



B1+. Battery positive (+)

LIN. Communication interface



P0004719

A Sensor cable

B Circuit breaker, accessories 12 V/24 V

C Circuit breaker, bow thruster, anchor capstans etc. (large consumers)

D **NOTICE!**
Connect to start array, negative

Extra Alternators

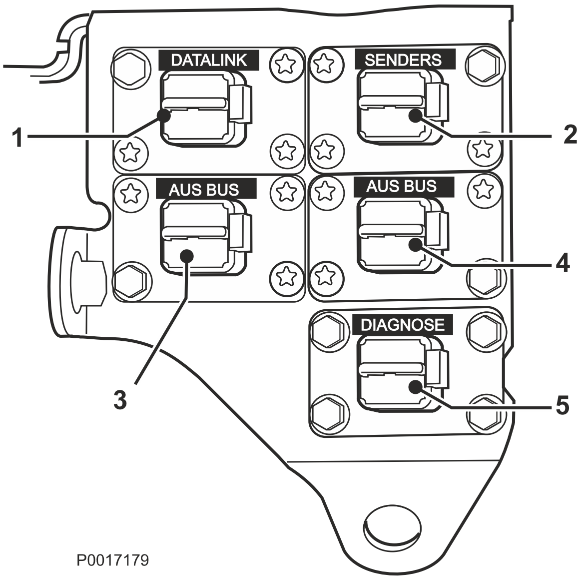
- Keep 12 V and 24 V systems separate.
- Connect the sensor cables to the correct voltage group, 12 V or 24 V.

Refer to *Power Take-off* for information regarding auxiliary alternators.

NOTICE! Large power consumers such as bow thrusters must have separate switches that are connected directly to the auxiliary battery positive terminal (+). Always install a circuit breaker to protect the electrical system.

Connection

Connection points

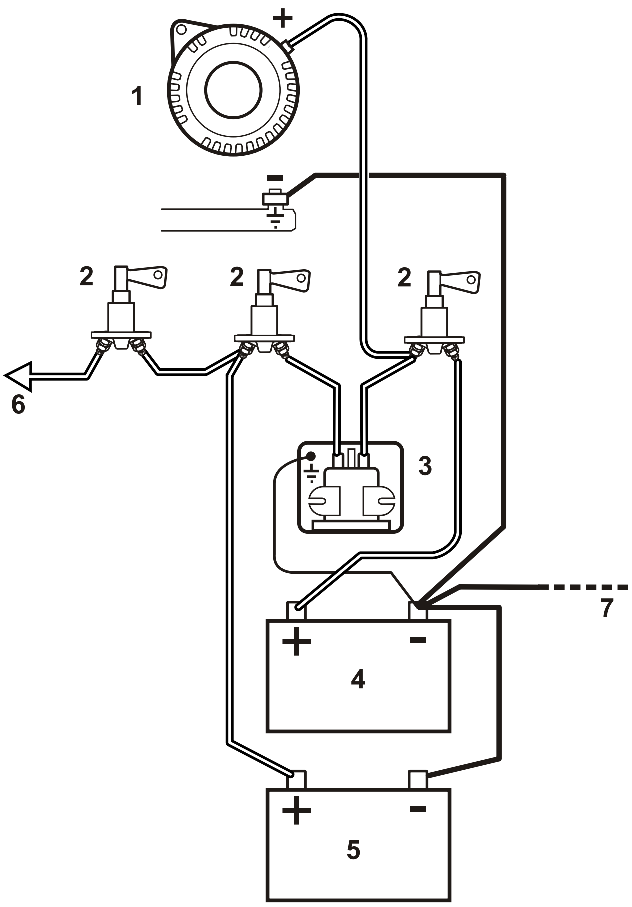


P0017179

The illustration shows the 5 connection points on the engine for e.g. diagnostics outlet, data link, AUX bus.

1 Datalink
2 Senders
3 AUX Bus
4 AUX Bus
5 Diagnostics

Battery Separator

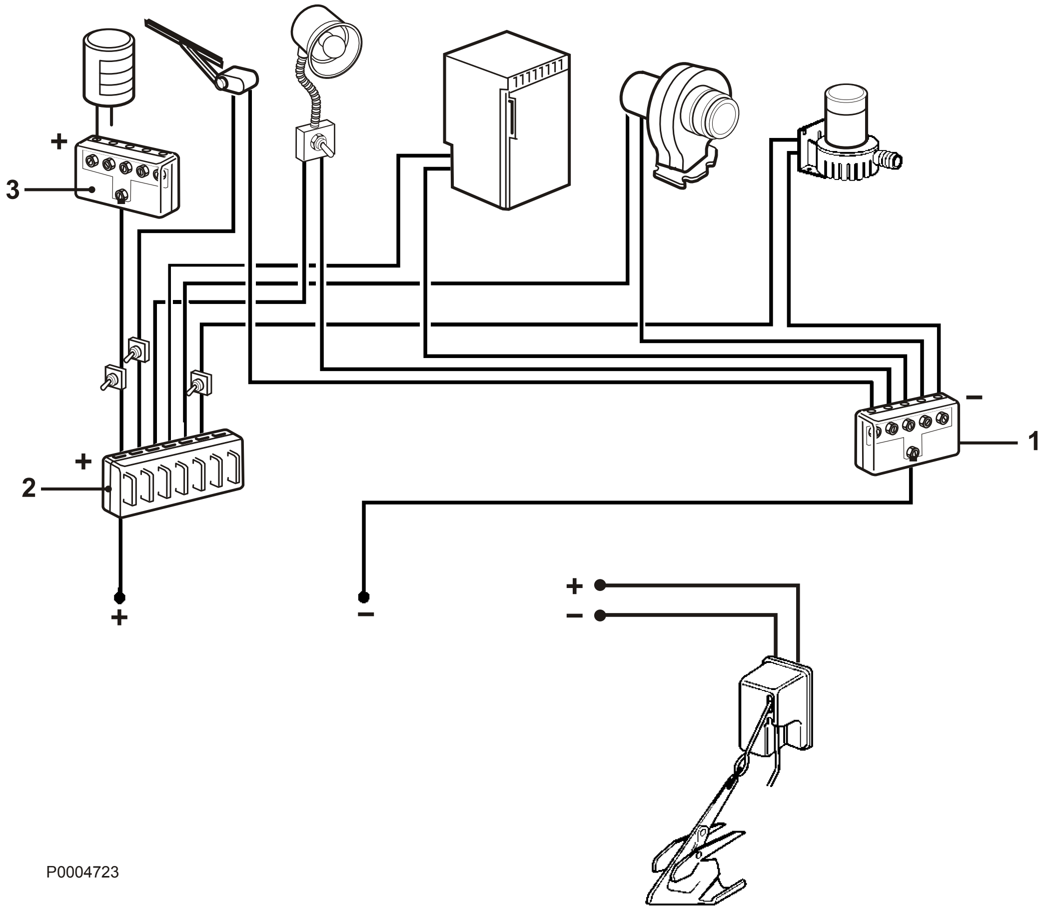


P0012094

The charge splitter automatically charges two batteries. One circuit is used to start the engine and the other circuit for other electrical equipment.

1 Alternator
2 Main switch
3 Split charge relay
4 Start battery
5 Service battery
6 To consumers
7 Next start battery (twin installation)

External accessories



1 Ground cable junction box (-)

2 Fuse box (+)

3 Junction box, lanterns

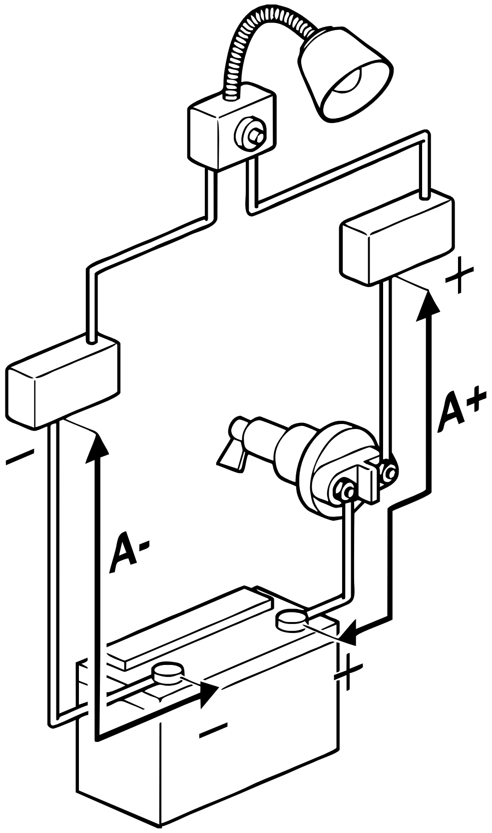
Before auxiliary equipment such as navigation equipment, auxiliary lighting, radio, echo sounders etc. are installed, their total power consumption must be accurately calculated in order to ensure that boat charging capacity is sufficient.

The above schematic shows how equipment may be installed in the boat. Fasten the cables to brackets at short intervals and mark the cables at fuse boxes and junction boxes (1-3) with each cable consumer such as communication radio, fridge, lanterns etc.

Install the electrical system control panel close to the instrument panel, in an easily accessible place that is not exposed to moisture.

If a 230 V system is installed, this part of the electrical panel must be clearly marked.

NOTICE! Make sure that all components used are suitable for marine environments. Spray all electrical equipment with water repellent spray.

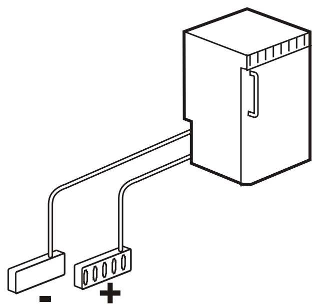


P0004724

Calculate the supply cable area

Note that power supply cable length and area (**A+**, **A-**) depends on the number of accessories connected.

- Add all the accessories (power consumers).
- Measure **the total length** of the supply cable (**A+**, **A-**) on the positive (+) and negative (-) sides.
- Refer to the chart . The chart shows supply cable area.

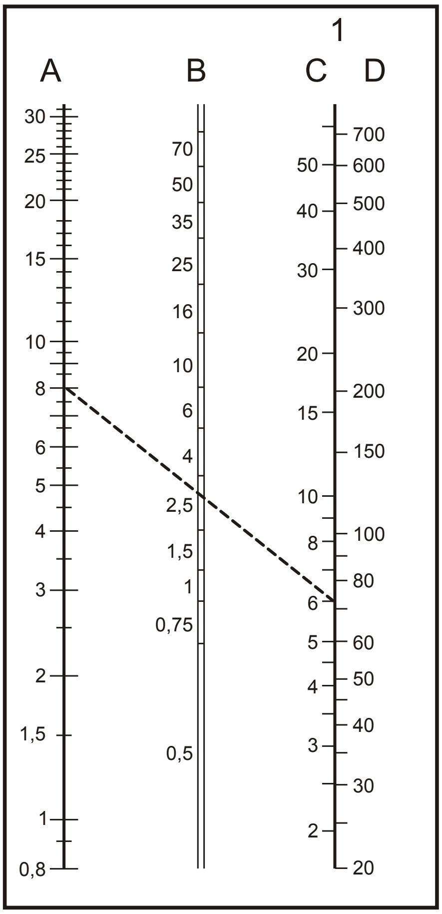


P0004723

Calculate cable area for power consumers

- Measure the distance from the terminal block to the accessory.
- Multiply the distance by two.
- Then calculate the cable area according to the chart .

Calculating cable area



P0010903

1 Load

A Length (m)

B Area (mm²)

C Current (A)

D Output (W)

AWG – American Wire Gauge

AWG	mm² (std)	mm²	sq. in
18	0,75	0,82	0.0013
16	1,5	1,31	0.0020
14	2,5	2,08	0.0032
12	4	3,31	0.0051
10	6	5,26	0.0082
8	10	8,37	0.013
6	16	13,29	0.021
5	16	16,76	0.026
4	25	21,14	0.033
3	25	26,65	0.041
2	35	33,61	0.052
0 (1/0)	50	53,46	0.083
00 (2/0)	70	67,40	0.104
000 (3/0)	95	84,97	0.132
0000 (4/0)	120	107,16	0.166

Example: If a 12 V fridge consumes 70 W and the distance between the terminal block and the fridge is four meters, draw a straight line between the number 8 (4 x 2) on the meter scale and the number 70 on the consumer scale.

The line dissects the area scale in the 2.5 space; 2.5 corresponds to the area required (2.5 mm^2).

The calculation is based on the maximum permissible voltage drop in all cables between the positive connection to the consumer and back to the negative connection.

Total voltage drop when applying the above table:

12 V system 0.4 V

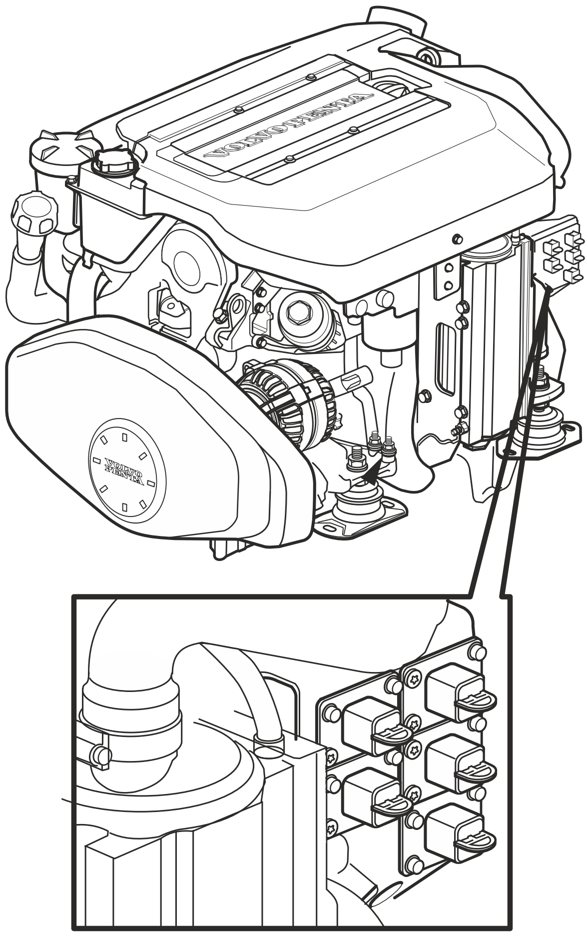
Fire Extinguishing System

Fire-extinguishing system, separate relay and connection

Fault codes will appear if the fire-extinguishing system input is activated:

VODIA/EVC display fault

Reset auxiliary stop button.
The stop input is activated, EMS PPID 6, FMI 11

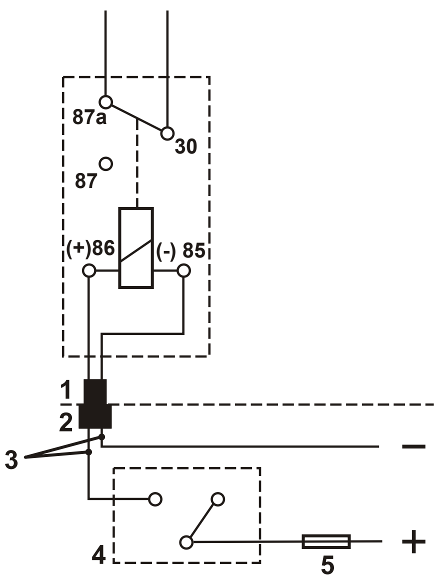


P0015143

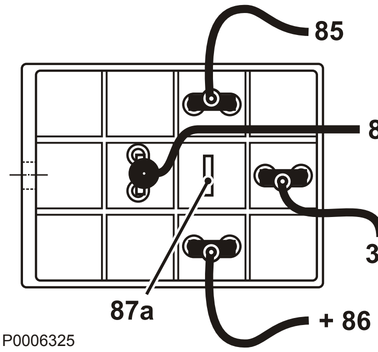
Recommended installation

Active (+) at stop (energized to stop)

1 Pin 1 R (+)
2 Pin 2 SB (-)
3 Accessory cable kit, 10 m (32.8 ft.)
4 Fire extinguishing system
5 From main switch (+) or accessory relay (ignition switch)

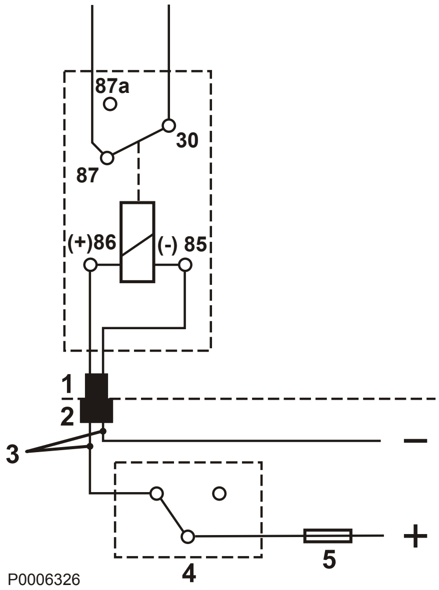


P0006324



P0006325

87a is not used.



P0006326

Alternative installation

Inactive (+) when closed (energized to run)

NOTICE! If there is a requirement for a pause function on the relay with an active positive (+) from the fire shut-off system when the engine is running, and no active positive (+) to switch off the system, the cables must be connected in the relay base as illustrated.

Terminal 85 is connected to the battery (-) and terminal +86 to the fire alarm unit.

The illustration shows a circuit diagram of an energized circuit.

1 Pin 1 R (+)

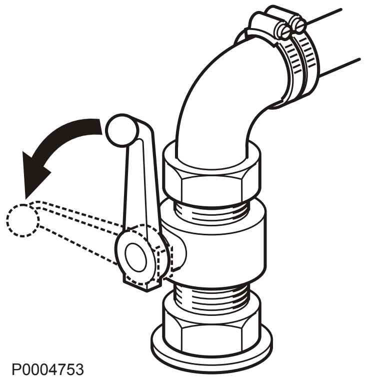
2 Pin 2 SB (-)

3 Accessory cable kit, 10 m (32.8 ft.)

4 Fire shut-off unit

5 Main switch (+)
Do not use accessory relay for EVC

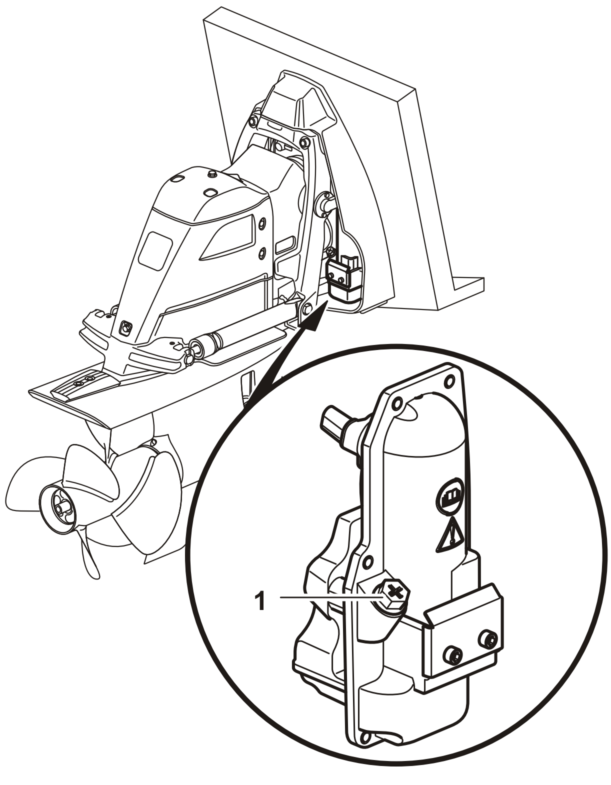
Launching and Sea Trial



Checks before launching

- Check that all valves and taps at hull fittings are closed.
- Check that the correct propeller size is installed. Also check that the propeller has the correct direction of rotation (left or right).
- Check that the sterndrive moves freely at its max tilt position.
- Gear lubricant (Aquamatic). Check the level and top up as necessary.
- Water-lubricated stern bearings. Check the water pipes are open.
- Check that the anodes on the transom shield and sterndrive are the correct types:
  Zinc anodes are the most suitable in most cases, and are installed as standard. Magnesium and aluminum anodes are accessories.
  Refer to the Operator's Manual.

Aquamatic drive:



Vent the system by trimming the sterndrive up and down.

No regular oil level checks are required unless trim system performance is poor. If system performance is poor, check the fluid level in the pump.

1 Trim the drive to the lowest trim position.
  IMPORTANT!
  If the drive cannot be trimmed down fully when the trim pump reservoir is filled it will result in an inaccurate fluid level. This may damage the trim system.

2 Swing the sterndrive hard aport to gain better accessibility to the pump.
  IMPORTANT!
  Clean the area around the cap before removing it to check the fluid level. Foreign objects in the fluid will damage the trim system,

3 Remove the cover (P) on the pump. The fluid must reach all the way up to the hole. Fill with Volvo Penta Power Trim and power steering fluid as necessary.

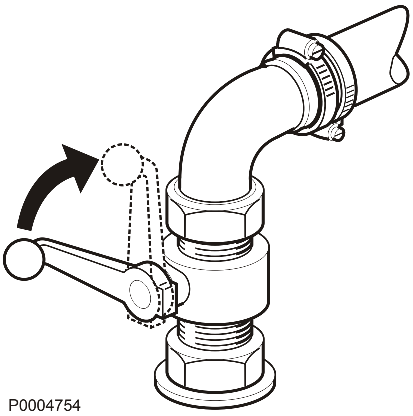
4 Replace the cap and tighten to 2–4 Nm (1.5–3 lbf.ft).

Checks after launching

Check the following **before** starting the engine.

IMPORTANT!

Recommendations for oil, fluids and grease: refer to the Operator's Manual.



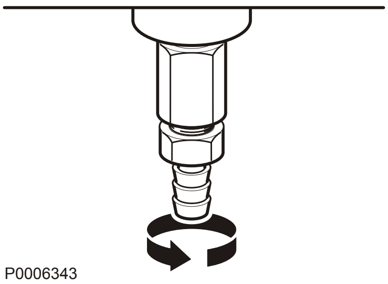
P0004754

Valves:

- Check valves.
- Check hull fittings.

Engine:

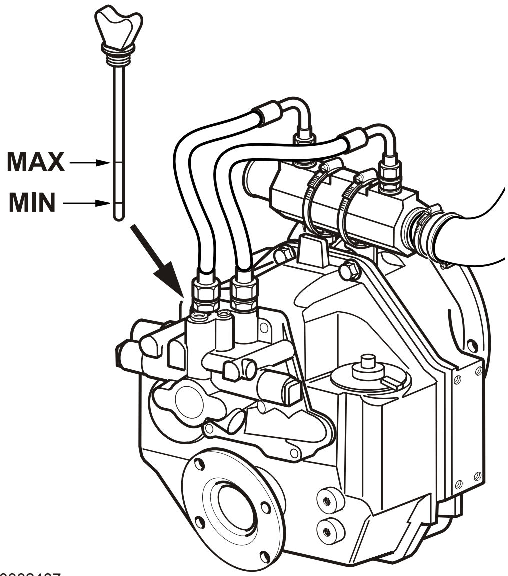
- Top up lubrication oil.
- Check the status of drain valves and plugs.
- Coolant.



P0006343

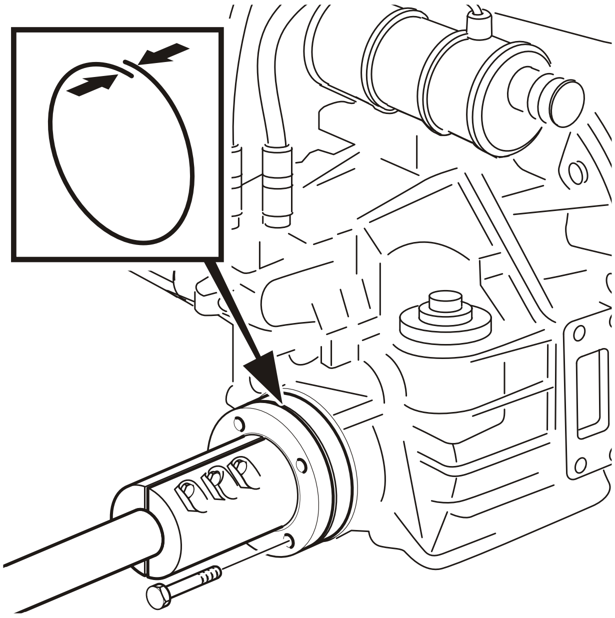
Inboard engines, reverse gear:

- Oil level, ATF oil



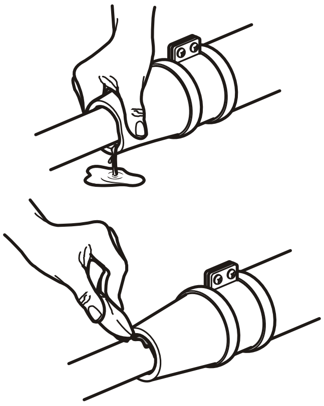
P0002487

Inboard engines, propeller shafts:



P0005976

- Propeller shaft alignment. Preferably after 12 hours in the water, with the boat rigged and ready.



P0002609

- Water-lubricated stern bearing: vent and grease the rubber seal. Pump approx 1 cm^3 (0.06 in^3) waterproof grease into the rubber seal, Volvo Penta part # 828250.

Fuel system, check:

- Fuel level
- Filters and taps
- Venting

EVC system:

- Check the battery terminals
- Carry out auto configuration. Refer to the EVC system installation manual.
- Make sure a complete calibration is carried out.
- Start the EVC display(s) and check functionality
- Check any fault messages

Starting the Engine (Cold Start)

⚠ WARNING!
Never use start spray or similar agents to start an engine. This may cause an explosion in the inlet manifold. Danger of personal injury.

IMPORTANT!

Also refer to the Operator's Manual for information on how to start the engine.

General information about starting

The throttle must always be in the neutral position before start. The engine control system ensures that the engine receives the correct amount of fuel, even when the engine is cold.

The engine is pre-heated by the control unit, which also allows the start motor to crank a few revolutions before fuel is injected. The colder the engine is, the more revolutions the engine is cranked. This increases the temperature in the combustion chambers, which guarantees a safe start and reduces starting smoke.

Idle speed is also controlled by engine temperature and is somewhat higher after a cold start.

EVC system checklist

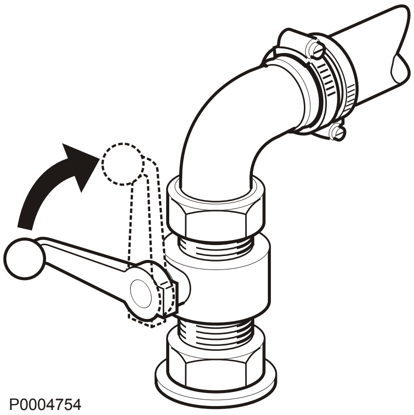
The following actions must be taken before the system is started:

1 Complete calibration

2 Start of EVC display(s)

3 Fault code checks

Pre-start checklist

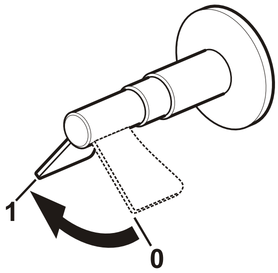


P0004754

Carry out the following before start:

1 Open the fuel cock.

2 Inboard engines: Open the seawater valve.

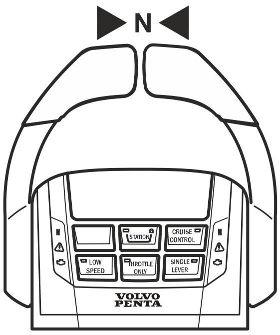


P0002431

3 Turn the main switches on.
IMPORTANT!
Never switch off the current at the main switch when the engine is running. It may damage the alternator.

4 Start the engine compartment fan, where fitted, and allow it to run *for at least four minutes*.

5 Check that there is sufficient fuel for the planned trip.



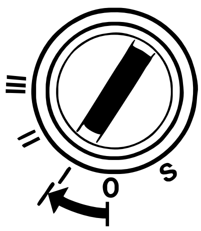
Pp0017161

Start method

Put the reverse gear/sterndrive in neutral

Put the reverse gear in neutral by moving the lever(s) to the neutral position at all helm stations.

Twin-lever control: Also check that the throttle lever is in the idle position.



P0006437

Turn the ignition on.

Turn the ignition key to the **I** position to switch on the ignition.

Check warning lamps and LEDs.

All light emitting diodes on the alarm display light up every time the ignition is switched on. Check the function of all light emitting diodes.

If the boat has more than one helm station, the light emitting diodes at the other helm station(s) cannot be checked before the control panel(s) is (are) activated.

Check the tachometer display

If a fault has been registered it will be indicated on the tachometer display.

P0002665

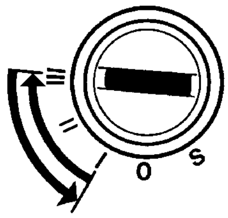
Activate the control panel and lock the system

Depress the **activation button** for at least one second. When the button is released, the indicator lamp lights up to confirm that the helm station is active.

NOTICE! If the indicator lamp flashes it means that the helm station is not activated because the control levers are not in the neutral position, or because the system is locked at another control panel.

If the boat has more than one control panel the system can be locked so that the engine can only be controlled from the active control panel. Depress the activation button for a further second to lock the system. The padlock symbol  lights up as confirmation.

Unlock the system by depressing the activation button for one second. This can only be done from an active control panel.



Start the engine

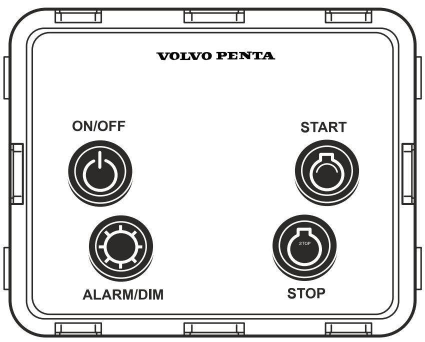
Start using the ignition switch.

Turn the key to position **III**. Release the key and let it return to position **I** as soon as the engine has started. Abort the start attempt if the engine does not start within 20 seconds.

NOTICE! If further start attempts are required, the key must first be returned to position 0.

Starting with the start button

Depress the start button. Release the start button as soon as the engine starts. Note that if you start the engine from another helm station, the ignition key at the main helm station must be in the **I** position. Abort the start attempt if the engine does not start within 20 seconds.



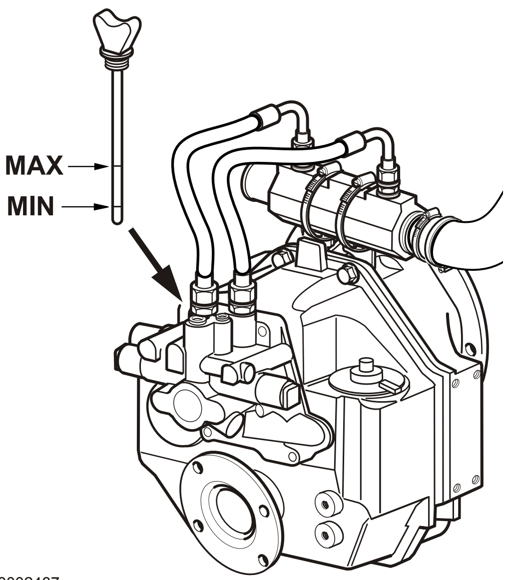
P0017170

Aquamatic

Turn the wheel hard to port and starboard at least five times to vent the power steering circuit.

Overheating protection

If the starter motor is allowed to run for its maximum activation time, the circuit will be disconnected to protect the starter motor from overheating. Allow the starter motor to cool for at least five minutes (if possible) before making a new start attempt.



P0002487

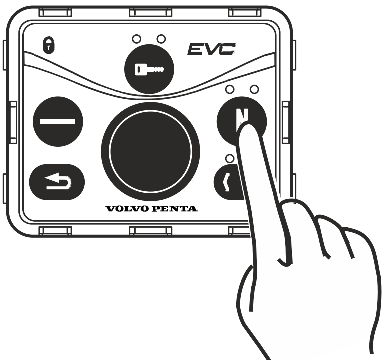
After starting

Read off the instruments and warm up the engine

1. First allow the engine to idle for ten seconds and then check that the instruments and displays are showing normal values.
2. Check that no alarms are displayed and that none of the warning lamps (accessories) are flashing.
3. Then warm up the engine at low rpm and with low load so that it reaches normal operating temperature before full power is demanded.
   IMPORTANT!
   Never race the engine when it is cold.
4. Check the oil level in the reverse gear when it has reached operating temperature.

Disconnect the gearshift function

The gearshift function can be disconnected so that the control lever only affects engine revolutions. Max engine revolutions **1 500 rpm**.



P0017177

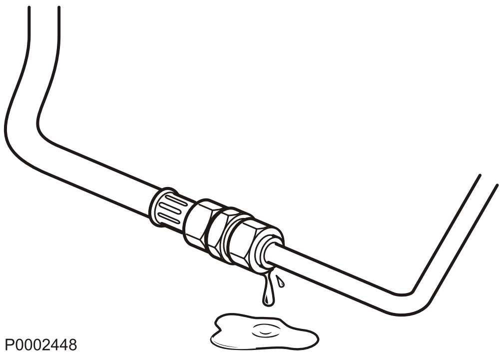
Do as follows to temporarily disconnect the gearshift function:

1. Move the lever to the **NEUTRAL** position.
2. Depress the neutral button (N) and hold it down while moving the control lever forwards to the **ahead** gearshift position.
3. Release the neutral button (N). The green indicator will flash to confirm that the gearshift function is disconnected.
   Now the lever only controls engine revolutions. The lever automatically connects gearshift function when it is returned to the neutral position. This is confirmed by the green indicator lamp showing continuously.

⚠ WARNING!

Be careful not to engage the reverse gear or sterndrive unintentionally.

Check the following when the engine is idling:



P0002448

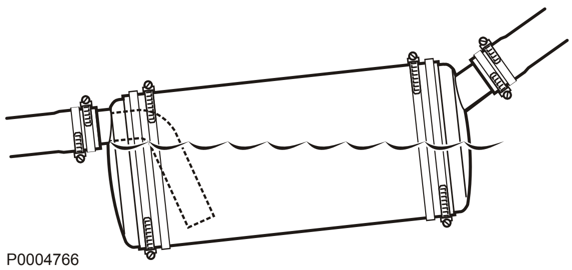
- Check for leaks in the fuel and cooling systems. Check hoses and pipes.

P0008272

- Check that instruments and gauges are functional and show the correct values
- Check the reverse gear oil level once the engine has reached operating temperature.
- Check that all equipment such as lanterns, instruments etc. is functioning normally.

Check idle revolutions

Idle revolutions depend on engine type. Refer to the EVC system installation manual if idle revolutions must be adjusted.


P0004766

Checks when engine is stopped

Switch the engine off and check the following:

1 Turn the key to position **0**.

2 Check coolant level.

3 Check the water level in the wet exhaust system. The level must be **well below** the lower edge of the silencer inlet so that there is no risk of water entering the engine. Note the limit specified by the manufacturer.

4 Check engine oil level when the engine is cold. Wait 15 minutes if the engine is hot.

P0008272

Sea Trail

Check during boat test run:

1 Instruments – Engine rpm, oil pressure, coolant temperature and battery charging.

2 Any occurrence of water, coolant, oil or fuel leaks in the engine installation.

3 Ability to reach maximum rpm; refer to the Operator's Manual. If it is not possible to run the engine at maximum rpm, the wrong propeller size may have been installed. It may also be because the boat is loaded such that it has the wrong trim angle in the water.

4 **Inboard engines:** Check exhaust back pressure. Refer to the *Engine Exhaust System* chapter.

Check across the entire speed range:

1 That engine temperature maintains an acceptable level.

2 That no abnormal noise or vibrations occur.

3 **Aquamatic:** Check that the drive does not cavitate abnormally, e.g. during hard turns. If the system cavitates it can be because drive toe-in requires adjustment. Refer to the *Propulsion Unit Positions, Calibration page 106* chapter. It may also be because the drive needs to be extended; refer to the *Water level at maximum load page 63* chapter.

4 **Inboard engines:** Check that propeller shaft seal water lubrication is satisfactory during operational trials. Also check that the water lubrication works well at planing speed and above.

5 Check that steering and controls are correctly connected and correspond to boat movements.

Checks after sea trials:

Fluid levels in power steering and Power trim.

Alphabetical index

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